# NOC MARINE AUTONOMY & TECHNOLOGY SHOWCASE

National
Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

noc.ac.uk/matshowcase

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

**Mr Adam Schink**

Marine Robotics Innovation Centre Manager NOC

# Session Chair Marine Robotics Innovation Centre One Year On and Project Update

# Mr Kevin Forshaw

Associate Director Innovation and Enterprise NOC

# Welcome to MATS 2016

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

**Mr Adam Schink**

Marine Robotics Innovation Centre Manager NOC

# Marine Robotics Innovation Centre
# “One year on”

# Marine Robotics Innovation Centre

'WHERE SCIENCE MEETS BUSINESS'


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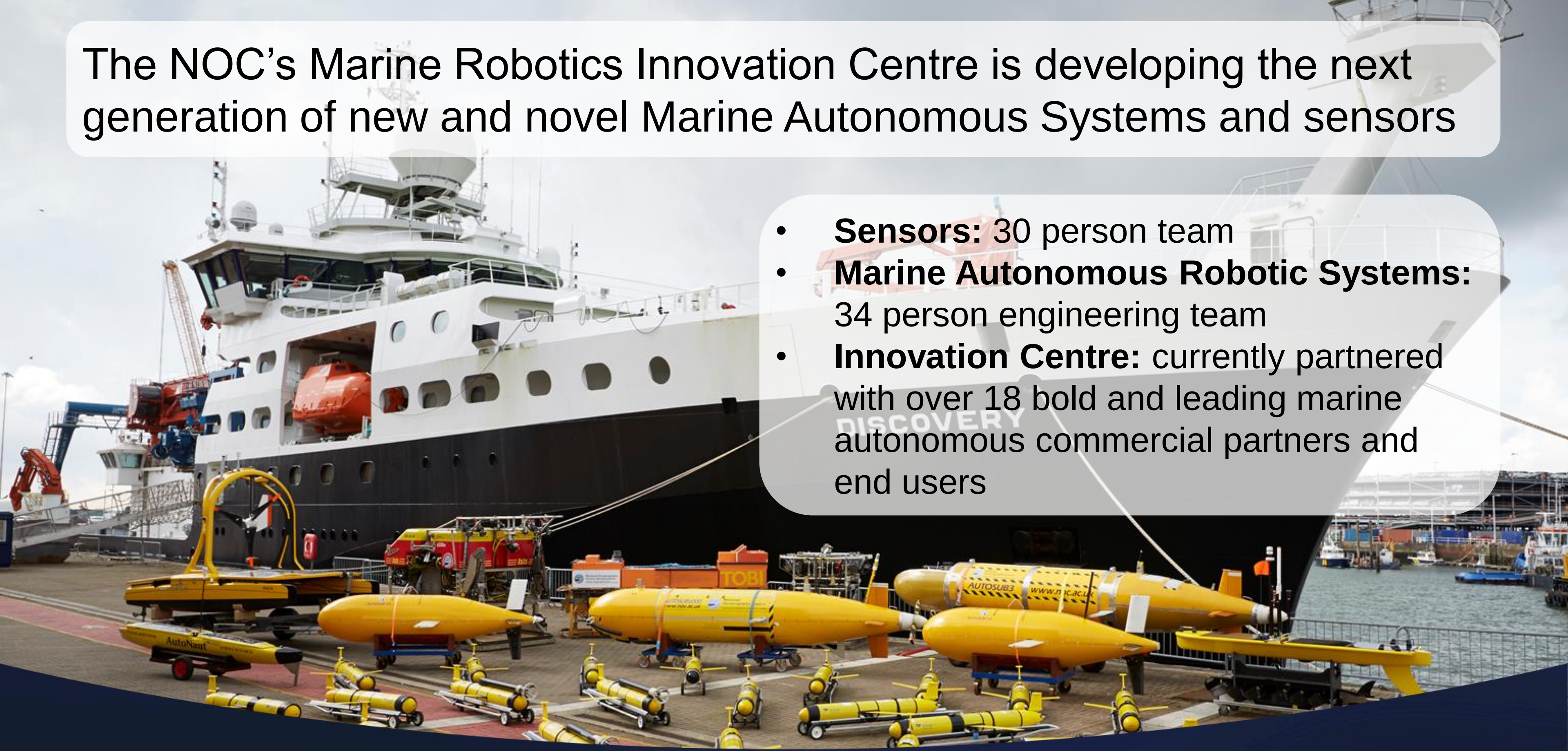
NERC SCIENCE OF THE ENVIRONMENT

# The NOC’s Marine Robotics Innovation Centre is developing the next generation of new and novel Marine Autonomous Systems and sensors

- **Sensors:** 30 person team
- **Marine Autonomous Robotic Systems:** 34 person engineering team
- **Innovation Centre:** currently partnered with over 18 bold and leading marine autonomous commercial partners and end users



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ATLAS ELEKTRONIK UK
A company of the ATLAS ELEKTRONIK Group

TELEDYNE MARINE
Everywhereyoulook™

Planet Ocean Ltd

THALES

NORTHROP GRUMMAN

STEATITE

ASV unmanned marine systems

BlueOcean MONITORING

Schlumberger

NORTEK

HYDROID
A KONGSBERG COMPANY

Sonardyne
SOUND IN DEPTH

AutoNaut
| A Seiche Company |

BMT

LIQUID ROBOTICS

QinetiQ

bp

seebyte

# MARINE ROBOTICS INNOVATION CENTRE

Celebrating our first year

## PARTNERSHIPS

**x8** companies working in partnership

**x11** Associate members

Companies in and associated with the centre have over… **300,000** …employees and operate in over 150 countries

# MARINE ROBOTICS INNOVATION CENTRE

Celebrating our first year

**WE ARE GLOBAL, NATIONAL AND LOCAL - PARTNERS HEADQUARTERS IN AUSTRALIA, NORWAY, SCOTLAND AND ENGLAND!**

# MARINE ROBOTICS INNOVATION CENTRE

Celebrating our first year

## INFLUENCE

**>40** companies have visited the centre 25% of those have visited more than once

Key visits from: G7, Innovate UK, UKTI Ambassadors, MP’s, NASA, Royal Navy

# 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)

# Marine Robotics Innovation Centre

'WHERE SCIENCE MEETS BUSINESS'

**Contact:**

**National Oceanography Centre**
**023 8059 6027**
**innovationcentre@noc.ac.uk**
**noc.ac.uk/innovationcentre**

National Oceanography Centre
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## Prof Matt Mowlem

OTE Group Head NOC


# Sensors Overview covering Sensor Capabilities, Achievements in 2016, What is in store for 2017 – highlighting potential license opportunities

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# Sensor Development

ACHIEVEMENTS AND FORWARD LOOK

MATT MOWLEM

HEAD OCEAN TECHNOLOGY AND ENGINEERING GROUP

# Ocean Technology and Engineering Group (OTEG)

Mission (***“To develop novel technology and engineering resulting in the greatest impact for environmental and marine science”***)

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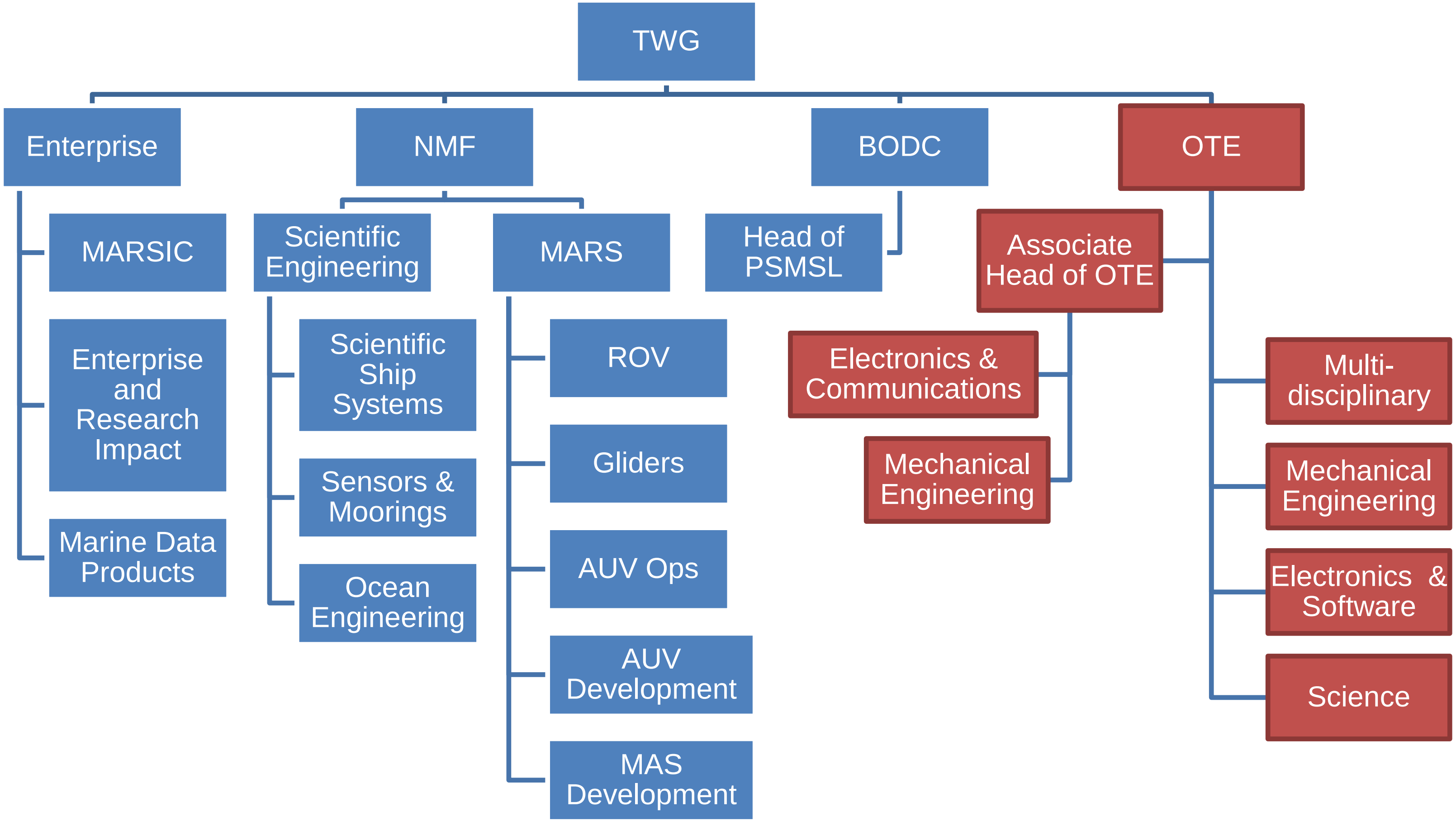
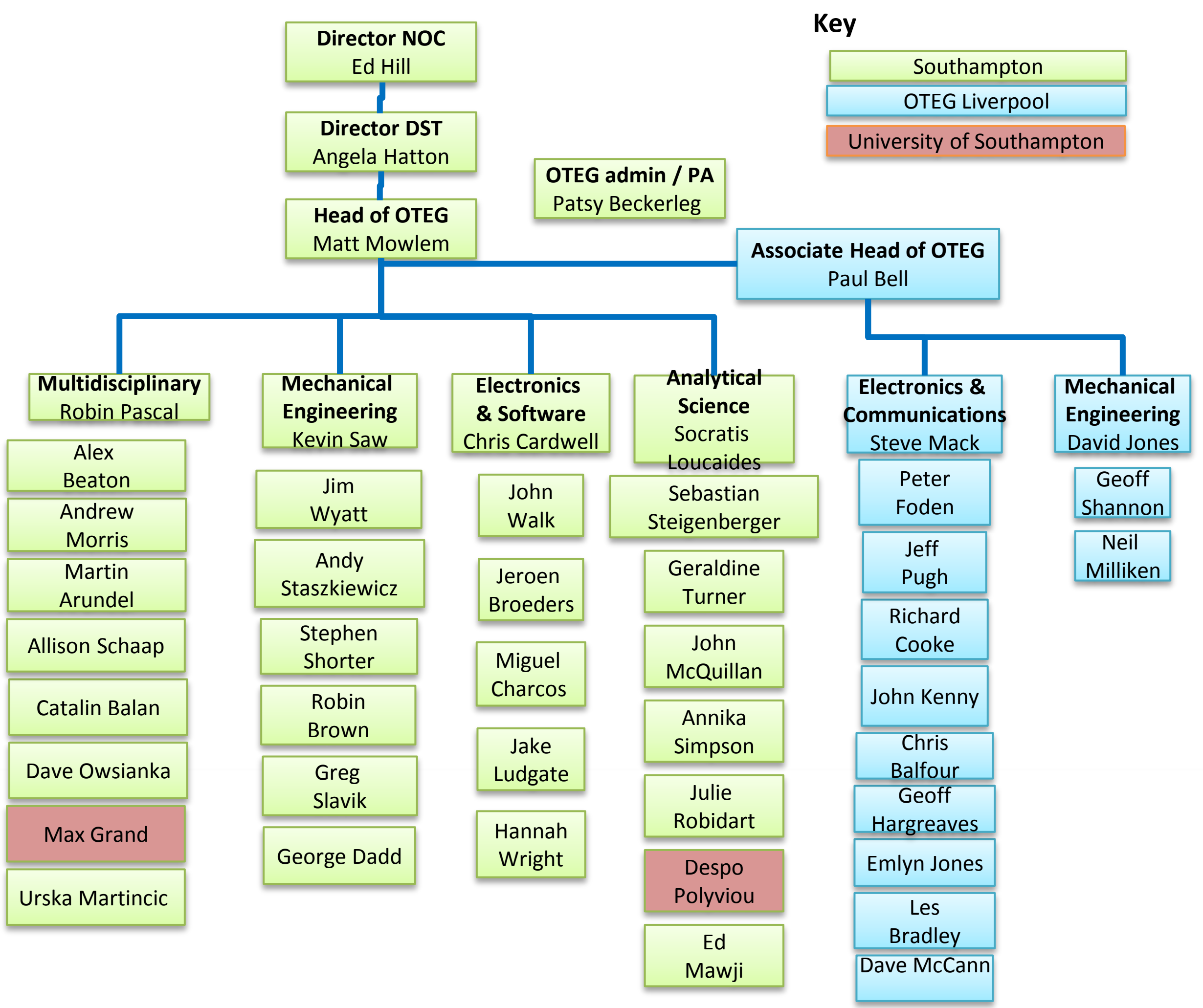
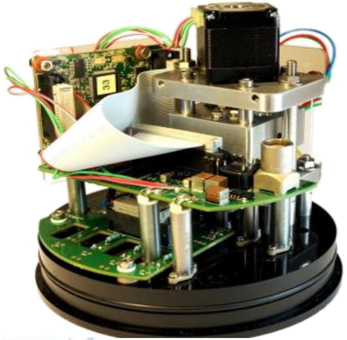

TWG
Enterprise
NMF
BODC
OTE
MARSIC
Enterprise and Research Impact
Marine Data Products
Scientific Engineering
Scientific Ship Systems
Sensors & Moorings
Ocean Engineering
MARS
ROV
Gliders
AUV Ops
AUV Development
MAS Development
Head of PSMSL
Associate Head of OTE
Electronics & Communications
Mechanical Engineering
Multi-disciplinary
Mechanical Engineering
Electronics & Software
Science

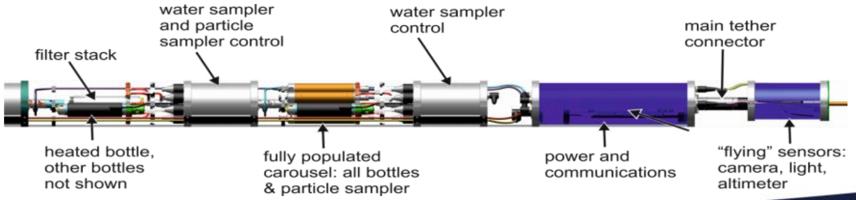

Key
Southampton
OTEG Liverpool
University of Southampton
Director NOC
Ed Hill
Director DST
Angela Hatton
OTEG admin / PA
Patsy Beckerleg
Head of OTEG
Matt Mowlem
Associate Head of OTEG
Paul Bell
Multidisciplinary
Robin Pascal
Alex Beaton
Andrew Morris
Martin Arundel
Allison Schaap
Catalin Balan
Dave Owsianka
Max Grand
Urska Martincic
Mechanical Engineering
Kevin Saw
Jim Wyatt
Andy Staszkiewicz
Stephen Shorter
Robin Brown
Greg Slavik
George Dadd
Electronics & Software
Chris Cardwell
John Walk
Jeroen Broeders
Miguel Charcos
Jake Ludgate
Hannah Wright
Analytical Science
Socratis Loucaides
Sebastian Steigenberger
Geraldine Turner
John McQuillan
Annika Simpson
Julie Robidart
Despo Polyviou
Ed Mawji
Electronics & Communications
Steve Mack
Peter Foden
Jeff Pugh
Richard Cooke
John Kenny
Chris Balfour
Geoff Hargreaves
Emlyn Jones
Les Bradley
Dave McCann
Mechanical Engineering
David Jones
Geoff Shannon
Neil Milliken

# Ocean Technology and Engineering Group Post MARS

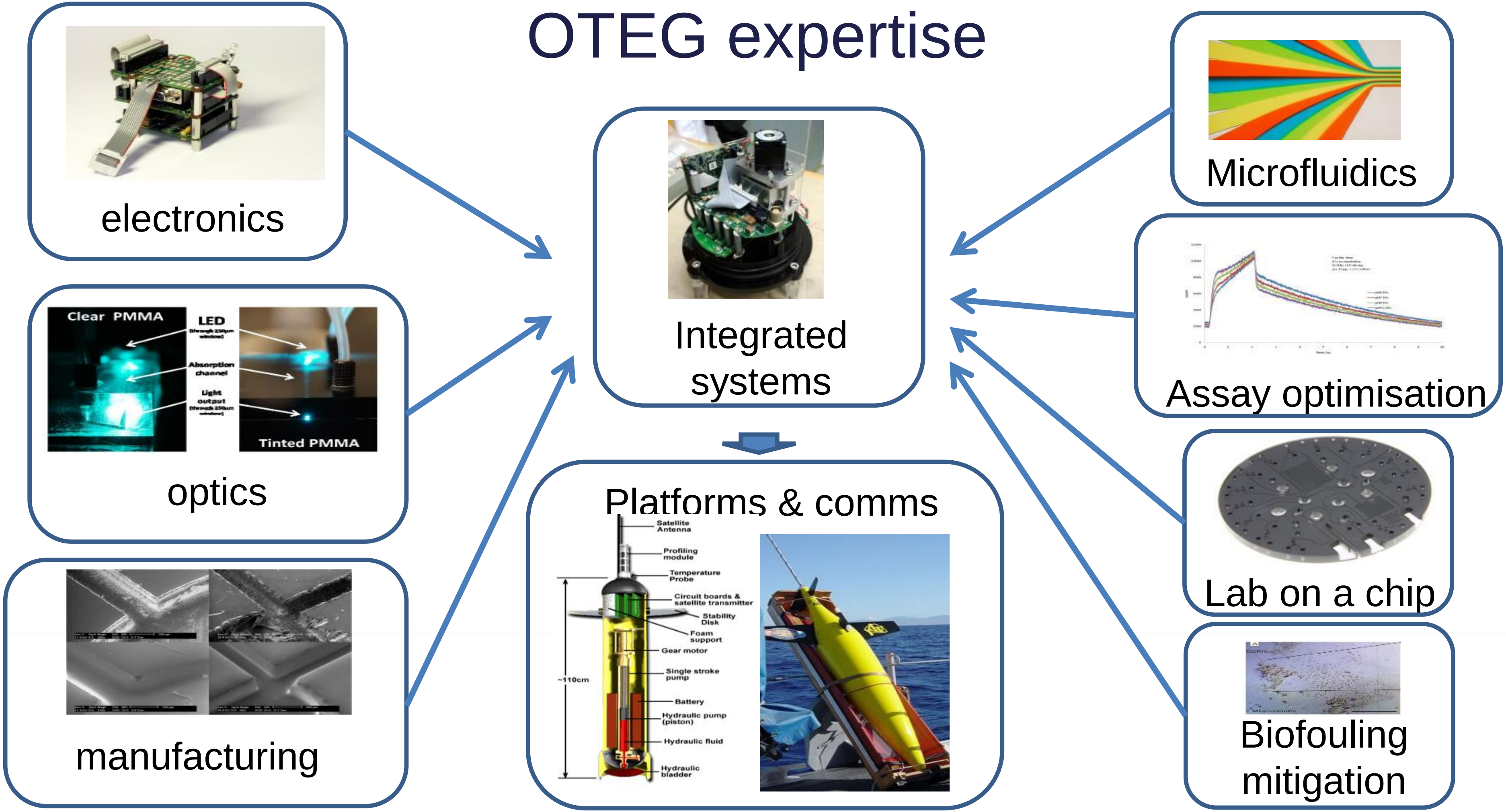
- ## Sensors
- Water physics (CTD)
- Water chemistry
- Water biology
- Sediment flow and properties
- Wave height / breaking
- Sea level
- Sea surface fluxes
- ## Enabling systems
- Metrology standards
- Interoperability and metadata
- Comms & Data flow
- Sensors on platforms
- Autonomous sea level



- ## Samplers
- Continuous water
- Gas tight water
- Particles
- Genomics
- ## Landers and benthic systems
- ## Communication systems
- ## Sterile probes / vehicles
- ## Vehicles: Gliders



# OTEG expertise



# GOOS EOV

Readiness level: CONCEPT | PILOT | MATURE [Click on each EOV for their repsective spec sheets]

| PHYSICS | BIOGEOCHEMISTRY | BIOLOGY AND ECOSYSTEMS |
|---|---|---|
| Sea state | Dissolved Oxygen | Phytoplankton biomass and productivity |
| Ocean surface vector stress | Inorganic macro nutrients | Harmful Algal Bloom (HAB) incidence |
| Sea ice | Carbonate System | Zooplankton diversity |
| Sea surface height | Transient tracers | Fish abundance and distribution |
| Sea surface temperature | Suspended particulates | Apex predator abundance and distribution |
| Subsurface temperature | Nitrous oxide | Live coral cover |
| Surface currents | Carbon isotope ($^{13}C$) | Sea grass cover |
| Subsurface currents | Dissolved organic carbon | Mangrove cover |
| Sea surface salinity | | Macroalgual canopy cover |
| Subsurface salinity | | |
| Heat flux / radiation | | |

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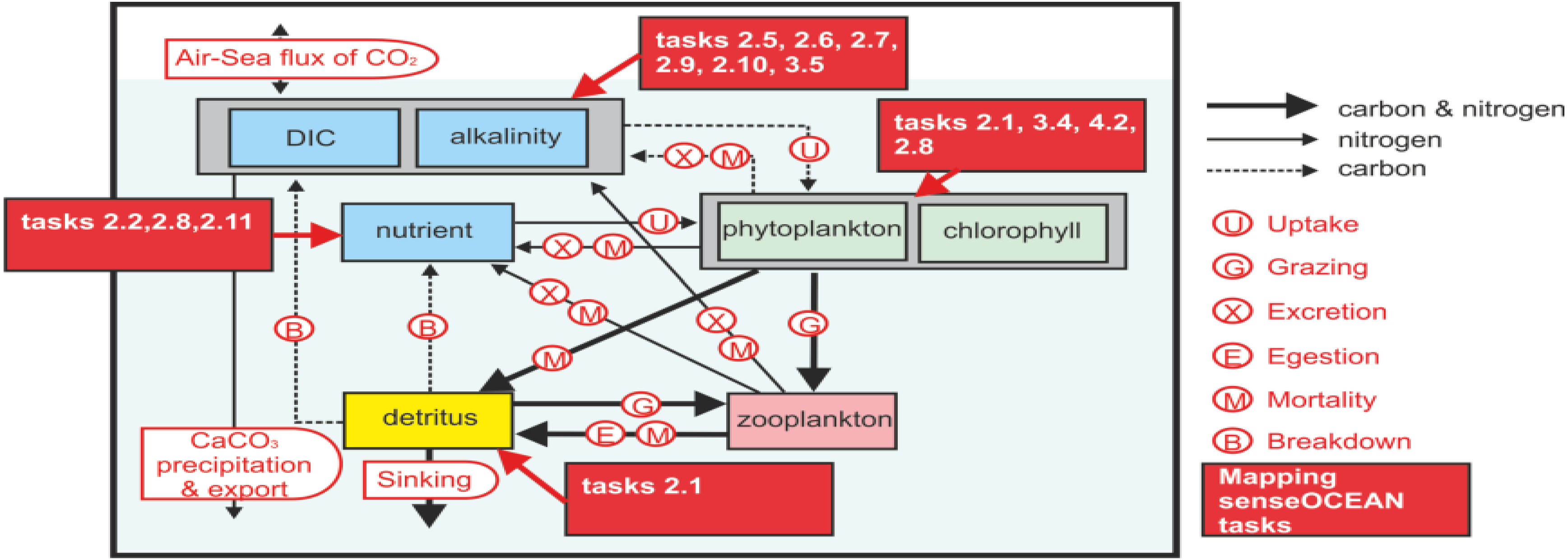
# biogeochemical model of the ocean system




Summary of the Tasks outlined in SenseOCEAN mapped onto the current state of the art

# Marine Sensors Technologies and TRL

## Microfabricated Solid State / Electrochemistry:

- Salinity 7
- Dissolved oxygen 7

## Optodes / optical sensors

- Gases inc. methane 6
- pH, $pCO_2$ 7
- Radionuclide 3

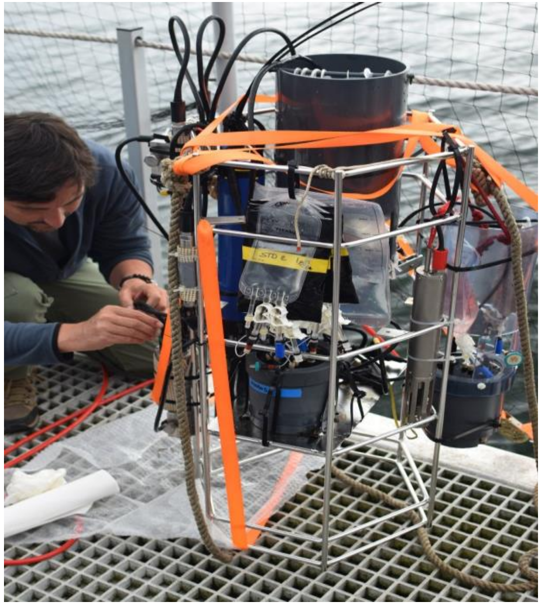
## Lab on Chip Cytometer

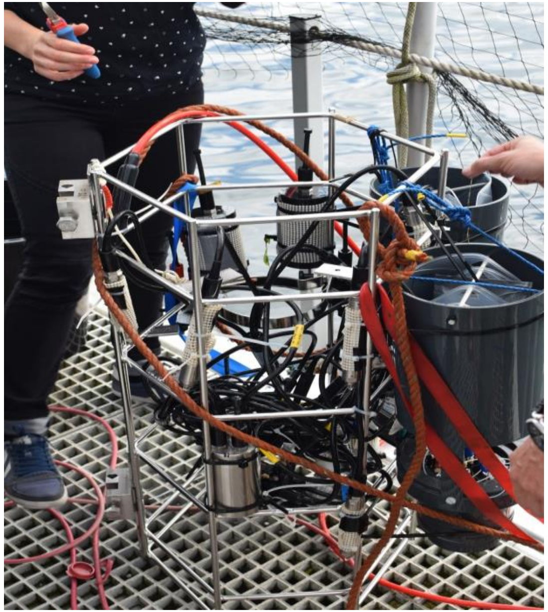
- Whole cells (label free) 5
- Labelled cells 5
- Microplastics 4
- Bead assays 3

## Lab on Chip Chemistry

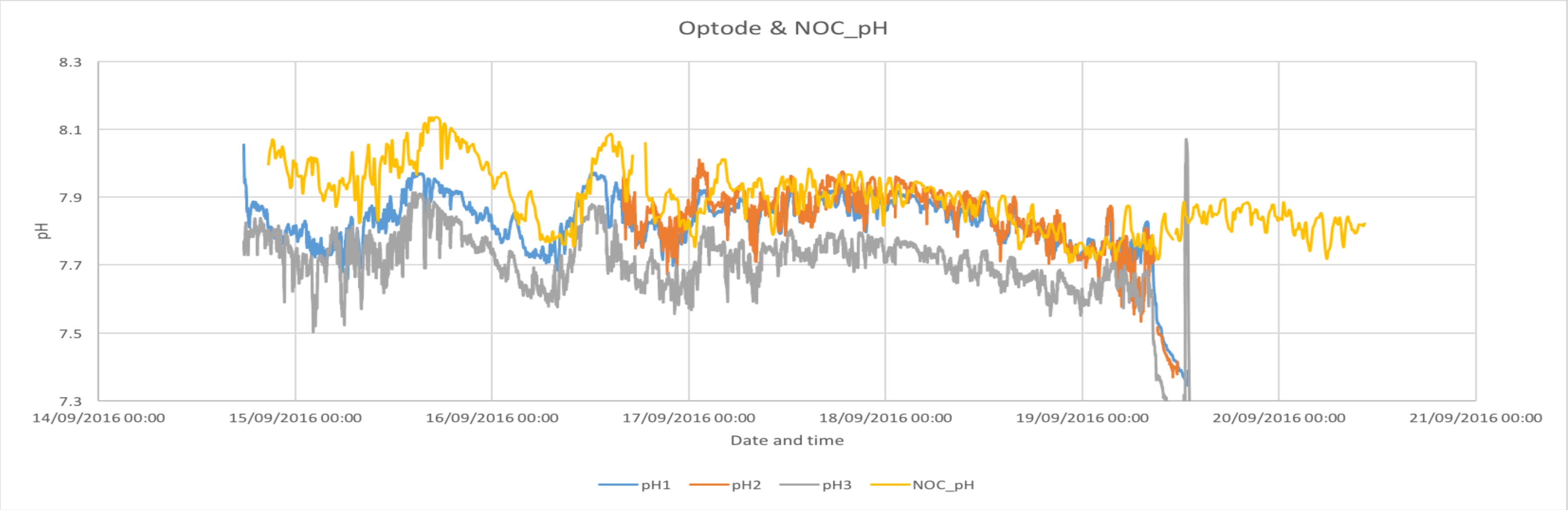
- Inorganic Nutrients 8
- Organic Nutrients 5
- Trace metals 7
- pH 7, TA 4, DIC 3, $pCO_2$ 4
- Small organics, e.g. PAH, PCBs (f-pM) 5
- Proteins and large organics (copies / L) 4
- Nucleic Acids (copies / L) 6
- Radionuclide 3

# Demo / test Kiel Fjord Sept. 2016





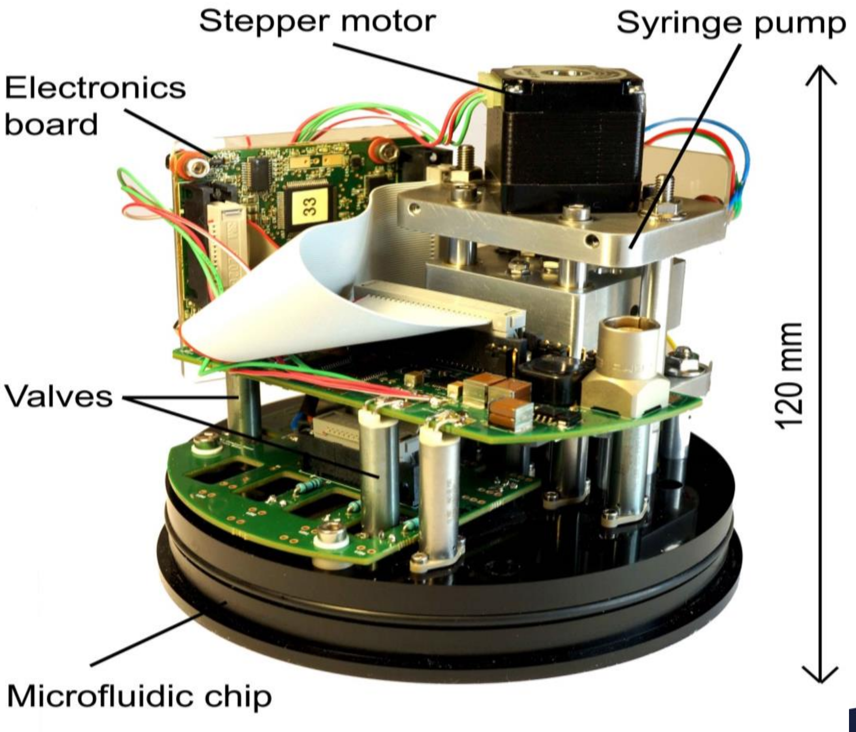
# Kiel Preliminary Results: pH




Preliminary LOC data from T. Yin (NOC) and TU Graz team (Optodes)

# NOC chemical sensor platform

- Now operational for several parameters
- Platform technology - easy to adapt to other absorbance-based assays
- Works at pressure (deepest deployment to date 4800 m)
- Small enough for glider/AUV deployment
- Low power (year long deployment on batteries achieved)



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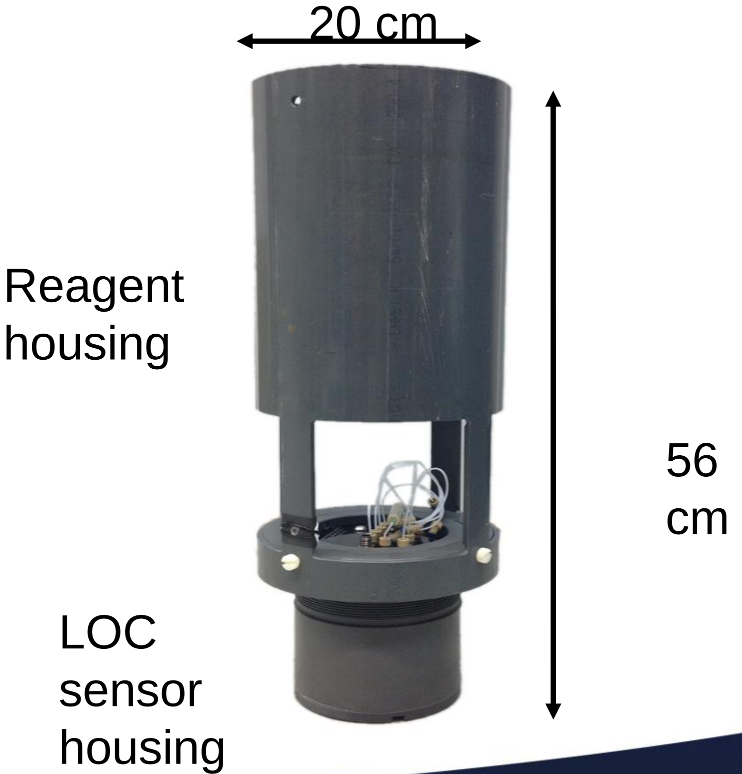


| LOC Sensor | Analytical method | Measurement type | LOD/precision* |
|---|---|---|---|
| **Nitrate + nitrite** | Griess assay (with Cd reduction) | Colourimetry (absorbance) | 20 nM |
| **pH** | Thymol blue | Dual wavelength absorbance | 0.001 pH units* |
| **Phosphate** | Molybdenum blue (modified) | Colourimetry (absorbance) | 30 nM |
| **Iron (II), Iron (III)** | Ferrozine (with ascorbic acid reduction for Fe (III)) | Colourimetry (absorbance) | 20 nM |
| **Silicate** | Silicomolybdic acid | Colourimetry (absorbance) | 20 nM |
| **Ammonium** | OPA + membrane | Fluorescence | 1 nM |
| **Total alkalinity** | BCG with TMT or single step | Dual wavelength absorbance | (2 µM)* |
| **DIC** | Membrane+ C of NaOH | Conductivity | (2 µM)* |
| **Organic N and P** | UV digester + inorganic system | Colourimetry (absorbance) | (20 nM) |

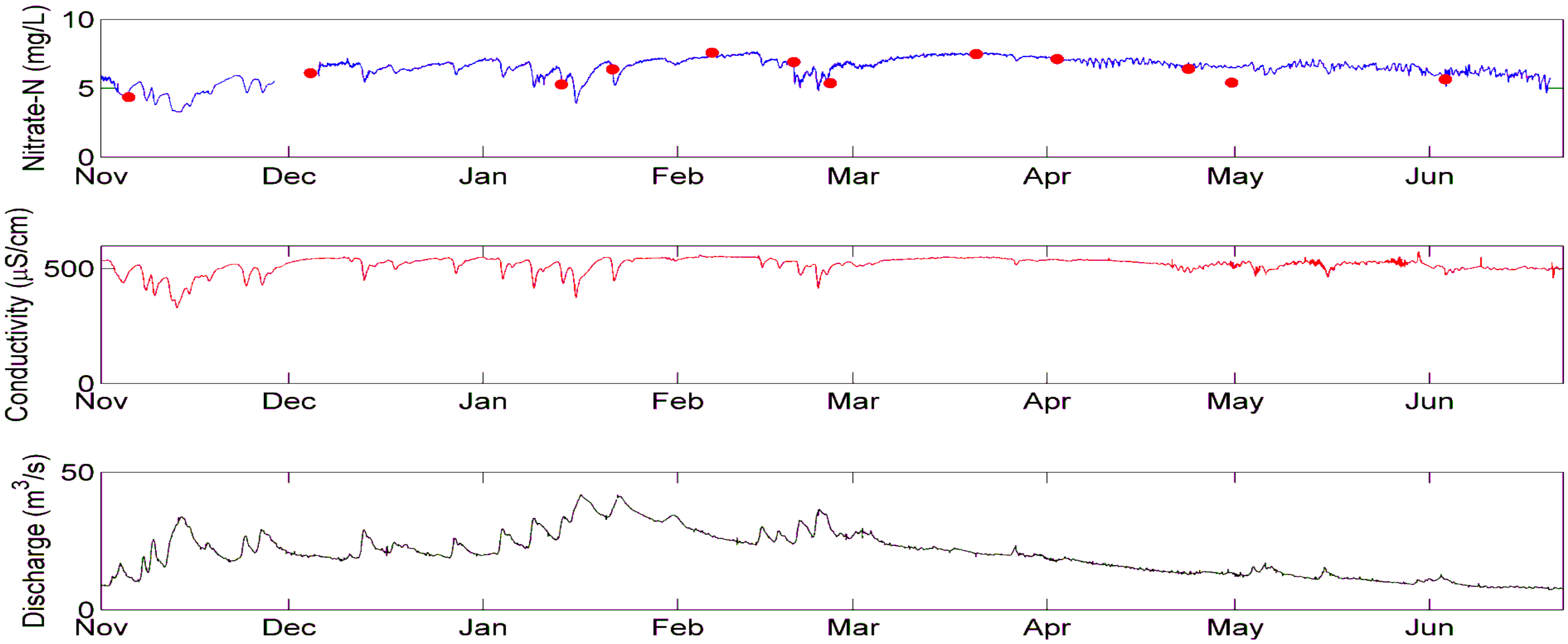
# NERC Macronutrient Cycles: Nitrate in a river

Hampshire Avon deployment site

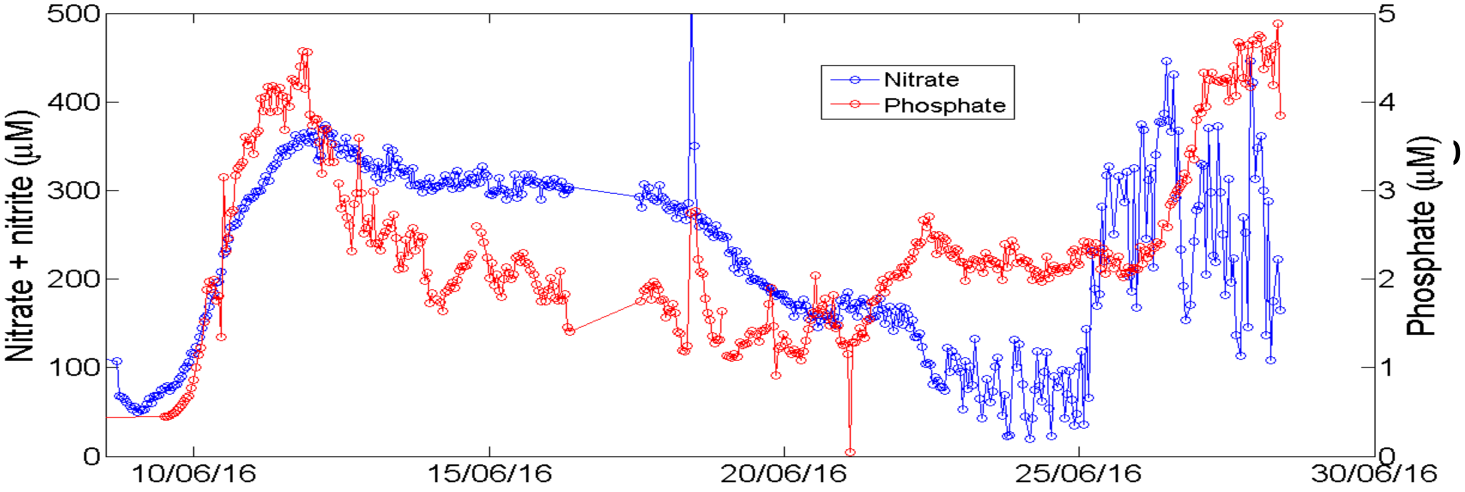
Sensor after deployment in River

Nitrate sensor in river

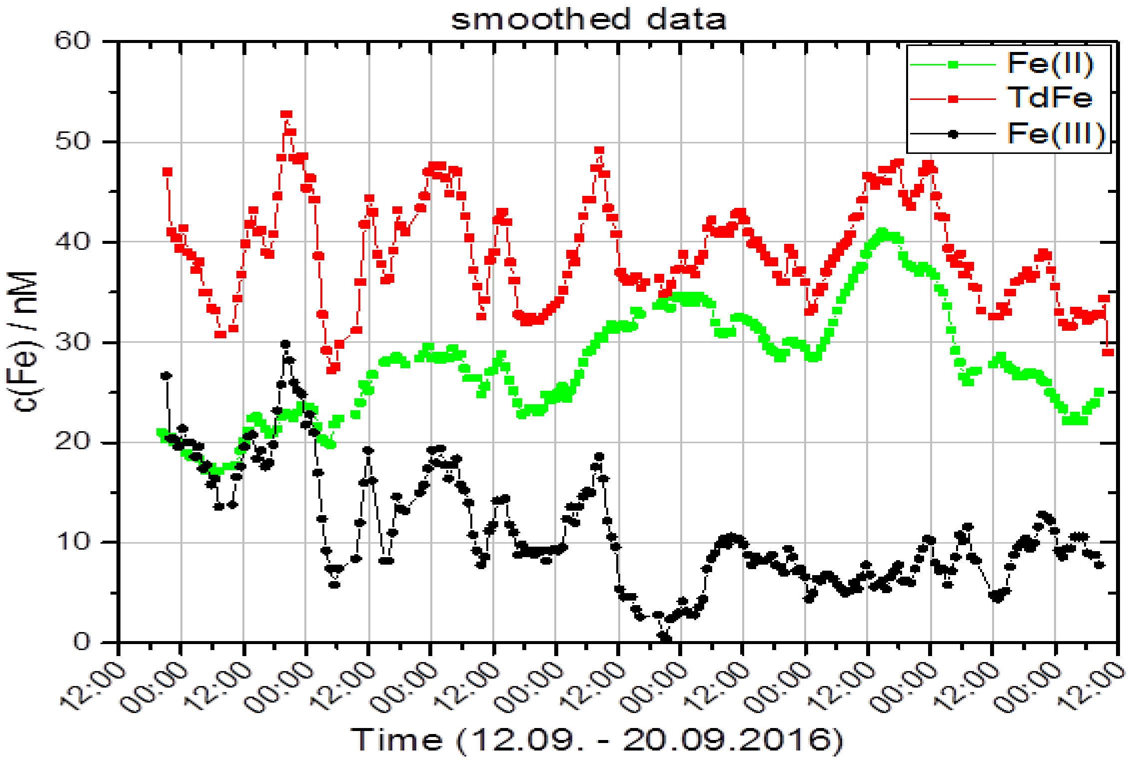
# NERC Macronutrient Cycles: Nitrate in a river



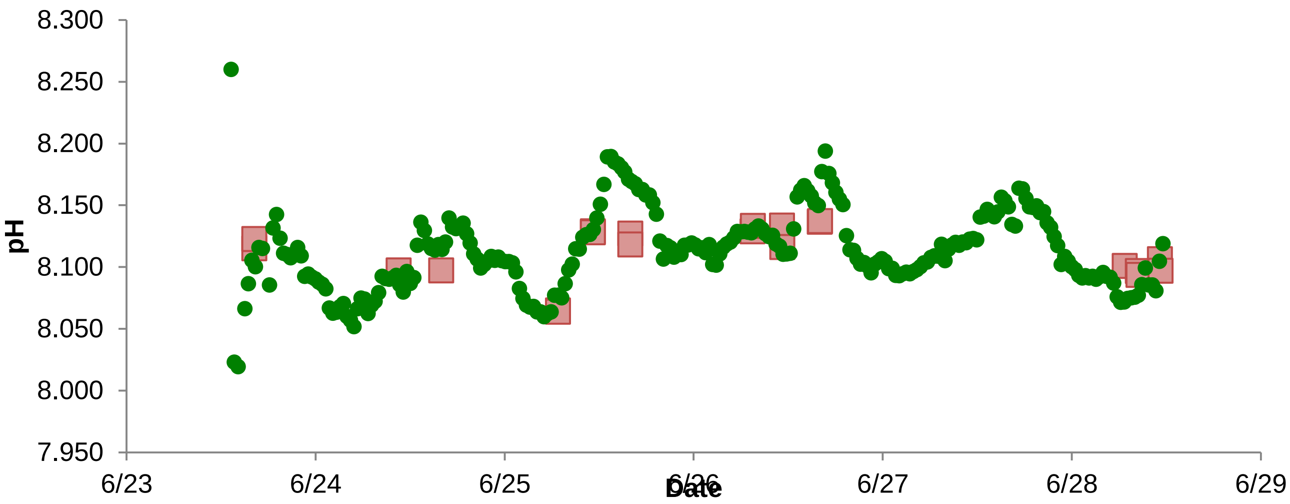
# Nutrient Challenge: Nitrate and phosphate in a Maumee River, Ohio



# SenseOCEAN: Dissolved iron in Kiel Fjord



# NOC pH sensor field tests

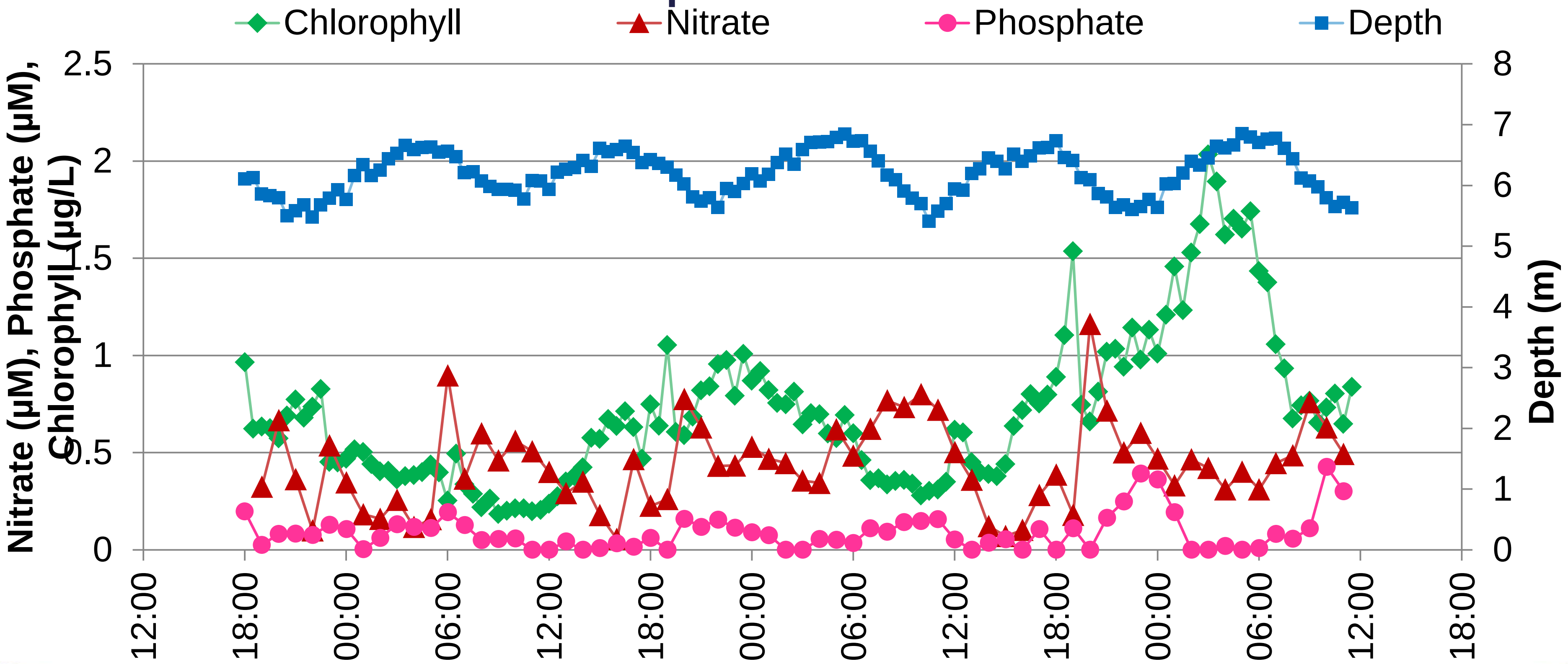




Gullmar fjord, Sweden June 2015

# CMEP: Tropical coastal waters


Allison Schaap

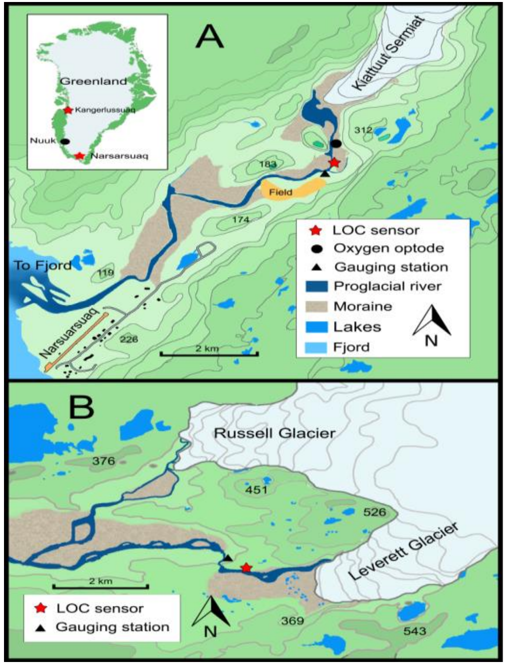
# CMEP: Tropical coastal waters

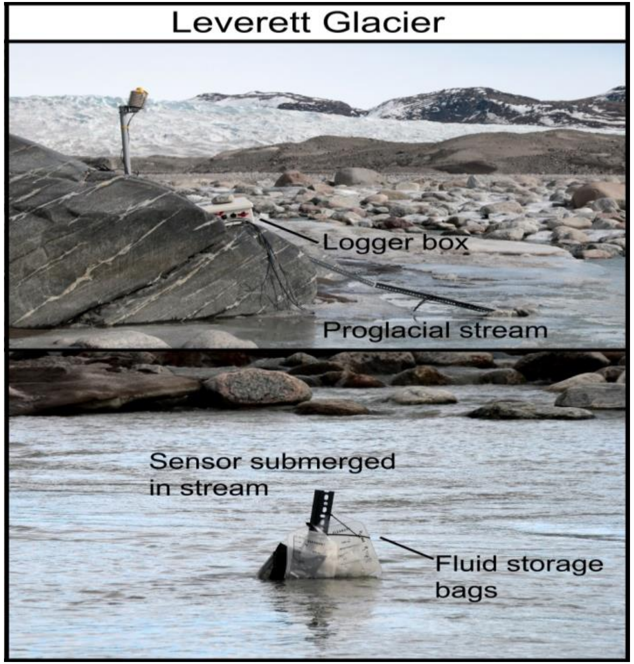


# DELVE: Nitrate in glacial meltwater

Nitrate sensor deployed in glacial streams draining Greenland Ice Sheet

Sub-zero temperatures and highly turbid waters



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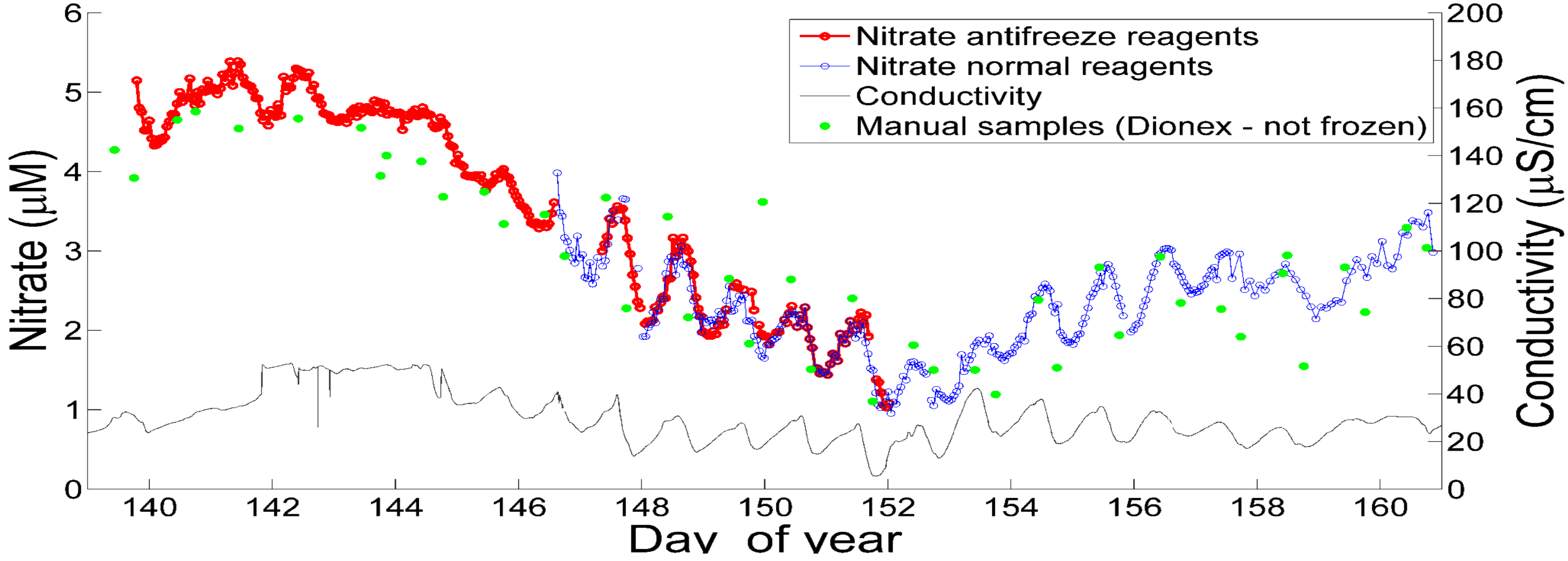
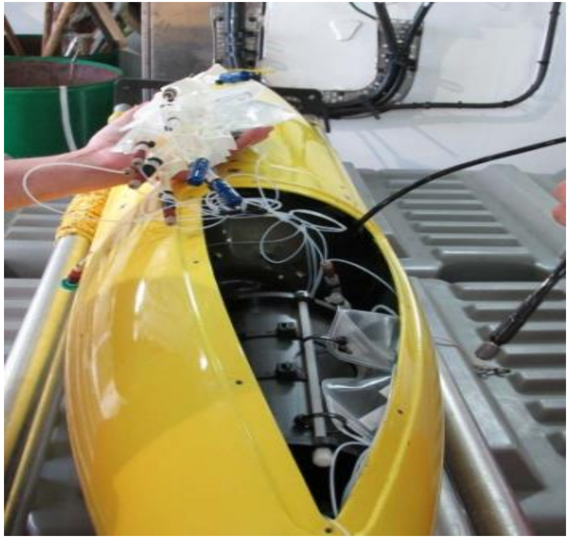


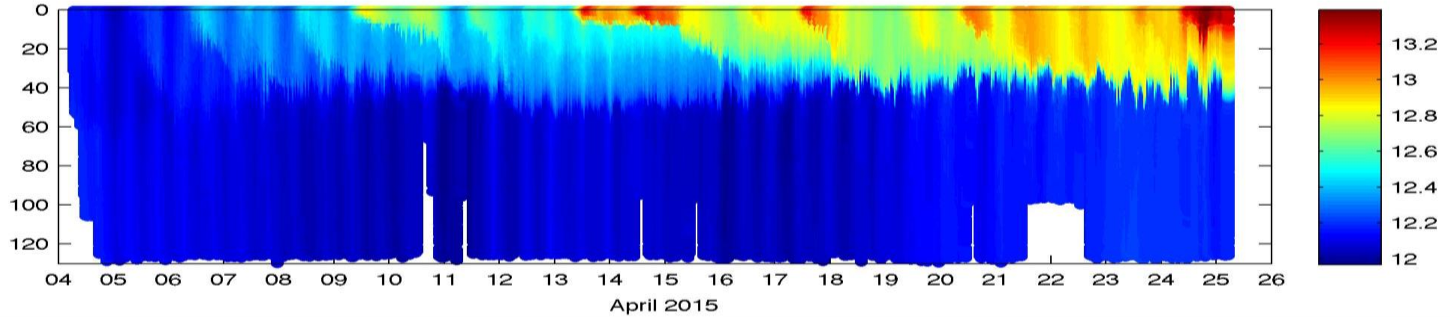
# Nitrate deployment on gliders

Celtic Sea, April 2015

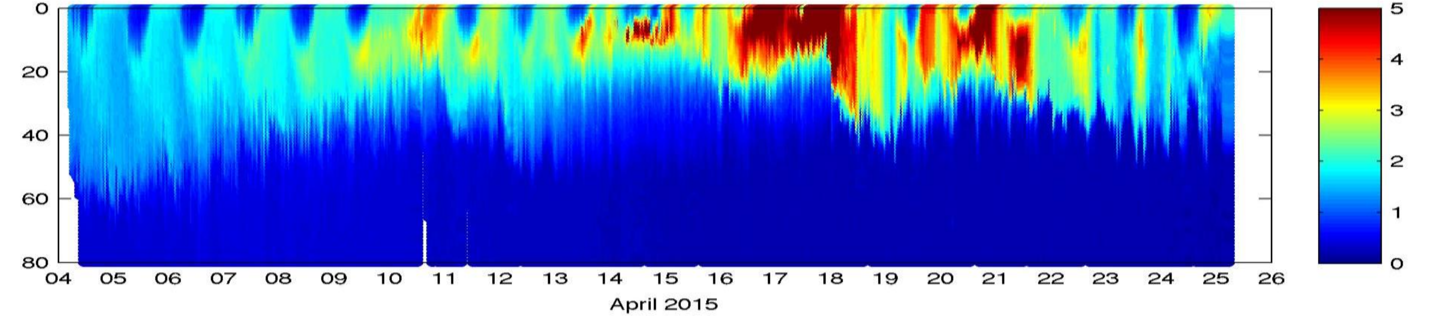



Alex Vincent & Maeve Lohan, NOC / SOES (U. Soton)

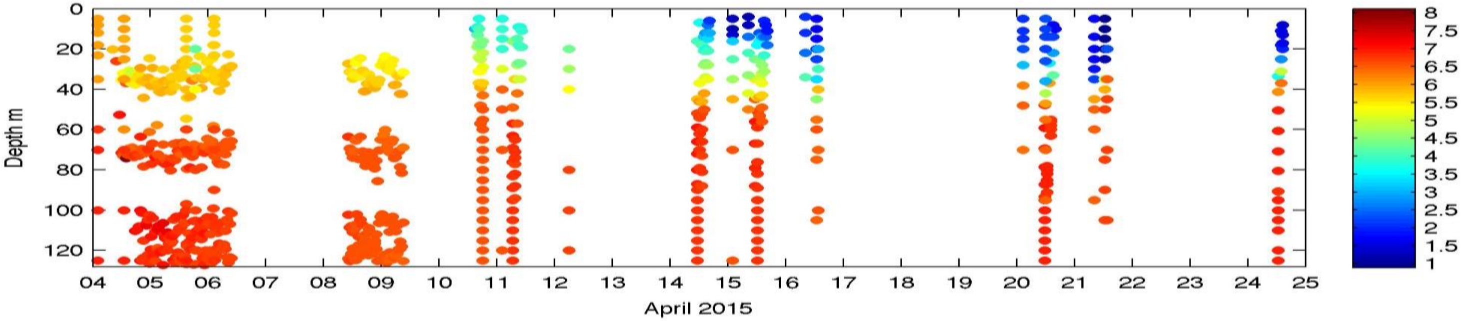
Temperature (°C)



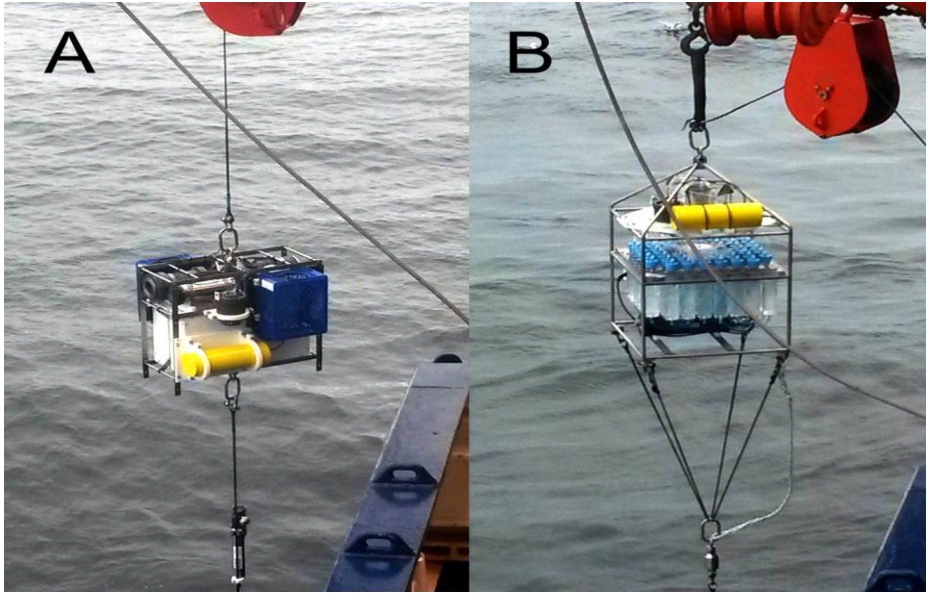

Chlorophyll ($mg/m^3$)




Nitrate (µM)



# FixO3 TNA: Year-long unattended in the Arctic




Funded by FixO3

LOC nitrate sensors deployed in two moorings on Fram Straight for one year (50 – 80 m deep, two measurements per day)

# Biosensing

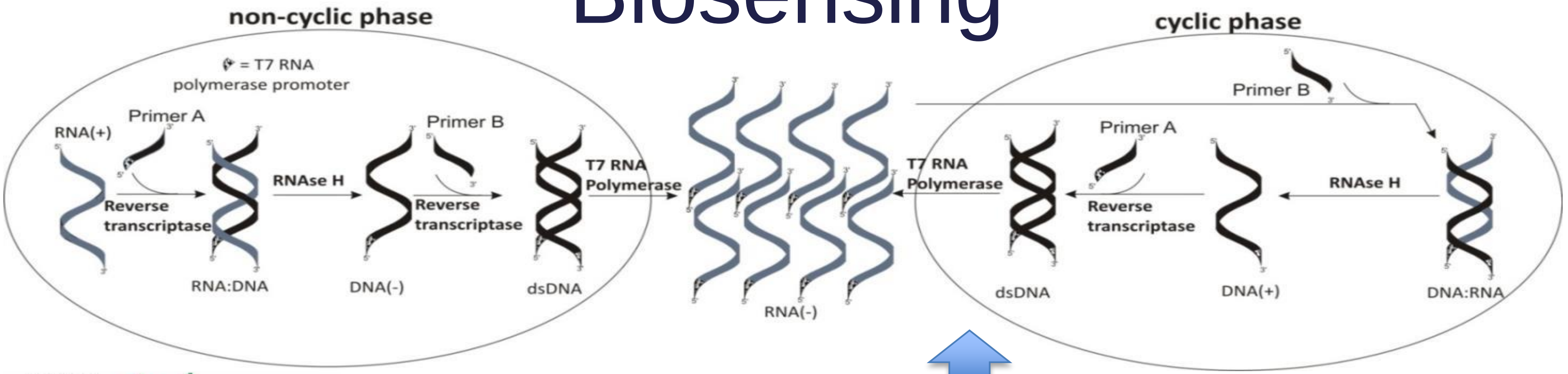



Figure  and work by M.N. Tsaloglou

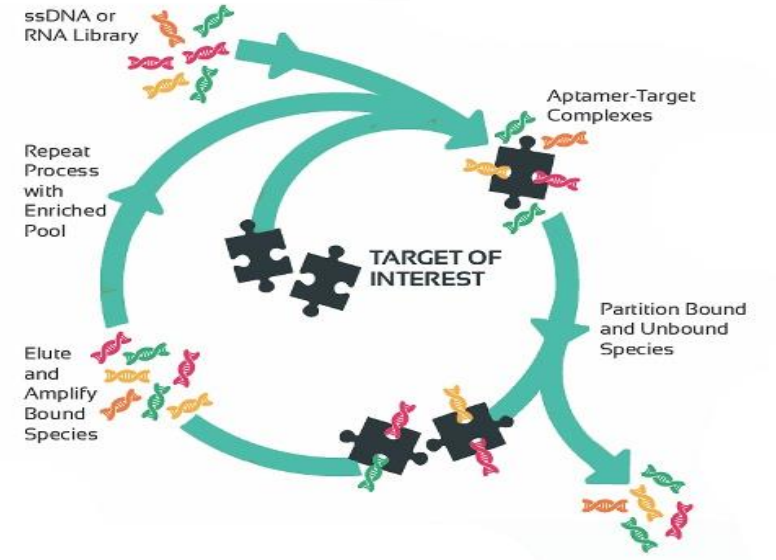
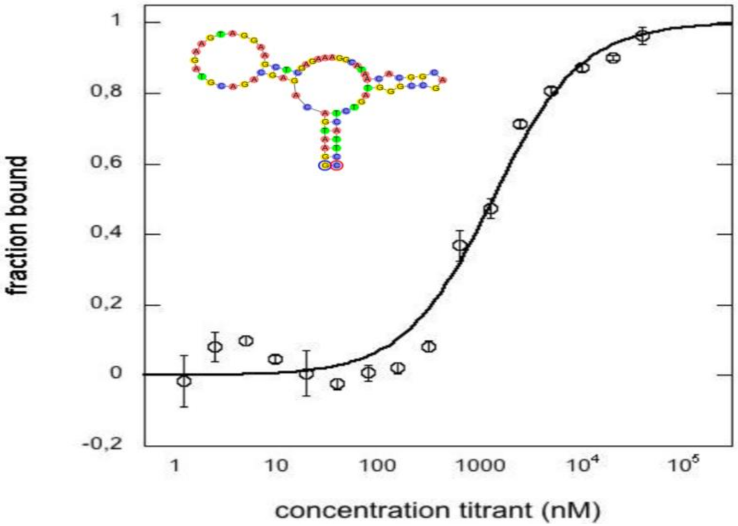
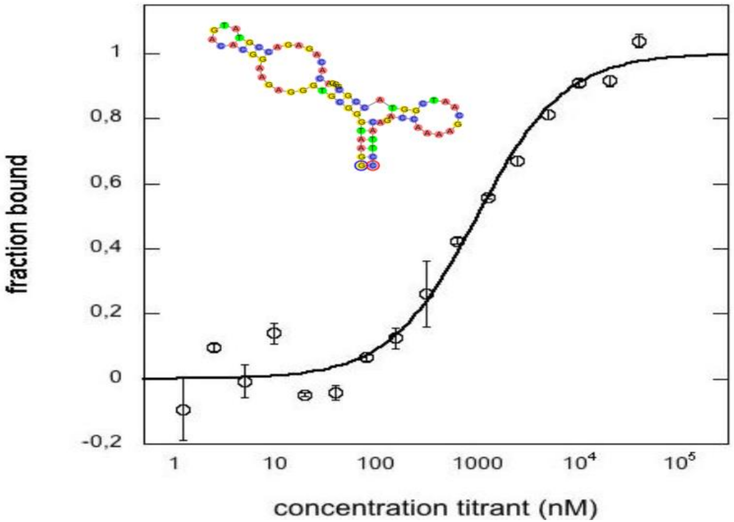



Image courtesy of our partners Aptamer solutions
http://www.aptamersolutions.co.uk/

# Contract Research Aptamer / Antibody PAH sensor proof of concept

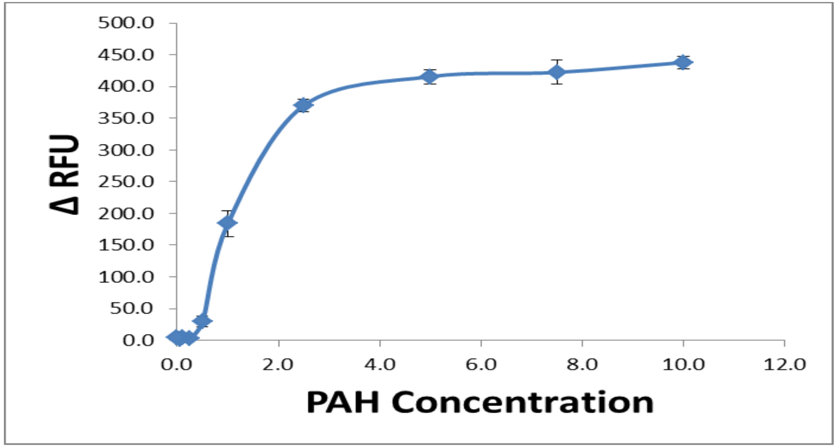



Naphthalene aptamer sensor
($K_d$ = 1.3 ± 0.3 nM)




Phenanthrene aptamer sensor
($K_d$ = 995 ± 208 nM)

# Fluorescence Curves for Aptamer Beacons in Seawater

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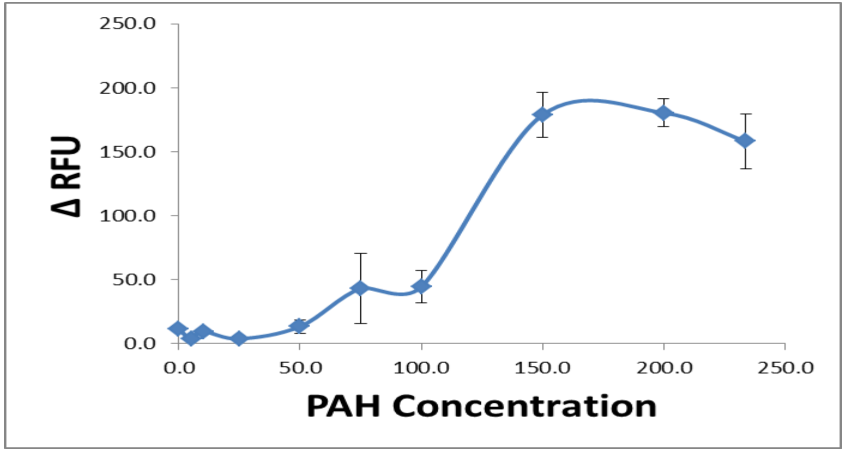
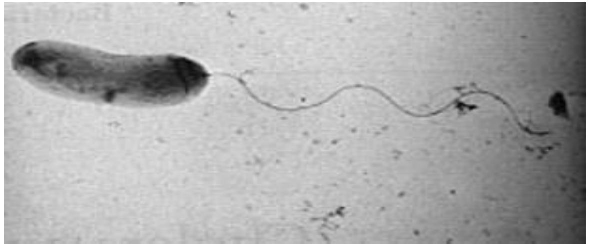
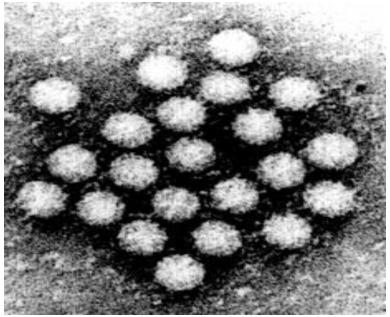



Phenanthrene aptamer sensor
($K_d$ = 995 ± 208 nM)

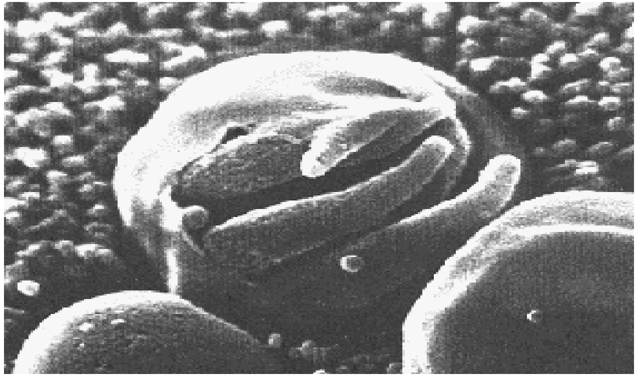
# BBSRC sustainable aquaculture: Pathogens in Shellfisheries Water



*Salmonella* spp.



Norovirus

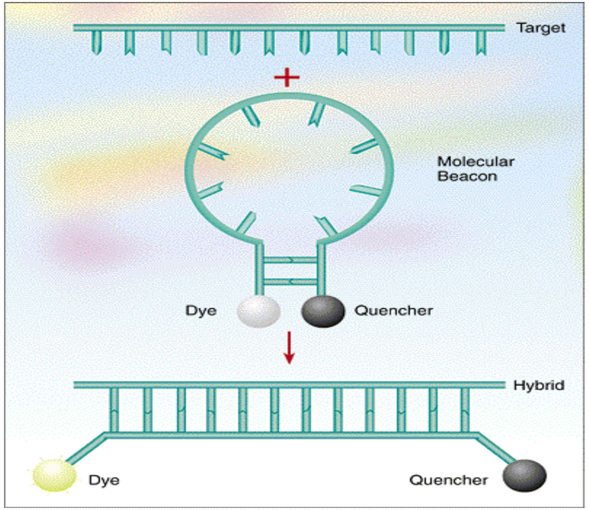


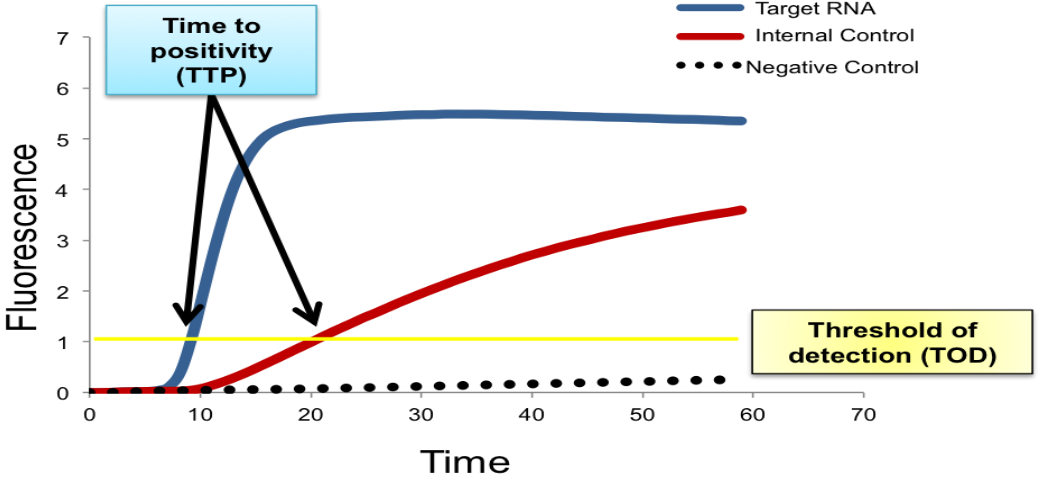
*Cryptosporidium*

## Water-borne pathogens are (typically) difficult to measure

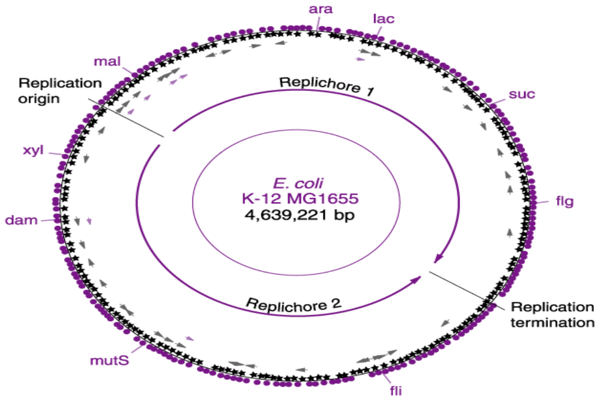
- Very diverse (bacteria, viruses, parasites, virulent and non-virulent strains)
- Low concentration / low infectious dose (e.g. Norovirus; ≥18 viral particles)
- Lack of good bio-analytical methods (many can't be cultured)
- Diseases of unknown origin

# Quantitation of Microorganisms in Natural Waters using the LabCard NASBA



# New NASBA Assays for *E. coli* DNA




Challenges:

- High genomic diversity In the environment.
- Genome size is approx. 4,000-5,000 unique genes.
- >2,000 sequenced genomes
- Approx. 300 core genes*
- Target sequences are not always unique

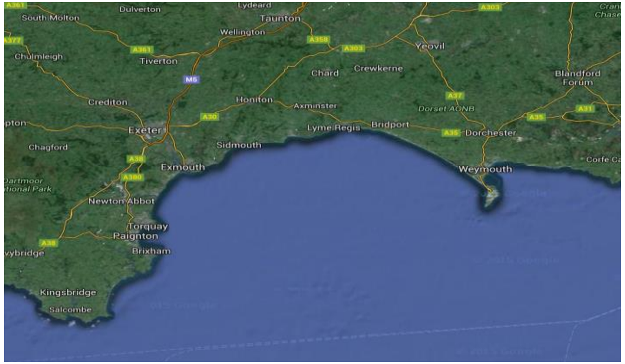
*Miriam Land *et al* (2015) Funct. Integr. Genomics 15, 141-161

Bioinformatics methods were employed to find *E. coli* sequences that were…

- Unique to *E. coli*
- Ubiquitous in *E. coli* strains

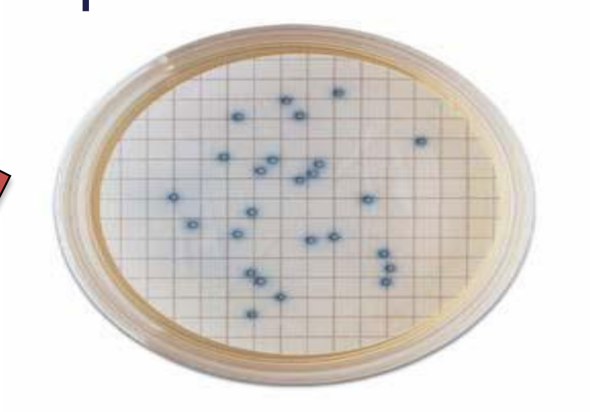
Confirmed experimentally using library of *E. coli* (ECOR) and non-*E. coli* bacteria from different hosts and geographical locations

# Monthly evaluation of the existing and new assays using “real” water samples

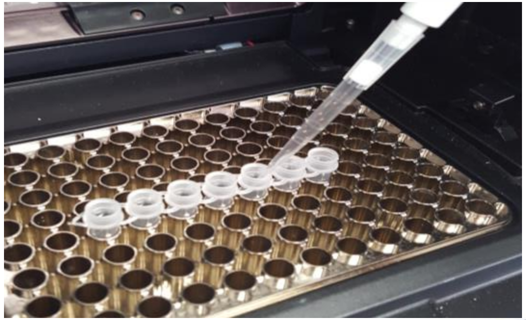



Samples Collected in Southwest England

Culture (Cefas)



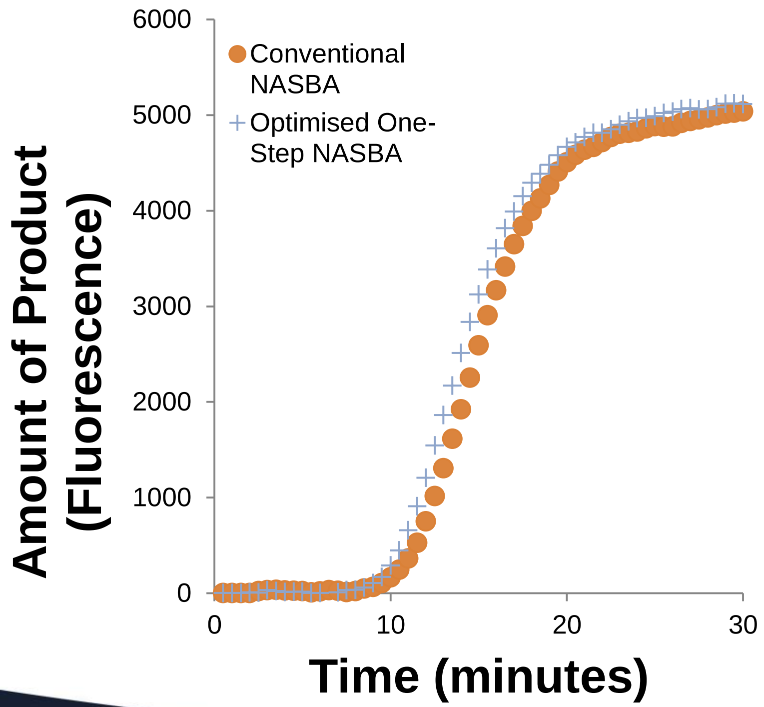
NASBA (NOC)



# Preliminary Results from Month One

| Sample | Plate Assay Mean (n=3) (CFU / 100 mL) | RNA Assay after thermal induction (Cell Equivalents / 100 mL) | DNA assay (Genome Copy / 100 mL) | Comment |
|---|---|---|---|---|
| Saline, inshore (bathing water) | **21** | **Not Detected** | **Not Detected** | Possible to detect ≥ 10 cells in pure culture. Negative result due to inhibitors? |
| Spiked saline (*E. coli* type) | **6533** | **3,100** | **8,500** | RNA underestimation; DNA overestimation |
| Estuarine | **1933** | **900** | **3,200** | RNA underestimation; DNA overestimation |
| Spiked estuarine (*E. coli* type) | **6600** | **400** | **8,700** | RNA underestimation; DNA overestimation |
| Tertiary sewage treatment works (post UV) | **121,500** | **Not Detected** | **Not Detected** | Sample inhibition |
| Tertiary sewage treatment works (pre-UV) | **274,667** | **Not Detected** | **Not Detected** | Sample inhibition |
| Secondary sewage treatment works | **149,000** | **Not Detected** | **Not Detected** | Sample inhibition |
| Positive control (*E. coli* type) | **274,667** | **211,500** | **430,200** | RNA underestimation; DNA overestimation |
| Negative control | **0** | **Not Detected** | **Not Detected** | |

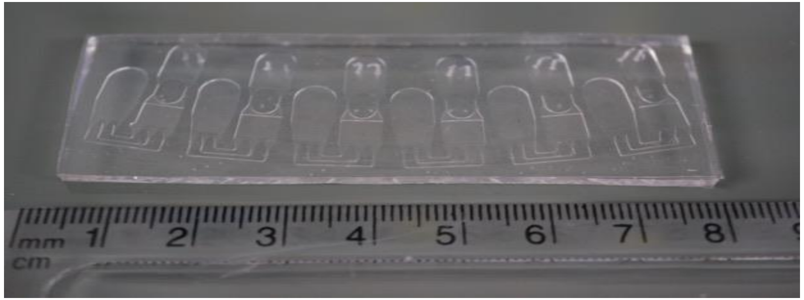
# Other developments: A New One-step NASBA

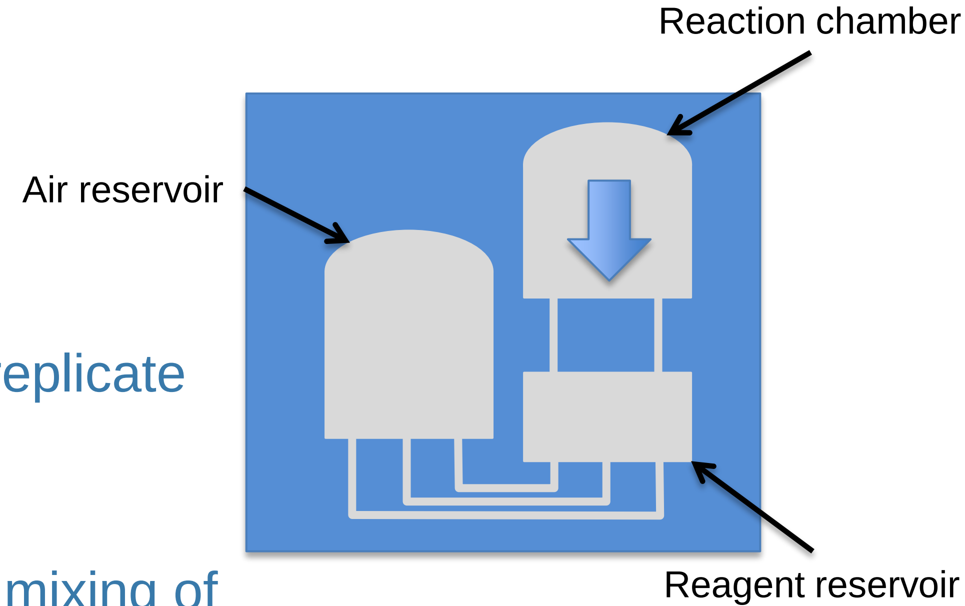



Development of new reagent preservation methods

Optimisation of primer annealing … zymes

# A New LOC for Spacial Multiplexing on Chip

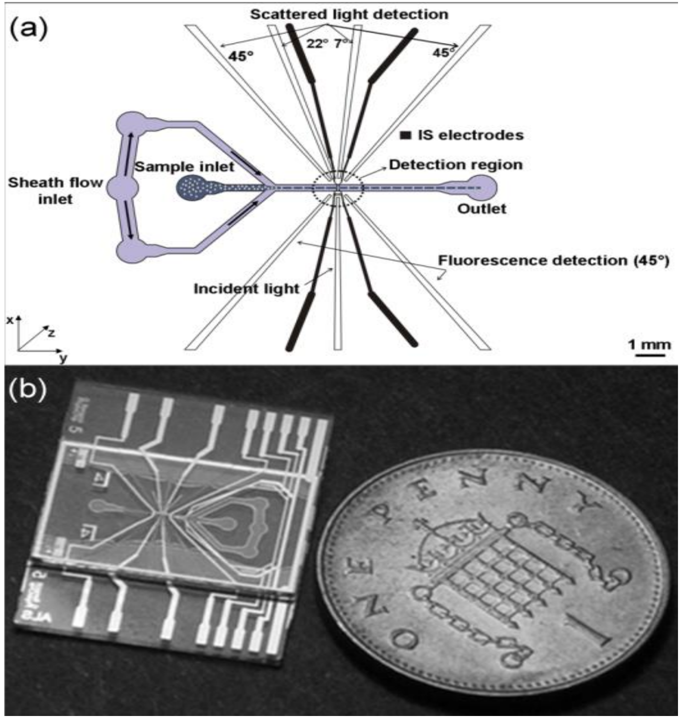



Six chamber chip supporting six replicate One-step NASBA reactions.

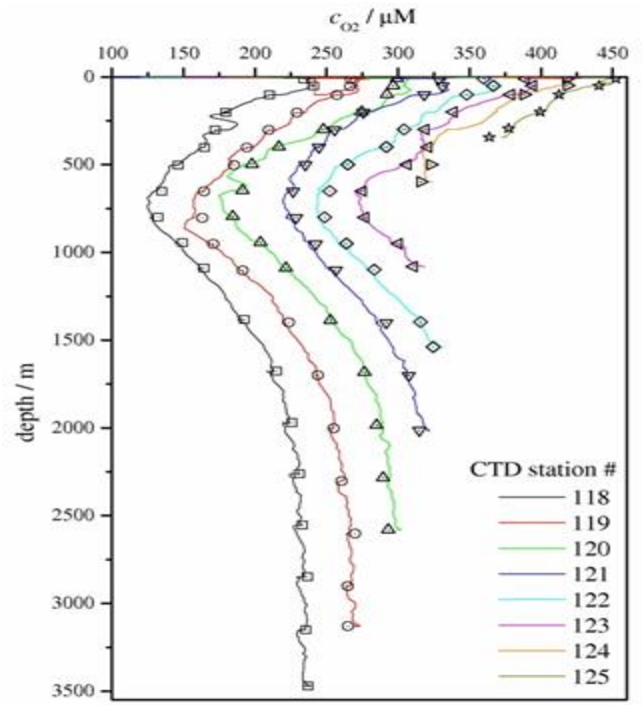
Uses centrifugal force to achieve mixing of sample with dehydrated reagents

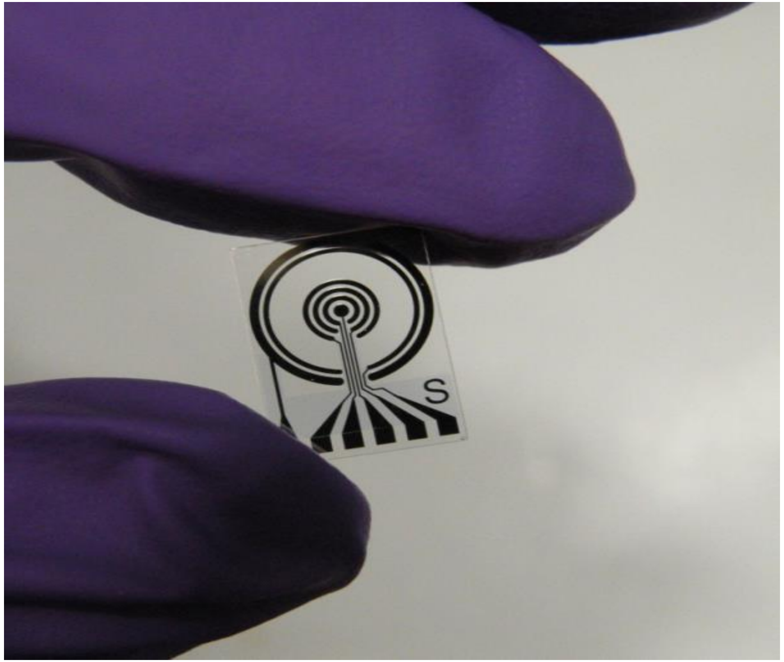
# BBSRC sustainable aquaculture: Cytometer for HAB detection and quantification

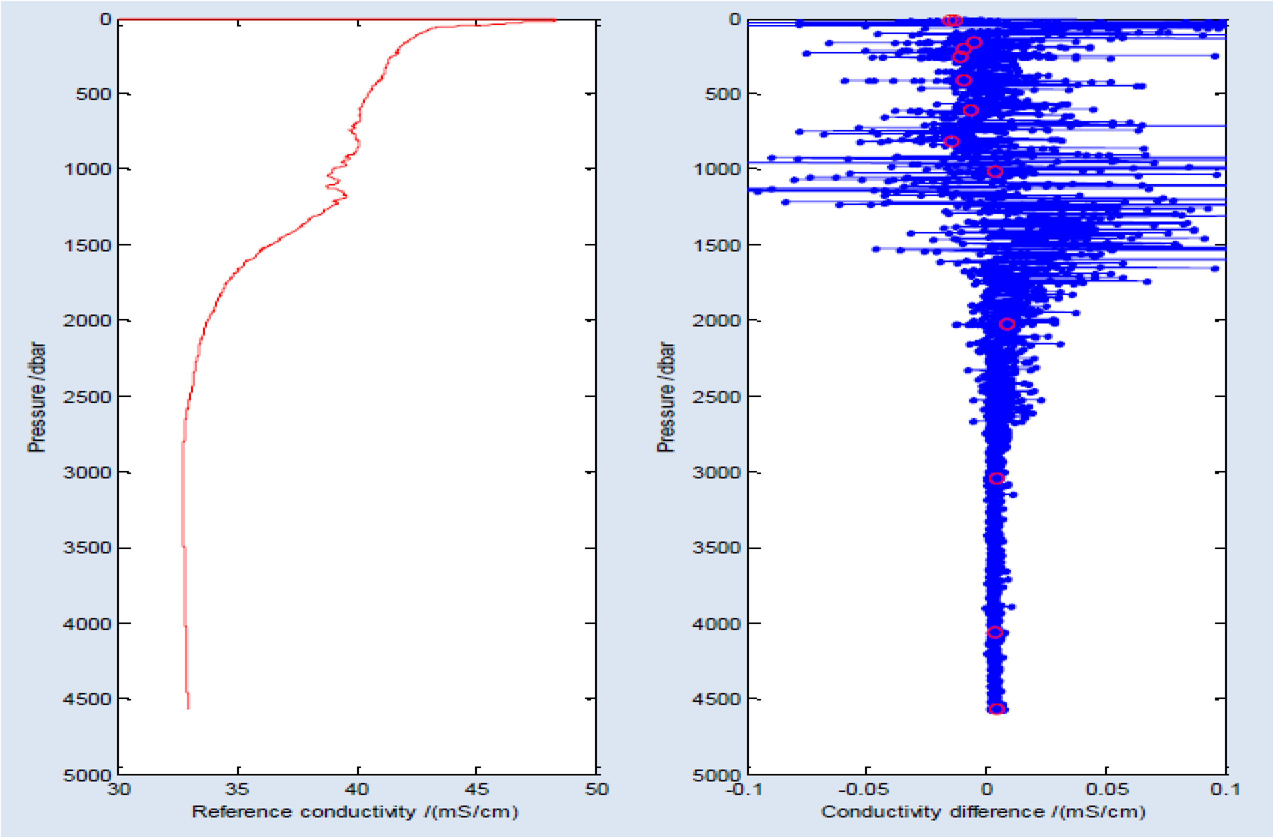



- Simultaneous measurement of electrical (impedance) and optical properties of individual cells
- In-lab prototype
- No air required for optics or operation (suitable for deep sea)
- Challenges include sample concentration, and optical detection limits (power in chip)

# CT-DO Sensor: Commercialisation




Pressure /dbar
Reference conductivity /(mS/cm)
Conductivity difference /(mS/cm)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
30
35
40
45
50
-0.1
-0.05
0
0.05
0.1

# Data Flow

- Easily discover sensors and their metadata
- Sensors and sensor observations discoverable, accessible and useable via the web
- Seamlessly integrate sensors from Sense Ocean Network with sensors from other networks

# The standards

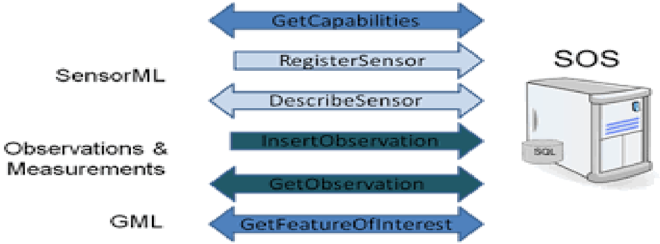
netCDF

GeoSPARQL

Turtle

OGC® Making location count.

RDF




O&M


W3C®

M2M

N-triples

W3C®

w3id

Controlled Vocabularies

W3C® SPARQL

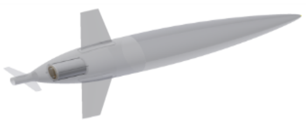
SKOS

JSON-LD

SensorML

# Proposed approach


Sensor passes UUID through to base station



Platform

Satellite

Base station/
Data centre

NERC
Linked data
(RDF, SPARQL)
server

UUID

SensorML
SSN (OWL)
JSON LD

netCDF EGO 1.1, CF1.6, LD

Data delivery by SOS server and linked ocean data server

Reference for netCDF Link Data conventions:
Yu J. et al. Towards Linked Data Conventions for Delivery of Environmental Data Using netCDF: pages 102-112; Springer., ISBN: 978-3-319-15993-5

```xml
<om:OM_Observation
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xmlns:gml=http://www.opengis.net/gml/3.2 xsi:schemaLocation="http://www.opengis.net/om/2.0 http://schemas.opengis.net/om/2.0/observation.xsd">
<gml:description>Observation instance with remote result</gml:description>
<om:type
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		<swe:uom code="umol/L"  xlink:href=”http://vocab.nerc.ac.uk/collection/P06/current/UPOX/”/>
		</swe:Quantity>
		</swe:field>
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# Publication & Discovery

SOS

SPARQL

Linked data

Mainly for machine to machine access!!!

# Marine Sensors Technologies and TRL 2011,2016,2021,2026

## Microfabricated Solid State / Electrochemistry:

- Salinity 5-8-9-9
- Dissolved oxygen 4-7-9-9

## Optodes / optical sensors

- Gases inc. methane 6-6-8-9
- pH, $pCO_2$ 4-6-8-9
- Radionuclide 1-3-5-8

## Lab on Chip Cytometer

- Whole cells (label free) 4-5-7-9
- Labelled cells 3-5-6-8
- Microplastics 2-4-7-9
- Bead assays 2-3-6-8

## Lab on Chip Chemistry

- Inorganic Nutrients 6-8-9-9
- Organic Nutrients 2-5-7-9
- Trace metals 4-7-8-9
- pH 5-7-9-9, TA 2-4-7-9, DIC 2-4-9-9, $pCO_2$ 2-4-6-8
- Small organics, e.g. PAH, PCBs (f-pM) 2-5-6-8
- Proteins and large organics (copies / L) 2-4-6-7
- Nucleic Acids (copies / L) 5-6-7-9
- Radionuclide 1-3-5-7

# OTEG LOC sensors development status

| LOC Sensor | Subsystems developed | Benchtop system | Shipboard measurements | In situ deployment |
|---|---|---|---|---|
| Nitrate | ✓ | ✓ | ✓ | ✓ |
| pH | ✓ | ✓ | ✓ | ✓ |
| Phosphate | ✓ | ✓ | ✓ | ✓ |
| Iron | ✓ | ✓ | - | ✓ |
| Silicate | ✓ | ✓ | 2017 | 2016 |
| Ammonium | ✓ | ✓ | ✓ | Late 2017 |
| Total alkalinity | ✓ | ✓ | 2017 | 2017 |
| DIC | ✓ | very close | 2017 | Late 2017 |
| Organic N and P | ✓ | ✓ | 2017 | 2017 |

# OTEG LOC sensors – *in situ* deployments projected

| LOC Sensor | River/ estuary | Coastal | At depth | Glacial melt | Year- long (unattended) | Glider or AUV | Argo float |
|---|---|---|---|---|---|---|---|
| Nitrate | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 2017 |
| pH | ✓ | ✓ | ✓ | | | 2017 | |
| Phosphate | ✓ | ✓ | ✓ | 2017 | 2018? | 2017 | 2017 |
| Iron | ✓ | ✓ | ✓ | 2017 | | | |
| Silicate | 2016 | 2017 | 2017 | 2018 | | 2017 | |

# 2017 Forward look highlights

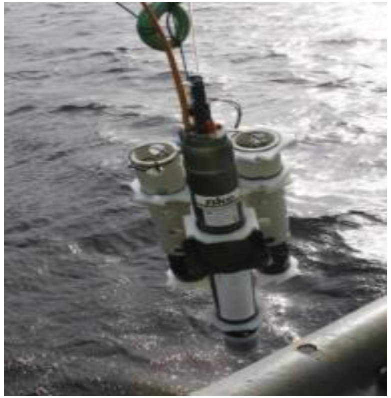
## SenseOCEAN final year / deployments / demonstrations

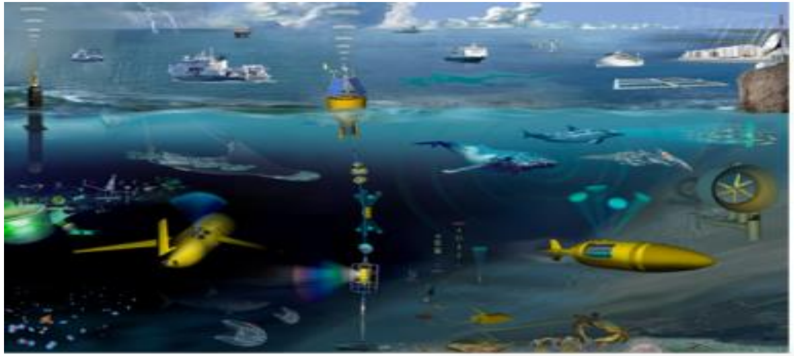
- Demonstration on Apex (PROVOR) (Nitrate, Phosphate, pH)

# Platforms targeted for demonstration

Floats
(LEGOS-CNRS)

Shallow cabled and
deep sea observatory
(AWI)






Bouys
(ILEGOS-
CNRS)

AUV
(AWI)

# 2017 Forward look highlights

SenseOCEAN final year / deployments / demonstrations

- Demonstration on Apex (PROVOR) (Nitrate, Phosphate, pH)

Integration into SLOCUM glider

# 2017 Forward look highlights

SenseOCEAN final year / deployments / demonstrations

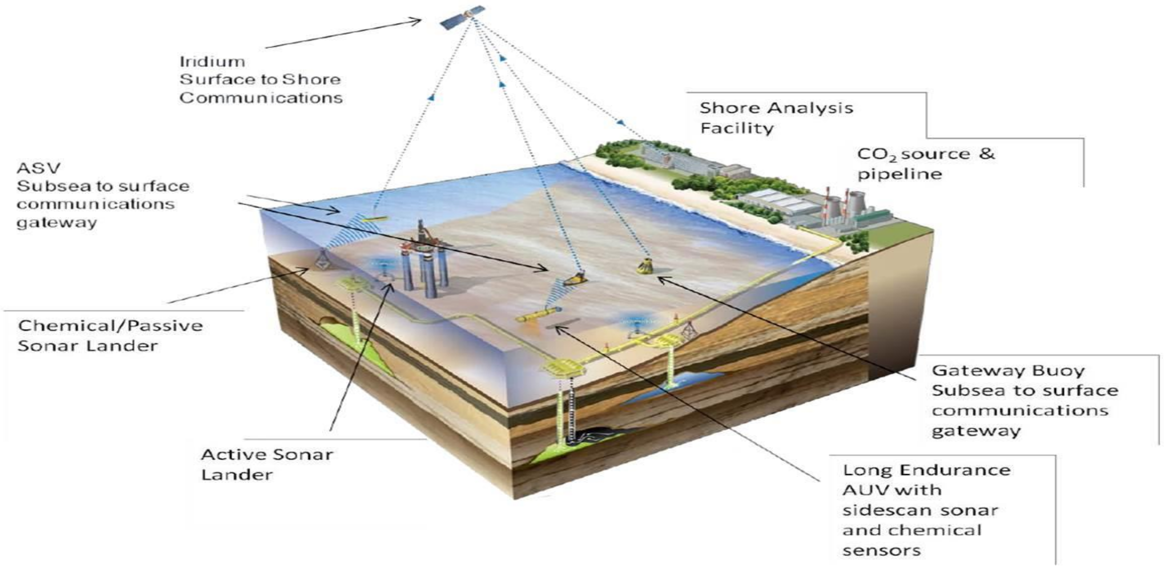
- Demonstration on Apex (PROVOR) (Nitrate, Phosphate, pH)

Integration into SLOCUM glider

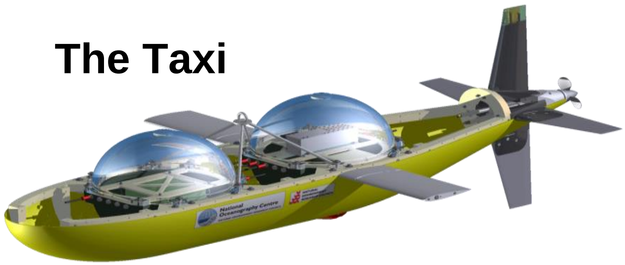
Integration into ALR and trials for ETI

# ETI CCSMV - Project

**The Concept**




**The Taxi**



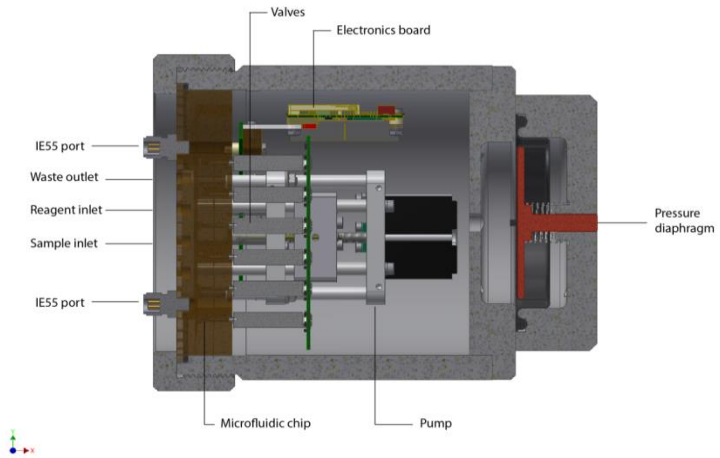
**The sensors**

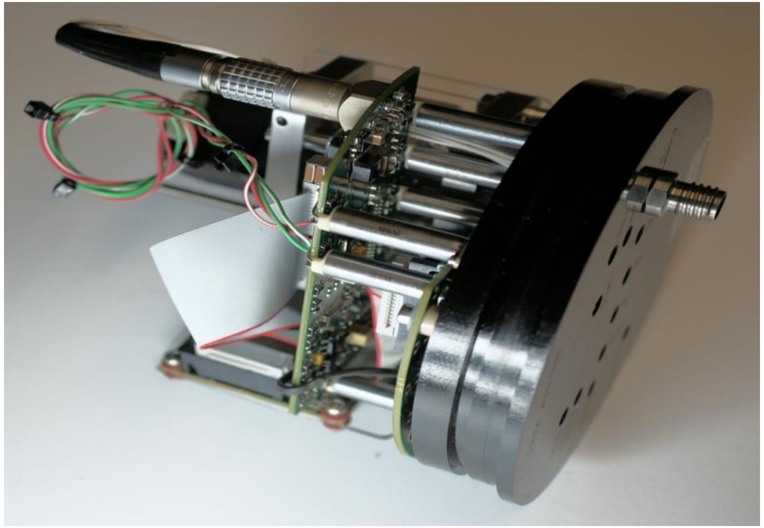
STEMM-CCS

# CCS Sensors package: commercial

SeapHOx SBE52 CTD SEAFET SBE43F DO

# CCS Sensors package: NOC



lab on a chip

TRL 7: pH, Phosphate, Nitrate

TRL 4-7: TA, DIC

# 2017 Forward look highlights

SenseOCEAN final year / deployments / demonstrations

- Demonstration on Apex (PROVOR) (Nitrate, Phosphate, pH)

Integration into SLOCUM glider

Integration into ALR and trials for ETI

Pathogen detection in the field

CTDO product launch

LOC license agreement / commercialisation

# Acknowledgements


## Work by current and past members of OTEG

**Group head: Matt Mowlem**

**Subgroup heads:**

Robin Pascal (Multidisciplinary)

Socratis Loucaides (Analytical science)

Chris Cardwell (Electronics & Software)

Kevin Saw (Mechanical)

NERC SCIENCE OF THE ENVIRONMENT

Collaborators at:
University of Southampton
NOC
Plymouth Marine Laboratory
Scottish Marine Institute
GEOMAR and others

Photos from Dave Owsianka, Alex Beaton, Martin Arundell and others

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Centre of Excellence in Satellite Applications


**Mr Grant Day**

University of Portsmouth


# South Coast Centre for Excellence for Satellite Applications Catapult,

# South Coast

Centre of Excellence in Satellite Applications


## Marine Autonomy & Technology Showcase

National Oceanography Centre

Grant Day

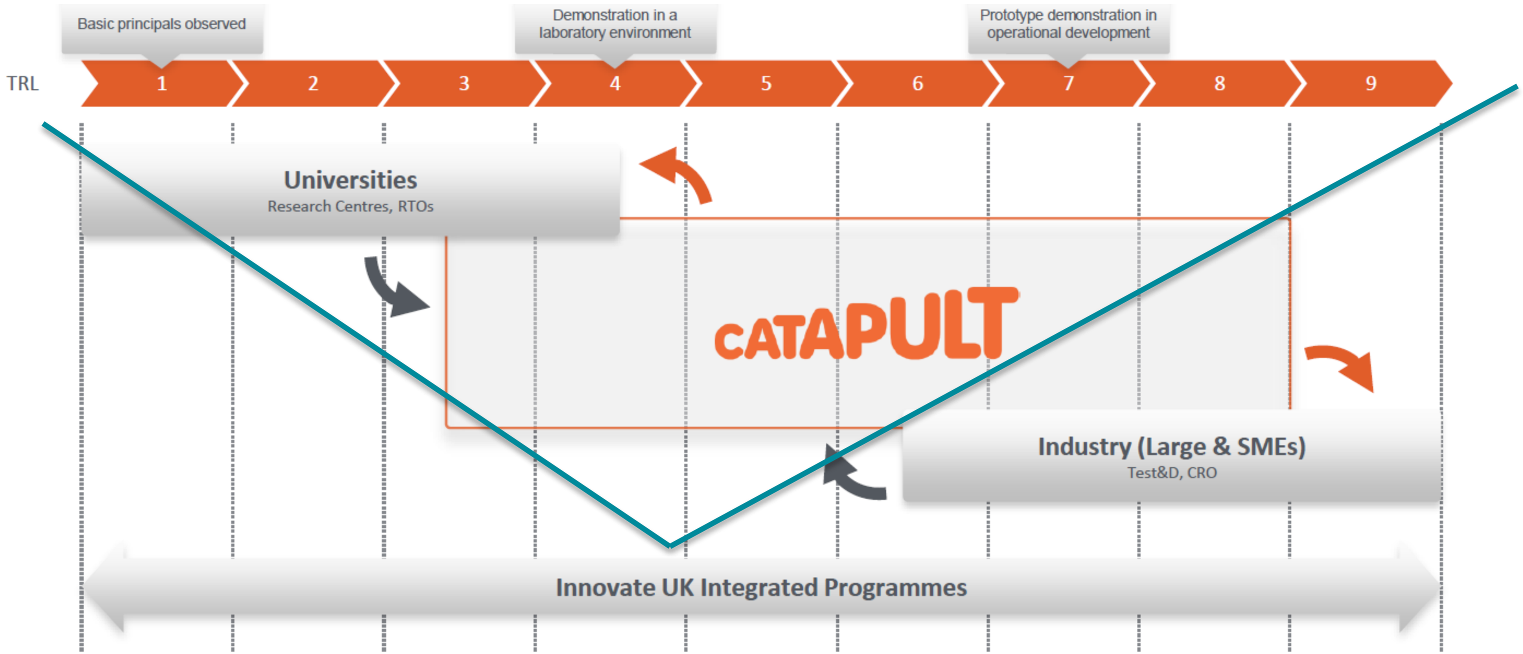
14/11/2016

UK SPACE AGENCY

Supported by

CATAPULT Satellite Applications

# Catapults – Innovation & Growth

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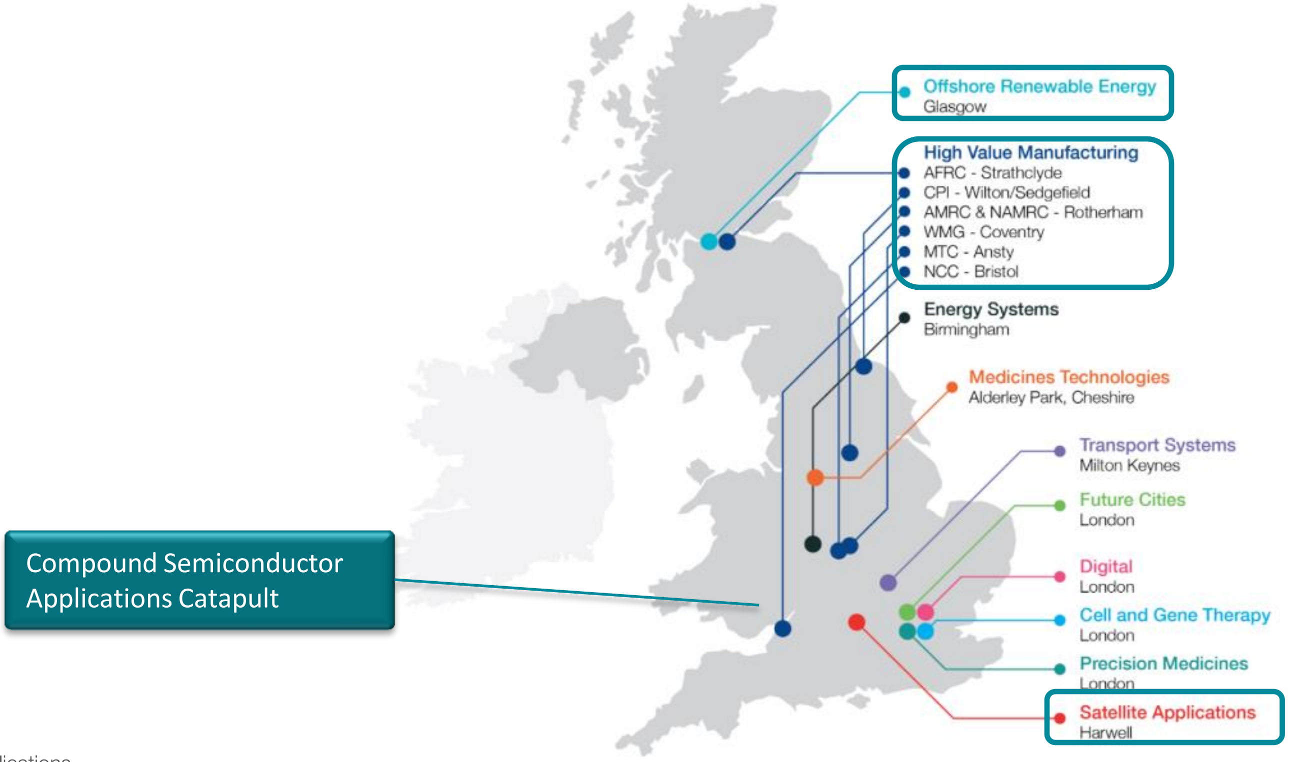
# Catapults – The Network

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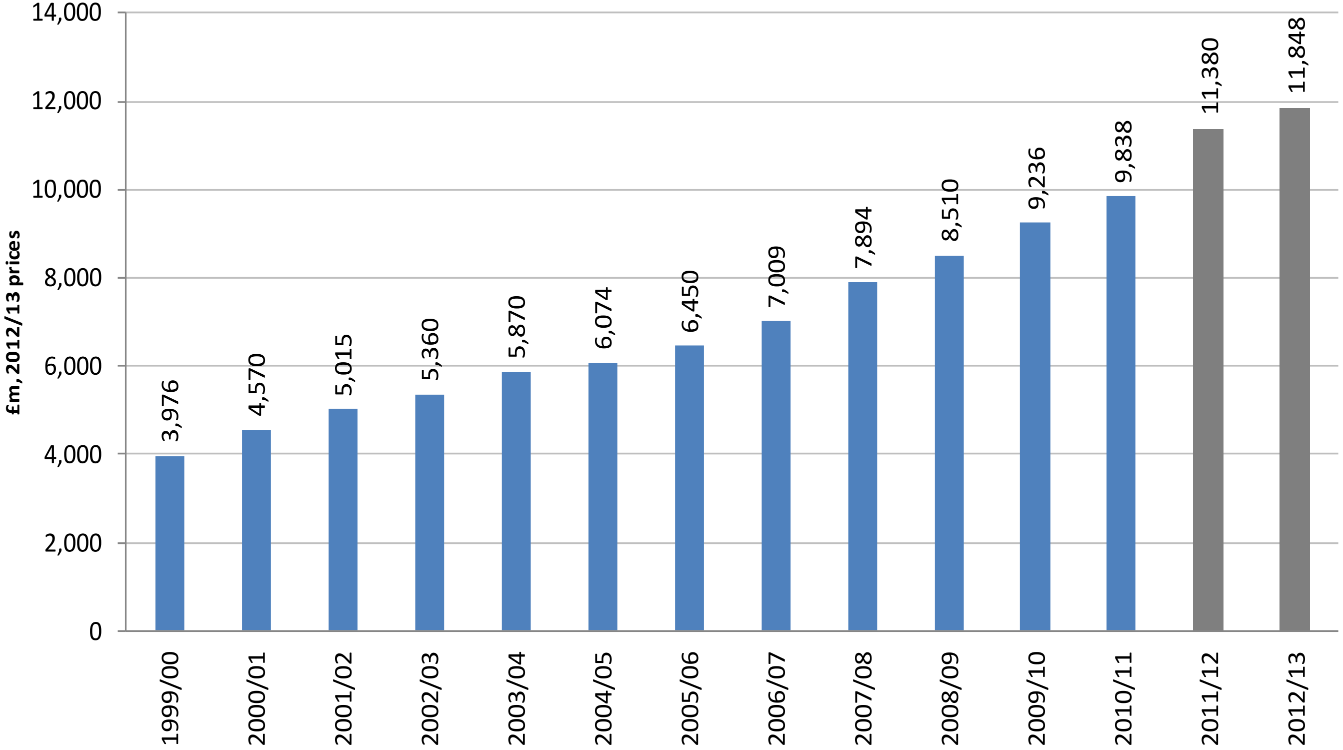
# Eight Great Technologies

Aggregate turnover of £11.8bn in 2012/13 Compound annual growth of 8.6% since 2008/09

High GVA, skills, productivity & exports

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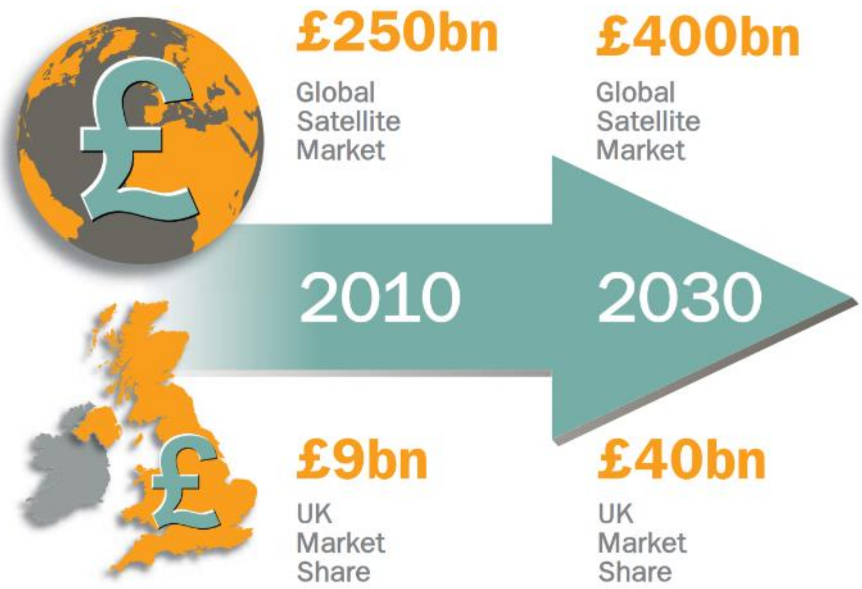
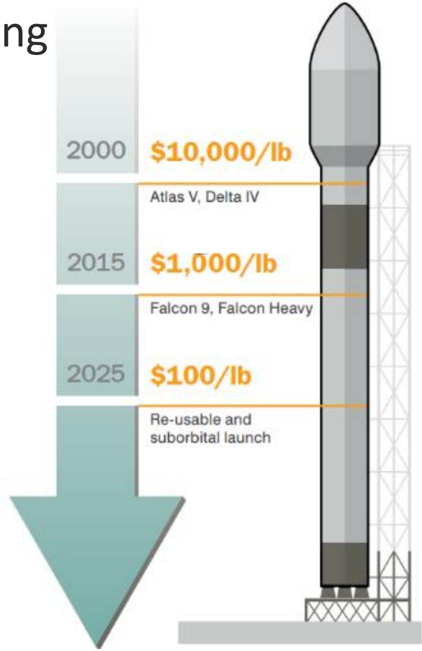
# Satellites - Growing Opportunity




97% economic growth downstream services

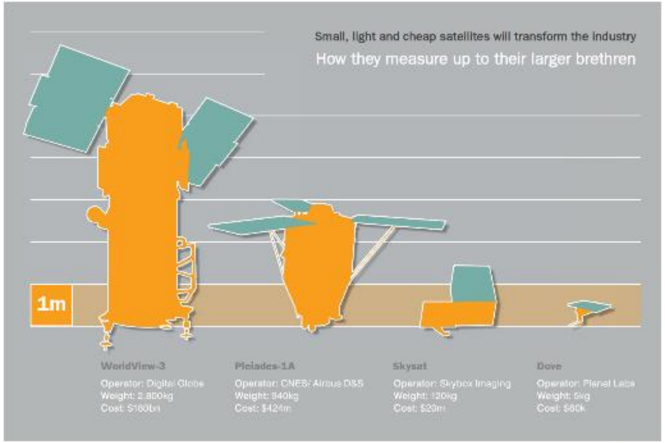
# Why are the costs falling?

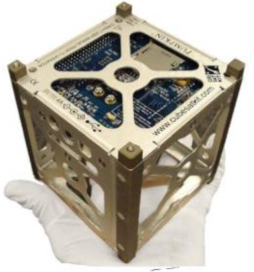
1. Cost of launch is reducing




2. Hardware is getting smaller, smarter and cheaper

3. Cost of satellite manufacture is reducing



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# The Satellite Applications Catapult

*'Solutions that have tangible societal and economic benefits, facilitated by satellite technology'*

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# Centres of Excellence


**Centre of Excellence**

- focal points for activity linking the science base with industry
- to enable the development of applications and solutions
- engage the wider end user market

UK SPACE AGENCY

- South Coast Centre of Excellence
- South West Centre of Excellence

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# Partners & Market Focus

Autonomous Systems

Blue Economy

Sustainable Living

Intelligent Transport

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

marine
south east

UNIVERSITY OF Southampton

University of Brighton

Hampshire County Council

CATAPULT Offshore Renewable Energy

University of Portsmouth

# Blue Economy: Market Focus and Expertise

1. Scale of regional economy

2. Diverse segments; growth opportunities

| Mature | Growth Phase | Pre Development |
|---|---|---|
| Ports & Logistics | Cruise | Ecosystem |
| Ship Building | Survailance | Wave & Tidal |
| Leisure | Coastal Protection | Bio Fuels |
| Oil & Gas | Offshore Wind | Blue Bio Tech |
| Fishing | Aqua Culture | Seabed Mining |

3. Strong Knowledge Base

4. Opportunity for Innovation
   - Agri-tech -> Aquaculture
   - Defence technology -> civil application

South East England:
- £12bn turnover
- 4,000 businesses
- 105,000 employees

In Solent region:
- £4bn turnover
- GVA= £1.9B (21% of the region)
- 1,750 businesses
- 48,000 employees

# Intelligent Condition monitoring with Integrated Communications

iconic

- 3-5% reduction in fuel consumption, coupled with a 25% increase in propulsion plant availability
- Satellites enable worldwide coverage & facilitate an advanced logistics solution to ensure optimal performance

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Centre of Excellence in Satellite Applications

University of Portsmouth
CATAPULT Satellite Applications
University of Southampton
STS defence
LW PARTNERS MARITIME INNOVATION
NGnuity

The South Coast Centre of Excellence in Satellite Applications set the following objectives:

## Grow business investment in satellite applications

Expand the community of businesses investing in collaborative projects using satellite services.

## Expand access to satellite facilities and know-how

Expand awareness of know-how and facilities available to innovation projects, across multiple organisations.

## Establish SCCoE as a regional innovation catalyst

Achieve strong recognition as a leading facilitator of market-led industry solutions, supported by the Satellite Applications Catapult.

## Leverage R&D funding

Secure a significant and growing level of income from collaborative research programmes via Innovate UK, EU and other funding opportunities.

# Strengthen Innovation Accelerators

**Map Opportunities** — Scope the capabilities, key players and sector needs of the region

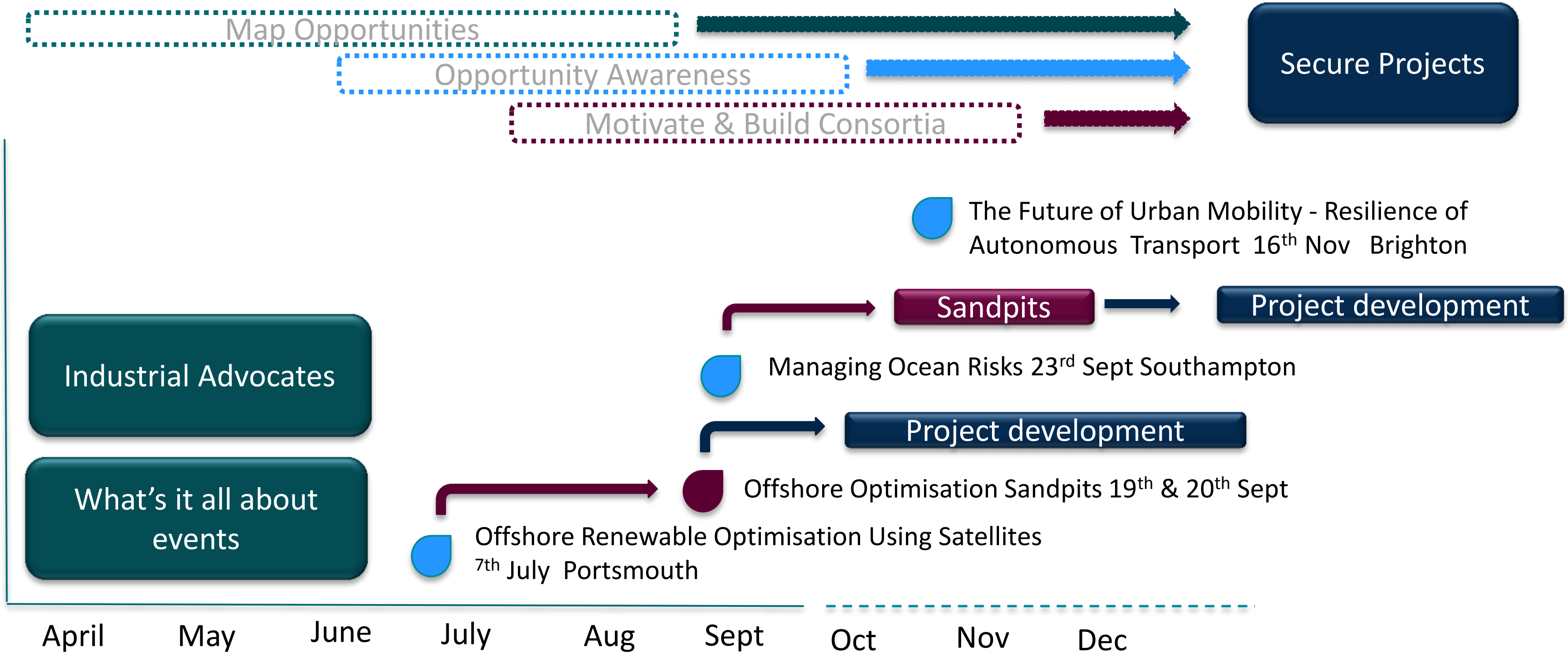
**Opportunity Awareness** — Showing companies the opportunities available through satellite applications, demonstrating the capabilities & commercial benefits

**Motivate & Build Consortia** — Facilitating workshops, focussed sandpits and direct brokering to stimulate partners, validate opportunities and identify key resources & facilities

**Secure Projects** — Build value proposition and submit bids to secure commitment and investment (industrial & public)

Proof of concept (TRL 3) → Technology demonstrator (TRL 6) → Commercial roll-out (TRL 9)

# Strengthen Innovation Accelerators



# Event Programme: Workshop1 Offshore Renewable Energy Optimisation

**7th July 2016, University of Portsmouth**

- Address the challenges facing the offshore renewable sector and how satellite technologies may support the offshore wind, wave, and tidal industry for the optimisation of their operating procedures.
- 35 delegates from industry, government, and academia attended the event.



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## 6. Sandpit Events: Offshore Renewable Energy Optimisation

Djamila Ouelhadj

**Sandpit events organized and chaired by the ORE Catapult, 19 and 20 Sept 2016, University of Portsmouth**

### Monday 19 Sep

- Sandpit 1: Fusing Datasets for O&M Smart Intervention Planning
- Sandpit 2: Giving the ORE Sector the Data it Needs

### Tuesday 20 Sep

- Sandpit 3: Site Sniffing: A More Cost-effective & Robust Approach
- Sandpit 4: Sonar Bells for the Location of Equipment on the Seabed

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# Event Programme: Workshop 2 Managing Ocean Risks

**Organised and chaired by Marine South East, 23rd Sept 2016, National Oceanography Centre**

Maritime satellite applications are booming an enabling technology for Blue Growth.

**Pollution detection and characterisation for optimised remediation**

**Marine litter surveillance to target intervention**

**Algal bloom surveillance and forecasting toxic impacts**


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# Plans for the next 6 Months :

**Workshop 3: The Future of Urban Mobility**

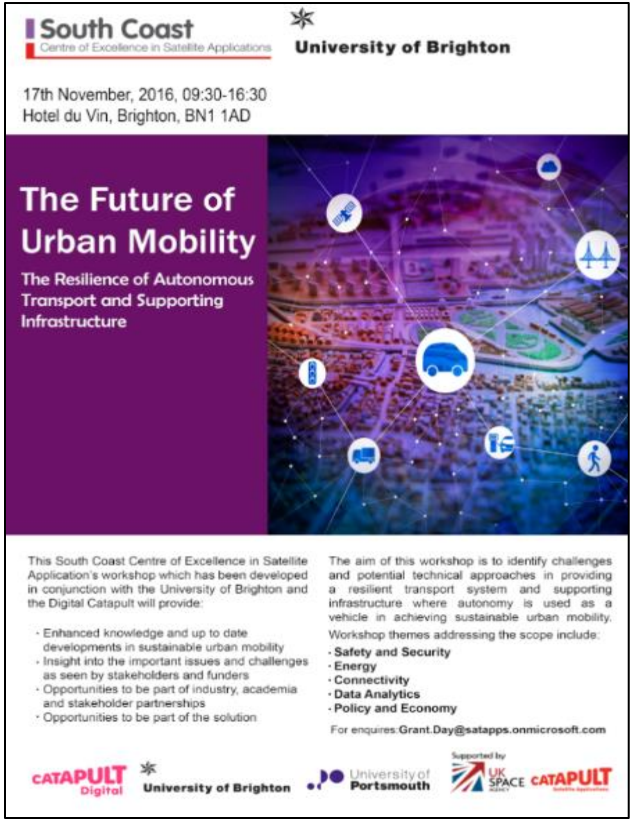
17th November 2016, 09:30-16:30
Hotel du Vin, Brighton, BN1 1AD
Lead Coordinators: University of Brighton

The aim of this workshop is to identify challenges and potential technical approaches in providing a resilient transport system and supporting infrastructure where autonomy is used as a vehicle in achieving sustainable urban mobility.

**Workshop 4: Connected Factories**

December 2016, 09:30-12:30
Langstone Technology Park, Havant
Lead Coordinators: University of Portsmouth

The aim of this workshop is to work with companies from engaging in digital manufacturing exploring the benefits in condition monitoring and dynamically connected supply and distribution channels

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# Plans for the next 6 Months :

**Workshop 5: Hands on Earth Observation**

February, Portsmouth
Lead Coordinators: University of Portsmouth

The aim of this workshop is to deliver a hands on – demonstrator style workshop for companies who may be starting to be aware of the opportunities that satellite imagery may have on their business but don't know how to take the first steps. The workshop will explore what data sets are available and how to access them, as well as tutorials in how to use the data

**Workshop 6: Data Reliability & Cyber Security in Marine Satellite Communications**

February, Southampton
Lead Coordinators: University of Southampton

**Workshop 7: Processed Remote Sensing for Insurance**
March, London

Exploring the potential in combining the vast resource available in satellite imagery with the analytical capabilities enabled through machine learning to provide insights to industries that require evidence of compliance rather than reporting by exception specifically for the insurance industries

# Thank you!

grant.day@port.ac.uk
grant.day@sacatapultcoe.org
023 9284 6204
@SouthCoast_CoE


UK SPACE AGENCY

Supported by CATAPULT Satellite Applications

# Networking Lunch

**Level 4 exhibition area Members of our team will guide you**

## 1.5 hour Break

Prof Russ Wynn

Chief Scientist Marine Autonomous and Robotic Systems MARS NOC

# Brief overview of NOC's Industry Autonomous Project

# NOC - industry projects in Marine Autonomous Systems

**Prof Russell B Wynn (Chief Scientist, MARS)**

# NERC Marine Autonomous and Robotic Systems (MARS)

- 2012-21: £25M of BIS capital investment into MARS
- MARS now operates >40 vehicles for UK science
- World-leading expertise in MAS sensor development
- Trend = >endurance/operability/AI, <size/speed/cost



*"Marine robotic systems will also be critical to cost effective routine mapping and monitoring of the oceans and seas, addressing the gross under sampling of the oceans…*

Minister for Universities & Science
Rt. Hon. David Willetts MP
"Eight Great Technologies"


# Working with MAS industries 1:
# New platforms, sensors and software solutions

# SBRI: Long Endurance Marine Unmanned Surface Vehicles (LEMUSV)

- 6 x £50k concept studies awarded 2012; down-selected to ASV and MOST AV in 2013
- Initial prototype trials Portsmouth Harbour Dec 2013; further trials Loch Fyne Feb 2014
- Platforms collect acoustic, metocean and biological data with a range of sensors
- Clean, quiet, portable, low-cost technology (compared to survey vessels)
- Future potential to remotely collect water samples for e.g. pollutants, eDNA

**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)

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

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

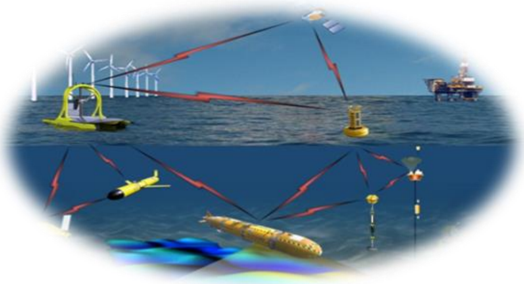
Marine Autonomy & Technology Showcase

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.

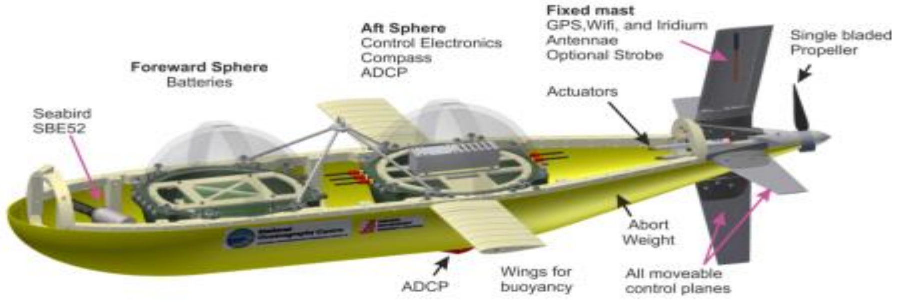


The two-phase competition was launched last September by the Natural Environment Research Council (NERC) in partnership with the Defence Science and Technology Laboratory (DSTL) and Innovate UK, with £1.5 million being made available for the project. Phase one saw nine consortia submit feasibility studies, 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.

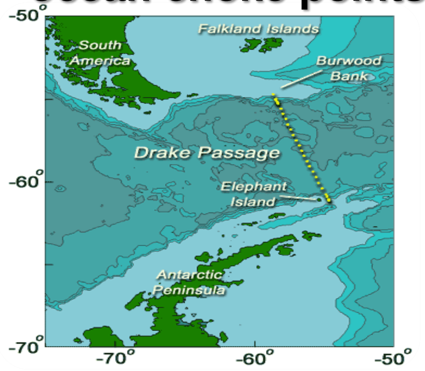
The two consortia moving forward to the final stage are led by SeeByte Ltd in partnership with ASV and the Marine Biological Association (MBA) and University of Exeter in partnership with Marine South East Ltd and the Met Office. Each will now spend the next 12 months developing their products, with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

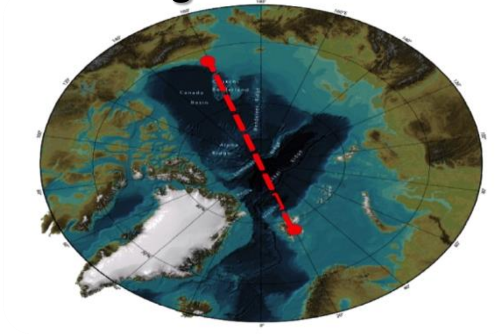
# MARS Autosub Long Range (ALR)



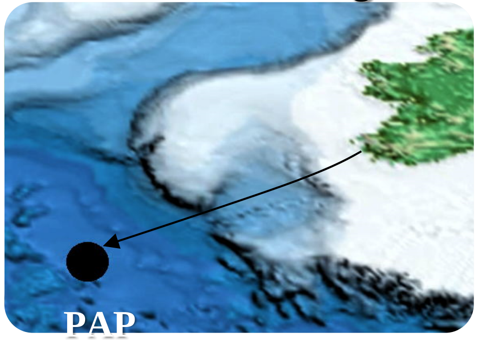

## Long-term observation of ocean choke points




## Crossing the North Pole

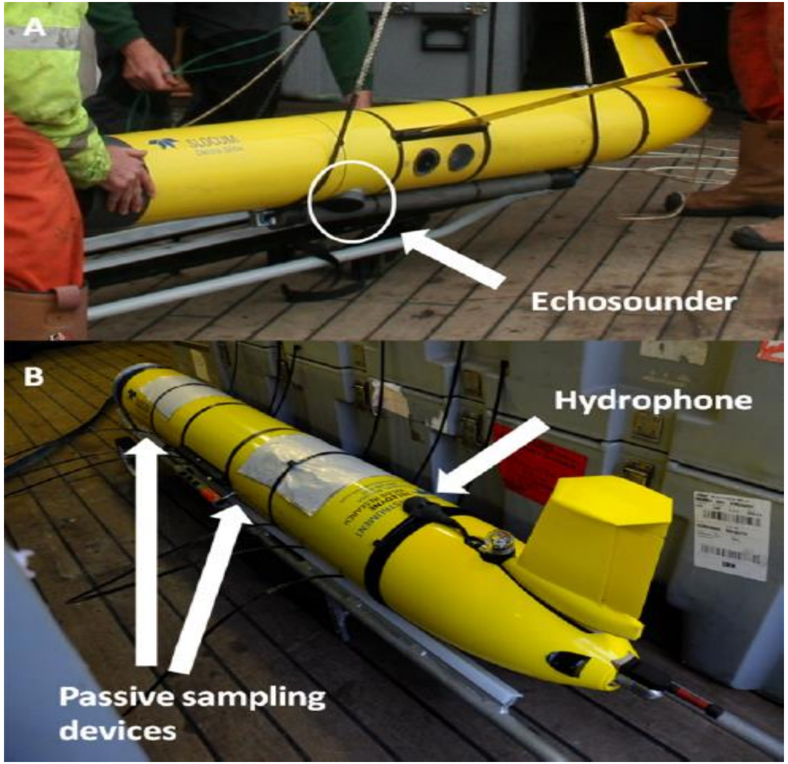


## Self deploying long-term moorings



# Working with MAS industries 2: MASSMO demonstrator missions

# GLAMOR (2013) Submarine gliders for persistent environmental observing




ELSEVIER

Methods in Oceanography

Volume 10, September 2014, Pages 70–89

Special Issue: Autonomous Marine Vehicles

Full length article

## Assessing the potential of autonomous submarine gliders for ecosystem monitoring across multiple trophic levels (plankton to cetaceans) and pollutants in shallow shelf seas

Lavinia Suberg[a], Russell B. Wynn[a], Jeroen van der Kooij[b], Liam Fernand[b], Sophie Fielding[c], Damien Guihen[c], Douglas Gillespie[d], Mark Johnson[d], Kalliopi C. Gkikopoulou[d], Ian J. Allan[e], Branislav Vrana[f], Peter I. Miller[g], David Smeed[a], Alice R. Jones[a, h]

Open Access funded by Natural Environment Research Council



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doi:10.1016/j.mio.2014.06.002

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## Abstract

A combination of scientific, economic, technological and policy drivers is behind a recent upsurge in the use of marine autonomous systems (and accompanying miniaturized sensors) for environmental mapping and monitoring. Increased spatial–temporal resolution and coverage of data, at reduced cost, is particularly vital for effective spatial management of highly dynamic and heterogeneous shelf environments. This proof-of-

# MASSMO1 (2014) Combining surface and submarine gliders

# GoPro image from Autonaut USV showing Gannet and towed acoustic array

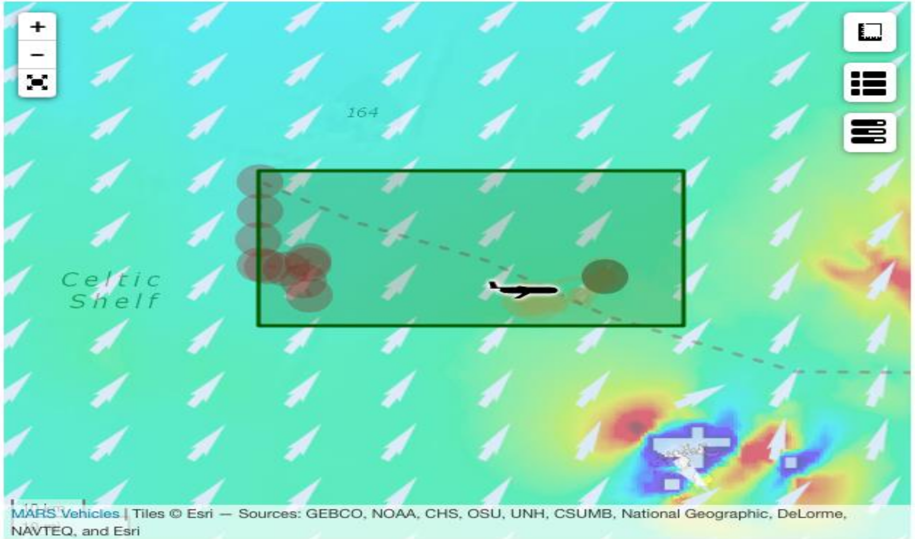
# MASSMO2 (2015-16) MAS for environmental and defence research

NMF Vehicles | Browse | Help | Login

## C-Enduro Thomas on mission MASSMO 2A-2

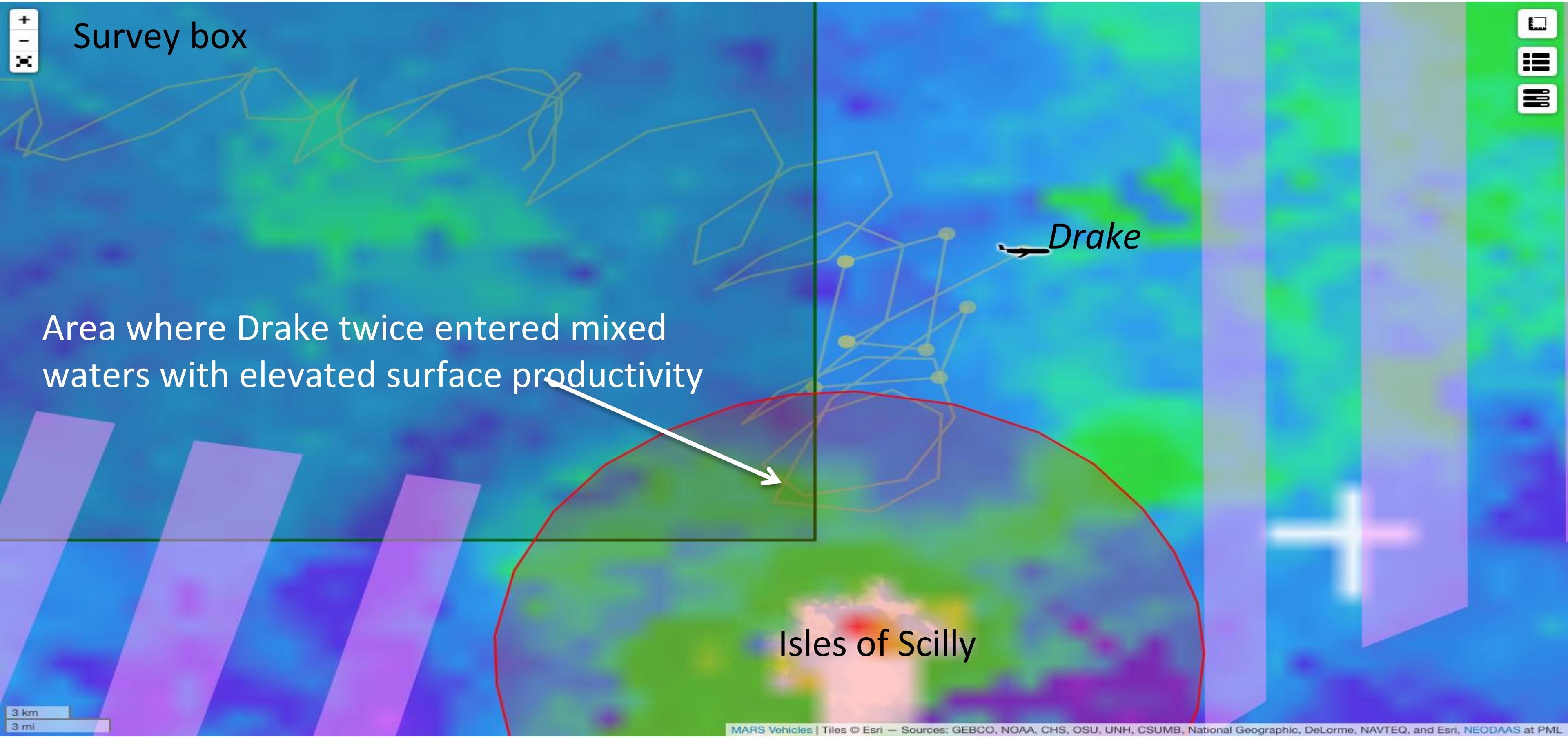
- **Public vehicle**
- Serial Number 996
- Operated by NOC on the MASSMO project
- Current Status: Deployed

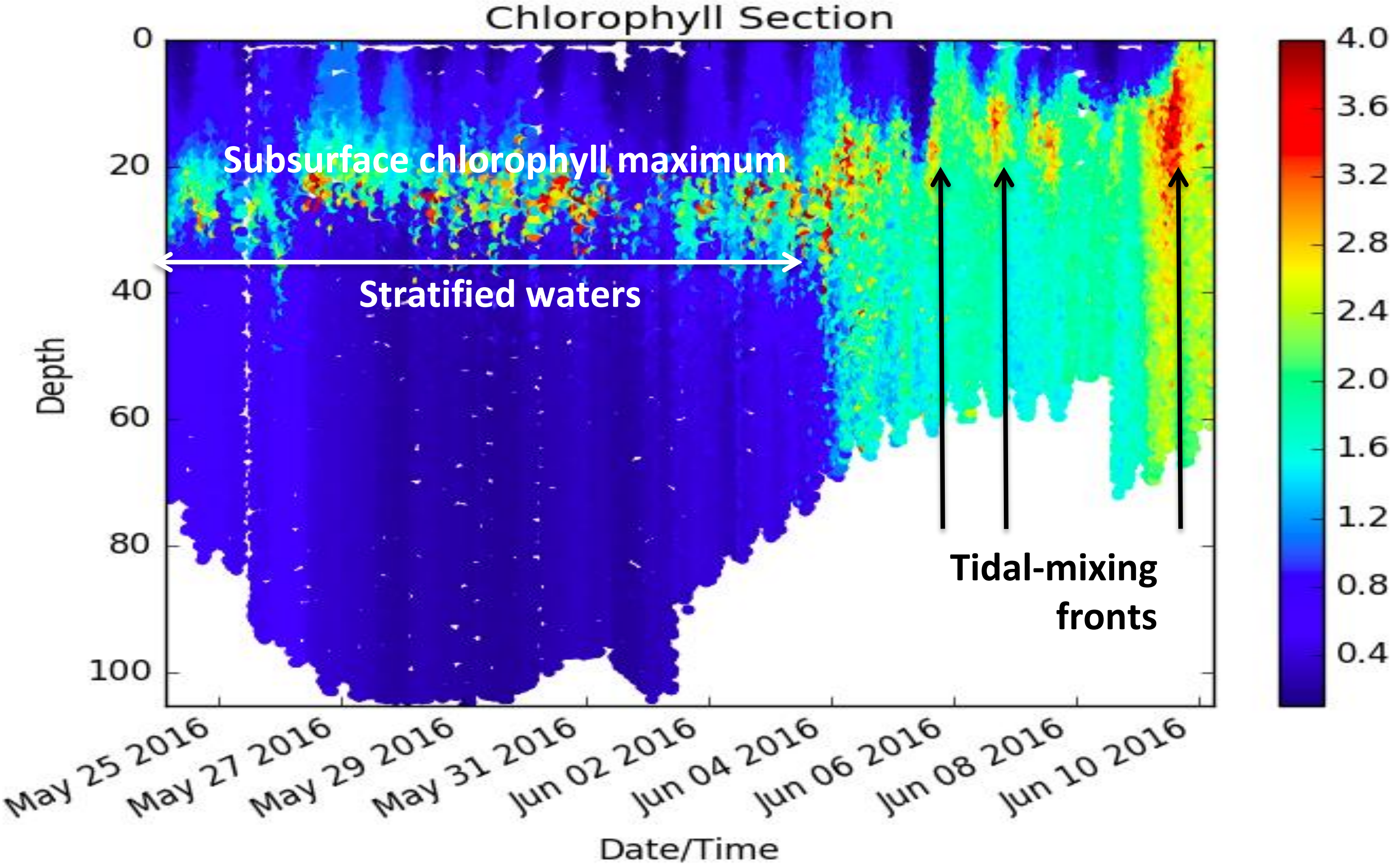
### C-Enduro Camera Feed



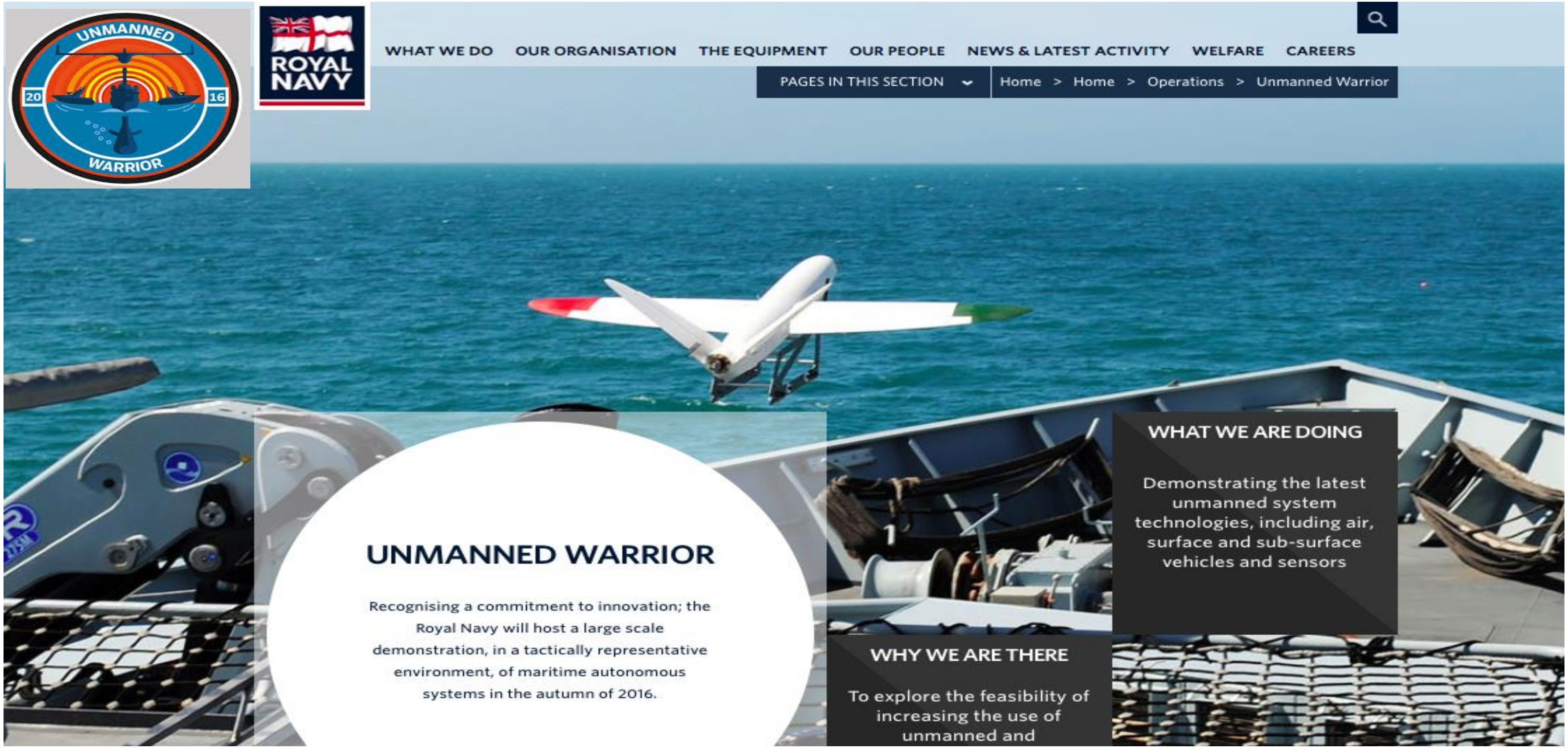

- **Deployed:** 2016/05/22 00:00:00 UTC (15 days ago) by David White
- **Time at Sea:** 15 days
- **Profiles Performed:** 118

# 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

# MASSMO3 (2016) Contributing to RN Unmanned Warrior



## 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 20 16 WARRIOR

ROYAL NAVY

[dstl]

Ministry of Defence

QinetiQ

**MASSMO3**
**Autumn 2016**

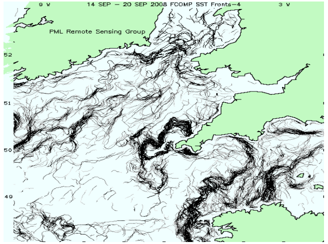
## Public engagement



## Data management

BODC British Oceanographic Data Centre NATURAL ENVIRONMENT RESEARCH COUNCIL

## Operational products




PML Plymouth Marine Laboratory

United Kingdom Hydrographic Office

Met Office

esri UK

helyx

seebyte

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NOC Events

Everyone's Gliding Observatories (EGO) Conference
September 26, 2016 - September 27, 2016

RRS Discovery in Liverpool
October 4, 2016 - October 7, 2016

Home ►

# 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.

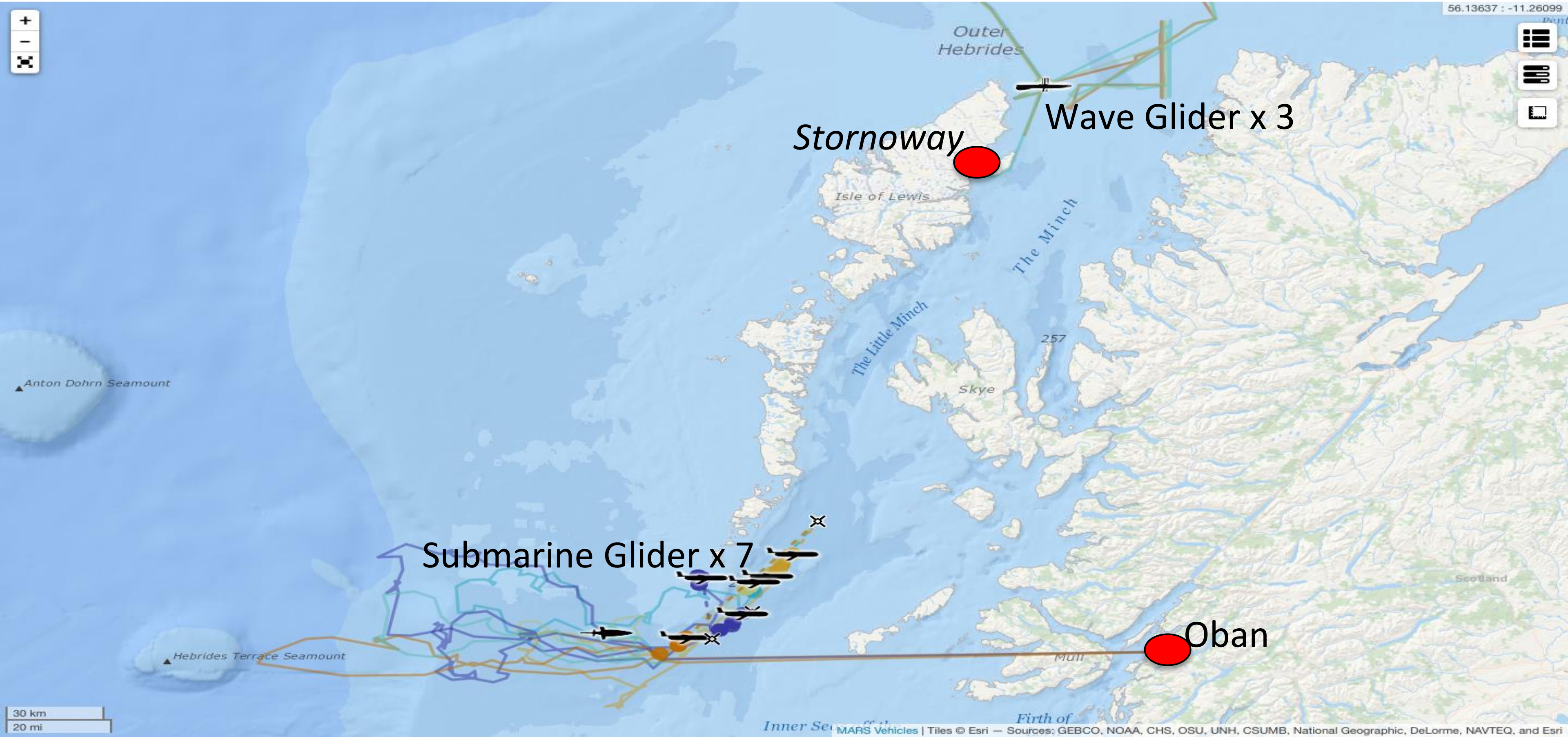
Phase two comprised two successive missions off southwest UK in 2015 and 2016, undertaken in partnership with World Wildlife Fund UK (WWF-UK) and Defence Science and Technology Laboratory (Dstl); these missions were used to further test how submarine gliders and unmanned surface vehicles can work together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

# Submarine glider being recovered by RN staff on 01 Oct 2016

## The MASSMO3 fleet at 0820 hrs on 01 Sept 2016

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

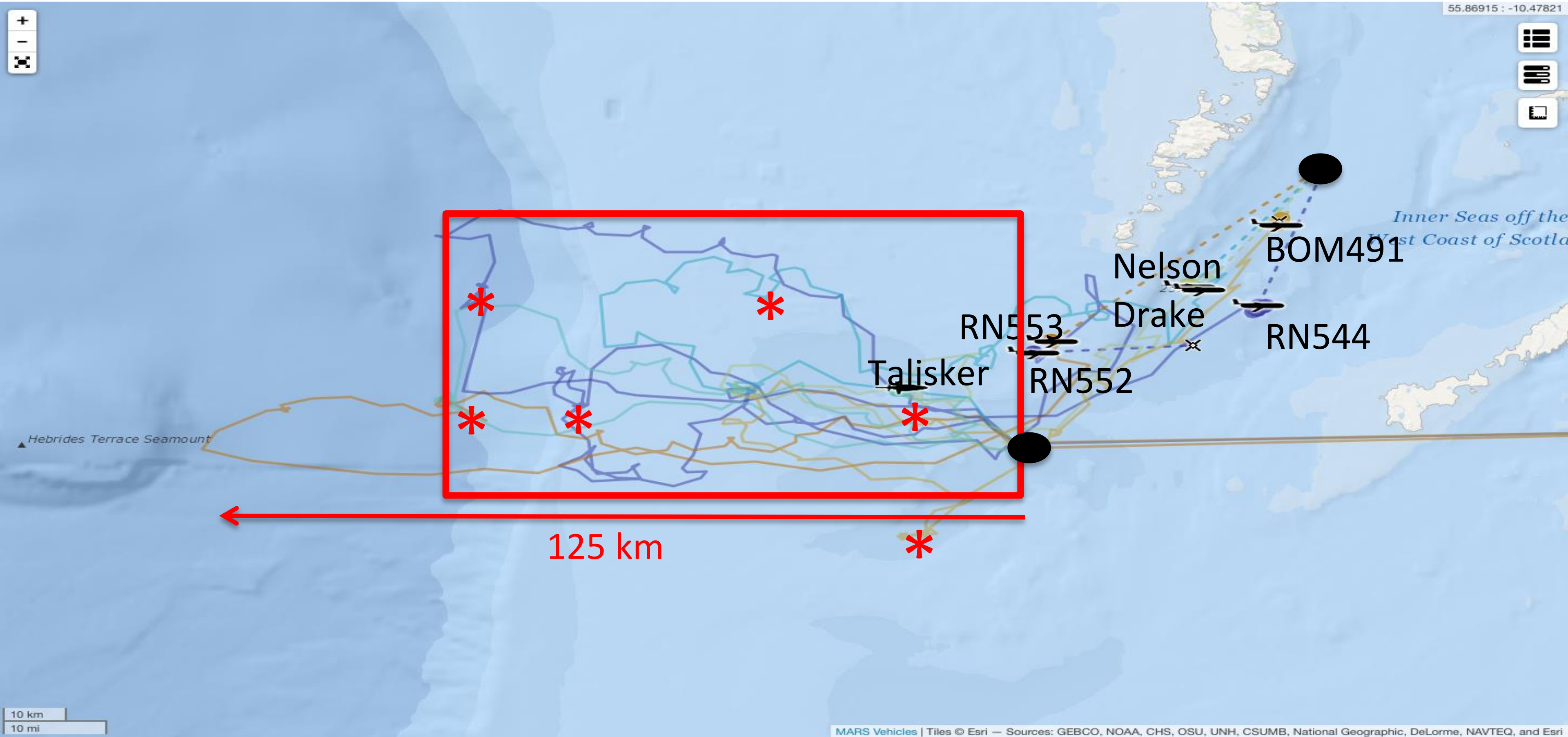


# MASSMO3 Operations Room at NOC on 29 Sept 2016

# MASSMO3 submarine glider positions on 01 Oct 2016

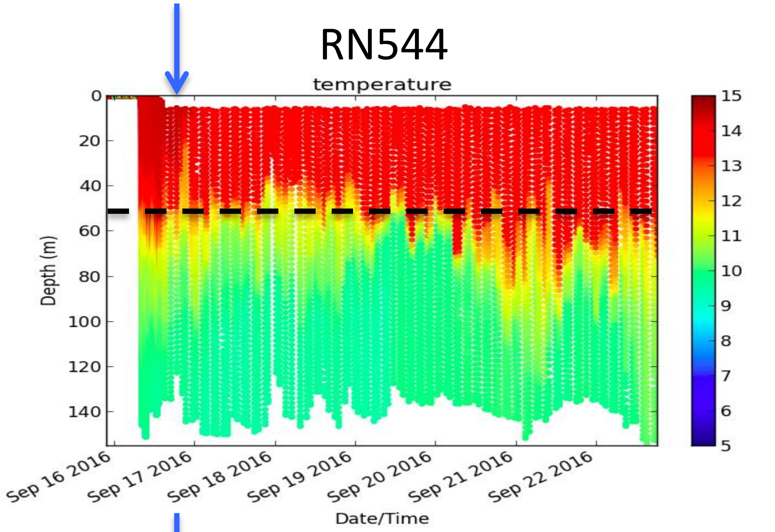
Gliders achieved excellent spatial coverage in two weeks (>1500 NM and >5000 km$^2$)

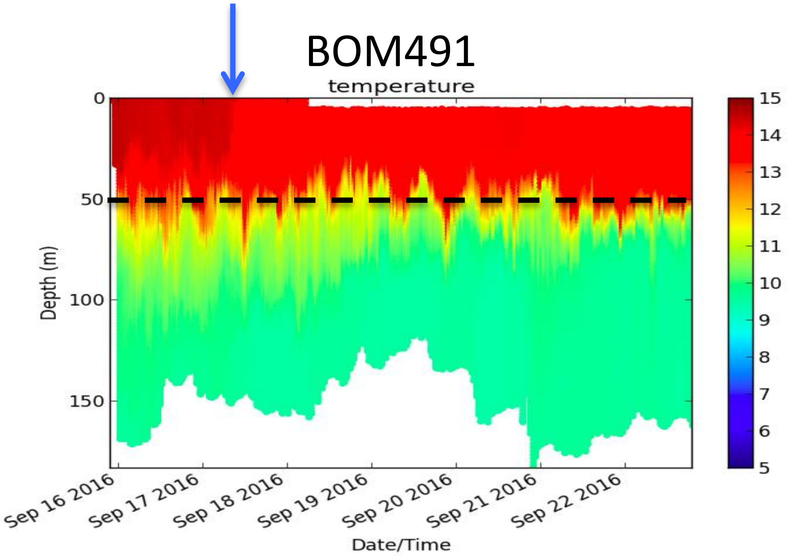
Gliders also undertook a two-day virtual mooring experiment

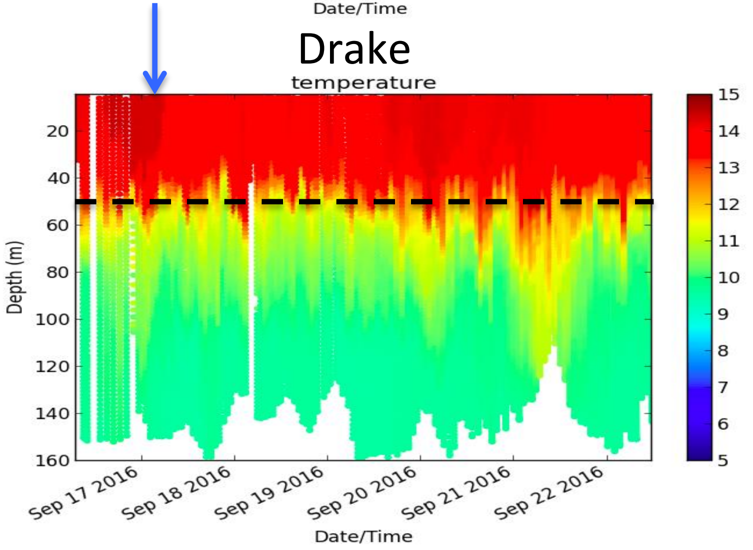


**Temperature data from three shallow gliders 16-22 Sept 2016**

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

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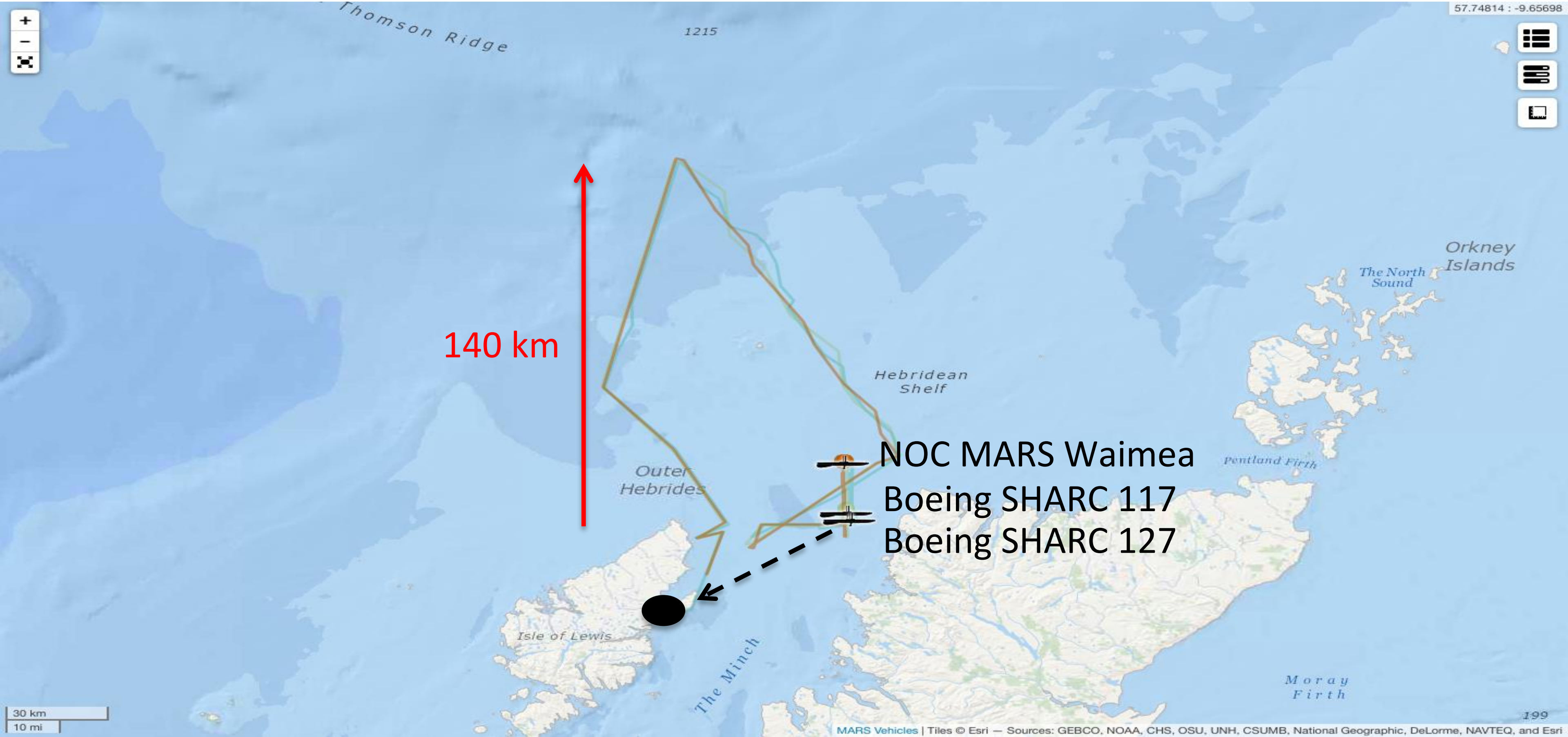
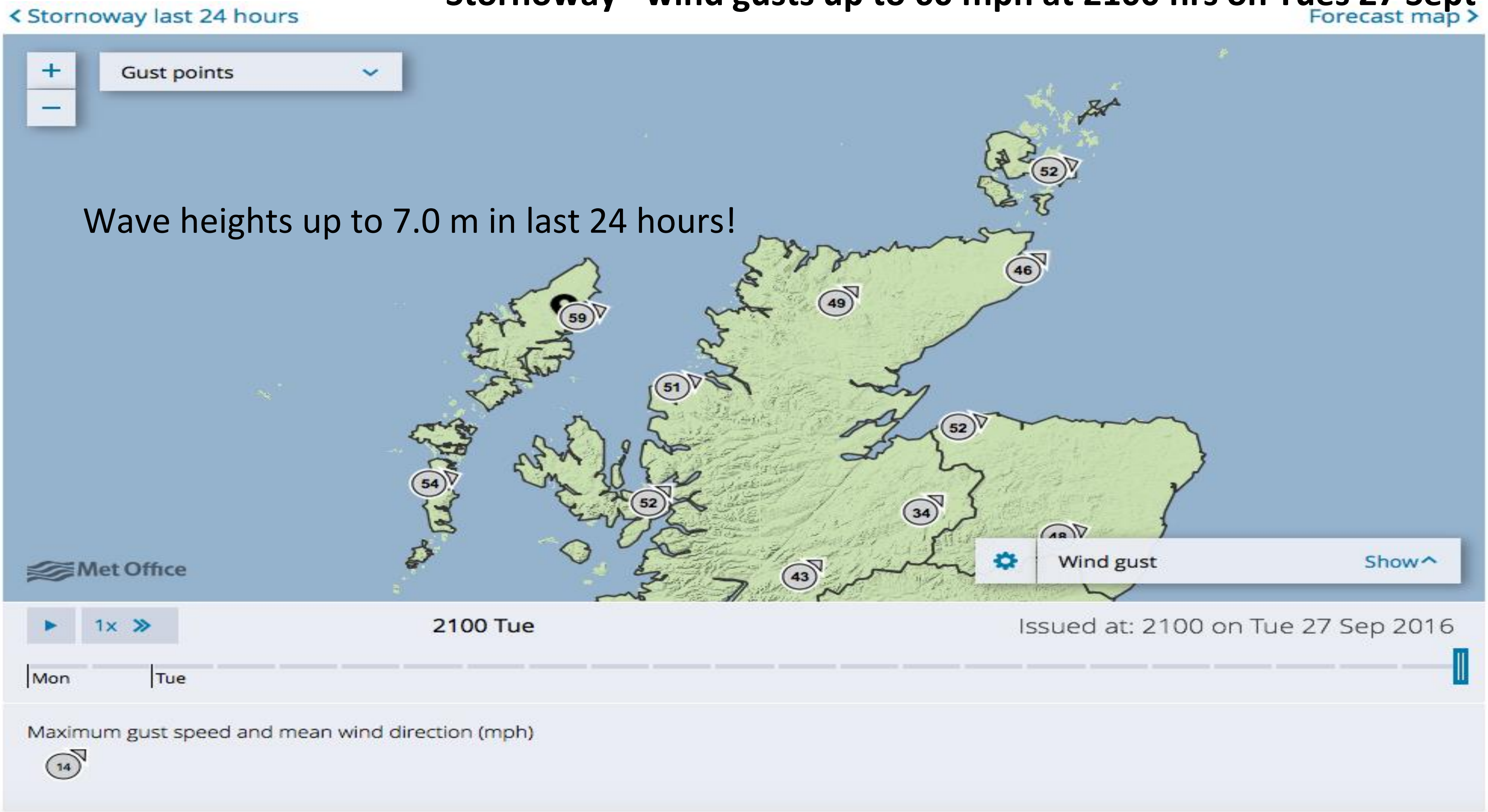
# Wave Glider locations at 1100 hrs on 29 Sept 2016

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

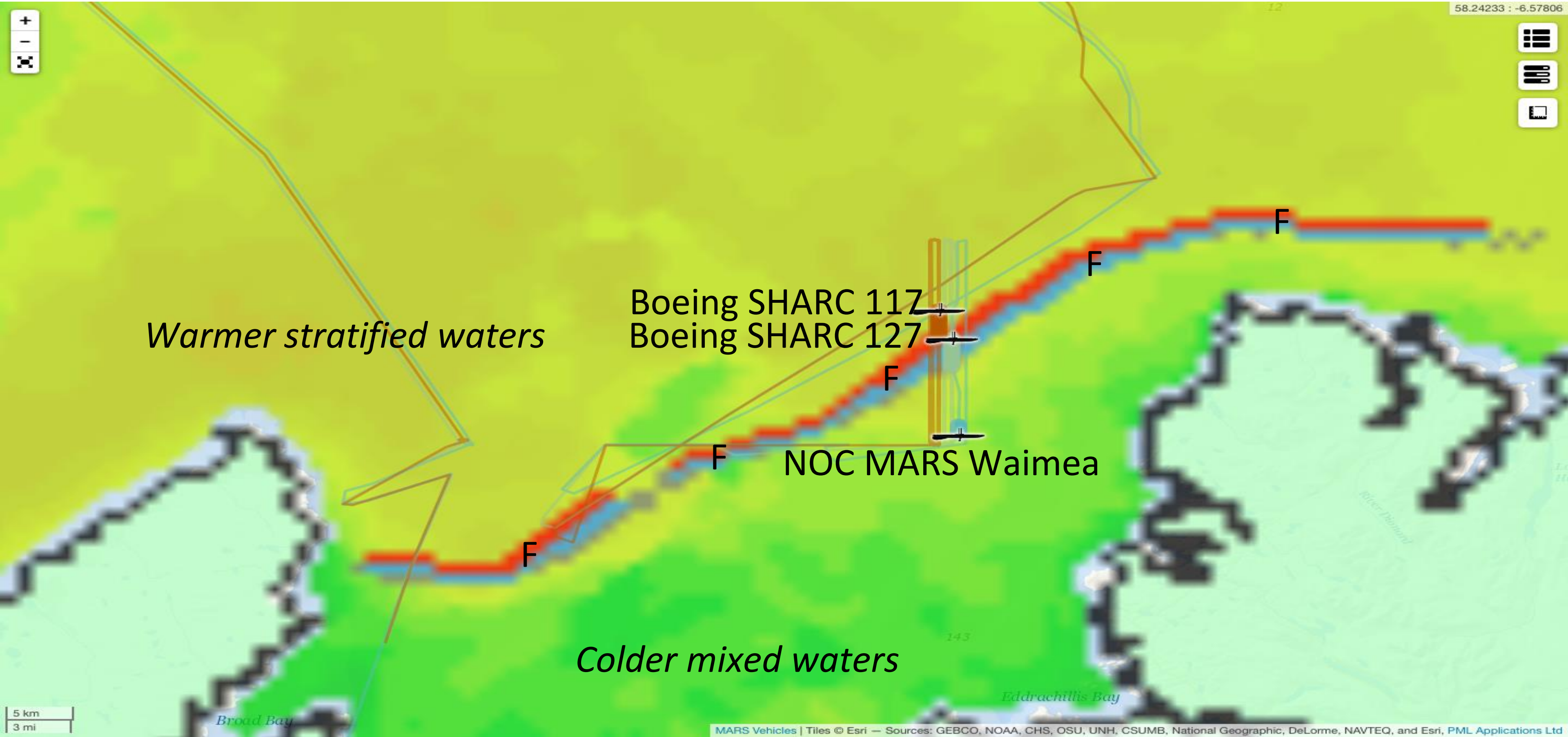



Wave heights up to 7.0 m in last 24 hours!

# Wave Glider locations at 0630 hrs on 28 Sept 2016

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

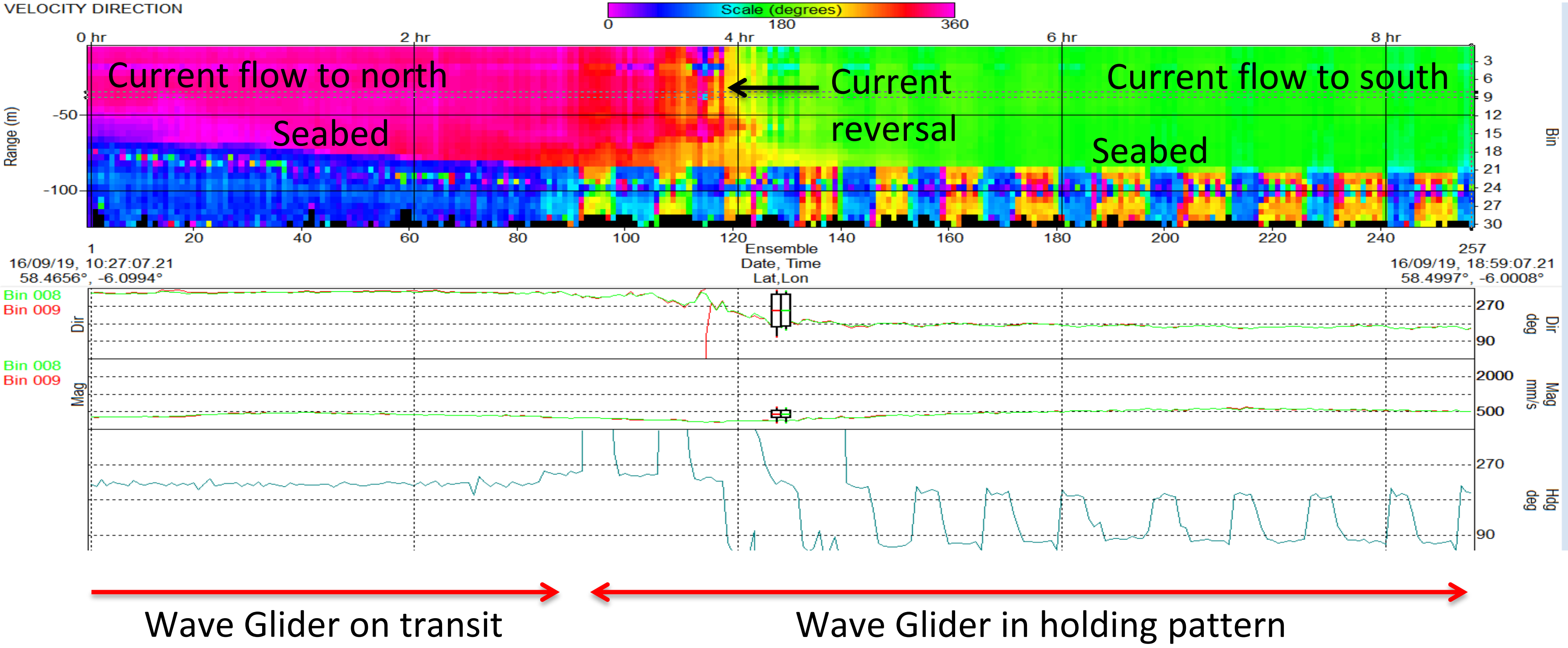
Sea surface temperature map shows colder mixed surface waters south of this front



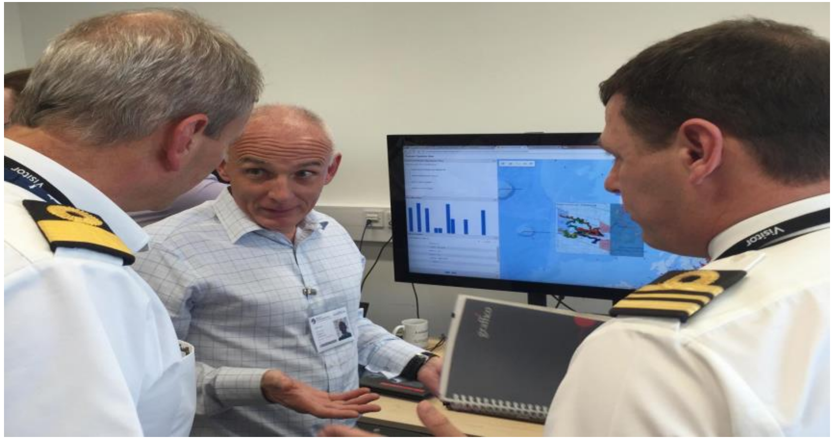
# Wave Glider ADCP data from 19 Sept 2016

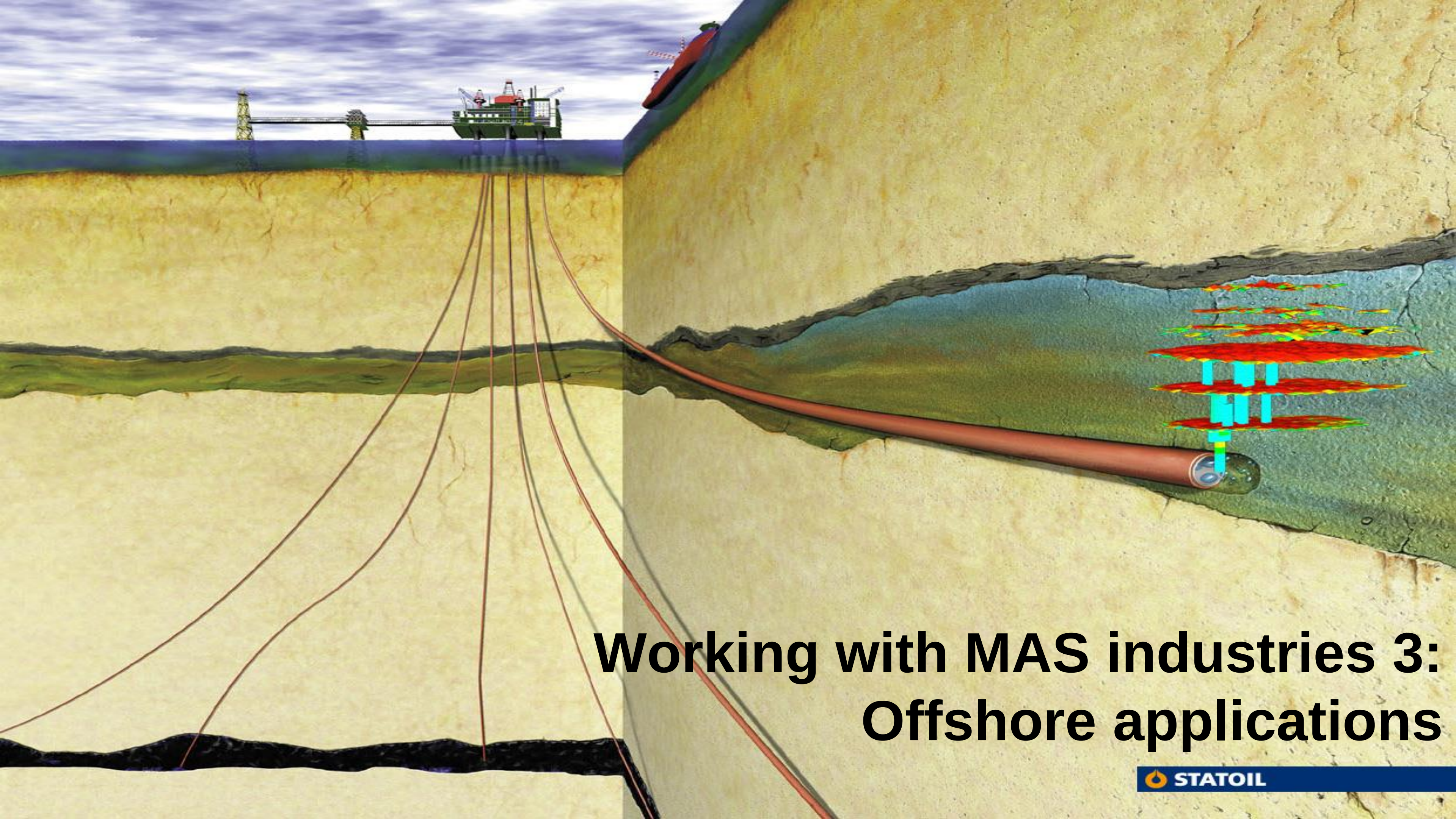
Wave Glider was in northern Minch, arriving on station for shakedown period

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



# MASSMO3 - VIP visit day to NOC Operations Room






# Working with MAS industries 3: Offshore applications

# Sub-seabed CO2 storage - monitoring leakage and ecosystem impacts



# ALR applications in long-term CCS monitoring

energy technologies institute

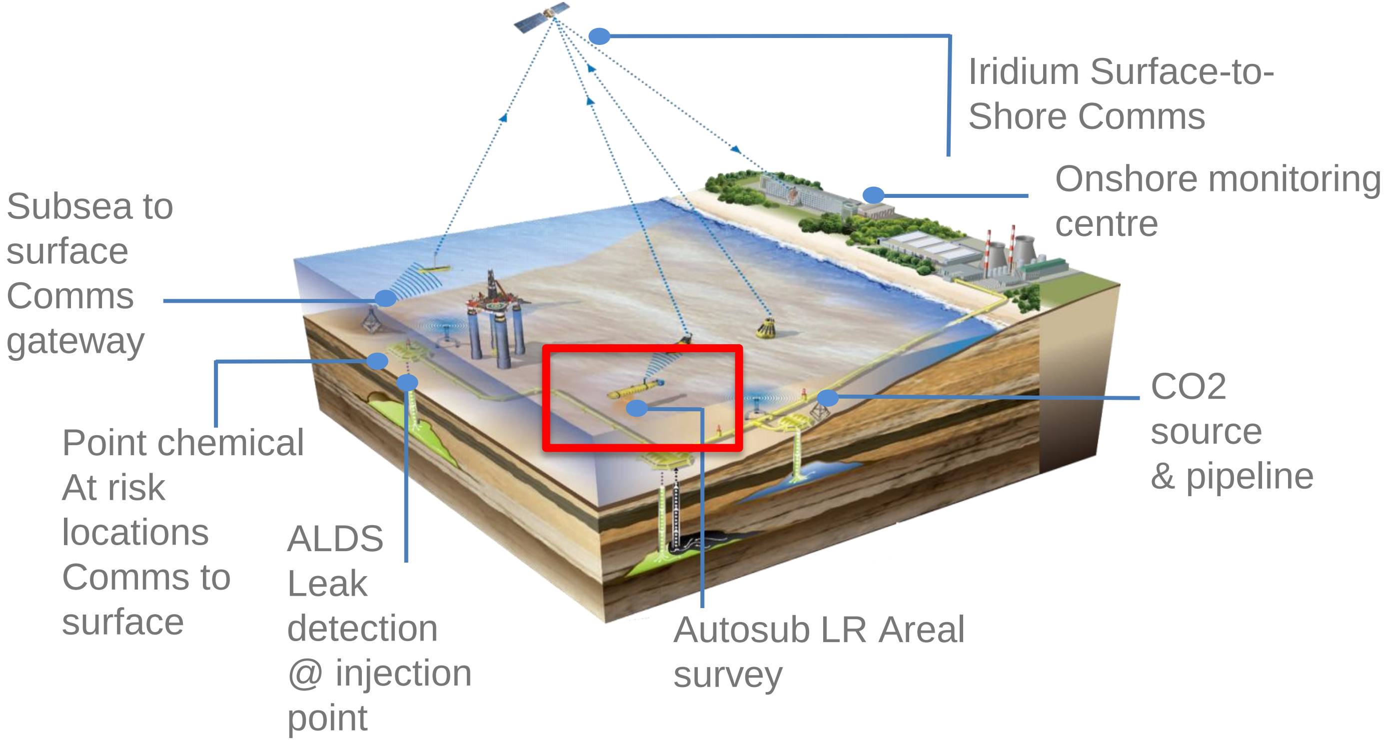
Sonardyne SOUND IN DEPTH

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.


MAREMAP Marine Environmental Mapping Programme
British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL
National Oceanography Centre
SCOTTISH ASSOCIATION for MARINE SCIENCE

**Investigating the feasibility of utilizing AUV and Glider technology for mapping and monitoring of the UK MPA network**

Final report for Defra project MB0118

Project Leader: Dr Russell B Wynn (NOC)



Report published and delivered in September 2012 by the National Oceanography Centre and the UK Marine Environmental Mapping Programme (MAREMAP) of the Natural Environment Research Council (NERC)

defra Department for Environment Food and Rural Affairs

# Marine Autonomous Systems for MPA mapping and monitoring

- Capacity
- Capabilities
- Limitations
- Case Studies
- Cost-benefits

*Wynn, R.B., Bett, B.J., Evans, A.J, Griffiths, G., Huvenne, V.A.I., Jones, A.R., Palmer, M.R, Dove, D., Howe, J.A, Boyd, T.J. and MAREMAP partners (2012) Investigating the feasibility of utilizing AUV and Glider technology for mapping and monitoring of the UK MPA network. Final report for Defra project MB0118. National Oceanography Centre, Southampton. 244 pp.*

# Working with MAS industries 4: Training

# 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.

RSS *Discovery* with its fleet of autonomous vehicles.

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:

# Working with MAS industries 5: Publicity and outreach

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**2 October 2014** Last updated at 18:01

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# Big robot fleet takes to UK waters

By David Shukman
Science editor, BBC News

The BBC's David Shukman: "We are now entering a new era of almost constant observation of the oceans"

**A fleet of marine robots is being launched in the largest deployment of its kind in British waters.**

Unmanned boats and submarines will travel 500km (300 miles) across an area off the southwestern tip of the UK.

The aim is to test new technologies and to map marine life in a key fishing ground.

In total, seven autonomous machines are being released in a trial heralded as a new era of robotic research at sea.

Two of the craft are innovative British devices that are designed to operate for months using renewable sources of power including wind and wave energy.

The project, led by the National Oceanography Centre, involves more than a dozen research centres and specialist companies.

Chief scientist Dr Russell Wynn told BBC News: "This is the first time we've deployed this range of vehicles carrying all these instruments.

**Related Stories**

- Deep-sea sub 'implodes' 10km-down
- Electric fish inspire agile robots
- UK sub surveys deep ocean floor

**Drones of the deep**

Marine robots come in a variety of strange shape and sizes, and no fewer than four different types

---

THE INDEPENDENT TUESDAY 14 OCTOBER 2014



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# New underwater robots set to revolutionise marine science

National Oceanography Centre launches ambitious new project

CHRIS GREEN Tuesday 07 October 2014

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A fleet of seven aquatic robots has been launched into the ocean off the south west of England, ushering in a new era of marine research carried out by unmanned vehicles.

The project, led by marine researchers at the National Oceanography Centre (NOC) in Southampton, is the most ambitious of its kind in Europe. The selection of crafts will travel 300 miles

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# 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

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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."*

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Science & Environment

# Arctic crossing planned for 'Boaty' sub

By Jonathan Amos
BBC Science Correspondent

24 minutes ago | Science & Environment | Share

Russell Wynn: "Boaty will extend the Attenborough's reach"

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


## Summary

Email: rbw1@noc.ac.uk

MAS companies working with NOC benefit from access to:

- *The most capable MAS fleet in Europe with >40 operational platforms*
- *A dedicated team of >30 MARS engineers and supporting infrastructure*
- *Decades of experience operating MAS in the harshest environments*
- *A large pool of world-leading multi-disciplinary scientists at NOC*
- *100's of marine science and engineering students registered at UoS*
- *High-profile ambitious demonstrator missions on an annual basis*
- *Potential for significant national and international media exposure*
- *Opportunities for large-scale MAS production and commercial operations*

# Mr Alan Gould

Project Manager (MAS) Steatite

# LIS Battery Project

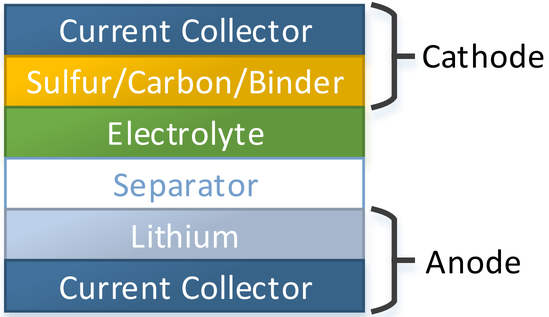
# A Pressure Tolerant Lithium Sulfur Battery for Marine Autonomous Systems

ALAN GOULD (STEATITE)

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL
STEATITE
MSubs Ltd
underwater vehicles & equipment
OXIS ENERGY
Next Generation Battery Technology
Innovate UK
Technology Strategy Board
dstl

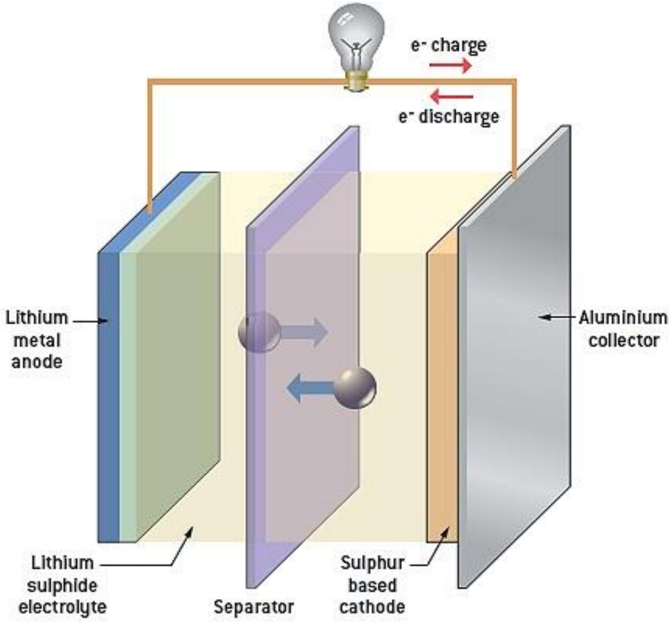
# Lithium Sulfur

- High Energy Density (theoretically 5x Li-ion)
- Lightweight (roughly the density of water)
- Lower cost materials
- Safer
  - “Passivation layer” protecting the anode
  - High-flashpoint organic electrolyte
  - Withstands crushing, puncture and short circuit
- 100% Depth of Discharge available
- Capable of long-term storage




# Lithium Sulfur - Challenges

- Unwanted electrolyte reactions
  - potential for irreversible loss of sulfur into intermediate polysulphides
- Volume expansion due to growth of mossy lithium
- Non-linear discharge
- Cycle-life



# Oxis Energy

OXIS has developed a breakthrough Li-S technology through more than 10 years of  research and a total investment of $100M

Key enablers:

- Lithium metal anode
- Carbon-sulfur cathode
    - Sulfur for energy storage
    - Carbon for conductivity
- High flashpoint electrolyte

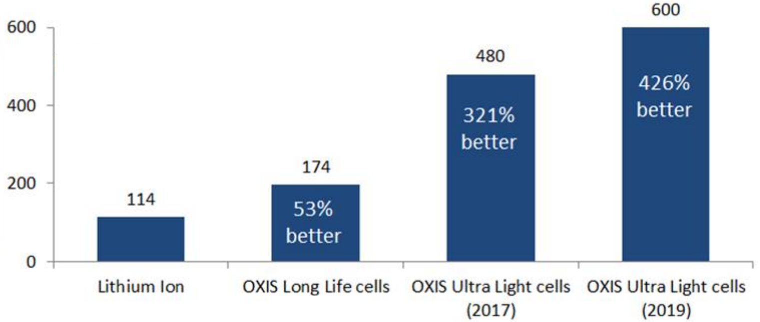
- €30 million investment over 3 years

- Strong patent portfolio protecting key areas of cell composition (80 patents granted, 97 pending, encompassing 25 families)

# Li-S for subsurface applications

- Higher Speeds
- Increased Endurance
- Greater Sensor Payload Capacity

Neutral buoyancy specific energy extremely high as:
a. Gravimetric Specific Energy is high
b. Mass density of cells similar to water so no buoyancy foam is required




| | Lithium Ion | OXIS Long Life cells (Today) | OXIS Ultra Light cells (2017) | OXIS Ultra Light cells (2019) |
|---|---|---|---|---|
| **Specific Energy (Wh/kg)** | 185 | 152 | 400 | 500 |
| **Mass density (kg/m$^3$)** | 2100 | 928 | 900 | 900 |
| **Foam mass (kg)*** | 0.616 | -0.126 | -0.167 | -0.167 |
| **Neutral buoyancy specific energy (Wh/kg)** | **114** | **174** | **480** | **600** |

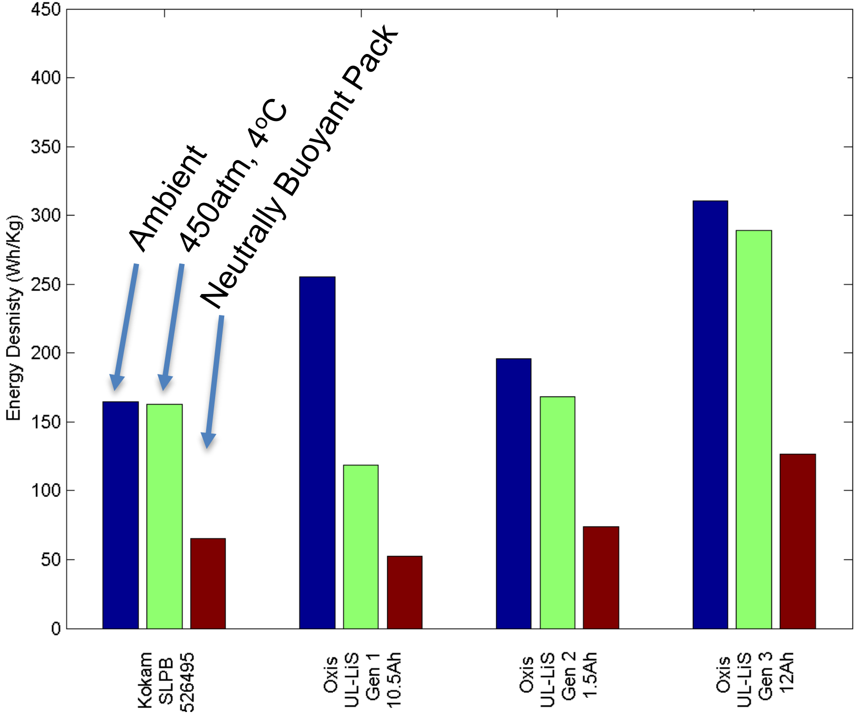
* Negative foam figure indicates that foam can be saved elsewhere on vessel

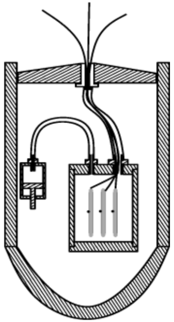
# The MAS Project

- Oct 2015 – Sept 2017
- Exploit volumetric energy benefits for underwater applications
- Test and improve cell performance at high pressure and low temperature
- Develop a multi-chemistry controller for challenging environments
- Build and demonstrate a LiS battery in a UUV
- Position to exploit improving cell capabilities to bring product to market shortly after project

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL
STEATITE
MSubs Ltd
underwater vehicles & equipment
OXIS ENERGY
Next Generation Battery Technology
Innovate UK
Technology Strategy Board
dstl

# Progress: Cells



- 90% increase in Neutral Buoyant Energy Density (NBED)
- Stable Performance Over Pressure / Temperature

| | Raw | NBED |
|---|---|---|
| Li-Po | 164 (Wh/kg) | 66 (Wh/kg) |
| Li-S | 289 (Wh/kg) | 126 (Wh/kg) |
| % Diff | +76% | +90% |

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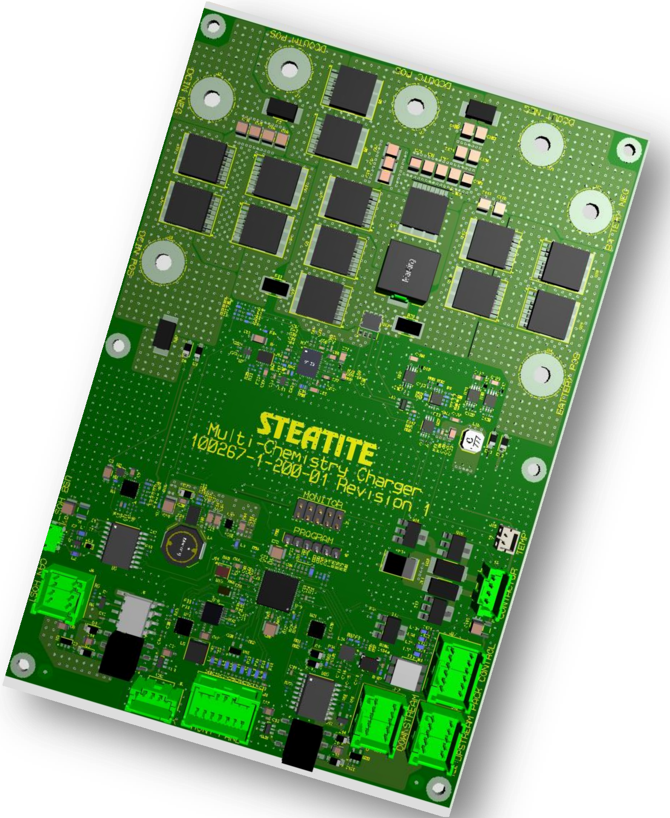
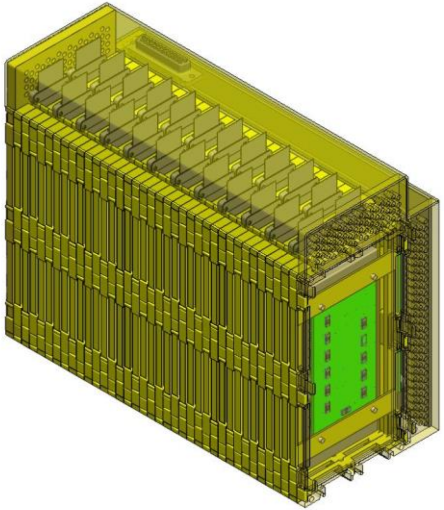
# Progress: Pressure-tolerant BMS

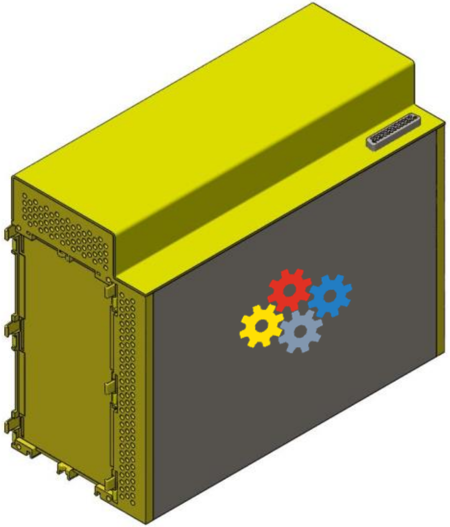
- Supports Lead-Acid, $LiFePO_4$ ,Li-ion and Li-S
- Battery voltages: 8V → 33V
- Discharge current: up to 30A continuous, 50A peak
- Charge current: up to 30A
- Integrated USB and CAN control interfaces
- Monitoring and balancing at cell level across entire pack
- PC-based management application



# Progress: Battery

- Initial configuration:
  - 12-cell unit, 6S2P
- Combined to provide 24v, 300Wh battery
- Trials using 600Wh battery pack
- Charge rate: 0.2C
- Discharge rate: up to 1C





# Next steps

- Continue characterisation, comparison and cycle performance tests
- Build and test of battery modules
- Integration and trials in two vehicles
- Development of product specification
- MAS Technical and Users Workshop  (January 2017)
    - Opportunity to shape the product definition and priority applications

**Alan Gould CEng, RPP**
*Project Manager (MAS)*
*Steatite Ltd*

**Tel:** 07793 420637
**Email:** agould@steatite.co.uk

For further information and to register for project updates please go to:

**www.steatite.co.uk**

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Mr Terry Sloane

Planet Ocean

# Launch and Recovery of Multiple AUV’s from a Surface Vehicle

# Launch and Recovery of Multiple AUV's from a Surface Vehicle
# Revisited

## NOC Marine Autonomy & Technology Showcase
## 14th November 2016

**Terry Sloane**

**Planet Ocean Ltd**

# Overview

- Planet Ocean Introduction
- How did we get here?
- Innovate UK Project
  - Why?
  - The challenge
  - System of Systems
  - Our approach
  - The partners
  - MARIC – The benefits of teamwork
  - The technology – where are we now?

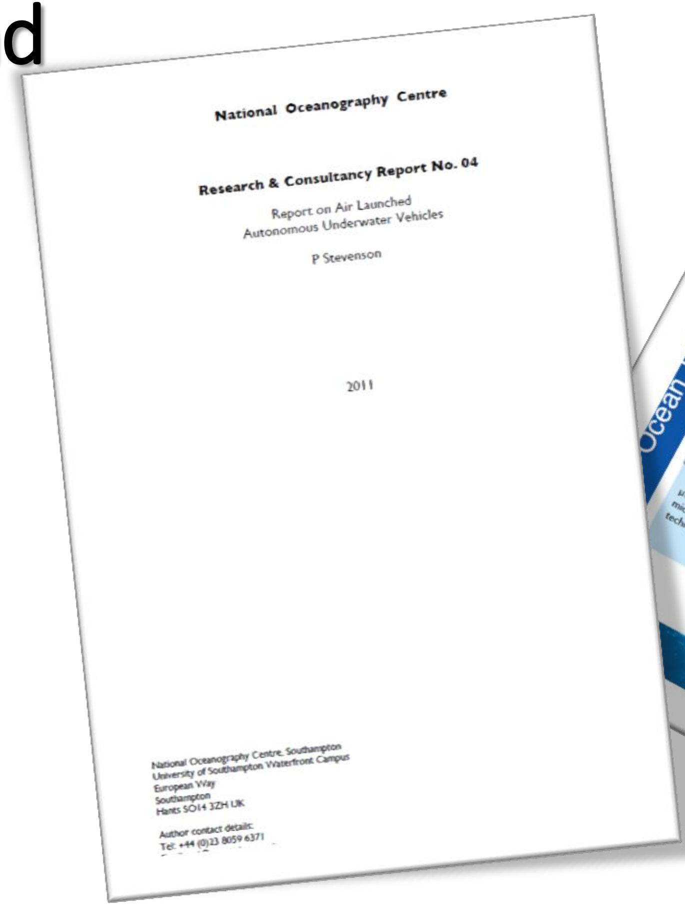
# Introduction to Planet Ocean

- Established in 2004
- Based in Camberley, UK
- Also, offices/workshop at NOC MRIC Innovation Centre
- Certified to ISO9001 & ISO14001
- Core business: distribution of in situ sensor and platform technology for marine science and environmental monitoring


# Background

2009

2011


National Oceanography Centre

Research & Consultancy Report No. 04

Report on Air Launched
Autonomous Underwater Vehicles

P Stevenson

2011

National Oceanography Centre, Southampton
University of Southampton Waterfront Campus
European Way
Southampton
Hants SO14 3ZH UK

Author contact details:
Tel: +44 (0)23 8059 6371

# Background

2012

**Micro-AUV**
**Design Review**
**&**
**Strategy Plan**



COMMERCIAL IN CONFIDENCE

**Planet Ocean Ltd**
**Unit 8 Camberley Business Centre**
**Bracebridge**
**Camberley**
**Surrey**
**GU15 3DP UK**
**Tel: +44 (0)845 108 1457**
**Fax:+44 (0)845 280 3349**
**Email: sales@planet-ocean.co.uk**

Planet Ocean Ltd

# Background

Meanwhile…

2013


ROBOTICS & AUTONOMOUS SYSTEMS

# Background

2014


Planet Ocean Ltd

A MARKET ASSESSMENT AND EVALUATION FOR COMMERCIALISATION OF A MICRO-AUV

An Opportunity Analysis

PRODUCED BY:
PLANET OCEAN LTD
February 2015
CONFIDENTIAL

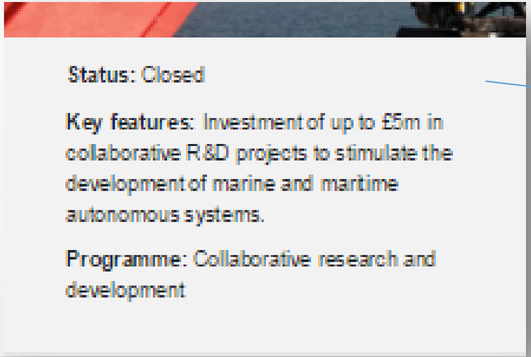
DOCUMENT#C13851 ISSB

ON BEHALF OF
NATIONAL OCEANOGRAPHY CENTRE
NATURAL ENVIRONMENT RESEARCH COUNCIL

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL
NERC
SCIENCE OF THE ENVIRONMENT

# Background

2014




# The Challenge

## Costly Deployment Platforms




# The Challenge

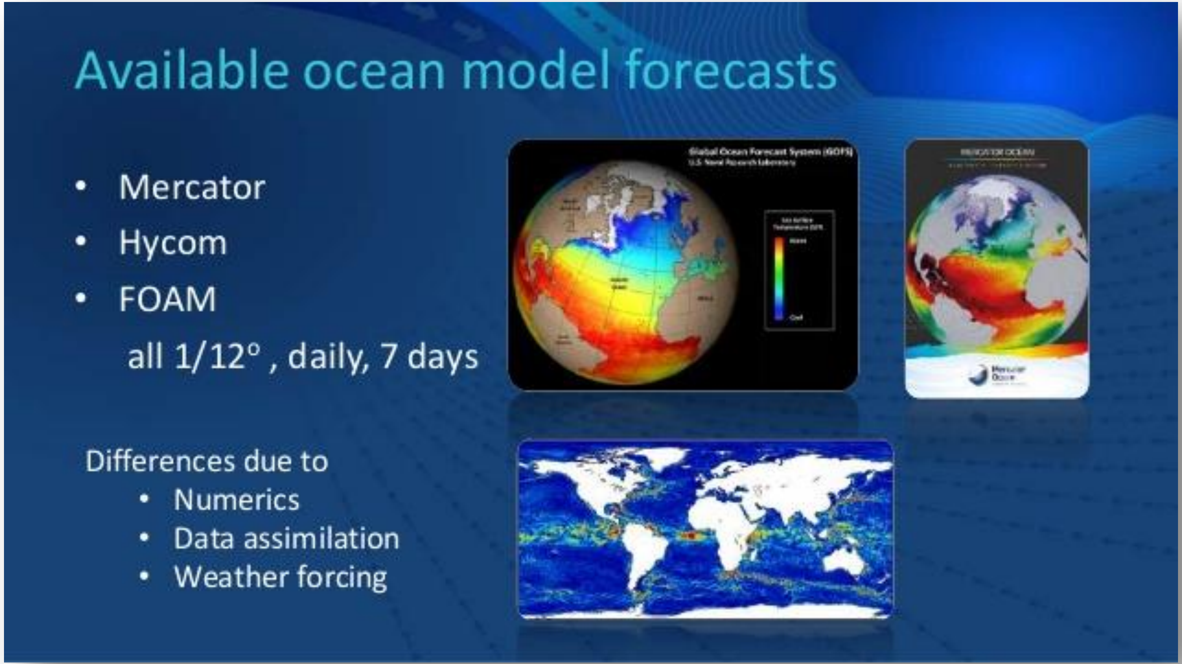
## Under Sampling of the Oceans

# The Challenge

## Under Sampling of the Oceans

# The Challenge

## Under Sampling of the Oceans

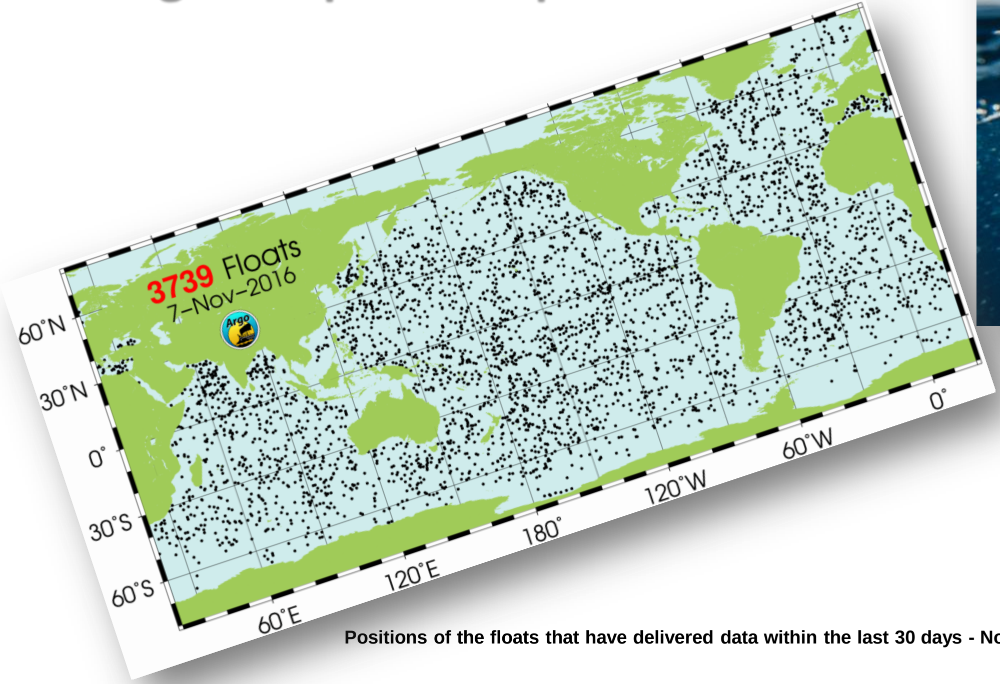


# The Challenge

## Safety

# The Challenge

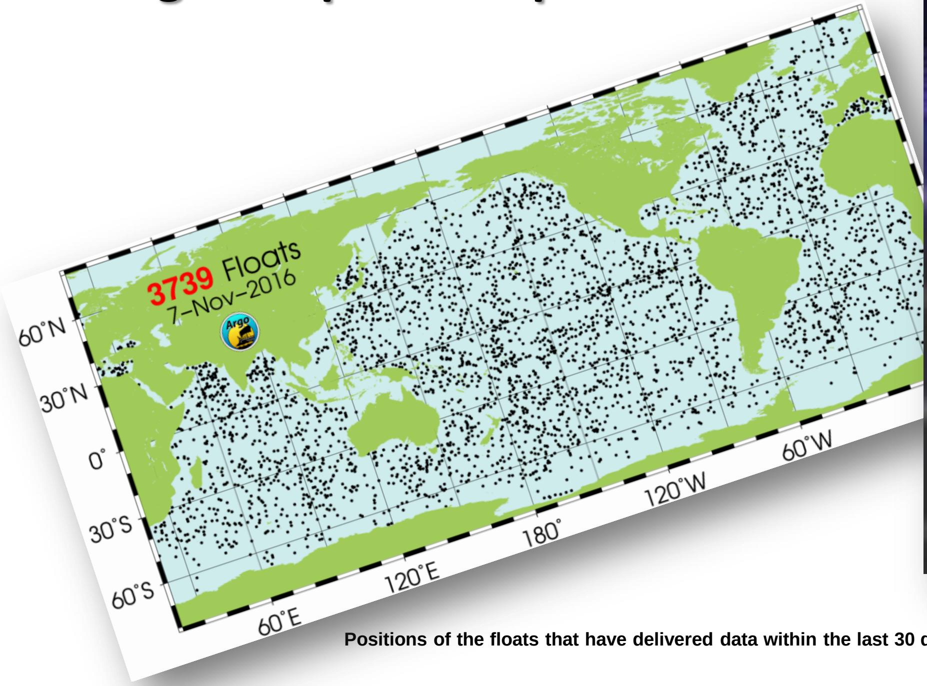
## Large Temporal & Spatial Data Sets

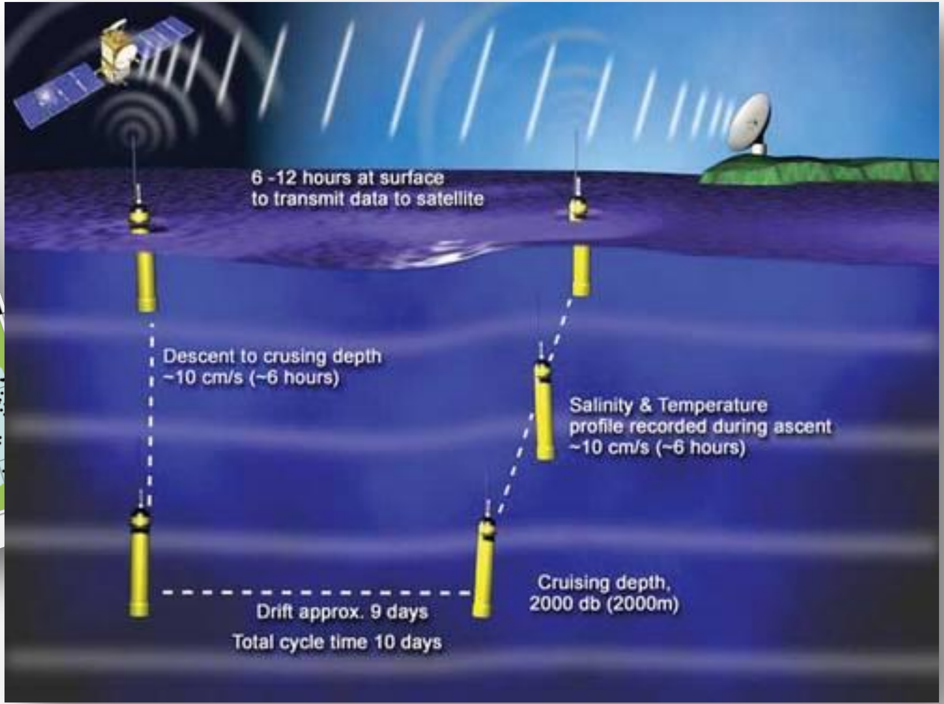



**Positions of the floats that have delivered data within the last 30 days - November 2016 page credit: AIC (Argo Information Center), USCD]**

# The Challenge

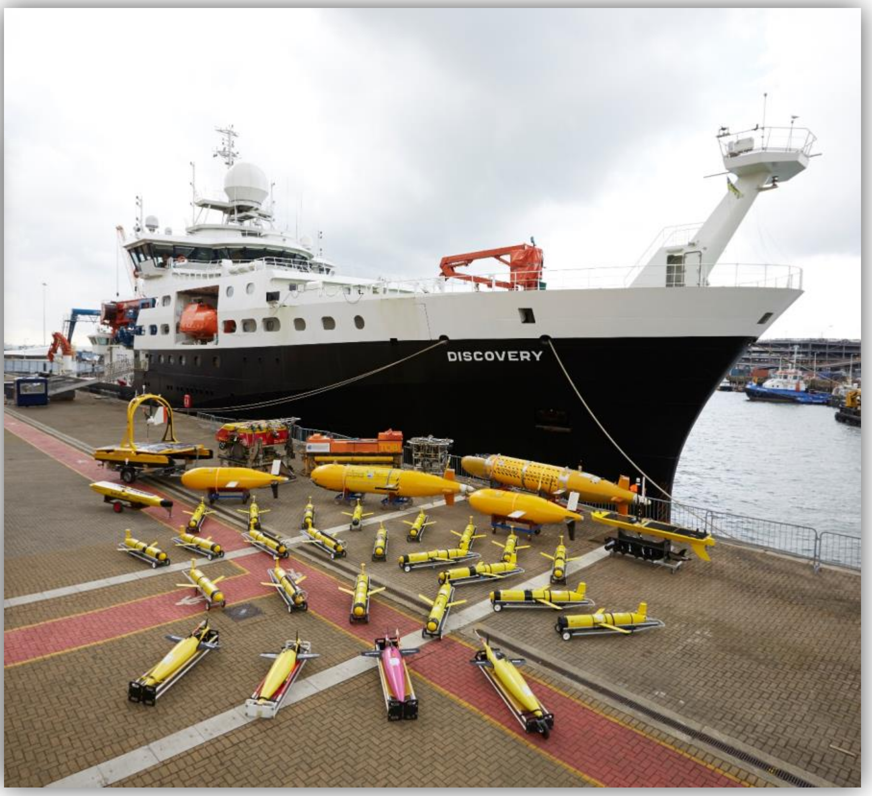
## Large Temporal & Spatial Data Sets



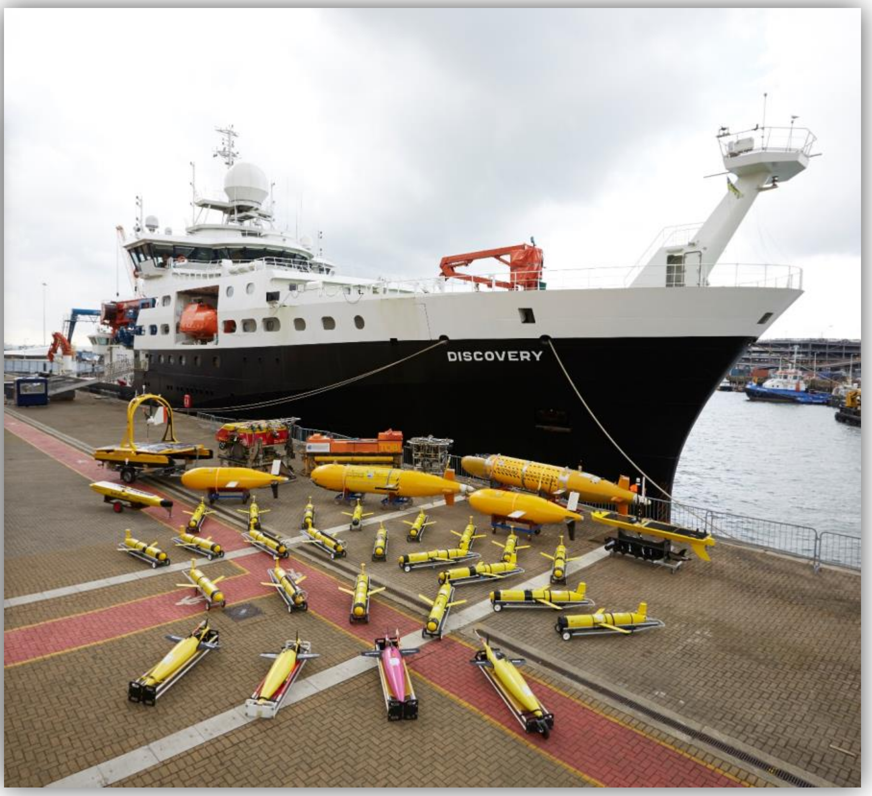

**Positions of the floats that have delivered data within the last 30 days - November 2016 page credit: AIC (Argo Information Center), USCD]**

# An Approach


**Floats - Gliders - Autonomous Underwater Vehicles**

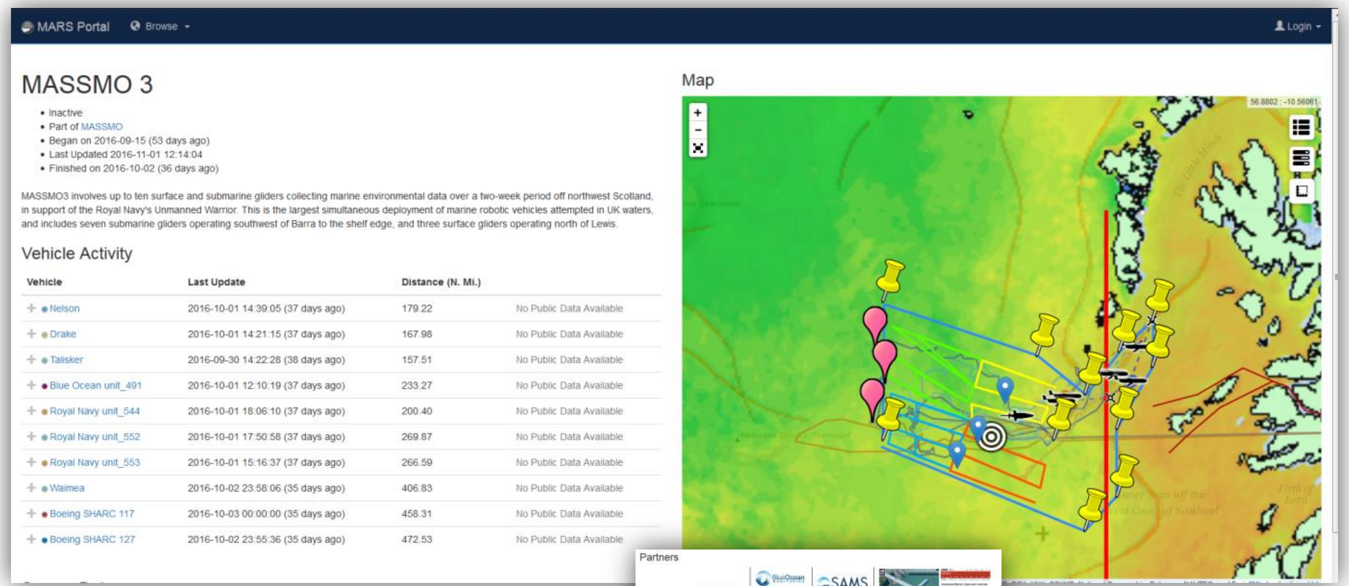
# An Approach


**Unmanned Surface Vehicles (USV)**

# System of Systems

## MASSMO 3



MARS Portal  Browse  Login

# MASSMO 3

- Inactive
- Part of MASSMO
- Began on 2016-09-15 (53 days ago)
- Last Updated 2016-11-01 12:14:04
- Finished on 2016-10-02 (36 days 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

| Vehicle | Last Update | Distance (N. Mi.) | |
|---|---|---|---|
| Nelson | 2016-10-01 14:39:05 (37 days ago) | 179.22 | No Public Data Available |
| Drake | 2016-10-01 14:21:15 (37 days ago) | 167.98 | No Public Data Available |
| Talisker | 2016-09-30 14:22:28 (38 days ago) | 157.51 | No Public Data Available |
| Blue Ocean unit_491 | 2016-10-01 12:10:19 (37 days ago) | 233.27 | No Public Data Available |
| Royal Navy unit_544 | 2016-10-01 18:06:10 (37 days ago) | 200.40 | No Public Data Available |
| Royal Navy unit_552 | 2016-10-01 17:50:58 (37 days ago) | 269.87 | No Public Data Available |
| Royal Navy unit_553 | 2016-10-01 15:16:37 (37 days ago) | 266.59 | No Public Data Available |
| Waimea | 2016-10-02 23:58:06 (35 days ago) | 406.83 | No Public Data Available |
| Boeing SHARC 117 | 2016-10-03 00:00:00 (35 days ago) | 458.31 | No Public Data Available |
| Boeing SHARC 127 | 2016-10-02 23:55:36 (35 days ago) | 472.53 | No Public Data Available |

Map



# System of Systems

## UNMANNED WARRIOR 2016

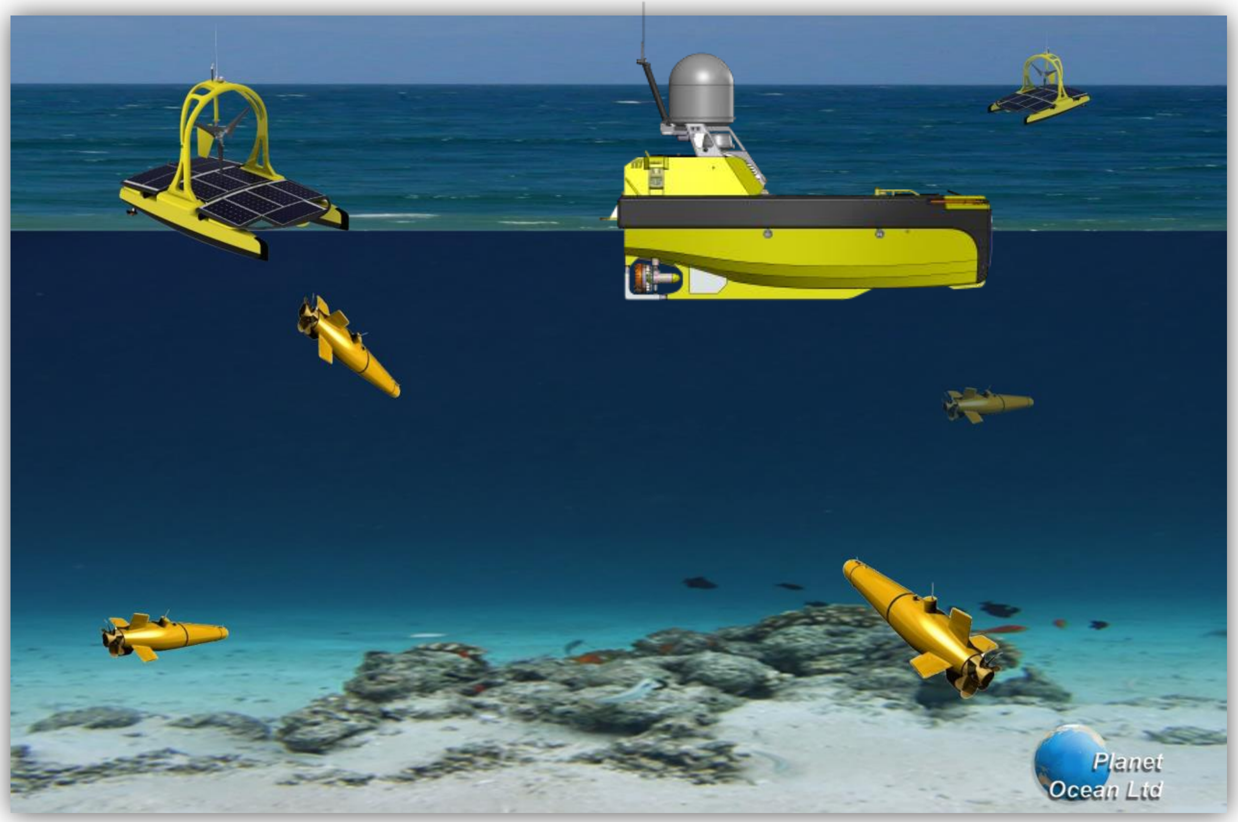

# Why are <u>we</u> doing this?

- ✓ **We wanted to do more than develop the vehicle, we wanted to integrate & automate the launch and recovery to maximise above and below surface assets.**
- ✓ **We, as a team believe in thinking differently, and challenging the status quo.**
- ✓ **We believe in great design.**

- ✓ We have a strong, mutually beneficial partnership with NOC.
- ✓ Only now does the latest sensor technology make small platforms useful.
- ✓ We wanted the end result to be suitable for mass deployment to provide large spatial resolution datasets quickly and affordably
- ✓ We wanted it to be easy and cheap to transport, deploy and recover
- ✓ We wanted it to need limited assets and resources to deploy & recover, reducing operational cost

# Our Approach

**ASV (USV) + AUV + AUV…**



# Innovate UK - Project

## Launch & Recovery of Multiple AUVs from an ASV

### Scope of core IUK project

- **Project to develop AUV ASV Launch & Recovery (L&R) system**
- **Two year project: started August 2015**
- **End User led project: O+G & OSR, Defence, Ocean Science & Forecasting**

The development of a low-cost AUV (Autonomous Underwater Vehicle) launch & recovery system from an ASV (Unmanned Surface Vehicle) for applications including;

defence, oil spill monitoring and science.  The AUVs will be autonomously deployed from an ASV, providing science users increased range, spatial sampling resolution and reduced cost versus existing solutions; thus eliminating dependence on expensive ship time.

# Innovate UK - Project

## Launch & Recovery of Multiple AUVs from an ASV

Partners

Planet Ocean Ltd

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

ASV unmanned marine systems

UNIVERSITY OF Southampton

# Innovate UK - Project

## The Marine Robotics Innovation Centre

# Innovate UK - Project

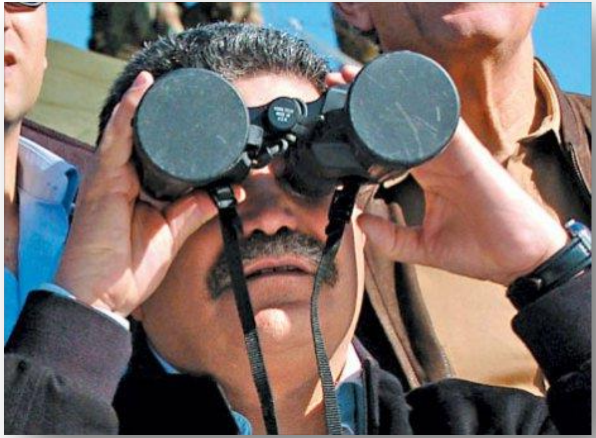
## **Launch & Recovery of Multiple AUVs from an ASV**

Launch


# Innovate UK - Project

## Launch & Recovery of Multiple AUVs from an ASV

Recovery



# Innovate UK - Project

**Additional Launch Options**

- Other ASVs

- Aerial Launch

-

Ship Launch

- Platform Launch

- Large AUV Launch

- RIB Launch

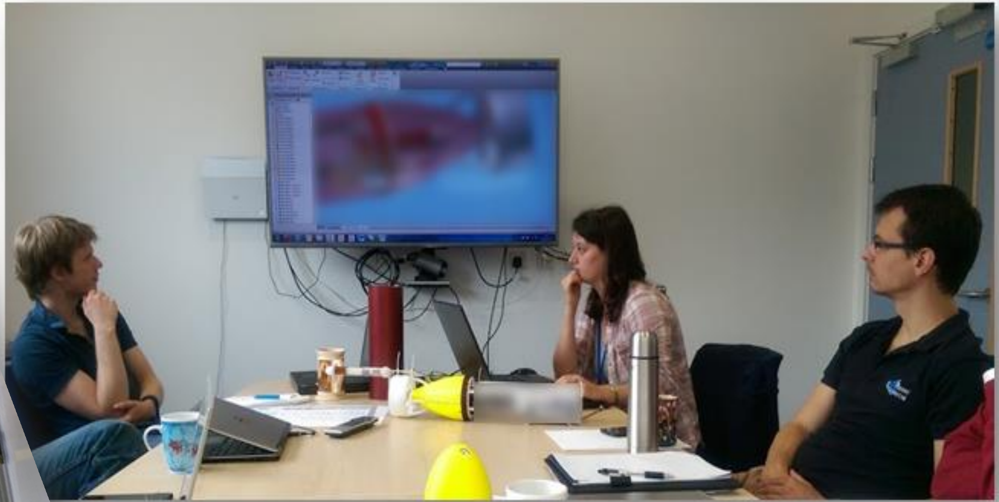
- Hand Launch

# Innovate UK - Project

## Iterative Design

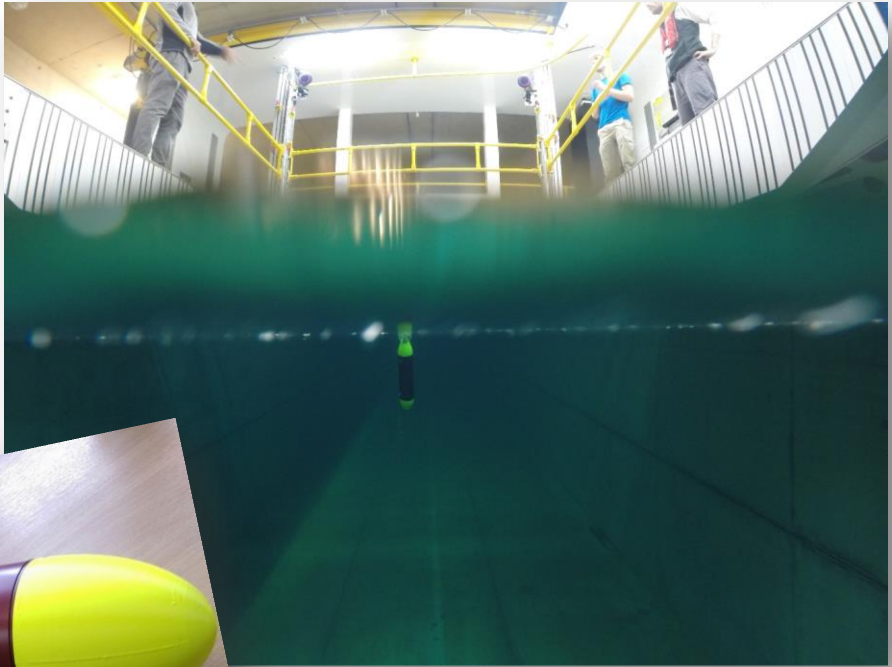
Iteration - 1 Allowed us to check assumptions and trail some options
Iteration - 2 Incorporated what was learned in Iteration – 1 and allowed some real-world testing of sub systems
Iteration - 3 Provided advanced prototypes that could be evaluated in all aspects.

# One Year On….



## We have a micro-sub!

# One Year On….

## We have a micro-sub!

# But it did not end there…

Photo: Owain Jones

# But it did not end there…

bp

- Encouragement
- Guidance
- Resources

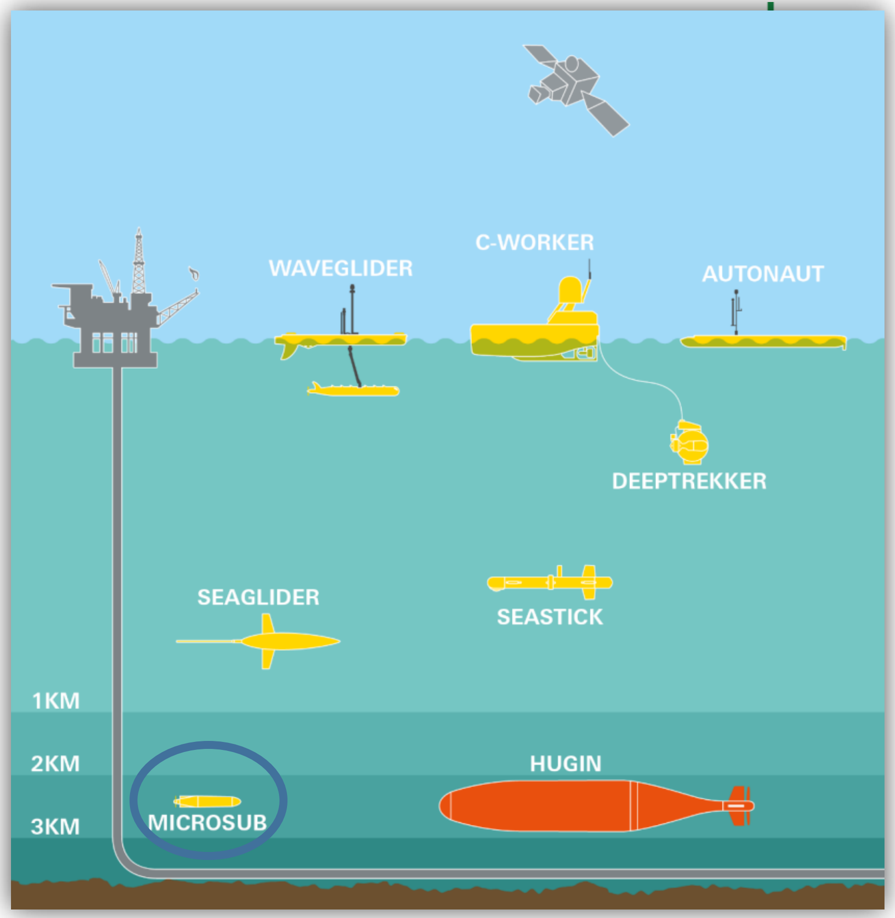
# External Engagement

BP identified needs exceeding the scope of the IUK Micro AUV concept developed

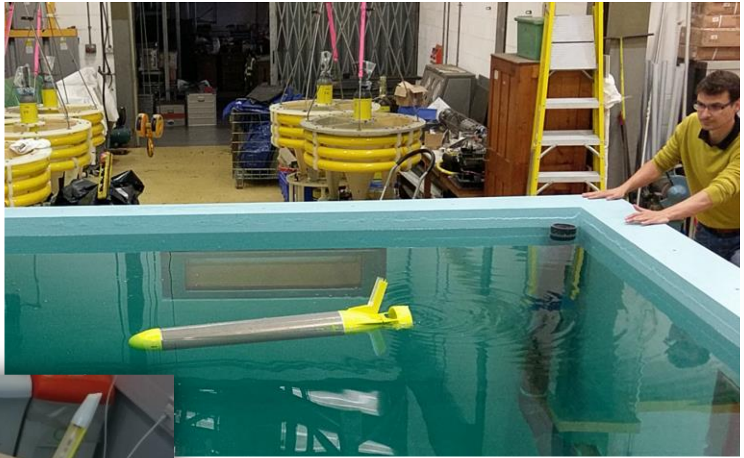
Desires included:

- Deeper rating
- Larger sensor payload capacity
- Faster

BP project vehicle expands the capability of the IUK developed Micro AUV whilst maintaining the concept of a small, low cost platform for affordable mass deployment



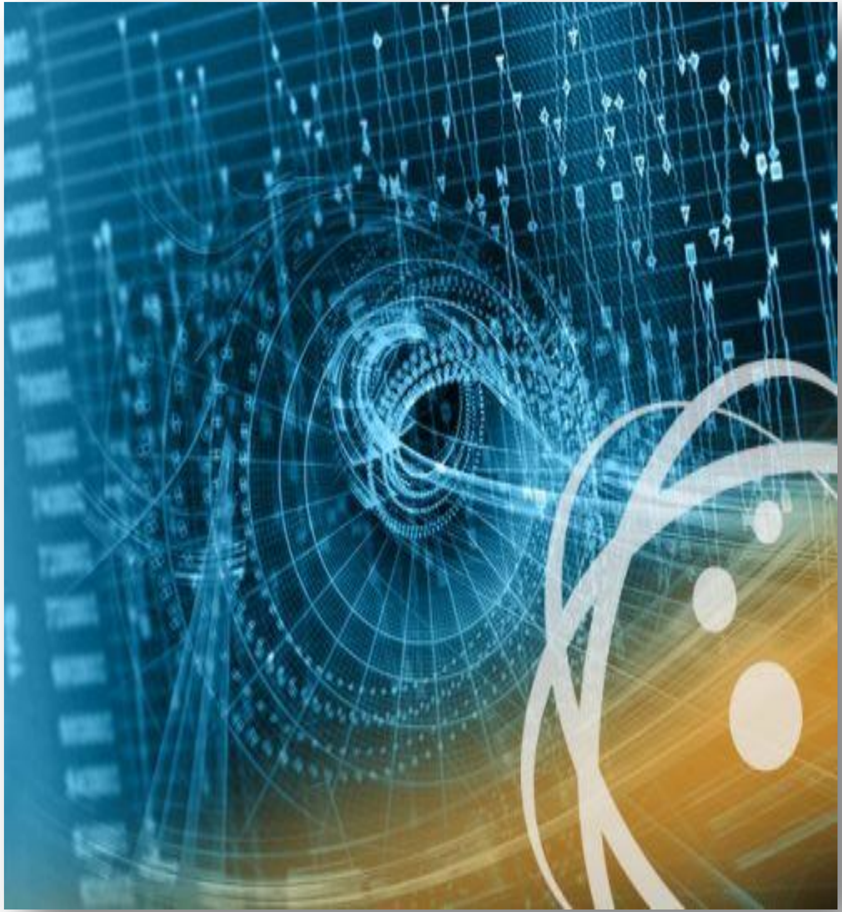
# External Engagement



And now we have two vehicles!

# The future……….

- More sensors
- New power sources
- New materials
- New communications
- Intelligent mission planning
- More missions – applications - capabilities
- More launch and recovery systems
- More vehicles



# Thank you

**NOCS Team**

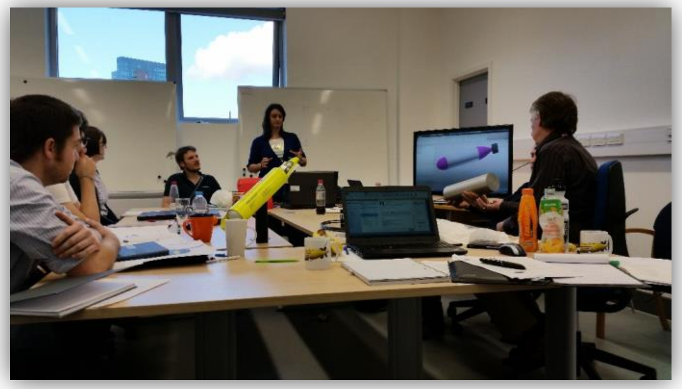
National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

Dr Maaten Furlong
Dr Alex Philips
Ella Richards
Dr Catherine Harris
Naomi Gold
Sebastian Thuné
Sriram Vikraman Sithalakshmi Amma
Georgios Salavasidis
Rob Templeton
Dr Nick Linton

**Planet Ocean Team**

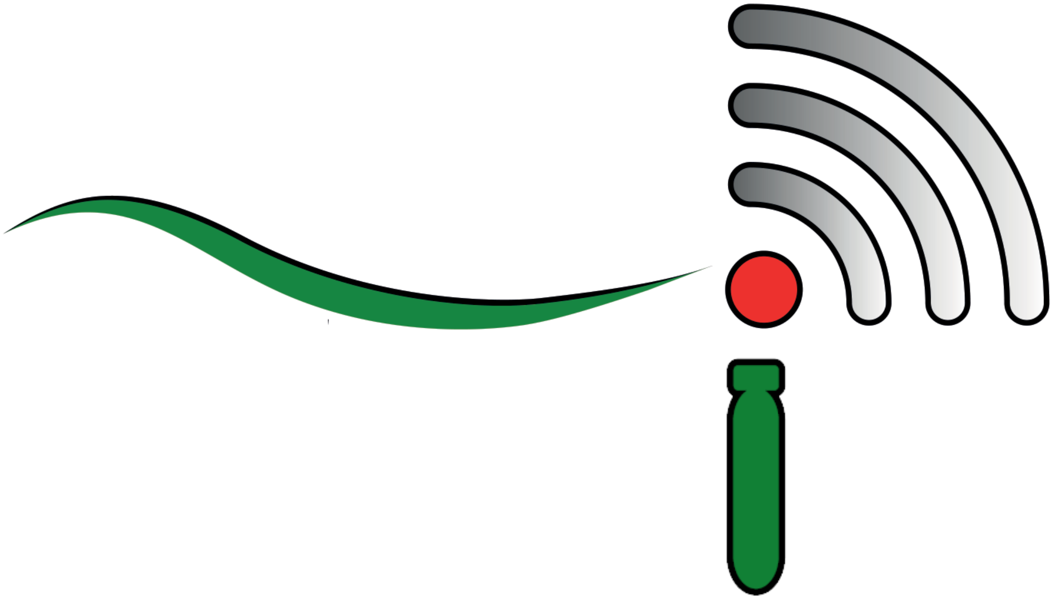
Planet Ocean Ltd

Dr Marcus Müller
Jérémy Sitbon
Iain Vincent
Alan Gould
Terry Sloane



# Thank you

Planet Ocean Ltd



ecoSUB

ecoSUB robotics™

ecoSUB robotics™

www.ecosub.uk

**Afternoon Refreshments**

**30 Minute Break**

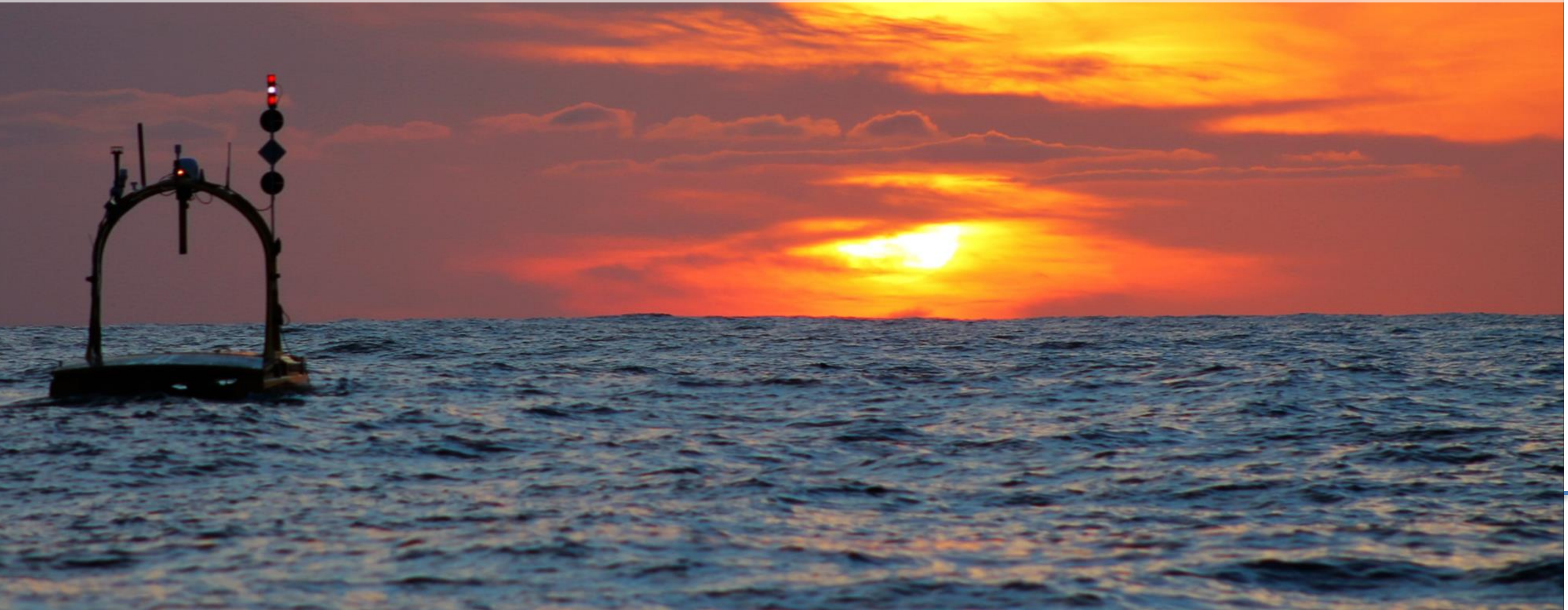
# Mr James Cowles

ASV

# Autonomous Surface and Subsurface System

# Autonomous Surface / Sub-surface Survey System (ASSSS)

**James Cowles**
Science and Survey product Manager, ASV



# Project Scope

This programme combines autonomous surface vessels (ASVs), autonomous underwater vehicles (AUVs) and novel communications technology into an integrated system to provide a means of conducting low cost shore based full water column marine surveys.

Success will accelerate the wider adoption of unmanned systems and will enable long term, low-cost survey and monitoring operations for offshore energy applications, deep sea mining prospecting and Carbon Capture and Storage (CCS) monitoring.

# Project Partners

ASV - Provision of Surface platform

NOC - Provide Subsea system

Sonardyne – Provide acoustic positioning, acoustic and optical communications and side scan sonar

SeeByte – Provide goal based planning software

Supported by:

# ASV in numbers

- **1.8**m smallest vessel
- **6** Years building vessels
- **11** Current production models
- **13**m Longest vessel
- **75** Engineers and support staff
- **80** Unmanned vessels built
- **100**kts fastest vessel
- **>1000** days of operations




ASV unmanned marine systems
National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL
Sonardyne SOUND IN DEPTH
seebyte
Supported by:
Innovate UK
Technology Strategy Board

## Introduction to Sonardyne

### Who are we? Where do we operate?


ASV unmanned marine systems

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

Sonardyne
SOUND IN DEPTH

seebyte
A BLUEFIN ROBOTICS COMPANY

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Technology Strategy Board

# SeeByte

*Smart software for unmanned maritime systems and sensors*

Offices in Edinburgh,  Southampton, UK and San Diego, US, 61 Employees

Exporting to over 20 countries around the world

Providing solutions to the oil and gas, naval and commercial maritime domains

Adding value to hardware through expert software engineering

Working in partnership with leading sensor / vehicle vendors

SeeByte is appraised at CMMI® Level 2

SeeByte is a subsidiary of Battelle


ASV unmanned marine systems

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

Sonardyne
SOUND IN DEPTH

seebyte

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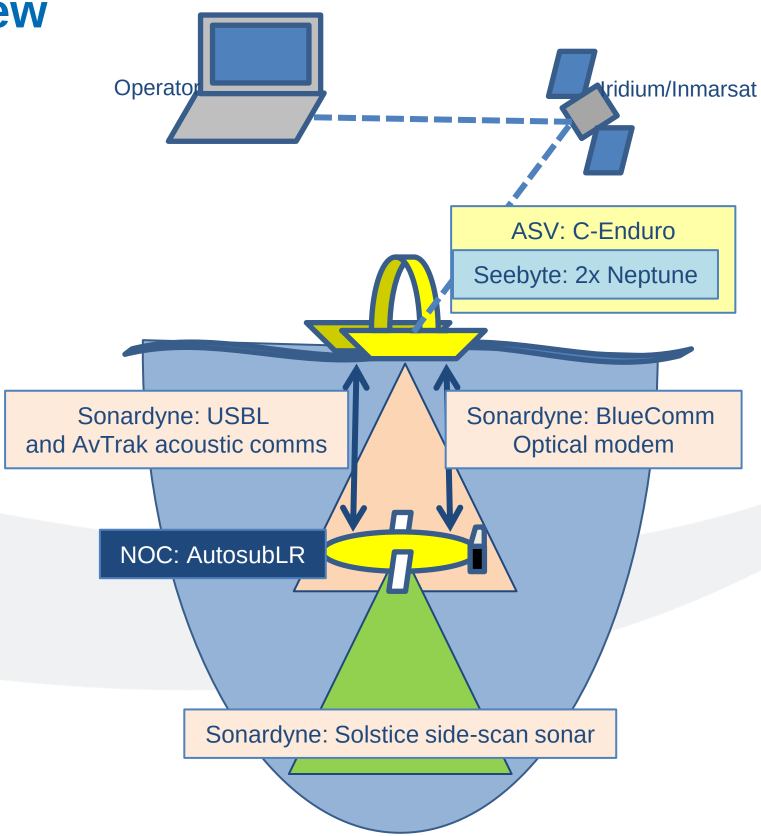
# ASSSS Concept overview






ASV unmanned marine systems

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# Autosub Long Range

**Mass** 600 kg
**Maximum Depth** 6000 m
**Maximum Range** 6000 km, 6 months
**Speed range** 0.35 to 0.8 $ms^{-1}$

**On-board energy** 29 kWhrs (primary lithium)

**Hotel power** 1 W (target)

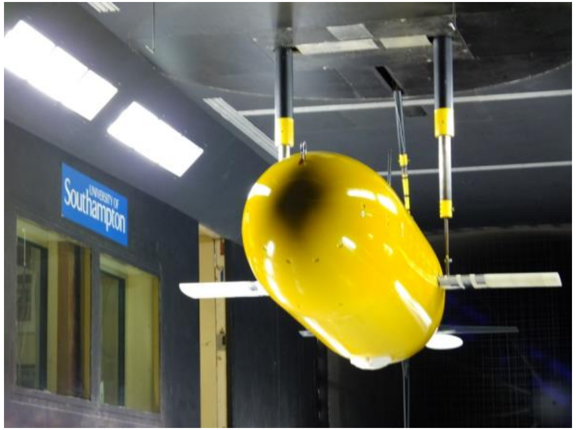
**Flight Modes** Depth, Altitude, Profiling

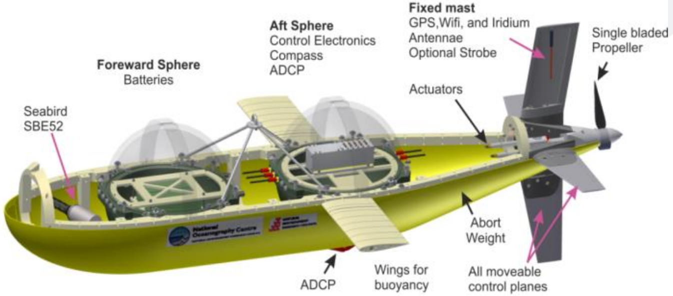
**Communications** Iridium & WiFi at surface

**Standard Payload** CTD (SBE 52), 300 kHz ADCP

**Payload volume** 30 litres
**Payload weight** 10 kg in water

**Optional Sensors** 600 kHz ADCPs (up / down)
Microrider turbulence probe
Wetlabs flourometer
Magnetometer
*Solstice* SSS

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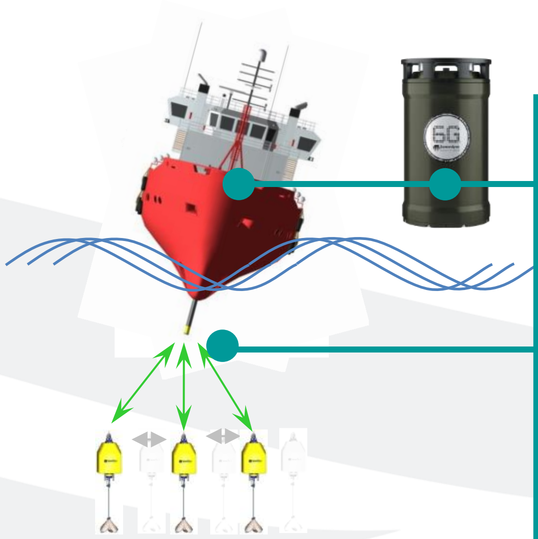
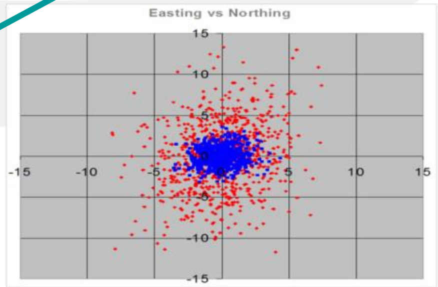
## More precise attitude correction = Enhanced USBL performance



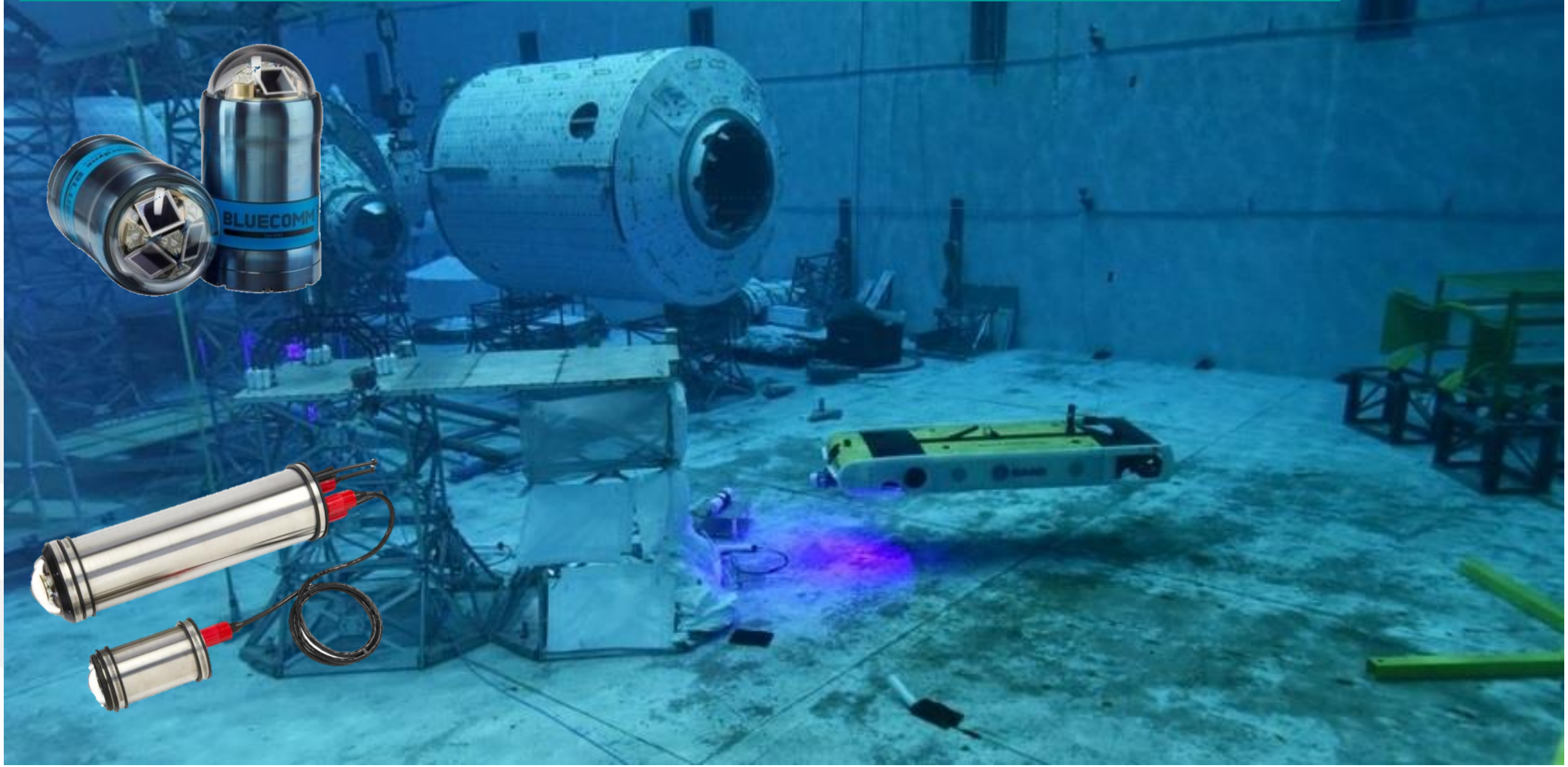
# GyroUSBL

- Vessel movement – pitch and roll is major error contribution.
- Adding Gyro sensors to acoustic positioning can correct for these errors
- Combining in one unit reduces weight and optimises performance



## BlueComm 100

### Saab Sabertooth > NASA Neutral Buoyancy Laboratory




ASV unmanned marine systems

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seebyte
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Supported by:

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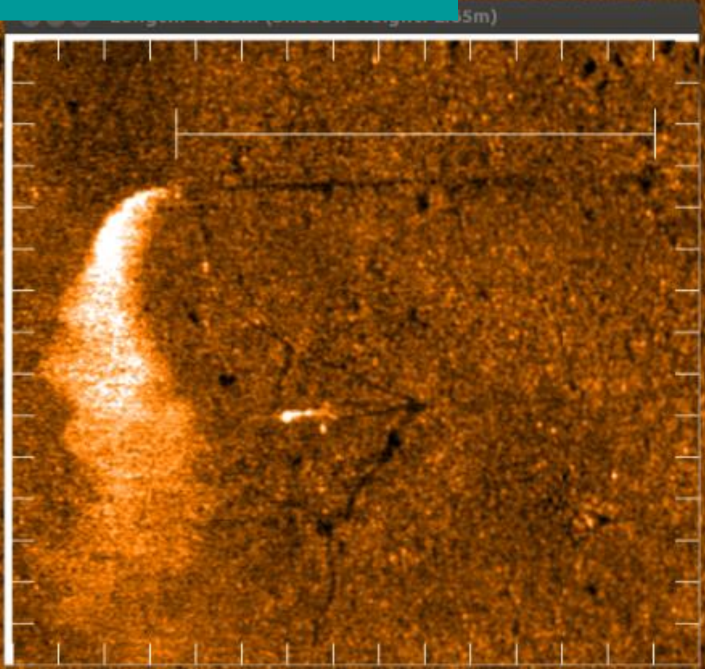
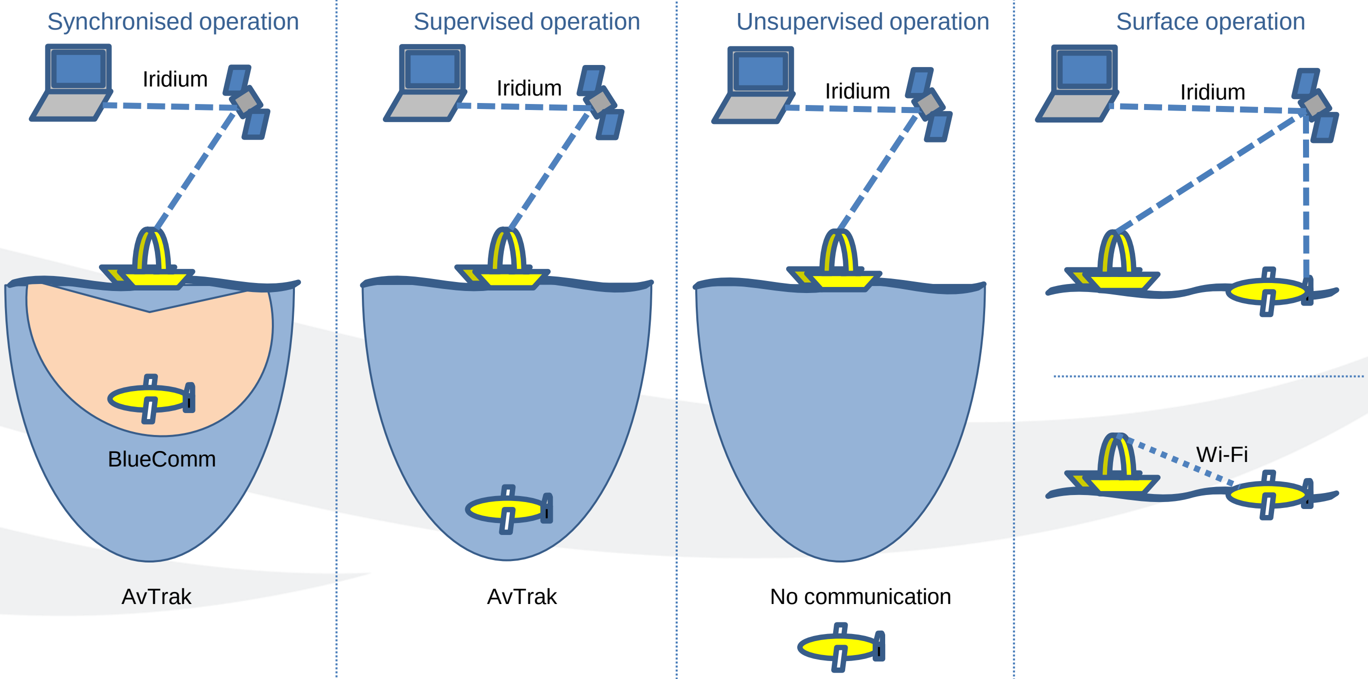
## Autosub Long Range Payload Development

### Solstice – AUV based low power wide area coverage leak detection with ATR

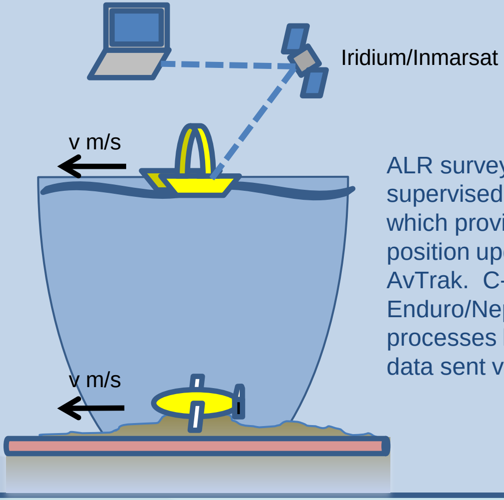
"10 l/min $CO_2$ gas leak, 2.65m tall plume from seabed"



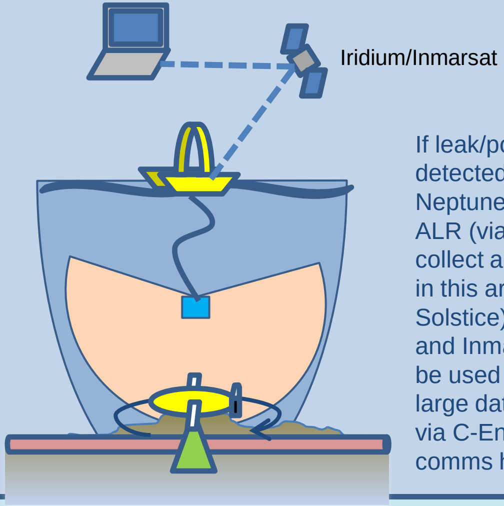
# ASSS Operating modes



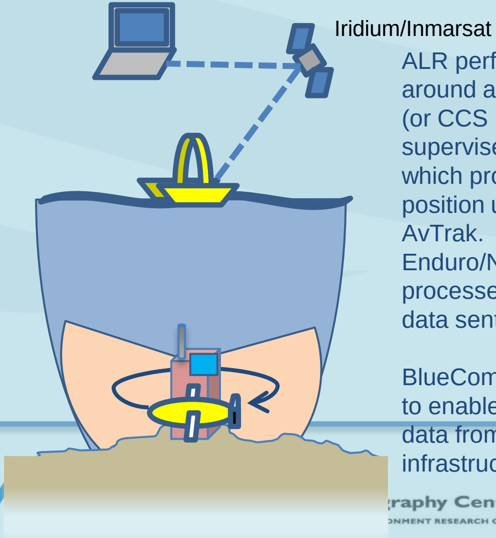

Supported by:




ALR surveys pipeline supervised by C-Enduro which provides regular position updates via AvTrak. C-Enduro/Neptune processes low-volume data sent via AvTrak.

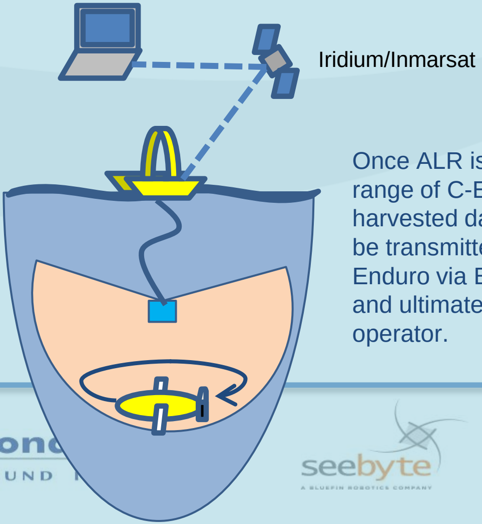



If leak/point of interest detected in data, Neptune can command ALR (via AvTrak) to collect additional data in this area (e.g. using Solstice). BlueComm and Inmarsat can then be used to transfer large datasets to user via C-Enduro as comms hub.




ALR performs box surveys around a subsea structure (or CCS reservoir TBC) supervised by C-Enduro which provides regular position updates via AvTrak. C-Enduro/Neptune processes low-volume data sent via AvTrak.

BlueComm may be used to enable ALR to harvest data from subsea infrastructure.




Once ALR is within range of C-Enduro, the harvested data may then be transmitted to C-Enduro via BlueComm and ultimately to an operator.

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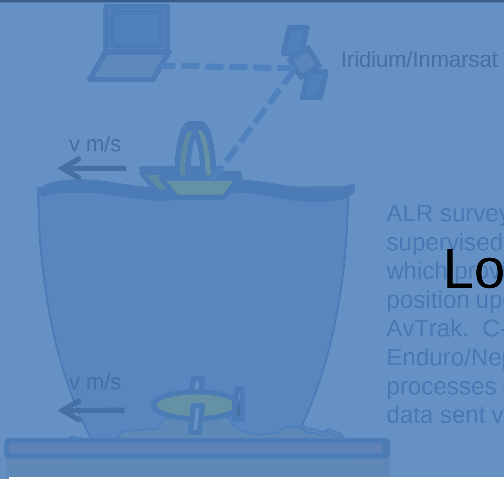
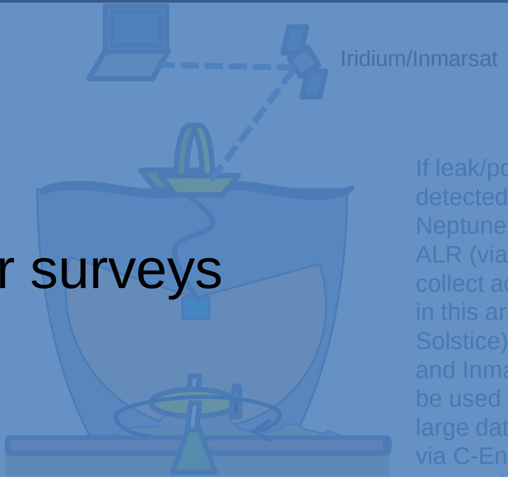
# Long linear surveys



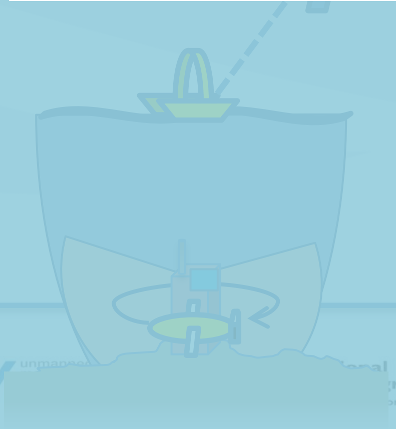

ALR surveys pipeline supervised by C-Enduro which provides regular position updates via AvTrak. C-Enduro/Neptune processes low-volume data sent via AvTrak.




If leak/point of interest detected in data, Neptune can command ALR (via AvTrak) to collect additional data in this area (e.g. using Solstice). BlueComm and Inmarsat can then be used to transfer large datasets to user via C-Enduro as

The core of the ASSSS project is to develop the co-ordination strategy between an AUV and an ASV. The project demos are proof-of-concept in areas of potential exploitation using ALR and C-Enduro/C-Worker. ALR and C-Enduro's long endurance/independence from both a ship and operators enables persistent presence around infrastructure for patrols/monitoring.

# Data harvesting

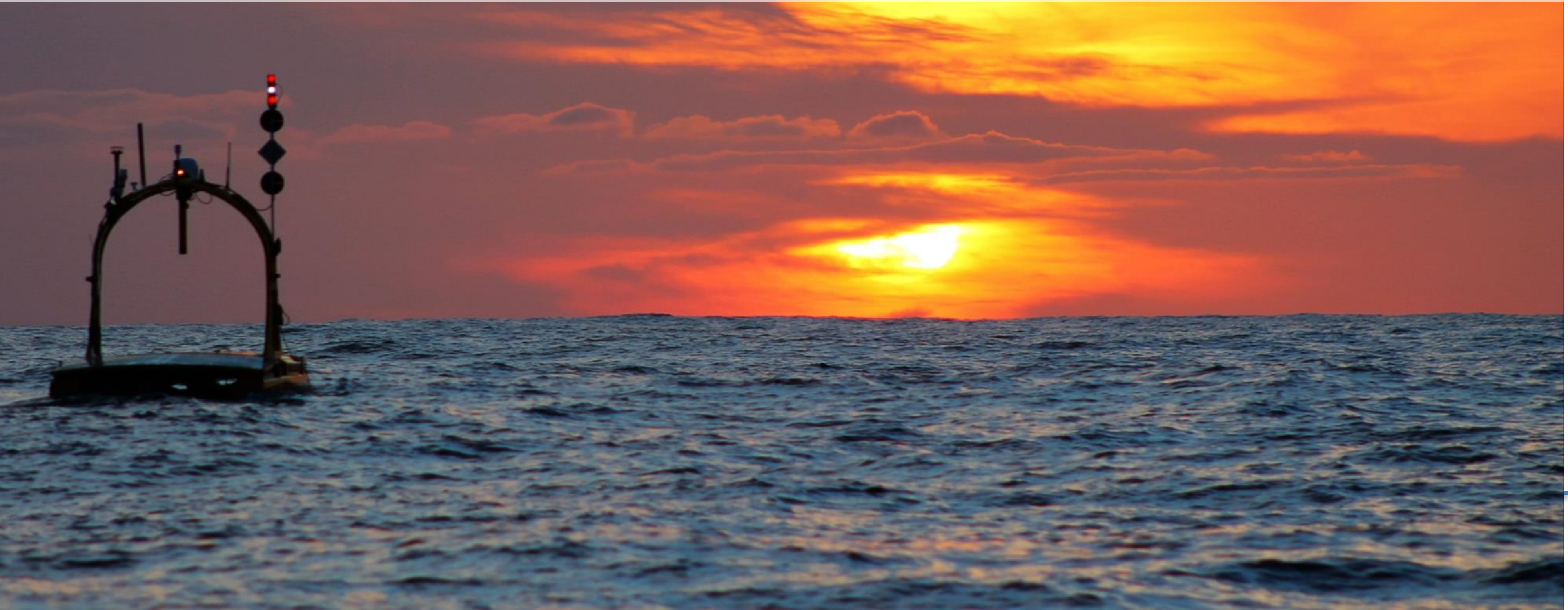


ALR performs box surveys around a subsea structure (or CCS reservoir TBC) supervised by C-Enduro which provides regular position updates via AvTrak. C-Enduro/Neptune processes low-volume data sent via AvTrak. BlueComm may be used

Once ALR is within range of C-Enduro, the harvested data may then be transmitted to C-Enduro via BlueComm and ultimately to an operator.

# Energy Game Changer: Autonomous Pipeline Survey System

**James Cowles**
Science and Survey product Manager, ASV



# Project Scope

This programme combines autonomous surface vessels (ASVs), autonomous underwater vehicles (AUVs) with acoustic communications technology into an integrated system to provide a means of conducting low cost autonomous pipeline surveys

This project will provide the data and information to develop an autonomous system capable of providing real time feedback on pipeline condition during autonomous survey.

# Opportunity

Worldwide the oil and gas industry spend over $400 million on survey work annually:

- UK has 45,000km  of pipeline
- Gulf of Mexico has in excess of 44,000km of pipeline which
- North Sea decommissioning will be gathering pace over the next decade

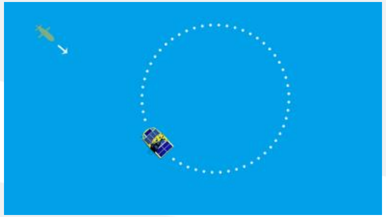
# End goal system

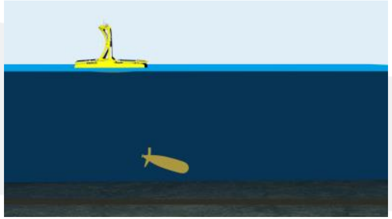
Following the completion of this project and the further development required the goal is to have a system capable of autonomously surveying a pipelines for several weeks.

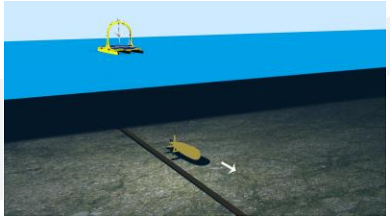
During the survey work any issues will be highlighted by the system using advanced on board data processing which would then send details of the issues to the shore base for further action to be taken.

**Key Benefits:**

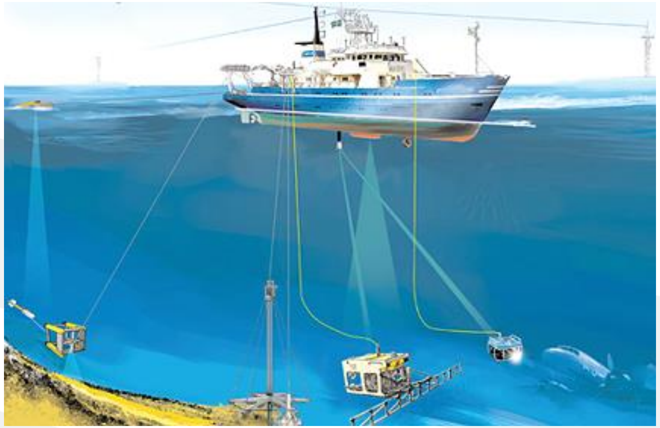
**- Cost** **- Safety** **- Environmental impact**



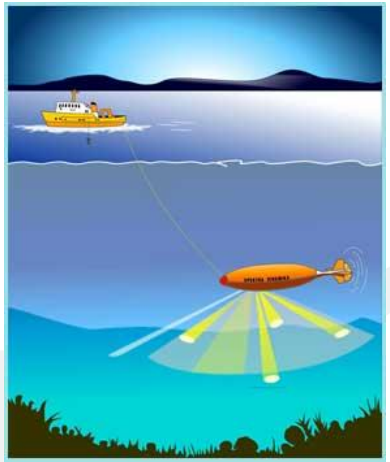




# Existing technology



- Surveys typically carried out using sensors towed from large vessels or from ROVS hosted on large vessels.
- The size of vessel required means there is significant cost in capital of the vessel and running costs with crew
- Manned vessels use significant quantities of fuel due to the size and domestic requirements of the crew




Supported by:

ASV unmanned marine systems

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www.asvglobal.com

@ASVLtd

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**Dr Cai Bird PhD. BSc. (Hons)**

Principal Researcher and Knowledge Transfer Associate marlan

# The development of marine radar as a tool for coastal nearshore survey: a research collaboration

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# The development of marine radar as a tool for coastal nearshore survey: A research collaboration


Dr Cai Bird (caib@marlan-tech.co.uk)
Dr Paul Bell (NOC) and Prof Andrew Plater (UOL)



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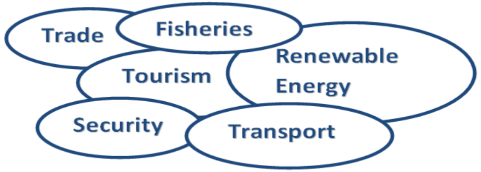
# Outline

- Introduction and Motivation
- Marine Radar Technology
- Brief History of Radar in Hydrographic Survey
- Intertidal Survey Methodology
- Accuracy of The Radar-based Survey
- Monitoring Morphological Change and Beach Health
- Applications to Port Operations and Coastal Managemen
- Ongoing Research and Commercial Collaboration
- Conclusions

# Introduction and Motivation




- Increased need to map and monitor vulnerable coastal areas.
- Current methods are time consuming, expensive and temporally limited.
- Marine radar is a ubiquitous tool in coastal environments.
- Used to derive wave spectra, heights and bathymetry.
- Powerful remote sensing method enables large areas to be imaged.
- This method enables waterline elevations (ACD) to be mapped within 4 km of the radar to a good accuracy when compared to a LiDAR survey.

# Marine Radar

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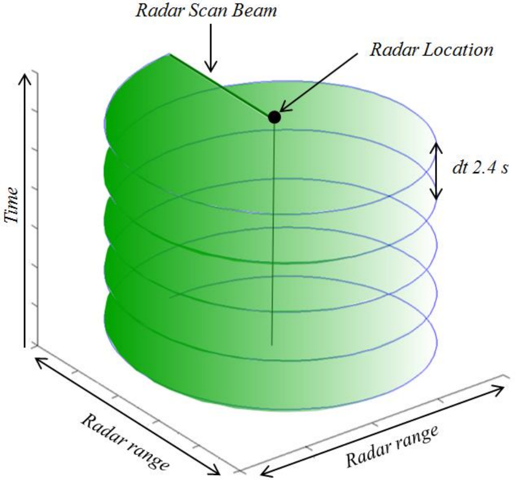
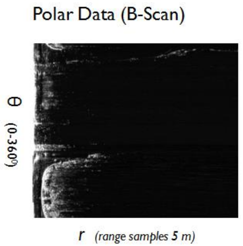
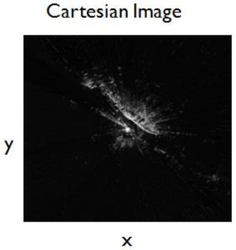
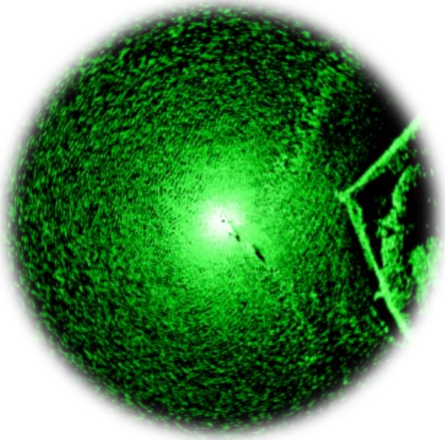


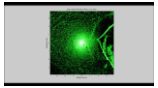




$$r = sqrt(x^2 + y^2) \; and \; \theta = tan - 1\left(\frac{y}{x}\right)$$



Wave field movie



# History of Radar in Hydrographic Survey

- 1970's Experiments show unique interaction between X-band radar waves and wind-roughend sea surface waves (Valenzuela, 1978).
- 1980's Researchers discover methods of measuring wave heights, periods and directional spectra using X-band marine radar (Young et al. 1985).
- 1990's Techniques are refined including measuring surface currents (Nieto-Borge et al., 1999) and bathymetry (Bell, 1999) and commercialised under the WaMOS system (Reichert et al., 1999).
- 2000's continued development of methods, especially accuracy of surface current measurement (Hessner et al., 2009)
- 2010's Bathymetric survey down to 50 m now possible using a moving ship's radar (Bell and Osler, 2011). Intertidal areas now able to surveyed robustly (Bell et al., 2016) and morphological evolution monitored (Bird et al., In Press).
- Future: Combination of methods = 'all in one sensor platform'. Integration with video camera techniques. Automation and operation alongside autonomous survey methods.

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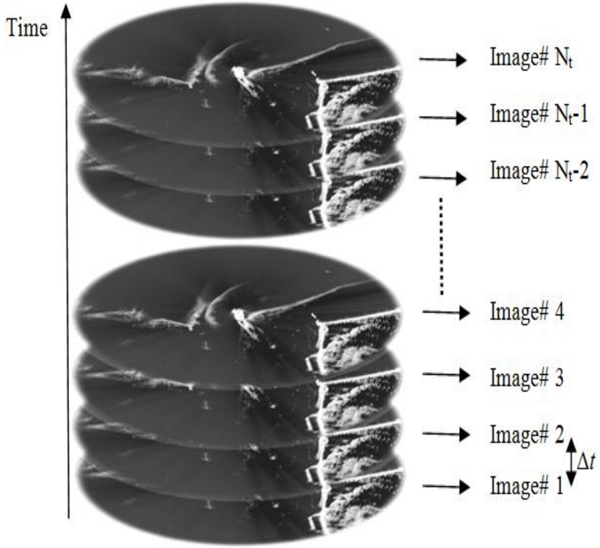
# Data Collection Site

# Surveying Coastal Topography





Coastal Engineering 107 (2016) 84–101

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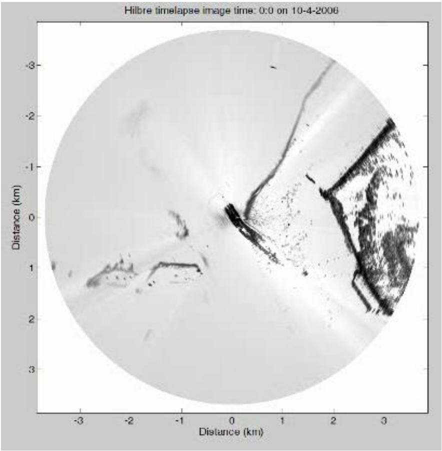
journal homepage: www.elsevier.com/locate/coastaleng


A temporal waterline approach to mapping intertidal areas using X-band marine radar


Paul S. Bell [a,*], Cai O. Bird [b], Andrew J. Plater [b]

[a] National Oceanography Centre, Liverpool, United Kingdom
[b] University of Liverpool, School of Environmental Science, United Kingdom


- Radar is able to image the rise and fall of the tide
- Patented technique makes use of these images and a tidal record

Method protected by NOC patent

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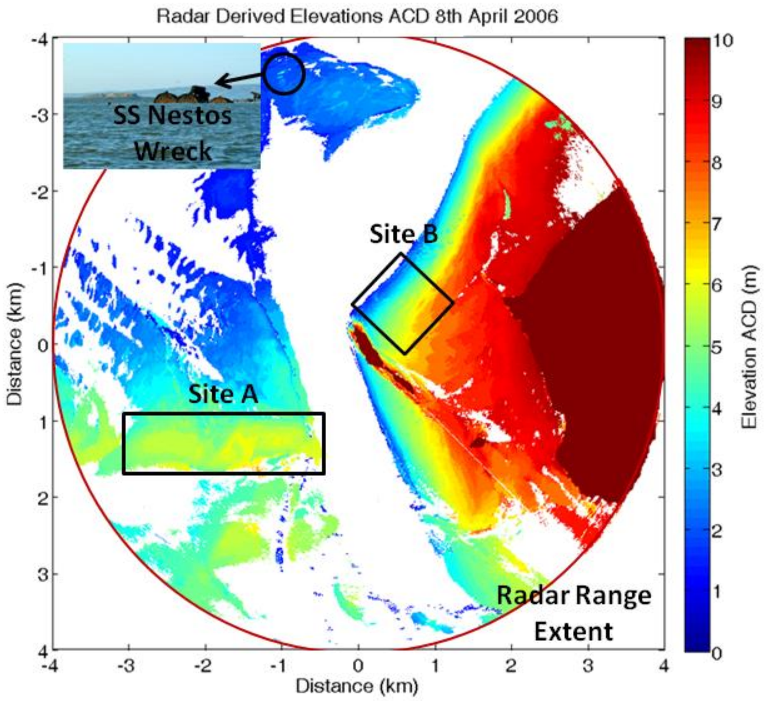
# Surveying Coastal Topography




- Radar is able to map beach elevations that are color-coded by height above Admiralty Chart Datum (ACD).
- Is able to pick out small objects such as the wrecked ship SS. Nestos on the sandbank.
- Survey covers large area

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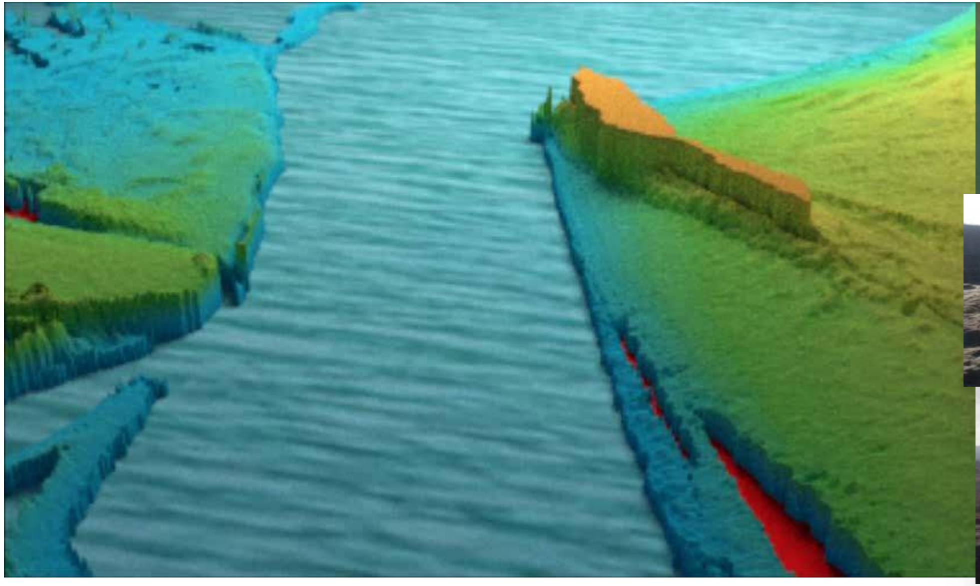
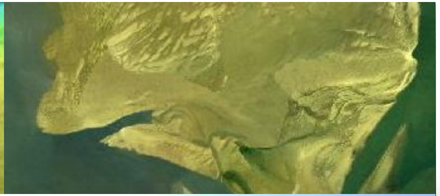
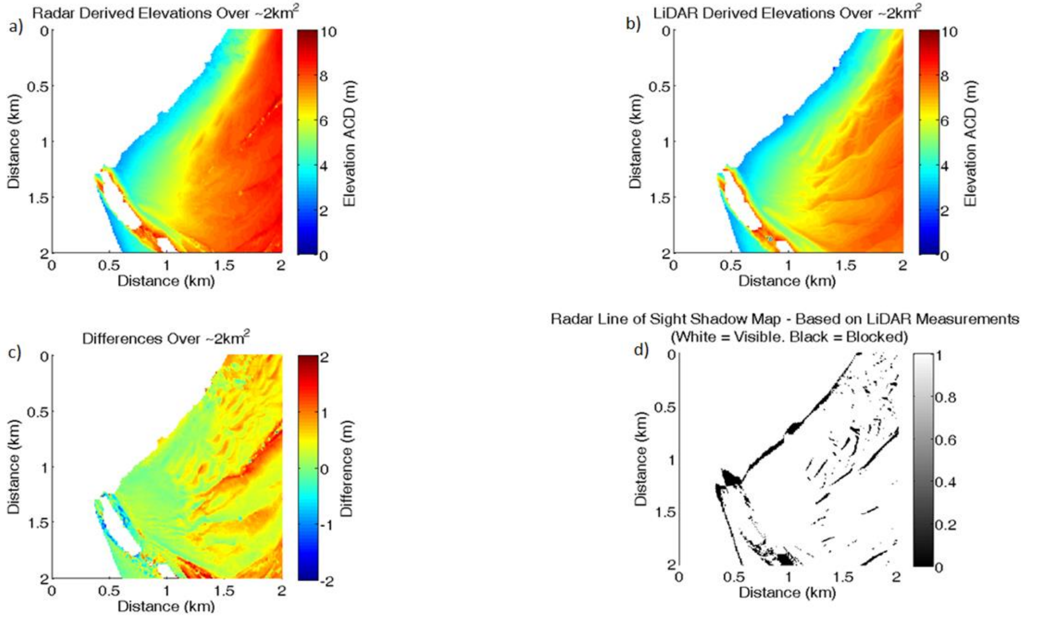
# 3D Tour of Topography

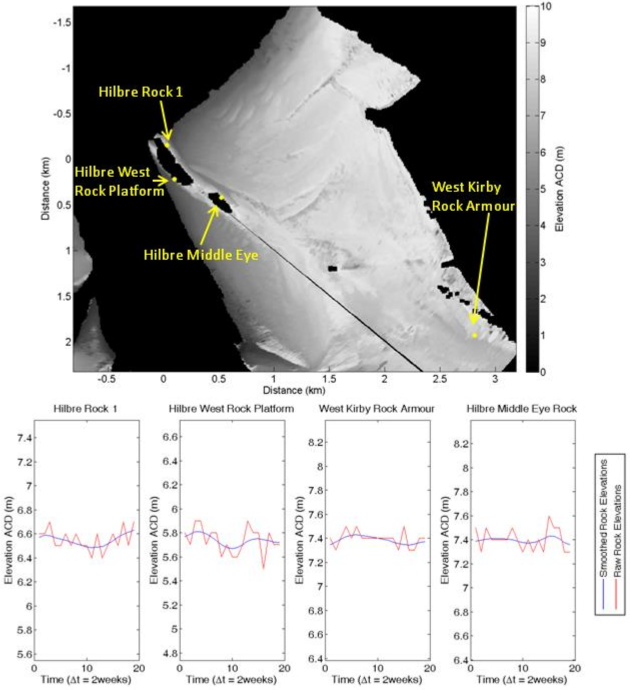




# Survey Accuracy Compared to LiDAR



# Stability Assessment

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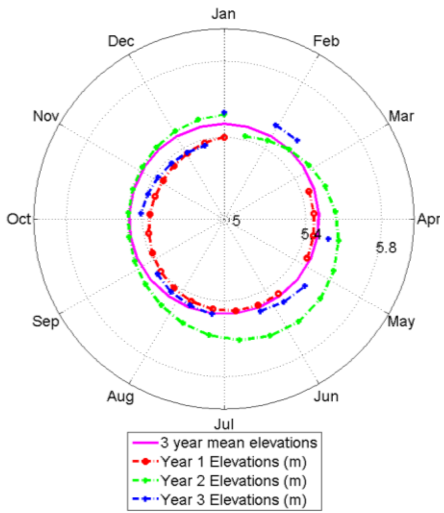
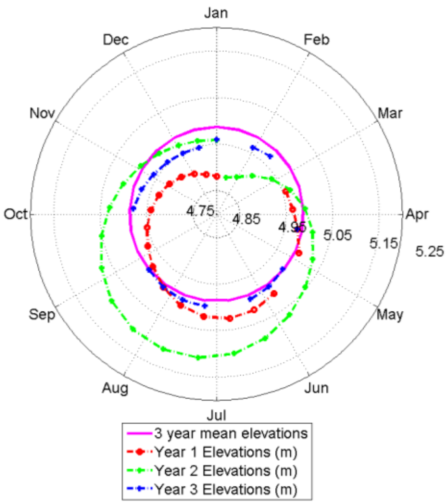
# Mean Elevation Change Over 3 Years

## Site A

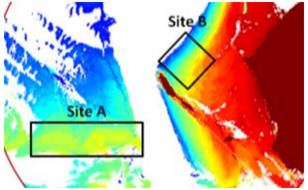



Highs in Spring
Lows in Autumn

## Site B




Highs in Summer
Lows in Winter




Results

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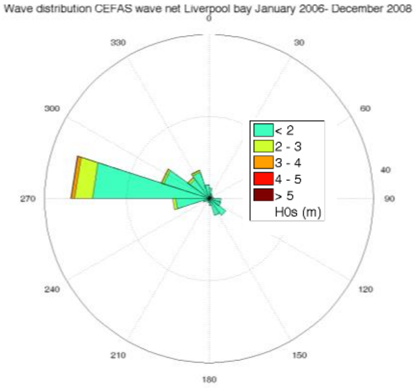
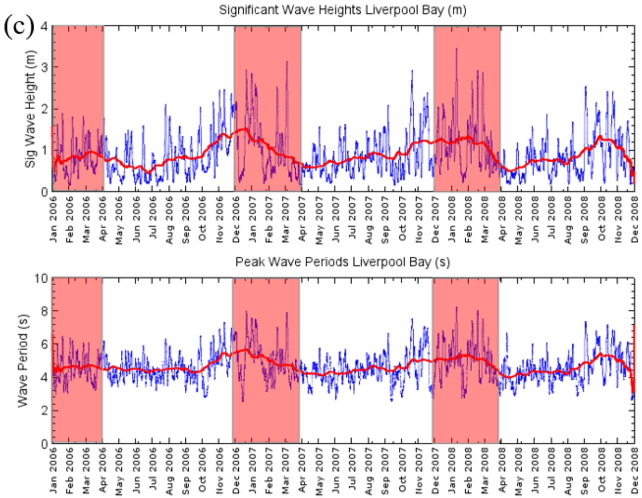
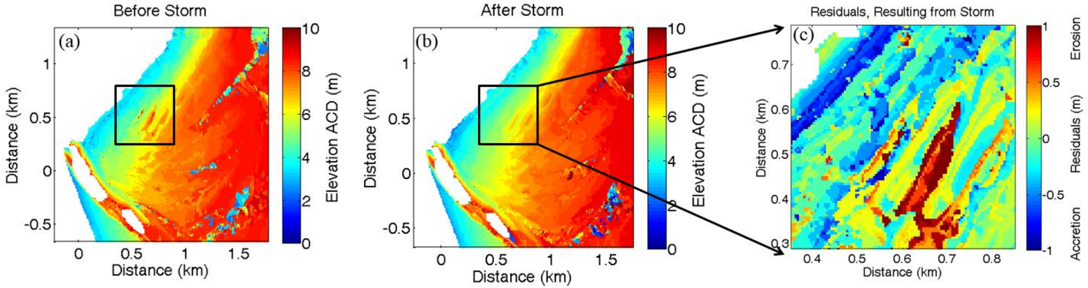
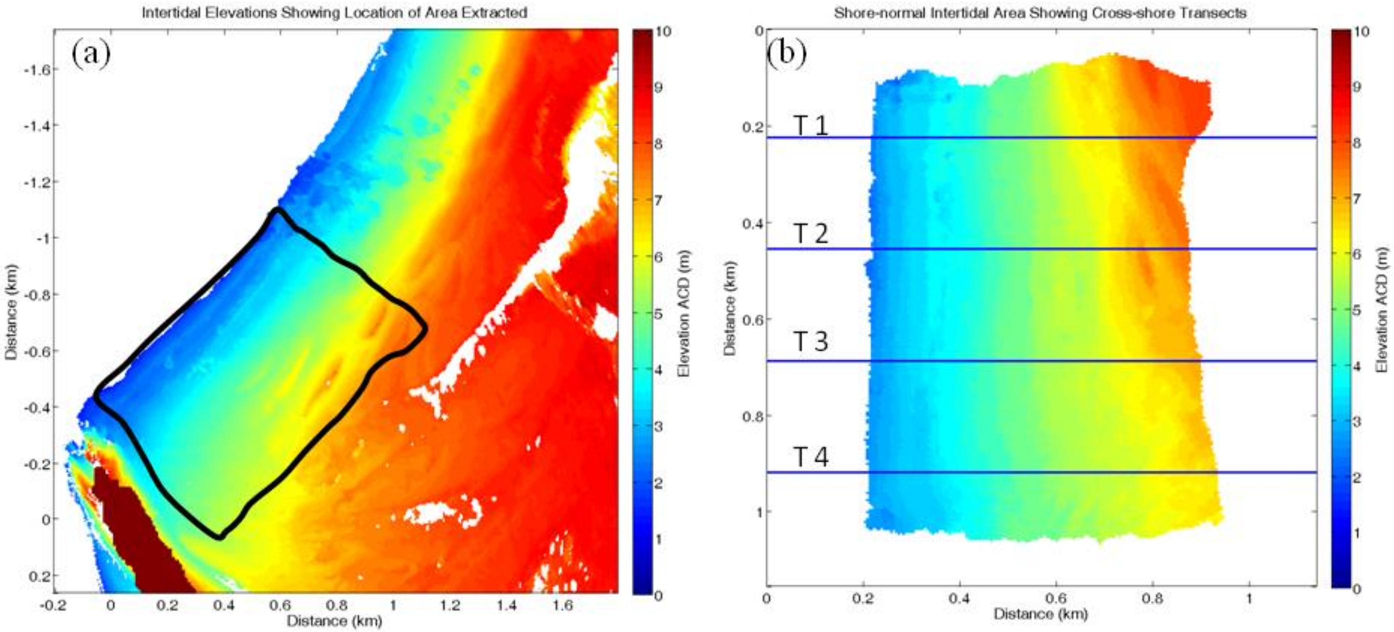
# Morphological Response to Storm Event



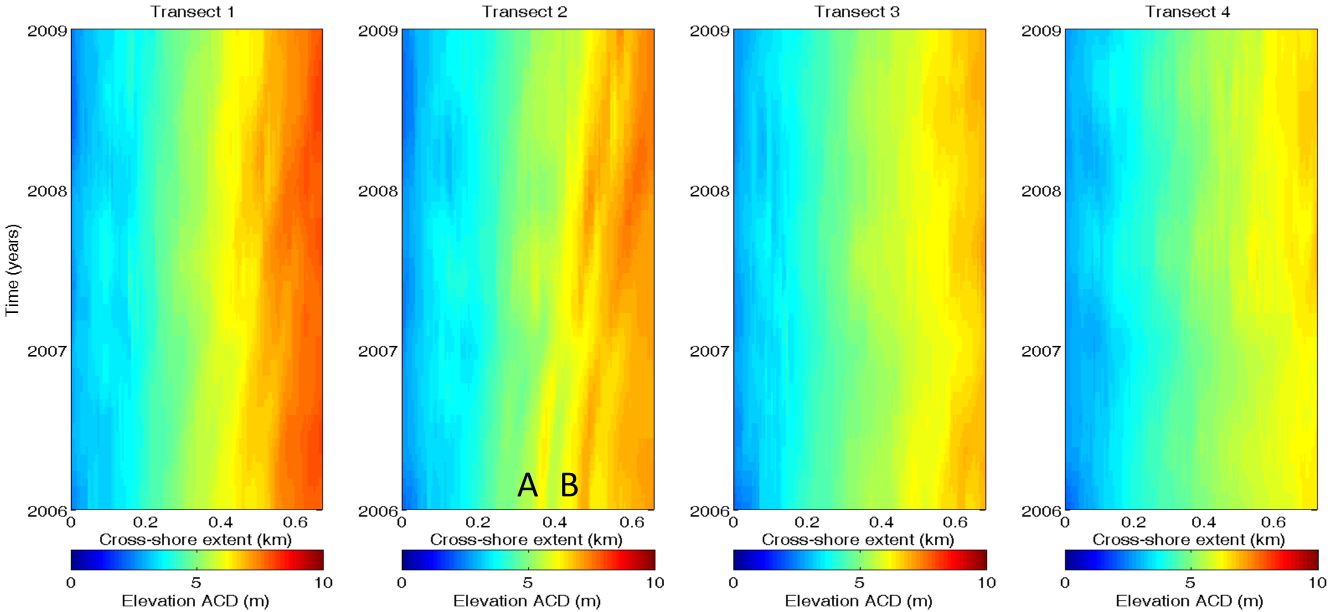



# Cross Shore Transects



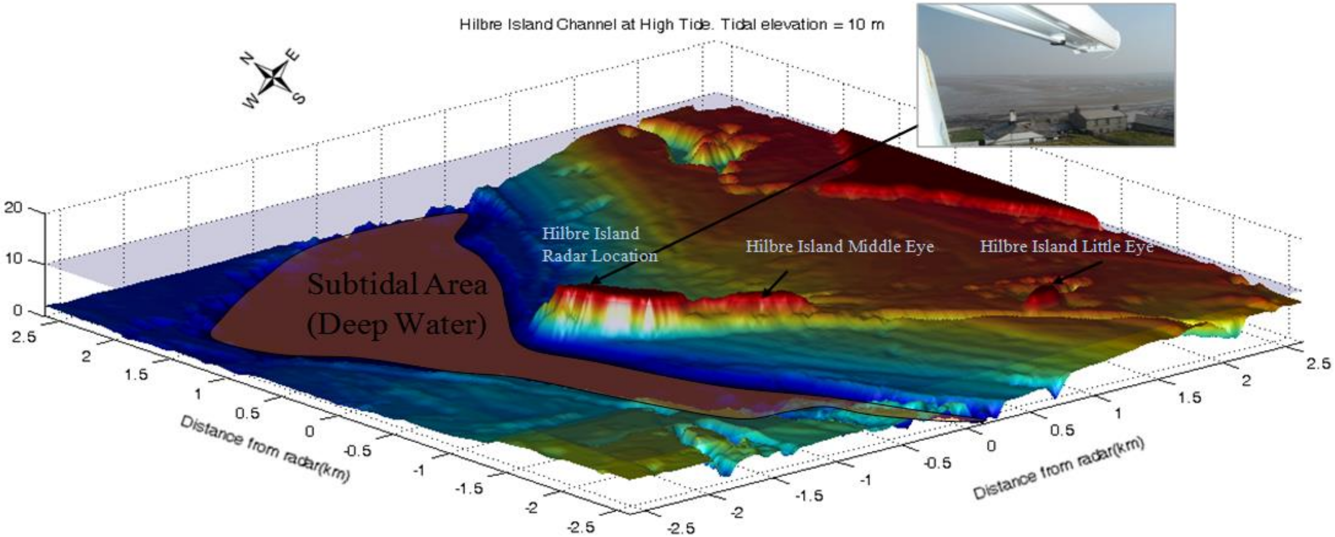
# Cross Shore Profile Evolution



# Deployable Survey Platform
## "*Rapidar*"

- 10ft ISO shipping container
- Solar powered (Wind turbine option)
- Deployment time = 1 hour

# 3D Bathymetric Environment



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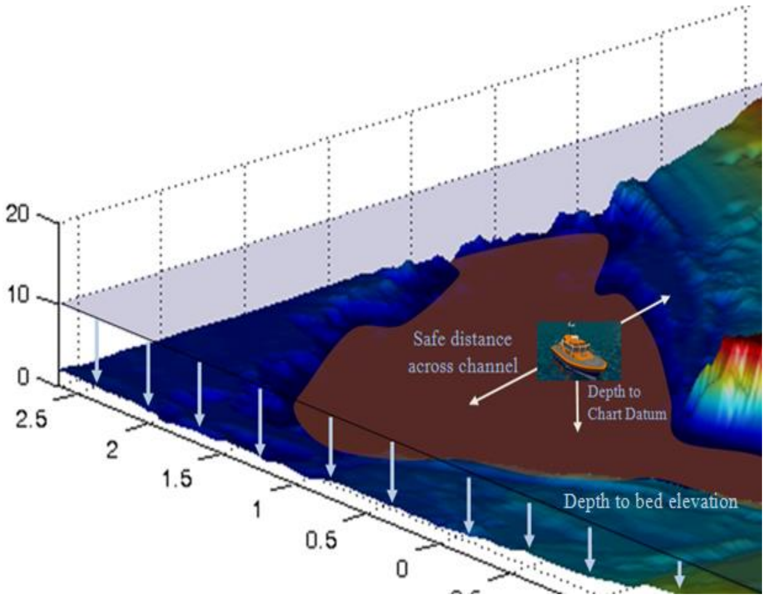
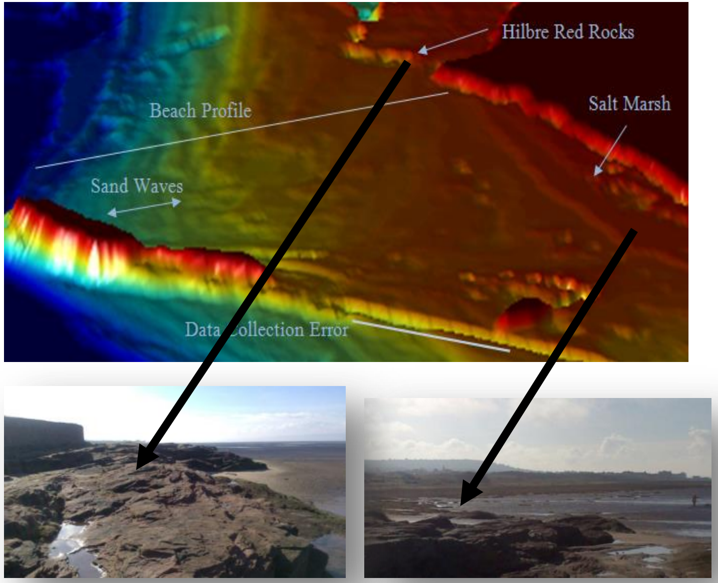
# 3D Bathymetric Environment



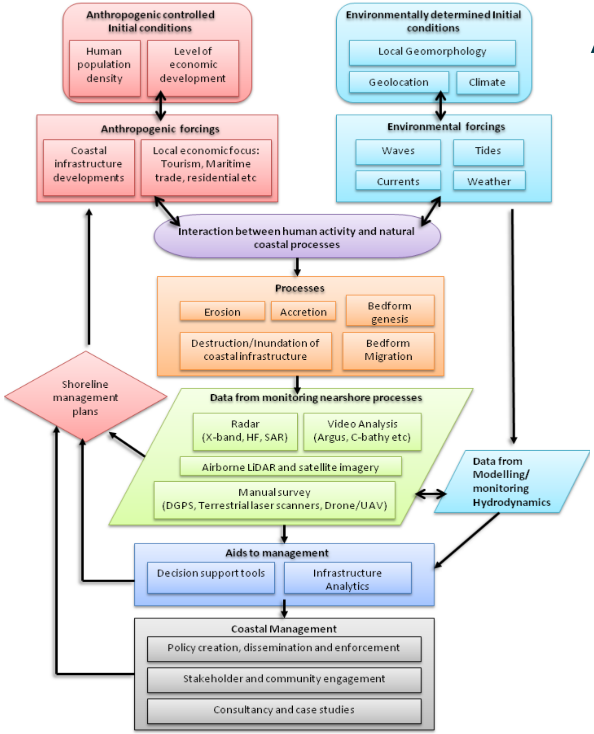

Conclusion

# Potential End Users

- **Local coastal councils + ports**
  - At significant risk of coastal erosion
  - Duty to monitor and maintain their stretch of coastline/ port environment
  - Also have significant budget constraints
  - Dredging operations and navigation channel migration

- **Coastal engineering consultancies**
  - Design and construction of coastal defences requires careful planning and monitoring (currently not easy to routinely survey)
  - Monitoring changes resulting from their constructions/ recharge operations

- **Scientific research projects**
  - Want to understand patterns of changing coastal erosion/accretion in relation to climate change and weather patterns over long time periods.
  - Also have budget constraints




## Applications to Coastal Management and Research Projects

- Observations and data on nearshore processes are central to the practice of coastal science and management.
- Hydrodynamic and other coastal models often require detailed bathymetric input data or data for validation.
- Near real time tracking of erosion and accretion over a relatively wide area. More cost effective than many current methods. Potential for continuous observation.

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# Ongoing Collaboration

KTP project to continue development

- Increase technology readiness level of radar-based survey
- Develop better quality control measures
- Automation of data processing
- Improvement of vertical accuracy
- Continue deployments
- Develop market and disseminate knowledge

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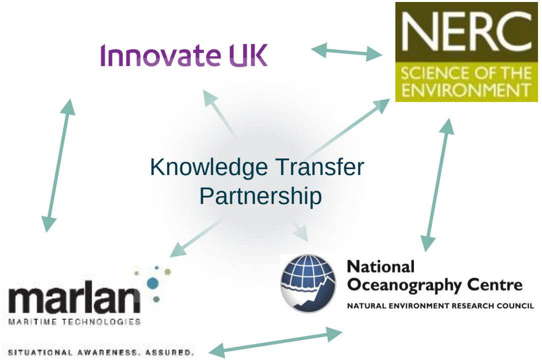


# For more information contact:


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  info@marlan-tech.co.uk

- Prof Andrew Plater
  gg07@Liverpool.ac.uk

- Dr Cai Bird
  caib@marlan-tech.co.uk

**Thank for attending today**

**Informal Icebreaker**
**You are welcome to join the team from 6.30**
**at the Dancing Man Brewery**
**Opposite the Royal Pier**