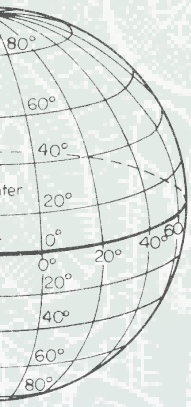
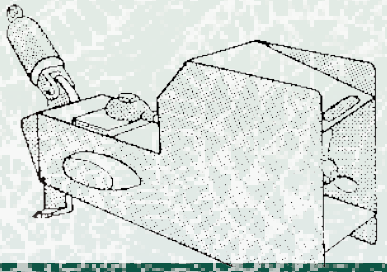


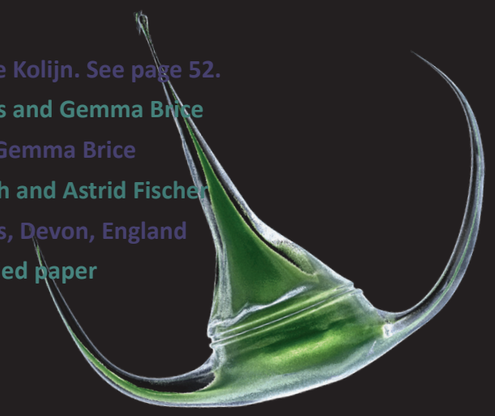
Sir Alister Hardy Foundation for Ocean Science

Monitoring the health of the oceans since 1931



2014 Annual Report

The Continuous Plankton Recorder Survey Est. 1931



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Director's review

Writing the introduction to SAHFOS' Annual Report is a genuine pleasure and a task to which I have come to look forward to doing. The reason for this is I am consistently pleased to see such an array of really fascinating and excellent work being done by a relatively modest number of people. SAHFOS is not a large organisation but we certainly have an impact way above our size.

SAHFOS' core activity is of course the maintenance of the Continuous Plankton Recorder (CPR) Survey. The CPR Survey started in 1931 and SAHFOS has had the considerable and weighty responsibility of continuing the running and safeguarding of the CPR Survey since 1990. Whilst the core of the Survey has remained largely unchanged (this is one of its greatest strengths), the ancillary activities and associated science have developed considerably and at an increasing rate. Many of these recent activities are covered in this report.

The success of the CPR Survey starts with the professionalism and dedication of the Workshop team, whose members ensure the CPRs and all the equipment for successful towing are maintained to a high standard. There is a fiendishly complex array of logistics needed to ensure CPRs arrive at the right ship at the right time, and ultimately are returned to us with their precious samples intact. I am pleased to say, through the excellent work of the workshop and logistics staff, SAHFOS has seen yet another record year of distance sampled (~140,000 nautical miles) with a consistently high success rate of sample integrity. Whilst this reflects the great work at SAHFOS, we are always very conscious of the huge measure of volunteer support we receive from shipping companies, ships' crews, agents etc. without which we would not be able to operate. Our position relies entirely on the goodwill of so called 'Ships of Opportunity'; this term rather underestimates the considerable resource that supports our operation and we are extremely grateful to everyone and every company involved.

Once the plankton samples, from all over the world, are safely returned to us, our excellent team of taxonomists get to work on them. SAHFOS has the largest permanent team of marine plankton taxonomists probably in the world. Unfortunately taxonomy in general is becoming a 'Cinderella' subject and is rarely taught now at an advanced level. Various other methods of identification are useful, for example, optical character recognition methods and genetic tools, both of which we use in SAHFOS. There are several examples of our developing molecular biology work in the report. However, in SAHFOS we rely on the careful and expert 'classical' identification of marine plankton and this will remain for the foreseeable future as the enduring basis of our long-term data series. We have again seen some interesting and unusual findings in our samples and I am always intrigued that the 'players' in the marine environment continue to diversify in this way. It is worth noting that it takes the extensive and temporal coverage of the CPR Survey to observe these changes.

SAHFOS' research continues to develop strongly. Although rooted in our expertise with marine plankton, SAHFOS research covers an increasingly broad front, and with a wide range of collaborators. This report covers a number of fascinating research areas investigated during the year, ranging from biogeochemistry through to how to manage the English Channel; projects reporting changes in the marine environment also feature strongly this year. I am sure there will be something in our research to fascinate everyone. A significant new development this year has been

"SAHFOS is not a large organisation but we certainly have an impact way above our size"

to initiate a major programme of instrumenting CPR bodies with state-of-the-art oceanographic sensors. There has been a limited amount of such work in the past but SAHFOS is now committed to a step-change in the quantity, quality and variety of provision of oceanographic data, including supplying some variables in near real-time. SAHFOS is committing significant resources to this project and I am sure there will be many exciting developments to report in the future.

A new approach to providing and visualising data is developing alongside the instrumentation programme. SAHFOS has long had the ambition to be able to provide an easy, web-based interface for users to interrogate and download specific data. The extra data handling needs, driven by the considerable increase in data volumes from the instrumentation programme, has stimulated an exciting IT project that looks set to revolutionise SAHFOS' external facing perspective. A new Data Product Team has been created to do the work and some of its early activities are reported here; I anticipate there being much more to report in future years.

There is much more I could comment on, including our developing science into marine policy work, enhanced knowledge exchange and outreach and communication activities but space precludes adding to the already excellent accounts to be found later in the report.

But before concluding I would like to thank various groups and individuals. First, SAHFOS really welcomes our developing relationship with Nexen Oil Company. We know we produce valuable information, expertise and knowledge for the marine science community but it is really rewarding to be able to provide value to a major commercial venture. We each are in the process of learning how to develop this relationship but meanwhile I would like to thank Nexen for their continuing support and it is excellent to see a contribution from Nexen colleagues in this report.

Second, I would like to thank Professor Peter Liss CBE FRS for his excellent chairmanship of the Board of Trustees and his support of me. Of course I must thank the Board of Trustees for their challenge but mostly support of SAHFOS and for all the time they give so freely: thank you, your commitment is most welcome. I also would like to thank members of the Science Advisory Board who also give their time freely to provide science advice to me and the Board. Again I am extremely grateful.

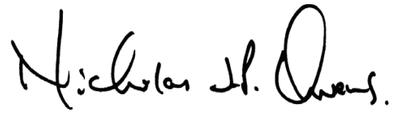
Thirdly, I am most grateful for the generous time given by my Hardy Expedition Fundraising Campaign Task Force (see Page 44). The Hardy Expedition Campaign has occupied a great deal of my time during the year but I have been considerably aided by the help and advice afforded to me by Task Force members – thank you so much. I hope and trust our campaign will be successful.

It remains only for me to end in the customary manner by thanking all SAHFOS' members of staff. You can all feel proud of your achievements, individually and collectively, over the past year, only some of which are reported here. Thank you for your commitment and hard work.

There were some staff changes during the year. We bade farewell to Dr Alessandra Conversi, Marie Curie Fellow early in the year; we all wish her well in her continuing work. We said 'hello' to: Dr Eric Goberville, Macro-ecology Research Associate; Dr George Graham, Marine Instrumentation and Data Scientist; Dr Claudia Martins, Molecular Postdoctoral Scientist; and Ms Nicola Rickard, Fundraising and Publicity Manager. Welcome to you all, I trust you will have a pleasant and rewarding career at SAHFOS.

Finally, not only is it a pleasure to write this introduction, I am proud to do so. Contained within these covers are some wonderfully exciting examples of our work and findings. I hope you enjoy reading about them as much as we have enjoyed producing them.

Thank you.



Our People

SAHFOS Board of Trustees in 2014

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

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Professor Geoff Boxshall FRS (Vice Chair)
Dr Peter Wiebe
Dr Erica Head
Dr Caron Montgomery
Dr Graham Hosie
Dr Stephanie Henson
Dr Petter Fossum
Dr Willie Wilson

SAHFOS Staff in 2014

Prof Nicholas J P Owens — Director
Prof Martin Edwards — Director of Science and Deputy Director
Mrs Gill Tanner — Director of Business Administration

Roger Barnard
Marine Engineering Technician

Dr Sonia Batten
Pacific CPR Project Co-ordinator

Kate Brailsford
Administrator, PA to Director of Science & Laboratory Assistant

Gemma Brice
Plankton Analyst

Martina Brunetta
Technician & Plankton Analyst

Clare Buckland
Plankton Analyst & Education Officer (on maternity leave)

Scott Calnon
Database Developer

Rob Camp
Plankton Analyst & Instrumentation Technician

Dr Claudia Castellani
Research Fellow & Plankton Analyst

Alec Colebrook-Clark
IT Support & Web Developer

Dr Alessandra Conversi
Marie Curie Fellow (until January)

Dr Dave Conway
Plankton Analyst (contractor)

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

Dr Eric Goberville
Research Associate (from October)

Dr George Graham
Marine Instrumentation & Data Scientist

Lance Gregory
Workshop Manager

Nick Halliday
Plankton Analyst (contractor)

Chris Harris
Marine Engineering Technician

Dr Pierre Hélaouët
Research Fellow

Linda Horsfield
Administrator & Laboratory Assistant

Usha Jha
Plankton Analyst

David Johns
Laboratory Manager

Tanya Jonas
Senior Taxonomist

"You can all feel proud of your achievements, individually and collectively, over the past year. Thank you for your commitment and hard work"
Nicholas Owens

Dr Priscilla Licandro
Research Fellow

Dr Claudia Martins
Molecular Postdoctoral Scientist (from April)

Dr Abigail McQuatters-Gollop
Science & Policy Research Fellow

Doug Moore
Plankton Analyst (Canada)

Julian Morley
Marine Engineering Technician

Jean Nyman
Finance Officer

Capt Peter Pritchard
Head of Operations

Prof Chris Reid
Senior Research Fellow

Nicola Rickard
Fundraising & Publicity Manager (from July)

Jennifer Skinner
Plankton Analyst

Marion Smith
PA to Director & HR Manager

Dr Rowena Stern
Molecular Plankton Ecologist

Darren Stevens
IT Manager

Claire Taylor
Plankton Analyst & Assistant Laboratory Manager

Dr Tony Walne
Plankton Analyst & Instrumentation Technician

Marianne Wootton
Deputy Senior Taxonomist

Claire Wotton
Plankton Analyst

SAHFOS Staff April 2015

Operations

Tow Logistics

Lance Gregory

SAHFOS is greatly appreciative of all the shipping companies, the ships' masters and the crews who assist with our survey. We are also supported by some wonderful shore-side managers and staff at the ports who ensure the correct CPR box is loaded on the correct ship at the correct time for us. If any of you are reading this and should find yourself in Plymouth, please do contact us, as we would be delighted to show you round our workshop and laboratory. You could then see the results of your work and the next stages of the survey.

During 2014, 24 ships completed 383 tows, collecting data from 140,203 logged nautical miles. Ships, companies and charterers involved during 2014 are shown in Appendix B. The overall sampling success rate in 2014 (over 90%) reflects the consistently high standards of the CPR workshop team and the reliability of the CPR. The CPR Survey on this scale would not be physically or economically possible without the generous support of ship owners, charterers, managers, port operatives and agents.

The marine scientific community is very much indebted to the international shipping industry. Plankton recorders are received at ports, placed on ships, towed on the set routes, landed and held ready for return to us at no commercial charge. It is a fine example of the kind cooperation between the international shipping industry and marine science.

CPR Workshop

2014 saw the workshop team consolidate after the reorganisation in 2013. There were, however, some changes to working patterns, with Julian Morley working full-time from May 2014 and Roger Barnard, after nearly 25 years' service, reverting to two mornings a week.

The working day for the workshop team starts with a briefing on the day ahead, where the technical tasks are rotated to ensure the technicians retain all the required skills to allow for continuity and contingency planning. As a team, we are constantly looking for ways to improve our working practices and keep current with legislation changes. In 2014, members of the team were instrumental in the redesign of the tow chit - this is the document that tracks the CPR sample from CPR set-up to the sample cutting stage. This chit is designed to capture all the information required for the efficient tracking and quality control of each individual CPR tow.

As the CPR fleet expands across the globe the logistics behind the scene becomes more complex. In 2014, together with our Dangerous Goods Advisor, we completely rewrote our policy document for sending chemicals both inside and independent of the CPR, plus samples, worldwide, by all modes of transport. This policy document is proving its worth with reduced transport costs and also helps to get the consignments delivered right the first time.

In the operations workshop.....

Julian Morley, who joined us in 2012 with a previous career as a small boats and ships engineering technician, is seen here using the lathe to produce shaft stops that are capable of being fitted with the prop protector blade. This is a device that helps keep the success rate of the CPR high in sea areas with increased detritus.

Roger Barnard, our long-standing CPR technician, can be seen here repairing the formalin tank on an ageing CPR. This is a particularly skilful task that requires absolute cleanliness of the components and the correct application of heat. Too much heat and the tank would fall apart.

Chris Harris, who is an expert boiler maker by trade, is carrying out stainless steel welding repairs to a CPR that was damaged whilst being recovered in rough weather.

Lance Gregory, whose previous career in the RAF included sea going service as an engineer on target towing and rescue vessels, is seen here explaining CPR towing techniques, to a group of visitors..

Martina Brunetta is busy preparing silk. During 2014 we produced 585 pairs of filter silks for SAHFOS and our sister surveys. We also produced 104 pairs for the business continuity strategic reserve. We used 1452m^2 of CQ23 silk that if stretched end to end would be nearly 8 kilometres long.

Workshop staff in 2014 worked closely with the Laboratory Manager to set up a protocol for the servicing of the microscope stages; this is scheduled to take place twice a year to fall in line with the general maintenance and filter changes carried out by our technicians and the specialist contracted company.

The CPR fleet expanded in 2014, with the three bodies and eleven internals that were with NOAA in the USA being returned to SAHFOS. This equipment is currently being brought up to our latest specification and checked thoroughly, ready to join the fleet in early 2015. The fleet will then consist of 54 bodies and 119 internals.

New Routes

SAHFOS has taken on responsibility for towing of the NOAA routes adding to our global footprint. They are the MB route which tows from New York to Bermuda from the Oleander, and the MC route which tows from Cape Sable to Portland, Maine, by the *Westerkade* in February to June then the *Skogafoss* from July.

Old and New Technologies

The Workshop has been working closely with the Instrumentation Team regarding the fitting and use of the new sensors coming on-line. These sensors will be able to give near real-time electronic data as the CPR breaks the surface on recovery. At the other end of the scale, Priscilla Licandro has been involved in a project towing the original, low-tech Hardy-type plankton indicators in the Mediterranean and Black Sea. SAHFOS technicians assisted with the resurrection of the old instruments, the manufacture of the filtering discs and sea trials in Plymouth Sound.

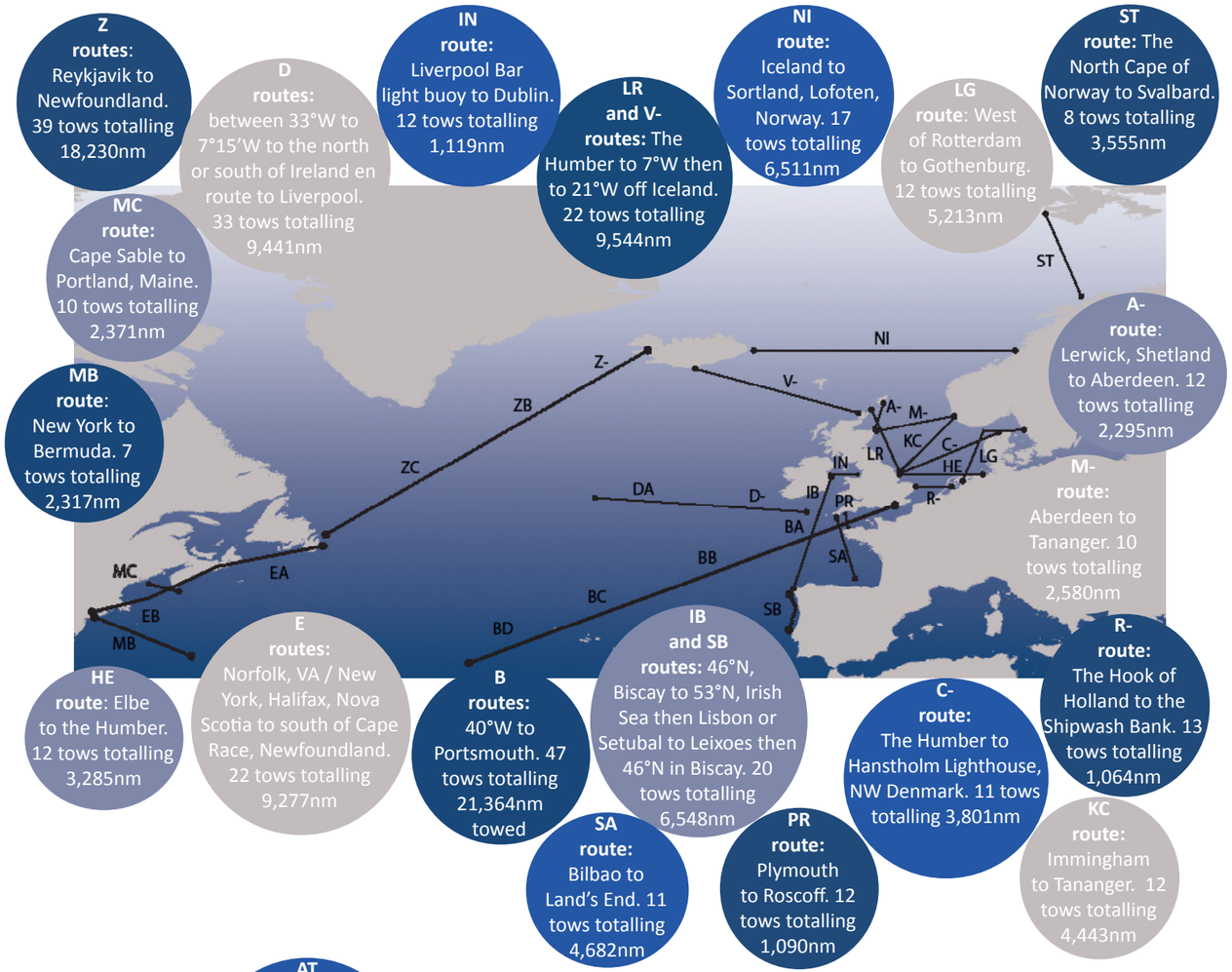
One of the benefits of working at SAHFOS is that we may be called upon to carry out various tasks outside of our normal engineering and logistics sphere. During 2014 we set up the workshop for visits and gave many talks to various groups, ranging from potential partners, MPs, visiting scientists and students. The feedback we received from each of these visits was tremendously complimentary and was a positive experience for us, knowing that we work for an organisation that is valued and punches above its weight.

We are all looking forward to 2015 and the challenges it will no doubt produce.

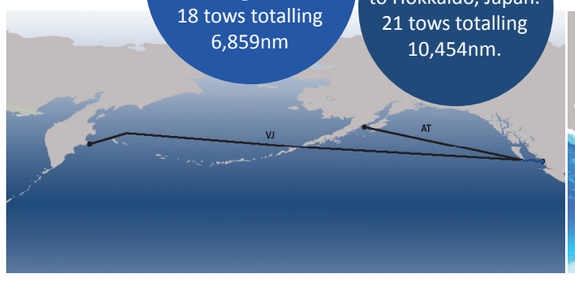
2014 Tows

140,203 nautical miles were towed in 2014; the highest in the history of the Survey. 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.

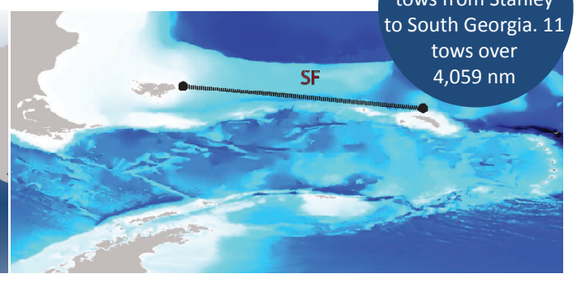
North Sea and Atlantic



Pacific



Southern Ocean



The Buzzard Field: The Problem with Injection

Joel Turnbull

Nexen Buzzard Area Development Manager

The Buzzard Field is the most recent "elephant" to be found in the North Sea - an elephant being a field that will produce more than 500 million barrels* of oil. In fact, this February, Buzzard will produce its 500 millionth barrel. A very important milestone.

Buzzard currently produces about 190,000 barrels of oil every day, and in 2013 produced 55 million barrels. This was more than 4 times as much as the next biggest field. In the same year Buzzard produced 25% of all the oil produced in the UK.

Oil in the reservoir is pretty incompressible, so as the oil is taken out of the reservoir, the reservoir pressure drops. This is significant since much of the energy to push the oil out of the wells comes from the reservoir. With less energy, the production rate of the wells reduces.

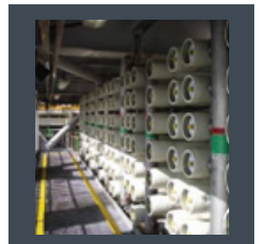
To prevent this, water is injected. This water also has the benefit of sweeping the oil from the reservoir into the production wells. At some point the fluid coming out of the wells is a mixture of oil and water.

Traditionally the water coming up the wells with the oil is cleaned and disposed of overboard into the sea. Inevitably there are still some small traces of oil in the water, so Buzzard was designed to re-inject this water back into the reservoir, to minimize the environmental footprint.

However, this has a knock-on effect. The produced water that is injected will only fill the void of the produced water that is made. Seawater is required to fill the void of the produced oil. Produced water and seawater do not mix very well!

Seawater is high in sulphates. Produced Water (which is a mix of formation water and injected water) is high in barium. Put them together and you get barium sulphate which forms an incredibly hard solid, which has the ability to completely clog up topsides, wells and subsea flowlines.

Buzzard was designed to remove the sulphates using a Sulphate Removal Package. Its termed a reverse osmosis unit but in fact it's just a big filter. This piece of equipment needs to filter 250,000 barrels of water down to 0.1 microns every day. The filter is cleaned regularly by an automated cleaning cycle of acid and alkaline washes.



One bank of the eight banks of micro-filtration

So where does SAHFOS come in? The vast majority of the material that is caught by the filters are plankton. There are issues with the filter performance through the year but particularly during the spring bloom period.

Nexen would like to understand what it is that is clogging up the filters. What type of plankton is it? Is the clogging material predominantly organic or inorganic? When do the bloom periods start, and when do they end?

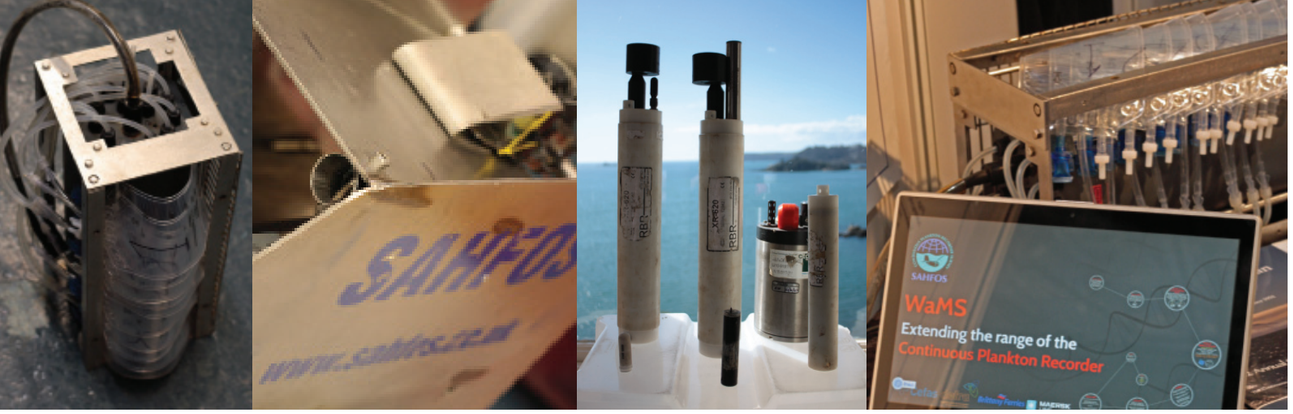
Every spring bloom the SRP performance is poor, due to the high concentration of plankton. Except in 2014, no drop in performance was seen. Why was that?

Nexen is working with SAHFOS to get a much better understanding of the issue.

Buzzard produces about 6% of the entire UK energy needs. The single most important factor that influences Buzzard's performance is the amount of water that can be injected. The most important constraint of the water injection system is the filtration. The filtration is influenced predominantly by the concentration of plankton.

So it is vital that we get a better understanding.

*$1m^3$ = 6.29 barrels



Instrumentation

George Graham, Anthony Walne and Robert Camp

The collaborative relationships with ships of opportunity, the spatial coverage (more than 120,000 nautical miles per year) and monthly tow frequency positions the CPR survey as a cost effective platform from which to monitor marine plankton. The survey has the potential to become a platform from which to make other marine observations that complement the biological measurements in order to make integrated observations of ocean health. There is a need to bridge the gap between existing fixed-point and distributed ocean observing schemes, which could be uniquely addressed by combining the SAHFOS network of CPR tows and new marine observation technologies. We see an exciting future for the Survey in providing crucial ocean surface observations to stimulate novel research into coupled biological and physical processes - generating rich datasets for use by the scientific community for verification of existing ocean observation networks, remote sensing systems and ocean modelling efforts.

By integrating additional marine sensing capabilities, the monitoring capability of the CPR can be enhanced. Currently, the traditional plankton measurements are complemented on a limited number of routes by additional measurements – such as the Water and Microplankton Sampler (WaMS) on the PR route - and a variety of different, low cost temperature sensing instruments. Realising the full capability of the Survey requires a rationalisation of these additional measurements. Since May 2014 the Instrumentation Team have been rationalising the deployment of existing temperature sensors on the North Sea routes (Fig. 1), which show good agreement with remote sensing observations, and updating the archive of historic temperature measurements (accessible at: http://www.sahfos.ac.uk/cpr-data/data-sets/temperature-data.aspx)

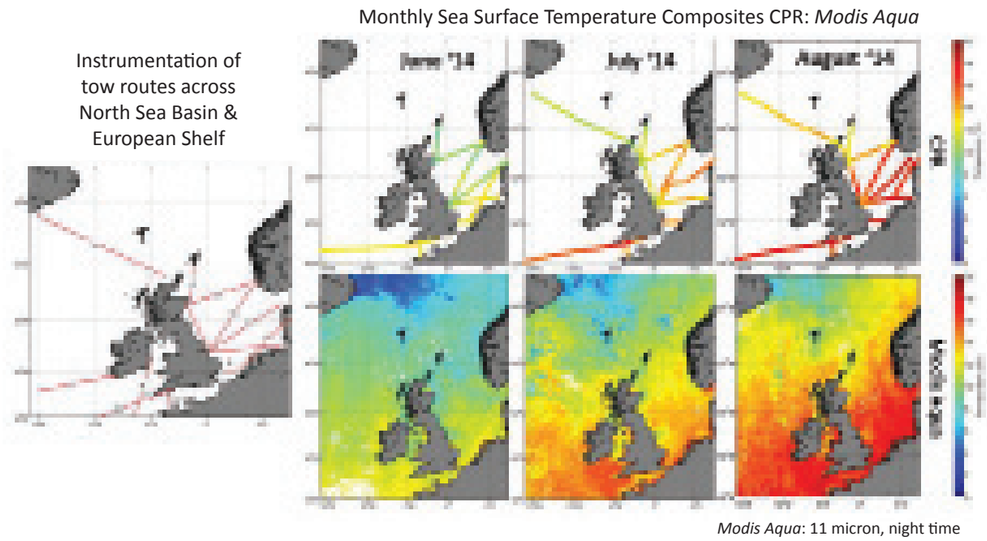


Figure 1. Illustration of temperature sensor data obtained after rationalising deployment of existing, low cost instrumentation on CPR routes in the North Sea, English Channel and North East Atlantic. Sea Surface Temperature along a range of CPR routes is illustrated for the months of June, July and August 2014 in comparison with surface temperatures from satellite remote sensing (*Modis Aqua*). Good similarity in both general warming trend and month-to-month spatial variability in Sea Surface Temperature can be observed between CPR based measurements and satellite derived observations.

Figure 2. Testing and deployment of new instrumentation on the CPR. Anthony Walne fitting instruments for temperature, salinity, pitch & roll (far left). Peter Pritchard and Márcio da Silva Tamanaha (Univali, Brazil) looking happy after a successful late night recovery of the CPR from the PR route with all instrumentation still attached (left).

Two new WaMS systems have been purchased to complement the existing work conducted on the PR route and enable expansion into additional routes, and are currently being cycled on the PR route awaiting the start of EU H2020 funded project AtlantOS.

In November, SAHFOS received the fantastic news of a successful funding bid, a NERC Capital Equipment grant of £396,095. This will help establish the basis of a programme to integrate plankton measurements and state-of-the-art marine environmental sensing technologies. The funding will enable the Instrumentation Team to develop and deploy novel sensors for Temperature, Conductivity and Fluorescence across a significant number of routes across the North West European Shelf (North Sea, English Channel, North East Atlantic) and develop the data systems required for providing these measurements in near-real time to a range of end users over the internet. Over the last 8 months a number of new sensing technologies have been undergoing testing on the CPR (Fig. 2). Initial comparisons of temperature and salinity measurements with existing industry standards, for example the FerryBox system, are very encouraging and suggest that accurate physical oceanographic measurements can be made from the CPR platform (Fig.3). The designs for CPR specific sensors are in the process of being finalised and operational measurements across the North West European Shelf are scheduled to begin in June 2015. The NERC funding will also enable the team to explore a range of new technologies for rapid characterisation of plankton community composition (using, for example, multi-spectral fluorometry) and link observations from the instrumented CPR program with existing global ocean observation programs by adopting industry standard measurement technology.

In April 2015, the Instrumentation Team will be moving to a new lab space within the Citadel Hill Laboratory. The new lab gives them room for instrument development as well as the setup, calibration and routine maintenance associated with operation of new sensing technology on CPR routes.

The whole team is looking forward to an exciting future developing new measurement capabilities of the CPR to complement the existing plankton measurements. Regular updates on progress will be posted on the SAHFOS twitter account, website, Plankton Post and in the Annual Report.

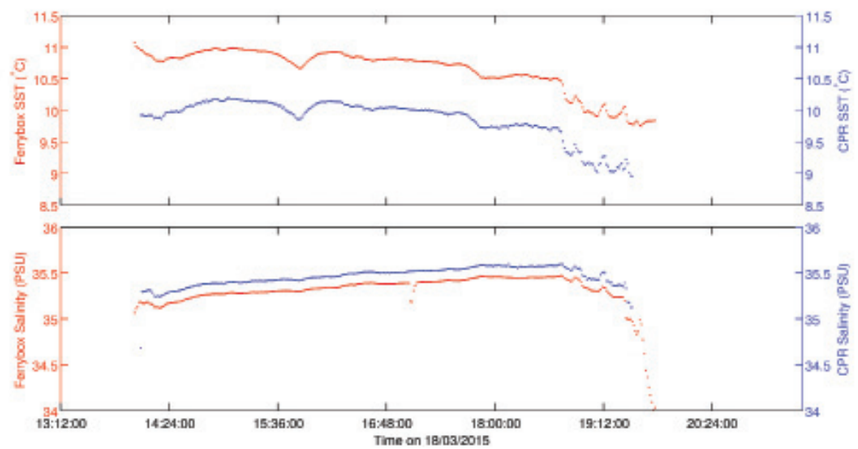


Figure 3. Comparison of sea surface temperature and salinity from a prototype CPR based sensor with the FerryBox system aboard *MV Armorique* sailing from Roscoff to Plymouth. The general agreement between observation systems in both the variation over time and the specific events is extremely encouraging. The CPR based sensor is reading approximately 0.8°C lower and 0.12PSU higher than the FerryBox system in this example and improved accuracy is expected once a full calibration has been carried out of the CPR based sensor system.

Antarctic Adventures

Marianne Wootton

"The opportunity to work in Antarctica as a scientist has been a childhood dream of mine and is what actually inspired me to pursue a career in science"

Since 2005 SAHFOS and the British Antarctic Survey (BAS) have collaborated in collecting CPR samples from the Scotia Sea. In 2014, an opportunity arose for me to work alongside BAS researchers onboard their Royal Research Ship, the James Clark Ross, for a six-week-long combined scientific and logistics expedition to the Scotia Sea. I pounced on the prospect of fulfilling a lifelong ambition to work in Antarctica and joined the ship at Punta Arenas in November 2014.

A series of CPR samples are collected in the Scotia Sea, during austral summer months, along transects running between South Georgia and the Falkland Islands; South Georgia and the South Orkney Islands; and between the South Orkney Islands and the Falkland Islands.

The data from these samples provide a baseline for monitoring change inside this region of the Southern Ocean, which hosts important squid, icefish and krill fisheries within the Falkland Islands and South Georgia Economic Zones.

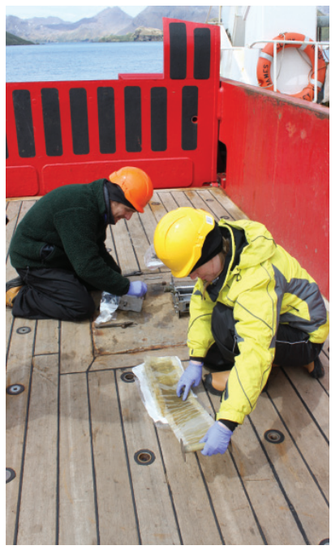
The CPR was the first and last piece of scientific equipment to be deployed on the voyage and was towed seven times throughout the cruise, towing in total for approximately 1600 nautical miles. The samples collected will be returned to the SAHFOS lab in June 2015, when the RRS James Clark Ross returns to the UK. The samples collected will add to the data already produced from previous tows and will also be used to answer specific research questions, in collaboration with BAS scientists.

As well as deploying CPRs I was involved in the deployment and retrieval of numerous types of plankton sampling equipment including Bongo nets, Multiple Opening Closing Net and Environmental Sensing System (MOCNESS), Rectangular Mid-water Trawl (RMT-8) and a Longhurst-Hardy Plankton Recorder. Having many years of experience in the identification of zooplankton from around the globe, I was part of the zooplankton sorting team, gave training in plankton identification and also collected a wide range of organisms to add to the SAHFOS plankton specimen collection.

As well as carrying out plankton-related science, one of the other main purposes of the cruise was to open up and provide 'base relief' to a number of research stations which BAS operates in Antarctica. Base relief is a physical and varied job, with tasks ranging from hacking through ice to get to the base, setting up a sanitation system, to the replenishment of basic, but essential, supplies of food and equipment needed to survive in and carry out science in the harsh Antarctic environment. Base relief, including an exchange of BAS personnel, was carried out at Bird Island, King Edward Point and Signy.

The opportunity to work in Antarctica as a scientist has been a childhood dream of mine and is what actually inspired me to pursue a career in science. I feel very privileged to have been given the chance to work with a renowned organisation such as BAS and to work alongside such dedicated and respected scientists and crew. Antarctica is a place of wild awe-inspiring beauty.

It is an experience I will never forget.



Cruising and working aboard the *RRS James Clark Ross* research vessel

The extraordinary abundance and variety of plankton in the Antarctic waters supports a similar extraordinary abundance and variety of wildlife in the seas.

Information Technology



IT infrastructure, Database and Software

Darren Stevens, Alec Colebrook-Clark and Scott Calnon

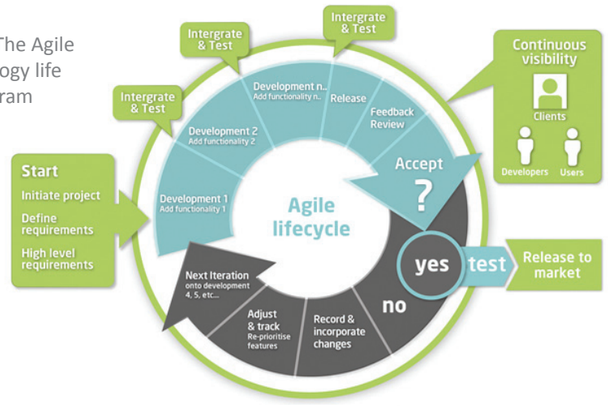
SAHFOS IT has continued to evolve during 2014, taking time-consuming processes and seeking out new and innovative ways to improve speed, efficiency and functionality of existing products or develop new ones. One of the steps taken to achieve these goals was the creation of the Data Product Team (DPT), designed to take the data processing techniques used by SAHFOS researchers and display those products openly online.

The DPT has embraced new technologies and services such as Google Earth and Google Chart, and these are now being incorporated into the SAHFOS website. We are also looking into NoSQL technologies for dataset integration. As part of this process we have also semi-automated the procedure for supplying data to the research community (Fig. 4).

We have also been able to expand the data in the CPR database this year by incorporating ~60,000 additional records for Phytoplankton Colour Index (PCI). The historical database processes had only stored information for CPR samples that were analysed for taxonomic information. This was improved upon in the 2008 rewrite of the data processing software and database redesign allowing for the incorporation of historical data.

During the year MBA and SAHFOS received training in version control systems. Although they were already in place, it was felt they were not being used to their full potential. We now have all development programs under the version control, enabling immediate rollback to previous system state should the testing phase highlight any issues. This has linked in very well with the adoption of the AGILE management style that has been incorporated into the IT department this year (Fig. 5). The main differences in this new style of project management are: 1) increased stakeholder involvement resulting in better user acceptance when the product is delivered and 2) the final product is delivered in stages, so the main features are delivered and in use quickly, thus having an immediate effect on efficiency. The project where this has had the largest immediate impact is the automated data extraction system. Though programs have existed to extract and manipulate CPR data for researchers (internal and external), there has not been the time to develop this into a polished product, this year the dream of a simpler system started to take shape. The initial product has been produced, and 2015 will see further functionality incorporated based on stakeholder feedback.

Figure 5. The Agile methodology life cycle diagram



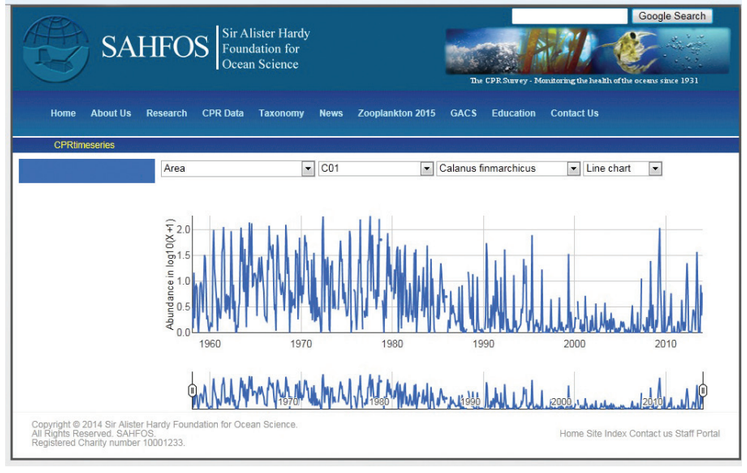


Figure 4. Screenshot of web data portal for CPR data (*Calanus finmarchicus* abundance data for CPR standard area C1 displayed)

The Data Product Team

Pierre Hélaouët, Alec Colebrook-Clark, George Graham, Abigail McQuatters-Gollop and Darren Stevens

SAHFOS is one of the world's most respected marine science organisations and as such, is specialised in a large variety of activities, ranging from collecting biological and physical data, addressing pressing ecological issues, educating the public, informing and supporting commercial decisions as well as environmental government policy at national, European and international levels.

Every year, SAHFOS collects a significant amount of observational data with its CPR monitoring survey, and adds value to this raw data by analysis and visualisation for research projects which utilise the datasets. In November 2014 the Data Product Team was officially launched at the Science Advisory Board meeting. The team has a clear purpose: to optimise the use of existing SAHFOS data, lead the design and acquisition of new data sources, and develop data products for research, public dissemination and revenue generation. Data products facilitate an end goal, using data collected by the organisation, whether this is driving internal efficiency by using data to examine optimal tow scheduling or combining CPR datasets with measurements of the physical environment in web-based visualisations that are used by third parties. The team's primary objective is to deliver results based on SAHFOS data.

The Data Product Team is articulated around three axis encompassing the SAHFOS Science Strategy: knowledge exchange, technology and ecology (Fig. 6). This ensures that the team will be able to maximise its support to both the scientific and general community.

The Visualisation Project

The first project that has been created by the data product team is the 'visualisation project'. The main goal is to propose online data products in the form of time-series and maps of key planktonic taxa. To achieve that goal, the first step was to revisit the way that CPR raw data are exported and pre-processed in order to create an automatic flow from the silk to the defined product. Once the new pre-processing procedure was in place, a set of new technologies were investigated to allow for online visualisation and dissemination of our products. It appears that Google Charts provides a perfect way to visualise the products on our website. Based on JavaScript, Google Charts provides many free tools and is highly customisable.

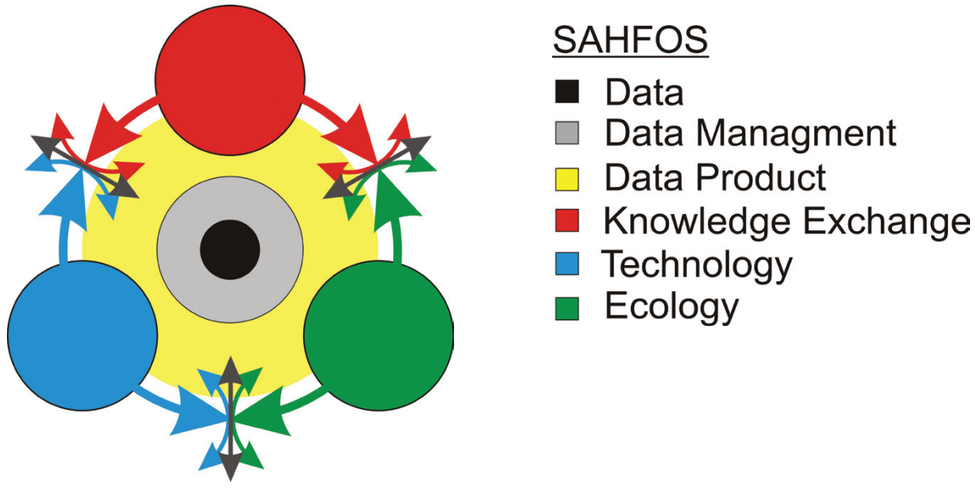


Figure 6: Diagram representing the Data Product Team and the interactions between its components.

A tool to explore and download timeseries of CPR data.

Once connected to our website, the user can choose to start a query from a given area or a given taxon. SAHFOS' Standard Areas were retained as a spatial unit and therefore offer the choice between 41 areas across the North Atlantic Ocean (Fig. 7).

A selection of five variables were made by SAHFOS including two key species of copepods (i.e. *Calanus finmarchicus* and *C. helgolandicus*), the two main components of the phytoplankton community (i.e. Diatoms and Dinoflagellates) as well as an indicator of the phytoplankton standing stock (i.e. the Phytoplankton Colour Index or PCI).

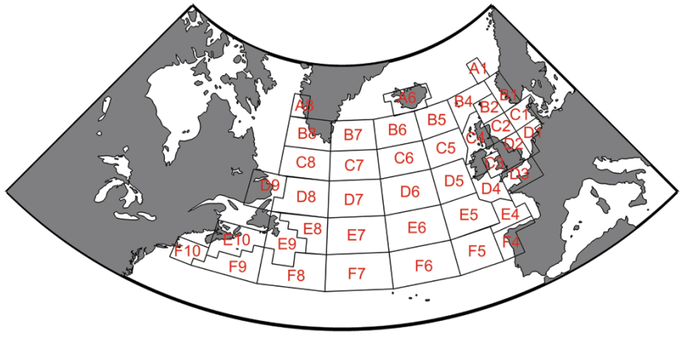


Figure 7: Map of SAHFOS standard areas.

Once both the variable and the area are selected, the time-series ranging from 1958 to 2013 will appear on the screen (Fig. 8)

A slider will also appear beneath the time-series providing the user a tool to select a given time window (e.g. from 1960 to 1970). The time-series will be automatically updated allowing the user to isolate the selected time period (Fig. 8).

The slider allows the user to slide the selected time period across the whole range covered by the time-series (i.e. January 1958 to December 2013). For instance, this makes it easy to have a first look on the evolution of monthly abundances of the selected taxon between the 1960s and 1970s (Figs. 9 and 10).

The next step

SAHFOS is currently putting in place a procedure for users to directly download the selected time-series. The strategy will be to allow scientists to register with SAHFOS, under the terms of the Data Licence Agreement and data policy, in order to gain immediate access to a selected subset of CPR data. This method of access will allow SAHFOS to monitor who and when people are accessing data, therefore mirroring the current system of data requests. Each online dataset will also be accompanied by an automatically generated Digital Object Identified (DOI) registered with the Data Cite web service, hosted by the British Library.

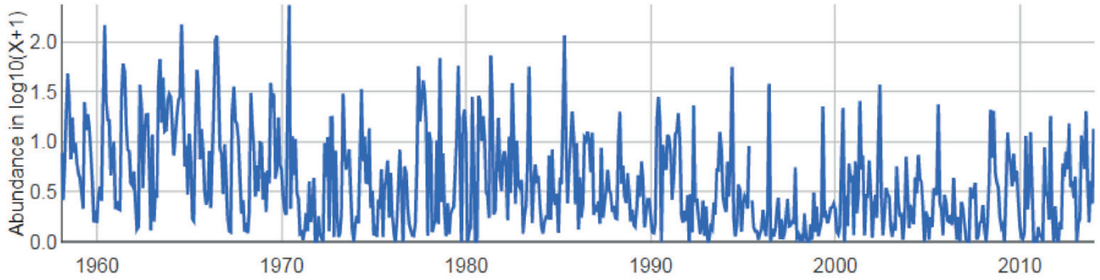


Figure 8: Timeseries of monthly averaged abundance of *Calanus finmarchicus* (log^{10} (x+1)) in the area C2 (West central part of the North Sea).

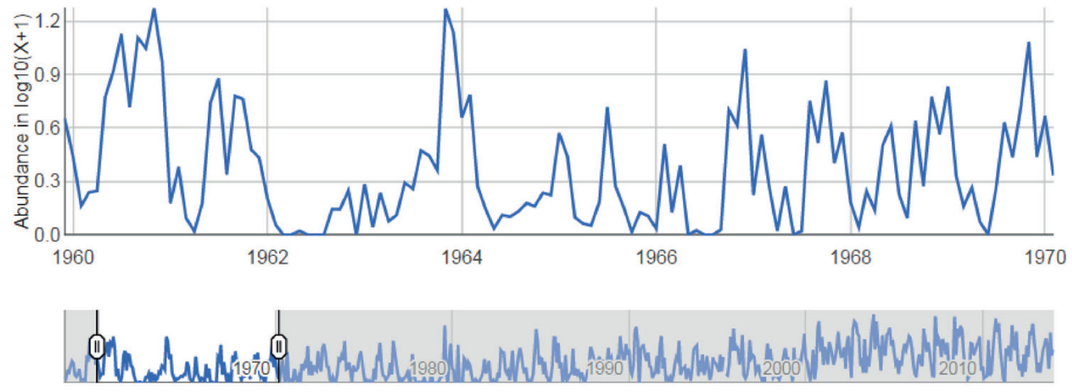


Figure 9: Timeseries of monthly averaged abundance of *Calanus finmarchicus* in the area C2 focused on the 1960s.

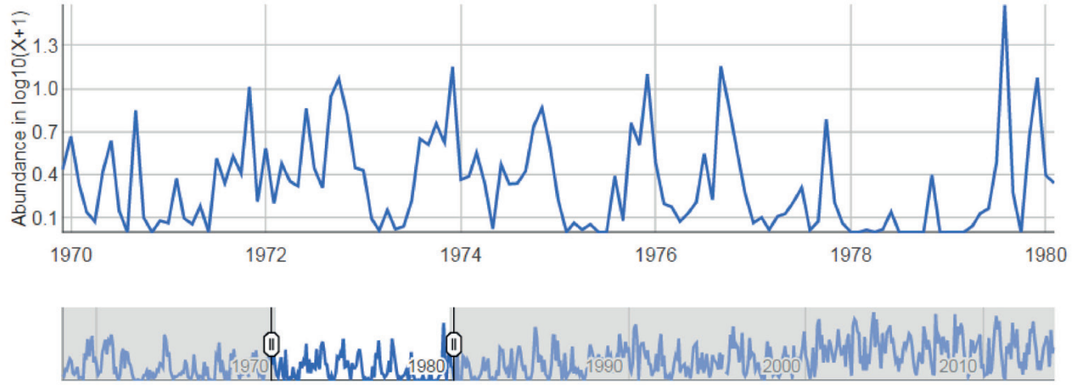


Figure 10: Timeseries of monthly averaged abundance of *Calanus finmarchicus* in the area C2 focused on the 1970s.

The DOI will make it easier for the data user to cite the data and for SAHFOS to track publications using CPR data. We also hope to receive feedback on the website and data products available, and will provide a mechanism to receive this (possible using the ticket tracking system JIRA), to further enhance the data products in harmony with scientific objectives (i.e. expanding geospatial datasets beyond CPR standard areas, for example to ICES areas).

What about space?

A prototype based on Google Earth has been designed allowing maps to be shown and downloaded as Keyhole Markup Language (KML). Unfortunately, Google recently decided to reject the application program interface (API), forcing us to re-design our methodology. New progresses are made using other technologies by the Data Product Team.

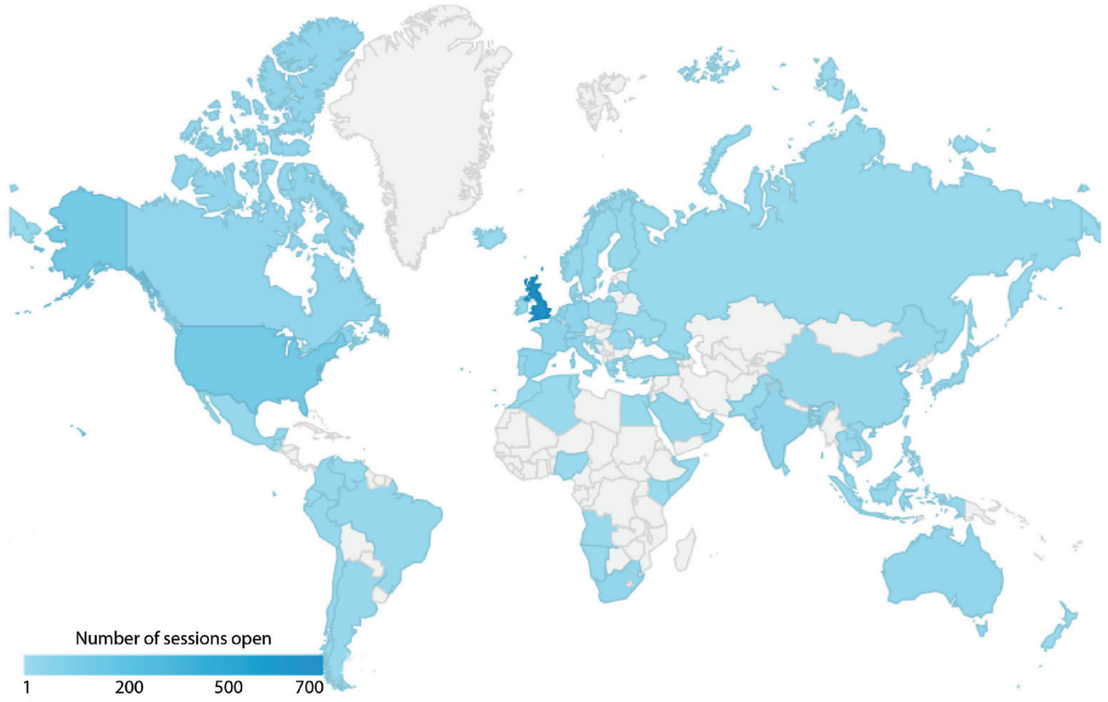
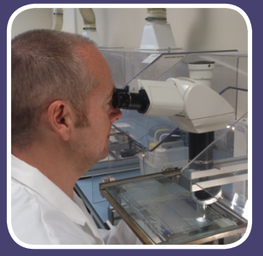


Figure 11: Maps showing the number of sessions open on our website per country as an example of metrics that can help SAHFOS better understand the community's needs.

Analysis



Sample Analysis

David Johns and Tanya Jonas

During 2014 there were almost 5500 samples analysed by the team (Figs. 12 and 13), the second highest number of samples in the history of the Survey. As in 2013, despite the large number of samples, it looks like we are on course for another early delivery of our data – final quality control procedures are in progress before we can release the dataset. This represents a great team effort, a number of staff were seconded onto other projects during 2014 that impacted on their ability to contribute to the analysis process, resulting in more work for less staff. Despite this, at the time of writing, the physical analysis of all 2014 samples has been completed. The 2013 quality-controlled core North Atlantic and Pacific data were available in late July, the earliest a complete year's dataset has been ready. We hope to better this with the availability of 2014 data.

Staff

During 2014 one of our more experienced analysts, Clare Buckland, was on maternity leave having given birth to William in December 2013. We certainly missed her valuable input to the analysis during the year and were pleased to welcome her back to the Team in December. To bolster the analysis team in Clare's absence, and increase capacity moving forward, in February 2014 Martina Brunetta joined the SAHFOS Analysis Team. Martina had already proved to be an asset to SAHFOS as a volunteer, helping with the zooplankton guide and working as a CPR silk preparer for the Workshop Team. During her free time she took every opportunity to learn how to identify plankton, attending training sessions and lectures. Martina is originally from Italy, where she completed her Degree in Environmental Science at the University of Venice. She then moved to the United States to continue her studies, earning an MSc in Natural Resources at the University of Nebraska-Lincoln, while working for the University Centre for Water Studies. After moving to Oregon, she decided to step away from science for a few years and dedicate time to her family. Martina and her family arrived in Plymouth in June 2010, following the decision for her husband to accept a position at the Plymouth Marine Laboratory. In Plymouth, Martina found the right conditions to return to science and thus her association with SAHFOS began.

Visitors

Two scientists, one from Brazil and another from Cyprus, had extended visits to SAHFOS, the main purpose of which was to be trained in identification of plankton collected by the CPR.

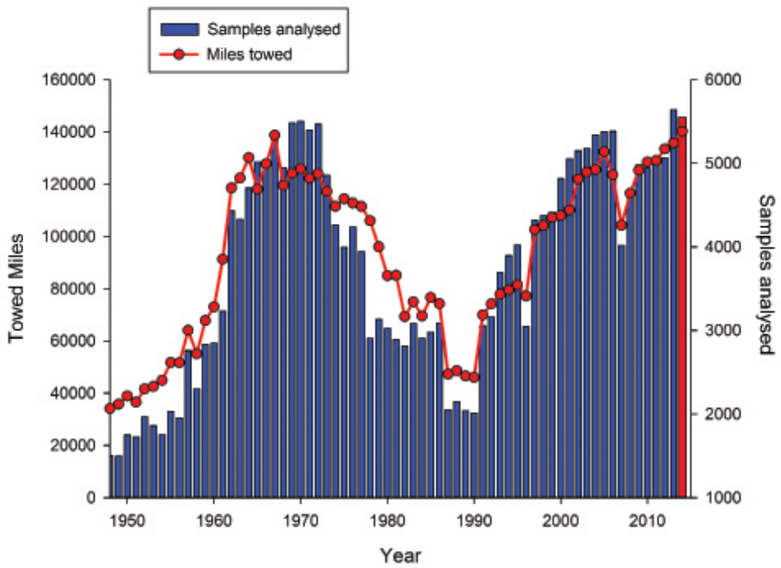


Figure 12. Miles towed and samples analysed since the inception of the CPR survey in 1931. 2014 Samples in red.

Márcio da Silva Tamanaha, a doctoral student at the Department of Environmental Science and Technology, Universidade do Vale do Itajaí, Brazil, stayed at SAHFOS for 7 months. He spent one month being trained in the CPR sample analysis methodology and also in the identification of zooplankton from around Brazil - he was already well versed in phytoplankton identification and is an expert in cyanobacteria. For the following two months he honed his skills and analysed samples that he had collected off the Brazilian coast. He found the experience with SAHFOS invaluable and we granted a request for an extension to his stay until December. Márcio, being experienced with isolating and culturing phytoplankton cells, used this time to assist Rowena Stern with a related project.

For his PhD thesis he is studying the relationship between plankton composition, oceanographic variables and the Brazilian sardine fishery. He hopes to establish a relationship with the oscillations of the oceanographic structure and shoal displacement in the pelagic system.

Rana Abu Alhaija, a Research Assistant at the Cyprus Institute (CI), spent five weeks in April and May learning CPR analysis methodology and plankton identification.
Rana had previously visited for a couple of weeks in 2013 for an introduction to CPR work, so it was a great pleasure to have her back at SAHFOS to complete her training. In October Rana and her colleague Carlos Jimenez (Associate Research Scientist at CI) carried out the first ever CPR tow between Haifa and Limassol.

Márcio da Silva Tamanaha and Rana Abu Alhaija

Training

We are often asked "How long does it take to train a CPR Analyst?" Basic training is intensive, takes two to three months (full time equivalent) and covers North Atlantic taxa only. On completion, the new Analyst is asked to re-analyse a range of CPR samples previously examined by experienced Analysts. The two sets of results are compared to ensure consistency. When this test is passed, the new Analyst can start to analyse North Atlantic CPR samples. However, it takes about two years or more for new Analysts to see the whole temporal and geographic range of North Atlantic taxa; during this period, they tend to ask many questions and we monitor their progress closely. After their two years on North Atlantic samples, Analysts will continue their training by examining samples from the North Pacific, and may go on to analyse samples from other CPR areas.

Training is actually continuous, even for very experienced Analysts, as there are always new things to learn and techniques to improve. Many of the numerous organisms we identify must also be staged and sexed and for some, the stages of the same animal or plant can look very different. We have recorded more than 800 different taxonomic groups in the CPR survey. Maintaining the same analysis methodology is crucial to ensure there are no breaks in the time series of data. So, how long does it take to train a plankton Analyst? Several lifetimes. We never finish learning.

CPR sample archive

The CPR Survey is one of the longest running marine plankton monitoring programmes in the world, providing a spatially and temporally unique dataset. While the historical dataset is familiar to many marine scientists, our sample archive may be less well-known, as its international importance has emerged only recently. Around 500,000 10 nautical mile sample sections are available for further scientific study, even though CPR samples from before 1958 have been lost or disposed of. Over several years, new questions have been addressed using these stored samples, for instance the increase and accumulation of microplastics in the oceans. Analytical techniques have been developed to enable fresh insights into the plankton retained in these samples, such as molecular analyses, stable isotope signatures and scanning electron microscopy.

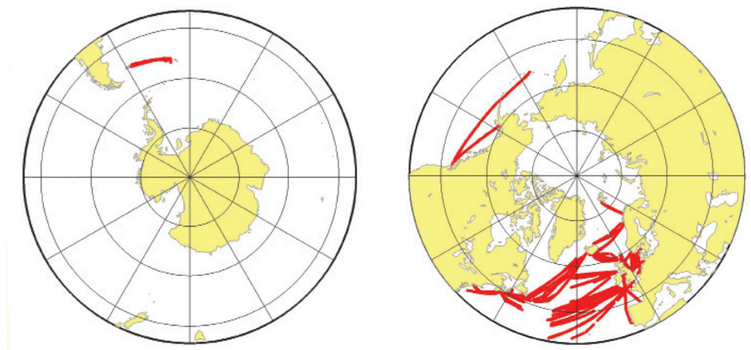


Figure 13. 2014 CPR Sample map showing Southern and Northern Hemisphere tows.

Taxonomy

Why is Taxonomy important?

Tanya Jonas, Marianne Wootton and Abigail McQuatters-Gollop

Taxonomic information provides a crucial understanding of the most basic component of biodiversity – which organisms are present in a region or ecosystem. Fundamental knowledge of taxonomy is necessary to assess diversity, gain insights into plankton responses to climate change, detect non-indigenous species, understand plankton community dynamics, and identify emerging scientific and policy issues. This type of detailed, species-level information can only be obtained through analysis by trained taxonomists. Unlike modern analysis techniques (such as automated visual identification, flow cytometry, satellite remote sensing, or fluorometry), which can for the most part only coarsely discriminate plankton groups, taxonomists can distinguish a wide variety of species relatively efficiently, generating information needed to investigate diversity in complex marine systems.

Several recent reviews and inquiries into the state of taxonomy in the UK (House of Lords 1992, 2002, 2008 and Linnean Society 2014), have expressed concern that taxonomy is a discipline in critical decline, with numbers of taxonomists steadily decreasing across all scientific disciplines. Against this general trend, SAHFOS is maintaining and expanding our taxonomic expertise. We have frequent ad-hoc requests to train UK and international scientists and our planned plankton training workshops are usually over-subscribed. SAHFOS, recognising the diminishing expertise among the users and producers of taxonomic references, is currently working on a plankton guide for the North Atlantic. We continue to focus on 'classical' morphological plankton taxonomy, but we have recently expanded our expertise to include the complementary newer molecular sequencing techniques developed since the 1990s. These molecular techniques allow us to identify and enumerate microbial organisms that are too small to examine using traditional light microscopy.

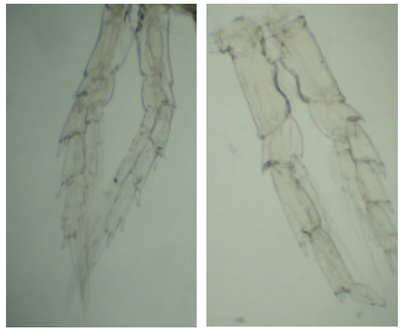
Taxonomic information is crucial for understanding change in the marine ecosystem. For example, *Calanus finmarchicus* and *C. helgolandicus* (two copepod species, both vital food sources for fish), are found in the North Atlantic and North Sea and have overlapping biogeographic distributions. They were not recognised as separate species until about 60 years ago. Each species thrives best in slightly different but overlapping temperature ranges. They have different biomasses, seasonal population peaks, nutritional values and roles in the marine food web. These two species are almost identical in their size and morphology and can only be separated by examining teeth on the last pair of swimming limbs

(Photos 1 and 2). Separating these two species has clearly shown the effects of temperature change in the North Sea and the resultant effects on the ecosystem.

Taxonomic understanding and data are essential for supporting effective ecosystem management. Policy indicators, particularly those for biodiversity and food webs, depend on this information. The UK and Europe are in the process of implementing the Marine Strategy Framework Directive (MSFD), Europe's most expansive piece of marine policy to date. CPR data are fundamental to MSFD implementation due to our long time-series of more than 800 plankton entities; all of the plankton biodiversity and food web indicators in the Northern Europe will therefore be populated with CPR data. Non-native species, also addressed in the MSFD, are a management issue with particular taxonomic relevance. Non-native taxa may be introduced to a region as the result of ballast water, aquaculture, or even purposely. Some non-native species may become invasive, requiring expensive management plans to mitigate impacts. Our expansive taxonomic expertise at SAHFOS allows us to recognise and identify newly introduced species and monitor their spread throughout the North Atlantic. For example, *Pseudodiaptomus marinus* (Photo 3), a small microscopic crustacean native to East Asia, was first found on North Sea CPR samples in 2011. *P. marinus* has persisted in CPR samples for the last 3 years and during this time has spread northwards, from the southern North Sea to the southern Skagerrak.

Taxonomy lies at the core of SAHFOS's work

Although taxonomy is a skill in decline, it lies at the core of SAHFOS' work and we are committed to furthering scientific understanding and effective management of the marine ecosystem through the expansion and promotion of this important skill.



Photos 1 and 2. *Calanus finmarchicus* and *C. helgolandicus* fifth pair of legs

Photo 3. *Pseudodiaptomus marinus*

Interesting and unusual biodiversity records in 2013/14

Marianne Wootton

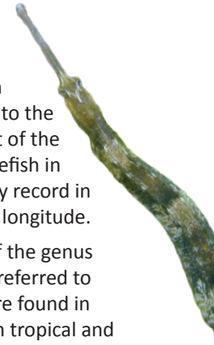
Phytoplankton

Neoceratium longirostrum (Photo 4), a rare warm-water dinoflagellate, was recorded approximately 250 miles to the southwest of Ireland on an April 2014 sample. This is the most northerly record of this species in the CPR survey for over 30 years. *Neoceratium contortum* (Photo 5) was observed on a September 2014 sample, approximately 100 miles off the coast of New York; having only being recorded 22 times in the history of the survey, this warm-water dinoflagellate is also considered to be rare. On another sample from September 2014, the large and distinctively triangular diatom *Triceratium favus* (Photo 6) was recorded in the southern North Sea. Despite being widespread and common in the North Sea, it has been over ten years since this diatom has been recorded in the Survey and represents only the tenth record. *T. favus* is restricted to coastal waters and typically appears in the plankton following turbulent water conditions.

During June of 2014 *Ephemera planamembranacea* (Photo 7), a delicate diatom associated with arctic-boreal waters, was found in exceptionally large numbers in the region of the Orphan Basin, north of the Grand Banks off Newfoundland. The bloom stretched for an unprecedented 150 miles; the last time such high abundances were observed in the survey was over 20 years ago. Visitors to the SAHFOS Laboratory regularly ask if SAHFOS has ever found a species new to science. Interestingly, the CPR survey is responsible for the discovery of *E. planamembranacea*; it was first described from CPR samples in the Northwest Atlantic in 1962.

The first record of *Membraneis challengeri* (Photo 8) in the North Atlantic CPR survey appeared on a March 2014 sample, near the southwest approaches to the Grand Banks of Newfoundland. This large diatom is typically associated with Antarctic waters, but can also be found in the North Pacific. In 2001, *M. challengeri* was first discovered in the North Atlantic, in the Bay of Fundy, by a programme dedicated to the monitoring of phytoplankton populations of the southwest New Brunswick region. Routinely sampling throughout the year in this region, the CPR survey is the ideal tool to monitor the spread of this alien species in the western North Atlantic.

Zooplankton

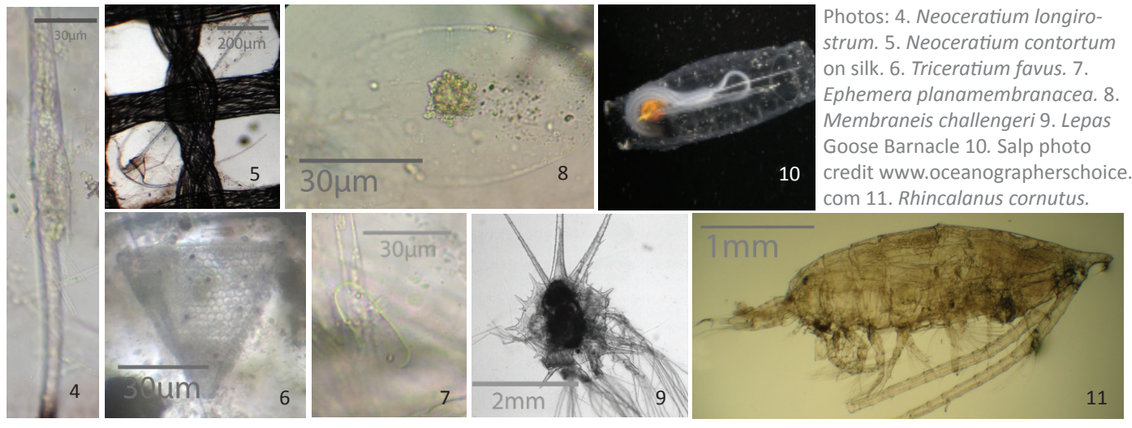


A 10cm long Pipefish (on right) was found on an October 2013 sample, approximately 100 miles to the east of Nantucket Sound off the northeast coast of the USA. Although the CPR occasionally catches Pipefish in the West Atlantic this is the most south-westerly record in the North Atlantic survey by over 30 degrees of longitude.

In the late summertime of 2013, larval stages of the genus *Lepas* (Photo 9), a type of barnacle (commonly referred to as goose barnacles) with a long fleshy stalk, were found in the central North Sea. *Lepas* are associated with tropical and subtropical waters and the adults are often found attached to driftwood or other floating debris. As they tend to hitch an aquatic lift, they are obliged to drift along with the current and it is not uncommon for these mesmerising creatures to be carried northwards in the north-eastern Atlantic. However, what is unusual about the CPR observations during August and September of 2013 is that this appears to be the furthest south *Lepas* have penetrated into the North Sea: perhaps indicating an increased inflow of oceanic waters to this region. Interestingly, also during August 2013, another organism associated with warm oceanic waters was found on the 'V- route', one of our most northerly transects, towing from northern Scotland towards Iceland.

It appears that 2013 was a record breaking year for the observation of salps (Photo 10) in the North Atlantic. Salps are transparent barrel-shaped organisms and despite being gelatinous in appearance are not related to jellyfish and do not possess stinging cells: they are more closely related to vertebrates! Salps are known to take advantage of favourable oceanic conditions and, when food is in abundance, can quickly reproduce to form large swarms. The number of salps seen in 2013 was exceptional and they were found throughout the North Atlantic: from our most southerly routes, in the subtropics, to one of our most northerly routes, off the north coast of Iceland, in the Arctic Circle.

In the region of the Faroe Islands a *Rhincalanus cornutus* (Photo 11), a copepod distinctive in appearance and considered a tropical oceanic species, was discovered. This confirmed sighting is the most northerly record of *R. cornutus* in the history of the CPR survey.



Photos: 4. *Neoceratium longirostrum.* 5. *Neoceratium contortum* on silk. 6. *Triceratium favus.* 7. *Ephemera planamembranacea.* 8. *Membraneis challengeri* 9. *Lepas* Goose Barnacle 10. Salp photo credit www.oceanographerschoice.com 11. *Rhincalanus cornutus.*

Species comparison of CPR and water samples in the English Channel

Rowena Stern, Tanya Jonas, Robert Camp, Astrid Fischer, Claire Taylor, Marianne Wootton, Priscilla Licandro, Lance Gregory, Chris Harris and Julian Morley

In many studies, sampling methods require cross comparisons. This is often performed to confirm a new test is accurate by comparing it with an established method. In this case, SAHFOS carried out a preliminary trial to compare species found on routine CPR samples versus those in samples collected at the same time by WaMS attached to the CPR (Fig. 14). Collection methods and volumes captured for both sampling techniques contrast widely. It would be expected that the CPR, with an entrance aperture of 1.27cm^2, filtering a large (~3m^3) volume of water through a 270µm filter mesh - (Fig. 14A) would collect the larger plankton, as they are less concentrated and less likely to slip through the holes than smaller plankton. By contrast the water sampler collecting 150cm^3 through an unfiltered aperture of 0.07cm^2 would be expected to collect smaller and abundant organisms more efficiently. However, there may be an unknown amount of overlap of taxa collected by these samplers, especially for fragile species that break up on contact with the CPR and find their way into the WaMS samples. Using molecular (DNA-based) assays, we found the water samples from WaMS had a different taxa assemblage to those on regionally equivalent CPR samples. Larger, robust species were generally found on CPR samples whereas smaller, delicate taxa tended to be present in the WaMS samples, confirming suspicions that the water sampler tends to collect smaller or delicate taxa (Fig. 15). This difference was not due to a bias in the molecular assays used on CPR samples compared to water samples as the molecular tests identified most (¾) of the taxa present on CPR samples, as measured by microscopic analysis.

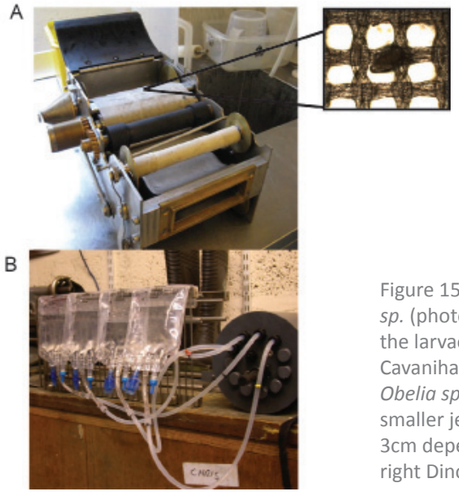


Figure 14: Panel A shows a CPR recorder with silk in it and inset-showing a close-up of the silk mesh with 270µm holes. Panel B shows water sampler (WaMS) device taken apart - a pump that collects a small volume of water into plastic, medical bags.

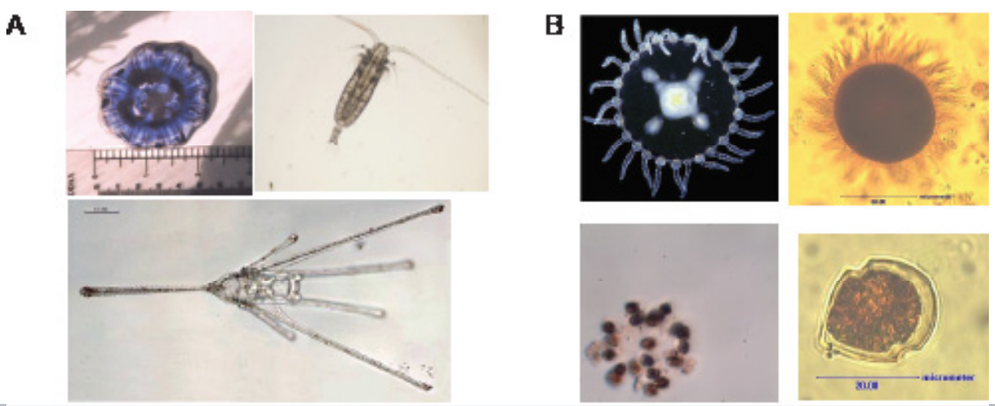
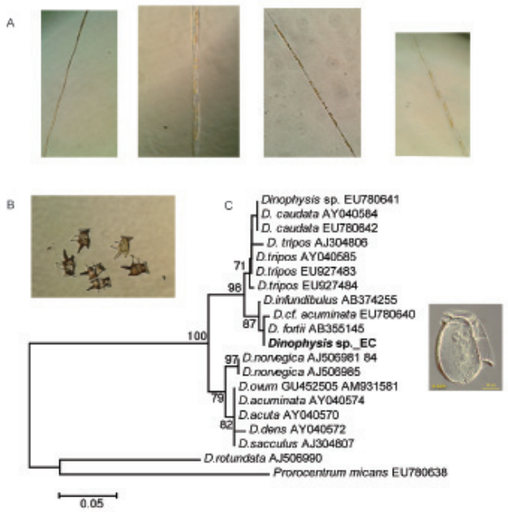


Figure 15: Panel A shows species on CPR - from top left to bottom right: *Cyanea sp.* (photo by Gary Lacey) a larger jellyfish, *Calanus* copepod (1mm) and the larvae of *Echinocardium* sea urchin around 2.5cm (photo by Jean-Marie Cavanihac, microscopy-uk.org.uk). The WaMS sampler (Panel B) found top left: *Obelia sp*. (photo by Wim van Egmond, microscopy-uk.org.uk)- top right: a smaller jellyfish, ciliate (100µm), bottom left *Phaeocystis* most are between 3µm-3cm depending on the colony size or if they are free-living, and finally bottom right Dinoflagellates (most are between 20-60µm).

Phytoplankton Species in the English Channel

Rowena Stern and Márcio de Silva Tamanaha

Márcio de Silva Tamanaha, a visiting scientist from Brazil, spent a month isolating phytoplankton species from the English Channel in order to generate a library of local living cultures as well as DNA that can be used for standards in molecular tests. Márcio collected phytoplankton several times a week both from harbour water and from the L4 station open water site in the English Channel in order to compare species living in different conditions.



During this time, there was a significant bloom of the harmful algae *Pseudo-nitzschia* (Fig.16A) and a substantial population of a second harmful alga, *Dinophysis spp*. Márcio collected eight cultures, of which six are now established and some of which appeared to be toxin-producing species. Studies are ongoing to determine strain and toxin levels in these cultures, as levels vary between strains. He also collected a variety of *Dinophysis* species isolates to use as a DNA library as some of this genus is notoriously difficult to identify using light microscopy. Species identified include *D. tripos* (Fig. 16B) and *Dinophysis fortii* (Fig. 16C), both of which are known to produce toxin. Such work will enable more accurate species detection in the English Channel as well as toxin testing to be carried out to determine regular and infrequent harmful algae

Figure 16: Panel A shows a selection of *Pseudo-nitzschia* species isolated and cultured from the English Channel. Panel B shows *Dinophysis tripos* isolates and Panel C DNA phylogenic tree using part of the Ribosomal Internal transcribed Spacer region identifying a *Dinophysis fortii* species (in bold type) besides similar species from public databases. An image of *D. fortii* from Stazione Zoologica Naples on-line Dinoflagellates database is used as an example.

For more information on *Dinophysis sp*. molecular identification at SAHFOS see: Stern, R.F., Amorim, A., Bresnan, E. Diversity and plastid types in *Dinophysis acuminata* complex (Dinophyceae) in Scottish waters (2014). Harmful Algae 39: 223–231

Marine Crustacean Zooplankton Workshop 2015

SAHFOS is delighted to announce they will be running a Marine Crustacean Zooplankton Workshop from 22nd June – 26th June 2015 in the city of Plymouth, UK. The workshop, open to 20 participants, is aimed at early career scientists, technicians, post graduates and marine ecologists with some knowledge of marine zooplankton. The interactive workshop will focus on the identification of key marine crustacean zooplankton including Copepoda, Decapoda and Euphausiacea which are found in the North Atlantic and European waters.

Internationally renowned taxonomic experts and SAHFOS staff will give lectures and conduct hands-on laboratory practicals in classical morphological identification and cutting-edge molecular techniques, including DNA barcoding and bioinformatic analyses.

A component in the course will cover an external quality control scheme for zooplankton identification and participants are invited to stay for the review of the NMBAQC identification tests which will take place in the week following the course. Secured speakers include:

Prof. Geoff Boxshall - Natural History Museum, UK

Prof. Ann Bucklin - Department of Marine Sciences University of Connecticut, USA

Dr Maria Grazia Mazzocchi - Stazione Zoologica of Naples, IT

Dr Antonina Dos Santos - Instituto Português do Mar e da Atmosfera, PT

Dr Ruth Böttger-Schnack - DZMB Senckenberg, German Centre for Marine Biodiversity Research, DE

Dr David Conway - The Marine Biological Association, UK

Dr Alistair Lindley - Sir Alister Hardy Foundation for Ocean Sciences UK

Dr Rowena Stern -Sir Alister Hardy Foundation for Ocean Science, UK

Marianne Wootton - Sir Alister Hardy Foundation for Ocean Science, UK

Dr Astrid Fischer - NMBAQC & Sir Alister Hardy Foundation for Ocean Science, UK

Mediopyxis in the North Sea: a truly coastal species?

Alex Kraberg (SAHFOS associated researcher) with
Maria Campbell and Rowena Stern

Mediopyxis is a large bipolar centric diatom (broad diameter up to 100 µm), which has been described in 2006 (Kühn *et al.* 2006), seen in Figure 17. Since then there have been many reports of a proliferation of this species in coastal areas of the North Sea with the formation of extensive blooms in some areas e.g. Helgoland, Norderney and the Dutch Wadden Sea. These areas are characterized by slightly reduced salinities and first experimental studies also indicate that this species grows fastest in salinities below 30 (Kraberg *et al*. 2012).

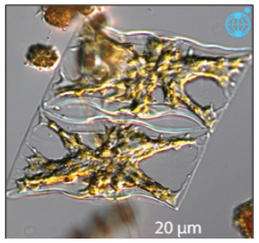


Figure 17: Live *Mediopyxis helysia* cell, collected at Helgoland Roads, source: planktonnet.awi.de.

However there have been no reports of the extent to which this species is distributed beyond coastal areas of the North Sea. Sporadic reports of *Mediopyxis* also exist from Aberdeen and Iceland but at these locations, *Mediopyxis* never forms blooms. Additional field data from the Helgoland Roads transect surveys also indicate that the highest densities of this species occur close to the coasts of the German Bight (and usually during periods of reduced salinity), see Fig. 18. However, while *Mediopyxis* blooms were very pronounced at Helgoland in 2010 they have since subsided. These data indicate that we still do not fully understand the dynamics of this potentially important species. To do so, we require more experimental data but also a better understanding of the distribution of this species.

'The CPR survey is the only available truly 'open North Sea' dataset'

As the only available truly 'open North Sea' long-term dataset is the SAHFOS CPR survey, a joint study was carried out in 2013 in which several SAHFOS silks were re-investigated to try and detect *Mediopyxis helysia*, which had not previously been recorded in the SAHFOS datasets. 24 Samples from 4 routes (M-, R-, HE and C-) in the North Sea were re-examined. All samples were from 2010, mostly May as this was the period during which *Mediopyxis* was most abundant at Helgoland. Ten transects were counted in the selected silks to detect *Mediopyxis* and we also carried out counts using the standardized SAHFOS method. Of the 24 stations investigated, *Mediopyxis* was only confirmed in two samples (290HE#1 and 290HE#2). Only in 290HE#1 did the standard SAHFOS method have a positive result, as in 290HE#2, only two small chains in total were found. These samples were taken just to the west of Helgoland and were therefore in an area where *Mediopyxis* might still be expected to occur. None of the open water samples (routes M- and C-) as well as in the English Channel (route R-) produced any positive results.

None of the open sea samples produced any positive results

In addition to establishing the biogeography of this species in the North Sea we also established a number of cultures so that the intraspecific diversity of this species could be assessed to determine whether different environmental clones would favour different salinity regimes. These clones were isolated from various stations in the German Bight located on two transects from Helgoland towards the Elba and Eider respectively.

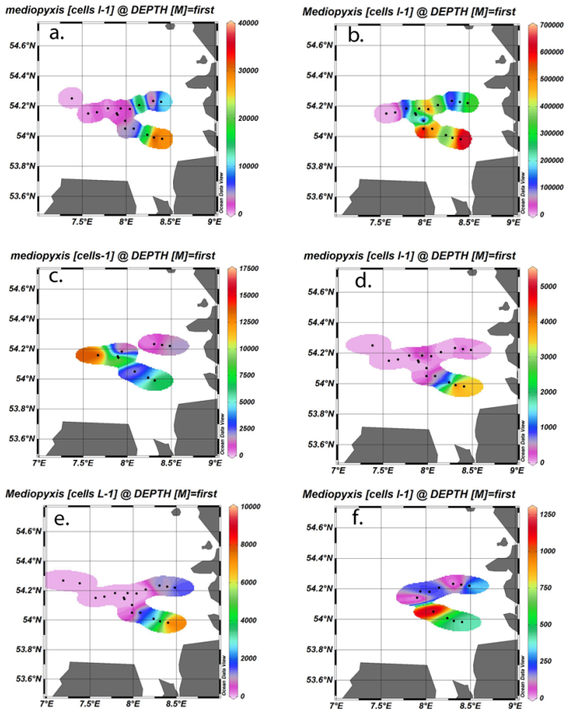


Figure 18: Distribution of *Mediopyxis helysia* in the German Bight in 2010, based on data from the Helgoland Roads transect surveys. Cell densities in surface samples are shown for the months April to September 2010. Cell densities were highest in May and in that month a bloom also occurred at Helgoland but decreased in the stations further to the west.

Bibliography

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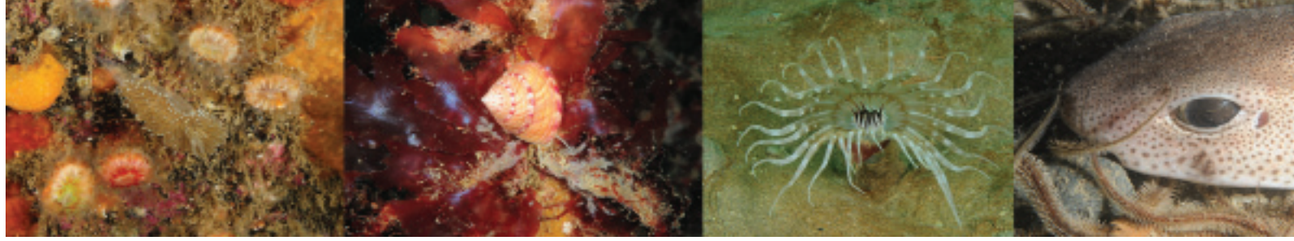
Kühn SF, Klein G, Halliger H, Hargraves P, Medlin LK (2006) A new diatom, *Mediopyxis helysia* gen. nov. and sp. nov. (*Mediophyceae*) from the North Sea and the Gulf of Maine as determined from morphological and phylogenetic characteristics. Beiheft zur Nova Hedwigia 130:307-324



The National Marine Biological Assurance Quality Control Scheme, NMBAQC

Astrid Fischer and David Johns

With David Johns being the Chair of NMBAQC and Astrid Fischer being the Technical Secretary, SAHFOS is very much involved in the important work that NMBAQC carries out to ensure quality assurance in marine biological sampling. SAHFOS, together with NMBAQC, launched its very first Trial Zooplankton Ring Test in 2014. As many may know, zooplankton analysis does not currently have any real recognised UK or international 'Standards', unlike phytoplankton which are subject to a whole host of Standards and Best Practices.

The test was open to participation for UK organisations, to assess the current level of identification in zooplankton analysis. SAHFOS prepared 10 samples of different zooplankton species and a written quiz where analysts had to answer some specific questions on identification and classification of zooplankton. The Trial Ring Test (Fig. 19) was sent out in November to seven different laboratories with 12 individual participants. Results are due in by early 2015 and a workshop is due to be held in July next year to discuss the outcomes and how to process this further.

Outside SAHFOS, the Joint Nature Conservation Committee (JNCC) took on the challenge to write a Best Practise Guide for the Epibiota component, which involves video and photo imaging of benthic substrates and identification of habitats and species. A very first draft of the guide was circulated among the committee and is now out for comment by stakeholders. The guide is going to be split into operational and processing guidelines.

The operational guidelines should ensure the quality of the data, whereas the processing guidelines should ensure the correct interpretation of the data.

The NMBAQC scheme is evolving to include an 'Own Sample' Particle Size Analysis (PSA) exercise in year 2014/2015, where participants can send their worked-up results for PSA to the PSA Scheme Contractor, and a sample will be selected at random for re-analysis by the PSA Scheme Contractor. This is a form of external quality control via re-analysis.

www.nmbaqcs.org

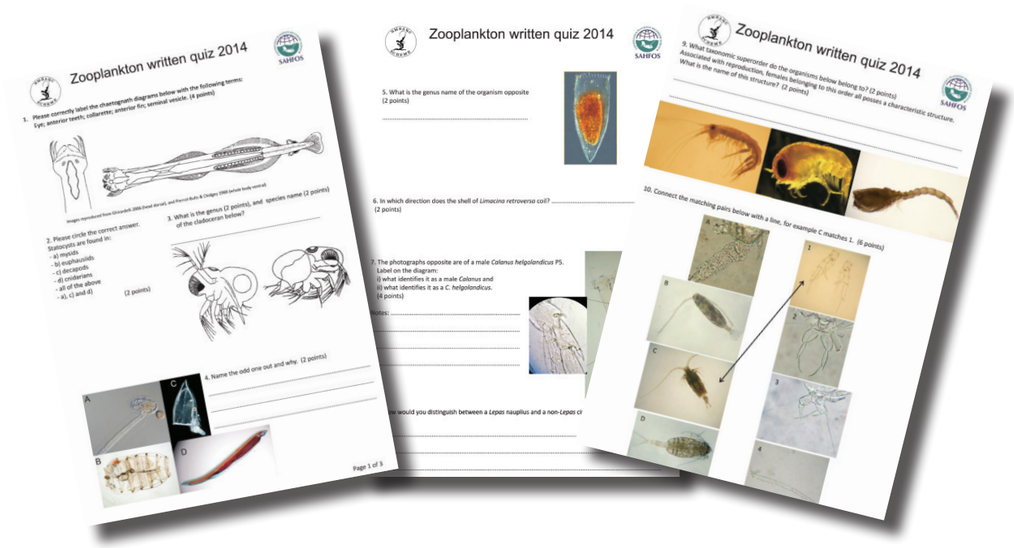
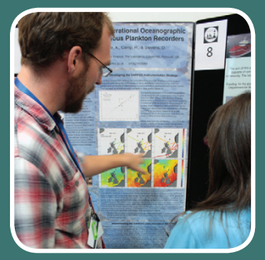
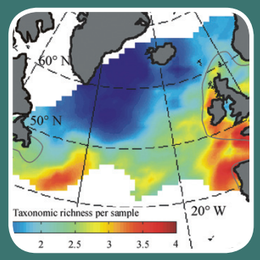


Figure 19. The Trial Zooplankton ring test, sent out to participating UK organisations.

Research Highlights





SAHFOS is involved in a wide variety of research activities, ranging from blue-sky research, 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.

Visions for the North Sea: the societal dilemma behind specifying Good Environmental Status

Abigail McQuatters-Gollop

The MSFD states that the North Sea ecosystem must be returned to Good Environmental Status by 2020

The North Sea ecosystem is degraded from multiple anthropogenic factors, and, according to the Marine Strategy Framework Directive, must be returned to Good Environmental Status (GES) by 2020. This degradation has manifested through alterations in ecosystem services such as resistance and resilience, transparent water, processing of nutrients, food production, and carbon storage and sequestration. These ecosystem services are linked to benthic functioning, changes to the extent and severity of which have been linked to the spread of industrialized trawling which began in the North Sea around 150 years ago. What would happen if we were able to restore the benthic community to its pre-industrialised trawling state? What societal sacrifices would restoration entail? In other words, if restoration is possible, would it be worth it?

Two extreme scenarios were constructed to address these questions: the 'Then' vision of the North Sea, based on ecosystem functioning prior to degradation and the 'Now' vision, representing the current state of the North Sea ecosystem. The elaboration of contrasting visions allows exploration of the choice society faces in choosing for a particular environmental status of the North Sea.

Benefits from the Then vision come from restoration of ecosystem resistance and resilience, and their support for continued supply of ecosystem services, including higher demersal biodiversity. Achievement of these benefits would be offset by societal costs. Because trawling caused the loss of benthic functioning, ecosystem restoration requires restraints on this activity. Alternative fishing techniques and/or careful delineation of trawling grounds to, for example, protect key habitats might be required. There are considerable uncertainties as to how quickly the Then vision might be realised, if it can be realised at all, and so the cost to fisheries, and therefore to society, is difficult to estimate. The Then vision involves a large marine ecosystem experiment that could take decades with few, if any, intermediate criteria for assessing progress.

Even though the Then vision is uncertain, it is vital to current discussions on Good Environmental Status. The Then vision provides perspective on what a relatively undisturbed state of the southern North Sea might be. As a long-term goal, it would give focus for specification of GES, whether or not targets are achieved by 2020. Sea-wide degradation of the southern North Sea was triggered by industrial trawling. While now subject to a wider diversity of anthropogenic pressures, any discussion of GES, any measure to achieve it, is moot if the issue of trawling regulation is not tackled.

'If we could restore the ecosystem to a pre-industrialised trawling state would it be worth it?'

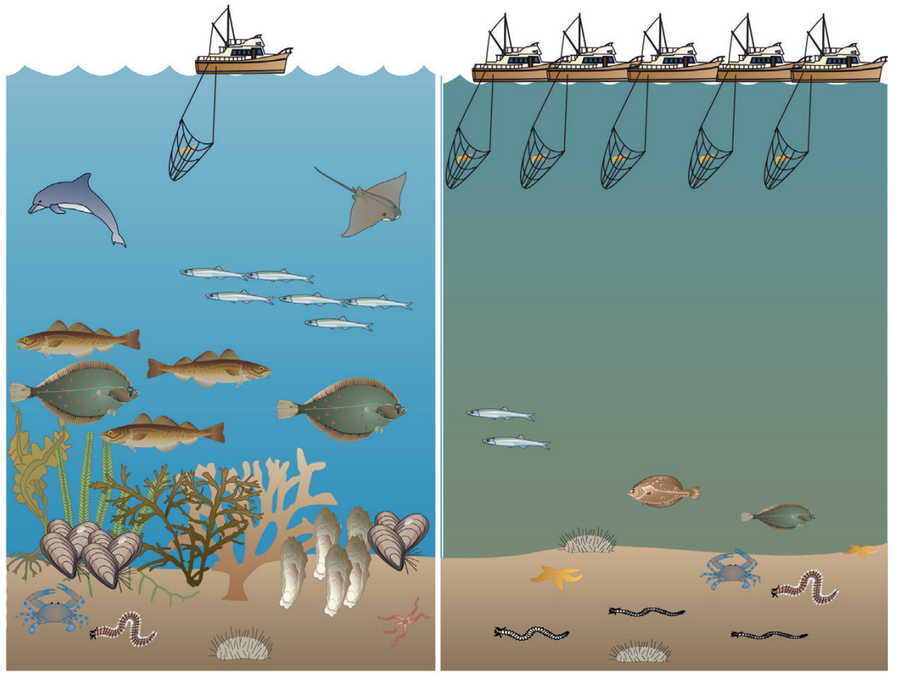
GES is, ultimately, a societal choice. Society may choose for a status that is little different from the Now vision because the uncertainties of achieving better may not be financially 'worth it'. This Now vision, however, maintains the southern North Sea as a turbid fishpond producing flatfish, and carries the risk of further state changes that could threaten supply of ecosystem services as a result of poor resistance and resilience.

Realistically, the choice is not simply between Now or Then as there are potentially any number of intermediates, although it is entirely possible that Now and Then broadly describe two relatively stable states so that small interventions (e.g. further decreases in anthropogenic nutrient loading) would have only marginal benefits. The effects of climate change have also been ignored here, but will in reality play a key role in shaping the specificities of either vision. A choice for the Now vision, which depends on the boreal species of cod and plaice, also carries uncertainties about future delivery of food production services. The Then vision could therefore widen our choices given the uncertain future of fish stocks.

Realistically, the choice is not simply between Now or Then

The effects of past and present pressures on ecosystems generate considerable uncertainty about setting and reaching targets for GES. This contrasting of two visions is intended to stimulate debate about the kind of North Sea society wants. Whatever vision emerges will need to be robust in the light of foreseen and unforeseen pressures from an increasingly globalised North Sea.

Read more: Gilbert, A.J., McQuatters-Gollop, A., Langmead, O., Mee, L. and Vermaat, J., 2014. Visions for the North Sea: the societal dilemma of specifying good environmental status.



The Then vision (far left) represents a biodiverse North Sea with transparent water and limited fishing while the Now vision (left) illustrates a degraded North Sea which is heavily fished and low in diversity.

Synchronous response of marine plankton ecosystems to climate in the North Atlantic

Eric Goberville, Grégory Beaugrand and Martin Edwards

The oceans may soon change at an unprecedented rate. In this context, plankton, which responds rapidly to environmental modifications, will help us to better track the influence of global climate change on marine ecosystems. Combining plankton monitoring and comparative approaches represents a powerful way in which to investigate how ecosystems respond to varying hydro-climatic forcing in time and space and to explore the non-linear mechanisms behind ecosystem responses to climate change.

> Plankton, which responds rapidly to environmental modifications helps us track global climate change on marine ecosystems

In this study, we performed a comparative approach in two regions of the North Atlantic (the Northeast Atlantic and the North Sea; Fig. 20) to examine long-term changes in the abundance of three marine plankton groups (i.e. dinoflagellates, diatoms and copepods) in relation to regional (physico-chemical environment) and large-scale hydro-climatic forcing.

To extract long-term changes in the environment, the regional climate and the different plankton groups between 1958-2007, standardised principal component analyses (PCAs) were performed separately on: (1) environmental parameters (nitrate, phosphate and silicate concentrations, oxygen, salinity and chlorophyll a), (2) climatic variables (SST, winds, precipitation, solar radiation flux and sea level pressure), (3) diatom, (4) dinoflagellate and (5) copepod species for each ecoregion. To identify the most contributing factors to changes in each region, cluster analyses were applied on PCA outputs. Based on cluster results, new PCAs were then performed to summarise the main long-term changes in both the Northeast Atlantic and the North Sea. To examine how climate change may have influenced marine plankton ecosystems in the two regions, Pearson correlation coefficients were calculated between hydro-climatic indices (the North Atlantic Oscillation (NAO), the Atlantic Multidecadal Oscillation (AMO), the East Atlantic (EA) pattern and Northern Hemisphere Temperature (NHT) anomalies) and long-term changes observed in each area. Finally, we performed bi-plot analyses for a visual appraisal of the relationships between each large-scale hydro-climatic forcing and ecosystems changes (Fig. 21).

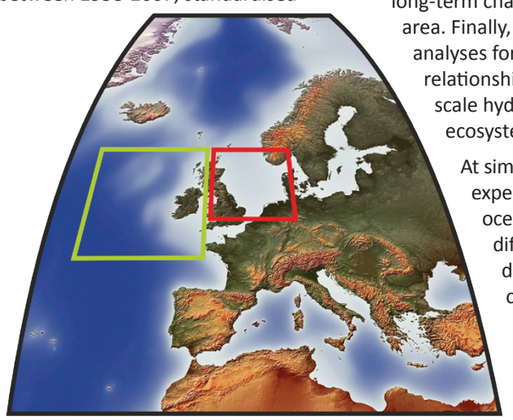


Figure 20. Location of the two ecoregions (1) the Northeast Atlantic (25°W–5°W and 47°N–60°N; in green) and (2) the North Sea (4°W–10°E and 51.5°N–60°N; in red).

At similar latitudes, it is expected that different oceanic regions react in a different way to climate due to biotope-related components such as basin configuration, nutrient regimes, current patterns and biotic features, including biodiversity and food-web organisation.

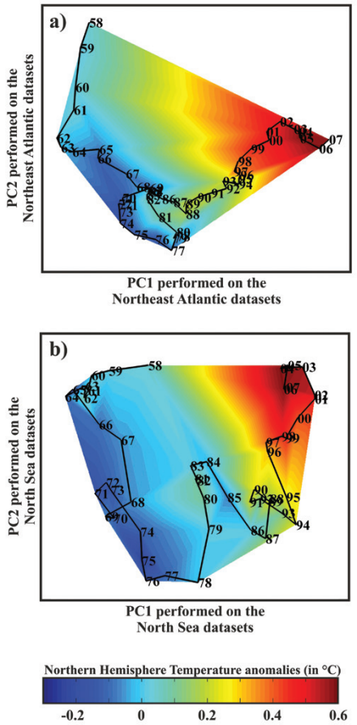


Figure 21. Relationships between the Northern Hemisphere Temperature (NHT) anomalies and the first two principal components (PCs) of the PCA performed for (a) the Northeast Atlantic and (b) the North Sea. Positive anomalies (an increase in temperature; from green to red) are related to the period 1989-2007 with a strong increase in SST at the end of the 1990s.

However, our study suggests strong similarities between long-term ecosystem changes in the North Sea and the Northeast Atlantic Ocean. Although having distinct inherent specificity, the two ecoregions have responded to climate change in a similar way and long-term ecosystem changes appear more governed by large-scale climatic variability and climate change (i.e. NHT anomalies and the EA pattern) than by regional processes.

Considered separately, year-to-year changes in environmental parameters, regional climate and plankton species abundances revealed gradual trends interrupted by abrupt changes detected circa 1976, 1987-1988 and 1996-2000. When environmental, climatic and biological components of the two ecoregions are combined in a single analysis, the study showed that the magnitude of changes is surprisingly important over the multi-decadal scale.

The strong significant correlations between the long-term changes in both ecoregions and large-scale hydro-climatic indices, which have a strong influence on sea surface temperature, suggest that temperature is the most important factor by which climate propagates through the ecosystem.

At a time when a lot of effort is devoted to better understand how ecosystems respond to climate forcing, monitoring programmes such as the CPR are essential to establish baselines and to tackle the issue of not only global climate change but global ecosystem change.

Read more: Goberville E., Beaugrand G., Edwards M., 2014. Synchronous response of marine plankton ecosystems to climate in the Northeast Atlantic and the North Sea. Journal of Marine Systems, 129, 189-202.

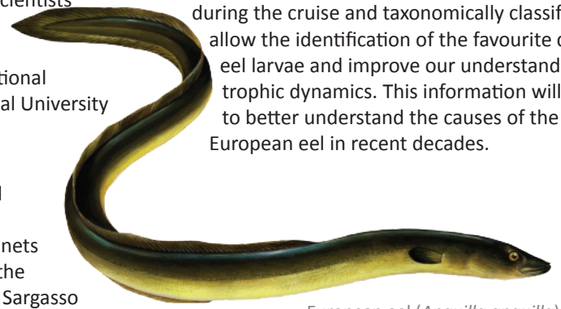
SAHFOS onboard the Danish Eel Expedition 2014

Priscilla Licandro and Peter Munk (DTU AQUA, Denmark)

SAHFOS participated in the Danish Eel Expedition 2014, helping to verify whether climate-related changes to ocean currents are contributing to the dramatic decline of the European eel (*Anguilla anguilla*), of which recruitment is at present less than 2% of the level prior to 1980.

To improve our understanding on the lifecycle of this eel and fill the knowledge gaps on the eel larvae diet and breeding habits, an international team of thirty-nine scientists from different Danish, British, French and American Institutions were involved in the Expedition, led by Peter Munk of the National Institute of Aquatic Resources at the Technical University of Denmark in Charlottenlund.

Priscilla Licandro from SAHFOS was onboard to study gelatinous zooplankton ecology and to help with the identification of gelatinous specimens collected using different types of nets in the Sargasso Sea, the spawning region of the European eel, and along a transect from the Sargasso Sea to the Azores. Previous studies based on molecular analysis of gut content have shown that eel larvae prey on a surprising variety of zooplankton, with a preference for gelatinous zooplankton. Therefore, to better understand the environmental pressures relevant for European eel recruitment, it is important to fill the knowledge gap on gelatinous zooplankton diversity and distribution in the Sargasso region. In addition, the DNA sequences extracted from the specimens of gelatinous zooplankton collected during the cruise and taxonomically classified onboard, will allow the identification of the favourite diet of European eel larvae and improve our understanding on their trophic dynamics. This information will hopefully help to better understand the causes of the decline of the European eel in recent decades.



European eel (*Anguilla anguilla*). Image credit: Scandinavian Fishing Year book via European Commission.

Line Reeh

Peter Munk

Rasmus Bech

Images from left to right: The *RV Dana* research vessel, scientists participating in the expedition, Priscilla Licandro working aboard the ship with Russ Hopcroft.

Mapping plankton diversity and plastic in the Mediterranean

SAHFOS onboard the 'Progetto Mediterranea' Expedition

Priscilla Licandro and Progetto Mediterranea

The 'Progetto Mediterranea' Expedition is a sailing, cultural and scientific expedition which for 5 years from May 2014 will travel across the Mediterranean Sea, the Black Sea and the northern Red Sea, aiming to connect people, share cultures and to improve our knowledge of the Mediterranean region

The sailing boat '*Mediterranea*', a 60-foot ketch, will be used as a floating laboratory, bringing together different research institutions interested in studying biodiversity, water and air pollution, currents and climate.

SAHFOS is collaborating with 'Progetto Mediterranea' to map the biodiversity of marine plankton, in order to study how and where biodiversity is mostly changing across Mediterranean regions. Moreover, for over a third of the route, plankton biodiversity will be assessed for the first time ever.

The analysis of samples collected by non-scientists on board during the first leg of the expedition in May-July 2014, has helped to identify the coastal regions most impacted by the presence of microplastics (Fig.22). Coloured plastic fibres up to 3cm long were found in all stations in the Ionian Sea, whereas the Cyclades were relatively plastic-free.

Eighty-nine phyto and zooplankton species/ taxa, all typically Mediterranean, characterised three main 'marine provinces' along the route Otranto-Monemvasia (stations 1-18, Fig.23). Among those, small species of crustaceans and gelatinous zooplankton were dominant, as they are well adapted to oligotrophic waters, typical of this region. Several fish spawning/nursery areas were also identified along the route.

Overall, the data collected from SAHFOS and the 'Progetto Mediterranea' provides important baseline information on marine communities that could help to improve the management/conservation of the coastal marine ecosystems in the Mediterranean and adjacent seas.

Images showing work completed aboard the vessel of plankton and microplastic sample collection using a plankton indicator.

All images courtesy of Progetto Mediterranea.

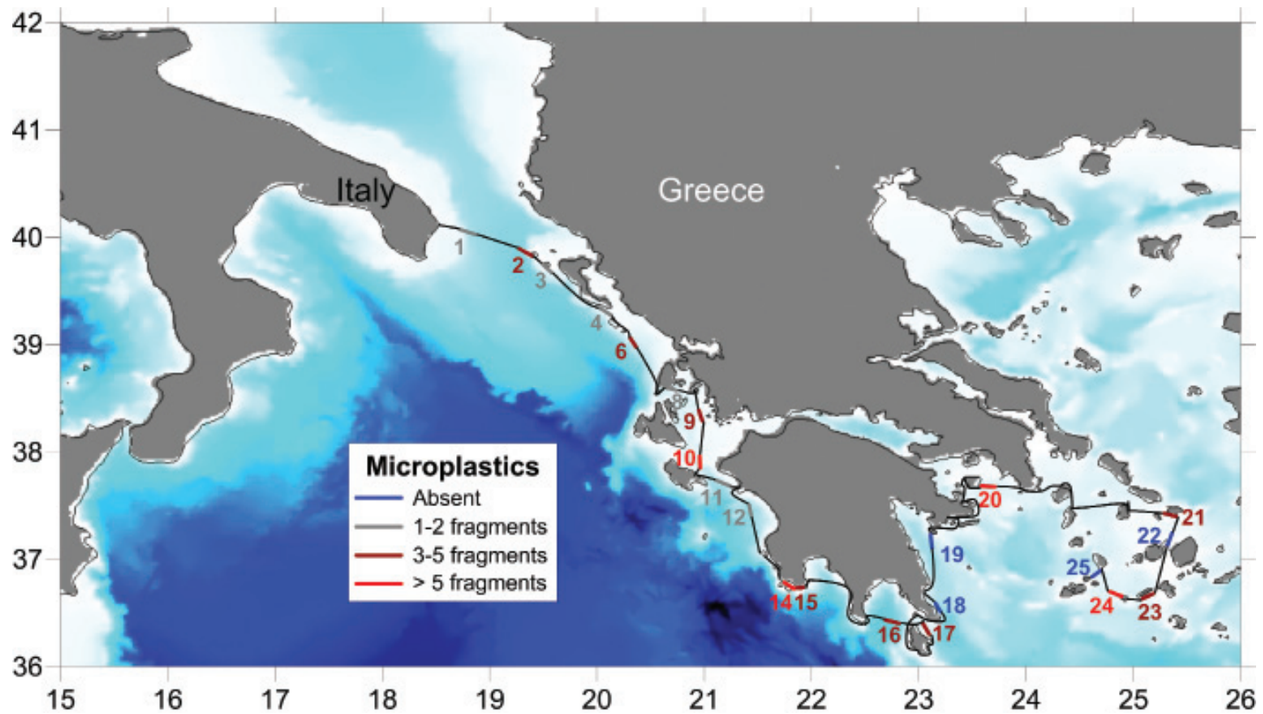


Figure 22. 31st May-28th July 2014, route Otranto-Milos. Stations 1-25, i.e. routes along which the 'Mediterranea Project' sampled horizontally the plankton in sub-surface waters. The coloured traits indicate the quantity of microplastics found in the samples (see legend for details).

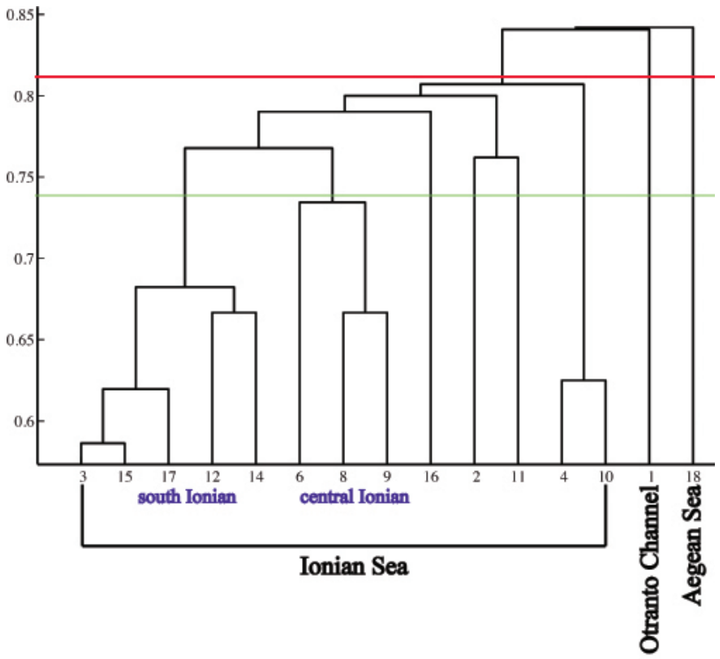


Figure 23. 31st May-25th June 2014, route Otranto-Monemvasia. Main coastal marine provinces characterised by different plankton populations, as identified by the analysis of the data collected by the 'Mediterranea Project'. The horizontal bars of the tree group stations (indicated on the x axis) based on their dissimilarity (measured by the distance coefficient of Jaccard, indicated on the y axis). The populations in the Otranto Channel, Ionian Sea and Aegean Sea were more than 80% different, while those in the central and south Ionian showed dissimilarities between 55-74%.

Find out more about this expedition at:

http://progettomediterranea.com/en/

For further information on microplastics and plankton diversity in the Mediterranean, please contact

Priscilla Licandro

prli@sahfos.ac.uk

Progetto Mediterranea is raising funds to support this project over the next five years. For further information please contact 'Progetto Mediterranea'

info@progettomediterranea.com

Multidecadal Spatial Reorganisation of Plankton Communities in the North East Atlantic

Vicky Harris and Martin Edwards

The goal of the study was to explore changes in spatial regions to identify climate signals that may be driving change

In a recently published study in the Journal of Marine systems we used data from the CPR survey to explore spatial reorganisation of species assemblages. We focused in particular on two groups of interest: copepods and diatoms. The goal of the study was to explore changes in spatial regions across a temporal "regime shift" and to identify climate signals that may be driving change. The timing of the "regime shift" was chosen as 1985, however, we also explored varying the timing using a sliding window analysis.

Several previous studies have found evidence of a northwards movement of cold water zooplankton species. It has been hypothesised that this is likely a response to rising sea surface temperature. In our recent work we found evidence for both a northwards shift and a reorganisation of the dominant copepod species across space. Across each location the species that accounted for the most variability were selected using a technique called sparse principal component analysis (SPCA). The correlation between the joint behaviour of the species selected by SPCA across time was correlated with several potential explanatory climate signals, in particular the Northern Hemisphere Temperature (NHT) trend, the North Atlantic Oscillation (NAO), the East Atlantic Pattern (EAP) and the Atlantic Multidecadal Oscillation (AMO). For the copepod assemblages the strongest correlation was with the NHT trend, lending weight to the hypothesis that change in their behaviour is driven by temperature.

The copepods' behaviour change appeared to be driven by temperature

The diatoms tell a different story. Of the climate trends that we explored, the AMO had the strongest correlation with the joint behaviour of the diatom assemblages and the correlation with the NHT trend was weaker. Figure 24 shows spatial regions as defined by the diatom species that account for the most variability both before and after 1985. These regions were determined by using k-means clustering, a method for partitioning a dataset and which has been used here to group together regions with similar species composition, using the species identified using SPCA in each time period (1958 to 1985 and 1985 to 2009). The regions appear more structured in the second half of the time period and appear to follow loosely the bathymetry (shown by the dark black lines overlaid on the figure). The latter time period corresponds to the movement of the AMO in to its high phase, which suggests this may be a driver of the spatial reorganisation. Further study is needed to better understand the mechanism by which the AMO signal might be influencing the diatom assemblages.

The AMO appears to be the driver of diatom assemblages

In conclusion this research offers insight in to how different climate drivers have a differential effect on different species assemblages, in particular expanding our understanding of the influences on the diatom communities and their spatial distribution. This also suggests avenues for future research. SPCA and k-means clustering can be used to create summaries of the complex multivariate spatio-temporal structure of the CPR dataset, which allows us to fully exploit its potential.

This research offers insight in to how different climate drivers have a differential effect on different species assemblages

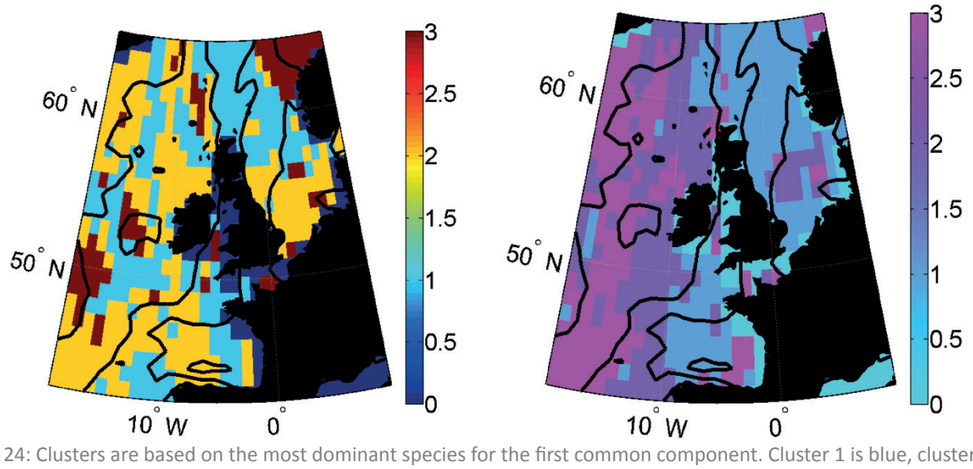


Figure 24: Clusters are based on the most dominant species for the first common component. Cluster 1 is blue, cluster 2 orange and cluster 3 dark red before 1985. Since the regions after 1985 may not be identifiable with those before a different colour scheme is used, with cluster 1 being blue, cluster 2 purple and cluster 3 pink. (a) Regions based on Phytoplankton species before 1985. (b) Regions based on Phytoplankton species after 1985.

Pathways for effective governance of the English Channel: lessons learned

Jennifer Skinner and Abigail McQuatters-Gollop

The English Channel is one of the most intensively used maritime regions in the world and supports a wide range of activities, including transport, energy production, aggregate extraction, commercial fishing, tourism and recreational pursuits. Each competes for limited marine space and each exerts pressure on the environment, which, as forecasts suggest, will likely expand over time as the regional population increases. In addition, due to its role as an international boundary, the area is governed not as a single system, but as two distinct regions resulting, in a complex and fragmented management approach which threatens the protection and sustainable use of the Channel ecosystem. The 'Promoting Effective Governance of the Channel Ecosystem' (PEGASEAS) project, funded by INTERREG, addressed the protection and management of the Channel region.

In order to support decision making in the Channel area it is vital we have a sound understanding of its marine ecosystem. Long-term datasets are rare but unrivalled in their ability to provide important information on the natural environment. It is essential we understand variation, trends and patterns in the ecosystem if we are to be able to discern, understand, quantify and manage change.
Long-term monitoring programmes that operate on a cross-Channel, transboundary level, such as the CPR survey, provide a valuable evidence base to support decision making.

Historically, there has been little cross-Channel communication between stakeholders in the Channel area. The PEGASEAS project held a series of Cross Channel Forums, which provided a platform from which to share ideas and management practices. Forums such as these provide a venue for the sharing of information and development of best practices amongst a broad spectrum of stakeholders from both sides of the Channel including scientists, industry members, policy makers, local interest groups and residents. Communication through cross-Channel events fosters open dialogue and enables relationships to be forged that support an integrated approach to the governance for this region.

Ecosystems do not recognise political boundaries and it is clear that the current partisan approach to the management of Channel resources is not sustainable. For example, a variety of non-indigenous marine species are currently present on the French coast of the Channel but not yet reported in the UK. The management and control of such species requires a co-ordinated, transboundary approach in order to avoid colonisation and the significant associated financial and ecological cost. In order to manage the Channel ecosystem sustainably, an integrated, cross-sectoral, transboundary management strategy is urgently required which considers the region as a single space.

Sustainable management of the Channel requires three key attributes, each fundamental to promote effective and comprehensive governance of the region. Firstly, a detailed understanding of the marine ecosystem is needed to provide the evidence required for policy and decision makers to make informed choices. Secondly, improved communication at a cross-Channel scale between all stakeholders will encourage the development of relationships and the sharing of ideas and best practices within and between different interest groups. Finally, a transboundary, integrated management approach that encompasses all relevant sectors and disciplines is required. Together these three attributes serve to promote a holistic approach to the governance of the region which is essential to conserve and protect the unique Channel ecosystem. The above findings have been published by PEGASEAS in a policy advice document entitled 'Pathways for effective governance of the English Channel', intended to support the effective governance of the Channel.

Abigail Mc-Quatters-Gollop, Penny Mordant MP and Jennifer Skinner launching the Pathways guide at the House of Commons.

Molecular Research team highlights

Rowena Stern

This year has focused on the development of technology and assays to identify and monitor harmful organisms, and has been very productive thanks to the addition of two members of the Molecular team. Charlotte Walker carried out her Masters project at SAHFOS to look for the presence and distribution of species belonging to the harmful Pseudo-nitzschia algae in the English Channel. Claudia Martins, who did her PhD in harmful algae and previously worked for the Environmental Protection Agency, started work as a post-doc in March and brings her considerable expertise in toxicology, molecular biology and policy to her work at SAHFOS. Whilst at SAHFOS, Claudia won a Santander scholarship to study toxic algae from European waters. Much of this work will continue with funding from H2020 AtlantOS.

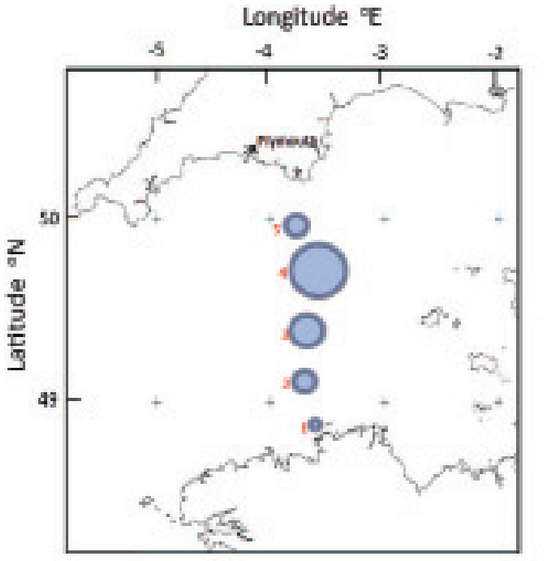
Pseudo-nitzschia in the English Channel

Charlotte Walker and Rowena Stern

My project with Rowena Stern at SAHFOS focused on the monitoring of the harmful algal bloom genus *Pseudo-nitzschia* in English Channel samples. *Pseudo-nitzschia* is a phytoplankton found globally. Some species within the genus have the ability to produce the neurotoxin domoic acid (DA). DA accumulates in the marine food chain and can have chronic neurological effects on a range of organisms including humans, marine mammals and crucial fish stock species. Identification of toxic species is complicated, species of *Pseudo-nitzschia* are very hard to differentiate between morphologically, however, molecular methods have proved highly effective in recent years.

My project aimed to identify the presence of individual species of *Pseudo-nitzschia* within samples using molecular methods published by Andree *et al*. (2011) that can rapidly quantify the harmful algae within days. The samples were collected by WaMS, towed by the Brittany Ferries route from Plymouth to Roscoff. We focused on one toxic species of *Pseudo-nitzschia* and used a specific genetic marker, a sequence of DNA unique to that species, to identify our target species. The project was successful in revealing different seasonal patterns of this potentially toxic species from 2011-12 and an unexpected non-coastal distribution (Fig. 25) from very small volumes of water. These findings will be published. The methodology shows good potential for a viable, long term *Pseudo-nitzschia* molecular monitoring program for UK waters.

Charlotte Walker, a MRes Student of Marine Biology (January-October 2014) supervised by Rowena Stern, graduated in November 2014 with distinction and is now doing her PhD at the MBA with Glen Wheeler.



Left: Figure 25. Map of sample site transect between Plymouth and Roscoff. Blue circles indicate amount of *Pseudo-nitzschia* (above) identified at each site during the project.

Development of rapid testing systems to identify harmful plankton species:

Quantitative testing of water samples from the Water and Microplankton Sampler (WaMS)

Claudia Martins

When harmful algae grow and spread with sea currents, aquaculture and fisheries need to respond within hours to days to decide whether to close the farm or whether to fish in an area. Many harmful algae cannot be identified to the level of detail required to be informative, leading to unnecessary aquaculture closures. Therefore testing systems need to be rapid and accurate to match this level of demand. In the long-term, these rapid testing systems also help to provide patterns of recurrence or any changes to new or existing species distributions for future marine management. As part of funding given to SAHFOS, Claudia Martins has developed and validated quantitative molecular tests for eleven harmful and potentially harmful microbial species from WaMS in the English Channel. These tests are intended to extend the monitoring capacity of SAHFOS, particularly to monitor health of the oceans, and could be used for long-term monitoring purposes or for rapid reporting. Four new assays showed positive species identification from WaMS environmental samples. The results showed useful patterns of occurrence for *Alexandrium* species (Fig. 26 shows an example of a test) and also revealed an unusual occurrence of a harmful algae and pathogens rarely or not reported before in the English Channel.

Trials of Harmful Algae microarray to detect harmful algae species from WaMS

Rowena Stern

The ability to test for multiple species in a sample is extremely advantageous but technically challenging, especially for environmental samples that contain species which each respond differently. The MIDTAL microarray project was started to develop a microarray that could test multiple harmful algae in one testing platform, that could deliver results within days. The project has been in development for many years and tested on multiple environments and is now being sold commercially by Microbia Environment in France. The advantage of this test is that most of the equipment needed is relatively inexpensive and many species can be detected in one test. In a pilot study, we wanted to see if species contained in small volumes of water collected by WaMS could be reliably identified by this microarray. Several water samples were tested on this platform, plus negative and positive control samples, the latter containing a mixture of known harmful algae to see whether the microarray could detect all the algae in the mixture. The results of this pilot study showed a high level of identification of species contained in the algae mix in the positive control. In the environmental samples, one sample was repeated twice and the test showed consistent repeatability within the sample. The negative control remained negative. The species detected in the environmental samples were consistent with other DNA tests, confirming their

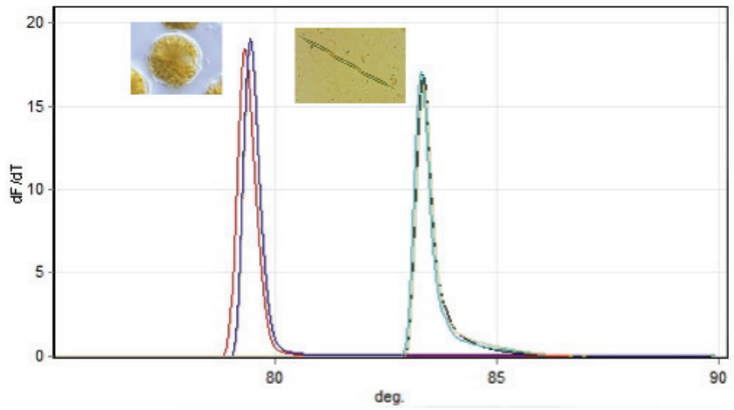


Figure 26: Example of DNA-based specific tests of plankton species using High Resolution Melt Curve analysis to differentiate species according to the melting temperature of their DNA. These tests also allow for quantification. Left curve shows species-specific identification of an *Alexandrium* species, whilst the right curve identifies a *Pseudo-nitzschia* species. The test can be done in a day.

Background picture is of the Water and Microplankton Sampler.

presence and a number of *Pseudo-nitzschia* species dominated the samples. However, additional harmful algae that we weren't aware of were also detected showing the value of the system. This assay has good potential to be used to rapidly identify multiple species in small-volume samples. Work will continue on testing its applicability for quantitative tests (as the assay was designed to test 10 times more sample volume than we do at the moment), and for formalin-preserved CPR samples.

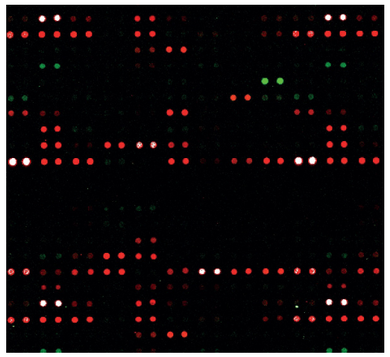


Figure 27: Example of microarray detection system on a SAHFOS sample. Coloured circles represent DNA probes that have positively detected a species. With 140 probes multiple species can be detected on the array- red and green colours indicate intensity of detection. There are many duplicate probes of any one taxa embedded within this microarray test to prevent false positive detection, providing a robust assay system.

Undirected conditional independence graphs: linking variability in the CPR-data to variations of hydrodynamic conditions

Ulrich Callies, Helmholtz-Zentrum Geesthacht

A wide range of multivariate statistical analysis techniques aim at the identification and description of relevant interaction structures between different parameters observed. In contrast to such statistical analyses, mechanistic models try to emulate a natural system's behaviour in terms of assumed underlying causal interrelationships. According to earlier studies, directed causal graphs representing conditional probabilities provide the opportunity for a proper combination of the two different concepts. Covariance selection modelling, producing undirected conditional independence graphs, is another statistical technique we explore in this context. In a recent paper we discuss the application of graphical techniques for a better interpretation of inter-annual variations in the Helgoland Roads monitoring data. The present cooperation between SAHFOS and HZG aims at a similar type of analysis for the CPR data. In particular we will explore the degree to which variability and trends in the CPR data can be explained by variations of hydrodynamic conditions represented, for instance, by long-term re-constructions produced in the context of climate research projects.

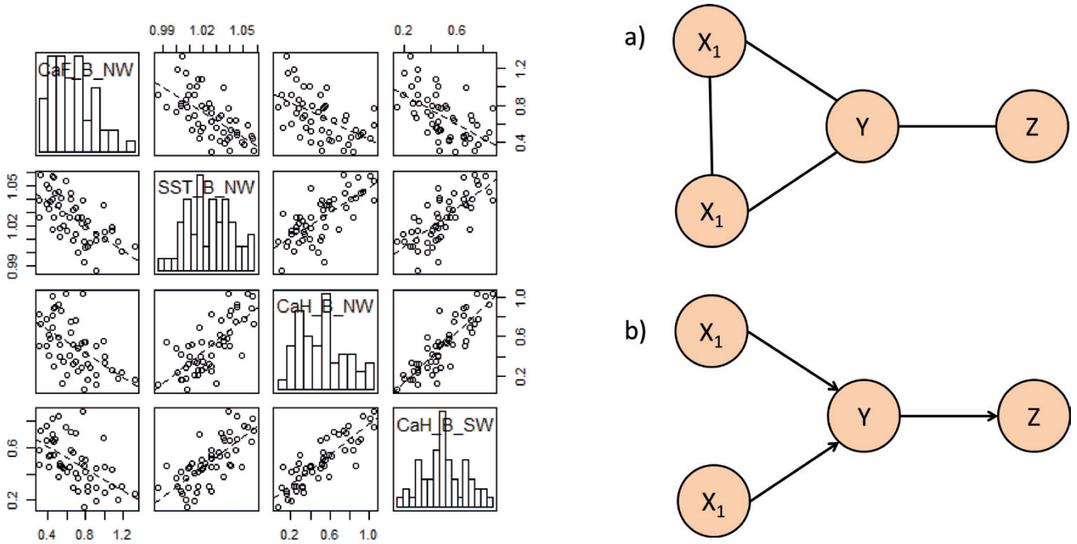


Figure 28. Left panel: Example scatter plot for a collection of four different variables. Right panel: a) a hypothetical undirected graphical model for four variables, based on partial correlations, and b) an example causal graph consistent with the undirected graph that represents information available from observations.

Do *Oithona* like it hot?

Claudia Castellani

The spatial and temporal distribution of species is determined by biotic and abiotic environmental conditions with ambient temperature, food availability and predation mortality being among the most important parameters.

Not all species, however, respond equally to changes in their environment as each one is characterised by specific adaptations, physiological plasticity and life cycle traits.

Therefore, knowledge of which environmental factors may affect a species is key to understanding the mechanisms determining its occurrence and predicting its persistence, particularly under a climate change scenario. As such the comparison of geographically distinct long-term time series represents a powerful tool to gain insight on how species respond to environmental change.

We investigated whether changes in ambient temperature and food availability could limit spatial and temporal changes in the abundance of the small cyclopoid copepod *Oithona similis*, by comparing the long-term trends in the abundance of this species (1988- 2013) at two stations in the North Atlantic (L4 station) and in the Mediterranean Sea (LTER-MC station). We focussed on *O. similis* as this species is considered one of the most abundant and ubiquitous metazoan species in the marine environment, with a distribution ranging from coastal to oceanic regions and from tropical to temperate and polar waters. Despite its reported widespread occurrence, published literature suggests that *O. similis* prefers arctic-boreal localities, whereas evidence of its presence in tropical areas is more sparse and in some cases doubtful.

The ubiquity and high abundance of *O. similis* has been mainly attributed to its ability to exploit oligotrophic environments, to its low energy requirement and to its low predation mortality compared to other copepod species. However, reports that *O. similis* populations peak in eutrophic conditions suggests that low food availability may limit its abundance and distribution in more oligotrophic areas. The North Atlantic and Mediterranean study sites were characterised by similar seasonal and interannual changes in phytoplankton stock but have very different temperature ranges.

Our results show that the abundance of *O. similis* at L4 was ~10 times higher than at LTER-MC. However, *O. similis* variability at both sites was mainly seasonal, with little changes in abundance and phenology over the 20 years period. The seasonal cycle of *O. similis* at LTER-MC consisted of a single annual peak in spring which occurred ~2 weeks earlier than the spring peak at L4 (Fig. 29). In contrast, the seasonal cycle of *O. similis* at L4 also showed several additional peaks throughout summer and autumn (Fig. 30). Correlation analysis suggests that seasonal changes in ambient temperature regulate the abundance of *O. similis* at LTER-MC but not at L4, while the effect of phytoplankton biomass on abundance although significant was not as important. We can see that the abundance of *O. similis* increases with phytoplankton standing stock up to ~20 °C and that higher temperature at LTER-MC represents the main limiting factor for the population growth of this species particularly during summer.

These findings might have important implications for the ecology and biogeography of the species, particularly under a global-warming scenario.

This article is a summary of work presented at the 2015 Aquatic Sciences Meeting: Global And Regional Perspectives — North Meets South. 22-27 February 2015. Granada, Spain. Castellani, C.; Licandro, P.; Fileman, E.; Di Capua, I.; Mazzocchi, M. G.; Does *Oithona similis* Like It Hot? (Abstract ID:26160)

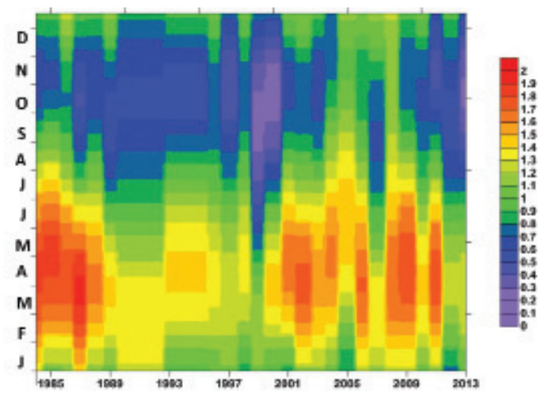


Figure 29: Interannual and seasonal change in the abundance of *Oithona similis* at the LTER-MC station between 1988 and 2013

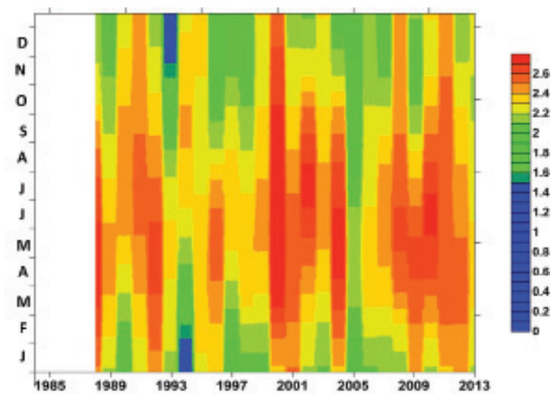


Figure 30: Interannual and seasonal change in the abundance of *Oithona similis* at the L4 station between 1984 and 2013.



CPR sampling in the NE Pacific: In hot water!

Sonia Batten

After several years of being cooler than average, the waters of the NE Pacific have been heating up recently. Whitney (2015) reported spring temperatures deviating 3.5 standard deviations from the long-term mean in the oceanic waters of the NE Pacific, covering the transition zone just south of where the CPR transects run. The paper concluded that winter primary productivity was the lowest in the satellite record and wondered about implications for higher trophic level productivity. By the autumn of 2014 researchers in Alaska were seeing waters 2°C above normal (Hopcroft, pers. comm.) with associated warm water plankton on the Alaskan shelf and speculated that the effects would be felt well into 2015. Although the VJ and AT routes have a relatively short time series of instrumentation, we can clearly see the warmth of 2014 in the records from the Vemco minilogger (AT route) and Brancker CTD (VJ route). Figure 31 shows the temperature data for spring 2014 for both routes compared with previous years (June data are plotted for the VJ route as this late spring transect has a very consistent path). 2013 was also relatively warm, but for the most part 2014 values were the highest in our records for much of the transect.

Plankton analysis is not quite complete for the 2014 data but provisional results suggest that the effects of the warmth are evident. Figure 32 shows some summary indices for two regions;

- Total diatoms for the oceanic NE Pacific region were low throughout the year, in some months the lowest monthly mean recorded in our 15 year time series. Its likely that the annual anomaly will be the lowest we've seen, once finalised data are available. Low abundance of the larger diatoms the CPR catches is consistent with the findings of Whitney (2015) further south, possibly resulting from increased stratification, reduced depth of mixing and so fewer nutrients available to support phytoplankton growth.
- Zooplankton abundance on the Alaskan shelf was very high in late spring and summer 2014, with June abundances twice as high as ever before seen for this month. At least for the copepods, which are identified to at least genus, the numbers were biased towards smaller species - the values for average Copepod Community Size were all smaller than the long-term mean.
- Although not yet quantified, the numbers of warm water species noted during analysis was high in 2014, likely the highest since the previous warm period in 2005. Species such as *Mesocalanus tenuicornis*, *Clausocalanus spp*. and *Corycaeus spp*. were noted.

These findings all have implications for how the ecosystem may be functioning under the unusual warmth. Potentially less primary productivity (at least fewer large diatoms) and smaller zooplankton will change prey quality for the fish, birds and mammals that feed on the plankton.

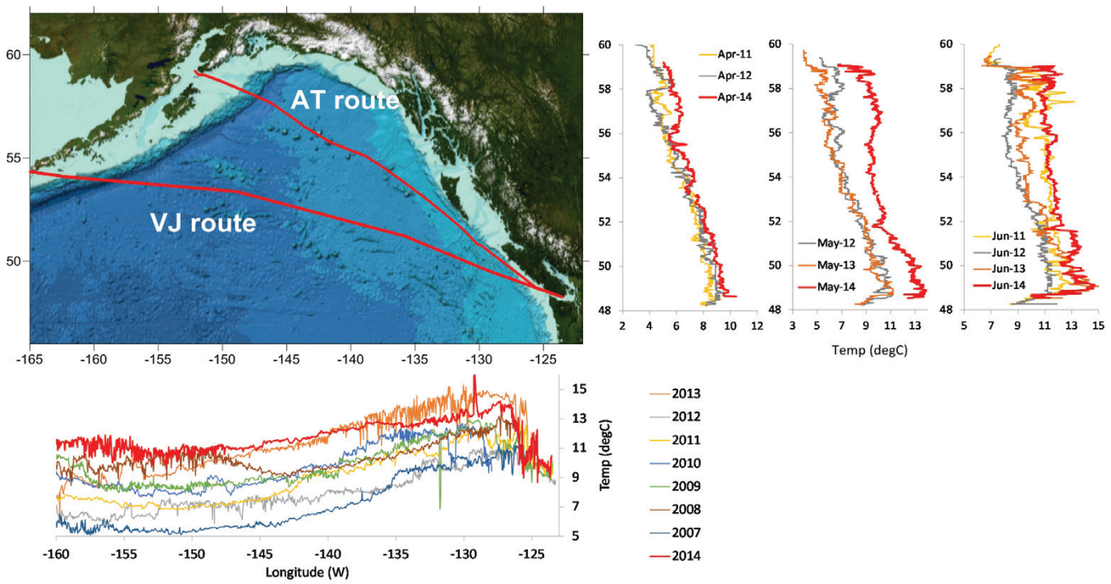


Figure 31. Along-transect temperature from instrumentation on the CPR. The AT data (upper right) shows the transects from April, May and June for 2011-2014. The VJ data (lower left) shows June/July transects from 2007-2014. In each case 2014 data are plotted in red.

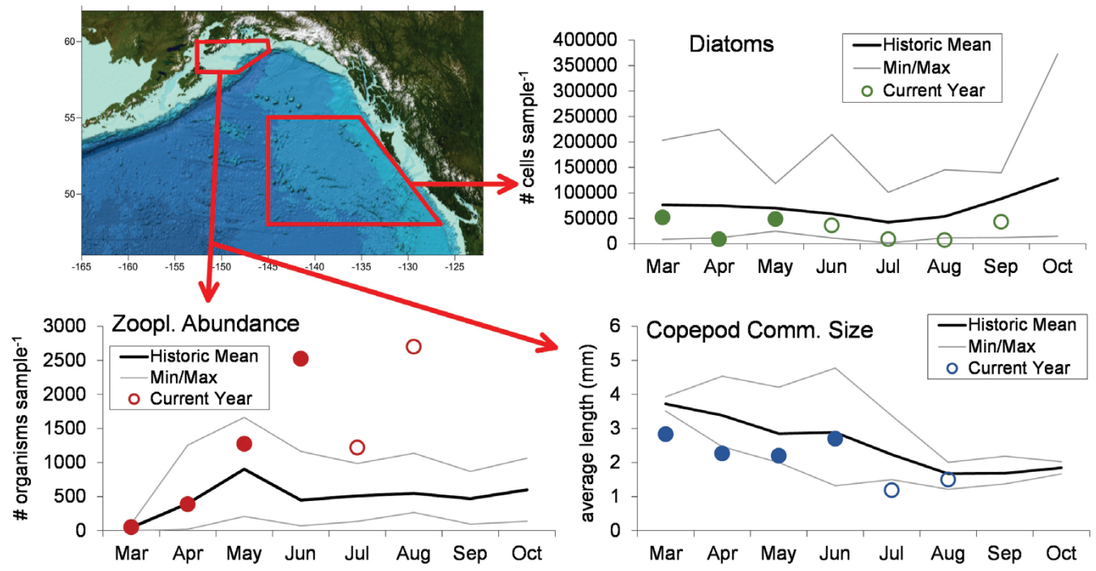


Figure 32. Summary plankton indices for two regions. In each case the circles indicate 2014 data – filled circles are finalised data, open circles are provisional values that are subject to change. The black line is the long term monthly mean (2000-2013) with the grey lines indicating monthly minima and maxima.

Literature Cited.

Whitney, F. A. (2015), Anomalous winter winds decrease 2014 transition zone productivity in the NE Pacific, Geophys. Res. Lett., 42, doi:10.1002/2014GL062634.



Education and Outreach

Gemma Brice

During 2014 SAHFOS staff undertook a number of educational and outreach events. These varied from running practical workshops, giving in-house tours, presenting SAHFOS research and attending organised events.

Outreach events 2014

- *National Science Week*
- *Introductory Zooplankton Workshop*
- *Royal Western Yacht Club lecture*
- *Haydon Bridge Church Group lecture*
- *Plymouth High School for Girls careers event*
- *Bioblitz*
- *3rd International Phytoplankton Workshop*
- *MRes students from the Plymouth University tour*
- *Members of Parliament visitors*
- *University of the Third age (U3A) tour*
- *Brittany Ferries Family Day*

SAHFOS received support for the running of many of its events from the PEGASEAS project. PEGASEAS was an INTERREG IVA cross-Channel project between France and the United Kingdom. Its objective was to produce effective governance of the Channel's ecosystem (see page 33). The project aimed to educate non-scientists about the issues facing the Channel and so educational outreach events were the perfect outlet to transfer this information.

The first event supported by PEGASEAS was National Science Week in March and SAHFOS joined forces with the Marine Biological Association. The Citadel Hill Resource Centre was opened in the daytime for booked teaching sessions and in the evening a series of talks were given. This event drew 260 attendees who learnt about some of the issues facing the Channel such as ocean acidification, invasive species and consequences of a warming ocean.

Brittany Ferries are a continuing supporter of SAHFOS, having towed our CPRs since 1974. In April we hosted a family day for employees and their children. This involved tours of SAHFOS where the workshop staff had put together a great challenge to explain how the CPR works. They had designed a giant CPR and tasked the participants with trying to get giant plankton soft toys through a hole and onto the silk net behind. The tour then moved into the Laboratory to see some live plankton under the microscope and have a go at some interactive games such as 'What do I grow into?'

In May SAHFOS delivered an Introductory Zooplankton Identification workshop for undergraduate marine biologists from the University of Leicester after an invitation from Prof Paul Hart. The students were introduced to plankton taxonomy via a presentation and then experienced a two hour practical microscope session. Here the students were able to practice their taxonomic identification skills on zooplankton specimens from the Channel. The students used the information from this course whilst attending a summer field trip to Madeira and it formed an invaluable introduction to the identification skills required.

Invitations for talks were received from the Royal Western Yacht Club in Plymouth, and a local church group at Haydon Bridge, Northumberland. Members of both clubs were informed about the work of SAHFOS via a 'Passionate about plankton and why you should be too' talk.

In July SAHFOS ran the Third International Phytoplankton Identification workshop, of which a full report is detailed on page 46. This workshop was in part supported by PEGASEAS, it gave a perfect opportunity to engage participants in some issues facing the Channel such as alien-invasive species and how plankton identification can affect policy.

Bioblitz was held at the Mount Batten Centre in September 2014. The event aimed to produce a comprehensive inventory of all the local flora and fauna in a designated area within 24 hours. Everything from marine organisms to insects, mammals and trees were recorded by a plethora of conservation organisations. Over 450 attendees joined the activities on offer. On the Friday SAHFOS ran a series of practical sessions to booked school children. After catching some plankton from Mount Batten Bay we explained what plankton are and why they are so important, before providing the children with the opportunity to investigate the plankton using microscopes. Members of the public were then welcomed into our pop-up lab from Friday afternoon through to Saturday afternoon. They had the chance to do some plankton catching themselves, then try to identify their specimens under the microscopes. This event was also supported by PEGASEAS, and the Mount Batten location within the Channel proved to be a great platform for looking at the challenges that face the governance of the area.

In September the MRes students from Plymouth University visited the SAHFOS Laboratory and workshop, as part of their induction. It was a short visit, but they showed a keen interest in our activities, and were particularly impressed by the research carried out by SAHFOS. They were also very enthusiastic about seeing some live plankton taken from the local L4 sampling station.

Plymouth High School for Girls held a careers event in November. The event was organised so the Year 11 girls could meet someone from their chosen area of interest, have a dummy interview and then receive feedback on their performance. Ten girls had expressed an interest in SAHFOS and the marine science field. They were all enthusiastic and expressed a thirst for knowledge

Two ferry companies, Brittany Ferries and DFDS, regularly tow our CPRs on their routes. Most of the passengers aboard are unaware of how these ferries collect plankton data by towing while they are on board. To engage ferry passengers in the CPR survey and the science taking place while they travel, large posters were designed and displayed on the ships, promoting the work of SAHFOS, the work of PEGASEAS and the support given by the shipping companies.

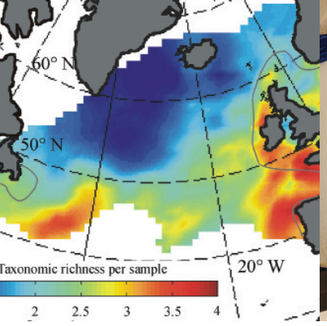
Proving that you are never too old to be a marine scientist for a day, a group from the University of the Third Age (U3A) toured SAHFOS in December to learn about the work that we do and to view plankton under the microscope. Many of the group were or had been scientists and they showed a lively interest in our work provoking some engaging discussions.

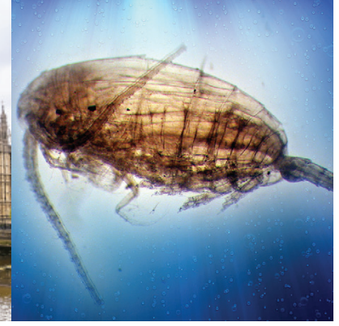



Brittany Ferry families day and U3A tour.




Oliver Colvile MP visit and Bioblitz at Mount Batten.





Science and Policy Update

Abigail McQuatters-Gollop

An important aim of SAHFOS 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 key link facilitating knowledge exchange between scientists and decision makers

SAHFOS continues to hold a place on the UK Marine Monitoring and Assessment Strategy (UKMMAS) Healthy and Biologically Diverse Seas Evidence Group (HBDSEG), a key link in facilitating knowledge exchange between scientists and decision makers.

In addition to its involvement in HBDSEG, SAHFOS remains active in the Cefas/Defra-funded Marine Ecosystem Health Working Group and multiple ICES and SCOR Working Groups.

In 2014 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), the European Environment Agency, the Marine Observation and Data Expert Group, PICES, ICES, the American National Science Foundation, and the Canadian Department of Fisheries and Oceans.

SAHFOS science is directly influencing UK and European marine policy

SAHFOS science is directly influencing UK and European marine policy. Abigail McQuatters-Gollop, SAHFOS' Science and Policy Research Fellow, continues to chair both the UK Pelagic Habitats Subgroup as well as OSPAR's Pelagic Habitats Team, key components of the UK's and OSPAR's implementations of the EU Marine Strategy Framework Directive (MSFD).

In 2014 the UK team's efforts focused on providing advice to Defra on the UK's integrated monitoring programme which will deliver the data needed to support the UK's MSFD implementation; the CPR is the major provider of offshore plankton data for this endeavour.

The CPR is the major provider of plankton data

At the European level, the OSPAR Pelagic Habitats Team began the testing of three regional MSFD plankton indicators. The test results will be presented to OSPAR's Biodiversity Committee (BDC) in February 2015. BDC is expected to approve continued development which means CPR data will be committed to informing these indicators at the regional level – an exciting achievement!

In 2014 SAHFOS played key science-to-policy roles in two European projects: INTERREG Promoting Effective Governance of the Channel Seas (PEGASEAS) and the European Marine Observation and Data Network Biology project (EMODNET Biology 2). SAHFOS has both a technical and policy role in EMODNET – Abigail acts as a direct link between the project and the MSFD implementation process. For example, the plankton biological trait database populated by SAHFOS analysts for EMODNET is now being used to support the development of OSPAR pelagic indicators. PEGASEAS is discussed on further on pages 33, 38 and 39 in this report.

SAHFOS plays key 'science to policy roles' in European projects

NERC KE Fellowship

Abigail McQuatters-Gollop continued her NERC KE Fellowship work in 2014 by participating in multiple science-policy conferences and working groups (see her Fellowship blog at www.planktonpolicy.org).

Abigail was an invited speaker at Coastal Futures 2014, the UK's science-policy briefing event. In February she travelled to Copenhagen for a meeting of the ICES Working Group on Biodiversity (WG BIODIV).

May saw a trip to Japan to speak at the University of Tokyo in a workshop entitled 'Towards the Better Collaboration between Scientists and Policy Makers'. The workshop was aligned with a multimillion dollar Japanese research project called NEOPS (The New Ocean Paradigm on its Biogeochemistry, Ecosystem, and Sustainable Use). The audience was a mix of Japanese government scientists and researchers, and the speakers were 'experts' in different aspects of science-policy working in Japan and internationally. Abigail spoke about the use of CPR data to develop policy indicators and what lies behind SAHFOS' successes in informing policy.

Abigail was also an invited speaker at the 2014 PICES (the North Pacific Marine Science Organization) Annual Meeting: Toward a better understanding of the North Pacific: Reflecting on the past and steering for the future. A talk was delivered in a session entitled 'Use of long time series of plankton to inform decisions in management and policy concerning climate, ecosystems and fisheries'. Sonia Batten presented SAHFOS work in the same session.

Abigail McQuatters-Gollop with Ken Furuya (University of Tokyo) and Jonas Rupp (Conservation International) at the University of Tokyo

Abigail also developed and chaired a science-policy session at the 2014 Challenger Society for Marine Science Conference in Plymouth; the session was attended by over 100 delegates (see page 48 for further info).

Data Requests and Availability

David Johns

CPR data are available for research purposes. Contact djoh@sahfos.ac.uk

Our plankton data are one of the main outputs from SAHFOS. All data are subject to a robust QA and QC system, which ensures the ongoing quality and reliability of the dataset. SAHFOS methodology has remained relatively unchanged since 1958, meaning that the majority of plankton taxa that are recorded are available from that time period. SAHFOS keeps metadata records for all taxa, new taxa can be added and their inception date noted (in addition to full training in their identification for the analysis team). All samples are stored in Plymouth, allowing the archive to be used for new research methods and questions as they come on line.

During 2014, there were 79 data requests, just short of the record number in 2013. The majority of these data requests (just over half) came from the UK, most often from research centres and universities. There was an increase in 2014 in requests from the USA, with most of the remainder from the EU. CPR data are used in blue-sky research and research projects. Most data requests initially are emailed to David Johns, who provides advice and recommendations, with the majority of the actual data extractions performed by Darren Stevens. A DOI generation system has now been produced, meaning that datasets sent out to researchers all have a unique DOI, which should allow for easier tracking on the usage of each dataset.

In recent months, an improved system of data extraction has been implemented, the main benefit is that it gives all SAHFOS researchers access to programs for automated processes for preparing data products (i.e. monthly means) which until now had only been accessible to the IT department. The programs have also been developed in a structure that should facilitate a web interface to be developed that uses the same algorithms, dependant on adherence to the Data Policy.

CPR data are available to use for *bona fide* research purposes, and further information can be found on our website at www.sahfos.ac.uk. In addition, SAHFOS can provide assistance and reports for commercial ventures.

Fundraising: The Hardy Expedition

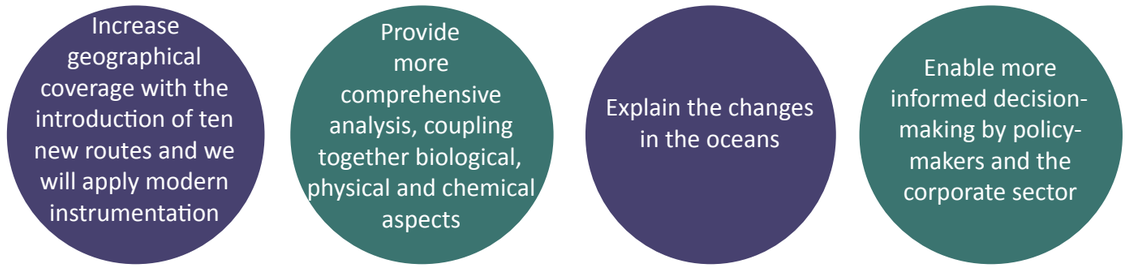
Nicola Rickard

SAHFOS traditionally has had three 'categories' of funding.

During 2014, SAHFOS introduced a fourth funding stream – The Hardy Expedition. To ensure our continued success, we will need to secure substantial additional funds over the next 5 years.

A wide range of investments will be sought from corporations, individuals, trusts and foundations under The Hardy Expedition. In addition to a continuation with current methods, SAHFOS will increase the geographical range and scope of research which will thereby enhance the reach and influence of SAHFOS's work. This is in response to a growing need for a more holistic look at the ocean's health. We will establish Hardy Fellows, attracting and retaining the best scientists.
These brilliant minds will explore new research areas and exploit the wealth of knowledge contained in our data holdings.

It is our goal to build relationships with like-minded businesses and groups to achieve common objectives.
These Discovery Partners will be at the forefront of scientific research, funding named Discovery Routes and Hardy Fellows.
In doing so, they will help SAHFOS to:



A special Task Force has been recruited to help drive The Hardy Expedition. Members include esteemed individuals from science, academia and industry, reflecting SAHFOS' global reach and the acknowledged importance and impact of our work.

Current members include:

- Professor Nicholas Owens, Director SAHFOS
- Professor 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
- Professor Howard Roe, Director Emeritus, National Oceanography Centre
- Dr Graham Shimmield FRSE, Executive Director, Bigelow Laboratory for Ocean Sciences
- Professor Bess Ward, Chair of Geosciences Department, Princeton University

SAHFOS would like to extend thanks to Charlie Michaud and Derval Costello from CCS Fundraising for sharing their extensive knowledge and setting us on the right path throughout the first 12 months of The Hardy Expedition.

The first year of endeavours has revealed it will take time to develop relationships with the right partners to support SAHFOS' goals. We are now building these with a number of potential donors.

Communications: Marketing, Public Relations and Social Media

Nicola Rickard

Key Priorities for 2014:

- Build on the existing communications
- Create a strategy for proactive and reactive media liaison
- Offer publicity and communications advice for SAHFOS teams
- Identify and communicate the achievements of SAHFOS

SAHFOS has engaged in a communications strategy

To complement The Hardy Expedition fundraising initiative, SAHFOS has also engaged in a Communications Strategy, the aims of which is to strengthen the SAHFOS 'brand'; support and promote positive interactions within SAHFOS and mutually beneficial external engagement; and to maintain and build on the reputation of SAHFOS.
The key priorities for 2014 were to build on the existing communications measures in place and provide additional support; create a strategy for proactive and reactive media liaison; offer publicity and communications advice for SAHFOS teams; and do more to identify and communicate the achievements of SAHFOS.

SAHFOS website received nearly 20,000 visits in 2014

The internet is SAHFOS's most effective form of communication, not just an instant and cost-effective form of public relations; it is a very efficient way to target specific groups of people (in both their interests and geography).
The SAHFOS website received nearly 20,000 visits in 2014, resulting in 66,000 pages views – just under 70% of these visits were made from new engagers.
An overhaul of the SAHFOS website is under consideration but SAHFOS social media sites have been easier to transform.

Almost 2 billion people in the world use social media, and with these huge numbers in mind, the SAHFOS Communications Strategy has considered the most effective ways to reach potential SAHFOS virtual visitors.
Engagement across Twitter has been aimed at local Plymouth businesses, potential fundraising partners and those outside of the scientific knowledge base.
It has proved successful, with the second half of 2014 seeing SAHFOS Twitter followers increase by a third to 1350.
Similar efforts are being exercised across Facebook, LinkedIn and Pinterest.

Most of this work is directed at ensuring SAHFOS's qualities are well-understood, both internally and externally.
Our message is that SAHFOS is a leader in its field and is gaining further international reputation; the CPR survey is long established and reliable; and the research that is conducted here matters. We want as many people as possible to know about the science that emanates from here and why it should be important to them.

SAHFOS Twitter followers increased by a third

We want people to know about the science that emanates from here

SAHFOS is on the following social media sites. Come and check us out:

www.facebook.com/sahfos

Pinterest: sahfos

Twitter: @sahfos

Google+: sahfosAcUk

FlickR: sahfos

YouTube: SahfosPlymouth

Third International Phytoplankton Identification Workshop

Gemma Brice and Claire Taylor

Following on from the success of the two previous workshops, SAHFOS was approached, along with assistance from the Marine Biological Association, to run a third International Phytoplankton Identification workshop for two weeks in July 2014.

Claire Taylor and Gemma Brice represented SAHFOS and planning started in earnest in order to ensure a successful repeat performance. The workshop again proved extremely popular, with over 50 people applying to participate; however, spaces were limited to twenty participants working within marine ecology. Representatives came from 10 different countries including China, Singapore, India and New Zealand. UK participants came from PML, Cefas, NOC, BAS, SAMS, DOE Marine Division and SAHFOS.

Application for support from The British Ecological Society was successful and the Society of Biology provided credits for continuous professional development.

We were very grateful to Zeiss and Olympus for the loan of state-of-the-art microscopes, and to Abdul Chrachri of the MBA who gave an introduction to microscopy techniques, ensuring participants achieved maximum benefit from the equipment provided.

The course comprised a mixture of presentations and laboratory sessions with an emphasis on practical microscopy skills. The participants had a microscope each and worked with advice and guidance from the speakers, the organising group and other SAHFOS and MBA staff.

> "Thank you so much for your fantastic organisation. I have thoroughly enjoyed this course and it is a huge help for my future"

Samples used for training (live and fixed material) were from a variety of sources. These included: preserved tow-net samples collected locally during the last 12 months, fresh tow-net samples, and samples from both lecturers and participants from their own geographical area of interest.

To open the workshop we had poster presentations from our delegates on the work they were involved in at their respective institutions.

Dr Karen Steidinger, from the University of South Florida, covered dinoflagellates. Karen gave a series of well structured lectures and practicals and organised one of the highlights of the course for many participants: the opportunity to model their own clay dinoflagellate. This gave them the chance to really explore their plate structure and subsequently provided an excellent learning platform; the work displayed by the participants was very impressive.

Rowena Stern, SAHFOS, gave two informative talks on alga classification and an introduction to molecular techniques - not easy subjects! Rowena was once again an asset to the course and was on hand to answer any difficult questions.

We welcomed Dr Ian Probert from the Station Biologique de Roscoff who did a thorough overview of Haptophytes and Flagellates, he had the participants puzzling over his mystery samples whilst they attempted to identify these with the information they had just learnt.

The course participants, lecturers and organisers of week one and two outside the Citadel Hill laboratories.

Unfortunately at the last moment Prof Carmelo Tomas was unable to attend the course; we were incredibly grateful to Dr Karen Steidinger, Dr Ian Probert and Dr Richard Pipe who willingly and very ably stepped in to do his lecture and practical sessions. Between them, harmful algal blooms, cell isolation techniques and enumeration/settling techniques were covered.

Dr Diana Sarno from the Stazione Zoologica Anton Dohrn, Naples, finished the week on diatoms. Diana was a fundamental speaker of the previous workshops and she continued her passion, imparting her knowledge of many species through both lecture and practical sessions. Diana also provided the participants with some excellent notes.

> "Thank you for organising this wonderful workshop. It was so valuable to me and I learnt so much"

To show participants how their work could have broader implications Abigail Mcquatters-Gollop, SAHFOS, gave a lecture titled 'Why does Marine Policy need Taxonomy?' For the closing session, participants were informed about the work of the organising institution receiving a lecture by Gemma Brice and a tour of SAHFOS by Claire Taylor.

Social events were an integral part of the workshop to allow participants and speakers to forge relationships for future work. The first week included an enjoyable evening meal at The Mission restaurant. On Saturday, keeping with the phycological theme, there was a visit to the Eden Project in Cornwall. The course finished with an evening meal in the Common Room. Marilyn and her team did a fantastic five-course meal and we are also very grateful to them for the amazing lunches they provided every day. Certificates were presented to all of the participants and the evening finished with some amusing entertainment in the form of a marine-themed Charades and 'Pictionary-type' game.

All of the participants replied to our feedback forms and were extremely positive. The participants enjoyed the course, achieving their objectives whilst giving the speakers a high rating. They were all complimentary about SAHFOS and appreciated the amount of effort put in by the organisers.

Course organisers and speaker Karen Steidinger

Tube pulling for isolation

Practical microscope sessio

Modelling clay phytoplankton

Karen Steindinger teaching

Pratical exercises






The Challenger Society for Marine Science 2014 Conference

Kate Brailsford

The Challenger Society for Marine Science hosts a Conference every two years which is held in a different part of the country on each occasion. The Conference attracts leading Marine Scientists and Science Managers from around the globe, as well as showcasing cutting-edge marine science and technology

In September, after 12 years absence, the Conference returned to Plymouth with Nicholas Owens being appointed Chair of the Organising Committee. As Plymouth is the home of the marine institutes of SAHFOS, The Marine Biological Association (MBA), Plymouth Marine Institute (PMI), National Marine Aquarium (NMA), Diving Diseases Research Centre (DDRC) and Plymouth Marine Laboratory (PML), they were recruited as members of the Local Organising Committee (LOC), formed of 11 staff in total, 4 of whom were from SAHFOS. At the first LOC meeting and after various investigations it was agreed Plymouth University would make an excellent venue: the size, location and facilities were all perfect.

We received an excellent response to the call for abstracts and after hours of reading the Committee selected 121 talks and 120 posters covering 12 Science themes to make up the programme. Several SAHFOS staff had successful abstracts to present oral and poster presentations. These can be read overleaf.

Members of the Local organising committee including: Nicholas Owens – Chair of Organising Committee, Kate Brailsford - Secretary/Coordinator, Abigail McQuatters-Gollop – Member of LOC and Chair of the Marine Policy Session, Usha Jha – Member of LOC and Priscilla Licandro (not pictured)– Chair of the Marine Time Series Session.

Over 300 delegates attended the Conference and 14 sponsors presented their technologies in the Exhibition. The timetable started off with the first day of oral and poster presentations followed by a breathtaking icebreaker event in the NMA amongst the large reef and shark tanks. During the week we were extremely fortunate to have two additional lectures:

Tuesday Evening, the 28th Annual Marine Science Lecture presented by Professor Ian Boyd, Chief Scientific Adviser to the Government's Department for Environment, Food and Rural Affairs (Defra) – Creating a storm or calming the waters – a view from a Chief Scientific Advisor.

Thursday afternoon, The Challenger Medal Lecture presented by Professor Harry Bryden, Ocean and Earth Science, University of Southampton – Advances in Ocean Circulation: Longer time scales and smaller spatial scales.

Throughout the week there were various other activities scheduled, from an early career event through to the Challenger Conference dinner to complete the week.

This was an excellent event for SAHFOS to be closely involved with, and we took the opportunity of having a stand at the Conference, showcasing the CPR with the promotional DVD animation projected on the wall.

Congratulations to Mike Blackett, SAHFOS' PhD student, who won Best Student Oral Presentation

Invited Keynote Speakers

Dr Emily Shuckburgh, British Antarctic Survey
The Great Planetary Mixer

Dr J Icarus Allen, Plymouth Marine Laboratory
Toward Next Generation Ecosystem Models

Dr Isabelle Rombouts, Laboratory of Oceanography and Geosciences
Pelagic Biodiversity: from Patterns to Emerging Processes

Dr Adrian Glover, Natural History Museum
Environmental Futures in the Deep Sea Mining Frontier

Prof Jason Hall-Spencer, Plymouth Marine Institute
Ecosystem effects of Ocean Acidification

The National Marine Biological Analytical Quality Control Scheme

Astrid Fischer

The NMBAQC scheme was set up in 1994 to provide a source of external quality control for UK competent monitoring authorities contributing to UK national or European monitoring programmes. It is also open to consultants and non-UK participants. The scheme reports to the Healthy & Biologically Diverse Seas Evidence Group under the UK's Marine Monitoring & Assessment Strategy. NMBAQC helps to standardise results and methods by providing Best Practice guides, taxonomic workshops and training exercises. The scheme comprises a number of biological component modules, each with its own set of training exercises and/or assessments. New components are developed as and when required, as determined by monitoring needs.

The NMBAQC poster displayed at Challenger.

Environmental Sensing and Operational Oceanographic Measurements from Continuous Plankton Recorders

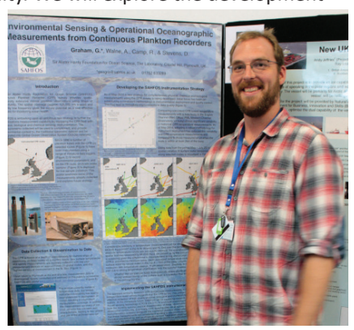
George Graham

Since 1931 the SAHFOS monitoring programme has collected epipelagic plankton using CPRs, towed by 'ships of opportunity', on regular monthly shipping routes in the North Atlantic, North Sea, North Pacific and Southern Ocean. To provide environmental context for the plankton samples, a number of these routes have been equipped with temperature sensors since 1998. We will examine some of these data sets and this instrumentation effort.

An important component of SAHFOS' strategy for the future is the development and delivery of complementary sensing technology for the CPR fleet. The organisation has embarked on an ambitious plan to equip its CPRs with a suite of environmental sensors with the intention of i) adding value to CPR taxonomic data by providing contextual information about the water bodies from which plankton are collected and ii) serving oceanographic data for integration into wider environmental intelligence and earth observation networks. The organisational ambition is to develop the CPR as a platform for environmental sensing and forge data-driven links with other data providers (e.g. FerryBox, ARGO, fixed point observatories).

The *in-situ* data sets obtained over SAHFOS tow routes will be valuable to users, such as Earth Observation scientists, for activities such as algorithm development and validation.

A comprehensive strategy is in development which includes proactive CTD and fluorescence measurements as initial variables, but the organisation has ambitions to expand its sensing capability and reactively develop the program of measurements in response to demand from the user community. We will explore the development of this strategy, data collection methodology, community requirements and data product dissemination pathways.



George Graham at his poster display.

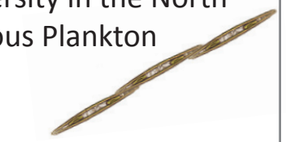
What value does taxonomy have in modern science and policy

Jennifer Skinner

The Marine Strategy Framework Directive (MSFD) takes an ecosystem approach in promoting a sustainable and healthy marine environment. It relies on a suite of indicators to help set useful, practical and attainable targets in order to achieve Good Environmental Status in European Seas by 2020. Developing ecological indicators is a challenging process, but is essential when setting realistic targets that allow for climate change, and will trigger management action if a manageable anthropogenic pressure is detected. Indicators for biodiversity and food web dynamics require a level of specificity to detect changes in community composition that bulk indicators such as, for example, phytoplankton biomass, cannot provide. Taxonomic studies, however, enable specific and responsive indicators to be selected and monitored over time to assess the impacts of drivers on the environment at the species level. Long term taxonomic data sets, such as the CPR survey and MarCLIM, have enabled the detection of significant changes in biodiversity, and help disentangle natural variation in species composition from changes caused by particular drivers, manageable or otherwise. Consequently, indicators derived from taxonomic data, such as those informing pelagic and benthic ecosystem components, are crucial to the success of directives, including the MSFD, and provide essential information to accurately help inform policy in implementing effective and cost efficient management programmes.

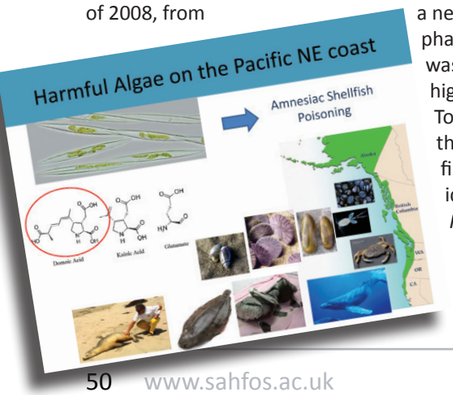
Jennifer Skinner presenting her talk

Pseudo-nitzschia diversity in the North Pacific from Continuous Plankton Recorder survey



Rowena Stern

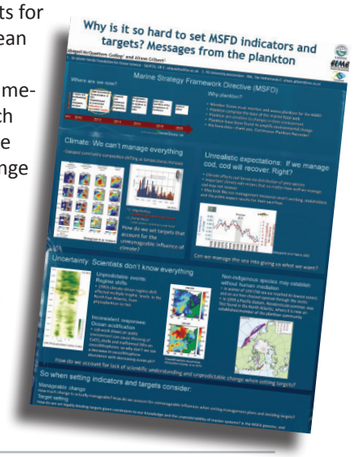
A common genus of harmful algae is *Pseudo-nitzschia*, a diatom that can produce the toxin domoic acid.
This toxin can be biomagnified through the food web to cause illness and death in marine wildlife and humans, as well as economic damage to fisheries. *Pseudo-nitzschia* blooms are an increasing threat to the west coast of North America, in particular through harvest closures of the commercial, recreational and subsistence fisheries off the Washington, Oregon, and California coasts and the deaths of marine mammals and seabirds in California.
A novel approach to monitor the diversity and abundance of *Pseudo-nitzschia* is with the CPR, used to survey the Pacific Ocean from Vancouver, Canada to Hokkaido, Japan since 2000. This study used Next Generation Sequencing (NGS) methods applied to the CPR survey samples to determine phytoplankton diversity and abundance of samples from the North-West American coast and an offshore Pacific region, using a *Pseudo-nitzschia* specific D1-D2 region of LSU over three climatically different years. Weighted abundance results revealed spatially distinct communities in the open ocean, dominated by assemblages containing *P. multiseries*, versus coastal assemblages dominated by *P. fraudulenta*. In the exceptionally cold year of 2008, from a negative La Nina phase, *P. hasleana* was also found in high abundance. To our knowledge, this was the first molecular identification of *P. hasleana* in the open Pacific region.



Why is it hard to set policy indicators and targets? Messages from the plankton

Abigail McQuatters-Gollop

Unprecedented basin-scale ecological changes are occurring in our seas. As temperatures warm, ocean pH is lowering, sea ice is decreasing, and marine stratification and nutrient regimes are changing. These unparalleled changes present new challenges for managing our seas as we are only just beginning to understand the ecological manifestations of these climate alterations. The Marine Strategy Framework Directive requires all European Member States to achieve Good Environmental Status (GES) in their seas by 2020; this means management toward GES will take place against a background of climate-driven macroecological change. Each Member State must develop indicators and set environmental targets to achieve GES; however, in order to do so an understanding of large-scale ecological change in the marine ecosystem is also necessary.
Time-series datasets, such as that from the CPR survey, indicate that North Atlantic and North Sea pelagic dynamics are responding to both climate and human-induced changes, presenting challenges to the development of plankton indicators and targets for achievement of GES in European Seas.
The preservation of existing time-series, particularly those which are multi-decadal, is key to the separation of the climate change signal from that occurring due to manageable human pressures. Apportionment of drivers behind ecosystem changes is needed in order to most efficiently manage our resources and construct a realistic vision of GES.



A Prospectus for UK Marine Sustained Observations: A special issue of Philosophical Transactions of the Royal Society A

Abigail McQuatters-Gollop and Nicholas Owens

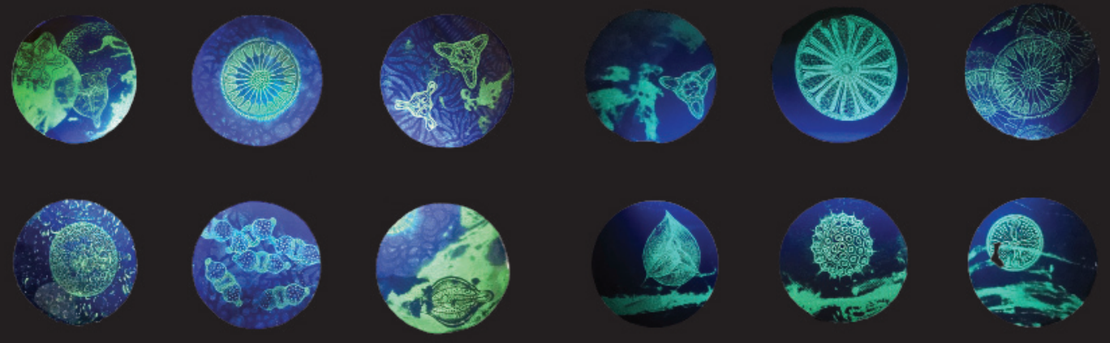
Managers and policy makers need to understand changes in the oceans in order to make informed decisions about issues such as fishing, the impact of climate change on ecosystems, coastal defence and dealing with extreme weather events. Some alterations to marine systems occur over many decades and can only be detected through time-series observations. Such sustained observations require long-term commitment from both the scientists and funders. The theme issue on UK marine sustained observations was commissioned by the Challenger Society for Marine Science in order to reflect on the contribution that UK sustained observations of the ocean have made to science and society and presents a vision for their future. The papers in this issue arose from a meeting hosted by the Challenger Society and the Scientific Committee on Oceanic Research at the Royal Society, London, in September 2013. Papers address observations of sea level, ocean circulation, biodiversity, ocean carbon and nutrient cycles, the sea and ice conditions in the Arctic and Antarctic and the importance of observations for climate predictions.

The Prospectus for UK Marine Sustained Observations special issue was co-conceived and co-guest edited by Abigail McQuatters-Gollop. The introductory paper 'Sustained UK marine observations. Where have we been? Where are we now? Where are we going?' was authored by Nicholas Owens. Prof Owens' paper presents a conversational look at the history of sustained observations in the UK, dating back even earlier than Stonehenge. The success of the CPR was also mentioned in several other contributions as well.

A key theme to emerge from the special issue contributions is that, despite its recognised importance to policy and scientific research, sustained funding of oceanographic time-series presents a challenge.
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. The principle reasons for the termination of established monitoring programmes are also historically consistent and near-ubiquitous - funding is limited and a time lag exists between data collection and scientific yield. Like many other sustained observational time-series that support decision making, the CPR survey is only partially publically funded. Supplemental funding, pieced together from disparate income sources, is required to fill this gap; this piecemeal approach is both risky and resource intensive. Prof Owens, in his special issue paper, concluded that support for sustained observations was typically based on their perceived value to the 'market', rather than solely scientific value. If we wish to maintain long-term funding for oceanographic time-series, both for scientific and applied use, a strategy to ensure their sustenance may be required, and convincing beneficiaries of the survey's 'market' value is of the utmost importance.

A Prospectus for UK Marine Sustained Observations: A special issue of Philosophical Transactions of the Royal Society A http://rsta.royalsocietypublishing.org/content/372/2025.toc

Read more: Postlethwaite, C., Hickman, A., McQuatters-Gollop, A., Bryden, H. and Woodworth, P., 2014. A prospectus for UK marine sustained observations. Philosophical Transactions of the Royal Society, 372.

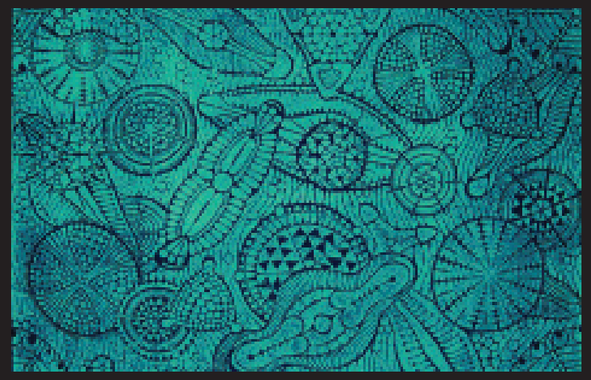


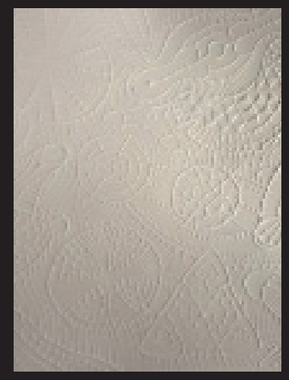
Plankton Silk in Art

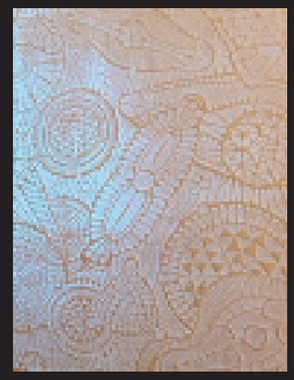
Eveline Kolijn

My intense interest in natural history, biology and complexity theory is expressed through printmaking and small, sculptural installations made from found synthetic materials.
By constructing organisms from plastic and Styrofoam, which share the same source as petroleum, I connect consequences of consumption of fossil fuels in our society with the beauty and fragility of the natural world. Environmental awareness is a strong theme in my art, but I also want to share my neo-Romantic sense of wonder in beauty found in nature.

Much of my art focuses on environmental pressures in marine environments. This is a personal issue, as I grew up in the Caribbean. Currently I live in Calgary, Canada. I returned to the Caribbean 17 years ago and I was shocked by the deterioration of the coral reefs in the 20 years I had been away! I have been back several times and the reefs continue to decline. I started to inform myself about the plight of the Oceans today: the issues around climate change, pollution and overfishing. This led me to connections in Australia, to the Living Data initiative from Dr. Lisa Roberts and the Lynchpin organization founded by Susan Anderson in Tasmania. Both initiatives strive to connect marine scientists with artists. The objective is to translate the sometimes abstract and specialist content of ocean science and climate change into art, to make this information more accessible to a general public and to increase awareness and generate discussion.



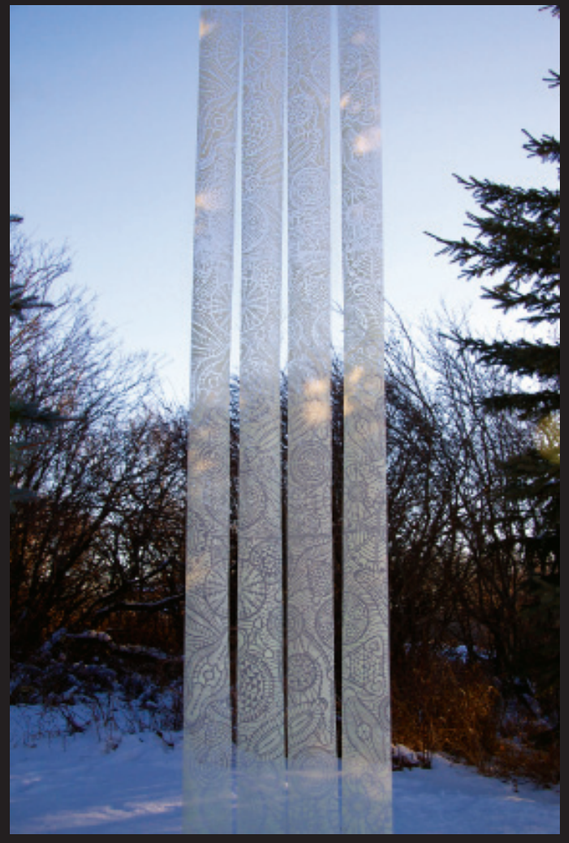


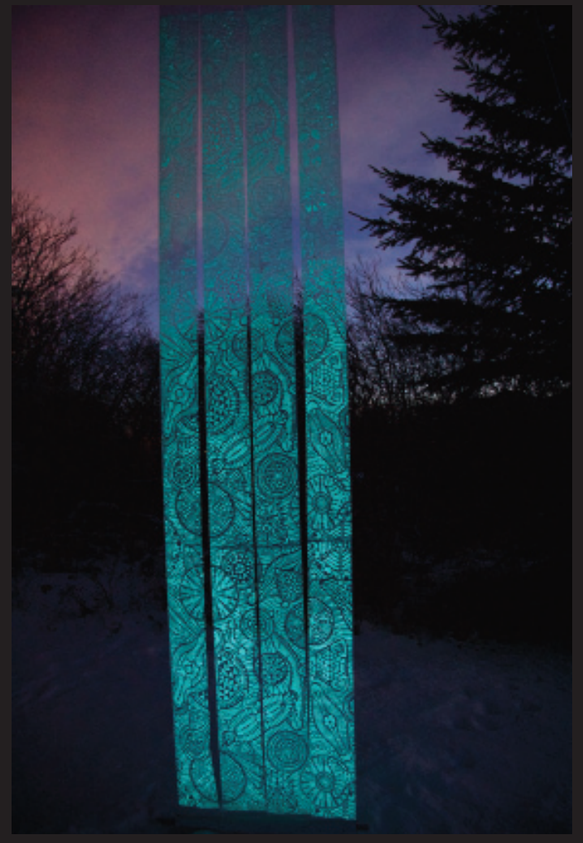


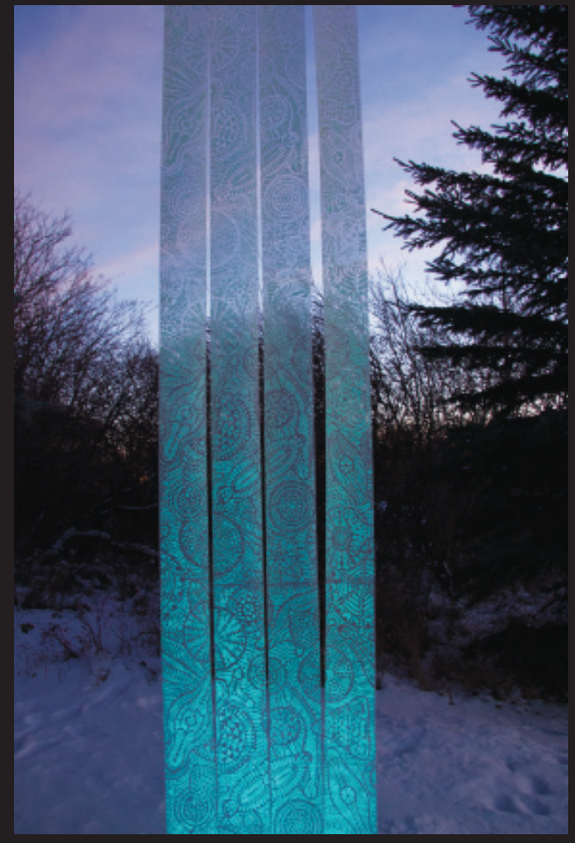
Lisa Roberts had sent me some samples of plankton collecting silk, which were given to her by her colleague Graham Hosie. The material inspired me to experiment with screenprint and glow in the dark inks. I wanted to reference the bioluminescence of some types of plankton. My bits of material were small, so I mounted them as microscopic specimens. This piece, Luminous Specimen, was exhibited at a Living Data exhibition in Sydney, Australia in 2013.

To my pleasant surprise I received an email in the spring of 2014 from Graham Hosie, stating he was visiting the Sir Alister Hardy Foundation in Plymouth and that unused rolls of plankton silk cut-offs and leftovers were available for me for further artistic exploration. These rolls have made their way to me here in Calgary, courtesy of Lance Gregory, where I printed a linocut with a diatom pattern with phosphorescent Europium powders on 3 meter long strips of plankton silk. This piece, Ocean Veil, will feature in an exhibition I proposed in Calgary in 2015, called Ocean Respiration. I connect the health of our atmosphere and the air we breathe with the health of the ocean and the status of its oxygen-producing organisms. I am grateful to SAHFOS, for supplying this wonderful material, which helps to strengthen the concept of my artwork.

www.evelinekolijn.com







SAHFOS-AWI Summer School on Time series and Climate Change

Priscilla Licandro

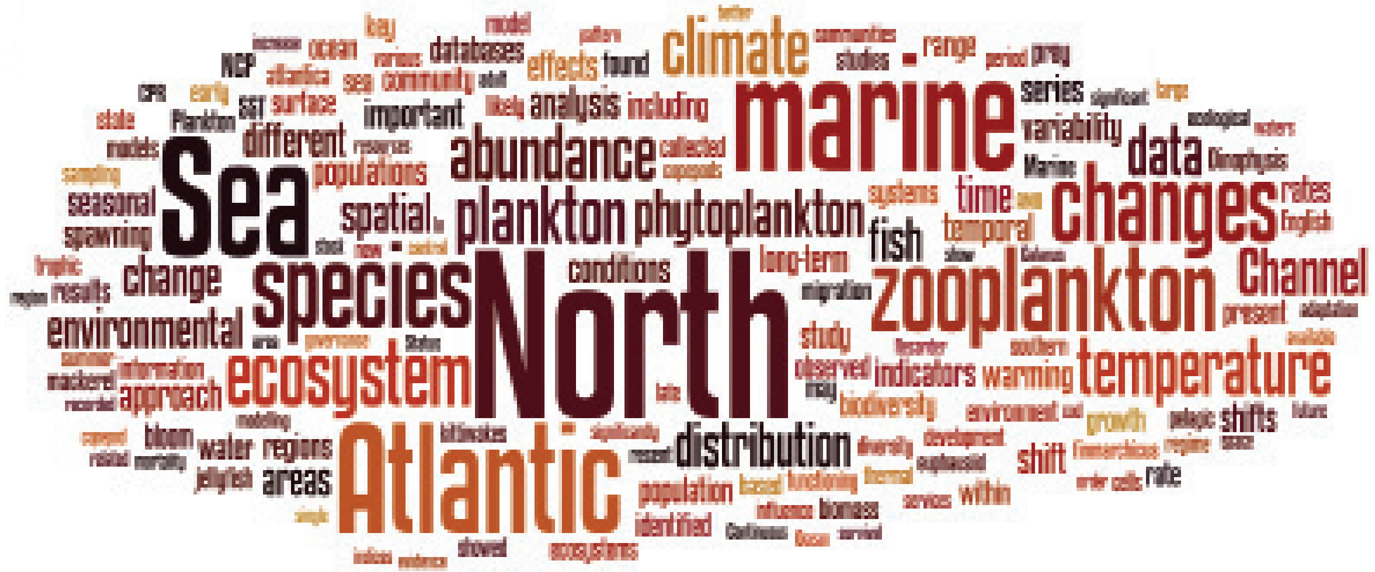
A Summer School on 'The utility of time series observations to assess the ecological and societal implications of climate change' was organised by Priscilla Licandro from SAHFOS and Dr. Alexandra Kraberg from the Alfred Wegner Institute (AWI) and held at the Marine Station in Helgoland (Germany) from the 22nd September to the 3rd October 2014. The School, funded by Volkswagen, was attended by twenty-four young scientists from all over the world (Croatia, Denmark, Egypt, Faroes, Finland, Ghana, Greece, Germany, Iran, Ivory Coast, Italy, Mauritania, Nigeria, South Korea, Spain, United Kingdom and United States), that were selected from among more than one hundred applicants. Seventeen lecturers from SAHFOS, AWI, GEOMAR, IRSTEA, West. Inc. and HGZ gave talks on various topics including sampling methodologies, data quality check procedures, different techniques of time-series analyses, data management and visualization and socioeconomics. Practical tutorials in R language and data-surgery sessions were also part of the program to help the students with their own projects.

The participants and lecturers enjoying some field work. Photo credit Paula Salgado

SAHFOS and AWI wish to thank all the participants and lecturers for their interest and cooperation in making a very successful and interesting workshop. A particular thanks to the local organisers for providing a nice and friendly environment to the workshop.

Publications 2014

Gemma Brice



The word cloud represents the titles and abstracts of the 2014 publications.

SAHFOS Staff in bold. *Associated Researchers/ Research Fellow/ PhD students

Refereed Publications

Batten, S.D., & Gower, J. F. (2014). Did the iron fertilization near Haida Gwaii in 2012 affect the pelagic lower trophic level ecosystem? Journal of Plankton Research, fbu049.

Batten, S.D., & Peterson, W.T. (2014). Lower Trophic levels, section 4.0 in Pacific Large Aquatic Basin climate change impacts, vulnerabilities and opportunities assessment I – marine species and aquaculture. Hunter, K.L. and J. Wade (Eds.) Canadian Manuscript Reports of Fisheries and Aquatic Sciences.

*Beaugrand, G., **Conversi, A.**, Chiba, S., **Edwards, M.**, Fonda-Umani, S., Greene, C., & Stachura, M. (2015). Synchronous marine pelagic regime shifts in the Northern Hemisphere. Philosophical Transactions of the Royal Society B: Biological Sciences, 370(1659), 20130272.

*Beaugrand, G., Harlay, X., & **Edwards, M.** (2014). Detecting plankton shifts in the North Sea: a new abrupt ecosystem shift between 1996 and 2003, Marine Ecology Progress Series. 502, 85-104.

Bicknell, A. W., Knight, M. E., Bilton, D. T., **Campbell, M.**, Reid, J. B., Newton, J., & Votier, S. C. (2014). Intercolony movement of pre-breeding seabirds over oceanic scales: implications of cryptic age-classes for conservation and metapopulation dynamics. Diversity and Distributions, 20(2), 160-168.

*Blackett, M., **Licandro, P.**, Coombs, S. H., & Lucas, C. H. (2014). Long-term variability of the siphonophores *Muggiaea atlantica* and *M. kochi* in the Western English Channel. Progress in Oceanography, 128(0), 1-14. doi: http://dx.doi.org/10.1016/j.pocean.2014.07.004

Bozzano, R., Fanelli, E., Pensieri, S., Picco, P., & Schiano, M. (2014). Temporal variations of zooplankton biomass in the Ligurian Sea inferred from long time series of ADCP data. Ocean Science, 10(1), 93-105.

Castellani, C., & Altunbaş, Y. (2014). Seasonal change in acclimatised respiration rate of *Temora longicornis*. Marine Ecology Progress Series, 500, 83-101.

Chust, G., **Castellani, C.**, **Licandro, P.**, Ibaibarriaga, L., Sagarminaga, Y., & Irigoien, X. (2014). Are *Calanus spp.* shifting poleward in the North Atlantic? A habitat modelling approach. ICES Journal of Marine Science: Journal du Conseil, 71(2), 241-253.

Conversi, A., Möllmann, C., Folke, C. & **Edwards, M.** (2015). Philosophical Transactions B, Theme Issue Marine regime shifts around the globe: theory, drivers, and impacts. Philosophical Transactions B, 370.

Conversi A., Dakos V., Gårdmark A., Ling S., Folke C., Mumby P.J., Greene, C., **Edwards, M.**, Blenckner T., Casini M., Pershing A., & Möllmann, C. (2015). A holistic view of marine regime shifts. Philosophical Transactions B, 370. DOI: 10.1098/rstb.2013.0279

Costello, M. J., Appeltans, W., Bailly, N., Berendsohn, W. G., de Jong, Y., **Edwards, M.**, & Mees, J. (2014). Strategies for the sustainability of online open-access biodiversity databases. Biological Conservation, 173, 155-165.

Feng, J., Stige, L. C., Durant, J. M., Hessen, D. O., Zhu, L., Hjermann, D. O., & Stenseth, N. C. (2014). Large-scale season-dependent effects of temperature and zooplankton on phytoplankton in the North Atlantic. Marine Ecology Progress Series. 502, 25-37.

Gilbert, A., **McQuatters-Gollop, A.**, Langmead, O., Mee, L., & Vermaat, J. (2014). Visions for the North Sea: The Societal Dilemma Behind Specifying Good Environmental Status. AMBIO, 1-12. doi: 10.1007/s13280-014-0536-5

Goberville, E., *Beaugrand, G., & **Edwards, M.** (2014). Synchronous response of marine plankton ecosystems to climate in the Northeast Atlantic and the North Sea. Journal of Marine Systems, 129, 189-202.

Grimes, D. J., Ford, T. E., Colwell, R. R., Baker-Austin, C., Martinez-Urtaza, J., Subramaniam, A., & Capone, D. G. (2014). Viewing Marine Bacteria, Their Activity and Response to Environmental Drivers from Orbit. Microbial Ecology, 1-12.

*Harris, V., **Edwards, M.**, & Olhede, S. C. (2014). Multidecadal Atlantic climate variability and its impact on marine pelagic communities. Journal of Marine Systems, 133, 55-69.

Hickman, A. E., Postlethwaite, C. F., Woodworth, P. L., **McQuatters-Gollop, A.**, & Bryden, H. L. (2014). Theme issue: A Prospectus for UK Marine Sustained Observations. Philosophical Transactions of the Royal Society of London, A, 372(2025).

*Hinder, S. L., Gravenor, M. B., **Edwards, M.**, *Ostle, C., Bodger, O. G., Lee, P. L. M., & Hays, G. C. (2014). Multi-decadal range changes vs. thermal adaptation for north east Atlantic oceanic copepods in the face of climate change. Global Change Biology, 20(1), 140-146. doi: 10.1111/gcb.12387

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McClellan, C. M., Brereton, T., Dell'Amico, F., **Johns, D. G.**, Cucknell, A.-C., Patrick, S. C., & Godley, B. J. (2014). Understanding the Distribution of Marine Megafauna in the English Channel Region: Identifying Key Habitats for Conservation within the Busiest Seaway on Earth. PLoS ONE,

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Montero-Serra, I., **Edwards, M**., & Genner, M. J. (2015). Warming shelf seas drive the subtropicalization of European pelagic fish communities. Global Change Biology, 21(1), 144-153.

Nicolas, D., **Rochette, S**., *Llope, M., & **Licandro, P**. (2014). Spatio-Temporal Variability of the North Sea Cod Recruitment in Relation to Temperature and Zooplankton. PLoS ONE, 9(2), e88447. doi: 10.1371/journal.pone.0088447

*Ostle, C., Johnson, M., Landschützer, P., Schuster, U., Hartman, S., Hull, T., & Robinson, C. (2014). Net Community Production in the North Atlantic Ocean derived from Volunteer Observing Ship data. Global Biogeochemical Cycles, 2014GB004868. doi: 10.1002/2014gb004868

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Patrick, S. C., Bearhop, S., Grémillet, D., Lescroël, A., Grecian, W. J., Bodey, T. W., & Votier, S. C. (2014). Individual differences in searching behaviour and spatial foraging consistency in a central place marine predator. Oikos, 123(1), 33-40.

Postlethwaite, C.F., Hickman, A.E., **McQuatters-Gollop, A**., Bryden, H. & Woodworth, P., 2014b. Preface: A prospectus for UK marine sustained observations. Philosophical Transactions of the Royal Society, 372: 20130341.

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Silva, T., Gislason, A., **Licandro, P.**, Marteinsdóttir, G., Ferreira, A. S. A., Gudmundsson, K., & Astthorsson, O. S. (2014). Long-term changes of euphausiids in shelf and oceanic habitats southwest, south and southeast of Iceland. Journal of Plankton Research, 36(5), 1262-1278.

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Stern, R. F., Amorim, A. L., & Bresnan, E. (2014). Diversity and plastid types in *Dinophysis acuminata* complex (Dinophyceae) in Scottish waters. Harmful Algae, 39(0), 223-231. doi: http://dx.doi.org/10.1016/j.hal.2014.07.013

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Wouters, N., Dakos, V., **Edwards, M**., Serafim, M. P., Valayer, P. J., & Cabral, H. N. (2015). Evidencing a regime shift in the North Sea using early-warning signals as indicators of critical transitions. Estuarine, Coastal and Shelf Science, 152, 65-72.

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Batten, S.D., Chiba, S., **Edwards, M**., Hall, J., Hosie, G., Melrose, C., **Muxagata, E**., Richardson, A. & Verheye, H. (2014). The Status of Zooplankton Populations, Twap technical report. 1-9

Edwards, M., **Helaouët, P**., **Johns, D.G**., **Batten, S**., *Beaugrand, G., Chiba, S., Hall, J., Head, E., Hosie, G., Kitchener, J., Koubbi, P., Kreiner, A., Melrose, C., Pinkerton, M., Richardson, A.J., Robinson, K., Takahashi, K., Verheye. H.M., Ward, P. & **Wootton, M**. (2014). Global Marine Ecological Status Report: results from the global CPR survey 2012/2013. SAHFOS Technical Report, 10: 1-37. Plymouth, U.K. ISSN 1744-0750

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ICES. (2014). Second Interim Report of the Working Group on Biodiversity Science (WGBIODIV), ICES, Copenhagen, Denmark, 44 pp.

Johns, D.G. (2015). USA Annual Report, WHOI Agreement Number 1154661, 5pp.

Johns, D. G. & **Helaouët, P.** (2014). Indicator Assessment (CLIM 015) Distribution of Marine Species, European Environment Agency, 5pp

Johns, D. G. & **Helaouët, P.**, (2014). Indicator Assessment (CLIM 014) Phenology of Marine Species, European Environment Agency, 5pp.

McQuatters-Gollop, A., Artigas, F., Aubert, A., Johansen, M. & Rombouts, I., (2014). Update report from the OSPAR ICG-COBAM pelagic habitats expert group: Report from 2014 pelagic habitats workshop, Report to OSPAR ICG-COBAM, 10 pp.

Stern, R. & Metfies, K. (2014) Molecular Methods. ICES Working Group for Phytoplankton and Microbial Ecology (WGPME) meeting report 2014. Edited Moran, X., *Kraberg, A.

Scherer, C., Gowen, R.J., Tett, P., **McQuatters-Gollop, A**., Forster, R., Bresnan, E., Cook, K., Atkinson, A., Best, M., Baptie, M., Keeble, S., McCullough, G. and McKinney, A., 2014. Finalising and implementing the development of plankton indicators and targets: Operationalising the Lifeform and State Space Method. Workshop report to Defra, Agri-food and Biosciences Institute, Belfast, 32 pp.

Skinner, J., Bailly, D., Coz, M. L., Fletcher, S., Glegg, G., Glenn, H., Herry, L., Molfese, C., Sewell, J. & **McQuatters-Gollop., A**. (2014). Pathways for effective governance of the English Channel. Sir Alister Hardy Foundation for Ocean Science, Plymouth, UK.

Papers submitted / accepted for publication

Allen, S., **McQuatters-Gollop, A**. & Howell, K., (in prep). A century of community change in North Sea phytoplankton.

Batten, S.D., Raitsos, D.E., **McQuatters-Gollop, A.**, Hopcroft, R., & Coyle, K., (in prep). Interannual variability in lower trophic levels on the Alaskan Shelf.

*Beaugrand, G., Harley, X. & **Edwards, M**. (in press). Detecting plankton shifts in the North Sea: a new abrupt ecosystem shift between 1996 and 2003. Marine Ecology Progress Series.

Burthe, S.J., Henrys, P.A., Mackay, E.B., Spears, B.M., Campbell, R., Carvalho, L., Dudley, B., Gunn, I.D.M., **Johns, D.G**., Maberly, S.C., May, L., Newell, M.A., Wanless, S., Winfield, I.J., Thackeray, S.J. & Daunt, F. Do early warning indicators consistently predict non-linear change in long-term ecological data? Journal of Applied Ecology. (Submitted)

Chiba, S., **Batten, S.**, Yoshiki, T., Sasaki, Y., Sasaoka, K., Sugisaki, H., & Ichikawa, T. (2014) Temperature and zooplankton size structure: climate control and basin-scale comparison in the North Pacific. Ecology and Evolution. (Accepted)

Decelle, J., Christen, R., Romac, S., **Stern, R.F.**, el Bendif, M., Zingone, A., Audic, S., Guiry, M.D., Guillou, L., Tessier, D., Vaulot, D. & de Vargas, C. (2014) PhytoREF : a reference database of the plastidial 16S rRNA gene of photosynthetic eukaryotes with curated taxonomy. Mol. Ecol. Res (in review)

Elliott, M., Borja, Á., **McQuatters-Gollop, A.**, Mazik, K., Birchenough, S., Andersen, J.H., Painting, S. & Peck, M., Submitted. Climate change will affect our ability to achieve Good Environmental Status for marine biodiversity. Aquatic Conservation: Marine and Freshwater Ecosystems.

Evariste, E., Claquin, P., Robin, J.-P., Auber, A., **McQuatters-Gollop, A.** and Dauvin, J.-C. The Channel Ecosystem, a cross-road of anthropogenic pressures and scientific studies: lessons acquired from the European INTERREG IV projects (2009-2015). Marine Policy. (submitted).

Gowen, R.J., Tett, P., Scherer, C., Allen, M., Atkinson, A., Baptie, M., Best, M., Bresnan, E., Cook, K., Forster, R., **McQuatters-Gollop, A**., Painting, S., **Castellani, C**., Mills, D.K. & van Leeuwen, S., (in prep) Variability in shelf seas plankton communities: can change be linked to anthropogenic pressure?

Greenstreet, S.P.R., Rombouts, I., Raicevich, S., Lynam, C.P., Bos, O., Probst, W.N., Schratzberger, M., Nilsson, H., Ojaveer, H., **McQuatters-Gollop, A**., Dickey-Collas, M., Hagebro, C. & Reid, D.G. Implementing an ecosystem approach to marine management at a regional seas scale: a selection process for identifying optimum "state" indicators. ICES Journal of Marine Science. (submitted)

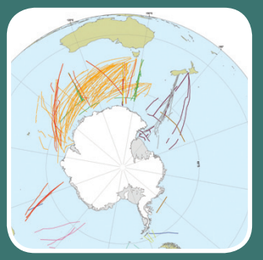
McQuatters-Gollop, A., **Edwards, M**., **Helaouët, P**., **Johns, D**., **Owens, N**, **J. P**., Raitsos, D.E., *Schroeder, D., **Skinner, J**. & **Stern, R**. The Continuous Plankton Recorder survey: enhancing and applying phytoplankton research in the Northeast Atlantic. Estuarine, Coastal and Shelf Science. (Submitted).

Montero-Serra, I., **Edwards, M**. & Genner, M.J. (in press). Warming shelf seas drive the tropicalization of European pelagic fish communities. Global Change Biology.

Postlethwaite, C., Hickman, A., **McQuatters-Gollop, A**., Bryden, H. & Woodworth, P., 2014a. A prospectus for UK marine sustained observations. Philosophical Transactions of the Royal Society, in press.

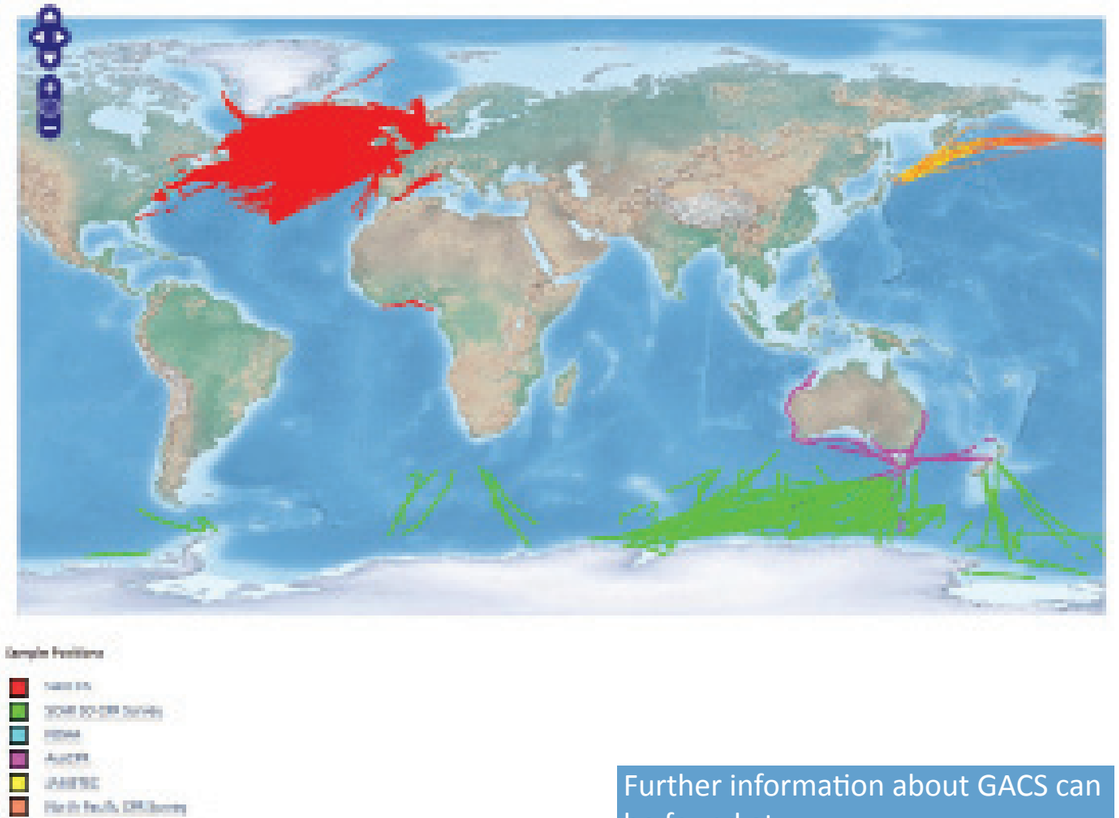
Stern, R.F., Picard, K.T., Hamilton, K.M., **Walne, A**., Tarran, G., Mills, D., **McQuatters-Gollop**, A. & **Edwards, M**. Submitted. An automated water sampler for probing marine microbial biodiversity with Ships of Opportunity. Prog. Oceanogr. (in review)

Global Alliance of CPR Surveys



The general goal of GACS is to understand changes in plankton biodiversity at ocean basin scales, through a global alliance of CPR surveys. To further this end, GACS consists of a network of organisations in both the Northern and Southern Hemisphere, which use CPRs to routinely study plankton populations – some of these surveys have been established many years, others are taking their first steps into the world of plankton monitoring.

Since its inception in 2011, the GACS community has grown to include 13 organisations: SAHFOS (UK), SCAR (Australia), JAMSTEC (Japan), NIPR (Japan), NIWA (New Zealand), NOAA (USA), FURG (Brazil), CSIRO (Australia), DEA, BCC (South Africa), IO-CAS (China), IPEV/UPMC (France), Cyprus Institute (Cyprus) and NIO (India). During 2014 unfortunately due to government cutbacks, US NOAA's NEFSC had to end their support for the US East Coast CPR survey in the Gulf of Maine and across the Mid Atlantic Bight. This Survey was the second longest running CPR programme after SAHFOS in the North Atlantic, and one of the longest running time series in the Northwest Atlantic.



Further information about GACS can be found at: www.globalcpr.org

Prof Graham Hosie, from SCAR SO-CPR survey, has been the dedicated Chair of GACS since September 2011. It was agreed at the first meeting that the Chair of GACS would be a three year term, and as of September 2014 Graham stood down. Previous Vice-Chair Dr Sonia Batten was elected as the new Chair and Dr Sir Hans Verheye was elected as the new Vice-Chair. Graham would like to thank the GACS members for their support and contribution, the various members of SAHFOS who contributed directly to GACS with the website, the database, and collating methodological procedures, Linda Horsfield who provided superb assistance as GACS Secretary and to NERC for providing the initial funding to establish GACS.

During 2014, all of the participant organisations ran a large number of successful tows and projects, too numerous to do justice to in this Annual Report. One of the main projects for a number of GACS members in 2014 was to produce various deliverables for the Transboundary Waters Assessment (TWA) Programme (see www.geftwap.org for further information), specifically: data (monthly or annual averages by region) of zooplankton indicators from each CPR survey; average copepod community size, and total mesozooplankton abundance, a final narrative summary report on the main messages from our results, suitable for a non-specialist audience and a final detailed technical report on the methods, data and conclusions from the zooplankton data. All GACS partners were co-authors on this.

Below is just one example of the innovative science being delivered by the GACS community.

Using CPR samples to investigate origin and spread of cholera in the Benguela Current ecosystem

Dr Sir Hans Verheye, DEA, South Africa

Vibrios are ubiquitous marine bacteria belonging to the class Gammaproteobacteria that are associated with abiotic substrates and biotic hosts including chitinous plankton. They use a chitin-binding protein for their attachment to the carapace of crustacean zooplankton. Because of their sheer abundance, zooplankton are considered to be a most important reservoir of vibrios in nature. The best known member of the genus *Vibrio* is *V. cholerae*, the causative agent of epidemic cholera.

A group of Italian scientists at the University of Genoa lead by Luigi Vezzulli recently developed a species-specific assay for the diagnostic detection of this bacterium in environmental samples and substrates, with a view to addressing some important questions regarding the role of human versus environmental factors in the origin, transmission and spreading of the cholera disease. The protocol was optimised for the analysis of formalin-fixed samples, such as historical CPR samples. Among the CPR collections used to test the protocol's sensitivity were 18 samples collected by the southern African CPR Sister Survey in the Benguela Current Large Marine Ecosystem (BCLME) during its inaugural survey in September 2011 along the coasts of Angola, Namibia and South Africa which represent endemic areas for cholera.

Three of the samples, notably collected in coastal waters off the cities of Luanda in northern Angola and Cape Town and Port Elizabeth in South Africa, tested positive for *V. cholerae*. Incidentally, some two months after CPR sampling, numerous cases of the disease were reported in the district of Lucapa, about 800 km inland from Luanda. It is presently unknown whether the *V. cholerae* DNA recovered from these samples is from toxigenic genotypes. Genotyping *V. cholerae* directly in CPR samples is the next goal and, to this end, scientists are in the process of developing a method based on the NGS sequencing technology.

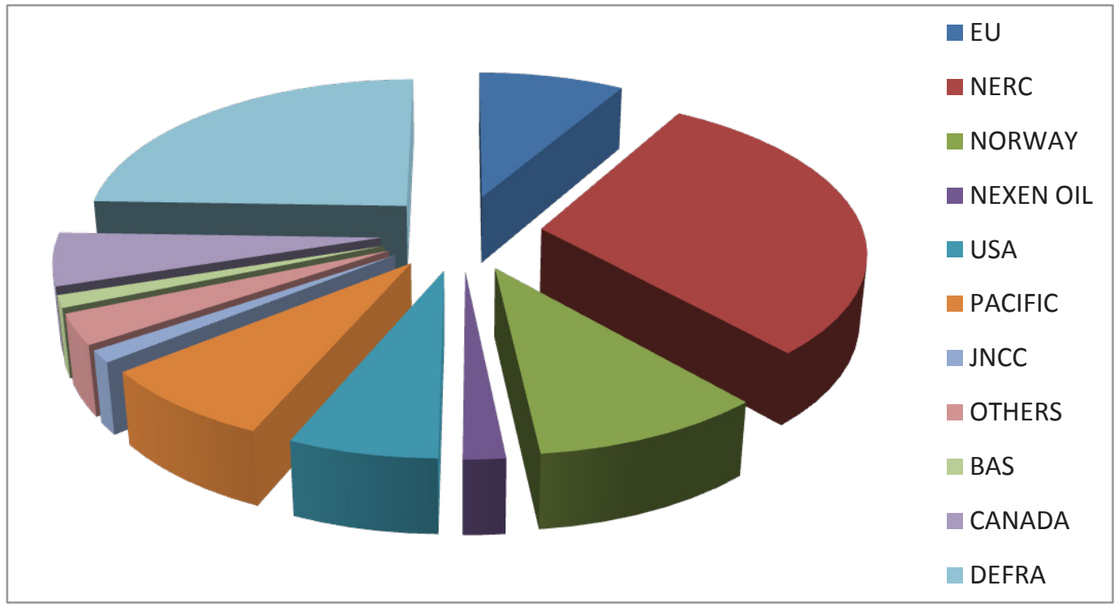
These findings demonstrate the usefulness of CPR technology in investigating the macro-ecology of vibrios in the aquatic environment over geographically and temporally extensive scales. In addition, a *Vibrio* relative Abundance Index (VAI), i.e. the ratio of *Vibrio* spp. cells to the total number of bacterial cells, was also measured on the southern African CPR samples.

Furthermore, using CPR technology in tracking cholera outbreaks and epidemics is of great potential interest considering that one 10 nautical mile CPR sample represents multiple point samples, which is the approach traditionally adopted in acquiring environmental cholera data. As such, using CPR samples is an improvement of the spatial sampling resolution by several orders of magnitude.

Further reading: Vezzulli L, Staunder M, Grande C, Pezzati E, Verheye HM, Owens NJP and C Pruzzo (2015). gbpA as a novel qPCR target for the species-specific detection of *Vibrio cholerae* O1, O139, non-O1/non-O139 in Environmental, Stool, and Historical Continuous Plankton Recorder Samples. PLoS ONE (in press)

Appendix A

Financial Summary



The principal sources of funding for 2014 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 2014 these were:

- UK Natural Environment Research Council (NERC)
- UK Department of Environment, Food and Rural Affairs (DEFRA)
- National Science Foundation U.S. (NSF)

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 2014 these were:

- Exxon Valdez Oil Spill Trust
- Dept of Fisheries & Oceans Canada
- European Union
- Institute of Marine Research Norway
- JNCC
- North Pacific Research Board
- British Antarctic Survey
- European Environment Agency
- Nexen Oil

Total incoming resources for 2014 have reduced during the year and together with other income from charitable activities, are reported at £1,558,537 (2013 £2,141,088).

Resources expended for 2014 had increased during the year, resulting in net outgoing resources of £263,140 (2013 net incoming resources of £370,665).

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.

Appendix B

Shipping Companies assisting the CPR survey in 2014

We would like to thank all ship's crew, owners, charterers, managers, port operatives and agents who support the CPR survey. We are much indebted to you all.

Thank you

Routes	Towing Vessels	Shipping Company
A-	*Hildasay*	Chartered by Serco NorthLink Ferries, Scotland from Seatruck Ferries, Heysham.
AT	*Horizon Kodiak*	Horizon Lines LLC, Charlotte, North Carolina, USA and Tacoma, WA, USA.
BA, BB, BC, BD	*Benguela Stream*	Seatrade NV, Groningen, Netherlands. Charterers: Geest Line Ltd, Fareham, England.
C-	*Ficaria Seaways*	DFDS Seaways, Copenhagen, Denmark.
D-, DA, EA, EB	*Atlantic Companion*	Atlantic Container Line, Gothenburg, Sweden.
HE	*Clipper Point*	Chartered by DFDS Seaways from Seatruck Ferries Ltd, Heysham, UK.
IB & SB	*Sophia*	Chartered by MacAndrews Ltd, London from Peter Doehle Schiffahrts KG, Haren/ Ems, Germany.
IN	*Norbay*	P&O Ferries (Irish Sea) Ltd, Larne, Northern Ireland.
KC	*Norrland*	Chartered by Sea-Cargo, Bergen, Norway from Brise Schiffahrt, Hamburg, Germany.
LG	*Ficaria Seaways*	DFDS Seaways, Copenhagen, Denmark.
LR & V	*Selfoss*	Eimskipafelag, Reykjavik, Iceland.
M-	*Sea Cargo Express*	Sea Cargo A/S Bergen, Norway.
MB	*Oleander* From April 2014	Marshall Islands Registry. Pacific. Bermuda Container line, Neptune Group, Hamilton, Bermuda.
MC	*Westerkade* Feb to June 2014 *Skogafoss* July to Dec 2014	Westerkade on Eimskip charter from Buss Shipping Germany Skogafoss chartered by Eimskip, Reykjavik, Iceland from W. Bockstiegel Maritine Service, Emden, Germany.
NI	*Skogafoss*	Chartered by Eimskip, Reykjavik, Iceland from W. Bockstiegel Maritime Service, Emden, Germany.
PR	*Armorique* *Bretagne* Oct/Dec 2014	Brittany Ferries, Roscoff, France.
R-	*Flandria Seaways*	DFDS Seaways, Copenhagen, Denmark.
SA	*Encounter*	Chartered by MacAndrews Ltd, London. Managed by Confeeder Shipping, Rhoon, Netherlands.
SF	*Pharos SG*	Owners: Byron Marine Ltd, Southampton, England. Charterers: Government of South Georgia & South Sandwich Islands, Stanley, Falkland Islands.
ST	*Green Frost*	Green Reefers AS, Bergen, Norway.
VJ	*Skaubryn*	Chartered by Seaboard International Shipping Company, from Doriko Ltd, South Korea.
Z, ZB, ZC	*Westerkade* *Reykjafoss*	Chartered by Seaboard International Shipping Company, from Doriko Ltd, South Korea.

LR route: Immingham to Sule Skerry

V- route: Sule Skerry to South East Iceland

NI route: East Iceland to Sortland

Skogafoss

A- route: Lerwick Shetland to Aberdeen

Hildasay

KC route: Immingham to Tananger

M- route: Aberdeen to Tananger

Norrland

ST route: Svalbard to North Cape

Green Frost

M- route: Aberdeen to Tananger

Sea Cargo Express

IN route: Dublin to Liverpool

Norbay

C- route: Humber to Hanstholm

Ficaria Seaways

IB route: Biscay to 53^{0}N

Sophia

LG route: Gent to Gothenburg

Freesia Seaways

PR route: Plymouth to Roscoff

Armorique & Bretagne

HE Route: Cuxhaven to Immingham

Clipper Point

D- and DA route: 33^{0}W to 7^{0}W and Liverpool

Atlantic Companion

SA route: Bilbao to Land's End

Encounter

R- route: Hook of Holland to Shipwash Bank

Flandria Seaways

North Atlantic tow routes and ships of 2014

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

MC route: Nova Scotia to Portland

Westerkade & Skogafoss

Z routes: Reykjavik to east of Newfoundland

MC route: Nova Scotia to Portland

Reykjafoss & Westerkade

MB route: New York to Bermuda

Oleander

Atlantic tow routes and ships of 2014

B Routes: 40^{0}W to Portsmouth

Benguela Stream

SB route: Lisbon to Leixoes then 46^{0}N

Sophia

E routes: Norfolk VA to south of Cape Race

Atlantic Companion

Pacific

AT route: Anchorage Alaska to Tacoma Washington State

Horizon Kodiak

VJ route: Vancouver to Hokkaido Japan

Skaubryn

Southern Ocean

SF route: Stanley Falklands Islands to South Georgia

Pharos SG

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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