National Marine Facilities

ANNUAL REVIEW 2017/18

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

Contents

INTRODUCTION

National Marine Facilities (NMF) operates the Royal Research Ships (RRS) James Cook and Discovery and the National Marine Equipment Pool (NMEP) on behalf of the Natural Environment Research Council (NERC).

As part of the National Oceanography Centre (NOC), NMF is based in Southampton and has access to a quayside capable of berthing the research ships as well as housing workshops, laboratories, testing facilities, calibration labs, warehousing and logistics capabilities along with the offices supporting the worldwide operations.

NMF provides these capabilities to the whole UK Marine Science research community as a centralised and cost-effective resource. While the ships are the most visible component of this resource, the National Marine Equipment Pool (NMEP) is equally important and ranges across numerous scientific disciplines including physical oceanography, marine biology, geophysics and chemical oceanography.

NMF supports between 12-15 scientific research expeditions from the RRS James Cook and RRS Discovery every year as well as operating equipment from the NMEP used on the British Antarctic Survey ships (RRS James Clark Ross) or US or European partner ships.

Who we are

NMF encompasses the mariners, engineers, technicians, project managers, logisticians and operations managers who all work together to deliver the Marine Facilities Programme (MFP). The main groups are shown in the Organisation diagram.

NMF aim

The aim of NMF is to develop, co-ordinate and provide major platforms, observing systems and technical expertise required by the UK's marine science community.

What we do

NMF undertakes approximately 15 research expeditions from the RRS James Cook and RRS Discovery every year as well as delivering and operating equipment from NMEP used on British Antarctic Survey (BAS) or European partner research ships.

In addition, we operate more and more Marine Autonomous Systems (MAS) Platforms (Autonomous Underwater Vehicles (AUVs), gliders, Unmanned Surface Vehicles (USVs), etc.) launched and recovered from the shoreline anywhere in the world, but piloted from our base in the UK.

NMF ORGANISATION DIAGRAM

- Marine Autonomous and Robotic Systems (MARS)
- NERC National Facility for Scientific Diving
- Research Ships Management
- Science and Project Support
- Programme Management
- Logistics and Warehousing
- Scientific Engineering

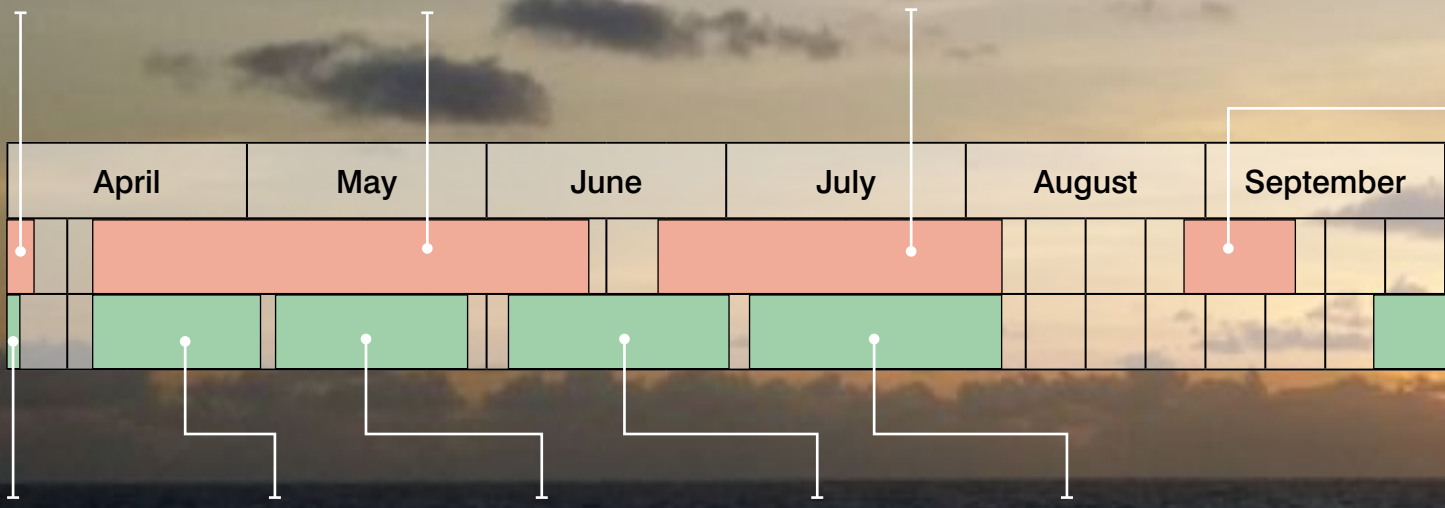
RESEARCH EXPEDITIONS TIMELINE

RRS JAMES COOK

JC145
28 February - 8 April 2017
RAPID-AMOC 26 N MOC mooring array

JC149
17 April - 20 June 2017
VOILA: Volatile recycling at the Lesser Antilles Arc: Processes and Consequences

JC150
27 June - 12 August 2017
Zinc, Iron and Phosphorus co-Limitation in the Ocean (ZIPLOc)



DY072
28 February - 2 April, 2017
Passive Imaging of the Lithosphere-Asthenosphere Boundary

DY077
14 April - 1 May 2017
Studies at the PAP open ocean observatory

DY078 - DY079
6 May - 28 May 2017
Extended Ellett Line & OSNAP

DY080
6 June - 2 July 2017
Distribution and Ecology of Seabirds in the Sub-Polar Frontal Zone of the Northwest Atlantic

DY081
6 July - 8 August 2017
ICY-LAB Isotope CYcling in the LABrador Sea

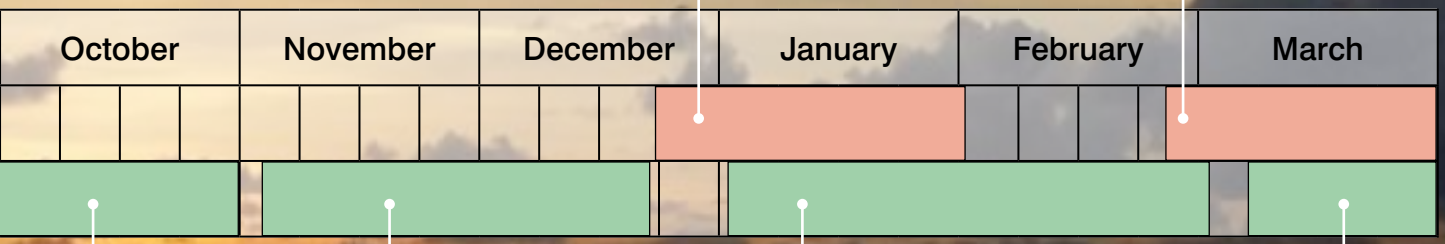
RRS DISCOVERY

Expedition core time

JC152
25 August - 12 September
Characterising leakage pathways through the overburden of the North Sea

JC156
20 December 2017 - 1 February 2018
The impact of mid-ocean ridges on the ocean's iron cycle

JC159
28 February 2018 - 10 April 2018
ORCHESTRA - Ocean Regulation of Climate through Heat and Carbon Sequestration and Transports: Atlan



DY084
23 September - 31 October 2017
Atlantic Meridional Transect (AMT)

DY086
6 November - 21 December 2017
COMICS: Controls over Ocean Mesopelagic Interior Carbon Storage

DY087
2 January 2018 - 2 March 2018
Paleogene Climate and Deep-water Evolution in the Southwest Atlantic

DY088
7 March 2018 - 2 April 2018
Geological and geophysical surveys of the South Scotia Ridge

Expedition core time

RESEARCH EXPEDITIONS MAP

RRS JAMES COOK

RRS DISCOVERY

RRS DISCOVERY RESEARCH EXPEDITIONS

PASSIVE IMAGING OF THE LITHOSPHERE-ASTHENOSPHERE BOUNDARY

DY072 28 February - 2 April, 2017

Catherine Rychert
Principal Investigator

Antonio Gatti
Master

Martin Bridger
Senior Technician

Laura Theurich
Expedition Manager

Equatorial Atlantic
Location

Collaborating Institutions
University of Southampton
Scripps Institution of Oceanography
IPGR Institut de Physique du Globe de Paris
DEPAS Deutscher Geräte-Pool für amphibische Seismologie
GEOMAR Helmholtz Centre for Ocean Research Kiel – Active seismics

NMEP Equipment
EM710/122 Swath bathymetry
EA640 Echosounder
Vessel mounted 150 & 75 kHz ADCP
Sea surface and meteorology sampling system
Data logging and processing system

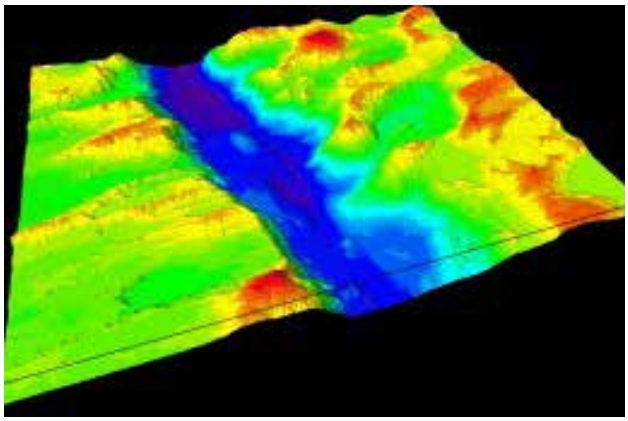
Scientific Research Objectives:

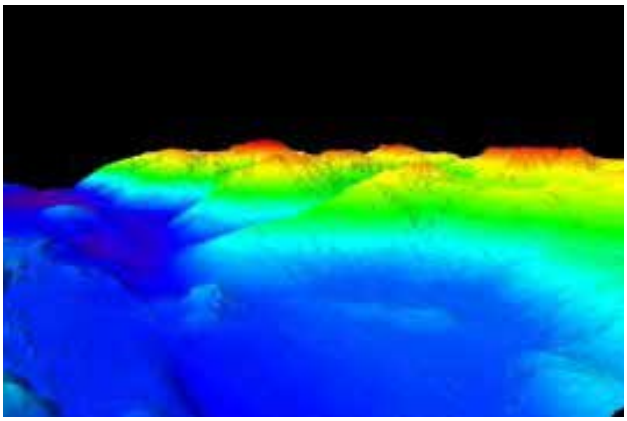
Plate Tectonics is the foundation of modern earth sciences, and provides basic framework for the origin of continents, ocean basins and mountain ranges. Plate Tectonics describe the division of the surface area of the earth into several plates that move independently over the surface of the planet. Each plate acts as an essentially rigid solid shell, which is called Lithosphere, and floats over the material below that flows slowly, called Asthenosphere. Most of the geological activities occur at plate boundaries as the solid lithosphere moves independently. The base of the lithosphere, Lithosphere Asthenosphere Boundary (LAB), is the lower boundary of the plate. Since continents have gone through a complex geological history, the precise depth of the LAB is rather poorly defined. Therefore, here we focus on the oceanic lithosphere where different models of evolution of the lithosphere can be tested and verified.

Precis of the Science Outcomes:

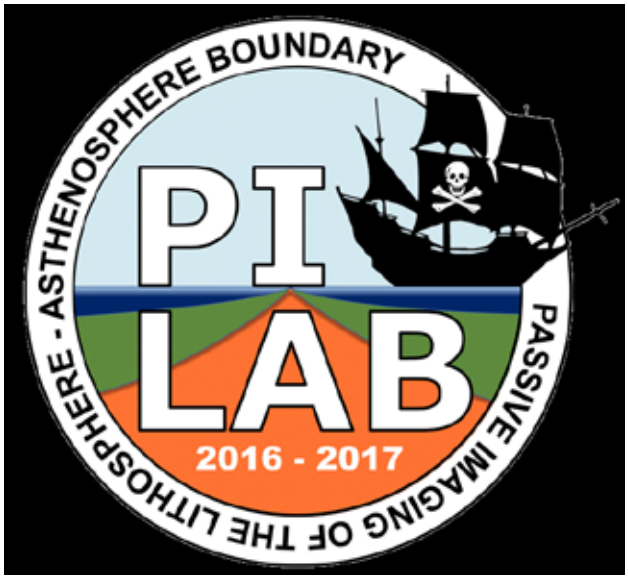
This research used ocean bottom seismometers to image the crust and upper mantle down to 300 km using passive seismic techniques and 3 Magnetotelluric instruments to measure ressitivity. It used surface and body waves to determine the isotropic and anisotropic structure of the crust and upper mantle, and converted phases to determine the character and depth of the LAB and other upper mantle discontinuities. It also used shear wave splitting to determine azimuthal anisotropy across the region and construct 1-D resistvity profiles at 0, 25 and 40 Ma seafloor.

▲ Both photos show work on OBSs





▲ Both images show multibeam echosounder for high resolution imaging of the mid-Atlantic ridge



▲ PI LAB logo

Technical Description of Equipment Deployed and Performance:

This expedition resulted in the successful recovery of 78 OBS/OBEM instruments which were deployed previously by a US research ship. Towed Magnetometer surveys were carried out in between the recovery stations along with use of the ship-fitted multibeam echosounder for high resolution imaging of the mid-Atlantic ridge.

STUDIES AT THE PAP OPEN OCEAN OBSERVATORY

DY077 14 April - 1 May, 2017

Richard Lampitt
Principal Investigator

Joanna Cox
Master

Nicolas Rundle
Senior Technician

Daniel Comben
Expedition Manager

Northeast Atlantic.
Porcupine Abyssal Plain
Location

Collaborating Institutions
National Oceanography Centre
Woods Hole Oceanographic Institution
Skidmore College
Alfred Wegener Institute
Center for Environmental and Marine Studies, University of Averio

NMEP Equipment
CTD Frame and Instruments
Stand-Alone Pumps SAPs
EM710/122 Swath bathymetry
EA640 Echo sounder
Vessel mounted 150 & 75 kHz ADCP
Sea surface and meteorology sampling system
Data logging and processing system
PAP Mooring winch system
Romica 5 ton GP winch

Scientific Research Objectives:

Led by the National Oceanography Centre (NOC), this expedition sampled the amount of microplastics in the water column and captured a continuous record of microplastics sinking to the deep ocean. Furthermore, the first controlled experiments investigating the impact of microplastics on tiny marine organisms at the base of the food chain were carried out on-board.

This was the first time at the PAP-SO that a range of methods measuring marine snow particles, which contain carbon and sink out of the upper ocean, have been used together. This has enabled a greater understanding of the differences between the methods, which will aid future dataset comparisons, and will create a clearer picture of how much carbon sinks to the interior ocean.

Precis of the Science Outcomes:

The cruise was a great success with all of the expedition aims met and 108 stations sampled in 13 days. Since 2002, a mooring has been in place with sensors taking a diverse set of biogeochemical and physical measurements of the upper 1000m of the water column. Some of the data is transmitted in near real-time via satellite. The PAP-SO is now part of the EuroSITES network of European deep ocean observatories, which will integrate and enhance nine time-series sites and coordinate missions to develop new sensors and techniques for observing changing oceans.

Technical Description of Equipment Deployed and Performance:

23 CTD measurements of pressure, salinity, temperature, oxygen, chlorophyll, plus water samples from some CTDs for chlorophyll, oxygen, salinity, DIC and Ammonia.

3 stations of Stand Alone Pump deployments for microplastics, ammonium, POC PA

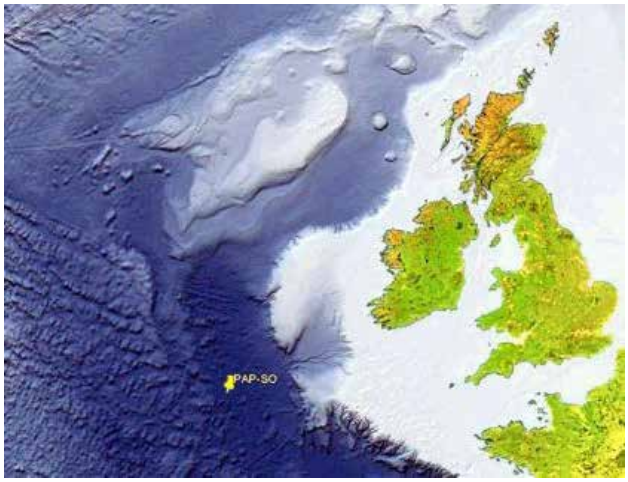
10 Marine Snowcatcher water samples deployments analysed for particle size and sinking speed Particulate organic matter (inc POC, PON)

5 WP2, plankton net, 200μm, to 200m, 3 x midnight, 3 x noon

2 Otter trawl samples of megabenthos

10 Megacore Multiple sediment cores for various analyses

PAP 3 and PAP1 moorings recovered and re-deployed.



▲ Image (top) Location of PAP-SO

▲ Image (bottom) Collecting samples

▶ Image (top) Deployment of a buoy

▶ Image (bottom) Deployment and release of a buoy

EXTENDED ELLETT LINE & OSNAP

DY078 - DY079 6 May - 28 May, 2017

Dr N. Penny Holliday
Principal Investigator

Joanna Cox
Master

Rob McLachlan
Senior Technician

Jonathan Short
Expedition Manager

North East Atlantic
Location

Collaborating Institutions
Natural Environment Research Council
Scottish Association for Marine Science
National Oceanography Centre
Plymouth University
Met Office

NMEP Equipment
CTD Frame and Instruments
Moorings and related instrumentation
EM710/122 Swath bathymetry
EA640 Echosounder
Vessel mounted 150 & 75 kHz ADCP
Sea surface and meteorology sampling system
Data logging and processing system
Megacorer
SAMS supplied MARS glider

Scientific Research Objectives:

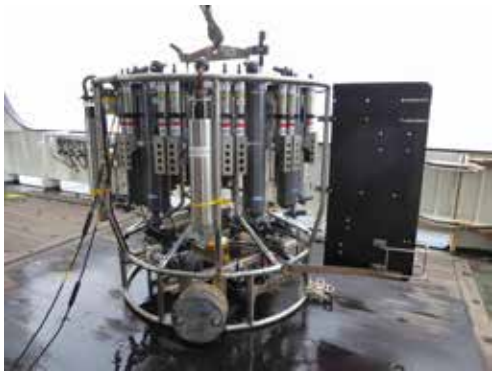
This annual CTD hydrographic section from Scotland to Iceland consisted of over 80 full depth CTD stations requiring 18 days to complete. In addition to the primary goals of measuring temperature, salinity, oxygen, nutrients, velocity, and carbon parameters there was other, opportunistic, data collection for gases (underway sampling), trace metals (samples taken from the extra water in the Niskin bottles), and opportunistic deployments of Argo floats. The expedition also supported the turnaround of the eastern end of the OSNAP mooring array consisting of 3 full ocean depth moorings and one trawler proof lander.

Precis of the Science Outcomes:

The Extended Ellett Line (EEL) is a full-depth hydrographic section between Scotland, Rockall, and Iceland. It is designed to capture the shallow, warm inflow into the subpolar gyre and the Nordic Seas and the deep, cold return flow that contributes to the lower branch of the Atlantic Meridional Overturning Circulation. The objective is to make an annual occupation of the EEL section and create a time series of the evolution of the Northeast Atlantic.

Technical Description of Equipment Deployed and Performance:

In addition to the standard deployments of CTDs and coring systems, a glider from the NMEP was used to gather additional data. All equipment worked well and was able to capture the data required.



▲ CTD array

▶ Image Recovering the foam sphere home to coral and anenome

▼ Image Removing the cores

DISTRIBUTION AND ECOLOGY OF SEABIRDS IN THE SUB-POLAR FRONTAL ZONE OF THE NORTHWEST ATLANTIC

DY080 6 June – 2 July, 2017

Dr. Ewan Wakefield
Principal Investigator

Antonio Gatti
Master

Candice Cameron
Senior Technician

Matt Tiahlo
Expedition Manager

North atlantic transit between UK and Canada
Location

Collaborating Institutions

University of Glasgow
GEOMAR
University of St. Andrews
CEFAS
University of Rhode Island
BirdLife International
Environment Canada
ISPA-Instituto Universitário
Sea Mammal Research Unit
University of Manitoba

NMEP Equipment
LNG
CTDs
General purpose winches

Scientific Research Objectives:

Seabirds are thought to be major consumers and may therefore exert top-down control on pelagic ecosystems. During the breeding season they transport large amounts of nutrients from the sea to land, providing important spatial subsidies to coastal terrestrial ecosystems. Furthermore, recent studies on cetaceans suggest that by rapidly resupplying nutrients (particularly iron) within the photic zone, they may also enhance marine primary production and possibly carbon drawdown. The scientific team aimed to estimate the distribution, abundance and behaviour of seabirds and cetaceans in the area centred on the sub-polar front, south of the Charlie Gibbs Fracture Zone and on transit to and from Southampton and St Johns.

▲ On the left is Ewan Wakefield and on the right is Dr Vladimir

Precis of the Science Outcomes:

To estimate the distribution, abundance and behaviour of seabirds and cetaceans in a study area centred on the sub-polar front, south of the Charlie Gibbs Fracture Zone (CGFZ), and to survey these species en route to and from the study area.

To develop non-lethal methods of catching seabirds at sea.

To estimate the diet, stable isotope and contaminant loading, faecal nutrient content and moult status of seabirds within the study area.

To determine the comparative habitat use of great and sooty shearwaters on and off the Canadian continental shelf and the timing of their movements between these areas.

To map the location of major frontal features and nutrient regimes within the study area.

To estimate the vertical distribution and biomass of mesopelagic nekton within the study area.

To conduct in vitro phytoplankton incubation experiments to estimate rates of nutrient cycling within the study area.

These are listed under Expedition Aims on the NOC website **noc.ac.uk/science/previous-expeditions**

▲ **Dr Paulo Catry**

Technical Description of Equipment Deployed and Performance:

With a focus on seabirds, this expedition didn't involve heavy usage of NMEP equipment. Scientists did regularly use a CTD rosette package for dawn and dusk profiling and water sampling. The ship-fitted EK640 and EM122 echo sounders were run continuously throughout the cruise, as well as hull mounted ADCPs. Scientists supplied a range of their own specialist equipment, including a variety of nets and other gear to enable the non-lethal capture of seabirds. Specialist cages were set up in the ship's hangar to safely hold birds while diet and tissue samples were obtained by the on-board team. A trace metal clean towfish was also used to collect underway water samples.

ICY-LAB ISOTOPE CYCLING IN THE LABRADOR SEA

DY081 6 July – 8 August, 2017

Katharine R. Hendry
Principal Investigator

Joanna Cox
Master

David Turner
Senior Technical Officer

Daniel Comben
Expedition Manager

Labrador Sea
Location

Collaborating Institutions
University of Bristol, National Oceanography Centre, University of Southampton, Columbia University, Huntsman Marine Science Centre, British Antarctic Survey, Cardiff University, University of Oxford, Open University, University of New Hampshire, Imperial College of Science technology and medicine, University of Alabama

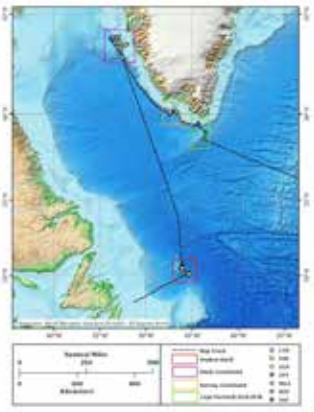
NMEP Equipment
ISIS ROV, AUV Autosub 6000, CTD Frame and Instruments, EM710/122 Swath bathymetry, EK60 fish finder, SBP120 Sub-Bottom Profiler, EA640 10&12KHZ Single Beam Echosounder, Vessel mounted 150 & 75 kHz ADCP, Sea surface and meteorology sampling system, Data logging and processing system, Mega Core, SMBA box core, Gravity Core, Rock Dredge, Radio Nuclide containerised laboratory, Liquid Scintillation Analyser, Fume Cupboard

Scientific Research Objectives:

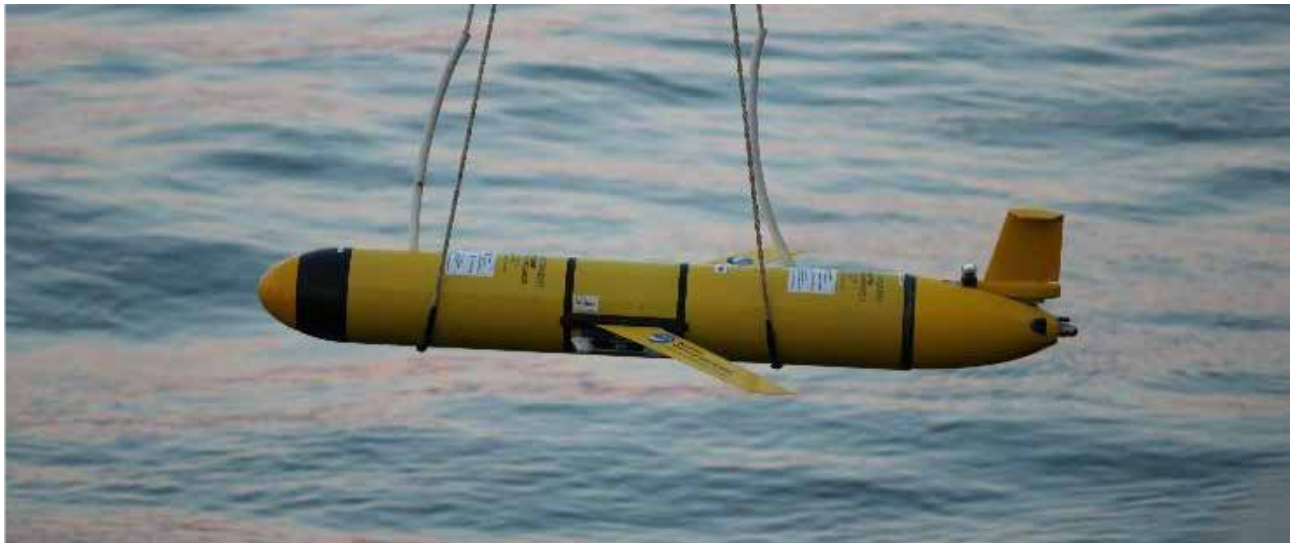
The 2 key work packages were design to:

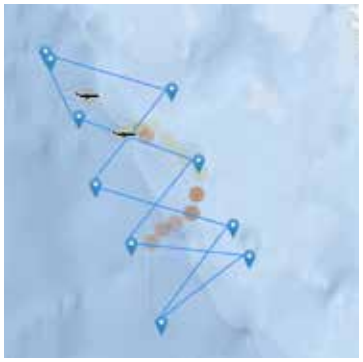
Understand silicon cycling in the Labrador Sea: The research aimed to answer questions on the impact of glaciers and fjord processes, and the role of ocean circulation and marine biology, on Si cycling in the region of the expedition. Various chemical tracers (trace metals, stable and radiogenic isotopes) were employed to quantify inputs to seawater. The impact of biogeochemical cycling on seawater chemistry was assessed by measuring dissolved and particulate nutrients and their isotopes.

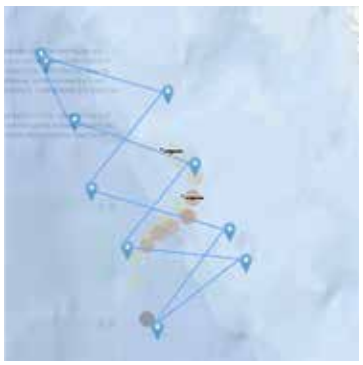
Understand growth in Labrador Sea siliceous organisms and their communities: The research aimed to investigate the biogeographical controls on sponge and diatom distribution in the Labrador Sea and Greenland fjords; the biological controls on Si isotope fractionation during growth of siliceous organisms; and the natural products of sponges, their communities and other deep-sea organisms.

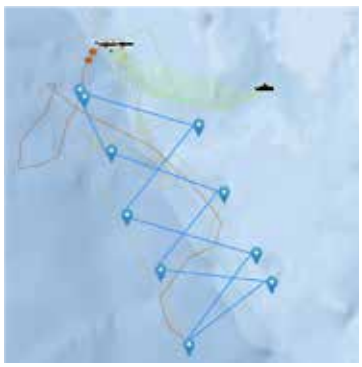


Overview map of DY081 ship route. Produced in mercator projection with a standard parallel of 55˚N









▲ Image (top) Glider being lowered into the water and glider transects

▲ Image x4 (bottom) Glider Track Northerly current influencing glider trajectory

Precis of the Science Outcomes:

The high-latitude regions are experiencing some of the most rapid changes observed in recent decades. Arctic temperatures are rising twice as fast as the global mean, Greenland's glaciers are experiencing significant mass loss, multi-year Arctic sea-ice is declining, and the Nordic Seas are warming at an accelerated rate. These processes are important locally, but their effects are likely to have a global impact: for example, the North Atlantic receives freshwater from the Arctic, Greenland and Canada and is a formation locus of the deep-water masses, which represent a major component of ocean circulation that drives global heat and nutrient fluxes.

The overall aim of ICY-LAB is to understand nutrient and isotope cycling in the climatically critical but understudied regions of the Labrador Sea and Greenland fjords, and the impact of cryosphere, biosphere and hydrosphere on the biogeochemistry of the region and the global oceans.

Technical Description of Equipment Deployed and Performance:

This was a heavy expedition with 13 ROV dives interspersed with glider deployments, 43 CTD casts, coring (mega/SMBA/gravity), rock dredging and use of the ship's acoustic suite. All equipment worked well and was able to capture the data required.

▲ **Image The ICY-LAB team, Credit Martin Bridger**

ATLANTIC MERIDIONAL TRANSECT (AMT)

DY084 23 September - 31 October, 2017

Dr. Andy Rees
Principal Investigator

Joanna Cox
Master

Dave Childs
Senior Technical Officer

Matt Tiahlo
Expedition Manager

North to South Atlantic
Location

Collaborating Institutions
Plymouth Marine Laboratory
Tartu Observatory
British Oceanographic Data Centre
University of Warwick
Partnership for Observation of the Global Oceans (POGO)
University of Southampton
University of Hawaii
Naturalis Biodiversity Center
Royal Belgian Institute of Natural Sciences
National Oceanography Centre
European Space Agency

NMEP Equipment
CTDs
SAPs
FRRFs
RN lab
ADCPs

Scientific Research Objectives:

The Atlantic Meridional Transect programme (AMT; www.amt-uk.org) is a NERC National Capability project which will provide a sustained open ocean in situ observing system to enable early warning of any fundamental change in ecosystem functioning and to better forecast the marine environment for society's needs. AMT will also provide a contextual logistical and scientific infrastructure for independently funded national and international open ocean biogeochemical and ecological research.

Precis of the Science Outcomes:

AMT addresses some of the strategic research questions prioritised by NERC including those related to carbon cycling and the diversity of microbial assemblages and their role in ecosystem function. AMT also contributes to two of Defra's Evidence plans: climate change and the marine environment. In particular, AMT provides a means to assess biodiversity trends in relation to environmental change, to improve understanding of the structure and functioning of marine ecosystems including the interactions between physical and ecological processes and the impact of climate change on the ocean.

Technical Description of Equipment Deployed and Performance:

AMT27 made extensive use of the National Marine Equipment Pool (NMEP) Stainless steel and Titanium frame CTD packages. Additionally, NMF supplied Stand Alone Pumps, Fast Repetition Rate Fluorimeters, ADCPs, and a Radionuclide lab container from the NMEP.

The scientific party supplied a wide range of additional equipment including a flow cytometer, nutrient autoanalyser, gas chromatographs, fluorometers and spectrophotometers as well as an underway pCO2 system. C-Band and ISAR radar systems were installed on the fwd meteorological platform, and scientist supplied Bongo and RMT nets were deployed for biomass sampling.

▲ Christabel Fernandes an AMT-POGO sponsored fellow from Goa, India measuring dissolved nitrous oxide and methane on CTD collected seawater

▲ Image shows AMT sampling stations between Southampton and Port Stanley

COMICS

CONTROLS OVER OCEAN MESOPELAGIC INTERIOR CARBON STORAGE

DY086 6 November - 21 December, 2017

Richard Sanders
Principal Investigator

Antonio Gatti
Master

Nick Rundle
Senior Technician

Jonathan Short
Expedition Manager

South Atlantic/Scotia Sea
Location

Collaborating Institutions
Natural Environment Research Council
University of Southampton
National Oceanography Centre
British Antarctic Survey
Heriot Watt University
Queen Mary University of London
Alfred Wegener Institute
University of Tasmania

NMEP Equipment
Glider
LNG
Moorings
ADCP
FRRF
VMP
SS & Ti CTDs
SAPs
RN container
Deck winches

Scientific Research Objectives:

The marine biological processes associated with the production, sinking and remineralisation of organic matter, collectively referred to as the biological carbon pump (BCP), store enough inorganic carbon in the ocean's interior to keep atmospheric CO2 200ppm lower than it would otherwise be. The precise size of this carbon store, and hence the composition of the atmosphere, is a function of the depth at which sinking carbon is remineralised in the "twilight zone" (TZ), the region extending from ~100-1000m. Understanding what controls the substantial spatial variability observed in this remineralisation depth is key to understanding how present day atmospheric CO2 level is regulated.

Precis of the Science Outcomes:

1) To measure the attenuation of flux with depth at a series of open ocean sites with differing environmental conditions and surface community structures.

2) To measure interior community structure, respiration, organic geochemistry and foodwebs using stable isotopes.

3) To examine the metabolic balance of the twilight zone at each site and develop an empirical relationship for flux attenuation.

4) To test novel paramaterisations for flux attenuation in the TZ in a highly efficient modelling framework.

5) To predict the future evolution of the inorganic carbon sequestered in the ocean by the BCP.

▲ Image Glider, gliding

▶ Image (Top) Red Camera frame on deck

▶ Image (Bottom) MAMMOTH net recovery

Technical Description of Equipment Deployed and Performance:

DY086 deployed stainless steel and titanium frame CTD packages from the National Marine Equipment Pool (NMEP). In addition, NMF supported Stand Alone Pump sampling and a 60-day glider mission. As well as bongo net, pellagra (neutrally buoyant sediment traps) and snowcatcher deployments, this was the first time that the two deep net systems (MOCNESS, RMT25) have been deployed using the fibre optic connection of a "deep tow" wire in advance of expected future use on the RRS Sir David Attenborough. In addition, a bespoke lander was used and 6 argo floats were released.

▲ Pellagra deployment

▲ Preparing to deploy a CTD

▲ Recovery of a bongo net

RRS JAMES COOK

RESEARCH EXPEDITIONS

RAPID-AMOC 26 N MOC MOORING ARRAY

JC145 28 February - 8 April, 2017

David Smeed
Principal Investigator

James Gwinnel
Master

Dave Childs
Senior Technician

Jonathan Short
Expedition Manager

North Atlantic
Location

Collaborating Institutions
Natural Environment Research Council
National Oceanography Centre

NMEP Equipment
Mooring deployment winches
Mooring hardware
Mooring Instrumentation
CTD Frame and Instruments
EM120 Swath bathymetry
EA600 Echosounder
Vessel mounted 150 & 75 kHz ADCP
Sea surface and meteorology sampling system
Data logging and processing system

Scientific Research Objectives:

Monitoring changes in the Atlantic Meridional Overturning Circulation (AMOC) is important for understanding decadal climate variability and change. The RAPID array across the Atlantic at 26°N has now observed the AMOC continuously for 10 years, and revealed greater variability than expected.

Low AMOC events in 2009-10 and 2010-11 coincided with cold winters in Europe and suggest a previously unsuspected role for the AMOC in climate variability. Understanding this requires a longer time series of observations, so the array will continue until 2020.

Precis of the Science Outcomes:

This expedition was the annual occupation and turnaround of the RAPID AMOC mooring array. Since 2004 the RAPID program has been continuously monitoring the AMOC and associated northward heat transport at 26°N. The time series of the AMOC produced by the RAPID program is freely available and is widely used by ocean and climate scientists around the world.

Technical Description of Equipment Deployed and Performance:

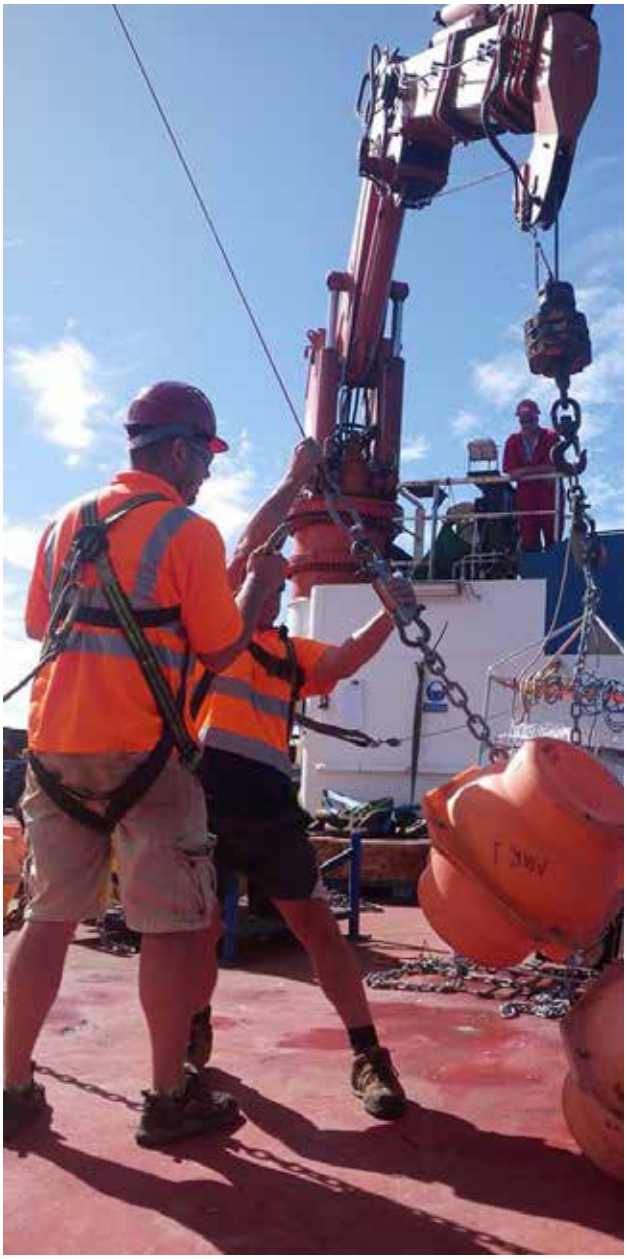
Complete RAPID mooring array turned around. The array consists of 30 full ocean depth fully instrumented moorings. Each mooring had a number of SBE39 Microcat CTD sensors, Anderaa RCM11 and NORTEK current meters and RDI ADCP current meters. 3 McLane RAS (Remote Access Sampler) were also deployed on moorings EB1, WB1 and MAR1.

22 CTD deployments were carried out for data integrity, calibration and release testing. Instruments on the CTD frame were; SBE3P temperature sensors, SBE4C conductivity sensors, SBE 43 Oxygen sensor as well as additional light sensors (Fluorimeter, transmissometer).

▲ (top) Image Lander Myrtle

▲ (bottom) image Lander Myrtle

▶ Image RAPID



VOILA:

VOLATILE RECYCLING AT THE LESSER ANTILLES ARC: PROCESSES AND CONSEQUENCES

JC149 17 April - 20 June, 2017

Dr. Jenny Collier
Principal Investigator

John Leask
Master

Jason Scott,
Andy Leadbeater
Senior Technicians

Matt Tiahlo
Expedition Manager

Caribbean Sea: Freeport, Bahamas to Pointe-a-Pitre, Guadeloupe
Location

Collaborating Institutions
Imperial College, London
Ocean Bottom Instrumentation Consortium
University of Southampton
University of Liverpool
Alfred Wagner Institute
Durham University
National Oceanography Centre
Scripps Institution of Oceanography

NMEP equipment
Seismic source
Gravitymeter
Vertical hydrophone mooring
Rock dredge

Science Research Objectives:

Geophysicists from six institutions were all involved in studying the active subduction zone of the Lesser Antilles. Their research also encompasses studies into the natural hazard risks, and potential resources at subduction zones. The expedition had three main scientific objectives, aiming to understand:

- How volatiles are delivered to the arc,
- How and where volatiles are stored in the arc crust,
- How and where volatiles control magma production and differentiation processes.

Precis of the Science Outcomes:

Determination of the hydration of the incoming plate, and specifically whether it varies along the strike of the arc. The experiment targeted a portion of the incoming plate covering two major fracture zones and the segment in between and compared its structure with that at the peak of the fore-bulge (generated by bending of the plate as it enters the subduction zone).

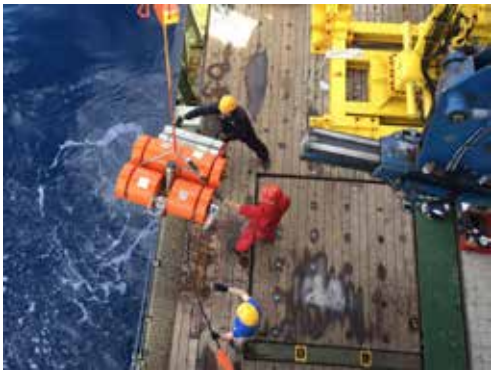


Image Recovery of an OBS instrument supplied by Alfred Wagner Institute following a 12-month deployment on the seafloor (credit Dr Jenny Collier).

Technical Summary of Equipment Deployed and Performance:

This expedition made intensive use of the vessels ship fitted sonar systems: specifically the sub-bottom profiler and swath bathymetry instruments, as well as the hull mounted Acoustic Doppler Current Profiler (ADCP) systems. These ship-mounted instruments allow scientists to study the seafloor and a short distance below the seabed. In order to gain insights into processes in action deeper below the seafloor, the expedition utilized a towed multi-channel seismic (MCS) array. This comprised four towed beams, each carrying three airguns to create a sonic source (over 27,000 airgun shots were fired). The reflected signals from these airguns were picked up by a hydrophone array towed up to 5000m behind the vessel, enabling scientists to study geophysical processes hundreds of meters below the seabed. Ocean bottom seismographs (OBSs) were also deployed and recovered from the vessel, these are instruments which sit on the seafloor and record seismic activity.

▲ Image Burt (AB), Martin (CPOS) and Tim Henstock (CoI) recovering depth control 'birds' from the MCS towed streamer (credit Dr Jenny Collier)

ZINC, IRON AND PHOSPHORUS CO-LIMITATION IN THE OCEAN (ZIPLOC)

JC150 27 June - 12 August, 2017

Claire Mahaffey
Principal Investigator

James Gwinnel
Master

Jeff Benson
Senior Technician

Jonathan Short
Expedition Manager

Transect across mid-Atlantic Ridge
Location

Collaborating Institutions
University of Liverpool
University of Southampton
Plymouth Marine Laboratory
Woods Hole Oceanographic Institute (WHOI), USA
Bigelow Laboratory for Ocean Sciences

NMEP Equipment
Stainless Steel CTD Frame and Instruments, Trace Metal CTD Frame and Instruments, Trace Metal winch system, EM120 Swath bathymetry, EA600 Echosounder, Vessel mounted 150 & 75 kHz ADCP, Sea surface and meteorology sampling system, Data logging and processing system, Fume Cupboard, Laminar flow hoo, Milli-Q pure water generators, Laboratory salinometers, Under way iron free water sampling system, Clean Chemistry laboratory containers, Fast Repetition Rate fluorometer (FRRf)

Scientific Research Objectives

The overal aims of the Ziploc project are to (i) determine the prevalence of zinc and iron limitation of alkaline phosphatase activity (APA) (ii) quantify the impact of zinc-phosphorus and iron-phosphorus co-limitation on biological activity and (iii) quantify the significance of zinc-phosphorus and iron-phosphorus co-limitation in driving phytoplankton productivity over basin scales and multi-decadal timescales in the phosphate deplete subtropical ocean.

Objective 1: Quantify the functional relationships between zinc and APA and iron and APA. We will perform bioassay experiments by adding zinc and iron and measuring the change in phosphorus, zinc, iron and APA.

Objective 2: Quantify the impact of zinc-phosphorus and iron-phosphorus co-limitation on growth, primary production, nitrogen fixation, zinc and iron-containing proteins and cellular metal quotas. We will perform bioassay experiments by adding zinc and iron and measuring the change in cellular elemental quotas, zinc and iron-containing proteins, rates of growth, primary production and nitrogen fixation.

Objective 3: Synthesis of bioassays in the oceanographic context of the subtropical North Atlantic. We will measure phosphorus, zinc, iron, community composition and APA in surface waters at < 50 nm resolution and combined with results from bioassay experiments, perform statistical analysis to investigate environmental factors that influence the community response to zinc and iron addition.

Objective 4: Quantify the impact of zinc- and/or iron-phosphorus co-limitation on contemporary and decadal scale trends in the biological activity of the subtropical gyres. We will extend the global ocean biogeochemical model, PISCES to include a representation of zinc cycling based on existing and our new observations, with new closures representing phosphate limitation, ocean circulation and nitrogen deposition scenarios.

Precis of the Science Outcomes:

The main aim of JC150 was to quantify the extent and impact of zinc-phosphorus and iron-phosphorus co-limitation on phytoplankton growth and biological processes in the subtropical North Atlantic Ocean. Experimentation to quantify this was carried out by occupying seven stations, travelling west to east between Guadeloupe and Tenerife, for between 4 and 7 days.

Technical Summary of Equipment Deployed and Performance:

JC150 made extensive use of the National Marine Equipment Pool (NMEP) stainless steel and titanium frame CTD packages (54 deployments).

Additionally, NMF supplied the NMEP trace metal water sampling system which was used on transit legs (towed at 7 knots allowing sampling every 2 hours).

▲ (Top) Image inside the clean chemistry lab container

▲ (Bottom) Image samples and equipment

▲ Image members of the science team and ship's crew

CHARACTERISING LEAKAGE PATHWAYS THROUGH THE OVERBURDEN OF THE NORTH SEA

JC152 25 August – 12 September, 2017

Jonathan Bull and Tim Minshull
Principal Investigators

John Leask
Master

Andrew Leadbeater
Senior Technician

Jonathan Short
Expedition Manager

North Sea
Location

Collaborating Institutions
Natural Environment Research Council
University of Southampton
University of Edinburgh
National Oceanography Centre
GEOMAR
Ocean Bottom Instrument Facility
Applied Acoustics Engineering Ltd and CGG.

NMEP Equipment
Bolt LL Seismic source "air gun"
GI seismic source "air gun"
Hamworthy air compressor containers
Seimics source deployment system "Cherry picker"
Mooring instrumentation
Mooring deployment winches
Sound velocity probe
Sub-bottom profiler
Simrad EM710 swath bathymetry system
Simrad EK60 fisheries echo sounder
Ultra short base line (USBL) system

Scientific Research Objectives:

The location of CO2 leakage and the potential intensity of CO2 leakage at the seafloor are critically dependent on the distribution of fluid pathways in the sediment overburden and on the permeability of these pathways. Evaluation of seismic reflection data as part of a recently completed EU project (ECO2) has revealed ubiquitous structures cross-cutting vertically through the overburden within the North Sea and Norwegian Sea. These seismically-imaged pipes and chimneys are considered to be pathways for sedimentary fluid flow. Natural gas from deeper strata is likely to have migrated through these structures into the water column at some point in geological time. If the CO2 plume reaches the base of these structures, and if their permeability is high enough they will act as pathways for CO2 leakage. To provide a reliable prediction of seep sites, and a quantitative assessment of CO2 emissions, the nature and especially the permeability of these pathways needs to be better constrained.

Image preparing to deploy the seismic source

Precis of the Science Outcomes:

The goal of JC152 was to identify a feature that may represent a type of fluid pathway, so-called "chimney" structures, which are common in the North Sea. These features are visible on seismic sections, and cross-cut the sediment layering in the sub-seafloor. Many of these are linked to depressions on the seabed known as pockmarks, which can reach hundreds of metres in diameter. Natural gas migrating upwards from deeper strata is likely to have transited through these chimney and pockmark structures into the overlying water column at some point in geological time.

This expedition carried out a detailed investigation of these pathways feeding one such pockmark that is actively venting gas. Multi-beam swath bathymetry was used to identify the "pockmarks" on the sea floor, whilst the EK60 echosounder clearly showed the gas ares. This was followed up using OBS landed on or around the "pockmark" to record seismic signals generated by the NMEP supplied and supported seismic sources to fully map the gas pathways.

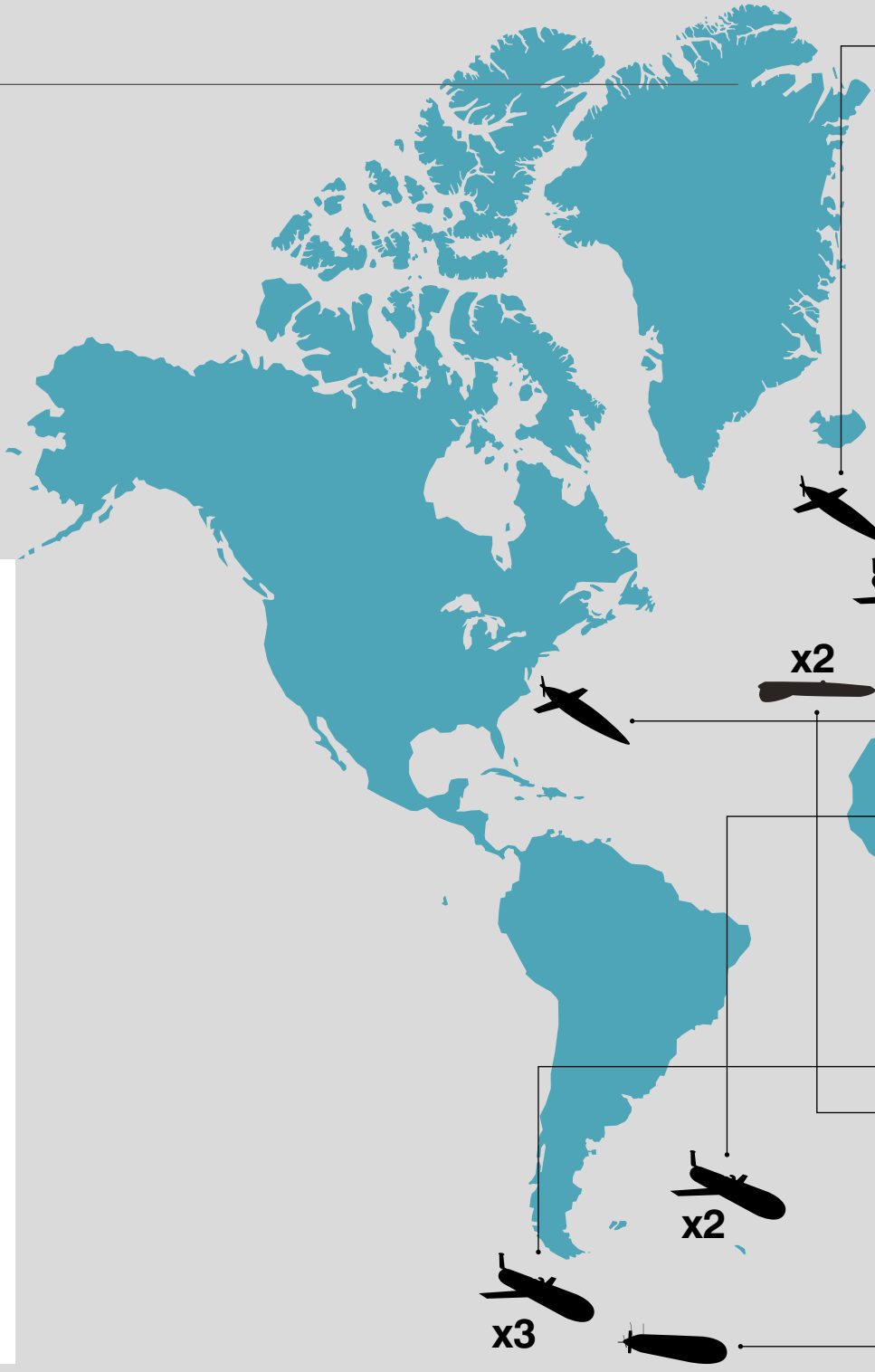
▲ **Image recovering the deep tow 'sparker'**

Technical Description of Equipment Deployed and Performance:

Whilst the seismic source produced the necessary 'bang' there were issue with the depth keeping of the system which adversely affected the planned waveform. A small mooring used to deploy an acoustic recorder worked well.

◀ **Image GI Gun deployment**

MARINE AUTONOMOUS SYSTEMS OPERATIONS



AUTOSUB

AUTONAUT

C-ENDURO

SEAGLIDER

SHARC

SLOCUM GLIDER

WAVEGLIDER

Arctic 'PRIZE'
2 x gliders in Norwegian Arctic

OSNAP
1 x glider off northwest UK

AlterECO
2 x gliders in North Sea (1 x UEA)

Mermeed
1 x glider in Bahamas

GO-CART
2 x gliders off South Georgia
2 x gliders off Namibia

ORCHESTRA
3 x gliders in Drake Passage
(1 x deployed)

FISS
1 x ALR Antarctic under-ice missions

ACSIS
2 x Wave Gliders in Canary Islands

Over 15 assets spread from Arctic to Antarctica covering a distance of >1500 km

MARINE AUTONOMOUS SYSTEMS IN SUPPORT OF MARINE OBSERVATIONS (MASSMO)

MASSMO 19 May - 06 June, 2017

Prof Russell Wynn
Principal Investigator

David White
Expedition Manager

NW Scotland
Location

Collaborating Institutions
Defence Science and Technology Laboratory
University of East Anglia
Scottish Association for Marine Science
Plymouth Marine Laboratory

NMEP Equipment
C-Enduro
Autonaut
Wave Glider
Slocum gliders

URLs
https://mars.noc.ac.uk/missions/massmo-4

Precis of the Science Outcomes:

(MASSMO4) was the fourth instalment of an annual series of large-scale marine robotics demonstrator missions.

- MASSMO4 was primarily focussed on collection of acoustic and oceanographic data.
- At least four species of marine mammal were recorded, as well as anthropogenic noise such as seismic shots and ship echo-sounders
- A Best Composite Picture experiment was conducted, integrating marine models, satellite images and real-time glider data over an area of 1500 km^2 in a 48-hour period.

Technical Description of Equipment Deployed and Performance:

MASSMO4 involved a fleet of 11 unmanned surface and submarine gliders, equipped with sensors to collect a wide variety of marine environmental data. The fleet was deployed from shore and from NRV Alliance, and worked up to 180 km offshore of NW Scotland in waters up to 1000 m deep over a two-week period; this is probably most complex and ambitious deployment of marine autonomous systems yet attempted in UK waters.

THE NERC FACILITY FOR SCIENTIFIC DIVING

NFSD Research 2016 - 2017

Martin Sayer
Head of the NFSD

Simon Thurston
Hugh Brown
Elaine Azzopardi
Andrew Mogg
Dive Technicians

NFSD, SAMS,
Scottish Marine Institute,
Oban, Argyll PA37 1QA, UK
Location

URLs
www.nfsd.org.uk/
www.sams.ac.uk/

The NERC Facility for Scientific Diving (NFSD), hosted by the Scottish Association for Marine Science (SAMS), provides divers, equipment, training and scientific/technical support that underpins a wide range of interdisciplinary research in the underwater environment. Established in 2002, access to NFSD support is through peer-reviewed application.

Scientific diving is a research tool that can sustain a wide range of scientific disciplines, particularly in complex environments, and contributes unique multidisciplinary datasets that add value to other ocean observation systems. Since its establishment as a National Facility, the NFSD has supported studies investigating topics as diverse as sea-level measurement, water-quality assessment, light measurement, functional ecology, cell biology, animal genomics, paleoclimatology, ocean acidification, biogeochemistry, eco-physiology, habitat mapping and science-based maritime archaeology.

From 2006 to 2018 the NFSD has contributed to nearly 170 ISI-rated publications with an average impact factor of 3.4 and an H-index of 31.

In 2017, the unit completed 526 diving operations in support of research programmes for over 20 university and NERC Centre Survey partners.

Research highlights (2017-18):

- A diving based study of UK kelp forests, undertaken over a latitudinal gradient, has shown that carbon assimilation and transfer through temperate marine ecosystems will be diminished under a warmer ocean climate (MBA Plymouth, Aberystwyth)
- Photogrammetric techniques have been used to accurately estimate the levels of coral bleaching and coral mortality in the Chagos Archipelago (UCL, Bangor, Exeter)
- Sampling by divers over a range of subtidal environments has shown the importance of wave exposure on the structural integrity of rhodoliths which, in turn, determines habitat structure and hence the levels of associated biodiversity (NHM, Bristol)
- Diving is providing the baseline data required for testing the effectiveness of AUVs as tools for monitoring and mapping the seabed in Marine Protected Areas (SAMS)
- Deep water diving in the eastern Mediterranean has resulted in the discovery of a new species of filamentous brown algae (Aberdeen)
- Underwater photogrammetry techniques have been employed to improve marine growth estimates on artificial habitats with direct relevance to the processes that will be required for future oil and gas platform decommissioning (SAMS and industry partners)

Innovation:

Recent (2017-18) examples of techniques and technologies being developed and evaluated through the NFSD are:

Fluorescence photogrammetry: The NFSD has been combining fluorescence photography with underwater stereophotogrammetry techniques to develop new methods for the rapid measurement of coral recruitment in damaged reef areas. The methods were assessed on reefs in Belize before deploying for wider area measurements in the British Indian Ocean Territory.

Fine-scale benthic sampling: A study has been completed that examined the influence of the retrieval method on the preservation of sedimentary and biogeochemical features when sampling soft-bottom, shallow coastal environments. The work has shown that inimal disturbance is recorded when comparing the laboratory measurements of the diver-retrieved cores with in-situ measurements made by benthic landers.

▲ **Image Evaluating diving-based fluorescence photogrammetry**

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