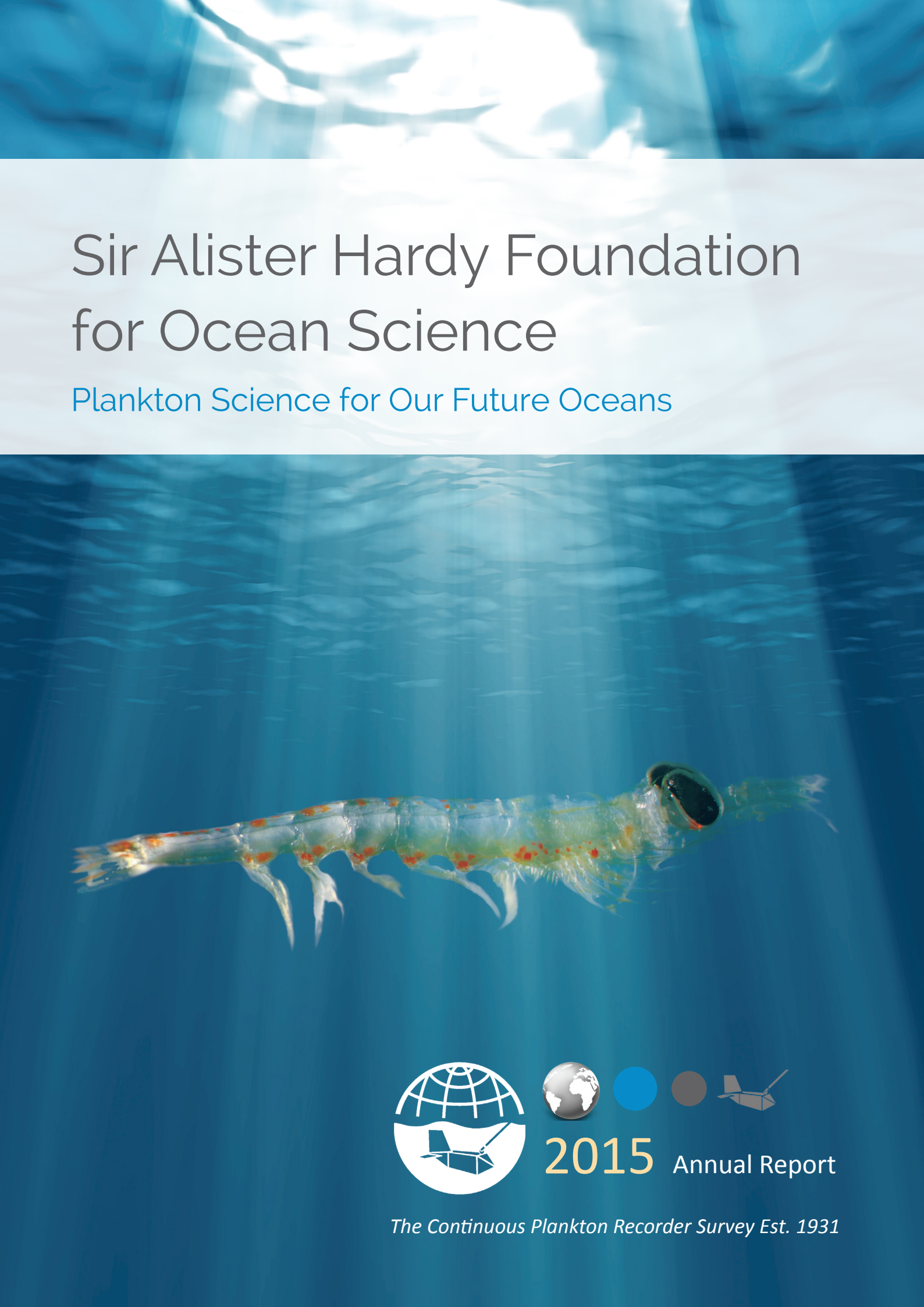
Sir Alister Hardy Foundation for Ocean Science

Plankton Science for Our Future Oceans



2015 Annual Report

The Continuous Plankton Recorder Survey Est. 1931

Our Tow Routes and Ships

North Atlantic

IN route: Dublin to Liverpool
P&O: *Norbay*

NI route: East Iceland to Sortland
MC route: Nova Scotia to Portland
Eimskip: *Skogafoss*

LG route: Gent to Gothenburg
DFDS*: Petunia & Freesia Seaways*

SA route: Bilbao to Land's End
MacAndrews: *Encounter*

HE Route: Cuxhaven to Immingham
DFDS: *Hafnia Seaways*

A- route: Lerwick Shetland to Aberdeen
SERCO Northlink Ferries: *Hildasay*

ST route: Svalbard to North Cape
Bring : *Norbjorn*

IB route: Biscay to 53^{0}N
SB route: Lisbon to Leixoes
MacAndrews*: Sophia*

M- route: Aberdeen to Tananger
KC route: Immingham to Tananger
Freshney: *Norrland*

D- & DA routes: 33^{0}W to 7^{0}W and Liverpool
EA & EB routes: Norfolk VA to Cape Race
ACL: *Atlantic Companion*
Jan-June

LR route: Immingham to Sule Skerry
V- route: Sule Skerry to South East Iceland
Eimskip: *Largarfoss*

EA & EB routes: Norfolk VA to Cape Race
D- & DA routes: 33^{0}W to 7^{0}W and Liverpool
ACL: *Atlantic Cartier*
Aug-Dec

MB route: New York to Bermuda
Bermuda Container Line:
Oleander

Z routes: Reykjavik to east of Newfoundland
Eimskip: *Reykjafoss*

B Routes: 400W to Portsmouth
MMD/ Geest Line: *Benguela Stream*

PR route: Plymouth to Roscoff
Brittany Ferries: *Armorique* & *Bretagne*

R- route: Hook of Holland to Shipwash Bank
DFDS: *Flandria Seaways* & *Anglia*

C- route: Humber to Hanstholm
DFDS: *Ficaria Seaways, Petunia & Freesia*

The CPR Survey would not be physically or economically possible without the generous support of ships, owners, charterers, managers, port operatives and agents. We are extremely grateful to all those involved, helping SAHFOS in all its operational activities – we could not do it without your continuing support.

VJ route: Vancouver to Hokkaido Japan
AAL Shipping: *AAL Melbourne*

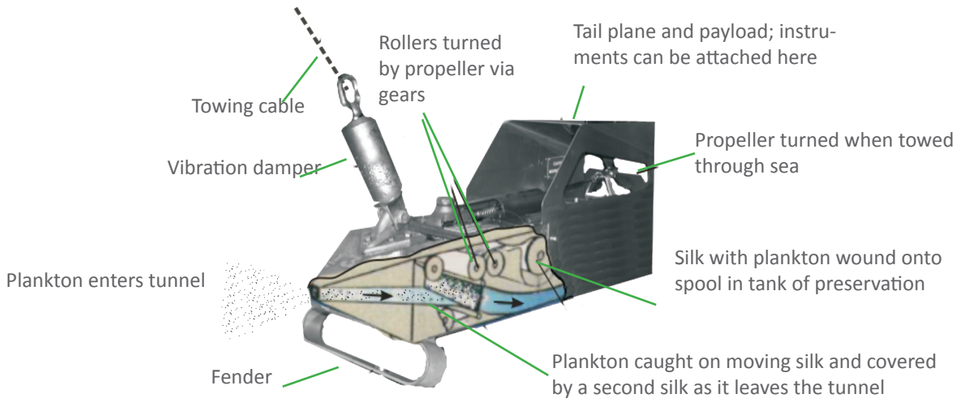
AT route: Anchorage, Alaska to Tacoma, Washington State
Matson Shipping: *Matson Kodiak*

SF route: Stanley Falklands Islands to South Georgia
Byron Marine Ltd: *Pharos SG*

Pacific

Southern Ocean

How our Continuous Plankton Recorder's Work



On the cover: A *Thysanoessa* spp. euphausiid caught in Antarctic waters.
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Director's Introduction

Willie Wilson

I should start by saying how truly honoured I am at being appointed to this prestigious position. As the new SAHFOS Director I have some tough and talented acts to follow, however, I am reassured that the SAHFOS team is a well-oiled machine. I am always buoyed up by the friendly yet professional atmosphere that pervades through this family, and yes, the amazing views of Plymouth Sound certainly help create a pleasant working atmosphere (see right). It seems the Board of Trustees wanted a younger model to direct SAHFOS (sorry Nick!), though my guess is they were keen to see someone closer to the research to help boost that area of the organisation. I take that particular challenge with relish and I look forward to directing a productive research programme that I hope will steer us towards new initiatives into the future.

My first challenge has been to look at ways to increase the exposure of SAHFOS, particularly at policy level. This must start by honing our message to a level that everyone can understand. We must be able to demonstrate the impact of the science we produce. It is very clear we hit well above our weight in publishing high impact papers. The quality of the research output is phenomenal with papers in prestigious journals such as Science, Nature Climate Change and Global Change Biology. However, this is the new normal, a baseline. What we do beyond this will separate us from the rest. A critical priority will be to get much better at translating scientific excellence; essentially use it to improve the SAHFOS brand and market ourselves much more widely than we have ever done. Improved marketing will feed into our fundraising, outreach, education, policy, and ultimately back to our science; I am convinced it will pay dividends to help ensure long-term sustainability.

Of course SAHFOS research will not be possible without a massive team effort, with the CPR Survey at its core, encompassing the huge operational effort (the engine room) and our team of analysts in what I have heard described as a 'Centre of Taxonomic Excellence' (certainly a term I hope to adopt moving forward), and finally it is all lubricated by a highly efficient administrative support team (in keeping with the 'well-oiled machine' analogy!) It is an important synergy and makes SAHFOS unique.

Easily a highlight was my trip to Immingham in November to drop off the Christmas chocolates to the teams that help smooth the way for the final part of the CPR journey on its passage to the designated ship of opportunity ("the last 500 metres" as Lance puts it). I got a real sense of the goodwill that is shown by a large number of volunteers, from the port staff who keep a watchful eye on our distinctive yellow box, to the crew and Masters of the different merchant vessels that go out of their way to safely deploy our CPRs. It was a privilege to be invited on board the MV *Lagarfoss* to meet Captain Magnus and his crew, where we spent some time working out how to adapt the CPR tow point to ensure easier and safer handling during CPR deployment. Captain Magnus welcomed me to the bridge. As a seafarer for over 30 years, he clearly understood the significance of the research we conduct at SAHFOS and seemed proud to be part of this important survey. All this volunteerism is at the heart of what we do at SAHFOS and when combined with 12,000 nautical miles towed per month (AND recently passing the 6.5million nautical mile mark!) it represents tremendous added value to our operational capability.

Over and above the normal business of SAHFOS, everyone has been engaged in the SAHFOS 'facelift'. I am referring to our new website, the design of which is well underway at the time of writing. I am excited at some of the early versions I have seen so far. We can look forward to a vibrant, professional and creative new look that will help deliver the important messages we all aspire to as a cutting edge scientific organisation.

I do hope you enjoy reading through our Annual Report, the incredible breadth and depth of SAHFOS activity astounds me. It is a large part of the reason these first few months have been such a steep learning curve for me, drinking water from a fire hose is the analogy I have often used! One particularly impressive example is Chris Reid's study that demonstrated the plankton regime shift in the mid-1980s (discovered by SAHFOS) was indeed a truly global phenomenon. It correlated with shifts in other climate indicators such as onset of cherry blossom in Japan to the arrival of sand martins in the UK. We are also starting to make progress with our instrumentation programme and use of molecular tools; both areas designed to increase the utility of the CPR and help shape the future of the CPR Survey.

Consistent with our aim to be a Centre of Taxonomic Excellence, we continue to run our ever popular taxonomic workshops. The workshops ensure that the taxonomic identification of plankton does not become a dying art, they have the added bonus of increasing the international pool of collaborators that we hope will continue to work with SAHFOS in the future.

Finally I want to mention what has been described as the most significant event in human history. France chaired and hosted the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21/CMP11), from 30 November to 11 December 2015. The result of the Conference was a new international agreement on climate change, applicable to all, to keep global warming below 2°C. There was a consensus between 195 countries on the need to cut greenhouse gas emissions; such a consensus in itself is extraordinary. Clearly there are significant challenges ahead for the planet if we are to achieve the goals set out in this historic agreement. You should know that SAHFOS played a part in these negotiations, Professors Chris Reid and Martin Edwards both attended and Chris gave a talk at Paris, and who knows, they may even have helped to convince some of the doubters by presenting world-class research on the impacts of climate change.
I like to think so. Well done Chris and Martin!

View From Citadel Hill

Our People

Length of Service	Number of Staff
<1 Year	5
1-5 Years	9
5-10 Years	9
10-20 Years	11
>20 Years	8

Admin 18%
Operations 20%
Researchers 24%
Analysts 28%
IT 4%
Instrumentation 6%

Males 49%
Females 51%

Board of Trustees

Prof Peter Liss, CBE, FRS (Chair)
Professor Geoff Boxshall FRS
Mr Richard Coombs
Ms Beth Greenaway
Prof Paul Hart
Prof Patrick Holligan (Vice Chair)
Mr Rob Hubble FCA (Treasurer)
Prof Jan Pentreath
Prof Peter Wiebe

Science Advisory Board

Prof Patrick Holligan (Chair)
Prof Geoff Boxshall FRS
Prof Martin Edwards
Dr Petter Fossum
Dr Erica Head
Dr Stephanie Henson
Dr Graham Hosie (until April)
Dr Caron Montgomery
Prof Peter Wiebe
Dr Willie Wilson

SAHFOS Staff in 2015

Prof Nicholas J P Owens. Director until 31 Aug

Dr William H Wilson. Director from 1 Sep

Mrs Gill Tanner. Director of Business Administration

Roger Barnard
Marine Engineering Technician

Dr Sonia Batten
Pacific CPR Project Co-ordinator

Kate Brailsford
Administrator & Shipping Clerk

Derek Broughton
Software Developer (from Nov)

Gemma Brice
Plankton Analyst

Martina Brunetta
Technician & Plankton Analyst

Clare Buckland
Plankton Analyst

Dr Dave Conway
Contract Taxonomist

Scott Calnon
Database Developer (until Aug)

Rob Camp
Plankton Analyst & Instrumentation Technician

Dr Claudia Castellani
Research Fellow & Plankton Analyst

Alec Colebrook-Clark
IT Support & Web Developer (until May)

Prof Martin Edwards
Chief Scientist

Dr Astrid Fischer
Plankton Analyst, Technical Secretary to NMBAQC & Laboratory Assistant

Dr Eric Goberville
Research Associate (until October)

Dr George Graham
Marine Instrumentation & Data Scientist

Lance Gregory
Operations Manager

Nick Halliday
Contract Taxonomist

Chris Harris
Marine Engineering Technician

Dr Pierre Hélaouët
Research Fellow

Linda Horsfield
Administrator & Operations Assistant

Usha Jha
Plankton Analyst

David Johns
Laboratory Manager & Plankton Analyst

Tanya Jonas
Senior Taxonomist (until Nov)

Dr Priscilla Licandro
Research Fellow

Dr Abigail McQuatters-Gollop,
Science & Policy Research Fellow (until Aug)

Doug Moore
Plankton Analyst (Canada)

Julian Morley
Marine Engineering Technician

Jean Nyman
Finance Officer

Capt Peter Pritchard
Head of Operations (until May)

Prof Chris Reid
Senior Research Fellow

Nicola Rickard
Fundraising & Publicity Manager

Dr Katrin Schmidt
Plankton Analyst (from April)

Jennifer Skinner
Plankton Analyst, Public Engagement & Education Officer

Marion Smith
PA to Director & HR Manager

Dr Rowena Stern-Kluckner
Molecular Plankton Ecologist

Darren Stevens
IT Manager

Claire Taylor
Plankton Analyst & *Assistant Laboratory Manager*

Dr Anthony Walne
Plankton Analyst (until March) & *Instrumentation Technician*

David Wilson
Ships Liaison Officer (from July)

Marianne Wootton
Deputy Senior Taxonomist (Senior from Nov)

Claire Wotton
Plankton Analyst

Distinguished Honorary Fellows

Dr Bob Dickson CBE
Prof Robin Pingree
Prof Franciscus Colijn
Dr Paul Dowland
Dr Arnold Taylor
Dr Luigi Vezzulli

Emeritus Life Fellow

Dr Graham Hosie

Research Fellows

Dr Gregory Beaugrand
Dr Anthony Richardson
Dr Declan Schroeder

SAHFOS Staff January 2016

Operations

Lance Gregory

SAHFOS is greatly appreciative and indebted to the international shipping community, the ships' masters and their crews who assist with our survey. We are also supported by some fantastic shore side staff, who are a crucial link in our logistics chain. If any of you should find yourselves in Plymouth then please contact us and we would be delighted to host you on a tour of our laboratory and workshop, so you can see the next stage after your efforts of this worldwide survey.

2015 started with the departure of Peter Pritchard. Peter was a passionate and dedicated member of staff who had completed 23 years of sterling service to the CPR survey. We wish Peter well with his retirement plans.

SAHFOS was fortunate enough to recruit David Wilson in the role of Ships Liaison Officer. David comes to us with a wealth of marine experience. We were also pleased to recruit Kate Brailsford as a Shipping Clerk.

Kate has a background in and extensive knowledge of the oil shipping industry. Together with Linda Horsfield, Operations Assistant, the three quickly became an effective team running our Operations Office.

Ship changes

2015 saw many ship changes, where we welcomed back some old friends. We are also extremely grateful to the two new companies who have agreed to tow the CPR for our long standing survey (AAL and Marine Supply A/S).

Visiting the ports and our volunteer ships is always a pleasurable experience where our operations staff get to meet and thank the many supporters of our survey.

During 2015 we were fortunate to be able to visit many of the ports and ships and we plan to continue this programme of visits in to 2016.

Ship changes

C- route	The *Freesia Seaways* kindly agreed to tow this route after many years of towing the LG route. However from November the C- route has been towed by the *Petunia Seaways* due to a fleet rotation.
E & D routes	After many years of service we said goodbye to the *ACL Companion* and now welcome the *ACL Cartier* to our fleet of volunteer ships.
HE route	The *Clipper Point* sailed off to a new charter and we are thankful to the *Hafnia Seaways* for the continuation of this route.
LG route	With the *Freesia Seaways* now towing the C- route we welcome back the *Petunia Seaways* now towing the Ghent to Gothenburg route. With the fleet rotation the *Freesia Seaways* resumed the LG route in November.
R- route	After many years of towing the CPR it was sad to see the *Flandria Seaways* go. We are again very grateful for all the efforts of the *Anglia Seaways* in resuming this tow.
ST route	Late in 2014 the *Green Frost* came off charter. We are thankful to Marine Supply in Tromso for permission to tow from the *Norbjorn* on our most Northerly route.
VJ route	We are grateful to Austral Asia Lines and their North American representative for permission to tow what is our longest route from the *AAL Melbourne*. We say a fond farewell to *Skaubryn* who has towed this route for many years.

Liaising with our ships

David Wilson

David Wilson joined the Operations Team in July 2015. He brings a wealth of life at sea to the job of Ships Liaison Officer. Dave maintains regular contact with all the ships that tow the CPR for SAHFOS and also the shoreside teams that fulfil the important job of getting the CPRs on and off the ships.

He leads on the logistics' chain and as point of contact with ship owners and ships' management and agents. When a tow route loses a ship or a new route is implemented, Dave researches the alternatives and negotiates with the shipping lines in order to effect a successful replacement or a new ship. When a new ship comes on stream, Dave will visit tow crews and conduct any necessary training.

Linda Horsfield

Linda Horsfield joined as Operations Assistant in February 2014. She processes the tow record sheets by entering the information on Console, pays the ships, creates Console reports and updates the record sheets with report details.

Linda has worked at SAHFOS for 10 years in the Administration Office but working for the Operations Team has put a whole new perspective on her role within the Foundation. Linda says "I now realise the importance of the work carried out by the Workshop and Operations Department as without their contribution there would not be any tows, nor plankton to analyse and no research to carry out! I find it interesting to see where the ships have towed as it brings home the truly global nature of the Survey".

Kate Brailsford

Kate Brailsford joined the Operations Team as Shipping Clerk in July 2015. She has previously been at SAHFOS for 3 years as a member of the Administration Team and decided to spread her wings within the company. Due to her previous experience within the fuel and oil Industry she possessed all the necessary skills in transport and logistics, and also has knowledge in the transport of dangerous goods.

Kate thoroughly enjoys the interaction with all concerned from personnel at the ports, who ensure our yellow boxes are placed on the ship, through the Captains and Crew who tow the CPRs for us. Kate says "It is a challenging job where we must not sit on our laurels; there is always a CPR to send or a tow log to process"!

The CPR continues to go global

At SAHFOS we always enjoy the opportunity to show off our organisation. One of the best ways to do this is when we have the opportunity to hold technical courses for visiting Scientists and Technicians.

Our courses are recognised by IMarEST, are tailored to suit individual requirements and can cover all operational and logistical aspects of running a CPR survey from both vessels of opportunity and research ships.

During 2015 we ran three separate courses. The first being for Prof Maarten Boersma, who subsequently has operated a CPR on a transit from Germany to South Africa from the Research Ship *Polarstern* (page 11).

Later in the year we ran two courses in conjunction with each other. We were fortunate enough that Lewis Cowie, a fisheries biologist with the British Antarctic Survey (BAS) operating from South Georgia was able to come to SAHFOS for an intensive week. Lewis will be looking after the CPR on our SF route which is a joint SAHFOS / BAS route in the South Atlantic.

Whilst Lewis was at SAHFOS we also ran a two-week course for Prof Erik Muxagata from Instituto de Oceanografia - Laboratório de Zooplâncton in Brazil and Mark Tonks from CSIRO, Australia. Both Mark and Erik are working with SAHFOS sister surveys using volunteer ships. Their course covered not only CPR maintenance but also all the skills and logistical knowledge to run such a survey efficiently and safely.

Supporting sister surveys

A continuing task of the Operations team at SAHFOS is to provide ongoing support for our sister CPR surveys. This support can take the form of ongoing technical or logistical advice, supply of complete CPRs and spares, or supplying prepared silks.

This year we have supported sister surveys and scientists from France, Australia, Brazil, Cyprus, Japan, South Africa, Norway, Germany and New Zealand.

Workshop

2015 has again been a busy year. This year we have towed 132,152 nautical miles and achieved 92.6% success rate, once again proving that the CPR is Cost effective Proven and Reliable and provides good value for money. As one of our more poetic members of staff put it: “To monitor the Ocean at the least expense, the plankton survey makes common sense”.

Silk preparation is a very time-intensive part of what we do. We import on a yearly basis a supply of silk from China. The silk initially undergoes a quality check here at SAHFOS, to ensure not only correct mesh size, but also thread diameter and weave type. This ensures a consistent methodology across the decades. This year alone we processed 1,285 square meters of silk that corresponds to 7km in length. The silk is prepared to a meticulous standard by our in-house team. This plays no small part in ensuring our high sampling success rate with the CPR, with “CPR jams” being kept to a minimum.

Our CPR fleet currently stands at 54 bodies and 118 internals. This fleet together with the ancillary gear, such as tow equipment, are maintained to a high standard by a small but dedicated team of technicians here at SAHFOS.

2015 has been a challenging year of change for the operations staff. The team has adapted well, and all members have gone the extra mile to ensure we consistently meet our targets. The new members of the team settled in quickly and efficiently. We look forward to the opportunities and challenges that our survey will present us in 2016.

Our Training Testimonials

Maarten Boersma

I am about to go on a cruise with the *Polarstern* from Bremerhaven to Capetown. During this training cruise we are planning to deploy the CPR en-route. To be able to do this, I had the immense pleasure to spend a week in the capable hands of the highly professional crew and was taught almost everything there is to know about the Continuous Plankton Recorder. In their certified course they took me through all the steps, and literally showed me the ropes of how to deal with the on-board workings of the CPR. I was shown how the silks were made, and taught how the internals were loaded, unloaded and cleaned, and how to deal with the body of the CPR once it comes out of the water. I left SAHFOS feeling very confident that I know what to do and how to deal with potential snags. The level of professionalism, care and commitment of the Operations Department of SAHFOS are truly admirable.

“The level of professionalism, care and commitment of the Operations Department of SAHFOS are truly admirable”

Erik Muxagata

With the recent acquisition of a CPR the Brazilian CPR program is about to start. Prof Erik Muxagata from the Federal University of Rio Grande came down to Plymouth to undertake the CPR Technician Course. “The course is really helpful and gives an overall and comprehensive coverage on all aspects related with the CPR operations, including maintenance and troubleshooting of the CPR internals and body, sorting all problems to get the CPR ready for the next deployment. The operational staff are amazing guys; really friendly with a great passion and dedication for the CPR research. I think this course is really important for all new and on going CPR programs to have an idea on the history and the people behind it that keep the Continuous Plankton Recorder sampling going.”

Mark Tonks

The SAHFOS Continuous Plankton Recorder workshop was comprehensive, interesting and informative. Over two weeks, the expert staff provided a supportive and enthusiastic environment in which theory and practical sessions were used to teach every aspect of the CPR Survey. After completing this course you should walk away knowing how to set up and service the CPR equipment in order to collect and store effective plankton samples and associated data. Other aspects of the workshop include advice on liaising with shipping companies and importantly taking precaution to safely protect, to the best of our ability, everybody associated with the Survey. If you are starting up a CPR survey this workshop is a must! For those with some experience you will also find it extremely useful. Thank you to all at SAHFOS for a great experience!

Lewis Cowie

In November 2015 I moved to South Georgia to work as a fisheries biologist with the British Antarctic Survey, as part of my job I will be helping run the Continuous Plankton Recorder route from South Georgia to the Falklands aboard the fisheries protection vessel *Pharos SG*. Prior to my deployment I went on a week long CPR training course at SAHFOS. I had no previous experience with the CPR so I can honestly say the course has been invaluable. The workshop staff are all extremely knowledgeable and genuinely enthusiastic about the project; this helped immensely and made the course extremely enjoyable. I now feel confident that I can carry out the CPR work in South Georgia and know that the guys are always there to help if anything goes catastrophically wrong! Anyone planning to use the CPR should definitely consider this course at SAHFOS, I cannot recommend it highly enough.

“Thank you to all at SAHFOS for a great experience!”

Erik Muxagata and Mark Tonks receiving training from Workshop Technician Chris Harris

“The operational staff are amazing guys; really friendly with a great passion and dedication for the CPR research”

Lewis Cowie working on a CPR in South Georgia

“Anyone planning to use the CPR should definitely consider this course at SAHFOS, I cannot recommend it highly enough”

Pacific Sampling Operations

Sonia Batten

After involvement in the Pacific Survey since its inception in 2000, Seaboard International closed its doors in 2015 and we had to find another vessel to tow the VJ route. It was a bit of a scramble but in the end Austral-Asia Lines agreed to let us use the AAL *Melbourne* on her route from Vancouver to Asia and a tow point was fitted just prior to her departure at the end of June.
However, it was not smooth sailing from then on. The Northeast Pacific has been unusually warm these last two years which may have contributed to some increased storminess. The AAL *Melbourne* deviated from its typical great circle route soon after leaving the shelf in June and sailed much further south than usual (no sampling in the Bering Sea). This was the first time in 16 years that the summer transect did not follow the typical route. Furthermore, the autumn tow also experienced bad weather, to the extent that the CPR had to be recovered at the exit to the Bering Sea, and not re-deployed again for some distance, another first for the Pacific Survey. We are grateful to the AAL *Melbourne* for their help in maintaining the VJ route and we hope for calmer seas in 2016!

The *Horizon Kodiak* continued to tow the AT line through 2015, although a dry-docking in early September compressed the sampling season somewhat and the last three tows were closely spaced (3 tows within 5 weeks). This will give us an opportunity to look at shorter term variability once the samples are analysed, especially since the spatial coverage is extremely consistent between tows.

New to the VJ route this year: the AAL *Melbourne*

The Nexen oil platform in the North Sea

Nexen

SAHFOS continued its close links with Nexen, a gas and oil company, during 2015.
During the year SAHFOS provided data from a route close to Nexen's area of operation, and a report on the plankton in the area. As SAHFOS has almost 60 years worth of data from the region, the seasonality of potentially nuisance plankton taxa can be examined, and with monthly tows continuing, rapid updates on plankton blooms can be provided. We plan to continue our work together into the future, with potentially new monitoring and prediction capabilities.

132,152	92.6%	1285
nautical miles towed	success rate	square meters of silk produced

Operations key statistics

A Floating Summer School

Maarten Boersma

In November 2015, the North South Atlantic Transect floating summer school on board RV *Polarstern* sailed from Bremerhaven in Germany to Cape Town, South Africa. The summer school was designed to provide participants with a thorough insight into the fundamental principles of biological oceanography.
The emphasis was 'hands on' practical experience and included sampling (Continuous Plankton Recorder, XBTs, Rosette sampler with CTD sensors, Bongo net, Ferrybox), sample processing (phytoplankton, zooplankton, and ocean chemistry), analysis of samples, data acquisition, along with incubations and growth experiments.
The practical work was supported by on-board lectures, discussions, practical exercises, data workup sessions and peer-led presentations.

The survey aimed to investigate and characterise the different regimes, biomes and the ecological geography of the Atlantic Ocean

The cruise covered a large biogeographic range with different hydrographic regimes. The NoSoAT survey aimed to investigate and characterise the different regimes, biomes and the ecological geography of the Atlantic Ocean. The survey brought together international participants through collaboration between the Alfred Wegener Institute, the Strategic Marine Alliance for Research & Training and the Partnership for Observation of the Global Oceans.


(Photo P. McGrane)

During the whole cruise we deployed the CPR, which we had on loan from SAHFOS, with the specific aim to introduce the participants of the summer school to the device. All of the students were taught how to load the internals, check the body and deploy the instrument. This was a great success, because whereas many of the participants had actually heard and read about the Continuous Plankton Recorder, only a few had seen it, and none had had the opportunity to actually work with the instrument. For me, Maarten Boersma, this was the perfect opportunity to test whether the CPR could be safely deployed from *Polarstern*, how much interference we would have with other activities on board, and the level of supervision needed to deploy the instrument on a regular basis. The whole cruise was a great success. The instrument was in the water for over 6000 miles without a hitch, and we are now investigating the possibility of making the CPR deployment a more permanent activity during *Polarstern* cruises.

I thank all the staff at SAHFOS for their great support and professional help. It was a pleasure to work with you all, and I am looking forward to continuing this in the future.

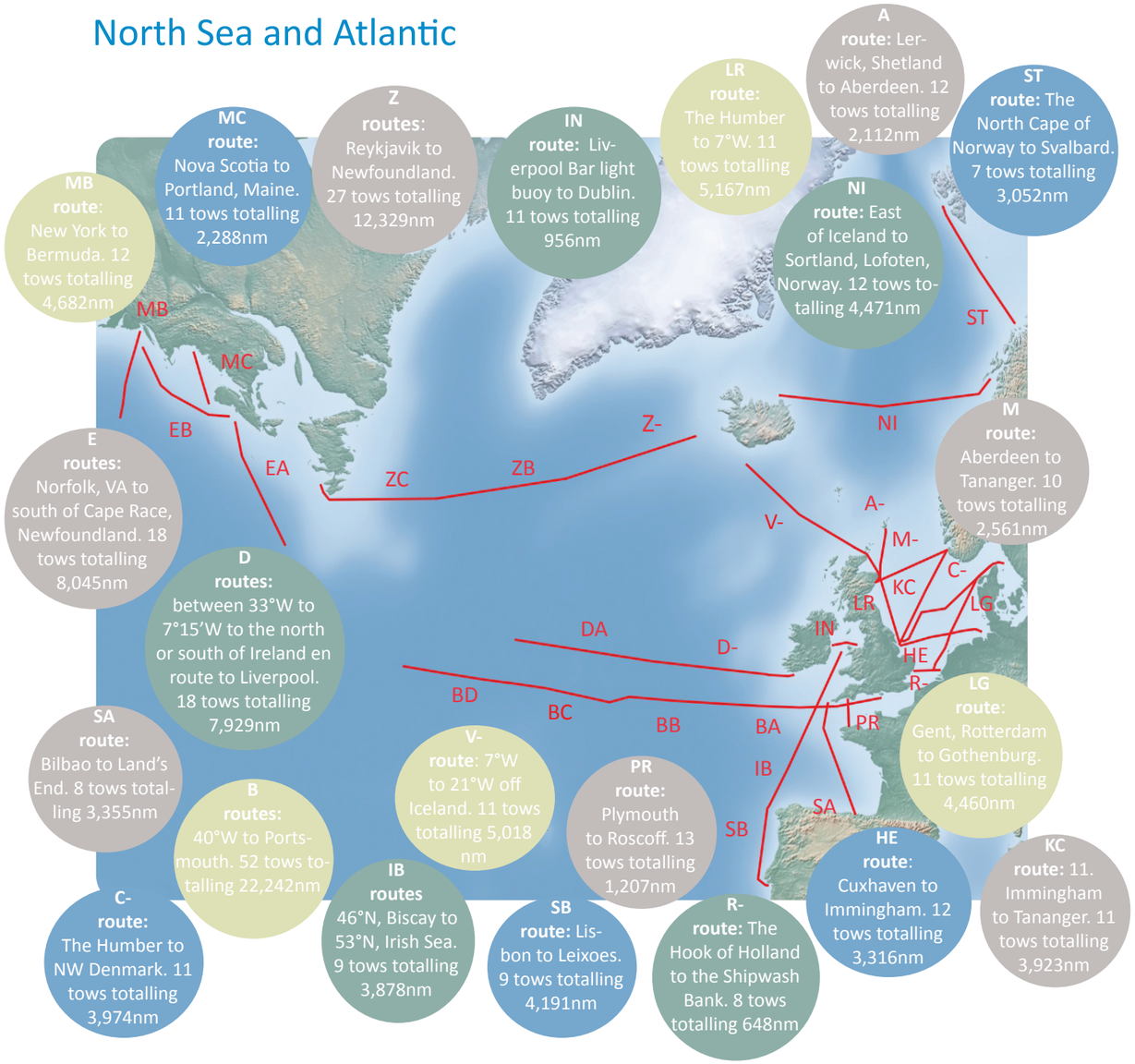
The CPR was in the water for over 6000 miles without a hitch

(Photo M.Boersma)

(Photo: M.Boersma)

Top right: Checking the CPR after coming on board, left: Hugo Maxwell from Ireland loading the silk into an internal, right: Deployment of the CPR from RV *Polarstern.*

North Sea and Atlantic



A route: Lerwick, Shetland to Aberdeen. 12 tows totalling 2,112nm

LR route: The Humber to 7°W. 11 tows totalling 5,167nm

ST route: The North Cape of Norway to Svalbard. 7 tows totalling 3,052nm

MC route: Nova Scotia to Portland, Maine. 11 tows totalling 2,288nm

Z routes: Reykjavik to Newfoundland. 27 tows totalling 12,329nm

IN route: Liverpool Bar light buoy to Dublin. 11 tows totalling 956nm

NI route: East of Iceland to Sortland, Lofoten, Norway. 12 tows totalling 4,471nm

MB route: New York to Bermuda. 12 tows totalling 4,682nm

M route: Aberdeen to Tananger. 10 tows totalling 2,561nm

E routes: Norfolk, VA to south of Cape Race, Newfoundland. 18 tows totalling 8,045nm

D routes: between 33°W to 7°15'W to the north or south of Ireland en route to Liverpool. 18 tows totalling 7,929nm

SA route: Bilbao to Land's End. 8 tows totalling 3,355nm

B routes: 40°W to Portsmouth. 52 tows totalling 22,242nm

V- route: 7°W to 21°W off Iceland. 11 tows totalling 5,018 nm

PR route: Plymouth to Roscoff. 13 tows totalling 1,207nm

LG route: Gent, Rotterdam to Gothenburg. 11 tows totalling 4,460nm

C- route: The Humber to NW Denmark. 11 tows totalling 3,974nm

IB routes 46°N, Biscay to 53°N, Irish Sea. 9 tows totalling 3,878nm

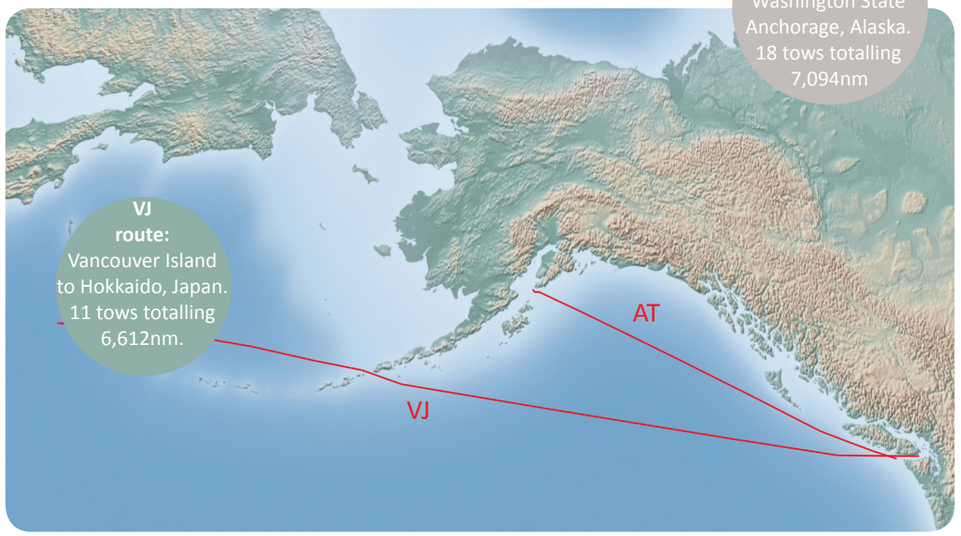
SB route: Lisbon to Leixoes. 9 tows totalling 4,191nm

R- route: The Hook of Holland to the Shipwash Bank. 8 tows totalling 648nm

HE route: Cuxhaven to Immingham. 12 tows totalling 3,316nm

KC route: 11. Immingham to Tananger. 11 tows totalling 3,923nm

Pacific



AT route: Tacoma, Washington State Anchorage, Alaska. 18 tows totalling 7,094nm

VJ route: Vancouver Island to Hokkaido, Japan. 11 tows totalling 6,612nm.

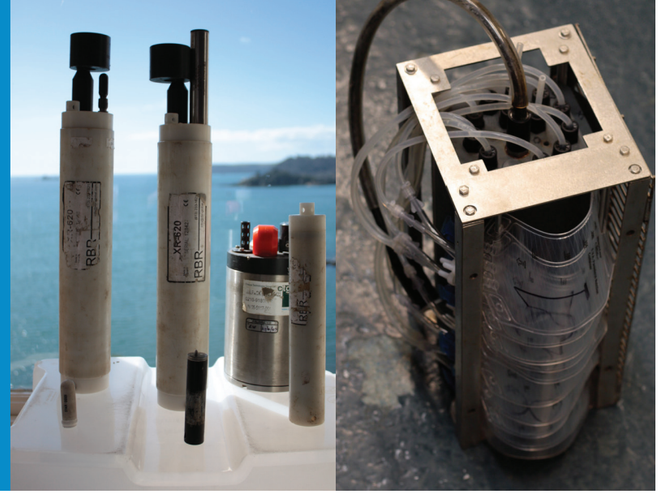
Southern Ocean

SF route: completed double tows from Stanley to South Georgia. 6 tows over 2,167nm

132,152 nautical miles were towed in 2015

The CPR Survey on this scale would not be physically or economically possible without the generous support of ships, owners, charterers, managers, port operatives and agents. We are extremely grateful to all those involved, helping SAHFOS in all its operational activities – we could not do it without your continuing support.

Instrumentation



Measurement Capabilities aboard the CPR – an update

George Graham, Anthony Walne and Robert Camp

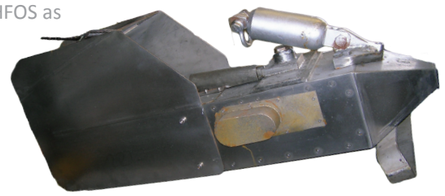
As part of our mission to capture the immediate environmental context for plankton samples and develop an integrated ocean monitoring platform, this year the Instrumentation Team has been developing and deploying bespoke sensing technology on board the CPR.

A significant amount of work has gone into developing and testing measurement instrumentation this year. Our primary focus has been on a sensing unit for conductivity, temperature, depth and chlorophyll-*a* fluorescence (Fig. 1). These instruments collect measurements at 1Hz on submergence and then transmit their data wirelessly to SAHFOS on emergence at the end of a tow. This capability is exciting since the Instrumentation Team no longer have to wait for the physical return of an instrument in order to examine the data. Analysis of the measurements can begin within minutes of the completion of a CPR tow, and we can gain insights about the physical environment and proxies related to the phytoplankton population well in advance of the CPR samples returning to the Laboratory. Conductivity is used to derive (a measure of) ocean salinity and combined with temperature and fluorescence parameters will provide us with *in-situ* information into the dominant environmental forcing on plankton distributions.

On our CPRs we can now measure: ocean salinity, temperature, depth, light Intensity, turbidity & chlorophyll-*a* fluorescence

Last year we reported some tests of a prototype instrument. This year, in collaboration with Valeport Ltd, we have been calibrating the temperature and salinity sensors of instruments to ensure the measurement quality, and physically testing their capabilities on our cross-Channel route (Roscoff Plymouth).

Figure 1. The CPR with CTD+F telemetry is fitted to the dive plane of CPR. It measures conductivity, temperature, depth, light intensity and fluorescence, the instruments have a rechargeable power system and offload data directly to SAHFOS as soon as a tow is complete.

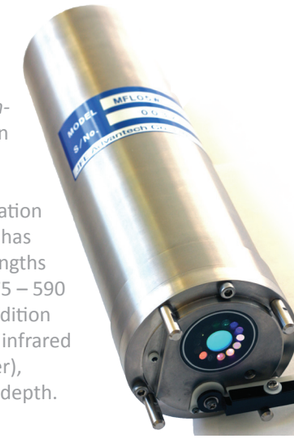


The results of these tests are extremely good. As an example, comparison of the calibrated instruments with the 'industry standard' measurements made by the on-board FerryBox from a single channel crossing are shown in Figure 2. Variation in salinity during the channel crossing is reported identically by both the CPR and FerryBox. This is a really good outcome, the calibration has removed the offset which we reported last year, and we are able to make reliable salinity measurements from the CPR. There is an offset in temperature (-0.5°C) between FerryBox and CPR which may be associated with the different sampling depth of the two systems. We're currently conducting some further validation work to investigate these differences. The temporal temperature signal indicates three distinct water masses separated by abrupt increases or decreases in temperature, with finer scale variations superimposed on top. These abrupt changes are ocean temperature fronts, which the CPR is able to resolve well. Chlorophyll-*a,* fluorescence from the CPR, is currently un-calibrated, but the signal tracks the temporal structure in the FerryBox measurements. The fluorometer provides a useful tool for identifying periods of relatively high or low fluorescence and may indicate periods of high phytoplankton concentration. Both the fluorometer and conductivity cell on the CPR are susceptible to contamination by bubbles, from the vessel wake, and there has been much concern about the quality of measurements that can be made from the CPR. The example results in Figure 2, and subsequent data we have collected, show no evidence of bubble contamination. The data quality is so good, that no post-processing is required to screen for bubble related artefacts. All 10 CTD+F instruments are now routinely deployed on routes across the Channel, North Sea and North East Atlantic and we are developing information products based on the incoming data stream.

Data are instantly wirelessly transmitted to SAHFOS as the CPR leaves the water

The structure evident in the fluorescence will be the focus of on going research activity when we link the *in-situ* optical proxy for chlorophyll-a with direct measurements made by the CPR. The optical signal has the potential to provide a rapid indicator of phytoplankton abundance. To further investigate this structure and quickly discriminate between groups of phytoplankton we will be deploying a number of multispectral fluorometers (Fig. 3) which are capable of classifying Cyanophyceae, Bacillariophyceae and Chlorophyceae based on their *in-situ* excitation spectra. This technology will provide us with the capability of rapidly identifying Harmful Algal Blooms and the ability to direct taxonomic expertise to samples of interest in advance of their arrival at the lab.

Figure 3. A multi-spectral fluorometer for *in-situ* determination of phytoplankton groups based on their optical excitation spectra. This unit has 9 discrete wavelengths over the range 375 – 590 nanometers in addition to turbidity (near infrared optical backscatter), temperature and depth.



Instruments are now routinely deployed on routes across the Channel, North Sea and North East Atlantic and we are developing information products.
Contact geogra@sahfos.ac.uk to find out more.

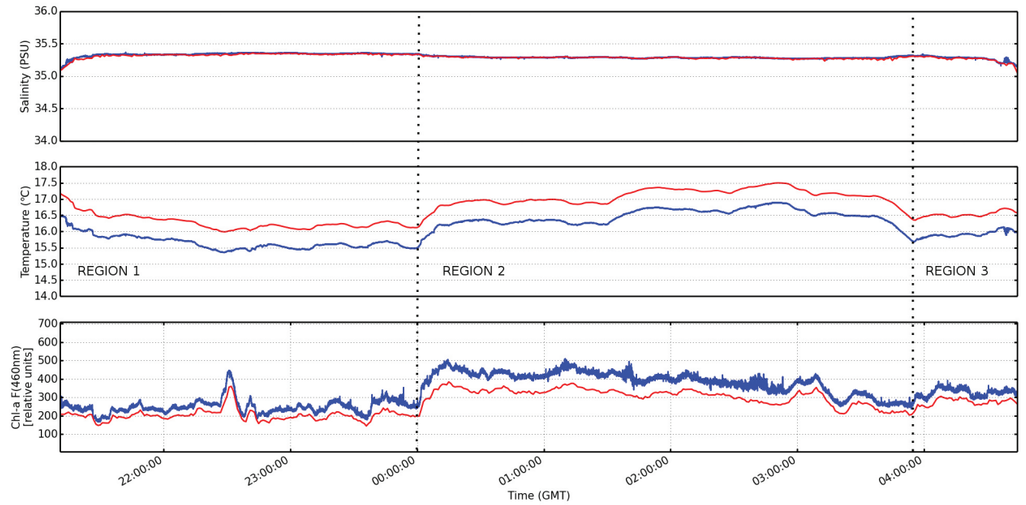


Figure 2. Time series of salinity, temperature and chlorophyll-*a* fluorescence obtained from CTD+F instrumentation aboard the CPR (1Hz, blue lines) and a FerryBox (0.017Hz, red lines) during a transit from Roscoff to Plymouth on 26th August 2015. The temperature field can be split into three regions based on abrupt variations (dotted vertical lines) and fluorescence is reported un-calibrated in relative units.

Where on Earth is that CPR?

Robert Camp, Anthony Walne and George Graham

To maximise impact of the new genetic and physical datasets SAHFOS is creating, it is important to enhance CPR tow positioning accuracy, and at the same time increase efficiency of a number of SAHFOS processes. Both SAHFOS researchers and external data requests will benefit from increased spatial and temporal accuracy, allowing CPR data to be more easily combined with satellite, glider, float and other Ships of Opportunity (SOOP) datasets. Knowing SOOP movements outside of CPR tows allows SAHFOS to investigate potential new routes without having to train new ship's crews, SAHFOS gains advanced warning should a vessel be delayed or be forced to deviate from its expected track and estimated time of arrival information improves CPR delivery and return logistics.

A ship's transponder uses a VHF transmitter to broadcast information on its location and course

Understandably for a survey that started back in 1931, recording tow information by the SOOP was originally an entire paper exercise, with shoot and haul positions and times calculated using a chart and marine timepiece, recorded on a paper log, and returned to SAHFOS inside the box containing the CPR. Nowadays, times and positions are usually recorded from the ship's bridge GPS, but still entered onto a paper log form (Fig. 4) – although this is then emailed back to SAHFOS so checking can begin, without having to wait for the CPR to return.

SAHFOS can take advantage of these data to improve accuracy and efficiency of a number of processes

Any queries with the information recorded on the tow log are difficult to resolve without creating extra work for the ship's crews, something SAHFOS always strives to avoid. More importantly, any transcription errors could mean a CPR is deployed but the data cannot be used. Internal QC generally prevents this from happening, but advances in ship-tracking technology could provide a simpler and more reliable solution.

Office use only			
Route No.		Mech	
Route ID		Prop.	
Validity		Start	
Date		Stop	

Name of Ship.....SOPHIA..... Route From....SETUBAL.....

Master.....ION, ADRIAN..... To....Latitude: 46° N.....

Writer of Log....Officer of the watch..... Rank....OOW.... Filter Mech. No 22/0.....

Date	Time	Operation			Position		Course	Distance	General Remarks
2014	GMT	Shot	Alt./ Co.	Haul	Latitude	Longitude			Wind/ Sea state/ Air °C/ Sea °C/ Cloud cover (1/8 etc.)
17.08	15:20	X			38°21'2N	009°05'5W	270°0	——	1014HPa; N-4; sea-3; 25°c; 2/8
17.08	15:54		X		38°21'2N	009°15'5W	302°0	7.8 nm	1014HPa; N-4; sea-3; 21°c; 2/8
17.08	18:15		X		38°38'8N	009°50'2W	000°0	32.5 nm	1014HPa; NNW-4; sea-3; 21°c; 1/8
18.08	14:15		X		43°11'9N	009°48'5W	024°0	273.1 nm	1016HPa; NNE-7; SEA-5/6; Air 21°c; 2/8
18.08	15:08		X		43°22'5N	009°41'5W	018°0	11.8 nm	1017HPa; NNE-7; SEA-6; Air 20°c; 2/8
19.08	02:38			X	45°56'1N	008°33'5W	018°0	161.1 nm	1018HPa; NNE-6; SEA-5; Air 17°; 1/8
								Total n.m.	486.3 nm

Figure 4. A paper log form showing times and positions; usually recorded from the ship's bridge GPS.

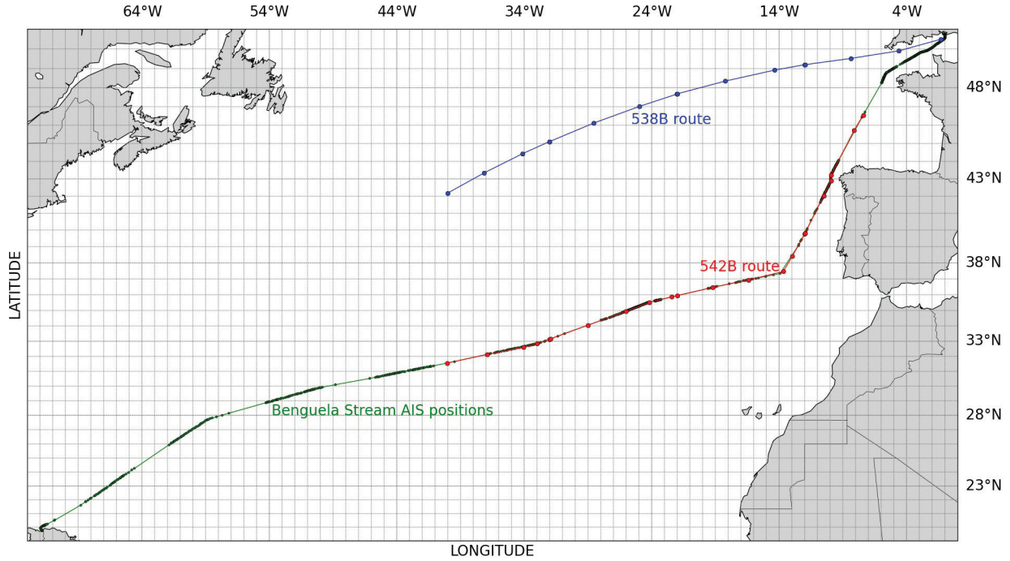


Figure 5 shows a good example of the benefits of utilizing AIS data. The *Benguela Stream* tows the B- route monthly, starting around 40°W 42°N. For the December 2015 tow, they were forced further south to avoid an Atlantic storm. With only the tow log data to go on, we may have queried the positions and asked the ship to confirm the data, but it shows good correlation with the AIS data and so we can confirm in-house that the tow log is correct.

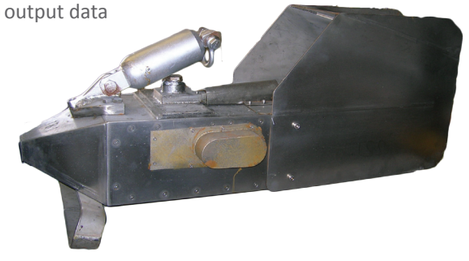
SAHFOS researchers and external data requests will benefit from increased spatial and temporal accuracy

A ship's Automatic ship Identification System (AIS) transponder uses a VHF transmitter to broadcast information to receive devices on other ships, land-based or satellite-based systems. Regular communications are sent and received, containing vessel identity and course, providing collision avoidance even when vessels do not have visual contact. SAHFOS can take advantage of this data to improve accuracy and efficiency of a number of processes.

For a number of years, CPRs have carried electronic instrument packages that can be used to verify the shoot and haul times provided on the tow log. Additionally, for more than a year, SAHFOS has been collecting AIS position data from a number of ships that tow CPRs and comparing this to the position information provided on the tow log. These two data sources can be combined and an alternative tow log created (Fig. 5), which can then be used to either confirm the accuracy of the paper tow log, or be used as an alternative to it.

There are additional benefits to generating the tow log using this method. Even if the tow log is accurate, this data is used to complete a paper log, emailed to SAHFOS, and manually inputted into our database. Transcription errors can occur when completing the log and when transferring the log to our database, each step requires ship's crew or staff time.

A fully electronic system can create a tow log without transcription errors, from the most accurate data sources currently available to SAHFOS. Because this data is machine readable, we can develop automatic database entry and reduce staff and ship's crew time to output data products.



Depth and Orientation of the CPR

Anthony Walne, Rob Camp and George Graham

The CPR is a fixed-depth sampling instrument, but the effect of payload and ship speed on depth and filtering is not known. We describe here measurements of the CPR sampling depth made during the routine monthly deployments of a CPR on the Roscoff to Plymouth route in 2015. We used a StarOddi instrument on the CPR towed from Roscoff to Plymouth (the PR route) to measure the tow depth, pitch and roll of the CPR. Tow speed was estimated from AIS data. All the monthly deployments used the same CPR, which also carried a Water and Microplankton Sampler (WaMS). There were 12 tows in 2015 at approximately monthly intervals, plus an additional tow to test equipment in August. Eleven of these tows were on the Brittany Ferries vessel MV *Armorique* and two with the MV *Bretagne*. In addition there was a test tow with the laboratory vessel MBA *Sepia* in September. To investigate the variability of depth with speed, each tow was divided into segments identified by approximately constant speed. For each segment, the average and standard deviation for CPR depth and pitch was calculated (Fig. 6). Previous studies had suggested that an increase in tow speed had little effect on tow depth, but this study showed that the CPR appears to have a minimum tow depth at about 12 or 13 knots and tows deeper at speeds above this.

We used a StarOddi instrument on the CPR to measure the tow depth, pitch and roll of the CPR

A 10 nautical mile CPR sample is assumed to filter 3m^3 of seawater, with this volume calculated from the area of the entrance aperture (1.61cm^2) multiplied by 10nm. If, however, the CPR was not towing with a level orientation, then the volume swept by an inclined entrance aperture would be reduced and the plankton density greater than that inferred from level flight. We investigated the orientation of the CPR in relation to tow speed. Zero pitch corresponds to the CPR body in a level orientation and a positive pitch is when the front of the CPR is elevated. The normal orientation of the CPR, when on land resting on its protective fender, has a pitch of +5°. Results suggest that between 12 and 23 knots, pitch increases with speed. However at the lower speeds experienced on the *Sepia* the pitch again increases. These results suggest that the optimum speed for towing a CPR is at about 12 knots, when the sampling depth will be about 8m and the CPR will have an orientation close to level.

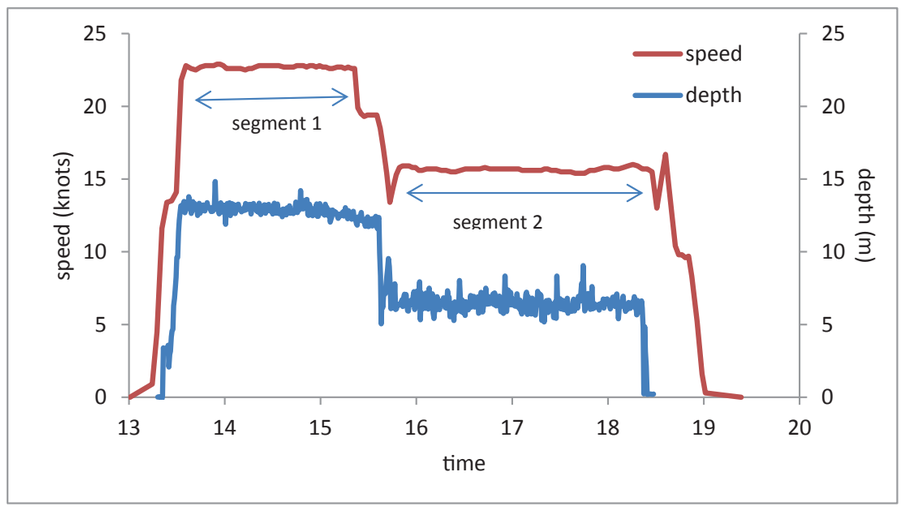


Figure 6. An example CPR tow (397PR 17/6/2015) showing variability of depth with speed. Two segments where speed was approximately constant have been identified .

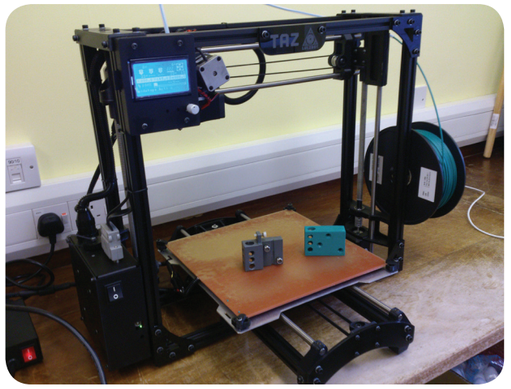
What is the effect of the increased pitch on filtered volume? Data have shown that with a deviation in pitch, there is a reduction in filtered volume, with a pitch of 20° equating to a 93% of theoretical maximum filtered volume. These results are surprising in showing the CPR 'flies' at a greater depth and steeper angle (more 'nose up') as the tow speed increases. Previous work found a mean towing depth of 6.7m, independent of tow speed. These studies were limited to a maximum speed of 17.1kn. Our findings challenge the assumption that faster vessels will tow the CPR closer to the surface and that this can be counteracted by towing on a longer cable. However even at the higher speeds, the inclined CPR presents an entrance aperture that should allow a filtered volume of >90% of the predicted 3m^3. Our observations were all made with the same CPR (instrument 192) whilst carrying the WaMS in the cargo bay. Future work will be to carry out similar measurements without the weight of the WaMS, and on other CPRs with/without the WaMS in the cargo bay.

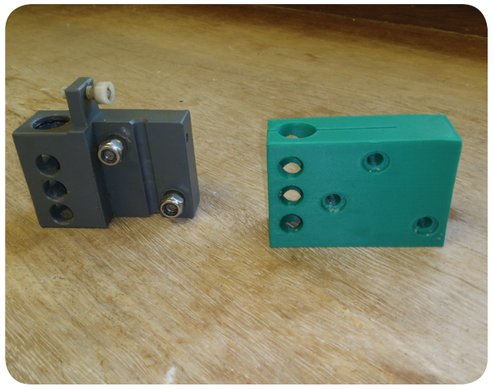
The results suggest that the optimum speed for towing a CPR is at about 12 knots, when the sampling depth will be about 8m and the CPR will have an orientation close to level

Instrumentation Updates

New 3D printer

The new instrument labortory houses a 3D printer which we will use for the in-house manufacture of instrument mounts and parts for prototyping new sampling mechanisms.



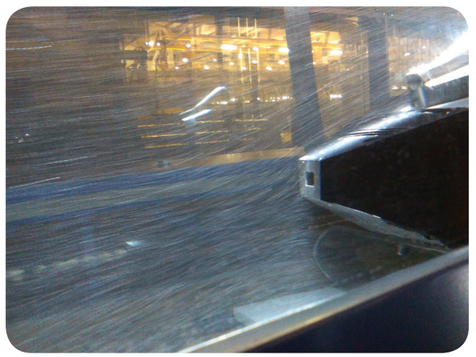


Left: The new 3D printer. Right: The green block on the right is a duplicate instrument mount and rapidly printed from our 3D printer.

Trialling a CPR in a laboratory flume

We recently trialled how adding additional instruments affected the water flow around a CPR. In collaboration with researchers at Plymouth University, and using facilities at the Universities COAST laboratory, we are able to look in depth at what happens to a CPR when underwater.

We are still in a trial phase, but have submitted a Technology Proof of Concept proposal to NERC to investigate further, watch this space for developments.



Information Technology

Darren Stevens

During 2015 a number of projects reached conclusion, the issuing of Digital Object Identifiers (DOIs) with all data requests is now a standard procedure, and an interface for internal researchers to request processed and raw data direct from the CPR database has been rolled out. SAHFOS also invested in a separate virtual domain for development and testing in accordance with our data protection policy. This equipment and software will be housed offsite, providing the additional functionality of Business Continuity in the event of a major incident.

Our data policy has been updated, the aim is to improve access to CPR data, foster closer collaboration between SAHFOS staff and the wider scientific community, whilst ensuring the continued traceability of CPR data use through correct citation.

In collaboration with Microsoft and Taurus, we have moved our email system into their cloud. SAHFOS is eligible as a Microsoft Qualified Non-profit Organisations. We would like to thank Microsoft for their support in providing this valuable service at no cost to SAHFOS.

GACS

The Global Alliance of CPR surveys (GACS) have established a Database Technical Team (DTT) which had its first meeting in October. At present the team are working on the structure of the database to include extra fields providing a clearer audit trail, and simplifying the process of updating the GACS database.

Website

The decision was taken in the final quarter of 2015 to outsource the design element of our web development to provide a fresh look for the website, with responsive design features accommodating the multitude of methods people now use to browse the internet. The new website is due to be launced in May 2016. If you have not visited recently check us out at www.sahfos.ac.uk

Derek Broughton

Derek is a Software Developer, with decades of experience in analysis, design and development in the IT field, and the last fifteen years in marine biodiversity. He has been with SAHFOS since November 2015. Previously he owned his own software business in Canada, providing contract work to various university-based projects (Canadian Healthy Oceans Network at Memorial University, St. John's; Ocean Tracking Network at Dalhousie, Halifax), the Centre for Marine Biodiversity, and the Canadian Department of Fisheries and Oceans. Before that he worked in banking and manufacturing, but found he preferred working with scientists.

Derek has a BSc (Computer and Information Science) from Athabasca University. At SAHFOS, he is currently working on a major revision of the CPR Console application and its associated database schema, and will be responsible for the software side of GACS.

Data Requests

David Johns

70 Data Requests

33 papers published

All datasets issued with **DOI**

Data requests from **Undergraduates** to **Goverments**

Countries requesting our data in 2015

Our database holds

>250,000

sample records

Every sample contains

Phytopankton and Zooplankton Information

We have

>175,000,000

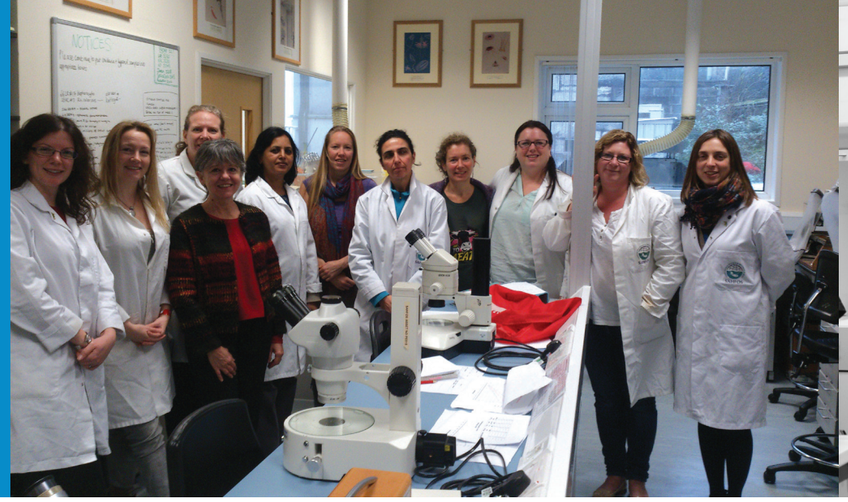
biological records

CPR data are available for *bona fide* research purposes, and further information can be found on our website at www.sahfos.ac.uk. SAHFOS can also provide assistance (expert knowledge and reports) for commercial ventures.

For further information contact David Johns djoh@sahfos.ac.uk

Analysis

David Johns and
Marianne Wootton



In 2015 more than 4000 samples from the North Atlantic and North Sea, Pacific and Southern Ocean were collected and analysed (Fig. 7). Being able to analyse plankton from such diverse seas and wide range of taxa gives SAHFOS analysts a very broad knowledge of pelagic plankton. In 2015, the previous year's data (2014) was fully quality-controlled and available to use by early July – the earliest point in the year so far, so a great effort by all the staff involved. As part of a commitment to help sister surveys through the GACS, SAHFOS has also continued to collect samples from the Gulf of Maine area throughout 2015, despite a the cessation of funding for their collection and analysis. These samples are currently stored awaiting funding to analyse them.

Staff

Sixteen CPR analysts (fourteen employees and two contractors) worked at the SAHFOS in 2015, including a new member of the team. Overseas we retain two analysts (Sonia Batten and Doug Moore) in Canada and a further three independent analysts (Sanae Chiba, Tomoko Yoshiki, and Yuka Sasaki) work in Japan. We have seen changes in staff with Tanya Jonas stepping down as Senior Taxonomic analyst, though still working part time as an analyst (the Senior Analyst is now Marianne Wootton), whilst Anthony Walne left the Analysis Team and is now working on a part-time basis with the Instrumentation Team. In 2014 Martina Brunetta joined the Analysis Team and following a successful period of intensive training, is now a core member of the North Atlantic Analysis Team.

After several years of experience in North Atlantic analysis Jennifer Skinner has progressed on to studying North Pacific plankton and is now a welcome addition to the Pacific Analysis Team. In April 2015 SAHFOS welcomed Katrin Schmidt to the Analysis team. During several months of intensive training she developed her skills in phyto- and zooplankton identification, and is now qualified to analyse samples from the North Atlantic, starting analysis of samples in December 2015. Katrin holds a PhD in Marine Biology from the University of Rostock and has worked as a scientist at the Baltic Sea Research Institute, the British Antarctic Survey and at Plymouth University. Her research has centred on the diet and feeding behaviour of euphausiids and copepods, and included the microscopic identification of their food.

If you are interested in training of identification of plankton, or interested in a collaborative project on plankton please contact David Johns djoh@sahfos.ac.uk

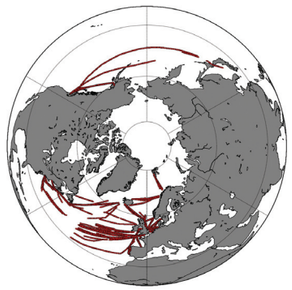
Our analysts have over **275 years** of combined taxonomic identification experience

Visitors

2015 has been another very busy year for visitors to the SAHFOS laboratory. We hosted a number of visitors from the GACS community, including members of the Board of Governance, at a meeting held in Plymouth during September 2015. Claire Taylor, in turn, visited the AusCPR Survey for two weeks to exchange best practice and methodologies and an insight into AusCPR plankton taxa (see page 33). Jennifer Skinner visited the MedCPR Survey in Cyprus, offering advice and guidance when setting up new routes or surveys (for the Mediterranean region) and she discussed how SAHFOS could help.

We also gave tours and an introduction into plankton identification to Oliver Colville MP, Johnny Mercer MP, Clare Moody MEP Eugene Bruins (National Marine Aquarium), NERC CE Duncan Wingham, George Eustice (Defra), Cdr Charles Crighton and Prof David Southwood (Imperial College, London).

We welcomed the BBC Natural History department in August to the lab, filming a piece about the plankton community as part of their Big Blue Live project. The end of the year saw a visit from Dr Maria Grazia Mazzocchi (Stazione Zoologica of Naples), who along with Claudia Castellani, has identified species of *Oithona* from our North Atlantic samples.



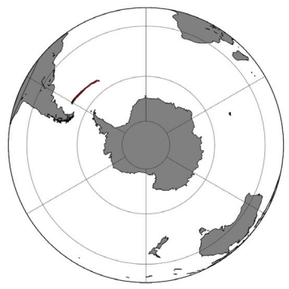


Figure 7. 2015 CPR Sample map showing Southern and Northern Hemisphere tows.

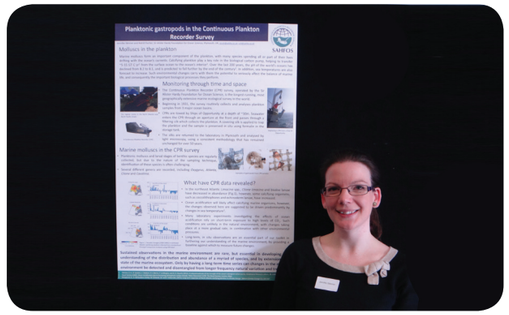
Images. Top left: Analyst training session with visiting scientist Dr Maria Grazia Mazzocchi. Top middle: Jennifer Skinner visiting MedCPR to offer them guidance on setting up a new survey. Top right: The BBC Natural History Department filming for the Big Blue Live program. Below: Analysing in the laboratory.

Training

Training and continual professional development are important aspects of the analysis culture at SAHFOS. By providing ongoing on-the-job training and encouraging Analysts to attend workshops or training events given by external scientists, SAHFOS invests in the long-term development of its Analysts, thereby promoting excellence. During 2015 over 23 scheduled training opportunities were offered to SAHFOS Analysts, covering a wide range of topics, from identifying invasive copepods in the North Sea to identifying phytoplankton endemic to Antarctic waters.

Porcupine Marine Natural History Society Annual Conference

In March 2015, Marianne Wootton and Usha Jha attended the Porcupine Marine Natural History Society Annual Conference at the University of Portsmouth. The theme for the Conference was 'Species: home and away', for which Usha and Marianne gave a talk on the appearance, persistence and spread of *Pseudodiaptomus marinus* in the North Sea. Coincidently, whilst at the meeting Usha and Marianne were delighted to meet one of the Porcupine's founding members, whose PhD examiner was Sir Alister Hardy in the 1970s!

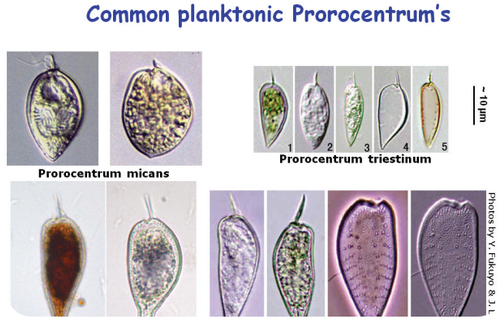


The Malacological Society of London Spring Meeting

Jennifer Skinner and Astrid Fischer represented SAHFOS at The Malacological Society of London spring meeting and AGM in April 2015. Held at the Natural History Museum, the theme of the meeting was planktic gastropods: biology, ecology and palaeontology (see page 28). In June 2015 SAHFOS hosted a Crustacean Zooplankton Workshop, (see page 30) providing many members of staff an amazing opportunity to learn from several of the great names in crustacean taxonomy.

MSc Biological Oceanography Course

SAHFOS is often requested to deliver training in plankton ecology and taxonomy to external scientists and students. Having developed strong links with Plymouth University, we were asked to develop a module for an MSc Biological Oceanography course. Throughout the autumn of 2015 Claudia Castellani, aided by Marianne Wootton and Astrid Fischer, successfully organised and delivered a series of eight lectures with a plankton practical.



NMBAQC Phytoplankton Inter-comparison Exercise

After successfully passing the NMBAQC Phytoplankton Inter-comparison Exercise, run by the Marine Institute, Ireland (see over). Astrid Fischer attended a follow-up training workshop in Denmark. The three day workshop, in November 2015, included identification training on *Pseudo-nitzschia, Chaetoceros* and *Prorocentrum* species.

CPR Sample Archive

In operation since 1931, the CPR survey collects and analyses planktonic samples from around the world. Unlike most other biological surveys, SAHFOS archives all of its samples and has approximately half a million samples in storage (image on right). Collected throughout the history of the survey and with samples dating back to the 1950s, the SAHFOS CPR archive is the largest, most geographically expansive plankton archive in the world. As new technologies (e.g. molecular techniques) and new research questions emerge about the health of our oceans, the sample archive has proved to be an invaluable resource and has led to the production of many peer-reviewed publications, both in-house and collaboratively with other institutions. Successful retrospective analysis (molecular and microscopic) has so far taken place on topics such as fisheries, cholera, harmful algal blooms and micro-plastics, on samples dating as far back as the 1960s. SAHFOS welcomes the opportunity to make use of this valuable resource and encourages collaborations with external scientists.

Should you want to know more about the archive or wish to develop a project please contact Marianne Wootton
mawo@sahfos.ac.uk

NMBAQC Phytoplankton Intercomparison Exercise

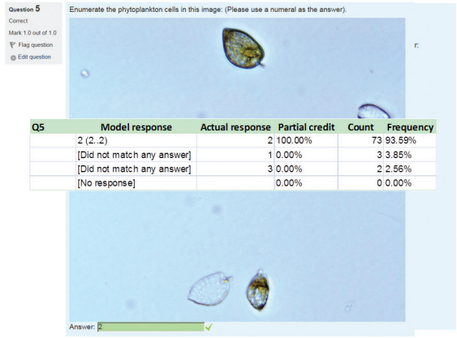
Astrid Fischer and Claire Wotton

In 2015, two of the SAHFOS Analysts took part in the NMBAQC Phytoplankton Intercomparison Exercise, run by the Marine Institute, Ireland, in collaboration with the IOC Science and Communication Centre for Harmful Algae, Denmark. The purpose of the exercise is to compare the performance of laboratories engaged in phytoplankton monitoring programmes and other labs working on phytoplankton in the European North Atlantic area. The exercise consists of two parts; enumeration and identification.

For the enumeration part, each analyst receives three natural phytoplankton samples. The samples are analysed using the Utermöhl technique, which uses a settling chamber and an inverted microscope for identifying and counting the species. The results given by the analyst are compared with the original analysis obtained by the Marine Institute, Ireland, and if within 2 standard deviations the analyst will pass their test.

The identification exercise consists of an online Harmful Algal Bloom species quiz (Fig. 8). This year the quiz also included a few non-marked questions, to ascertain the level of identifications by the various laboratories in the world. The quiz consisted of seven enumeration questions, four theory questions and twelve identification questions.

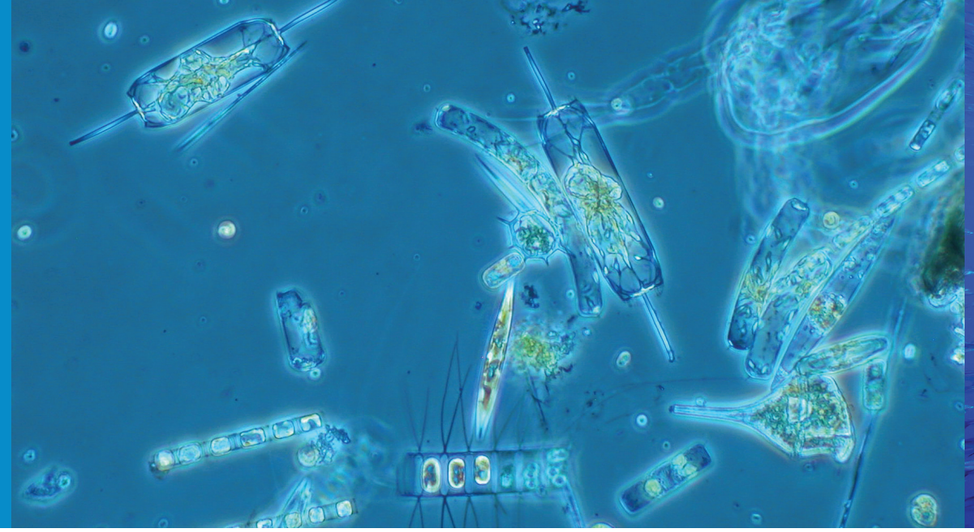
The results of all the tests were discussed at a workshop in Denmark in November, which Astrid Fischer attended. For the enumeration component SAHFOS did very well, with both analysts having low standard deviations compared to the Marine Institute results. For the identification component Claire Wotton had a score of 95.7% and Astrid 89.1%, so both analysts passed the exercise with flying colours. During the workshop it was also discussed that the 12 unmarked questions showed that there was agreement between analysts around the world.



Q5	Model response	Actual response	Partial credit	Count	Frequency
	2 (2..2)	2	100.00%	73	93.59%
	[Did not match any answer]	1	0.00%	3	3.85%
	[Did not match any answer]	3	0.00%	2	2.56%
	[No response]		0.00%	0	0.00%

Figure 8. An example of the online quiz questions, answers and laboratory results, as presented to the analysts by Rafael Salas.

Taxonomy



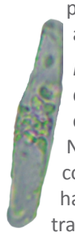
Interesting and Unusual Biodiversity Records

Marianne Wootton

Phytoplankton

The CPR survey monitors many phytoplanktonic organisms which are considered harmful to both human health and to other marine organisms. Given the right conditions, many of these organisms can reproduce in large numbers, causing what are known as Harmful Algal Blooms (HABs).

Dinophysis norvegica is an armoured dinoflagellate which is known to be one of these HAB species. Associated with cold temperate coastal waters, it produces toxins which can cause diarrhetic shellfish poisoning events. Although not unusual in CPR samples, the summer of 2015 saw record high abundancies and frequency of occurrences of *D. norvegica* in the CPR survey. The area affected seemed to be limited to the northern North Sea, in particular a region close to the Norwegian coastal city of Stavanger. Interestingly in this same region, off the coast of Stavanger, the autumn months of 2015 saw the reappearance of a diatom called *Pseudosolenia calcar-avis*. This long cylindrical diatom species occurs around the globe and is usually associated with warm coastal waters. Although observed over 150 times in the history of the CPR survey, typically on warm coastal water samples off the northeast coast of the USA, *P. calcar-avis* has never been found in the North Sea: that is until 2013. Since 2013 it has been found yearly in small numbers in the northern North Sea, and has so far been observed three times in 2015 CPR samples. A recent study of historical data from the Helgoland Roads Biological station (Alfred-Wegener Institute) discovered that *P. calcar-avis* was identified in samples during 1906-1908, but then seemed to disappear from the North Sea during the latter half of the 20th Century. Speculation that this species may have become locally extinct in the North Sea can now be disproved; however, its apparent sudden reoccurrence perhaps stimulates more questions than it answers.

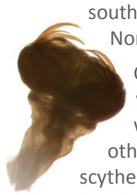


Ephemera planamembranacea is a delicate diatom associated with boreal waters, commonly occurring in northern waters of the North Atlantic. However, in the last two years, confirmed sightings of *E. planemembranacea* have been recorded on CPR samples from traditionally sub-tropical – temperate waters of the northeast Atlantic, during summer months. Interestingly, the seemingly anomalous 2015 observations coincide both temporally and geographically with a region of 'much colder than average' water, as reported by the National Oceanic and Atmospheric Administration (NOAA).

Tripos kofoidii (synonym *Ceratium kofoidii*), a rare warm-water dinoflagellate, was recorded approximately 150 miles to the southeast of New York, on an August 2015 sample. The last time this species was seen in the CPR survey was over 7 years ago, to the west of Ireland, and this represents only the 12th record in the history of the survey.

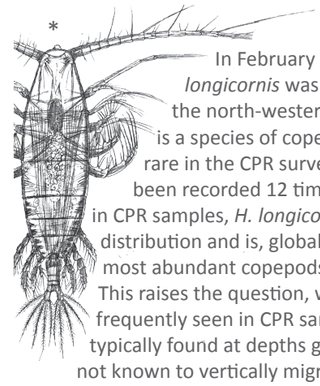
Zooplankton

The phylum Brachiopoda, commonly known as lamp shells, refers to a group of sessile benthic organisms that are similar in appearance to bivalves. Even though brachiopods have a worldwide distribution, the appearance of their larval phase in plankton samples is rare. The first observation of brachiopod larvae in the CPR survey was in 2006, found on samples to the southwest of the Grand Banks and off the Dutch coast. In 2015 brachiopod larvae were observed in February and April, to the southwest of the Georges Banks in the western North Atlantic.



Chaetognaths, commonly known as arrow worms, are like the lions of the planktonic world. These ferocious predators capture other planktonic organisms using the large scythe-like spines on either side of their head. Once captured, some chaetognaths are known to immobilise their prey by injecting them with a powerful neurotoxin. Although common in plankton samples, September 2015 saw unusually high abundances of these carnivores in samples taken from the entrance to the Skagerrak, in the North Sea.

Farranula gracilis, a small copepod approximately 1mm in length, was recorded twice in the 2015 survey. Having only previously been observed 13 times in the core North Atlantic survey, these two records are also unusual in that they represent both the most northerly and southerly occurrences of this species. In CPR samples, former records of *F. gracilis* have been restricted to the warm waters off the northeast coast of the USA; however, the 2015 sightings were located in the mid North Atlantic, above the Mid-Atlantic Ridge. The genus *Farranula* belongs to a curious family of copepods which possess a peculiar pair of large eye lenses.



In February 2015 a *Haloptilus longicornis* was observed on a sample in the north-western Atlantic. *H. longicornis* is a species of copepod and is considered rare in the CPR survey, having only previously been recorded 12 times. Despite its scarcity in CPR samples, *H. longicornis* has a cosmopolitan distribution and is, globally, considered one of the most abundant copepods in pelagic ecosystems. This raises the question, why is it not more frequently seen in CPR samples? *H. longicornis* is typically found at depths greater than 200m and is not known to vertically migrate; given that the CPR is towed in the top 10m of the ocean it is not surprising that the CPR rarely encounters this species. The 2015 sighting was taken from a sample in the region of the Gosnold Seamount, to the southeast of the Georges Banks, and represents the most south-westerly record of *H. longicornis* in the CPR Survey.

In 2011 the CPR Survey recorded the appearance of a non-native newcomer to the North Sea, the copepod *Pseudodiaptomus marinus*. This copepod of Asian origin has steadily worked its way around the globe over the last 50 years and first appeared in waters around the UK in 2010. Upon its discovery in the North Sea CPR samples in 2011, it was not known whether this alien species would remain in the region. Since 2011, up to the present (2015), it has persisted in CPR samples taken in the southern North Sea and to the entrance of the Skagerrak.

* Drawing from GO Sars, An Account of the Crustacea of Norway

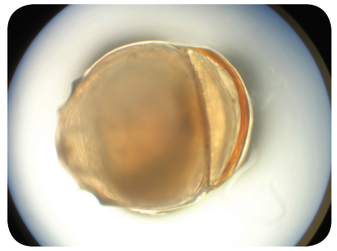
Planktic gastropods

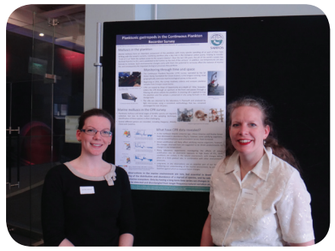
Jennifer Skinner and Astrid Fischer

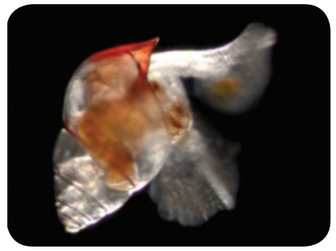
In April, the Malacological Society of London held their spring meeting and AGM, entitled 'Planktic gastropods: Biology, Ecology and Palaeontology' at the Natural History Museum in London. This meeting was attended by researchers from across the world, offering excellent networking opportunities for further collaborative work.

The programme of lectures included a wide range of topics relating to Pteropods and ocean acidification. Several talks focused on the difficulties associated with culturing molluscs to study them. The ability to sample these animals *in-situ*, across basin scales, with known sampling locations, on a repeat basis was widely recognised as the optimum technique – highlighting the important role the CPR Survey can play in ecological studies.

SAHFOS presented a poster on molluscs in the CPR Survey which included the changes in abundance and distribution our data have shown over the last fifty years. Attending this meeting served to promote the CPR dataset to the international community of researchers interested in molluscs and ocean acidification, some of whom had previously (incorrectly) assumed that the CPR was unable to collect and record planktonic molluscs due to the nature of its sampling technique....



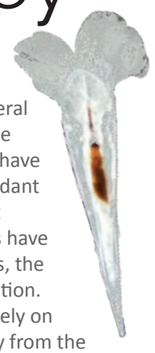




Images from left to right: A *Diacria quadridentata* gastropod. Jennifer Skinner and Astrid Fischer with their poster presentation. The pteropod *Heliconoides inflatus*. Credit Katja Peijnenburg & Erica Goetze

Molluscs in the CPR Survey

Jennifer Skinner



Molluscs are soft-bodied creatures that often build their own hard shell for protection. Some have evolved without such armour, and belong to the genus *Gymnosomata*, (Greek for "naked body"). A wide variety of marine molluscs inhabit the plankton for either part, or all, of their life histories. Many benthic species such as mussels and clams begin life as larvae, drifting with the ocean's currents, before maturing and settling onto rocks. Others remain planktonic for the duration of their lives, like sea butterflies and sea angels, and appear to fly through the water beating their wing-like appendages.

Environmental changes are taking place in our oceans that have the potential to negatively affect the organisms inhabiting them. For marine molluscs, increasing sea temperatures and ocean acidification are two of the largest threats they face. CO_2 is more soluble in colder waters, and it can impact on the levels of a mineral, aragonite, required for shell formation. Studies have suggested that surface waters at high latitudes are likely to become under-saturated with the mineral faster than other regions. Sea butterflies may be the "canary in the coal mine" as although they have a global distribution, they are particularly abundant in polar regions, where they form an important component of the foodweb. Laboratory studies have shown that when exposed to low pH conditions, the shells of sea butterflies showed notable dissolution. Predators such as sea angels, that feed exclusively on sea butterflies, will likely suffer not only directly from the changing environmental conditions, but also indirectly, through the impact on prey. Monitoring the distribution and abundance of marine molluscs is therefore essential in charting these environmental changes and developing our understanding of the impacts such changes may have on oceanic flora and fauna.

The spatio-temporal coverage of the CPR Survey offers a unique insight into the distribution and abundance of the near surface plankton communities, including marine molluscs. Since its inception, the Survey has collected and recorded more than fifteen different genera of marine mollusca, including *Oxygyrus, Atlanta, Clione* and *Cavolinia*. Our data have shown that over the last fifty years some species have shown a reduction in spatial extent and abundance in the North East Atlantic. Bivalve larvae have experienced an overall decrease throughout most of the North Atlantic since the 1990s. Other molluscs, like sea angels, have shown strong regional responses, with abundance declining in the North Sea and Western English Channel. Any change in the plankton has the potential to have serious implications further up the food web. In addition to affecting ocean, and therefore ecosystem health, many molluscs are cultivated commercially for human consumption and a decline in abundance may also have negative economic impacts. Sustained observations in the marine environment are rare, but essential in developing our understanding of the distribution and abundance of myriads of species, and by extension, the state of the marine ecosystem. Only by having long-term time series, such as the CPR Survey, can changes in the marine environment be detected and disentangled from longer frequency natural variation and trends.

Image: Pteropod *Heliconoides inflatus.* Credit Katja Peijnenburg & Erica Goetze.

National Marine Biological Analytical Quality Control Scheme

David Johns and Astrid Fischer

SAHFOS staff continue to Chair and act as Technical Secretary for the NMBAQC scheme. In November 2014 SAHFOS sent out a trial zooplankton ring test to 12 UK participants from 6 laboratories, containing 10 actual zooplankton specimens from the North Sea and 10 written questions (Fig. 9). Participants were given 8 weeks to complete their test, and results were examined by SAHFOS' senior taxonomists. The deadline for result submission was January 2015, and all participants returned their answers within the specified deadlines. The results showed that the level of zooplankton identification in the UK amongst participants is very good, and that the zooplankton trial ring test was a useful training exercise. For the specimen test, the most difficult to identify specimen proved to be *Clausocalanus* spp and *Branchiostoma* spp. In the written quiz, the participants struggled to specify what characterise the identification of a *Calanus* P5 and especially that of a male *Calanus helgolandicus*.

In July 2015, directly after the Crustacean Zooplankton Workshop, a small workshop was held to discuss the results of the trial ring test and to give some further training on zooplankton identification. The workshop was held to reach consensus on the judging of the results and to ascertain what participants thought of the test. The general consensus was that all participants would like to participate in further zooplankton ring test and that the inclusion of an enumeration component would be useful. SAHFOS is intending to create a further zooplankton ring test including an enumeration component for the next NMBAQC operating year (2016/2017).

Apart from the zooplankton, the epibiota component also had further development with the publishing of the NMBAQC epibiota operational guidelines. NMBAQC is currently working on a draft for the epibiota analysis guidelines with input from all the UK laboratories that engage in this type of analysis. The particle size analysis (PSA) component developed an own sample module and trialled its first pass/fail criteria. From 2016 the pass/fail criteria will be applied to all the PSA modules. The benthic invertebrate module had to cancel its macrobenthic component due to lack of interest. However, interest in the other benthic invertebrate modules is still strong and the 2015 results showed the usefulness of the modules as there is still a lot of difficulty in the correct identification of certain polychaetes.

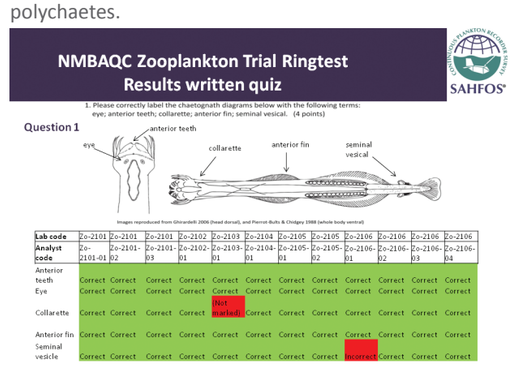


Figure 9. An example of the ring test question, answers and inter-laboratory results.

Crustacean Zooplankton Workshop

Tanya Jonas

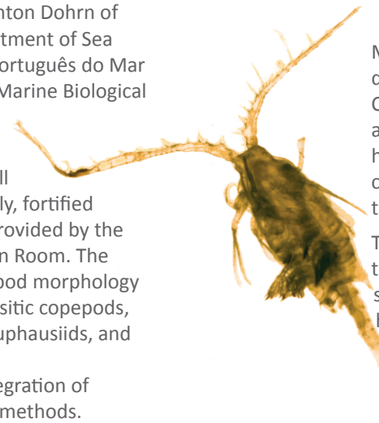
Preparations for the Workshop began about two years ago following an approach by ICES (International Council for the Exploration of the Seas). It had been recognised that taxonomic and identification skills were diminishing and that a new generation of scientists needed to be trained.

SAHFOS last hosted a Zooplankton Workshop in the Citadel Hill Laboratory in 2006, so this course proved to be timely and popular with nearly 60 people from around the world applying to attend. Space and equipment restrictions meant we could only host 21 participants and it was a very difficult task indeed to select those from an impressive well deserving list of hopefuls. Eventually we chose 21 applicants from 14 different countries (Hawaii, Australia, Iceland, Croatia, the Philippines, Denmark, Cyprus, Norway, South Africa, Spain, Poland, Saudi Arabia, Scotland and England).

The few weeks before the workshop were particularly intense. Sourcing enough samples and specimens in preparation for the practical sessions was quite challenging. Compiling course notes and delegate packs, setting up the lab with microscopes, computers and associated software, ensuring accommodation and meals were booked kept us on our toes!

The course lecturers were experts in their field, coming from our own knowledgeable staff (Dr Rowena Stern, Marianne Wootton, Dr Alistair Lindley (former employee) and Dr Astrid Fischer and a number of other institutes. We were privileged to have the services of Prof Geoff Boxshall (Natural History Museum), Prof Ann Bucklin (University of Connecticut), Dr Ruth Böttger-Schnack (DZMB-Senckenberg and GEOMAR), Dr Maria Grazia Mazzocchi (Stazione Zoologica Anton Dohrn of Naples), Dr Antonina Dos Santos (Department of Sea and Marine Resources at the Instituto Português do Mar e da Atmosfera) and Dr David Conway (Marine Biological Association of the UK).

Each day of the workshop was busy with lectures and practicals from 9am till 6pm, though somehow we managed ably, fortified with coffee, tea and delicious lunches provided by the first-rate staff in the Citadel Hill Common Room. The topics covered in the course were copepod morphology and development; identification of parasitic copepods, large and small calanoids, cyclopoids, euphausiids, and decapods using light microscopy.
One day was spent on exploring the integration of traditional and molecular identification methods.



Marianne set the participants a copepod identification quiz which was won by Julian Uribe Palomino (Australian CPR). You can see his delight when claiming his prize of a “decapod” teeshirt at the course dinner. The dinner, held in the Citadel Hill Common Room, also provided a chance to hand out certificates and express our thanks to all the lecturers, helpers and participants.

The course was not all hard work and the participants took time to investigate the delights of Plymouth and surrounding areas, visiting the aquarium and local hostelries. Luckily the weather helped as we enjoyed a week of sunshine.

The organisers made every effort to ensure the success of the workshop – there were things we got just right and some areas for improvement. All of the analysts benefitted from the chance to learn from experts in their field, network with other scientists and make new friends.

Organisers: Claudia Castellani, Tanya Jonas, Claire Taylor, Rowena Stern, Astrid Fischer, Marianne Wootton and Kate Brailsford.

Dr Dave Conway lecturing participants

Practical microscope session

Molecular session

Course socialising

Julian Uribe Palomino receiving quiz prize

Carnival time for the CPR

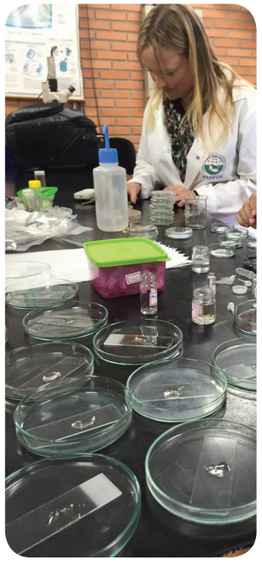
Marianne Wootton

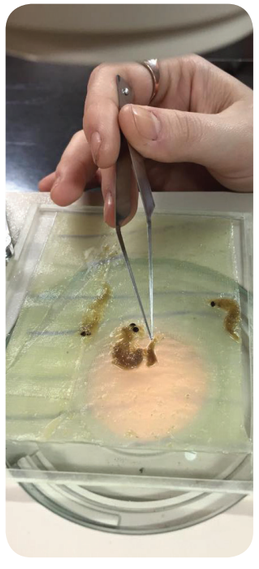
At the beginning of 2015 SAHFOS received an award from the Research Council UK (RCUK) and the Brazilian Council of State Funding Agencies (CONFAP) Research Partnership.

The aim of this partnership is to provide short-term support for small scale research and networking via the Newton Fund, to develop the long-term sustainable growth and welfare of the partner country, through building research and innovation capacity. In partnership with the University of Itajaí, Brazil (UNIVALI), and the University of Rio Grande, Brazil (FURG), SAHFOS was awarded a grant to provide tuition in CPR maintenance, deployment and other associated operations concerned with the smooth running of a CPR survey, to enable Brazil to set-up and operate its own autonomous CPR monitoring survey. Prof Erik Muxagata, a GACS member from FURG, used the fund to attend training in the above, at the SAHFOS laboratory, during Sept-Oct 2015. Prof Muxagata and FURG are now the proud owners of a CPR and intend to use it on a cruise from Brazil to Antarctica in January 2016.

Another outcome of the RCUK-CONFAP grant was to organise and run a plankton workshop in Brazil. In July 2015 Marianne Wootton travelled to Brazil to teach on a Plankton Workshop at the Universidade do Vale do Itajaí. Marianne was a guest lecturer providing tuition in CPR analysis methodology and copepod taxonomy. The workshop was aimed at Brazilian early career scientists and technicians, and also covered subjects such as phytoplankton identification (taught by Marcio Tamanaha) and zooplankton identification (taught by Prof Muxagata).

In 2014 Marcio Tamanaha visited SAHFOS to receive training in CPR methodology and zooplankton identification, as part of his PhD from UNIVALI. Scientists from UNIVALI have developed their own plankton recorder, closely based on a standard CPR, but which is designed to be light enough to be towed behind fishing vessels. Working on a project to monitor the composition and distribution of plankton in the fishing area of Brazilian Bight, the grant has allowed Marcio to purchase a microscope designed specifically for CPR analysis.





Images: Marianne Wootton, an invited guest lecturer, teaching in the Plankton Workshop in Brazil.

Australia Exchange

Claire Taylor

One of the initiatives arising from GACS was to set up an exchange of staff between organisations. I was very fortunate to be chosen to represent SAHFOS and travel to the Australian CPR Survey (AusCPR) in Brisbane for two weeks to exchange ideas, best practice and methodologies along with an insight into tropical plankton.

My host Anthony Richardson, project leader for AusCPR, met me; and took me to the Ecosciences precinct to meet with the rest of the AusCPR team. As the Tasmanian team were up visiting too, it was an ideal opportunity for a get together and we spent much of the first week thrashing out flow charts, taxonomic summary sheets and naming protocols. I also gave a well-received presentation to the team regarding SAHFOS past and present, our methodologies and procedures, explaining the differences between the two Surveys.

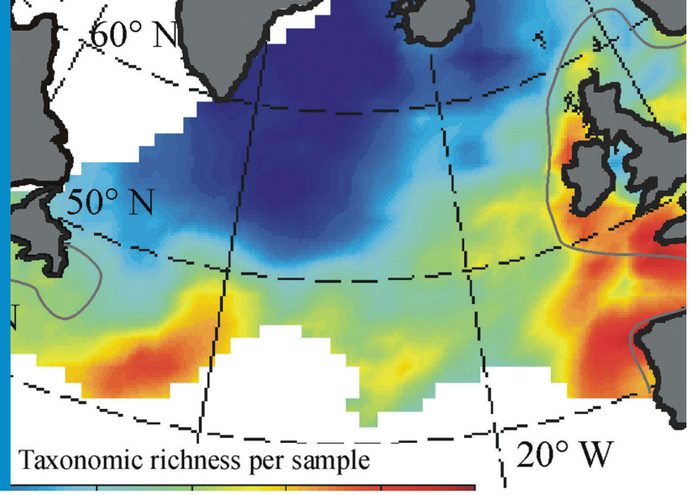
The next week was more focused around working in their laboratory. I began by assisting Frank with unloading and cutting of the silk and the entering of ships data. Julian then showed me some National Research Station (NRS) samples. It was great to see tropical net hauled specimens and I soon developed an appreciation of just how small tropical zooplankton actually are in comparison to their North Atlantic cousins. This led onto Frank running through both AusCPR Phytoplankton and Zooplankton counts; it was comforting to see we both find the same things difficult to speciate and have nicknames for some things we just don't know what they are!

One lunchtime was spent at the University of Queensland where Anthony also lectures. We were joined by a pesky water dragon who took a bit of a shine to our pizza, getting a tad bit close. Other wildlife I encountered were wallabies, galahs, king parrots, sting rays, crimson rosella and golden orb spiders. Sadly the high swell meant a boat trip to the local NRS station was cancelled, a bit disappointed to miss the opportunity of seeing science in action.

I had a thoroughly enjoyable few weeks and learnt a lot. I hope I have given the AusCPR team a few ideas too. Many thanks to Anthony for the opportunity, CSIRO for funding my travel costs and also to Claire, Ruth and Felicity from Hobart and to Frank, Anita, Mark and Margaret in Brisbane, for making me feel so welcome. It was an amazing opportunity and would love to return one day.....!

Images. Left: Brisbane's Skyline. Right: The Ecosciences Building

Research Highlights



SAHFOS is involved in a wide variety of research activities, ranging from blue-sky research and new technologies, to policy-driven work. As such, research is carried out not only by the Research Group at SAHFOS, but also in the wider scientific community all over the world, by researchers, students and in major research projects.

The following short research articles are provided by SAHFOS staff, Fellows, Associate Researchers and Students. Some articles are novel for this report, whilst others are short summaries based on published work, and a reference is given for further information.

CPR Phytoplankton Colour provided the first evidence for the 1980s Regime Shift

Philip Reid and Renata Hari

A stepwise increase after the mid-1980s in the Phytoplankton Colour Index (PCI) sampled by the CPR in the seas around the UK (Fig. 10) provided the first evidence for what was later called a regime shift in the North Sea. In a paper published in Global Change Biology in January 2016, Reid *et al* demonstrated, with significant statistical evidence from 72 long time series, that this regime shift, centred on 1987, occurred at a planetary scale. The event is evident in a wide range of the Earth's biophysical systems (Fig. 11) ranging from the atmosphere (stratosphere and troposphere) winds, pressure, storms, carbon dioxide, temperature; to the depths of the oceans, currents, biology (including PCI), temperature, salinity; on land, in rivers and lakes, river flow, pH, biology, phenology (e.g. seasonal timings), forest fires, temperature; to the cryosphere, sea-ice, snow and in the carbon sinks of the land and oceans.

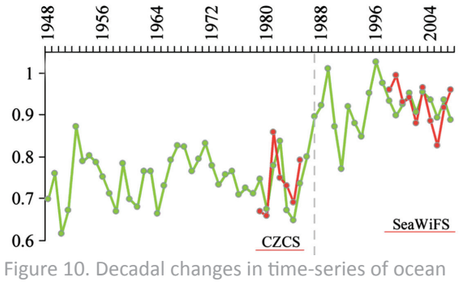


Figure 10. Decadal changes in time-series of ocean colour derived from Phytoplankton Colour (PCI) transformed to Chl-a, CZCS adjusted Chl-a and original SeaWiFS Chl-a, depicting the variability of Chl-a in the Northeast Atlantic Ocean and the North Sea since 1948 (Fig. 10 from Raitsos D *et al.* 2014 From silk to satellite: half a century of ocean colour anomalies in the Northeast Atlantic Glob. Chang. Biol. 20 2117-23

A marked decline in the increase rate of CO_2 in the atmosphere occurred after the regime shift and coincided with a sudden increase in the land and ocean carbon sinks. The carbon sinks are where a substantial part of the natural and anthropogenic CO_2 that is added each year to the atmosphere is taken up; in this way reducing the rate of rise of global warming. It is estimated that either side of the regime shift (between the two periods 1960-1989 and 1990-2009) the combined carbon uptake of these two sinks increased by more than 50% and that this represented 64% of the increase in anthropogenic emissions between the two periods. If a sink of this magnitude reversed to a CO_2 source as quickly as the ~1987 change occurred, it would lead to a rapid rise in global temperature over a short period.

It is hypothesised that the mechanism for the regime shift is a rapid rebound that followed cooling induced by the major El Chichón volcanic eruption in 1982

The increase in the land carbon sink fits with strong evidence for: an increase in vegetation, both in PCI and in the greenness (NDVI) recorded by satellites over Northern Hemisphere land. It also coincides with an earlier and longer growing season, especially in northern boreal and temperate regions, increased plant growth at higher altitudes and associated changes in vegetation composition and biomass. The timing of the regime shift may be

72 long time series demonstrated that this regime shift occurred at a planetary scale. The CPR survey provided the first evidence for this

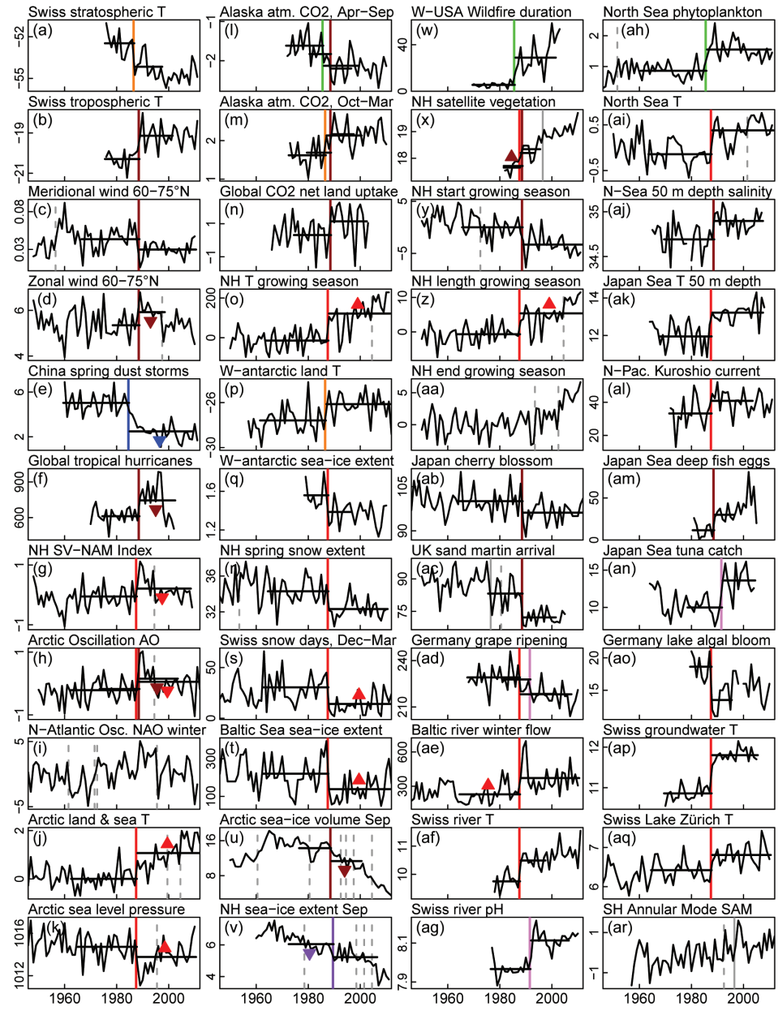


Figure 11. Significant regime shifts in time series representing a range of different Earth systems. Vertical lines denote regime shift years, coloured to reflect the '1980s period of interest' (1983–1990): 1984 (blue), 1985 (green), 1986 (orange),1987 (red), 1988 (brown), 1989 (purple), 1991 (pink as a lagged effect); grey lines mark regime shifts outside the 1980s. Horizontal lines for the longest test-period with a significant result, triangles point up or down to indicate the direction of a significant trend before or after the shift year. The sequence of the plots is atmosphere (a–p) and (ar), cryosphere (q–v), terrestrial biosphere (w–ad), and hydrosphere (ae–aq). For further details for each of the time series see Tables 3 and S3 in (Reid *et al*., 2016).

associated with the increase in major disasters such as forest fires, storms, floods and the spread of pests seen in recent decades. The 1980s regime shift was much larger than any similar event, previously or since, within the last century and probably within the last 1000 years, based on evidence of the flowering dates of cherry blossoms in Japan, Switzerland and the USA.

Using simulations from a group of IPCC models (CMIP5) and statistical modelling, it is hypothesised that the mechanism for the regime shift is a rapid rebound that followed cooling induced by the major El Chichón volcanic eruption in 1982, when natural and anthropogenic forcing combined to produce a sudden acceleration in global warming. The scale and speed of the increase in temperature that followed after the regime shift is considered to be the main forcing of the cascade of environmental changes at this time, although volcanic and human aerosols, interactions with clouds and global brightening may also be involved.

This time series study is important as it indicates that global warming may be reinforced after a major volcanic eruption

This time series study is important as it indicates that global warming may be reinforced after a major volcanic eruption, contrary to the previous belief that such eruptions only cool the Earth for one to two years afterwards. A cautionary approach to geoengineering proposals needs to be taken on the evidence that unavoidable natural events like major volcanic eruptions may interact with anthropogenic warming with unforeseen multiplier effects.

Reid P C, *et al.* 2016 Global impacts of the 1980s regime shift. Global Change Biology. 22 682-703.

The Future of Global Marine Biodiversity

Gregory Beaugrand and Martin Edwards

We know so little about marine biodiversity

About 70% of the worlds population lives within 60km of the shoreline. Humanity uses 8% of the aquatic primary production, this fraction reaching 25% for upwelling and 35% for non-tropical continental-shelf ecosystems. An estimated 80 million tonnes of fish are caught every year and marine biodiversity is seen as both a source of new marine bioresources, medicines and biofuels. Marine biodiversity is also strongly involved in global biogeochemical cycles and especially the ocean carbon cycle that contributes to the regulation of our global climate. Any reorganisation of marine biodiversity will affect us in some way and will inevitably affect interactions among species and consequently how the ecosystem functions and how productive the ecosystem is.

We know very little about marine biodiversity. Although over 200,000 marine species have been described, scientists believe this represents only 10% of marine biodiversity; in other words, the number of species in the sea may approach 2 million. Because we know so little about marine biodiversity, it is difficult to predict the outcome of climate change on global marine ecosystems. Until now, attempts to understand the implications of climate change on marine biodiversity have either extrapolated results from just a few key species, or have applied ecological niche models to many species. However, both approaches are limited by our poor knowledge of species distribution.

It is difficult to predict the outcome of climate change on global marine ecosystems

We used a novel approach and generated thousands of theoretical species, each having a unique response to local changes in climate

In a new study published in Nature Climate Change, we used a novel approach based upon the theory that the way biodiversity is distributed in the ocean is a result of the interaction between the multidimensional domain of environmental tolerance of species and fluctuations in the environmental regime. In the study we generated tens of thousands of theoretical species, each having a unique response to local changes in climate (sea surface temperature) which were allowed to colonise the sea providing the local environment was suitable. In this way, we reconstructed oceanic biodiversity for the past, the present and also for a range of projections of biodiversity for the end of the 21st century.

We reconstructed oceanic biodiversity for the past, the present and a range of future scenarios

The results (Fig. 12) showed that provided future global warming remains below 2°C, which is the amount of warming the international community considers to be below the threshold that would place natural systems at risk of grave damage, only 15 % of the global ocean surface would experience a change in biodiversity of greater magnitude than occurred over the last 20,000 years since the Last Glacial Maximum. Likewise only 25% of the ocean's surface area would experience a change in biodiversity greater than observed over the last 3.3 million years between the mid-Pliocene and today. Interestingly, these amounts are similar to annual changes seen between 1960 and 2013. As a result we provided evidence that if we can keep global warming below 2°C, the effects on marine biodiversity predicted by their model may be within acceptable levels of change. However, more alarming, the other three levels of global warming we examined each indicated that they would place the marine biosphere at risk of increasingly significant changes. When warming reaches the dangerous threshold of 2°C, the model predicts that between 37% and 46% of the surface ocean would experience a change in marine biodiversity that is greater in magnitude than occurred between either the Mid Pliocene or the Last Glacial Maximum, and the present day, respectively. When global warming rises above the dangerous threshold of 2°C, it was estimated that between 50 and 70% of the global ocean may experience a change in marine biodiversity indicating a major effect of climate warming on marine biodiversity.

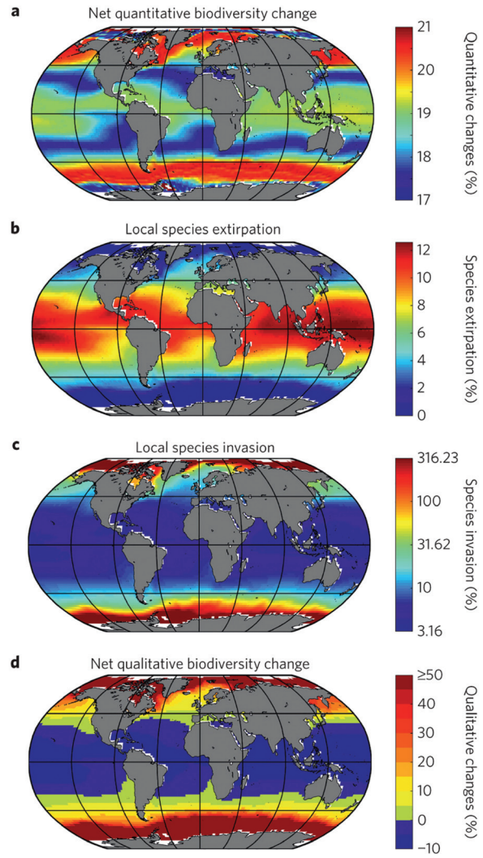


Figure 12: Expected sensitivity of biodiversity to a 2°C increase in temperature. a–c, Net quantitative changes in biodiversity (a), local species extirpation (b) and invasion (c). d, Net qualitative biodiversity changes resulting from the difference between species invasion and extirpation. All changes are expressed as a percentage.

Beaugrand G, Edwards M, Raybaud V, Goberville E, Kirby R. 2015. Future vulnerability of marine biodiversity compared with contemporary and past changes. Nature Climate Change, 5: 695-701.

Phytoplankton time-series are crucial to delivering Good Environmental Status

Abigail McQuatters-Gollop

Due to their multi-scale dynamics phytoplankton datasets are increasingly important for supporting decision making

Due to their multiscale dynamics, phytoplankton datasets which are 20-30 years in length, spatially extensive and taxonomically detailed are increasingly important for supporting decision making. Phytoplankton time-series datasets, such as that from the CPR Survey, therefore play a key role in implementation of the EU's Marine Strategy Framework Directive (MSFD). Data from the CPR supports the MSFD in multiple ways including the development and informing of indicators, the setting of targets against a background of climate change and the provision of supporting information used to interpret change in non-plankton indicators.

The CPR Survey database plays a key role in implementation of the EU's MSFD

The MSFD seeks to deliver Good Environmental Status (GES) in Europe's seas by monitoring indicators towards environmental targets. The way in which plankton indicators are constructed is crucial to the success of the directive. Useful indicators must comprise detailed taxonomic information at wide spatial and long temporal scales. The CPR has collected over 6.5 million nautical miles of samples throughout the North Atlantic and North Pacific during the past 85 years.
In addition to representative spatio-temporal scales, the most sensitive biodiversity indicators depend on data of plankton species or functional groups; these data can only be obtained by trained taxonomists. Unlike modern analysis techniques which can only discriminate coarse phytoplankton groups, taxonomists can distinguish a wide variety of species relatively efficiently, generating information needed to investigate diversity in complex marine systems. At the wide spatial and multiple decadal scales monitored by the CPR, detailed taxonomic information forms the foundation to understand spatiotemporal changes in global distributions of species and alterations to community composition.

Unlike other modern analysis techniques, our taxonomists can distinguish a wide variety of species efficiently

Because the Northeast Atlantic phytoplankton community has experienced climate-driven changes, defining phytoplankton targets for GES is not as easy as simply selecting a historical state to which to aspire (see page 46). In the case of target-setting for MSFD indicators, the CPR's multidecadal time-series provides context between contemporary and historical plankton community states. By considering the temporal context revealed by a long time-series, environmental targets can be selected which are both ecologically meaningful (i.e. they represent GES) and realistic (i.e. the targets reflect a vision of GES which acknowledges climate variability and past ecosystem use).

In addition to the development and application of plankton indicators for the delivery of the MSFD, CPR data regarding phytoplankton community composition may also be used to inform non-plankton indicators. For example, any management measure put in place to control fishing pressure, must also acknowledge changes to fish diet due to climate-driven changes in the plankton.

Long-term time-series need to be recognised for their service in supplying vital ecological information

The CPR's contribution to marine policy continues to expand with the development of genetic techniques and the use of CPR data in conjunction with other datasets, such as fixed point and remote sensing data. Regardless of its recognised importance as both a freely available source of data for collaborative research projects and a key dataset supporting policy, sustained funding of the CPR Survey presents a challenge.

The CPR's contribution to marine policy continues to expand with the development of genetic techniques and the use of CPR data in conjunction with other datasets

This is not a new problem or one unique to the CPR; there is a recognised scarcity of long-term ecological datasets, particularly in non-coastal regions, driven by a lack of funding. Long-term time-series such as the CPR need to be recognised for their service in supplying vital ecological information and to ensure their continued contribution to evidence-based environmental policy.

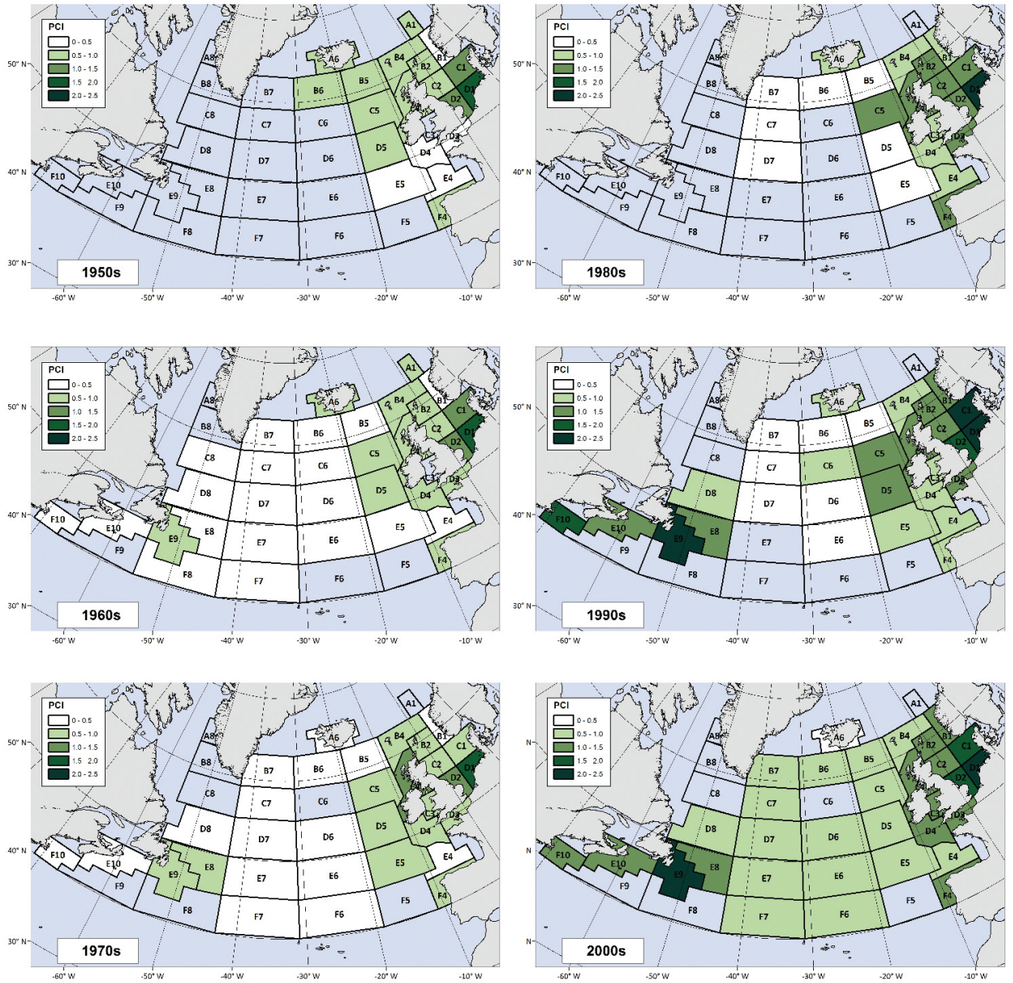


Figure 13. Phytoplankton biomass 1960s-2000s calculated from the CPR time-series. Data and understanding gained through analysing long-term datasets, particularly those at wide spatial scales, are critically needed to inform policy objectives.

McQuatters-Gollop, A *et al.* 2015. The Continuous Plankton Recorder survey: how can long-term phytoplankton datasets deliver Good Environmental Status?. Estuarine, Coastal and Shelf Science, 162.

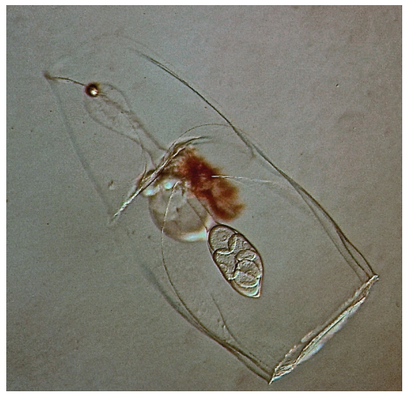
Population Ecology of *Muggiaea atlantica* in the Western English Channel

Michael Blackett

Jellyfish play a key ecological role as predators and competitors that can modulate the structure and dynamics of marine communities. Due to their opportunistic ecology, jellyfish populations often fluctuate dramatically, with dense accumulation separated by periods of absence or rarity. As a result, their structuring effect on pelagic ecosystems is complex and dynamic. Developing knowledge of the mechanisms that regulate jellyfish populations is fundamental to our understanding of the functioning of marine ecosystems. The inter-relationships between different jellyfish life-cycle stages represent key knowledge gaps in our understanding of their population dynamics.

In temperate biomes of the 3 great oceans the siphonophore *Muggiaea atlantica* (Image on right) is a major component of neritic jellyfish communities. Recent observations suggest that this species is expanding its geographical distribution, with important consequences for coastal ecosystems and the services that they provide to humans. Knowledge of the population dynamics and environmental requirements of *M. atlantica* is needed to understand the mechanisms behind this range expansion and to fully appreciate its role in coastal marine ecosystems. However, our understanding is hampered by a paucity of data on its different life stages.

We addressed this knowledge gap by modelling the functional relationship between the two main life-cycle stages (the polygastric and eudoxid stages) of *M. atlantica* over a 5-year period (2009–2013) in the Western English Channel. Our main aims were to determine the key features of the species' population dynamics and to identify how local environmental variability influenced the seasonal development of its populations. A tight coupling of the abundance of the two stages could be expected because the eudoxid stage is produced directly by the polygastric stage (via asexual budding), and eudoxid production rates are linearly related to the size of the polygastric colony. With this in mind, we modelled the functional relationship between the abundance of eudoxid and polygastric stages using simple linear regression, with retention of the residuals for further analysis.



A female eudoxid on the siphonophore *Muggiaea atlantica*

The residuals represent deviations from the typical linear relationship, with positive residuals indicating an increase in the relative abundance of the eudoxid stage, and negative residuals indicating the inverse. The temporal pattern of the residuals was compared to the phenology of the species population blooms, and biotic (food availability) and abiotic (temperature) environmental variability.

Our results highlighted a strong coupling between the timing of specific environmental conditions and the development of the *M. atlantica* population, thereby explaining interannual differences in the phenology of its blooms. The onset of population development in spring was consistently associated with the occurrence of high relative eudoxid abundance (Fig. 14A & B). Considering the biology of *M. atlantica*, this result was interpreted as the initiation of eudoxid production by the overwintering polygastric stages. This reproductive event was significantly linked to the onset of a spring temperature threshold (10–11°C), suggesting a critical basal limit of 10°C for eudoxid production. Interannual variability in the timing of this threshold modulated the degree of mismatch between the developing *M. atlantica* population and the availability of copepod prey (Fig. 14C & D). Unusually cold conditions in the spring of 2010 and 2013 limited the capacity for *M. atlantica* to initiate eudoxid production leading to late population development, poor trophic phasing and the production of single autumn cohorts. In contrast, warmer conditions during spring 2009, 2011, and 2012 facilitated earlier population development, optimal trophic phasing and the production of both summer and autumn cohorts.

These findings represent an important contribution to our understanding of the ecology of *M. atlantica* in the northeast Atlantic. Our results represent the first quantitative, *in-situ* evidence for the overwintering mechanism employed by this holoplanktonic jellyfish, confirming an earlier hypothesis derived from laboratory experiments. The identification of critical environmental ranges for reproductive activity is essential for the inclusion of jellyfish in ecosystem models, and for understanding current and predicted distribution changes. Increasing our understanding of the interaction of climate and phenology at the species level and across trophic levels is central to our understanding of the functioning and resilience of marine ecosystems in a changing climate.

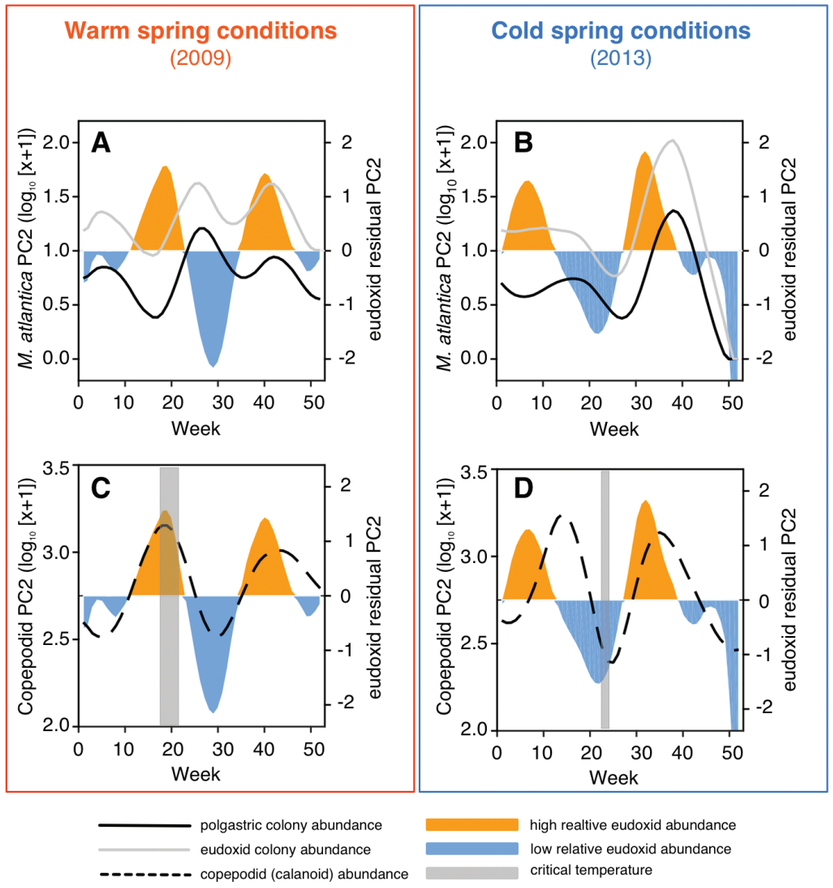


Figure 14. Examples of the population dynamics of *Muggiaea atlantica* during years characterised by warm spring conditions (left panel) and cold spring conditions (right panel). (A & B) The relationship between the abundance (colonies m 3) of the polygastric (solid black line) and eudoxid (solid grey line) stages (left axes), with the relative eudoxid abundance (as the residuals) indicated by the shaded areas (right axes). (C & D) The relationship between the relative eudoxid abundance and food availability (as the abundance of calanoid copepodids; dashed black line). The vertical grey shaded area represents the occurrence of the critical thermal range for reproductive activity (10–11°C). Data are represented by the second principal component (PC2), the second most important trend.

Blackett M, Lucas C, Harmer R, Licandro P. 2015. Population ecology of *Muggiaea atlantica* (Cnidaria, Siphonophora) in the Western English Channel. Marine Ecology Progress Series 535:129–144

Is the Russell cycle a true cycle?

Conor McManus, Priscilla Licandro and Steve Coombs

The Russell Cycle is one of the classical examples of climate influence on biological oceanography, where shifts in the marine plankton over several decades have corresponded to warm and cool conditions. The Russell Cycle has been described based on changes in distinct biotic (plankton) indicators and qualitatively linked with environmental conditions in the Western English Channel. We recently reviewed the validity of this cycle, analysing an updated data set of zooplankton taxa/groups and fish larvae collected off Plymouth. Additionally, we compared the major trends of the Russell Cycle to climate, to test the influence of the environment on plankton changes.

We found that in the Western English Channel biotic indicators were mainly characterised by long-term (> 50 years) variability, rather than by a true cyclical oscillation. Among the biotic indicators considered, “non-clupeid larvae”, “south-western zooplankton groups” and “total zooplankton biovolume” were identified as the main descriptors of the variability of the zooplankton community, accounting for 37% of overall long-term changes (Fig. 15). No clear correlation was found between changes in biotic indicators and large-scale hydroclimatic oscillations, even though the latter were significantly correlated with water temperature oscillations in the region.

These results suggest that significant changes in the marine plankton of the western English Channel associated in the past with the Russell Cycle are more a reflection of different regime shifts, rather than true cyclical variability.

Equal subsamples of mesozooplankton in May from the time series at station L5 illustrate the dramatic nature of the change in the English Channel Ecosystem in different phases of the Russell Cycle (Photo © Marine Biological Association)

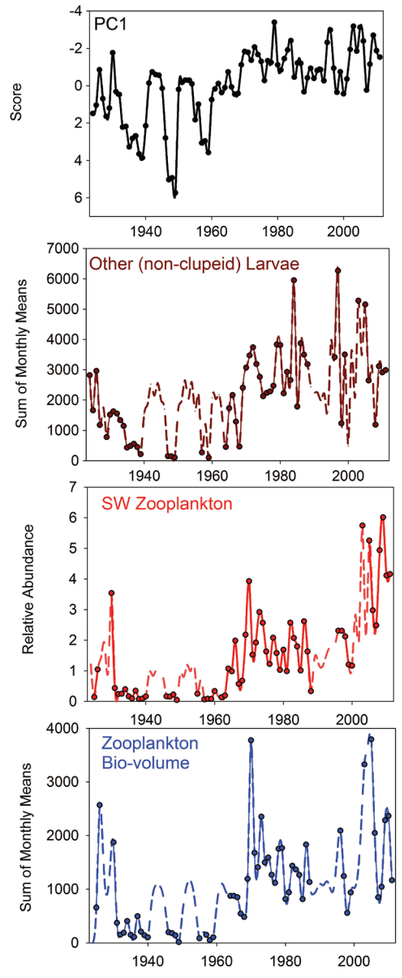


Figure 15. Time-series of the first PC (plotted as the inverse) and the three highest contributor parameters plotted as raw data with interpolated data shown by the dashed sections.

McManus, C., Licandro, P., and Coombs, S. H. 2015. Is the Russell Cycle a true cycle? Multidecadal zooplankton and climate trends in the western English Channel. ICES J. Mar. Sci.

Stability of phytoplankton communities in the North East Atlantic

Stephanie Allen, Associate Researcher

The ocean environment is changing rapidly in response to global climate change, especially in higher latitudes with increased pressure from rising temperatures. Changes to the composition of marine phytoplankton communities have previously been suggested to have major consequences for wider ecosystem functioning, due to their pivotal roles in the marine environment such as the cycling of nutrients and the role of primary producer underpinning the food web. Long-term research programs such as the CPR Survey provide long time-series to ocean regions and support multi decadal analysis. Temporal analysis has been completed using the Phytoplankton Colour Index from the Survey, and the assessment of communities by using data from large functional groups, however, these methods lack important species-specific information.

In this study, Bray-Curtis dissimilarity coefficients were used to quantify changes within the phytoplankton community composition between 1969 and 2013, for CPR Standard Areas B5, C5, D5 and E5 of the North East Atlantic. There were clear inter-annual fluctuations in community composition, with the most drastic shifts occurring in regions B5 and C5 in the mid 1980s and early 1990s. However, community dynamics appear to consistently return to a baseline configuration suggesting a highly stable community formation. Previous studies have highlighted the sensitivity of phytoplankton to physical changes within the environment. Results of correlation analysis however, determined no link between community composition and three key physical drivers; sea surface temperature (SST), mixed layer depth (MLD) and the North Atlantic Oscillation Index (NAO). Such results suggest that physical drivers do not have the same influence on inter-annual timescales that have previously been demonstrated in seasonal studies, and consequently community fluctuations here are suggested to be linked to biological factors such as predation.

The North East Atlantic is a highly dynamic environment, experiencing several naturally occurring changes to its physical environment over long time periods. This study demonstrates the phytoplankton population in this region to be highly stable, with changes occurring as part of the community’s natural variability.

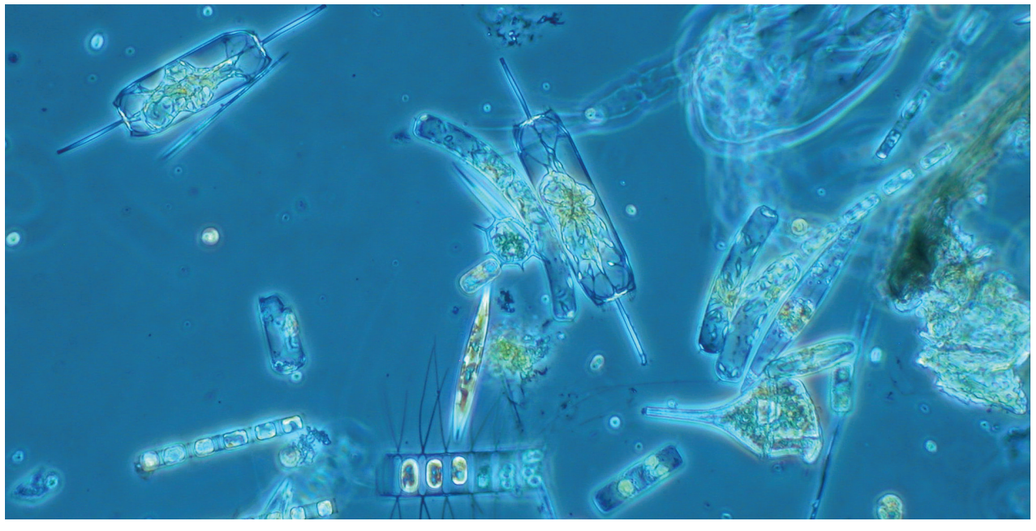


Image: A mixed phytoplankton sample. Photo credit Julie Kuo.

NE Pacific plankton – in hot water!

Sonia Batten

The North East Pacific has experienced unprecedented warming during the last two years. First evident from satellite images as an offshore anomaly late in 2013, the warm pool was nick-named "The Blob", and it subsequently impacted the eastern continental margin during 2014. Strong El Niño conditions also took hold in 2015, potentially adding to the effects. The CPR towing the AT route has had a temperature logger fitted since 2011 and the data from it verify that the Blob was first evident in the off-shore region in August 2013 at the depth of the sampling. By September 2013 the offshore was 4°C warmer than in Sept 2012, more than 5°C warmer than Sept 2011, and the warmth was evident all the way from Juan de Fuca Strait to Cook Inlet (Fig. 16).

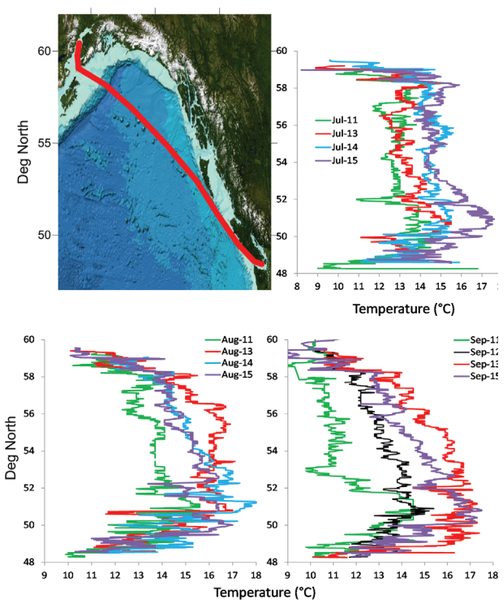


Figure 16. Along-transect temperature data from loggers on the CPR for July-September 2011-2015. The map on the left shows the transect location. Temperature is plotted against latitude.

What consequences have we seen in the plankton? This is a subject of current high interest and focus, with only the space here to summarise some of it.
The Pacific survey has experienced an earlier warm period in the mid-2000s, which was followed by unusually cool conditions before this recent warming. Using the Pacific Decadal Oscillation (PDO) as an index of ocean climate (when positive, conditions are warm and when the PDO is negative, conditions are cool. 2015 saw the most positive PDO of the CPR time series) we are able to say whether the recent plankton dynamics match what we expect.

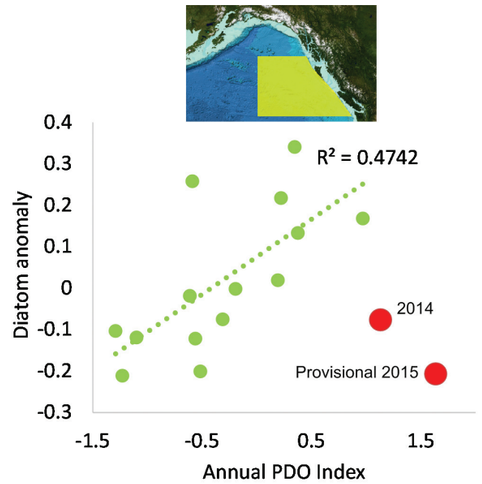


Figure 17. The relationship between the annual diatoms abundance anomaly and the annual mean PDO index from 2000 to 2013. Map above indicates the region samples were averaged over. Red points indicate the data from 2014 and 2015 (data for July to October 2015 are not yet complete so this point may change slightly).

The first example concerns the large diatoms caught by the CPR in the offshore region west of British Columbia, Canada. Between 2000 and 2013 there was a highly significant relationship between the mean annual PDO index and the annual diatom anomaly (Fig. 17, $p<0.005$). However, in 2014 and likely in 2015 too, diatoms were very low in numbers, not what would be expected. Furthermore, when we examined the composition of the diatoms we discovered that the cell types that were long and thin in shape (e.g. *Proboscia* spp., *Pseudo-nitzschia* spp.,) were relatively more numerous in the spring of 2014 and 2015, while the rounder cell types (e.g *Thalassiosira* spp.) were much less abundant. Figure 18 shows that in spring 2015, for the first time, the long thin cell types made up more than 50% of the diatom

We discovered diatoms that were long and thin in shape were more numerous while the rounder cell types were much less abundant

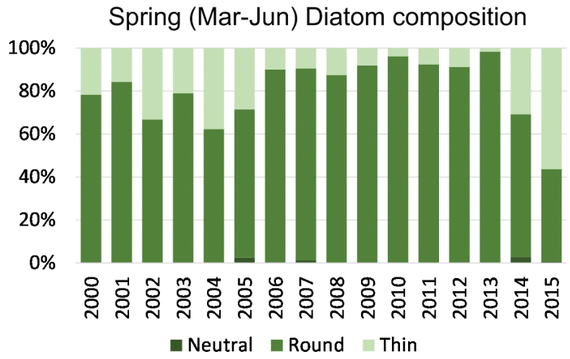


Figure 18. The ratio of the different diatom cell types in spring of each year, for the region shown in Figure 17. "Round" diatoms are all centric cell types, "thin" diatoms includes pennate forms and those centric cells that have one axis much longer than their diameter. "Neutral" are those cells that may be rectangular in cross section but not especially long.

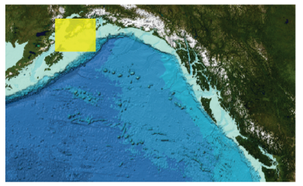
community sampled by the CPR. Diatoms that are long and thin have a higher surface area: volume, meaning they are more efficient at absorbing nutrients. Their growth would therefore be favoured over the growth of round cells in low nutrient conditions, which are likely to result from reduced mixing under the warm conditions and possibly also the Blob source waters. We can also speculate that with more structure: cell contents these long thin cells would be less nutritious to grazers. Coupled with low abundance this could have implications for the productivity of the ecosystem.

Long, thin diatoms have a higher surface area: volume, meaning they are more efficient at absorbing nutrients so their growth would therefore be favoured

There was a similar pattern of lower diatom abundance (contrary to expectations) and increased proportion of long, thin diatoms in the Alaska Shelf region for 2014 and 2015 too. In this region the zooplankton were also clearly responding to the warmth. Figure 19 shows the spring abundance of small copepods, which was relatively high in spring 2014 and very high in spring 2015. Small copepods are typically more abundant in warm years. There was a positive relationship between their spring abundance and the PDO from 2004 (when this region was first sampled) to 2013, and the 2014/2015 data fit with this pattern ($r2=0.34$, $p<0.03$ for the whole time series). The contribution of the small copepods to the total zooplankton community, however, was at record values for spring 2014 and 2015, at over 80% and 90% respectively.
These levels are only usually found in summer/autumn samples. There was no previous relationship between the PDO and spring small copepod contribution so this represents a change in the community in the Blob and El Niño affected years.

The zooplankton community was also biased towards smaller organisms, implying that biomass and perhaps nutritional content was also reduced

We have shown just some of the unusual dynamics displayed by plankton sampled by the CPR in 2014 and 2015, likely in response to the unprecedented warming. Diatoms were unexpectedly low and biased towards cells that do better in low nutrients. The zooplankton community was also biased towards smaller organisms (also in the offshore region shown in Figure 17), implying that biomass and perhaps nutritional content was also reduced. These changes occurred over a wide area, although there were differences in the degree of response from region to region. These data may go towards the way to explaining impacts on higher trophic levels in the NE Pacific.



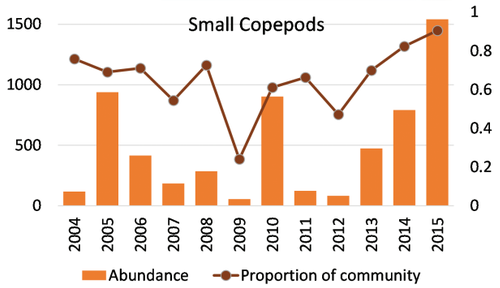


Figure 19. The abundance (bars, left axis) of small copepods in spring each year (Mar-Jun) on the Alaskan Shelf (region shown above. The proportion of the total zooplankton community that was made up of small copepods is also shown (line, right axis).

Bond, A *et al.* 2015, Causes and impacts of the 2014 warm anomaly in the NE Pacific. Geophys. Res. Lett., 42, 3414–3420.

Force majeure: Will climate change prevent Good Environmental Status in pelagic communities?

Abigail McQuatters-Gollop

North Atlantic marine species are responding to climate change in multiple ways including changes in species distributions (bioegeographical shifts), community composition and alterations to seasonal cycles. Plankton, with their short lifespans and sensitivity to their surroundings, are particularly responsive to environmental change.

Plankton are particularly responsive to environmental change

While climate change is driving large-scale alterations to our seas, society is recognising the need to manage human activities impacting the marine environment. In Europe, this is happening via the MFSD, the objective of which is to achieve GES in European seas by 2020. The simultaneous influence of manageable human pressures and climate change on Europe's seas presents formidable challenges to EU policy makers and marine scientists: what are the interactions between climate change and the MSFD descriptors? How can we separate changes driven by climate, unmanageable at the MSFD time scale, from those driven by manageable anthropogenic pressures? Will climate change prevent the achievement of GES?

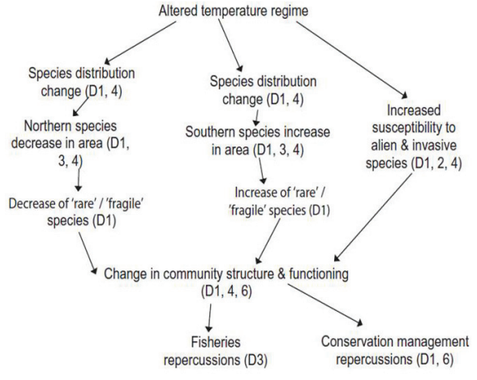


Figure 20. From Elliott *et al* 2015: Species re-distribution and community response due to altered temperature re-gime. MSFD descriptor numbers in parentheses. Descrip-tor 1 (D1): Biodiversity, D2: Non-indigenous species, D3: Commercial fish, D4: Foodwebs, D6: Seafloor integrity.

In the new paper by Elliot *et al* (2015) we show how one aspect of climate change (altered temperature regimes) interacts with one aspect of marine ecology (species re-distribution and community response) (Fig.20). These effects have been observed in CPR data where marine plankton are responding to warming oceans through biogeographical shifts. So, as North Atlantic sea surface temperature increases, warm-water plankton are shifting northwards, while cold-water taxa are squeezed poleward (Fig 21). The conceptual model shows what we know, or think we know, about this small aspect of climate change influence on the plankton. This model illustrates the complex nature of interactions between climate change and marine ecology, which interact with MSFD descriptors. It is these interactions which foster confusion when setting baselines, defining GES, and constructing environmental targets.

The marine ecosystem we see today is different from that of a century ago and different still from what it will be in twenty years. While part of ecosystem change is attributable to anthropogenic pressures, climate change is also a key influence, affecting the temperature, chemistry and hydrology of our seas, and shifting the baselines needed to set targets. This means that ecological targets set today may not be applicable in a decade's time. If we set, for example, an abundance target representing GES for plankton, or for any other mobile species, how do we account for climate-driven distributional and range shifts in that species which may prevent us from meeting our target? Baselines, and therefore targets, must be dynamic, rather than static, triggering management action only where necessary. Monitoring is needed to evaluate the current state of the marine environment and to assess progress towards GES targets. If there is no clear picture of our ecosystem and how it changes, how will we know if we have indeed achieved GES?

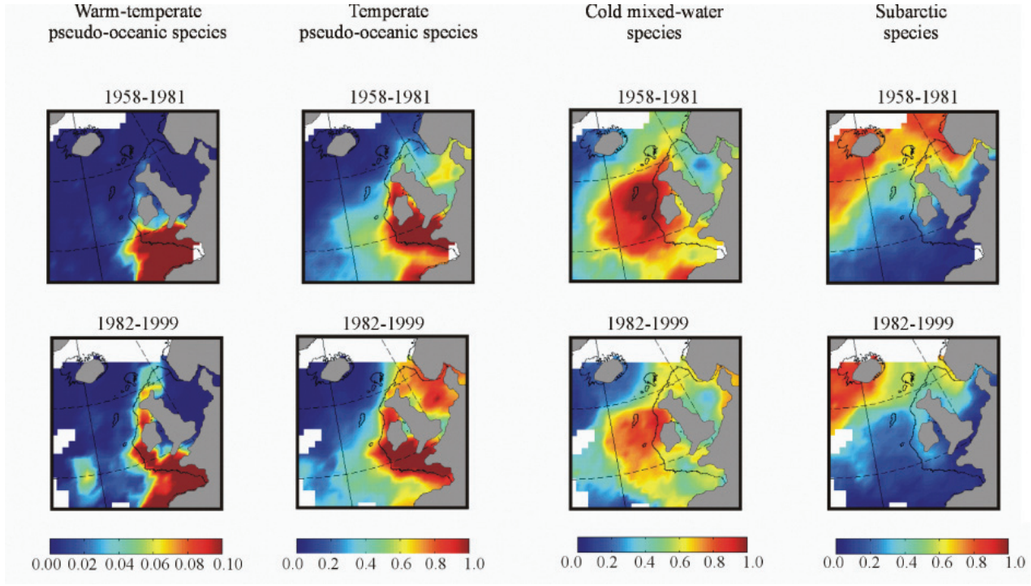


Figure 21. As North Atlantic sea surface temperature increases, warm-water plankton are shifting northwards, while cold-water taxa are squeezed poleward (from Beaugrand *et al* 2002). This is an illustration of a climate-driven biogeographical shift.

Maintaining ecological time-series is crucial for providing the data necessary to inform baselines used for target setting and to asses and interpret change.
When it comes to managing the marine environment during this time of unprecedented climate change, it is no surprise that gaps in our scientific knowledge exist and there are still many things we do not understand, such as how climate change affects organisms' physiology, community interactions and responses to habitat change. While modelling advancements are increasing our knowledge of ecosystem responses to climate change, ecological data, often obtained from monitoring programmes, are needed to further our understanding of many issues.

So, will climate change affect our ability to achieve GES? Is the achievement of GES *force majeure* – out of our control? Climate change is one of the greatest challenges to effective marine environmental management; however, GES is still attainable through the setting of robust targets that accommodate climate change but trigger management action when undesirable change is caused by an anthropogenic pressure.

Separating the climate signal from that caused by anthropogenic pressure, however, is not an easy task, and remains a key scientific challenge. Good data are integral to meeting this challenge, giving monitoring programmes like our CPR survey a place to shine.

Good data are integral to meeting this challenge, giving monitoring programmes like our CPR survey a place to shine

Elliott, M. *et al.* 2015. Force majeure: will climate change affect our ability to attain Good Environmental Status for marine biodiversity? Marine Pollution Bulletin, 95:7-27.

Diversity of microbial species from an automated Water and Microplankton sampling (WaMS) platform

Rowena Stern

The very smallest plankton species are often missed in plankton surveys because they are either too small for the collection method, or lack distinguishing features. However, these plankton are likely to make a large contribution to the microbial food web. The Tara Oceans project made a global assessment of planktonic organisms and found that the pico- and nano-sized plankton (0.8-5µm) were the most abundant size class representing approximately 50% of organisms present and had the highest overall diversity. We carried out a genetic diversity assessment of water samples collected from a WaMS deployed within the CPR device. Since these smaller plankton are more abundant, we expected to capture these preferentially over larger plankton. The smallest autotrophic chlorophytes were very abundant along with the alveolates (a diverse group of plankton that can be autotrophic, heterotrophic or parasitic). Photosynthetic and parasitic alveolates represented 8% and 9% of spring and winter plankton in 2011 respectively.

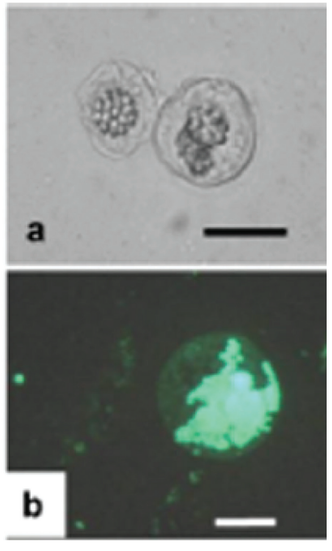


Figure 22: Photomicrograph of Rozzellida parasitic fungi that have infected amoebae cells (a), Panel b shows the parasite when its DNA is stained with a fluorescent agent. Images taken were from a study by Corsaro *et al.* (2014).

The very smallest plankton species are often missed in plankton surveys because they either are too small for the collection method, or lack distinguishing features

Fungi were very common and amongst the more recognised species. We found an unusual presence of parasitic fungi from the Rozellomycota lineage, called the “LKM11” group (Fig. 22). Normally this group is found in soils, but it represented approximately 43% of species present in winter and spring months of 2011. It is thought this group may target water moulds (other fungal parasites that infect diatoms), but they have also been found to infect amoebae, revealing further complexity of microbial food web dynamics.

We carried out a genetic diveristy assesment of water samples collected from WaMS

When we compared the most commonly captured taxa from our study with previous studies from different stations in the English Channel, we found very similar profiles. This suggests that a core set of pico- and nanoplankton re-appear every year. These were a broad group of heterotrophs called the MAST group, Prymnesiophyceae, Cryptomonads and Telonemids, Dinoflagellates, Chlorophytes, Ciliates and certain marine alveolates (see Fig. 23). These have a range of trophic modes; heterotrophic, autotrophic or both

We compared the most commonly captured taxa from our study with previous studies from different stations in the English Channel and we found very similar profiles

LKM11 fungal parasites represented nearly half of species present in winter and spring months of 2011

of these, whilst the marine alveolates we found were parasitic. Our findings that pico-sized alveolates were highly abundant corresponded well with their global abundances.

This study highlights our lack of knowledge on the role of parasites in marine food webs. It is thought that parasites play an important role in species succession and food web regulation and may promote species diversity. Their presence may not be a sign of poor marine health, but simply an unrecognised role in regulating species dynamics. Our diversity study covers one year, and we hope to gain more insights over a five year period to discover if seasonal patterns emerge for these common plankton types and the impact they have on other marine organisms.

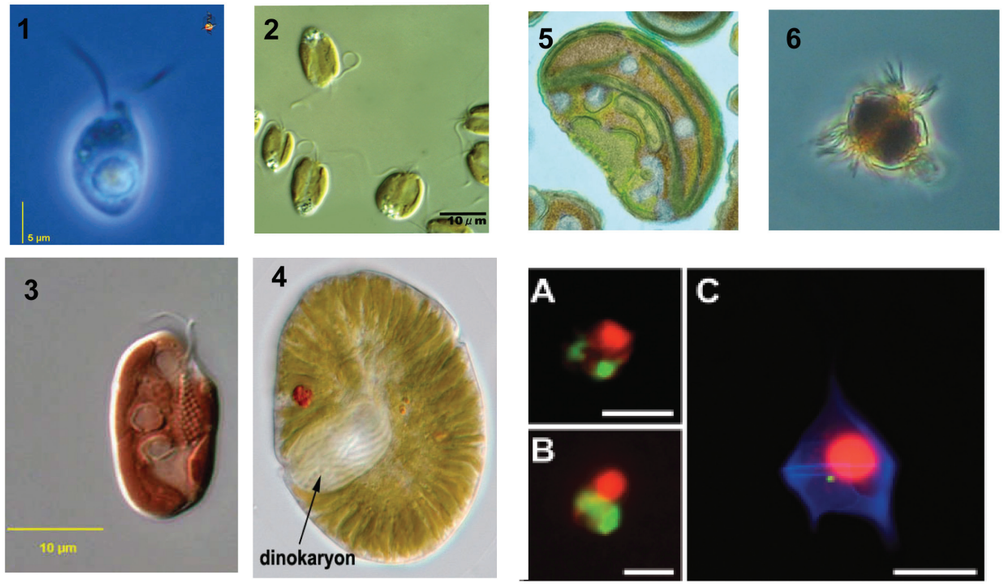


Figure 23: Photomicrographs of common small plankton groups found in the English Channel from combined genetic studies. Telonemid (1), Prymnesiophyte (2), Cryptophytes (3), Dinoflagellates (4), Chlorophyte (5), Ciliates (6). Parasitic marine alveolate are shown in panels A,B show free living parasites whilst panel C shows parasite (in red) infecting an algal cell (in blue). Images were taken from a study by Siano *et al.* (2011). Images from panel 1 from Micro*scope, panel 2 from National Institute for Environmental Studies culture collection, Japan, panel 3 from K. Hoef-Emden (Tree of Life), panel 4 from M. Hoppenrath (Tree of Life), panel 5 is an electron microscopy image by Eikrem and Throndsen University of Oslo, panel 6 from J. Dolan (WoRMS picture gallery).

Stern, R. Picard, K. *et al.* (2015). An automated water sampler for probing marine microbial biodiversity with Ships of Opportunity. Prog. Oceanogr. 137: 409-420.

Detecting *Pseudo-nitzschia* and *Alexandrium* spp. from archival CPR samples using molecular techniques

Jess Clarke and Rowena Stern

Archival CPR samples hold a unique opportunity to re-investigate the changing dynamics of plankton using modern techniques. This masters project developed molecular methods to identify harmful algae from archival CPR samples. The aim was to identify non-toxic variants of two harmful algae genera, *Pseudo-nitzschia* and *Alexandrium*. Both genera contain several species that produce potent toxins that can cause Amnesiac Shellfish Poisoning (ASP) and Paralytic Shellfish Poisoning (PSP) respectively. This causes mortalities in a wide variety of marine animals up to higher trophic levels, and economic losses to the aquaculture industry. Because of this, most research has focused on toxic species. Species within *Alexandrium* and *Pseudo-nitzschia* genera cannot be distinguished by light microscopy, so toxic and non-toxic species are difficult or impossible to distinguish. Genetic analysis has enabled species and populations within species to be identified. Such studies have revealed that non-toxic variant strains can exist, even as a subpopulation within a known toxic species. It is not clear why these algae exhibit variable toxicity. One possibility is that the environmental conditions modulate toxin production, or create a niche in which non-toxic variants thrive. However, there is

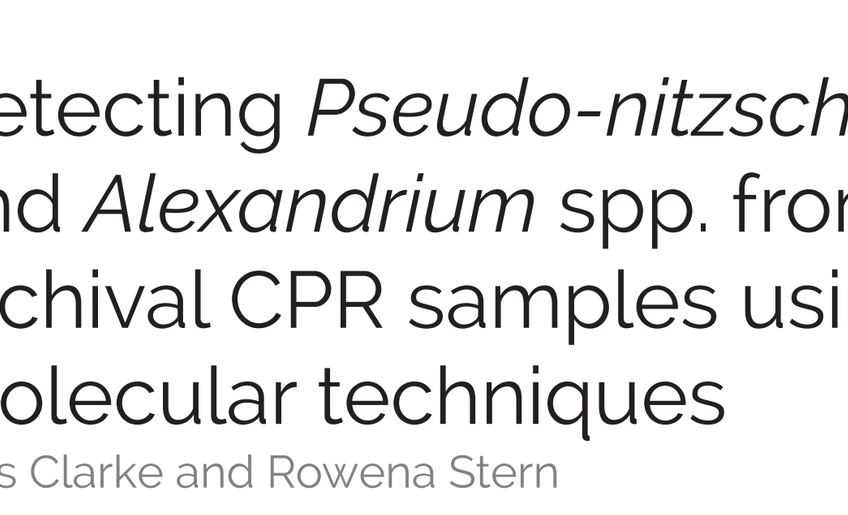


Figure 24. Panel A shows a map of the A- route in the North Sea towing the CPR from Aberdeen (north east Scotland) to Lerwick (Shetland Islands) over three years from 2011. Each red dot represents one sample. The shipping route may vary slightly from year to year. Panel B depicts three years of PCI values (2012-14) from a series of tows going from Aberdeen to the Shetland Islands in Scotland. For each year, monthly averages were calculated to obtain the dataset used. Three non-consecutive months were interpolated to avoid any missing values. The frequency of occurrence and quantity of DNA of *Alexandrium* is represented on the diagram by grey circles where size is proportional to their quantity, while presence of *Pseudo-nitzschia* is represented by a cross. The presence of total *Pseudo-nitzschia* and dinoflagellates from CPR taxonomic counts are also indicated.

Toxic and non-toxic variants of harmful algae may thrive in different niches

scarce data with which to compare toxic and non toxic strains. Information on non-toxic strain dynamics (e.g. seasonality, distribution) is important as toxic and non-toxic algae dynamics can be compared. This will allow more accurate prediction of harmful algal occurrence.

This study applied quantitative molecular methods to identify two smaller phytoplankton species belonging to *Pseudo-nitzschia* and *Alexandrium* considered to be non-toxic. Tests were carried out on archival CPR samples from three regions: The English Channel, North Sea and the Iberian coast between 2011-2014. Additionally, water samples from the WaMS device were also tested in the English Channel over the same time period. The non-toxic *Pseudo-nitzschia* sp. was successfully identified in both CPR and WaMS samples, where it was present in all three regions, exhibiting inter-annual variability with seasonal peaks generally during Autumn. Other toxic *Pseudo-nitzschia* species cohabit these regions, but little data exist on their species-level dynamics, which remains a subject of interest at SAHFOS. By contrast, the non-toxic *Alexandrium* was successful identified but only in off-shore North Sea near Scotland, where it was present in low levels all year round with no seasonal dynamics. It was absent in both CPR and water samples from the English Channel. Non-toxic *Alexandrium* sp. was previously reported in coastal Scottish sites where it exists alongside a toxic species. In the future, we aim to test both toxic and non-toxic species to determine if they have different environmental preferences that would allow modellers to predict their occurrence. Figure 24a shows the North Sea sampling area and Fig. 24b reveals the presence of both species compared to overall phytoplankton biomass (as measured by chlorophyll-*c*). It is clear both species do not follow the seasonal pattern of most phytoplankton species in the North Sea, *Pseudo-nitzschia* has a different seasonal pattern to larger relatives that are observed on the CPR survey.

Several limitations were identified when using CPR samples to determine species occurrence; one of which was that DNA was progressively altered in the formalin preserved samples with time. Therefore species detection is often under-represented. However, these alterations are reversible with the use of special reagents that can be used in future studies. Regardless of these limitations, molecular detection of ecologically important algae species on these archival samples remains a useful tool with the potential to test long-term patterns of toxic and non-toxic algae in these regions.

Jess Clarke completed this project as part of her Masters of Research in Marine Biology and is now characterising algae at the University of St. Andrews

Stern, R. Helaouët, P., Clarke, J. (2015) Smaller HAB types identified on archival samples from the Continuous Plankton Recorder Survey. Harmful Algae News (accepted)

New pathogens detected in UK waters

Claudia Martins and Rowena Stern

To determine the health of the English Channel, an area of high anthropogenic impact, water samples from the WaMS were tested for the presence of pathogens using molecular assays. One potentially concerning discovery was the presence of both a protozoan amoeba pathogen and a pathogenic bacteria parasite in 6-10% of the samples. The parasitic bacteria were always present whenever the amoeba was detected. These were present at all sites in the English Channel in most samples from 2011 but only in one sample in 2012. In our study most parasitic bacterial genotypes were unknown environmental types, but two were found to be related to clinically pathogenic strains. It is unclear why 2011 samples had more of these pathogens compared to 2012, but it could be a number of environmental or anthropogenic influences. These organisms usually exist in freshwater environments but multiple studies have demonstrated their existence in marine systems and their source is unknown. Given the potential harmful nature of these organisms, more research is planned to test for their presence and abundance in riverine environments plus a range of zooplanktonic organisms that may harbour these organisms.

Microbes that potentially infect humans were found in almost 10% of samples from the English Channel

Flow cytometric analysis of phytoplankton collected by WaMS

Rowena Stern and Glen Tarran

Flow cytometry is a method that can separate groups of small phytoplankton cells based on light scattering and pigment fluorescence. Whilst it does not identify species, it is useful for measuring cell numbers smaller than approximately 20µm and enables comparisons of marine phytoplankton community structure at different sites, which may be important for assessing the health or ecological status of the water. Moreover, results can be obtained within a day, which could alert stakeholders to make more detailed tests.

SAHFOS has tracked changes in five phytoplankton groups from 2011-2012 in the English Channel through flow cytometry. We compared the abundance of these five groups over five stations across a 92 mile transect of the English Channel using the WaMS deployed within the CPR, with that of two single coastal stations (L4, E1) at the Western Channel Observatory (WCO) off Plymouth, see Fig. 25. The aim was to identify any differences between near coastal sites versus far coastal (WaMS stations 1 and 5) and open water (WaMS stations 2-4). The English Channel is considered well mixed, station 5 can become stratified near the coast, experiences seasonal stratification and is influenced by river outputs. Stations 3 and 4 are subject to Atlantic frontal influence.

Overall we found similar patterns of abundance between the WaMS sampling system and that capture by standard collection methods at stations L4/E1 but the location and cell abundances varied. Coastal and open water regions differ in timing and abundance of phytoplankton. Coastal sites had a greater abundance of nanoplankton and cryptophytes compared to far-coastal or open water regions. Photosynthetic *Synechococcus* cyanobacteria from WaMS had altered abundance between coastal (L4/E1) and offshore sites (WaMS stations 3, 4). Picoeukaryotes were far more abundant in open water regions in the WaMS samples compared to coastal sites (L4/E1). Many picoeukaryotes and photosynthetic bacteria prefer low nutrient conditions. Coccolithophores also attained higher abundance in open water regions.

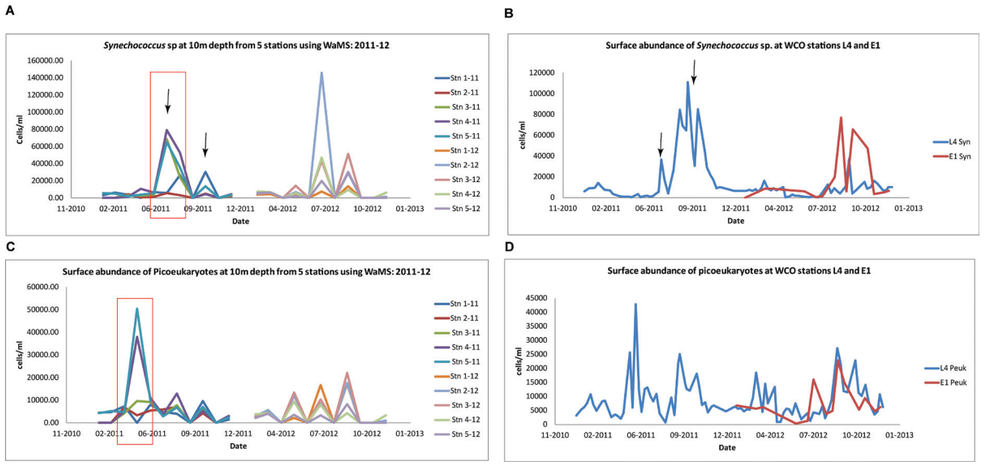


Figure 25: Seasonal patterns of two of the five phytoplankton groups measured by flow cytometry between 2011 and 2012. Panels A and C represent offshore samples collected by the automated WaMS device, whereas panels B and D are samples taken at coastal locations L4, E1 of the English Channel. The timing of peak cell abundance were similar between WCO and WaMS sites but spatial locations were different. The red boxes in panels A and C show how cell abundances can be very different depending on the location of the sampling stations (stn). Picoeukaryotes are highest at stations 1 and 2 (nearest to the UK coast) in panel C, in concordance with WCO coastal measurements (panel D). However, the arrows show that WCO records can differ from WaMS samples. In 2011 a small and a large *Synecoccocus* bloom was recorded in June and September respectively (panel B) at the WCO. The additional station measurement of WaMS (panel A), revealed a large bloom in June 2011 off the French coast to mid- English Channel (Stn 1-3), which was missed in the WCO records. However the WaMS missed peak abundance of the bloom in September 2011 because it is towed less frequently.

Tarran, G. Bruun, J. (2015) Nanoplankton and picoplankton in the Western English Channel: abundance and seasonality from 2007–2013, Progress in Oceanography, Volume 137(B): 446-455.

Towards a comprehensive monitoring system for harmful microbes

Rowena Stern

This year has seen the development of molecular assays to monitor a range of harmful algae and other microbes that would otherwise be missed by traditional techniques. The Defra-funded project allows more marine autonomous observations. Part of this initiative is to improve the speed of these observations for key harmful species. The molecular team developed quantitative DNA-detection assays for a number of harmful organisms (six harmful algae, four pathogens) that are commonly found in UK waters or were found by diversity assessment of the WaMS. The assay, called high resolution melt-curve quantitative PCR (HRM-qPCR), shown in Figure 26 is a relatively inexpensive and rapid technique that can specifically detect a DNA fragment from its melting properties when heated. At the same time, the technique can quantify the number of DNA fragments in environmental samples by comparison with known standards.

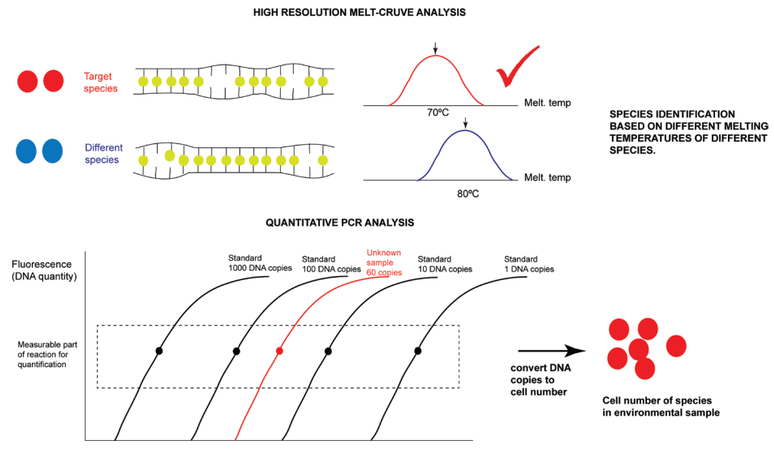


Figure 26: Schematic of the genetic methods that can rapidly and specifically identify harmful algae such as *Pseudo-nitzschia* from DNA extracted WaMS water samples and CPR samples. High-resolution melt curve (HRM) analysis uses the fact that DNA from different species is unique and when heated will ‘melt’ or separate the DNA strands in different ways, allowing the species to be recognised uniquely. The DNA is labelled with a fluorescent marker (yellow balls) so that it can be measured by a machine. In this case we combined HRM method with quantitative real-time PCR (not shown here), a method that can quantify the amount of DNA and thus cell abundance in the original environmental sample.

Knowledge Exchange

A year of engagement

Jennifer Skinner

Knowledge exchange is an important part of SAHFOS' ethos. Communicating our science, and most crucially, the impact of our science, is essential in conveying why our work is so vital.

2015 kicked off with British Science Week, an annual event held here at Citadel Hill, and nationwide. Over 120 primary and secondary school children attended over 2 days and were immersed in all things marine including the secret world of plankton. Students identified live plankton samples collected from Plymouth Sound, rich in young jellyfish and barnacle larvae, engaging students and teachers alike. Staff also visited a local primary school deliver an ocean science themed school assembly and to assist with the children's science fair.

International students from the Plymouth University's Access course visited in March for a hands-on plankton taxonomy practical. This visit formed part of their coursework on biodiversity and speciation, and helped them understand the necessity of knowing which species occur where, in terms of indicators of environmental change and the implications into policy and environmental management decisions.

The first Marine Ecology and Conservation Network Conference, organised by the University of Exeter, was held in June 2015. SAHFOS delivered a presentation-showcasing the CPR as a monitoring platform, capable of monitoring more than just plankton. This event offered a brilliant opportunity to network with like-minded individuals, increase people's awareness of SAHFOS and our monitoring potential, and provided an opportunity to liase with Education Institutes for future research and outreach collaborations.

SAHFOS also took advantage of local events to engage with the general public about our work. Our partners, Brittany Ferries, kindly donated a prize of a family trip to France for a competition we ran at Plymouth's Lord Mayors Day, asking how much of the planet's oxygen is produced by plankton (*answer at the bottom of the page!). SAHFOS teamed up with local seafood restaurant Rockfish, who sponsored this years' Blue Mile event, involving a sponsored 1 mile swim/kayak/stand up paddle board in Plymouth Sound – participants were amazed to see the variety of plankton in a pot of seawater under the microscope!

Bioblitz took place this year in September in Salcombe, Devon. Attracting local families and schools this annual event sets out to find and record as many species of flora and fauna as possible in a given area over 24 hours. In conjunction with the Marine Biological Association, SAHFOS led a plankton safari carrying out plankton trawls, collecting samples and sorting through the specimens.

Images top left to right: Building plankton models for Big Bang Near Me, entering competition on Lord Mayors Day, the MedCPR participants. Above: Plankton comes in a cuddly format too!

Outreach Events 2015

- PlyMSEF lecture
- British Science Week at Citadel Hill
- St Andrews school assembly & science fair
- Access students plankton workshop
- Plymouth Lord Mayor Day
- Big Bang Near Me, City College on World Oceans Day
- Marine Ecology and Conservation Network, Penryn
- International Zooplankton Workshop
- BBC filming at SAHFOS
- Ocean City Festival – Rockfish Blue Mile
- MedCPR workshop, Cyprus
- Bioblitz, Salcombe, Devon
- NERC summer of science- RRS *Discovery*, London
- Thackrah Club talk (local interest group)
- MP Visits - George Eustice MP & Oliver Colvile MP, Clare Moody MEP, Johnny Mercer MP

In July, SAHFOS ran an International Crustacean Zooplankton Workshop, attracting participants from around the world; see page 30 for a full report.

SAHFOS' newest sister survey, operated by The Cyprus Institute, organised a Mediterranean CPR workshop in September, and invited Jennifer Skinner as a guest lecturer. Attendees from across the Mediterranean gathered to learn more about the CPR Survey, including how to set up and run a survey, applications of CPR data and research and its role in informing national and EU policy. We were able to visit the ship which tows the CPR for the Institute between Cyprus and Israel and meet some of the crew, who were only too pleased to host us. This was an important visit to highlight the strong link and essential role of the shipping community in terms of the operation of the CPR Survey to the workshop participants.

In October, SAHFOS boarded the Royal Research Ship *Discovery*, as part of NERCs "Summer of science" 50th anniversary celebrations. For this special event, RRS *Discovery* left her usual base in Southampton and travelled up the Thames, to be moored alongside HMS *Belfast* in the centre of London. Visitors from science, industry, government, business and members of the public boarded the ship to learn more about NERC funded science and research. *Discovery* was full of scientific research equipment and technology, including high spec unmanned aerial vehicles, radar sensors and, of course, a SAHFOS CPR. People were fascinated to learn that a CPR was first tested on the original *Discovery* in the 1920s by Alister Hardy and has since gone on to form the backbone of the longest running and most geographically extensive survey of its kind in the world.

*Over half of the world's oxygen is produced by phytoplankton!

Science and Policy Update

Abigail McQuatters-Gollop

Policy drivers influence research at SAHFOS and an important aim of the organisation is to use CPR data and the expertise of SAHFOS scientists to deliver evidence-based advice to policy makers and ecosystem managers. SAHFOS continues to hold a place on the UK Marine Monitoring and Assessment Strategy (UKMMAS) Healthy and Biologically Diverse Seas Evidence Group (HBDSEG). In addition to its involvement in HBDSEG, SAHFOS remains active in multiple ICES Working Groups.

In 2015 SAHFOS expertise and CPR data also contributed to policy-relevant products for the following UK, European and international bodies: Defra, the Marine Climate Change Impacts Partnership (MCCIP), OSPAR, the European Marine Observation and Data Network (EMODNET), ICES, Royal Society for the Protection of Birds (RSPB), the American National Science Foundation, and the Canadian Department of Fisheries and Oceans.

SAHFOS science is directly influencing UK and European marine policy, through involvement in the UK's implementation of the EU Marine Strategy Framework Directive (MSFD). SAHFOS is involved at both the UK and OSPAR (northern Europe) levels and CPR data are crucial to these efforts. During 2015 the first draft of the OSPAR-level plankton indicators was completed and reviewed. The indicators will be presented to the OSPAR Biodiversity Committee in March 2016 for approval. These indicators will contribute to the OSPAR-level Intermediate Assessment for the MSFD, which will be published in 2017. SAHFOS also plays an integral role in the "Addressing gaps in biodiversity indicator development for the OSPAR Region from data to ecosystem assessment: Applying an ecosystem approach to (sub) regional habitat assessments (EcApRHA)" project. EcApRHA, led by OSPAR, supports MSFD indicator development for plankton, benthic and foodweb ecosystem components.

SAHFOS's policy work reached an international audience during 2015. In July 2015, Abigail delivered an invited keynote about the role of CPR data in the MSFD at the Australian Marine Science Association's Annual Conference in Geelong, Australia. She then delivered a workshop at the Great Barrier Reef Marine Park Authority in Townsville, Queensland. Australia is in the process of implementing a management plan for the Great Barrier Reef and the workshop disseminated some of the challenges, successes, and lessons learned from MSFD implementation in Europe. It is very exciting for SAHFOS to play a role in conserving the Great Barrier Reef! While in Australia, Abigail also spoke about SAHFOS's science-policy work at Queensland University and University of Central Queensland. CPR data and SAHFOS research were also used in the UN's first ever World Ocean Assessment (WOA), published in December 2015. The WOA is the first ever global assessment of the state of the world's oceans, the aim of which is to provide a sound, scientific basis for decisions at the global level on the world's oceans and seas, and a framework for national and regional assessments and management decisions.

Assessments, talks and workshops such as these provide a mechanism to transfer scientific information to decision makers and facilitate the evidence-based development of monitoring programmes and policy measures. These activities also increase the profile of the CPR dataset and SAHFOS research.

Images: Far left Abigail McQuatters-Gollop was invited to deliver a workshop to aid the Australian Great Barrier Reef Authority in implementing a management plan.

Right: Abigail taking some time out to meet some of the locals.

Communications: Publicity and Social Media

Nicola Rickard

Good progress has been made with the development of SAHFOS's public profile. The Foundation has featured across television, radio, newspapers and online media outlets and we are developing ideas to make this happen more frequently. The biggest media highlight for 2015 would undoubtedly be our feature within BBC One's The Big Blue series in August. Wildlife presenter Richard Taylor-Jones and his film crew came to Plymouth to shoot the CPR survey process, from early morning instrument collection with Brittany Ferries at Millbay Docks through to arrival at the workshop, silk cutting and then under the microscope in the lab. The feature was broadcast on BBC One at the end of August – it also brought further local publicity and saw SAHFOS feature on BBC Spotlight, BBC Radio Devon, Western Morning News and Plymouth Herald.

Following this work with the BBC Natural History Unit, SAHFOS were then called upon to assist with scripting for a feature piece for the channel's evening magazine show, The One Show. They were looking into zooplankton migration – Senior Taxonomist Marianne Wootton helped their team.

The plan going forward is to boost this further, and publicly highlight the unique, large scale and pioneering work emanating from SAHFOS. Staff papers and publications will be presented to non-scientists in a way that highlights what will impact them, steps which shall now be easier after developing better relationships across various press and media platforms.

After careful consideration, the re-development of the SAHFOS website has been put out to tender to give it a fresh new look in the early part of 2016! It can be difficult for global institutions, such as SAHFOS, to reach out to different international regions and organisations, but we believe this new easy-to-use and engaging website will create that first step. The SAHFOS website received just over 23,000 visits in 2015 (highest figures ever), resulting in 72,000 page views, 2/3 of these were made by new visitors.

Engagement continues across SAHFOS social media and is paying dividends. SAHFOS followers on both Twitter and Facebook have almost doubled within the past 12 months. Twitter followers have nearly reached 2,000 and Facebook 'likes' has passed 500. Social media acts as a quick tool to instantly reach a large audience. Our on-line activities will be pushed even further once our new-look website is live.

Images. BBC One's The Big Blue series. Wildlife presenter Richard Taylor-Jones and his film crew came to Plymouth to shoot the CPR survey process: Left Workshop Manager, Lance Gregory being interviewed on-board Brittany Ferries *Armorique*. Center and right: Director Nick Owens being interviewed in front of Plymouth Sound and analysing in the laboratory.

Dont forget to follow us!

Fundraising

Nicola Rickard

Work continues with SAHFOS fundraising efforts and we have started to establish relationships with a number of partners. Our approach to fundraising will have a fresh look for 2016 with a stronger focus on the impacts of our science and how they might be applicable to like-minded businesses and groups. We are confident this adjustment in our fundraising approach will prove more fruitful in donations received.

Task Force

The SAHFOS Task Force has been working on the development of a number of exciting projects. These might not be evident for a few years but they all have the common objectives of raising the profile of SAHFOS's work and bringing in additional funding.

2015 members included:

- Dr William Wilson, Director SAHFOS
- Prof Geoff Boxshall FRS, Merit Researcher, Natural History Museum, London
- Richard Coombs, Chairman, South West Investment Group
- Karen Morgan OBE, former Chairman UWE, former board member Environment Agency and former council member NERC
- Dr Dan Laffoley, Ocean Conservationist and Marine Biologist
- Prof Howard Roe, Director Emeritus, National Oceanography Centre
- Dr Graham Shimmield FRSE, Executive Director, Bigelow Laboratory for Ocean Sciences
- Prof Bess Ward, Chair of Geosciences Department, Princeton University

London Fundraising Event

To raise the profile of SAHFOS, expand its network of prospective donors and increase interest in the fundraising campaign, SAHFOS held its first fundraising event at the Smith Centre, Science Museum in London at the end of October, with welcome remarks by Sir Martin Smith, founder of the Smith Centre and Smith School of Enterprise and the Environment, Oxford. Attendees represented a wide range of governmental and academic sectors at an afternoon event, with a separate event in the evening for both commercial and philanthropic sectors. We are now working on developing partnerships with a number of both event attendees and invitees.

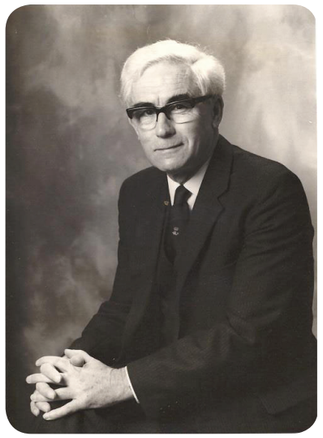
Easyfundraising

SAHFOS is now a registered cause at www.easyfundraising.org.uk. The website allows for online shoppers to donate to a cause of their choice when purchasing via registered online businesses, who then give cash back to the cause, with no extra cost to the shopper. Registered sites include John Lewis, Ebay, Amazon, plus almost three thousand other retailers.

Willie Wilson and Sir Martin Smith at The Smith Centre, Science Museum, London.

From donations to in-kind gifts, there are numerous ways to support SAHFOS, Please contact Nicola Rickard nicric@sahfos.ac.uk for further details.

Roland Stanley Glover BSc, FSB, FRSE. Born 9 June 1922. Died 22 November 2014.



Roland Stanley Glover (nicknamed "Ro" by close friends) was born in Manchester on 9 June 1922.
He attended Manchester University where he was awarded a BSc in Zoology, Botany and Chemistry in 1944. He became a Scientific Officer, then Honorary Lecturer in the Departments of Oceanography and Zoology at Hull. Ro Glover was then recruited in 1950 to the Edinburgh Oceanographic Laboratory (EOL) of the Scottish Marine Biological Association (SMBA), to work on Sir Alister Hardy's Continuous Plankton Recorder (CPR) survey.

In the 1960s, Ro Glover oversaw an expansion of the CPR survey into the Atlantic and new developments which transformed CPRs into undulating servo-powered samplers, which obtained vertically integrated (10-70m) samples of plankton. This resulted in new collaboration with US oceanographers, and an expansion of the Edinburgh staff from 12 to 36 scientists and engineers.
In 1966 he was promoted to Director. Soon after, he made a strategic redirection of research at Edinburgh by integrating both experimental and field observations in marine biology and oceanography. This enabled a better understanding of the structure, function and performance of marine ecosystems. Together with his Edinburgh colleagues he successfully applied this "systems ecology" approach to the CPR time series yielding a quantitative understanding and insight of phytoplankton, zooplankton and commercial fish larvae in the North Sea and the North Atlantic Ocean.

The success of this approach convinced the Natural Environment Research Council (NERC) to set up a new Institute for Marine Environmental Research (IMER) in 1970 to also tackle shelf and estuarine ecosystems and marine pollution. At first it seemed possible that IMER might be established on the new campus of Heriot Watt but NERC decided in favour of Plymouth so as to promote new synergies with the fundamental research conducted at the Marine Biological Association (MBA). The relocation controversy was settled only after the involvement of the Secretary of State for Scotland and the UK Minister of Education and Science (Mrs Margaret Thatcher). NERC compensated Edinburgh with a new research unit for its Institute of Terrestrial Ecology.

Throughout the 1970s, Ro Glover worked tirelessly to enhance and relocate the CPR team from Edinburgh to Plymouth, and to integrate them with young marine biologists, physicists, chemists and computer specialists who were recruited and temporarily housed in converted premises. Thereafter he meticulously planned and supervised the construction of the new IMER research and experimental laboratories and ensured that they were equipped with the latest experimental, analytical, shipborne and computing facilites with a capacity for 160 staff. The new laboratory overlooking Plymouth Sound was finally inaugurated in 1977 by Dr David Owen MP and was his crowning glory.

Ro served as council member of the MBA, SMBA, and BES and as a Director of SAMS and SAHFOS. He served on the editorial boards of Marine Ecology Progress Series, Marine Biology, Journal of Applied Ecology and Journal of Plankton Research. He authored 86 publications, reports and reviews, many in top journals.
He was elected a Fellow of the Royal Society of Edinburgh in 1960 and of the Institute of Biology (now the Society of Biology) in 1971.Ro Glover's legacy is that he laid down foundations for large scale marine ecosystem observation, experiments and their synthesis using simulation modelling. This ecosystem legacy lives on in the two highly successful organisations that followed on from IMER: the Plymouth Marine Laboratory (PML) and SAHFOS.

Following his retirement in 1983, Ro Glover joined the Royal Society of Arts and took up painting to depict his beloved ocean. Thereafter, he shunned visits to his marine laboratory not wishing to 'shadow' his eminent successors. He died on 22 November 2014, aged 92, in Bournemouth.

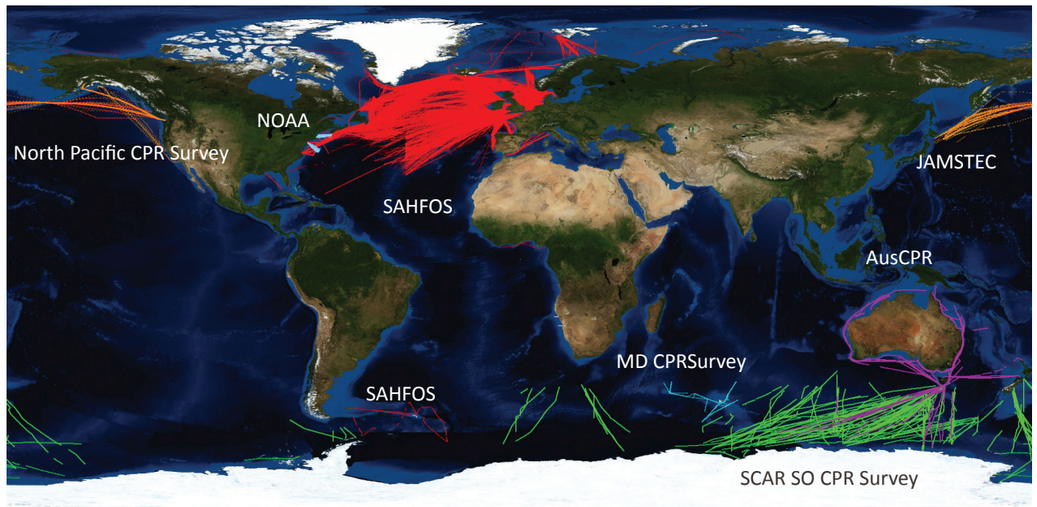
Reproduced by Marion Smith with the kind permission of Professor (Emeritus) R Fauzi C Mantoura BSc PhD FRSC Former Director, Plymouth Marine Laboratory and The Royal Society of Edinburgh

Global Alliance of CPR Surveys

Sonia Batten

The Global Alliance of Continuous Plankton Recorders, known as GACS, brings together the regional CPR surveys around the globe to foster collaboration within the CPR community and to act as an interface between it and other global observing programmes. The most recent annual meeting was held in September 2015 where progress was reviewed and priorities set for the upcoming year.

Training and capacity building has been a particular strength of GACS recently, with a workshop held in September 2015 at SAHFOS to provide CPR training to survey members from Brazil and Australia. It was originally intended that participants from India would also attend but visa problems caused last minute changes to that plan. SAHFOS agreed to host an additional training workshop for the Indian participants early in 2016. A methodology and taxonomy training workshop was conducted in March 2015 in Cape Town for the South African and Namibian CPR personnel, via support from an inaugural Scientific Committee on Antarctic Research (SCAR) Visiting Professorship awarded to Dr Graham Hosie, together with the support of the Department of Environmental Affairs (DEA) South Africa. Dr Kunio Takahashi has been awarded a Scientific Committee on Oceanic Research (SCOR) Visiting Scholars Program in 2015 to help teach the Southern Ocean taxonomy and method for an Indian Ocean/Southern Ocean group. Exchange of personnel between SAHFOS and AusCPR and between SAHFOS and Brazil occurred in 2015 which further enhanced inter-survey cooperation and standardisation.



Sample positions from the GACS surveys

In the Southern ocean, 50 CPR tows were conducted during the 2014/15 Antarctic field season from seven vessels, which led to approximately 4,000 samples collected over ~20,000 nautical miles this season. The AusCPR Survey has had some challenges with changing shipping routes and funding cut-backs but continued good coverage around Australia in 2015. Shipping challenges also occurred in the North Pacific Survey during 2015, all but one tow went ahead as planned. MedCPR continued to sample in 2015, and although challenged with finding new funding sources later in the year the initial success has been promising. The first Brazilian survey sampling in Drake's passage occurred early in 2016 so the GACS coverage continues to increase.

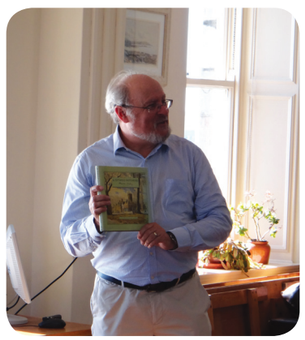
Conducting and publishing the first global analysis from the GACS database was seen as a major priority, and will focus initially on representative ecosystem Essential Ocean Variables (EOVs) currently being discussed by the Global Ocean Observing System (GOOS) community. GACS offers the best opportunity for describing plankton community variability at approaching-global scales.

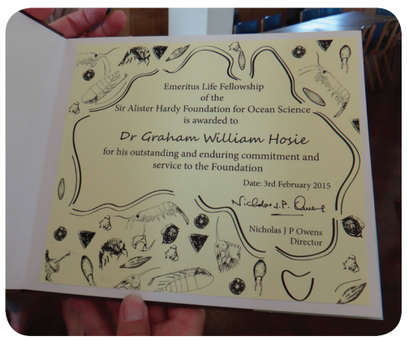
The recently established GOOS Biology and Ecosystems Panel invited Sonia Batten as the Chair of GACS to participate as a panel member. The panel will use the experience of its members with sustained ocean biological and ecosystem observations to develop and identify relevant EOVs. It is hoped that promotion of the EOVs and expanding successful observing systems will enable them to become part of a sustained, GOOS framework. The goals of GACS match very closely with the goals of the panel and our involvement should be mutually positive.

To find more out about the global alliance of CPR Surveys please visit our website www.globalcpr.org

First Emeritus Life Fellow: Dr Graham Hosie

In recognition of Graham's long-standing service and association with the CPR and SAHFOS since 1990, Graham was awarded the honour of being the first Emeritus Life Fellow of the Sir Alister Hardy Foundation for Ocean Science. Graham considers the support and advice from SAHFOS central to the success of the Southern Ocean CPR Survey, getting 12 nations involved and making it the largest international Southern Ocean/ Antarctic Biological monitoring programme. It was a natural progression to help establish the domestic CPR programmes in Australia, New Zealand, Japan etc and then help SAHFOS advance its agenda, especially going global and the establishment of GACS. Graham became a Trustee of SAHFOS in 2006 and then a member of the Science Advisory Board (SAB) in 2013. He retired from the Southern Ocean CPR Survey and Chair of GACS and subsequently the SAB in April 2015. Graham was presented with his Certificate, which was mounted in an original copy of etchings and watercolours by Alister Hardy entitled: A Cotswold Sketchbook on 30 September 2015 by Dr Willie Wilson, Director of SAHFOS during Graham's visit to Plymouth with his wife Karen and daughter Fiona.





Images: Dr Graham Hosie receiving his ELF award from Director Willie Wilson

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SAHFOS Staff in bold. *Associate Researchers/ Research Fellows/ PhD Students

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Ocean Silk Roads

Caroline Carver

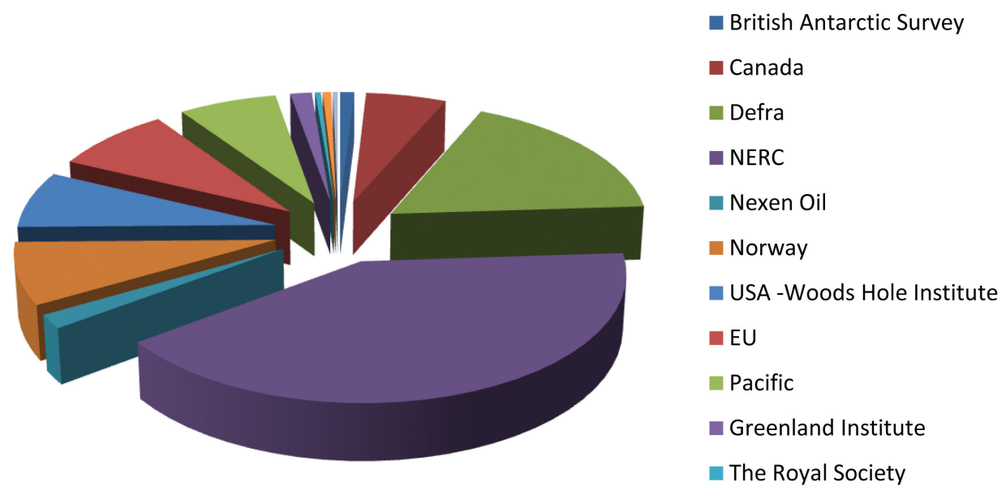
like fishermen of the moon
laboratory technicians
have installed this drum
with its layers of finest Shanghai silk
which now stream out behind our ferry
collect samples of plankton
precious as rubies
before winding them in for their last journey
back to the lab perhaps
no worse an end
than any other

'Ocean Silk Roads' inspired by the CPR Survey. This poem features in the newly released book 'Fish Eaters'.

Fish Eaters is a beautifully illustrated book of poems inspired by the seas and oceans of the world. The poems are all authored by Caroline Carver who has been 'poet in residence' at Plymouth University's Marine Institute. The book is the result of a year's work and is available to purchase through the Plymouth University Press.

Grant and Contract Income Summary

Jean Nyman



The principal sources of funding for 2015 are broadly derived from grants and contract income from Primary Funding Organisations, and Research & Academic Organisations.

Primary Funding Organisations provide support funding to enable the general operation of the CPR Survey.

In 2015 these were:
- UK Natural Environment Research Council (NERC)
- UK Department of Environment, Food and Rural Affairs (Defra)
- US NSF National Science Foundation.

Research & Academic Organisations commission SAHFOS to undertake specific research, or tow specific routes. SAHFOS may also collaborate with other research groups, sometimes under the umbrella of International Organisations.

In 2015 these were:

- Prince William Sound Science Centre
- North Pacific Research Board
- Dept of Fisheries & Oceans Canada
- British Antarctic Survey
- European Union
- European Environment Agency
- Institute of Marine Research Norway
- Greenland Institute
- Nexen Oil
- Royal Society
- Gordon & Betty Moore Foundation
- Others

The grant and contract incoming resources for 2015 remain level, excluding other income from charitable activities, these are reported at £1,548,556 (2014 £1,558,537).
The complete audited accounts are available on the SAHFOS website.

The Foundation is dependent on securing funding from external sources through contracts and grants to enable it to continue its work. Different sources of funding continue to be investigated in order to diversify the funding stream.

The Sir Alister Hardy Foundation for Ocean Science (SAHFOS) is an internationally funded charity that operates the Continuous Plankton Recorder (CPR) Survey. The Foundation has been collecting plankton with the resulting data providing information on biogeography and ecology of the planktonic community. More recently, work has been expanded to include other regions around the globe including the Arctic and Southern Ocean. The results of the Survey are used by marine biologists, scientific institutes, governmental bodies and in environmental change studies across the world.
The SAHFOS team is based in Plymouth, England, and consists of scientists, technicians and administrators, who all play an integral part in the running of the Survey.

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