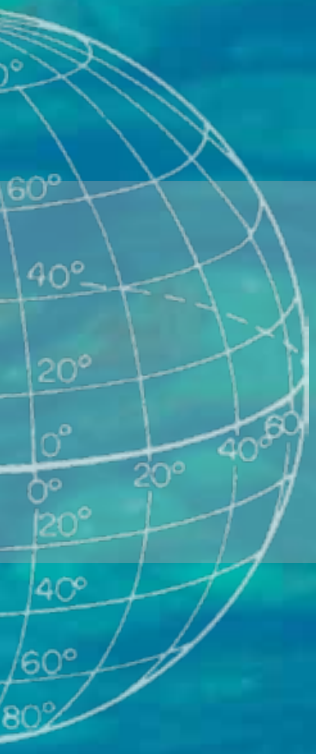
Sir Alister Hardy Foundation for Ocean Science

Monitoring the health of the oceans since 1931



2013 Annual Report

The Continuous Plankton Recorder survey Est. 1931

About Us

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 from the North Atlantic and the North Sea, and the resulting data have provided information on biogeography and ecology of the planktonic community since 1931. 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.

Front cover image: *Cotylorhiza tuberculata*, Mike Blackett

Back cover image: *Tomopteris*, Mike Blackett

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Proofreading: Marion Smith and Astrid Fischer

Printer: Kingfisher, Totnes, Devon, England

Printed on recycled paper

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Director's Review of the Year

It is a pleasure to be introducing the SAHFOS Annual Report for 2013, my first full year since becoming Director. It has been a fascinating year as I have become more familiar with SAHFOS and, having now completed a full business-cycle, I am feeling very much at home.

There is much about which I could comment and, as always at SAHFOS, there are a number of fascinating stories in the pages that follow. I shall refer to only a few of these but I would encourage you to delve into the detail of the report where you will find articles as diverse as alien plankton to Twitter statistics!

The operation of the Continuous Plankton Recorder Survey, involving the deployment, towing and analysis of the multitude of samples we collect is a major logistical task, which lies at the heart of SAHFOS. This year has seen us beat last year's record by towing CPRs for more than 140,000 nautical miles of the ocean, the highest in the Survey so far. This has provided us with over 13,000 samples, which has allowed us to analyse and describe the surface plankton community to the detail of almost 800 taxa, from the Arctic Ocean to the Antarctic. Indeed, 2013 saw us achieve the record deployment of CPRs at the most northerly and southerly latitudes since the Survey started in 1931. In an interesting collaborative venture with the *Tara* expedition a CPR was towed in an almost complete circumnavigation of the Arctic Ocean broken only when ice conditions were too hazardous to tow the instrument.

Recalling the *Tara* Expedition is a cue to recognising that SAHFOS is a hugely collaborative organisation. We are entirely dependent upon the supportive relationships we have with all the shipping companies, agents and crews of the merchant ships around the world which tow our CPRs. We have excellent professional academic relations with our international partners involved in the Global Alliance of Continuous Plankton Recorder Surveys (GACS), for which I like to feel we act as the 'mother ship'. We have really valuable relations with international funders, including the US National Science Foundation, the Canadian Department of Fisheries and Oceans and the Norwegian government through the Institute of Marine Research in Bergen. Sadly, the US National Oceanic and Atmospheric Administration withdrew funding for two CPR routes off the NE coast of the USA in December 2013, having previously supported the routes for many years. These are important sampling routes, providing unique data for the sound management of the region, and SAHFOS will continue to support the routes until alternative sources of funding can be found. More optimistically, however, a new CPR survey was initiated in the Levantine Sea, E Mediterranean and run by new colleagues at the Cyprus Institute. We welcome them most warmly to our community and look forward to seeing their fascinating results.

And, in another exciting development, we welcome a new partnership with Nexen, an oil production company, which operates a large field in the North Sea, close to several of our longest established CPR routes. Nexen is interested, *inter alia*, in the plankton communities in its operating area and I am delighted to be able to establish what I hope will become a sustained mutually beneficial relationship.

An important development for SAHFOS was completed during the year, namely, a reorganisation and development of our governance structure. Our chairman, Professor Peter Liss, CBE, FRS, has referred to this in his welcome so I shall say no more other than to thank Peter and all our Trustees and members of the Science Advisory Board. All of us in SAHFOS are very grateful for the time, dedication and contributions given so freely to help make SAHFOS a success. I personally look forward to developing even stronger links with our Boards during 2014.

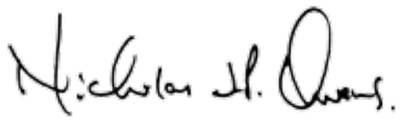
A major exercise was initiated during the year to develop a plan to diversify SAHFOS partnerships and supporters. We were helped in this project by retaining the services of Community and Counselling Service (CCS Ltd). This activity was greatly assisted through the good offices of a small volunteer group of individuals, a Development Committee*, who helped SAHFOS, facilitated by CCS, to create a development plan. This was completed right at the end of 2013 and I look forward to taking this forward in 2014.

Other developments to increase our profile have seen us tweeting, google+ing and facebooking SAHFOS to an ever increasing community of followers and friends. There is a more informed piece later in the report but it seems we are making an increasingly large splash in the social media ocean. Meanwhile, I am still very much a beginner and still 'paddling in the shallows'; however, I am finding it an interesting and different way of promoting SAHFOS.

And what is SAHFOS if it is not all about our people? I have already mentioned my indebtedness to our Trustees, Science Advisory Board and Development Committee members.

But it is the SAHFOS staff who continue to make SAHFOS a success. As usual we have had some leavers and starters. We said goodbye during the year to Mike Flavell, our Database Manager, who remains in close contact with us in his new role at the international environmental database, OBIS. Maria Campbell left us to join her husband in the USA, Clare Buckland has left us temporarily for maternity leave and Delphine Nicolas left us for a post as Project Manager at Irstea, a marine research laboratory in France. I am pleased to welcome Martina Brunetta, silk preparer and Scott Calnon, who joins us as a database developer. A number of members of staff already with us have added to or changed roles during the year and it is excellent to see this degree of flexibility which really benefits SAHFOS. Perhaps most significantly of these were David Johns and Astrid Fischer who became the Chair and Secretary, respectively, of the National Marine Biological Analytical Quality Control Scheme (NMBAQC) while retaining their existing positions. I thank them and all my colleagues at SAHFOS for their dedication throughout the year.

I hope you will enjoy reading about what we have been doing during 2013.



* SAHFOS Development Committee. Prof P Liss, Prof G Shimmield, Lord Selborne, Dr K Morgan, Dr M Parker and Mr R Coombs

Citadel Hill, Astrid Fischer

Change & Continuity

The Finance and Resources Committee: Prof Jan Pentreath, Prof Paul Hart, Mr Rob Hubble and Prof Peter Liss. Not in photo: Mrs Jean Nyman and Mrs G Tanner.

Many changes are taking place at SAHFOS now and will continue into the future but many other things carry on as before. First the changes.

We have a (relatively) new Director in Nick Owens who is settling in well, getting to know the staff and enjoying life in Plymouth. Nick's family home is in the North East and he tries to make the long journey there on as many weekends as possible. As new Directors should, he is making substantial strides in modernising our structure and approach to management. Instead of the former Council we now have a Board of Trustees, which I chair, a Science Advisory Board chaired by Patrick Holligan and a Finance & Resources Committee of which Paul Hart is chair. The new structure seems to be working well, with each of the 3 committees having clearer defined roles than the much broader remit of the old Council.

SAHFOS is a charity governed by its Board of Trustees, which has the responsibility for financial, legal, safety and many other managerial aspects of what we do. It is a 'soft money' institution with funding dependent on continuing support from its several sponsors. We are very grateful for this support, without it SAHFOS would not exist. But in the present tough economic times we have to look to additional ways of funding our activities. This is in part to protect our work from the vagaries of relying on contracts that are often quite short-term and susceptible to cuts and termination with little notice. But the other reason is more positive, because a sounder financial base would allow us to do more science. This could include: increasing the number of CPR routes; exploiting the fantastic CPR database we have extending over more than 8 decades to gain direct knowledge of how ocean biology has changed during this period of large man-induced global intervention; further instrumenting the existing CPRs with sensors to obtain physical, chemical and biological data and generally modernising our sea-going and land-based operations. To help us achieve these ends we have engaged a professional company to advise on raising significant funds over the next 3 to 5 years. If you would like to join us in this, either as a donor or to help to encourage others, including industry, foundations and individuals, please contact Nick (njpo@sahfos.ac.uk). We look forward to hearing from you!

Now a few words on things that do not and should not change. As already mentioned the CPR survey was created by Sir Alister Hardy 82 years ago and is still going strong and delivering according to its mission.

Throughout that long period the quality and consistency of the data collected and archived have been world class. This is a priceless and continuing legacy telling us about many environmental and climatic aspects of ocean science not achievable in any other way. It is clear that the longer the CPR collects data, the more valuable it becomes. All this depends in large measure on the skill and devotion of the staff, whether on the technical, analytical, data analysis and interpretation sides of the work. I salute them and commend them for their hard work and achievements; long may it continue.

Peter Liss

Peter Liss CBE, FRS

Chair of SAHFOS Board of Trustees

January 2014

The Board of Trustees from left to right: Mr Rob Hubble, Mr Richard Coombs, Mrs Gill Tanner, Ms Beth Greenaway, Prof Martin Edwards, Dr Peter Wiebe, Prof Paul Hart, Prof Peter Liss, Prof Nick Owens, Prof Geoff Boxshall, Prof Patrick Holligan and Prof Jan Pentreath. Ms Marion Smith as Secretary.

The Science Advisory Board: Dr Erica Head, Prof Martin Edwards, Dr Graham Hosie, Dr Peter Wiebe, Prof Patrick Holligan, Prof Peter Liss, Prof Geoff Boxshall and Prof Nick Owens. Not in photo: Dr Caron Montgomary and Dr Stephanie Henson.

Our People

SAHFOS TRUSTEES in 2013

Professor P Liss CBE, FRS (Chair)
Professor G Boxshall FRS
Dr K Brander (until March 2013)
Mr R Coombs (from March 2013)
Ms B Greenaway
Dr R P Harris (until March 2013)
Professor P Hart
Professor P Holligan (Vice Chair)
Dr G Hosie (until March 2013)
Mr R Hubble FCA
Mrs C Mitchell (until March 2013)
Professor R J Pentreath
Mr A G A Wates MBE (until March 2013)
Professor P Wiebe

SAHFOS STAFF in 2013

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

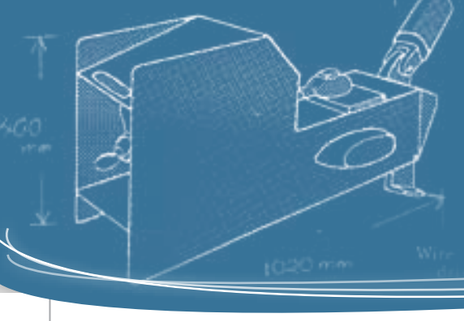
Roger Barnard
Marine Engineering Technician
Dr Sonia Batten
Pacific CPR Project Co-ordinator
Kate Brailsford
Administrator and PA to Director of Science
Gemma Brice
Plankton Analyst
Martina Brunetta
Technician
Clare Buckland
Plankton Analyst & Education Officer
Scott Calnon
Database Developer (from September)
Rob Camp
Plankton Analyst
Dr Claudia Castellani
Research Fellow & Plankton Analyst

Alec Colebrook-Clark
IT Support & Web Developer
Debbie Cracknell
Silk Cutter (until January)
Dr Dave Conway
Plankton Analyst (Contractor)
Dr Alessandra Conversi
Marie Curie Fellow
Dr Astrid Fischer
Plankton Analyst & Technical Secretary to NMBAQC (from April)
Mike Flavell
Database Manager (until April)
Lance Gregory
Workshop Manager
Nick Halliday
Plankton Analyst (Contractor)

Chris Harris
Marine Engineering Technician
Dr Pierre Hélaouët
Research Fellow
Linda Horsfield
Administrator
Jess Haapkyla
NMBAQC Secretary (until March)
Usha Jha
Plankton Analyst
David Johns
Laboratory Manager
Tanya Jonas
Senior Taxonomist
Dr Priscilla Licandro
Research Fellow
Dr Abigail McQuatters-Gollop
Science & Policy Research Fellow
Doug Moore
Plankton Analyst (Canada)
Julian Morley
Marine Engineering Technician
Dr Delphine Nicolas
VECTORS Post Doc (until January)

Jean Nyman
Finance Officer
Capt Peter Pritchard
Head of Operations
Prof Chris Reid
Senior Research Fellow
Jennifer Skinner
Plankton Analyst & Laboratory Technician
Marion Smith
PA to Director & HR Manager
Dr Rowena Stern-Kluckner
Molecular Plankton Ecologist
Darren Stevens
IT Manager
Claire Taylor
Plankton Analyst & Assistant Laboratory Manager
Dr Tony Walne
Plankton Analyst & Instrumentation
Marianne Wootton
Deputy Senior Taxonomist
Claire Wotton
Plankton Analyst

SAHFOS Staff, Plymouth Hoe, Summer 2013



Survey Operations

In 2013:

140051 nautical miles were towed, the highest in the history of the Survey.

6.34 million nautical miles have been towed since 1931.

91.6 % sampling success rate (does not include *Tara* Arctic tows).

Towed 3577 nautical miles between 51°S and 63.5°S and 25°W to 57.6°W during January and February on the Ocean Acidification South cruise by the *James Clark Ross*.

The *Tara* Arctic Expedition towed 3915 nm during the Arctic circumpolar expedition from June to October 2013.

The new KC, Immingham to Tananger route was started in February to fill the gap in North Sea coverage.

Tow logistics and Operations in 2013

Peter Pritchard

6,343,609 nautical miles have been towed since September 1931 to the end of 2013 - producing one of the largest data sets of marine plankton from the longest running marine biological time series in the world. 311 merchant and other ships have towed CPRs since the German *Albatross* in 1931. This is a great achievement and is due to the ease of operation, reliability and robustness of the CPR.

During 2013, 26 ships completed 428 tows on 22 routes, collecting data from almost 130,000 analysable nautical miles. Ships, companies and charterers involved during 2013 are shown in Appendix B. There were seven ship changes during the year. February: *Norrland* on the KC route; April: *Skogafoss* on the NI route; May: *Skaubryn* on the VJ route; July: *Energizer* on the SA route; October: *Westerkade* on the Z route; November: *Bretagne* on the PR route; December: *Freesia Seaways* on the LG route. The overall sampling 91.6 % success rate in 2013 reflects the consistently high standards of the CPR workshop team. All tow equipment aboard the ships has a planned maintenance and safety inspection regime that complies with the International Lifting Operations and Lifting Equipment Regulations (LOLER) and the Marine International Safety Management (ISM) Code.

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, who often work in arduous conditions. 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. We are extremely grateful to all those involved, helping SAHFOS in all its operational activities – we could not do it without your continuing support.

CPR Workshop

Lance Gregory

2013 saw some reorganisation of the SAHFOS workshop. Martina Brunetta started in her post of silk preparation Technician early in January, quickly grasping the required skills and is now producing high quality filter silk for the global CPR fleet. Roger Barnard reverted to two days a week and SAHFOS is grateful that we retain his considerable knowledge and experience in the team. At the same time Julian Morley increased his working pattern to four days a week.

The production of CPR filter silk rolls from the Shanghai silk is a major task for the workshop team. During 2013 we produced completed rolls of filter silk for several of our sister surveys, the SAHFOS survey and as part of the business continuity plan the SAHFOS strategic reserve. In 2013 with over 1300 hours of technician time we processed nearly 10km of silk!

Cost effective Proven and Reliable

This year one our machines reached its 75th Birthday. CPR 12 came in to service in August 1938 and has now towed in excess of 90,000 miles and as of writing is being prepared for yet another tow, this time on the HE route

The Global CPR fleet in 2013 gained its newest member, CPR 208, which after final assembly and the necessary QA checks by our technicians was exported to NOAA in the USA in October. This, with our ongoing technical support to our sister surveys, highlights the global reach of our small team. This year was no exception to the rule, that several CPRs sustain damage during their more arduous deployments, but due to the robustness of the design and the skills of the workshop team we achieved an annual success rate of 91.6%, up from 87.5% in 2012.

Our technicians completed various mandatory training in 2013, such as renewing forklift licences and passing Lifting Equipment Engineers Association accredited courses as examiners. One particular highlight was Julian Morley gaining professional recognition with qualifications and membership from IMarEST and the UK Engineering Council. Our IMarEST recognised courses have proved popular this year with them being run at SAHFOS for the Cyprus CPR project (see page 16) and for our own South Atlantic survey. A short course was also run on board the French sailing research vessel the *Tara* prior to her departure on an Arctic circumnavigation (see page 14). The team is fortunate that Lance Gregory and Chris Harris hold formal teaching / instructing qualifications which enhance these courses.

As Marine Technicians it is always nice to get some sea time in. During 2013 Chris Harris went to sea to trial the 'Hardy Plankton Indicator' with Dr Priscilla Licandro to see if the indicator is suitable for a potential project that Priscilla is working on. It was also decided this year as a continuing process to "uphold excellence" to update our tow wire strain readings at various speeds with and without payloads fitted to the CPR (see page 13). Julian Morley completed this task successfully after trips on-board the local laboratory boats and the Brittany Ferries' *Armorique*.

Looking forward to 2014 the team is enthused ready for the expansion of the CPR tows that will be fitted with electronic packages and with the reorganisation of the team we are in good shape for all the challenges ahead.

Losses of CPRs at sea during 2013

17th February 2013: CPR 190 body with filter cassette 190/1 and Vemco Minilog 0491T lost during recovery at 62°25'N, 18°02'W from the *Selfoss*. 2nd May 2013: CPR 171 body with filter cassette 171/0 was lost between 0001 and 0830 on 2nd May 2013, between 75°16'N, 15°31'E and 77°18'N, 13°00'E from the *Green Frost*. The ship was heading northwards to Svalbard.

Technical developments (Instrumentation)

The Brancker XR620 CTD unit continued to operate successfully on the LR and V routes between Immingham, Sule Skerry and SE Iceland. The other Brancker XR620 CTD+F unit has operated successfully on the VJ route to Hokkaido from Vancouver Island. Dr Rowena Stern, Dr Tony Walne and Robert Camp have worked with the water sampler from Cefas Lowestoft. This was deployed in CPR 192 with a Star Oddi CTD and Minilog on the Plymouth-Roscoff, PR route. The water sampler is being used to identify phytoplankton species that are too small to be successfully filtered by the 280µm CPR mesh. This route is being operated on a fast analysis basis with the filter mesh being cut and analysed within two working weeks of receipt at SAHFOS after the tows. Vemco temperature minilogs are used on the BB, BA, DA and D routes and these are primarily for tow sequence verification. Star Oddi CTD units were used on the Norway to Iceland (NI) and North Norway to Svalbard (ST) routes. The turn round time for the Star Oddi on the NI route was shortened to seven weeks due to deploying it from the *Skogafoss* between Reykjavik and Sortland, Lofoten, Norway. It is landed at Reykjavik on the return leg then returned to the UK. The Star Oddi on the ST route had a turn round of 2 to 3 months due to slow returns from Bodo, Norway.

New KC route in the central North Sea

Peter Pritchard and Tanya Jonas

There has been a gap in North Sea CPR sampling since the losses of the K route (variously towing Leith-Copenhagen and Aberdeen-Stavanger) in 1983 and the LE route (Tyne-Esbjerg) in 1997. The region sampled by these tows included the exclusive economic zones of several countries having valuable fishing grounds and oilfields. It is an area of high biodiversity, encompassing the shallower waters of the Dogger Bank and southern North Sea, the deeper waters of the Norwegian coast and areas influenced by Atlantic inflow. Several shipping companies routes were studied. It was found that the Sea-Cargo route between Immingham on the Humber and Tananger in south west Norway could provide the required monthly sampling frequency. Permission was requested from Sea-Cargo management to ask the ship's owners, Brise Schiffahrt of Hamburg for their approval. This was forthcoming in late 2012. The new route was designated KC, and the first tow using CPR 164 was successfully completed by the *Norrland* from the Humber to Tananger on 19th-21th February 2013, with monthly tows thereafter (Fig. 1).

The earlier tows from February to April sampled blooms of diatoms particularly *Thalassiosira*, *Skeletonema* and *Chaetoceros* species. By May and June the diatom bloom was subsiding and replaced by dinoflagellates, mainly *Neoceratium longipes*, *N. horridum*, *N. macroceros* and *N. tripos*. In July and August, just to the north of the Dogger Bank, there were strong blooms of coccolithophores, indicating stratified nutrient-poorer, warmer water.

There were three records of *Lepas* nauplii from the July and August tows. These are usually found in warmer waters, but as adult *Lepas* ('stalked barnacles') attach to various substrates, including shipping, they can be carried into European waters. From April to July there were high numbers of echinoderm larvae, particularly over the Dogger Bank but by September these were all but gone, with just a few post-larvae being caught in the tows in the latter part of the year. High numbers of fish eggs and larvae in April, May and June coincided with a peak in numbers of the calanoid copepod *Calanus finmarchicus*, important prey for young fish. As the CPR tow sampled over the north-west edge of the Dogger Bank we also recorded a few organisms, such as caprellids and hydroids, that are more readily associated with the sea bed.

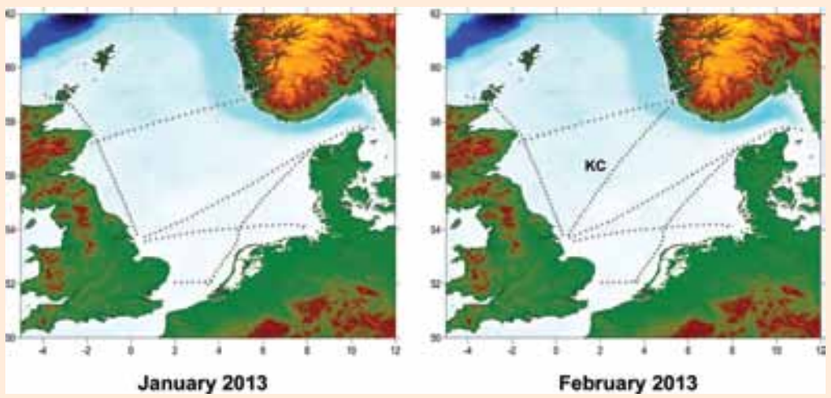


Figure 1. The plankton sampling in the North Sea in January 2013 (far left) with the gap. Then in February 2013 with the new KC route towed and filling the gap (left).

Ocean Business Event

Robert Camp

In April 2013, the operations team consisting of: Peter Pritchard, Lance Gregory, Anthony Walne, Chris Harris, Roger Barnard, Martina Brunetta, Julian Morley and Robert Camp attended Ocean Business 2013 at the National Oceanography Centre, Southampton. This is a well organised and highly professional event with a diverse range of exhibitors and attendees. Previous testimonials have stated "this is one of the friendliest, best organized and well attended events in the industry".

Robert Camp attended a meeting with Baldur Sigurgeirsson from Star-Oddi, covering their miniature multi data logger CTD, 3D tilt and compass heading technology, PatternFinder (graphic data analysis software), new additions to their instrument range and also the background to the company. This was most informative and also an opportunity to discuss the use of their CTD by SAHFOS.

Lance Gregory and Anthony Walne attended a demonstration of a Fast Repetition Rate Fluorometer by Chelsea Instruments on board the *RV Callista* (the research vessel owned by the University of Southampton). Peter Pritchard, Roger Barnard and Julian Morley attended a demonstration of a sidescan sonar system by EdgeTech on board the *Bill Conway*. Staff had opportunity to visit the exhibitors' stands and discuss marine technologies that could be combined with the CPR, as well as promoting the research undertaken at SAHFOS. Exhibitors were most impressed with our coverage and mileage towed, however our name isn't widely known. When discussed, people were impressed with the fact we have such a large archive of actual samples collected over many decades. Even though new technologies are coming on stream and their costs will come down, the CPR still offers cost effective large scale data collection. To deploy larger instruments we could consider CPR tows without an internal - collecting just the electronic data in some circumstances.

From a team point of view the day was hugely beneficial to all, especially raising awareness outside of the usual SAHFOS channels, in the fact we do have competitors and we must not rest on our laurels.

The Operations Team at Ocean Business 2013

Ocean Acidification South

Lance Gregory

Following on from the success of the UK Ocean Acidification (OA) cruise North in 2012, where the CPR was deployed as far North as 79° N, a CPR was again deployed on the OA cruise South early in 2013. The CPR was designed for single cassette tows of up to 500 nautical miles and the success of these OA cruises has proved the recent modified methodology that allows the CPR to be used on multiple short range tows from a single cassette. One of the enduring qualities of the CPR is its robustness, and the OA South cruise from the *James Clarke Ross* saw the CPR deployed in the 'roaring forties' and as far South as 63.4°S.

The CPR again proved its worth with a high success rate of samples collected, indeed the OA South cruise generated approximately 350 of CPR samples which have been analysed and the data uploaded to BODC. An additional benefit of the CPR being deployed on these OA cruises is that SAHFOS is now expanding its global footprint. The samples from these Polar regions will enhance the extensive archive of actual plankton samples collected over many decades which are stored in Plymouth.

Background.The Buzzard Field production platform.

Below. Water samples from the filtration system being settled and analysed

SAHFOS works with Nexen

Mark Bracewell (Nexen)

The Buzzard field (located in the Outer Moray Firth, central North Sea, 100km north-east of Aberdeen, UK, and 55km from the coast at Peterhead) operated by Nexen, a wholly owned subsidiary of CNOOC, is currently the most prolific producing oil field in the UK sector of the North Sea. The field straddles two licences – P.986 (blocks 19 / 10 and 20 / 6) and P.928(S) (blocks 19 / 5a and 20 / 1S. The water depth in the area is about 100m.

The production platforms to enable the field to be produced were installed in 2006, with production commencing in 2007. Since then over 400 million barrels of oil have been produced, with the field expected to still be producing, albeit at a very much lower rate, in 2041.

As oil is produced from the reservoir, around 7800 and 9100 feet below the seabed, the reservoir pressure would naturally fall. On Buzzard, the development plan calls for reservoir pressure to be maintained by an active water flood programme using treated seawater supplemented by produced water (water separated from the oil in the processing facilities on the platform). As time passes, the rate of water 'production' increases and the rate of oil production falls. Treated seawater is used to replace the oil in the reservoir, whilst produced water is injected to replace the water. The injection water is pumped into the reservoir through twelve injection wells.

Unlike most other oil fields, the treated seawater used for injection is not simply filtered but flows through a reverse osmosis plant prior to injection. This removes the risk of barium sulphate scale forming in, and close to, the production wells, which would limit production. This is a common effect found on fields that use water for pressure maintenance, particularly those which contain quantities of H2S in the reservoir fluids.

The reverse osmosis plant requires very finely filtered water to function, so Buzzard has a very large membrane filtration system designed to remove all solids > 0.1 micron. There is only one other offshore oil field operating which uses such a sophisticated water filtration system.

The presence of solid organic algal material in the seawater, particularly during the seasonal bloom period, makes operation of the upstream filtration system difficult. Nexen are pleased to be working with SAHFOS to understand the problem, predict the effects and optimise the operation of the filtration system to maintain production.

Safety at Sea: Tow strain generated by a CPR

Lance Gregory

Looking at the quaint photographs of Alister Hardy deploying the early CPRs from a 1930s merchant ship (photo top left) and comparing this to the modern vessels that routinely tow the CPR (photo top right), we considered the stresses and strains that are now put through our CPRs. SAHFOS is currently fitting instrumentation packages of various sizes to the CPRs, which may affect the wire strain loadings. We are also driving towards increasingly better QA and QC at SAHFOS, it was therefore considered timely to carry out tow trials to ascertain the load strains at various hull speeds generated by a modern CPR tow.

We sourced a calibrated load cell and carpenter clip. Julian Morley went to sea onboard the *Plymouth Quest* to take some strain readings at the lower end of the speed scale. The CPR was deployed in the usual way, then the carpenter clip was attached to the tow rope (photo bottom left), the strain gauge was fitted and the ship's winch backed so the strain was recorded at various hull speeds (photo bottom right). It is worth noting that this method records the steady pull on the wire in kilograms. From previous experiments onboard a Royal Navy frigate several years ago it was recorded that the transient or dynamic strain on the wire was increased by a factor of 1.5 over the steady pull readings.

On July 23rd 2013 workshop staff boarded the Brittany Ferries *Armorique* and again carried out several wire strain tests against higher hull speed readings on the southbound trip to Roscoff. Whilst in France a large instrumentation package in the form of the water sampler was fitted to the CPR for a repeat of the experiment on the northbound return trip. The results of these experiments were collated and can be seen on graph below (Fig. 2). A SAHFOS internal report was produced and the results presented at the October staff meeting. The findings show that our current towing arrangements and equipment are fit for modern CPR purposes up to a maximum hull speed of 26 knots without instrumentation and 24 knots with a large payload fitted to the CPR.

SAHFOS wishes to thank Brittany Ferries for all their assistance.

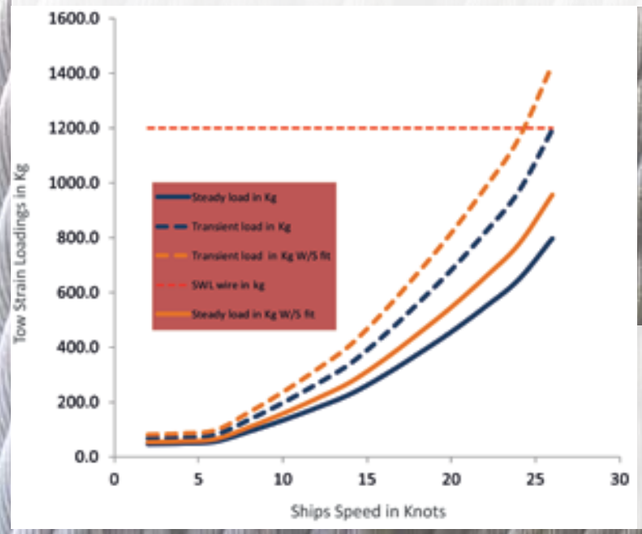


Figure 2. The graph shows the tow wire strains generated by a CPR in its standard format and with a large instrumentation package fitted, in relation to the ship's hull speed.

First Polar Circumnavigation with a CPR

Lance Gregory, Marc Picheral and Claudie Marec (Tara Expeditions)

Far Left image: CPR being recovered on deck of the *Tara*. Credit: Vincent Hilaire

Left image: Route travelled by *Tara*. Credit: Romain Troublé

Background image: The *Tara* vessel. Credit: A. Deniaud

The *Tara* is a research sailing vessel run by *Tara* Expéditions, which embarked on a scientific cruise in 2013 that was circumnavigating the Arctic to complete the Tara Oceans world study of plankton (started in 2009). The cruise route was a return trip from Lorient (France), turning around the North Pole counter clock wise, passing the North East and West passages in the same season.

During May 2013 Lance Gregory visited the *Tara* in Lorient to run a short course on CPR techniques with Marc Picheral and Claudie Marec prior to departure. Marc and Claudie reported "The course provided good training and we did not experience any difficulty with the clock-like machine that is the CPR".

The CPR was on board to compliment the other plankton sampling equipment used during the cruise, which included many types of instrumented nets from 20µm to 680µm mesh sizes. The aim of the CPR tow was to collect samples from the high Arctic for standard CPR taxonomic and molecular analysis, and to add to the sample archive with physical samples from this inaccessible region.

The CPR was towed between sampling stations when possible, according to the weather conditions, ice coverage and ship speed. During some night passages the *Tara*'s hull speed was reduced due to the prevalence of sea ice and on these occasions the CPR wasn't deployed. The normal deployment method of the CPR that utilises a ship's mounted winch was modified according to *Tara*'s available winches and capstans. We kept use of the steel cable and added a textile rope for manoeuvring, using manual winches. This arrangement allowed CPR deployments in wind speeds up to 45 knots. Early on in the cruise it was evident that the CPR was not rotating the silk fast enough for standard analysis to take place due to the low hull speed of TARA. With the benefit of modern communications, Marc was able to communicate with the technicians back at SAHFOS. It was decided to attempt a modification of the CPR propeller to increase the silk transport efficiency. Trials were performed with an on-board modified propeller. Workshop staff at SAHFOS then redesigned the CPR propeller, increasing its efficiency. A replacement propeller was then sent to join the *Tara* in Norway, which proved successful, increasing the miles per sample division. With some 'out of the box' thinking by Marc and SAHFOS technicians plus the accurate recording of tow positions and occurrences, the CPR was deployed successfully.

Sampling in such high latitudes has in the past resulted in large catches of plankton, and the *Tara*'s cruise was no exception. As of writing the samples are returning to SAHFOS to await analysis and curation.

Cyprus CPR Survey

Lance Gregory and Carlos Jimenez, Cyprus Institute (CyI)

2013 saw Med-CPR from The Cyprus Institute (CyI) join the international family of CPR surveys. They plan to set up a route to study and monitor plankton populations of the Levantine Basin on a seasonal basis.

The *Petrolina Ocean* tanker, owned by Lefkaritis Bros Marine Ltd, will be towing the CPR on its journey from Cyprus to Haifa, Israel completing a 140nm route (Fig. 3). This will be the first ever CPR tow and the first systematic survey (seasonal resolution) in open waters in the Eastern Mediterranean Sea.

The ambitious initiative is launched through the EU-PERSEUS project (Policy Oriented Marine Environmental Research for the Southern European Seas). PERSEUS aims to set up monitoring programmes in the Black and Mediterranean Seas that will provide the information needed to induce the reinforcement of those policies that will lead to clean seas by the year 2020.

The CPR is a vital part of the project for the information that the samples will provide. With the expanding global footprint of the existing CPR surveys, the Cyprus operated Eastern Mediterranean tow, is a welcome addition.

The Levantine Basin presents new challenges for the CPR. The area has been characterised as the Sahara of the oceans as it is highly oligotrophic. The bulk of nutrients flowing into the Mediterranean Sea from the Atlantic Ocean are quickly consumed in its westernmost part leaving minimum (in)organic matter to reach the Levantine Basin. From previous plankton studies we expect the amount of plankton on the CPR samples to be low but non-the-less diverse. Other interesting aims of the study will be to locate plankton hot-spots and the presence of Red Sea species as they migrate through the Suez Canal.

With an aim of launching the CPR survey in 2013, the CyI purchased CPR number 203 and the associated equipment from SAHFOS in 2012.

In addition to purchasing the necessary equipment to run a CPR survey, staff members from CyI have completed two training courses at SAHFOS.

Carlos Jimenez, an associate research scientist at the CyI, attended the SAHFOS / IMarEST CPR technical set up course at the Citadel Hill Laboratory for two weeks in July. The course covers all aspects of the logistical and technical set up of a new CPR survey.

Carlos was impressed by the running of CPR programmes at SAHFOS and particularly enjoyed the non-Darwinian evolutionary forces lurking at the SAHFOS workshop, which promoted the increase in the number of fingers needed for the CPR service and setting-up of the internal. The course finished with a pleasant drinks and nibbles celebration held in the SAHFOS workshop where Carlos received his technician's certificate.

Carlos Jimenez and Rana Abu-Alhaija practising loading the CPR mechanism

Later in the year, Rana Abu-Alhaija, graduate student at the CyI, attended a one week introductory training course in CPR processes, which covered sample retrieval, cutting, analysis methodologies and recording of results. She also attended the PCI and methodology workshops at the CPR sample analysis laboratory among other GACS members.

Rana enjoyed a full trip in the world of the CPR, meeting members of the research, analysis and technical teams.

She was amazed by the warmth and the professionalism which distinguishes SAHFOS staff and GACS members and has hence baptised them "The CPR Family".

As of writing the MV, the first Eastern Med-CPR tow, is expected to happen soon.

SAHFOS has been providing advice and assistance post course and looking forward to 2014 when we expect to have the initial results of the Med-CPR survey.

Cyprus CPR delivered to the ship

Figure 3. The proposed tow route for the Cypriot survey

The North Pacific Survey

Sonia Batten

After the eventful 2012 sampling season it was good to have a quiet, routine year during 2013! We achieved our goal of sampling the north-south (AT) transect 6 times between April and September, and the east-west (VJ) transect 3 times during spring, summer and autumn. This year the VJ was towed by the *Skaubryn* again, after a couple of years of towing from alternative Seaboard vessels, and it was good to be back! We have now completed 14 years of sampling the North Pacific, a creditable time series. All our Pacific tows are now instrumented, the AT with miniloggers, the VJ with an extremely reliable Brancker CTD-F. There are no plans to change activities in 2014, and while funding is never fully secure, sampling should go ahead as planned.

SCAR Southern Ocean CPR survey

Dr Kunio Takahashi, Director of the SCAR SO-CPR survey, c/o National Institute of Polar Research (NIPR) Japan.

Dr Graham Hosie, Deputy-Director SO-CPR, c/o Australian Antarctic Division (AAD).

Ms Karen Robinson, National Institute of Water and Atmospheric Research (NIWA), New Zealand.

2013 has proved to be one of the busiest and successful years for the Southern Ocean CPR Survey. The 2012/13 Antarctic season was the most productive season to date with more than 90 CPR tows completed. South Africa and France have officially joined the Southern Ocean survey. Peru, South Korea, India and China have expressed their interest in conducting CPR work around the Antarctic. We have been busy with a number of training and data analysis workshops, which contribute to major publications and international projects and developing a new database for easier data management and data exchange.

Field work

We anticipated that we would do up to 60 CPR tows in the 2012/13 Antarctic field season. In fact we conducted 94 tows from seven vessels from Australia, Japan, New Zealand, South Africa and France. South Africa commenced the season in July 2012 with a series of tows from their new ice breaker *MV SA Agulhas II* during its maiden voyage south of Africa. This provided rare winter samples down to the sea-ice zone. South Africa then continued with more tows from September through to May 2013, completing 19 tows in total. France started its new *RV Marion Dufresne* CPR (MDCPR) Survey completing 15 tows in the Kerguelen and Crozet region in February-March 2013. This area is north of the normal Southern Ocean CPR survey region but the work fills a gap in the southern Indian Ocean, and will complement the SO-CPR Survey tows conducted to the south. The *Aurora Australis* completed 26 tows south and west of Australia between September and February 2013, *Shirase* five tows in the same region in December and March, *Umitaka Maru* seven tows in the same region in January, *San Aotea II* nine tows between New Zealand and the Ross Sea in December and February, and *Tangaroa* completed 13 tows between New Zealand and the Mertz Glacier region south of Tasmania in February 2013. Approximately 5,400 samples were collected over ~27,000 nautical miles this season. When all 2012/13 samples are processed we have records for about 42,000 samples (equivalent of 210,000 nautical miles) as shown in Figure 4.

The 2013/14 Antarctic season commenced in October 2013 with a series of tows from the *Aurora Australis* from Hobart to the Antarctic station Davis. We expect to complete about 20 tows before the end of March 2014. *Shirase* has completed three tows already south of Freemantle on route to Syowa station. Three more tows will be completed on its return route south of Tasmania in March 2014. The New Zealand fishing vessel *San Aotea II* has departed Timaru New Zealand in December for its annual run to the Ross Sea region. Overall, we expect to complete a set of 40-50 tows during the season using vessels from Australia, Japan, New Zealand, South Africa and France.

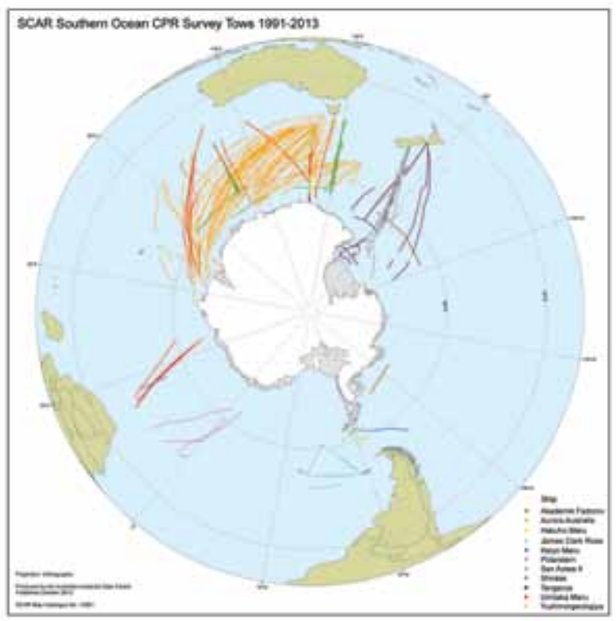


Figure 4. Southern Ocean CPR tows 1991 to 2013, including tows around South Georgia conducted by SAHFOS. Map 14261 courtesy of the Australian Antarctic Data Centre © Commonwealth of Australia 2013.

New database

For much of 2013 we have been developing a new more efficient database and an associated data portal for the SO-CPR data to better serve us. This will make data entry, access and distribution quicker and easier for all users. It will also improve the exchange of data with other international agencies and databases/portals such as the new GACS global CPR database, SCAR's Antarctic Biodiversity Information Facility (AntaBIF), Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), Southern Ocean Observing System (SOOS), Ocean Biogeographic Information System (OBIS) and the Australian Integrated Marine Observing System (IMOS). Access to the database will require registration by users. This will help us monitor usage and gather statistics which in turn will help demonstrate the importance and value of the data. Users of the data will need to acknowledge in any publication that the SCAR SO-CPR Survey and the contributing partners as owners/custodians of the data. The new database and portal will be commissioned soon. It is hosted by the Australian Antarctic Data Centre. The SO-CPR database is officially a SCAR Business Product.

Data analysis and publications

Requests for use of the data remains steady and have led to the publication of several papers in the last few years. Data have been used in various bioregionalisation analyses, and for analyses and status reports produced by GACS. In addition the data have been used for a number of chapters in the new book "The CAML/SCAR-MarBIN Biogeographic Atlas of the Southern Ocean" which will be published in 2014. One chapter is solely devoted to the analysis of the Southern Ocean CPR database to define the zooplankton biogeographic zones for the upper surface layers for each month. Four major biogeographic zones were consistently defined: a Sub-Antarctic Zone, the southern boundary corresponding closely with the Sub-Antarctic Front which also is the northern boundary of the Antarctic Circumpolar Current; an inner (southern) and an outer (northern) Sea-Ice Zones; and an Open Ocean Zone in between the sea-ice zones and the Sub-Antarctic Zone. The zooplankton species composition was defined for each biogeographic zone. While there were distinct species dominating and characterising the sub-Antarctic (e.g. *Neocalanus tonsus*) and the sea-ice (notably Antarctic krill *Euphausia superba*), most of the taxa had wide circumpolar distributions, especially the cyclopoid copepod *Oithona similis* which was abundant in all biogeographic zones. Often it was variations in the relative abundances of the zooplankton taxa that separated the near-surface assemblages more than substantial major changes in species composition between the biogeographic zones (Fig. 5).

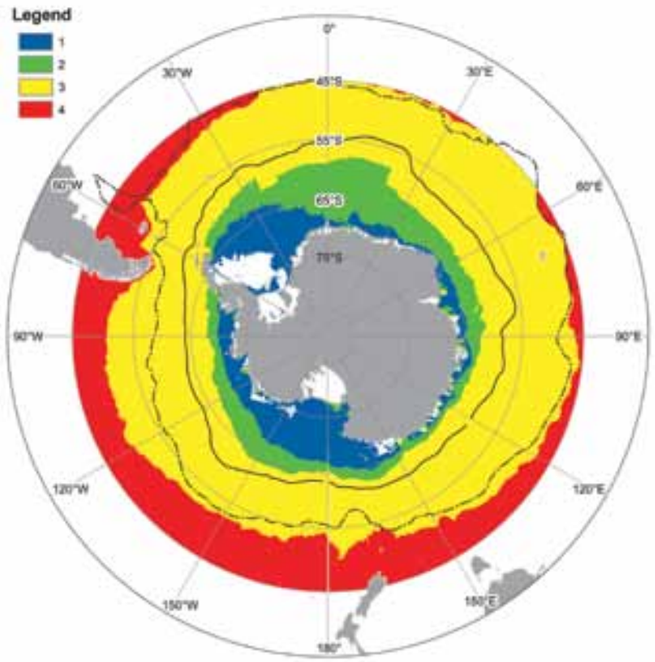


Figure 5. Zooplankton biogeographic zones predicted using Generalised Dissimilarity Modelling of the SO-CPR Database. SAZ (red) = Sub-Antarctic Zone, OOZ (yellow) = Open Ocean Zone, OSIZ (green) = Outer Sea-Ice Zone, ISIZ (blue) = Inner Sea-Ice Zone. Dashed line is the average position of the Sub-Antarctic Front. The solid black line is the maximum northern winter sea-ice extent. Figure produced Sophie Mormede (NIWA, New Zealand) and Huw Griffiths (BAS, UK).

In August 2013, NIWA hosted a data analysis workshop to compare the Ross Sea region south of New Zealand, and the eastern Antarctic region south and west of Australia. The results were interesting in showing that patterns of annual abundances and composition of copepods were different between the two regions despite being connected by the Antarctic Circumpolar Current. There appears to be a shift towards larger species of copepods in the eastern Antarctic region accompanied by a general increase in zooplankton abundance, whereas no similar patterns were observed in the Ross Sea. Instead the Ross Sea recorded much higher abundances overall. Chlorophyll *a* concentrations were also

higher in the Ross Sea region than in the eastern Antarctic area. There is also an indication that variability in zooplankton abundance in the Ross Sea region is higher than in the eastern Antarctic region (Fig. 6). Especially high zooplankton abundances occurred in December 2009 as a result of a >10-fold increase of *Fritillaria sp*. which corresponded with unusually high Chl-*a* throughout the Ross Sea. A substantial report was prepared for the New Zealand Ministry for Primary Industries (MPI) by Karen Robinson at the NIWA Christchurch CPR Laboratory. The report will be published by MPI in early 2014. The results of the workshop will also be used in a global analysis of CPR data for the GEF - Transboundary Water Assessment Programme. Dr Sonia Batten of SAHFOS is coordinating the CPR analysis (see page 44).

Following the report, the New Zealand Southern Ocean CPR survey received further funding from the MPI to continue the CPR work for another five years between the South Island of New Zealand and the Ross Sea. The continuation of this survey is made possible by the collaboration with the fishing company Sanford Limited who own the *San Aotea II*. The vessel has just departed from Timaru for the Ross Sea and is expected to return late February 2014. The vessel and its crew have been instrumental to the success of the first five years of CPR surveying in this area of the Southern Ocean.

Workshops

The SO-CPR Survey involves numerous countries with analysis conducted by experienced and well recognised plankton and Antarctic researchers albeit in several separated laboratories. Consequently, we take every opportunity when we meet to run workshops on methods and taxonomy to ensure we are maintaining the highest level of procedures and identification standards for quality control and assurance. We also regularly exchange information and images electronically. Over the last few years we have conducted a number of workshops for SO-CPR partner members in Tokyo, Wellington, UK and Rio de Janeiro. A training workshop was conducted recently at the AAD Hobart for the French programme, and we had a refresher taxonomic training session on euphausiids in Christchurch, New Zealand in November. Our aim has been to conduct at least one workshop per year. These workshops have been made possible by the Scientific Committee on Antarctic Research (SCAR) providing support through their Expert Group on CPR Research (EG-CPR) to coordinate the workshops, plus additional support from various SO-CPR partners, National Institute of Polar Research (NIPR) Japan, National Institute of Water and Atmospheric Research (NIWA) New Zealand, SAHFOS and the Australian Antarctic Division (AAD).

The next workshop will be in Cape Town in early 2014 for South African and Namibian CPR personnel, thanks to a SCAR Visiting Professor Award to Dr Hosie and the support of the Departmental of Environmental Affairs (DEA) South Africa.

Change in Leadership

In July 2012 Dr Graham Hosie took over as the Chief Officer of SCAR's Standing Scientific Group – Life Sciences. Consequently, Dr Kunio Takahashi, NIPR Tokyo has become the new CO of EG-CPR, which is a subsidiary group of SSG-LS, taking over from the previous co-Chairs Dr Hosie and Prof Mitsuo Fukuchi who has retired from NIPR. Dr Takahashi has been a very active member of the SO-CPR team, participating in numerous Antarctic expeditions, and has been leading the Japanese CPR work since 1999. He's also been an active publisher of CPR papers and served as Deputy-Director of SO-CPR during 2013.

Dr Hosie has now retired from the Australian Antarctic Division, as of December 2013, after 30 years of service and 17 Antarctic expeditions. He will now focus more on doing CPR/plankton research, and continuing his roles as Chair of both the SCAR SSG-LS and the Global Alliance of CPR Surveys. During the last year, he has been working with Dr Takahashi to take over as Director of the SO-CPR Survey. We have now swapped roles, with Dr Takahashi becoming Director of the SCAR SO-CPR Survey and Dr Hosie will continue as Deputy-Director and advisor for the foreseeable future. Dr Hosie will also continue acting as an 'Ambassador' for the SO-CPR Survey to help further develop the Survey.

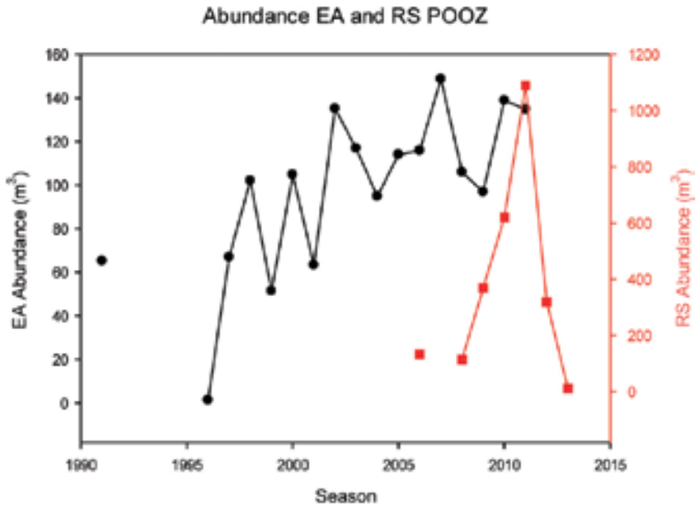


Figure 6. Mean total abundance per cubic metre for the Permanent Open Ocean Zone (POOZ) for the East Antarctic (black circles) and Ross Sea (red squares).

At the local level, the Australian component of SO-CPR will now be led by Dr Andrew Davidson of the Australian Antarctic Division. Dr Davidson is an expert in the ecology of Antarctic marine microbes, specialising in the impacts of environmental change on the microbial community, in particular the effects of UV, increasing temperature and ocean acidification. Mr John Kitchener will continue as the CPR Operations Manager and Senior Plankton Analyst at the AAD.

Final comment from Graham Hosie

I am very pleased with the current status of the SO-CPR survey. Thanks to the support, contributions and advice of the various international partners, especially the scientific staff, ships and crew who have been involved in towing CPRs in the Antarctic, you have helped me take the survey from a one man operation conducting a few tows south of Australia in 1991, to an international programme under the SCAR banner. The data are supported and recognised as one of SCAR's Business Products. We have also become an endorsed programme of the Southern Ocean Observing System (soos.aq), and a founding and active member of the GACS (www.globalcpr.org). To date we have collected about 42,000 samples (equivalent of 210,000 nautical miles) using 16 vessels from 11 nations. It's a great effort by everyone, and more nations wish to participate in CPR work around Antarctica. I now leave the leadership of Survey in the safe hands of Kunio Takahashi.

US NOAA Survey

Chris Melrose, Research Oceanographer, NOAA/NMFS/ NEFSC, Narragansett, USA

In December 2013, the U.S. CPR Survey conducted by the U.S. National Oceanic and Atmospheric Administration's (NOAA) Northeast Fisheries Science Center (NEFSC) ceased operations after 42 years due to a loss of funding. There were two long-term routes in this survey (Fig. 7). The first route crossed the Gulf of Maine and had been started by SAHFOS's predecessor in Edinburgh in 1961 before operational responsibility was transferred to NOAA. The second route crossing the shelf in the Mid-Atlantic Bight from New York towards Bermuda began in 1971.
A short-term extension of the Mid-Atlantic route crossing the Sargasso Sea to Bermuda was also conducted between October 2011 and June 2013. In close cooperation with SAHFOS, efforts are ongoing to restore sampling on the long-term U.S. CPR lines and to minimize any disruption to this valuable and unique time-series.

While the NEFSC has ceased CPR operations, its plankton monitoring work in support of fisheries management continues in the form of research vessel surveys using bongo nets. NOAA vessels perform these surveys up to six times per year between North Carolina and Nova Scotia.

NEFSC will also continue to participate in GACS in an advisory capacity and the existing CPR data and sample archive will remain available to researchers.

Daniel Smith, the CPR survey technician at the Northeast Fisheries Science Center retired in January 2014. Dan worked on the NOAA CPR survey for over 40 years. Dan was trained by SAHFOS and worked on nearly every aspect of CPR survey during his career, including CPR maintenance, loading cassettes, ship visits, sample preparation and sample analysis. He was the only staff member dedicated full time to the CPR survey at the time of his retirement.

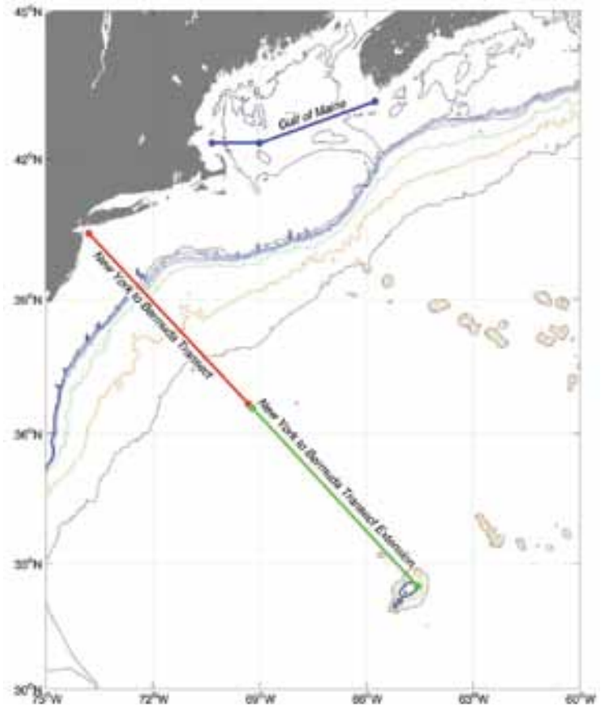


Figure 7. The three CPR routes towed by the US NOAA Survey.

A fond farewell from the US

Jack Jossi

Jack Jossi has worked at NMFS (NOAA), Narragansett in the US, and has operated the sister survey in the Gulf of Maine. After over 50 years of service for NOAA, Jack retired in 2013, and the following is a farewell piece. We would like to say a big thank you from the eastern side of the pond for all Jack's hard work over the years.

Some Fond Memories:

As a career choice in the 1960's, standardized monthly monitoring of the marine environment had its drawbacks. It was expensive, required a commitment to a relatively narrow career focus, and was especially boring to those approving research funds until someone had managed to keep it going for a decade or two. Fortunately, an example of its value existed in the thirty-plus year old CPR Survey operating out of Edinburgh. Equally important was the foresight of a group of scientists within the Bureau of Commercial Fisheries: Harvey Bullis, J. Lockwood Chamberlain, Robert Edwards, Kenneth Sherman, Paul Smith, and Paul Sund, who, by the late 1960s/early 1970s, had put together a nationally coordinated program of ocean monitoring called MARMAP (Marine Resources Monitoring, Assessment, and Prediction) that included a component using the CPR. I joined this new program in 1972 to manage the CPR program in the northwest Atlantic.

"I met people who had a zeal for long term monitoring that I had never seen before"

The first part of the job took me to Edinburgh and to Plymouth (where the CPR Survey headquarters were relocating). There I met people who had a zeal for long term monitoring that I had never seen before. They immersed me in the standards by which the Survey lived and breathed. Bill Purves and N.C. Black showed me how to bang dents out of the CPR bodies, repair gear boxes, and set the pitch on the drive impeller. Joe Scrivener showed me the art of loading internal mechanisms, and, in a small closet set aside for such things, how to cut, fold, iron (with an ironing board and iron), glue and mark CPR silks. He also shared great stories about Sir Alister Hardy, for whom he had worked. Captain John Beatson explained the ins and outs of dealing with shipping companies, the vital link to program success, and Eric Sutherland took me on a memorable ride to Glasgow to visit a volunteering ship, and taught me the importance of properly behaving when on board, and the respect and gratitude that needed to be shown to the officers and crew for their help in our mission. He also introduced me to nearly every pub on the way home to Edinburgh. John Roskell made sure I was acquainted with the techniques for charting and navigating the continuous record of plankton. Harry Hunt briefed me on their data processing techniques, and prepared their software, making it very easy to set up on our computer back home. Michael Colebrook patiently elevated my weak statistical skills to an acceptable level, and gave me still-used ideas about analysis. Michael and his wife invited me to their home, with its beautiful garden, and shared dinner with me. Gerry Robinson, Vernon Bainbridge, L.T. Jones, Bob Williams, Dora John, and Gordon Cooper taught me the skills necessary for identifying waffled plankton. Gerry and his wife invited me to their home, took me to watch their son sailing, and on a tour to the border castles, which were a favourite of theirs. Ro Glover educated me on the politics of science, his ideas for us both expanding the Survey in the North Atlantic, offered wonderful anecdotes about Sir Alister Hardy, and treated me to lunch at an inn on Dartmoor, near where my maternal grandfather grew up. The help of these people was what made my stumbling efforts to build a CPR survey in the US, a success. Some of these people are gone now, but I will never forget their skill, enthusiasm, generosity, and graciousness.

"We shared great stories about Sir Alister Hardy"

After over forty years since that visit, a small multitude of people and institutions have aided in its continuance. First, the volunteering ships must be mentioned, who made the hundreds of tows that build our data base. Many a trip to Boston and Gloucester met with ships coated in ice from a tough crossing, but never a complaint was heard for having towed the CPR. We are forever grateful to the officers and crews of the ships run by Eimskipafelag, Icelandic Steam Shipping Company, Reykjavik, Iceland; by the United States Coast Guard; by Caribou Seafoods, Burgeo, Newfoundland; and by Hapag-Lloyd (America) Inc.

Over the years, our dependence of the CPR Survey (now SAHFOS) staff didn't seem to diminish. It involved help in determining why the plankton was on the outside of the silk when unrolled from the take-up spool, in developing a commercial standard for 'phytoplankton colour', in recovering from the withdrawal from production of Swiss bolting cloth, in correcting for strays from analysis methods that we mistakenly had thought were a good idea, in finding reasons for poor internal mechanism performance, in finding or borrowing equipment, in wondering how to study day and night samples without bias, in locating cooperating shipping companies, etc., etc. Our countless requests for help usually started with Roger Barnard, Sonia Batten, Clare Buckland, Martin Edwards, Tony John, David Johns, Tanya Jonas, Peter Pritchard, Chris Reid, or Marion Smith, but probably impacted many others-- Tony, Chris, and Peter bore the brunt of it. The response was always the same: Friendly, courteous, and professional. They put us back on track, and made us feel good for having bothered them.

"I visited the ships that towed the CPR and was taught the importance of properly behaving when on board, I was also introduced to nearly every pub on the way home!"

After the late 1990s, sample analyses were shifted from Narragansett to the Zaklaad Sortowania I Oznaczania Planktonu in Gdynia, Poland. This long distance operation has proved to be very successful, thanks to Leonard Ejsymont, Tomasz Linkowski, Wanda Kalandyk, and especially to Hanna Skolska and Katarzyna Kohnke.

The list to be recognized at Narragansett is very long, including summer students, volunteers, ex- bank managers, reporters. I hope they all remember the hard work they did, as much as I remember how important their efforts were to us. A few names must be mentioned. Robert Marak and John Colton, who had used CPR's in the Gulf of Maine in the 1950's to collect fish eggs and larvae contributed greatly to the early years of the program at Narragansett. William Brennan who delivered CPR's to ships for us before he went on to become Director of the National Marine Fisheries Service. Steven Cook who joined us, bringing with him the Ships of Opportunity Program, which was making physical oceanographic measurements from merchant ships in the North and South Atlantic and Gulf of Mexico. Carolyn Griswold and Kevin Thomas, who made more computer runs and produced more graphics than anyone should be expected to do. Chris Melrose and Jon Hare, who more recently have joined the survey and who are applying technology and fresh ideas that have been needed for a long time.

Last, but by far not least, I want to express my thanks to Robert Benway, Julien Goulet, and Daniel Smith. Until his recent retirement, Bob ran the survey like a fine watch. There was not a detail he didn't worry about, a gesture to a ship's captain and crew that he forgot about, or a loose end he didn't tend to. As good a friend and right-hand-man as one could ask for. Given the simplest or most complex problem, Julien Goulet became silent, went to the blackboard, and produced the equations that settled the issue. His English was all right, but his mathematics were superb. Daniel Smith, in the early years produced the plankton data from hundreds of CPR cruises, maintained the towed bodies and loaded, and still loads, the internal mechanisms, and has logged so many miles on interstate-95 between New York and Boston, that the highway should be named after him. His corporate memory has saved the day many times.

It has been a privilege to have known and worked with you all. Thank you.

Jack W. Jossi

Narragansett, RI 18 September, 2013

Information Technology

Darren Stevens, Alec Colebrook-Clark and Scott Calnon

SAHFOS launched the latest version of CPR Console, in January 2013, providing over 150 improvements. Console development during 2013 had been on hold, primarily due to staff changes; Mike Flavell left SAHFOS to take on the role of Database Manager for OBIS (Ocean Biogeographic Information System) at UNESCO in April, and Scott Calnon joined SAHFOS in September, from EDF Energy.

The IT team took this opportunity to take stock of the situation, checking current operating systems, server proliferation, and planning for the future. This allowed for a planned and controlled removal of Windows XP operating systems (ahead of schedule) from the network prior to the support being withdrawn from Microsoft, controlled and managed upgrading of Linux servers to the current long-term support version of Ubuntu and future standardisation for open source operating systems. In addition, it allowed for the planning, financial management and agreement of a robust testing and development environment for software development and network testing (to be implemented in 2014). The software for monitoring staff time also proved inadequate (due to software issues) at the beginning of 2013, so this software was also upgraded.

2013 gave the IT team the opportunity to use the programs developed in 2012 to provide data for internal research. This proved very successful with the entire dataset processed into a useable format within 48 hours of the full year's worth of CPR data being available (including testing for consistency). Subsequently, these programs have been re-used to provide data to our PhD students and Research Fellows, having a positive impact on the productivity of the IT team.

Since Scott has joined the team we have been able to give more time to the development of the instrumentation database. The initial aim was to make the historical data collected more accessible before investigating more efficient procedures for linking currently collected data with CPR data. This work is progressing and we hope to implement an initial product during 2014.

Confluence

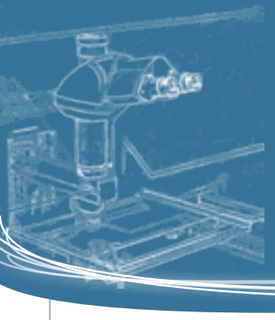
In collaboration with the MBA, and with the generosity of Atlassian Software, SAHFOS led the introduction of Confluence across the Citadel Hill site. Confluence provides an online centralised location for common documents, as well as providing a historical document management system. Under discussions with both SAHFOS and the MBA management teams we were able to develop a system that provides a clear structure for storage of procedure documents, Health and Safety documents, internal forms and minutes of meetings plus other documents. Thus far the solution has been well received and people are looking for ways to improve its use, i.e. contract document management.

Resource Space

Resource Space, a web-based image repository that stores all of SAHFOS's images and available online at //192.171.193.52/resourcespace/ is now available to external users. The system requires registration, with many of the images freely available to download for publicity material or publications, provided the citation is included. The majority of the images in the system are of plankton and the metadata information includes the WoRMS Aphia ID (unique ID number from the World Register of Marine Species www.marinespecies.org) providing an easy way to link the image to more detailed taxonomic information and subsequently through to OBIS (//www.iobis.org/) for geospatial and temporal information on the taxa. The facility is provided by Montala, using ResourceSpace software under an open source license www.resourcespace.org.

Datacite

SAHFOS has now subscribed to the Datacite Digital Object Identifier (DOI) system, managed by the British Library. Thanks must be given to the British Library for hosting a series of free workshops about DOIs that have helped enormously with our planned integration. This means that all data requests for CPR data, will now be issued with a DOI, which is a recognised way of citing datasets. This will make CPR data more discoverable and easier to reuse in the future. All 2014 data requests will have a DOI.



Analysis

David Johns and Tanya Jonas

Analysis

During 2013 there were 5641 samples analysed by the team, (Figs. 8 and 9) the highest in the history of the Survey. Despite this record number, sample analysis was completed at its earliest point of the year. All that remains now before the release of the 2013 dataset is the completion of all the quality control and assurance procedures we have in place for the production of our dataset.

SAHFOS, throughout its operations in the world's oceans, records over 300 phytoplankton taxa, and almost 500 zooplankton taxa. The majority of these taxa have been recorded for many years, but with new areas being surveyed, new species arriving and new research ideas appearing, the list is dynamic and new taxa can be added. At the end of 2013 it was decided that a number of Tintinnid genera would now be enumerated (in addition to those already counted), and due to the ongoing research into ocean acidification, 8 coccolithophore taxa would also be included (see page 33). We hope to report on the distribution of these new taxa soon.

SAHFOS is involved in the European Marine Observation and Data Network, EMODnet, and in 2013 the analysis team undertook a project to assign biological traits to as many plankton taxa as was possible. In total, over 6700 traits (such as feeding method, habitat, spawning method etc.) were assigned to almost 400 taxa. This is part of a larger project, collecting such information for many ecosystems. The work highlighted not only the diverse nature of plankton, but how little is known about a great many of the taxa that are routinely recorded, and produced as many new questions as answers.

Staff

The Analysis Department's new staff structure is proving effective and the everyday running of the laboratory is much improved. David Johns and Claire Taylor manage the laboratory and analysis programme, and Jennifer Skinner, managed by Claire, has undertaken the role of Laboratory Assistant since January (while continuing her part-time work as CPR Analyst). Tanya Jonas and Marianne Wootton are now able to give more time to quality control, training and taxonomic matters.

In November, Maria Campbell left SAHFOS to join her husband in the US. Maria had been working as a CPR Analyst since 2005 and had also undertaken a PhD studying deep-sea corals. She has analysed more than 2000 samples from the North Atlantic and North Pacific. Retaining her enthusiasm for all aspects of marine science, she hopes to continue promoting SAHFOS.

Clare Buckland, an Analyst since 1999, started maternity leave in December, shortly before the birth of her son William. Clare was also the Education Officer for SAHFOS, promoting the Foundation through her work with schools, universities, education web pages and the work experience programme. Clare's experienced analyses of North Atlantic, Pacific and South Atlantic samples are greatly valued, and her fellow Analysts are looking forward to her return to the Team next December.

In December 2013, 14 CPR analysts (12 employees and 2 contractors) were working at the Plymouth Laboratory. We will appoint a new Analyst in January to ensure we meet future analysis commitments and enable us to make the proposed improvements to our quality assurance.

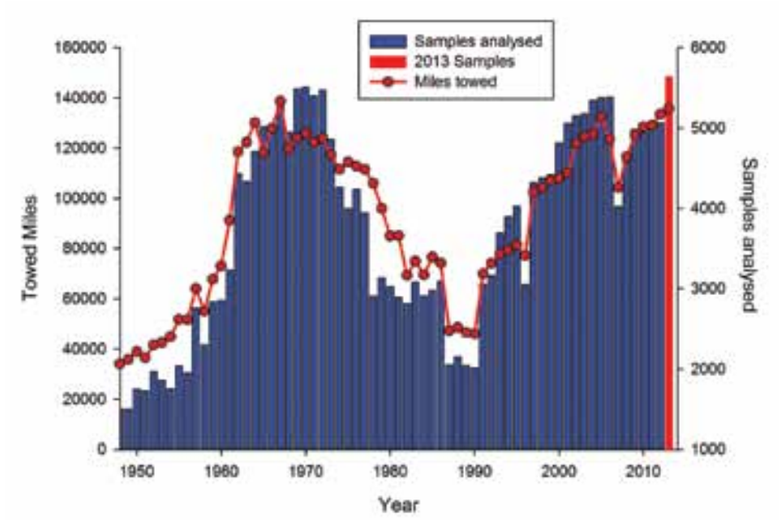


Figure 8. Miles towed and samples analysed since the inception of the CPR Survey in 1931.

Training

During 2013 we conducted 24 training sessions at the SAHFOS laboratory, some internal for all analysts, others for individual needs or tasks, some for the whole GACS community (see GACS training workshop, page 34). Training was varied, covering taxonomic questions such as the speciation of calanoid copepods and *Neoceratiaceae*, sample processing, record keeping, analysis methodology and recording of microplastics. We also organised a couple of lively quizzes. Rob Camp, Astrid Fischer and Usha Jha completed their training in Pacific plankton. They are now analysing samples from that area as well as from the North Atlantic. Two members of staff attended external training courses. Tanya Jonas, the Amphipoda families course, run by Marine Ecological Surveys Limited in Bath (see page 29) and Marianne Wootton, the zoological nomenclature course, organised by the Distributed European School of Taxonomy and held at the Muséum National d'Histoire Naturelle, Paris.

In 2013, two staff from the Cyprus Institute, Rana Abu-Alhaija and Carlos Jiminez, joined GACS. They propose a CPR tow from Cyprus to Israel so, following the GACS workshop in September, we gave Rana a one-week introduction to running various aspects of a CPR survey. She will return to SAHFOS in 2014 to complete training in analysis.

When Graham Hosie visited in April, he tutored us in the identification of South Atlantic euphausiids, a group of particular significance in the region. Peter Ward (British Antarctic Survey) added to our knowledge when he visited us in October for an informal training session on South Atlantic copepods and euphausiids.

Console and Data Availability

Since 2008, Console has been SAHFOS's interface for tow and analysis data entry. February 2012 saw the implementation of a major upgrade to the system with over 150 improvements, thanks to a couple of years of hard work by our Database Manager, Mike Flavell. Two of the developments – the automatic totalling of counts of some taxonomic groups and cross-referencing of data – have enhanced our quality control. Mike departed for pastures new in March, and we are very grateful for his efforts to complete the upgrade in time. Later in the year, Scott Canlon replaced Mike and more improvements to Console will follow.

The 2012 quality-controlled core North Atlantic and Pacific data were available on 6 August 2013 – the earliest date yet achieved for the release of a previous year's data. We also released the North Atlantic data for the ocean acidification contract a full month ahead of schedule.

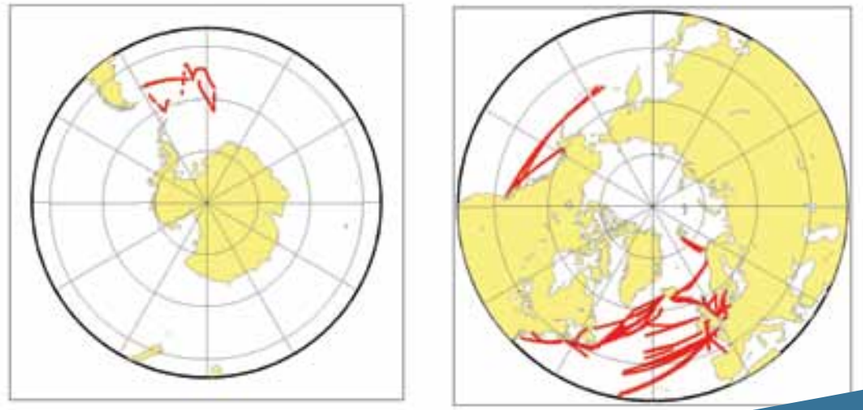


Figure 9. 2013 CPR sample map, showing Northern and Southern Hemispheres.

Taxonomy

Interesting and unusual biodiversity records in 2012/2013

Marianne Wootton

Phytoplankton

Neoceratium breve, a warm water dinoflagellate, was recorded on an August 2013 sample from the mid-Atlantic. The CPR survey identifies over 40 species belonging to the *Neoceratium* genus, however this particular species has only previously been recorded four times in the survey.

Zooplankton

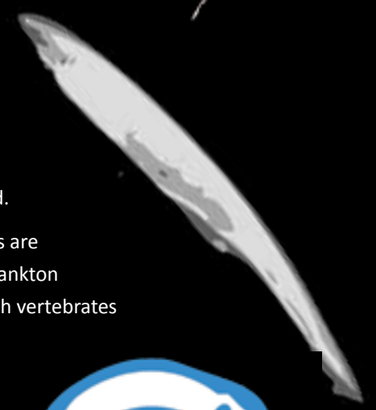
The CPR analysis team has added a new species to the list of planktonic organisms found in the North Atlantic survey - *Aetideus acutus* - a type of microscopic crustacean, which belongs to the subclass copepoda. A specimen of *A. acutus* was found on a warm water oceanic sample from November 2012. Although there are some previous records of *A. acutus* in this region, it is the first time it has been found on a CPR sample.

In 2013, unprecedented numbers of juvenile *Branchiostoma* were found in the North Sea, off the northwest coast of Denmark. *Branchiostoma*, sometimes known as lancelets, are regularly recorded in North Sea CPR samples in low numbers. However, in August the highest abundances ever recorded in the Survey, many hundreds per sample, were observed.

Branchiostoma are peculiar and interesting organisms, which resemble primitive fish. Adults are typically 5cm in length and are benthic; however, larvae are known to migrate up into the plankton and surface waters in late August. Possessing anatomical and genomic characteristics of both vertebrates and more primitive organisms, they have frequently been used to study the evolutionary transition from invertebrates to vertebrates.

CPR sampling can damage soft bodied organisms, such as jellyfish, rendering them unidentifiable to species level using standard microscopy techniques. In August 2013, vibrant blue pieces of Cnidaria (jellyfish) material were found on a sample off the coast of Hull, England, in the North Sea. The piece of gelatinous material found on the sample was so distinctive in colour it was able to be identified as *Cyanea lamarckii*, commonly called the Blue Jellyfish, by our Cnidarian expert. *C. lamarckii* is a common visitor to the North Sea and typically feeds on plankton.

Heterophryxus appendiculatus, a parasitic isopod crustacean that infests euphausiids (krill), was found on a sample taken from the northeast coast of the USA in October 2012. *Heterophryxus* differ in appearance to their other isopod relatives, as they possess modified legs, which allow them to clasp onto and feed from the head region of their host. The CPR survey began recording these gruesome parasites in 2003 and has since recorded them nine times.



Amphipoda

Tanya Jonas

Crustaceans of the suborder Amphipoda form an important, highly diverse, group found in marine, freshwater and terrestrial habitats. There are more than 6,000 species, assigned to more than 100 families. Most are aquatic, benthic organisms, with about 400 species, mostly of the suborder Hyperiidea, being truly pelagic, inhabiting all latitudes and depths of the seas.

The classification of Amphipoda has been in a state of flux for some time and has recently undergone a major review with the creation, in February 2013, of a new suborder, Senticaudata, which now includes a number of families from the traditional suborder Gammaridea as well as two demoted suborders, Corophiidea and Caprellidea.

Given these changes, and as SAHFOS have undertaken to produce a guide to North Atlantic and North Sea plankton, it was timely that in early 2013, Tanya Jonas attended a two day course on the identification of Amphipod families. The course, concentrating on the suborder Gammaridea, was run by Marine Ecological Surveys Limited (Bath), a company established in 1975 to conduct benthic and epibenthic surveys in marine habitats. Twelve participants attended, all from the UK and Europe, with most having an interest in benthic surveys or taxonomy. It proved to be an excellent opportunity, not only to hone identification skills for gammarid and hyperiid families, using features common to both groups, but also to meet other biologists working with those taxa. Fortunately, even with the recent changes to classification, the traditional shortcuts to identification of gammaridean amphipods are still applicable.

For amphipods, the SAHFOS Plankton Guide deals mainly with the suborder Hyperiidea, though a very small section covers other suborders. Hyperiids are exclusively marine, contributing majorly to the planktonic biomass, particularly in cold-water regions, where they may swarm and be eaten by large predators including whales, seals and fish. Hyperiid characteristics reflect individual species' lifestyles—body shape is extremely variable (from globular to needle-like), eyes may cover the entire surface of the head or be absent and the body integument may be coloured, thick and tough or transparent and thin. Many hyperiids are parasites or commensals of gelatinous zooplankton such as medusae, siphonophores, ctenophores and salps, so correct hyperiid identification may aid recognition of associated gelatinous organisms, few of which survive the CPR collection process in an intact state.

Identifying *Calanus* species in the North Atlantic CPR survey

Usha Jha, Astrid Fischer and Marianne Wootton

One of the dominant crustacean genera that we identify in North Atlantic CPR survey is *Calanus*. It is a herbivorous calanoid copepod, which grazes mostly on phytoplankton. Members of the *Calanus* genus are an important food source for juvenile stages of economically important fish (e.g. cod, haddock, herring and mackerel). Some *Calanus* species, *C. hyperboreus* in particular, are very rich in lipids (oils). This high energy content, coupled with the high abundance of *Calanus* in the northern North Atlantic, makes *Calanus* an important and nutritious prey item for many planktivorous organisms.

In the North Atlantic there are four species of *Calanus*, each being an indicator of a different water types: *C. hyperboreus* is associated with deep arctic waters; *C. glacialis* is an indicator of arctic shelf waters; *C. finmarchicus* indicates boreal (sub-arctic to temperate) waters; and *C. helgolandicus* can be found in temperate to subtropical waters. Therefore, by mapping the spatial and temporal distribution of *Calanus,* it is possible to monitor, observe and potentially predict the response of plankton to climate change scenarios. For this reason, the correct identification of the various species of *Calanus* is critically important.

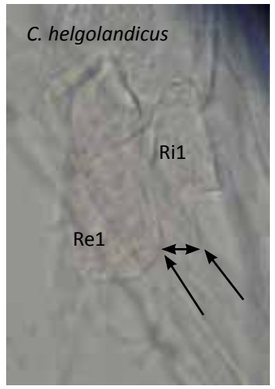
So, how do we differentiate between these ecologically important species? *C. hyperboreus* is easily distinguishable from its other sister species, as it is large in size (up to 10 mm

By identifying and mapping the distribution of different Calanus species, it is possible to monitor, observe and potentially predict the response of plankton to climate change scenarios.

in length) and has a characteristic spine on the end its body. The smaller (2-6 mm) trio of *C. glacialis, C. finmarchicus and C. helgolandicus* however, are all very similar in shape and size. *C. glacialis* adults can be separated by size, genetic, or molecular techniques. *C. finmarchicus* and *C. helgolandicus* can readily be separated by using morphological features on their fifth pair of swimming limbs. Characteristics on the fifth swimming leg, commonly called the P5, are used to identify adult or pre-adult (CV) developmental stages of *C. finmarchicus* and *C. helgolandicus* and can be seen in Figures 10 and 11.

To encourage and maintain high standards, plankton analysts at SAHFOS are required to undergo regular refresher and comparison training exercises. In July 2013 all our analysts participated in an internal training session on the identification of *C. helgolandicus, C. finmarchicus* and *C. glacialis*.

Figure 10. In adult females and CV *Calanus,* the shape of the toothed border on the base segment, called the coxa, of the P5 can be used as an identifying feature. In *C. helgolandicus* the toothed border is concave and in *C. finmarchicus* the border is straight. This feature cannot be used for adult males, as in both *C. finmarchicus* and *C. helgolandicus* the males have concave teeth. The pictures are taken from CPR samples.



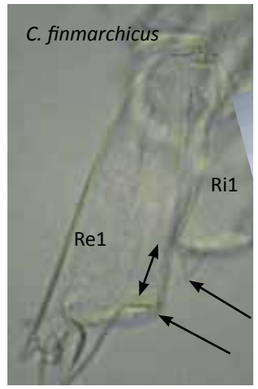


Figure 11. P5 identification features used by the SAHFOS CPR Survey to identify *C.helgolandicus* and *C. finmarchicus.* In *C.helgolandicus* the spine on the first endopod segment (Ri1) reaches the inner distal end of the first exopod segment(Re1) In *C. finmarchicus* and *C. glacialis* the spine on the first endopod segment (Ri1), does not reach the inner distal end o the first exopod segment (Re1).

Calanus Distribution

Marianne Wootton

Two of the most common copepod species to occur in North Atlantic CPR samples are *Calanus finmarchicus* and *Calanus helgolandicus.* Although almost identical in appearance, they inhabit two different niches, appearing to have two distinct thermal tolerances. *C. finmarchicus* prefers cooler subarctic waters whilst *C. helgolandicus* prefers warmer temperate waters. In CPR samples *C. finmarchicus* is abundant to the south and west of Norway and also dominates the planktonic copepod fauna off the northeast coast of America. In contrast *C. helgolandicus* is typically associated with temperate European shelf-edge waters. However, in the winter of 2012 small numbers of *C. helgolandicus* began to be found off the east coast of the USA, from southern Delaware to southern Newfoundland (Fig. 12). The abundance of *C. helgolandicus* increased in January 2013 and persisted in this region until May.

C. helgolandicus is known to occur off the east coast of North America, and the CPR survey does have records of its presence in this region. However, records are rare and the last time *C. helgolandicus* was observed in these CPR samples was 13 years ago.

Calanus hyperboreus, the larger cousin of *C. helgolandicus* and *C. finmarchicus*, is endemic to Arctic waters and is regularly found on northerly North Atlantic CPR samples. Occasionally this species is found in our North Sea samples and in April 2013 it was recorded off the northwest coast of Denmark (Fig. 13). This is the most southerly record of *C. hyperboreus* to be found in North Sea CPR samples.

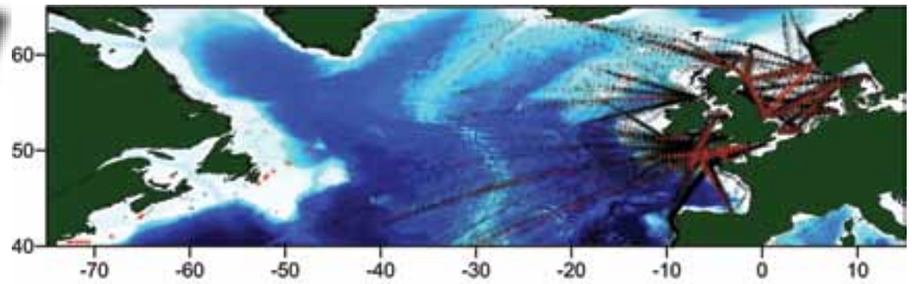


Figure 12. *Calanus helgolandicus* distribution in the map area – 2013 records are in red (note West Atlantic records)

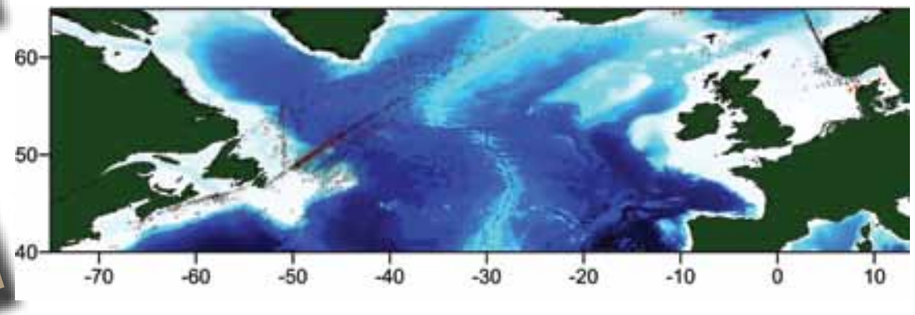


Figure 13. *Calanus hyperboreus* distribution in the map area – 2013 records in red (note east North Sea records).

Alien species in the survey

Usha Jha and Marianne Wootton

The North Atlantic CPR survey has a strong history of detecting and monitoring non-native plankton taxa, for example the phytoplanktonic diatoms *Odontella sinesis* and *Coscinodiscus wailesii*, and the zooplanktonic water flea-like *Penilia avirostris*.

In December 2011 the CPR survey identified its first *Pseudodiaptomus marinus* (Fig. 14), on a sample from the R route transect which tows between the Hook of Holland and Felixstowe, in the southern North Sea. A month later the Survey received some mystery copepod specimens, from the Leibniz Institute for Baltic Sea Research plankton group, also collected in the winter of 2011, from the German Bight. The CPR team identified these unusual copepods as also being *P. marinus*. The identification of these specimens has subsequently been confirmed by Chad Walter, who is considered an expert in the *Pseudodiaptomus* genus.

P. marinus is a small calanoid copepod, a type of microscopic crustacean, which is native to East Asia. Over the last 50 years it has spread across the Pacific to the west coast of the USA and, in 2007, was reported in the Mediterranean, its first record in European waters.

Pseudodiaptomus is a highly diverse demersal genus containing over 70 species and although circumglobal in distribution, throughout tropical and temperate coastal waters, only a handful of species have relatively recently been observed in the North East Atlantic.

It has been suggested that in 2010 *P. marinus* was first brought to the southern Bight of the North Sea and Calais harbour by ballast water, possibly via cable ships. In CPR samples *P. marinus* has persisted in late autumn/winter for the last 2 years and during this time has spread northwards, from the southern North Sea to the southern Skagerrak. Studies of previous geographical records suggest that this microscopic alien is able to tolerate a wide range of temperatures and salinities, indicating the likelihood of further spread into the North Sea and potentially the Baltic.

Read more: Jha, U., A. Jetter, J. A. Lindley, L. Postel and M. Wootton (2013). Extension of distribution of *Pseudodiaptomus marinus*, an introduced copepod, in the North Sea. Marine biodiversity records 6: e53, doi:10.1017/S1755267213000286

P. marnius, a copepod native to East Asia, was first identified on CPR samples in December 2011 in the English channel

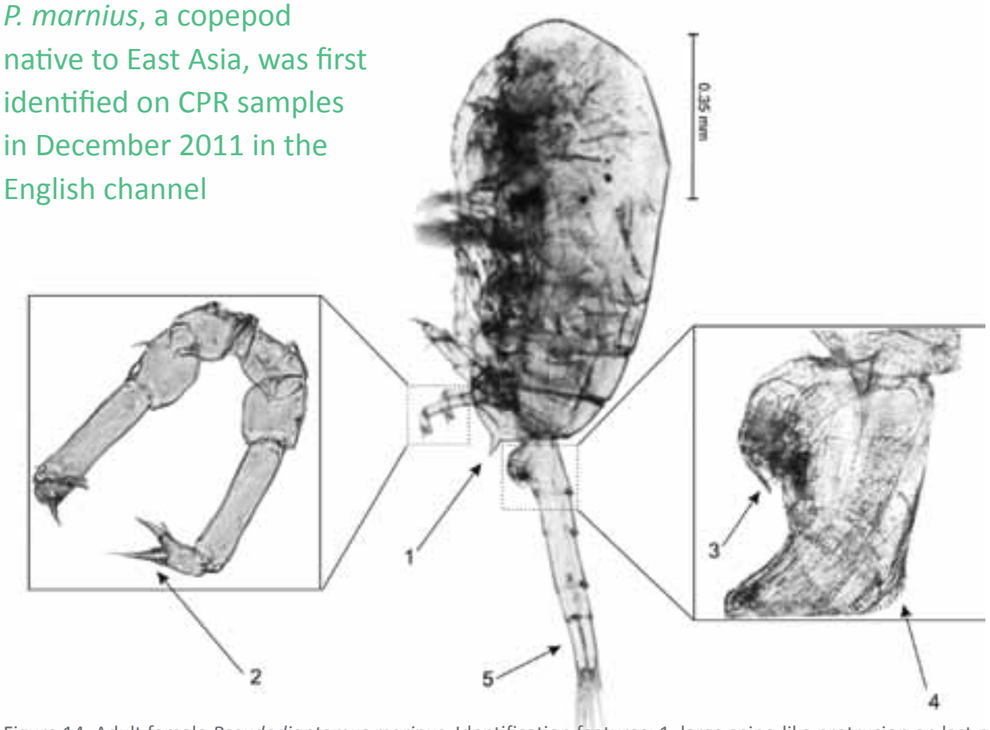


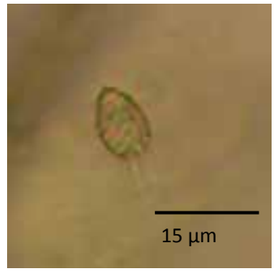
Figure 14. Adult female *Pseudodiaptomus marinus.* Identification features: 1, large spine-like protrusion on last prosome segment; 2, elongate fifth pair of limbs with pincer; 3, swollen genital segment with flange; 4, rows of denticles; 5, elongate caudal rami.

Coccolithophores and the CPR Survey

Gemma Brice

Coccolithophores are tiny, spherical-ovoid shaped haptophytes rarely exceeding 30µm but usually <10µm. They have a worldwide distribution, almost exclusive to the marine environment with their highest diversity in the euphotic zone. Their major identification feature is their calcium carbonate plates (termed coccoliths). Their presence on CPR samples has been recorded since 1965, and enumerated since 1993. Despite having a mesh size of approx 300µm, considerably larger than most coccolithophores, they are caught none the less. They preserve well and are able to withstand the sampling of the CPR.

Historically, identification to a higher taxonomic resolution has not been part of routine analysis, but after investigation and training sessions, using subtle differences our analysis team are able to identify several species under light microscopy. From January 2014 SAHFOS's data will include the speciation of the following Coccolithophores caught by the CPR.



Acanthoica quattrospina
Lohmann, 1903

7-13µm long, 6-9.5µm wide

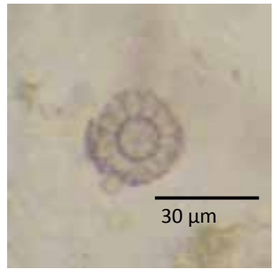
Dimorphic species, 4 spines protrude at the polar end, 2 long, 2 short. Spineless coccoliths over the rest of the coccosphere. Slightly elongated.

On CPR cells tiny and faint

Coccolithus pelagicus
(Wallich) Schiller, 1930

Up to to 32µm diameter

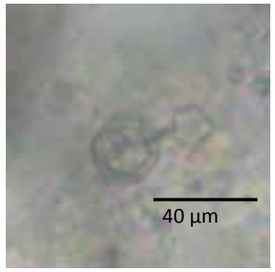
A large distinct coccolithophore with easily visible overlapping dark liths.



Discosphaera tubifera
(Murray & Blackman) Ostenfeld, 1900

Cell 15-20µm trumpets 5-7µm

Large trumpet-shaped protrusions from a spherical cell with uniform liths which overlap.

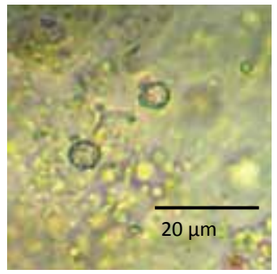


Braarudosphaera bigelowii
(Gran & Braarud) Deflandre, 1947

12-16µm diameter

A distinctive regular pentagonal dodecahedron covering 12 tightly joined pentaliths that fit together.

Sole species in genus, thought to possibly be resting cyst.



Emiliania huxleyi
(Lohmann) Hay & Mohler, 1967

5-8µm diameter

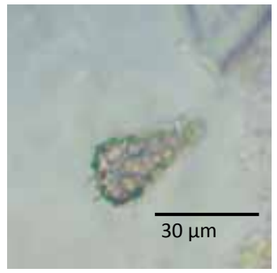
A small dark irregular jagged circle, liths often are detaching and hence give jagged appearance.

Looks like a cauliflower on CPR!

Rhabdosphaera claviger
Murray & Blackman, 1898

10µm-12µm diameter

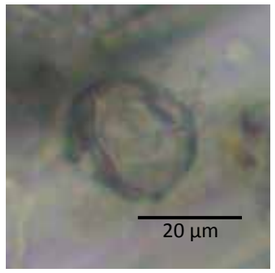
Spherical cells with covering of plates of which some protrude long spines.



Syracosphaera pulchra
Lohmann 1902

12-39µm diameter

Variable cells, often elongated or 'strawberry –shaped' produce different liths to cover surface. Liths are next to each other not overlapping. Outline with a distinct flagella area.



Scyphosphaera apsteinii
Lohmann, 1902

20-25µm diameter of cell body
Lopadoliths 7-25µm long

Large Lopadoliths with longitudinal ridges surround cell, often missing on CPR samples.

All images of Coccolithophores are from CPR captured silks.

GACS workshop for analysts

Marianne Wootton

As SAHFOS hosted the annual meeting of GACS in September 2013, the most was made of the partners' presence in Plymouth to run a workshop for CPR analysts as soon as the meeting finished. We were able to bring together representatives from the United Kingdom, Canada, Japan, Australia, South Africa, India and Cyprus. The main aim of the workshop was to: ensure a level of consistency within and between the different surveys; prevent skills drift; and encourage communication between analysts from the different regions. Practical sessions and discussions were held on: analysis methodology; standardising the identification and recording of microplastics; identification, confirmation and knowledge sharing on the phytoplankton Neoceratium genus and coccolithophorid group; and Phytoplankton Colour Index (PCI) assessment verification.

Plastic fragments or fibres of less than 5 mm are termed microplastics. They may originate from the breakdown of larger pieces of plastic, or may come from human effluent in the form of synthetic fibres. The increase in plastic pollution is of concern to marine scientists, as plastic persists in the environment, with so far uncertain consequences, and numerous organisms are known to ingest the small particles. Saeed Sadri (a SAHFOS PhD student) gave a presentation about his work on the microplastics found on SAHFOS samples. He also addressed issues regarding contamination and recommended some ways in which the surveys might record and monitor microplastic pollution in the future. A group discussion led to the decision that, in an ideal world, the following should be recorded: type of plastic, abundance of fragments/fibres, size range, and colour. These factors were seen as easily identifiable and of potential use for further research into the increase of plastic pollution and into the main sources of plastic in the plankton. They would also be relevant for those studying the transfer and availability of microplastics to different trophic levels. SAHFOS 'Resource Space' (a web-based digital asset management programme) was demonstrated as a method of documenting images of the plastics found on CPR samples and sharing them with the GACS' partners.

Neoceratium and coccolithophore sessions included the identification verification of several species, common to many surveys, and a sharing of frequent identification problems and tips. Identification validations, between and within the different surveys, were made for eight species of *Neoceratium*, the genus *Ceratocorys* and three species of coccolithophore. Verification exercises like these are useful quality assurance events and ensure that the same organism is identified and known by the same taxonomic name by different analysts, thereby promoting best practice.

Phytoplankton Colour Index (PCI) is a simple visual assessment used to estimate the amount of photosynthetic pigment present on a sample, thereby alluding to an amount of primary productivity. Claire Wotton gave a presentation on the processes involved in sample cutting and PCI determination. 11 PCI assessors were then invited to allocate PCIs along the length of a towed silk (from the English Channel). Assessors came from different surveys and their experience varied from the SAHFOS 'gold standard' to complete beginners. Although one would expect variability, this was mitigated by a very encouraging agreement as to the strength of colour, showing that consistency is achievable within and between surveys.

Marianne Wootton (SAHFOS, UK); Saeed Sadri (University of Plymouth/SAHFOS PhD student, UK); Nagappa Ramaiah (CSIR – National Institute of Oceanography, India,); Hans Verheye (Department of Environmental Affairs, South Africa); Rana Abu Alhaija (The Cyprus Institute, Cyprus); Frank Coman (Commonwealth Scientific and Industrial Research Organisation, Australia) ; Sanae Chiba (Japan Agency for Marine-Earth Science and Technology, Japan).

Photo Credit Tim Mackie

The National Marine Biological Analytical Quality Control Scheme (NMBAQC)

Astrid Fischer and David Johns

SAHFOS has been hosting the Secretariat of NMBAQC for a few years now. NMBAQC (www.nmbaqcs.org) aims to promote quality assurance in biological marine sampling, and includes components on benthic invertebrates, fish, macroalgae and phytoplankton, as well as particle size analysis. Each component has its own set of training exercises and assessment modules, but it is not an accreditation scheme.

"NMBAQC aims to promote quality assurance in biological marine sampling"

NMBAQC sets standards for quality assurance and helps to ensure these standards by the provision of ring tests and Best Practise guides. In 2013 David Johns took on the role of the Chair, Astrid Fischer is currently the Technical Secretary to NMBAQC. Further committee members are drawn from the UK marine competent monitoring community, with most members' contract managing a specific component of the scheme, as well as a number of external contractors on the group. The scheme is managed primarily by the Environment Agency.

NMBAQC was tasked by the Healthy and Biologically Diverse Seas Evidence Group (HBDSEG) to ascertain if there were gaps in quality assurance for biological datasets likely to be included in the development of indicators for the forthcoming Marine Strategy Framework Directive. Two of the identified gaps are currently being addressed. Firstly, epibiota, organisms that live on the surface of the seabed, currently studied usually with video imaging of benthic substrates and identification of habitats and species. There is a great need for setting standards, and previous ring tests performed by NMBAQC have shown the large variance in methods used, quality of data and interpretation of results. In order to make a good assessment, good quality data are required, and a workshop organised by Natural England at the Plymouth University stressed the need for standards in methodology and data analysis. NMBAQC is now working on a Best Practise Guide for the epibiota component (led by JNCC), and aims to set up further ring tests in the future. All competent monitoring agencies will help draft the final document so that a uniform working method can be used and future samples are more comparable.

The second component to be identified lies closer to the heart of SAHFOS - zooplankton sampling and identification. The only existing zooplankton standard is related to water quality. In early 2013, NMBAQC sent out a questionnaire Europe-wide on zooplankton analysis to gauge interest in creating a new zooplankton quality assurance best practice. The results from the questionnaire show that most laboratories only have a very limited number of analysts, therefore internal cross-checking on challenging species would be done via photos or by sending samples away. Zooplankton analysis is generally carried out to investigate ecosystem functioning, biodiversity assessments and as part of long-term monitoring programmes. Most laboratories use plankton nets and light microscopy for identification to the lowest possible taxonomic level. There is a general interest in quality assurance for zooplankton analysis, providing it is in the right format. This reinforces that it can be difficult to identify zooplankton to species level, and therefore a scheme that assists in this could well be beneficial to many groups. NMBAQC is now in the process of collaborating with essential partners, such as the ICES Working Group on Zooplankton to come up with a Best Practise Guide. In 2014 it is anticipated that SAHFOS will initiate a small-scale ring test between UK zooplankton monitoring groups as a first step in developing a new scheme.

"In 2013 NMBAQC has been gauging European interest to create a new zooplankton quality assurance best practise"

SAHFOS is involved in a wide range 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 Team 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, students and Associated Researchers. Some articles are novel for this report, whilst others are short summaries based on published work, and a reference is given for further information.

Seasonal and diel patterns in the abundance of *Calanus finmarchicus* using MOCNESS data in Georges Bank: a comparison with Continuous Plankton Recorder

Pierre Helaouët, Grégory Beaugrand and Gabriel Reygondeau

C. finmarchicus abundances assessed from the CPR data have rarely been compared to other more conventional surveys. Here, we examine and compare diel and seasonal patterns in the abundance of *C. finmarchicus* with another sampling technique in the Georges Bank area. Our results provide evidence that *C. finmarchicus* is well sampled by the CPR survey.

We used data from the programme U.S. Georges Bank (http://globec.whoi.edu/jg/dir/globec/gb/). This biological dataset extends from 65.64 °W to 69.76 °W of longitude and 40.27 °N to 44.1°N of latitude during the period between January 1995 and February 2000 (Fig. 15). In this study, only vertical trawl samples (44,872 measurements) with a similar gear and mesh size (i.e. MOCNESS-1 nets of 335 µm) were chosen to perform the comparison with the CPR data.

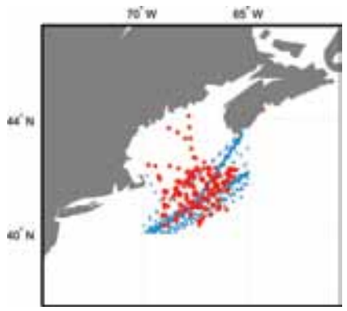


Figure 15. Spatial distribution of CPR samples (in blue) and GLOBEC samples (in red) in Georges Bank (the Gulf of Maine) for the period 1995-2000.

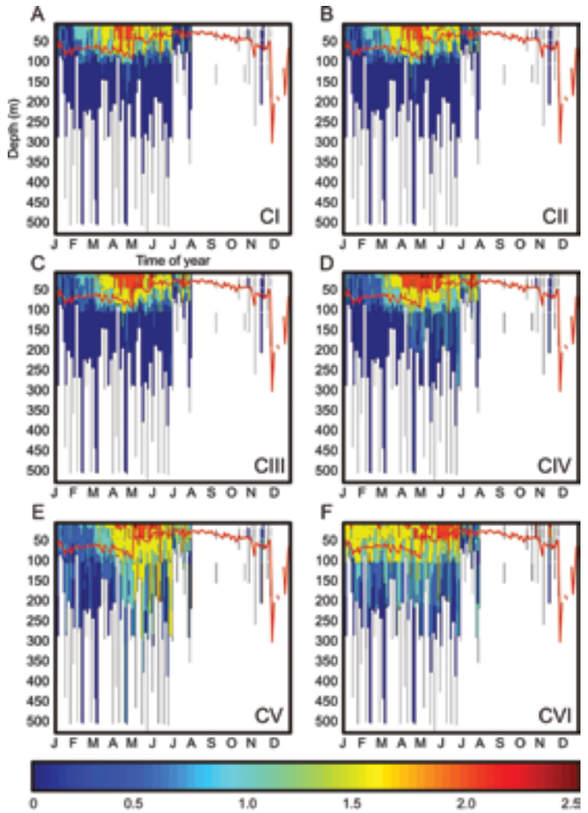


Figure 16. Seasonal and 2-hour changes in the vertical distribution of the abundance of each copepodite stage of *Calanus finmarchicus*. Abundances are given as $\log^{10}$ (X+1). Each month has twelve 2-hour periods and the total of considered time periods is 12 two hours x 12 months=144. The vertical location of the thermocline is superimposed in red.

We calculated the abundance of each copepodite stage of *C. finmarchicus* (i.e. abundance in ind.m^{-3}) to examine the vertical distribution as a function of depth (every one meter from 0 to 522 meters) and month. For each month, vertical profiles were composed of 12 segments of two hours (from 0 to 24), thus creating for each depth an averaged time series of 144 measurements (12 months x 12 2-hour time periods; Fig. 16).

Both diel and seasonal changes in the vertical distribution of *C. finmarchicus* were investigated in relation to the depth of the thermocline (Fig. 16). Maximum abundances were in general observed between April and June for all stages. The abundance of CVI remains elevated in winter. Copepodite stages I-IV were most often distributed above or just below the thermocline. No sign of diel vertical migration was detected for these stages. Copepodite stages CV-CVI were not limited by the thermocline, although their maximum abundance was observed above it. Vertical variability was observed at a daily scale, although no clear pattern of diel vertical migration was identified.

To examine how temporal patterns of abundance may be altered as a function of depth, Pearson correlation coefficients were calculated between subsurface abundance (patterns of abundance at 1 meter) and all other depths (every meter from 1 to 100m) (Fig. 17). Correlations were tested using a Monte Carlo procedure based on 10,000 simulations and the random selection of half (72) of the total number of couple of points (144). For each simulation, the minimum and maximum correlation as well as the 5th, 50th (i.e. median) and 95th percentiles were assessed (Fig. 17). Only data ranging from 0 to 100 meters are represented because the number of missing data were too high to allow the calculations of the correlations between 0 and 522m (Fig. 17).

We investigated the relationships between the seasonal and diel patterns in the abundance of *C. finmarchicus* observed at 1m and those observed at a deeper depth down to 100m (Fig. 17). Seasonal and diel patterns in the abundance of *C. finmarchicus* at 1 meter were highly correlated ($r > 0.9$, $p < 0.001$) to the abundance down to 10 meters for each copepodite stage except CVI (Fig. 17). The correlations values remain highly significant ($r > 0.7$, $p > 0.0001$) at 70 meters for stage CI to CV. Copepodite stages CVI exhibits a higher variability but the median of the correlations (i.e. 50th percentile) remained high ($r > 0.7$, $p > 0.0001$) down to 40 meters. Patterns in the abundance of all stages remained significantly correlated ($p < 0.01$) down to 100m.

A monthly time series of the abundance of *C. finmarchicus* was calculated by averaging data from the CPR dataset which were extracted following the same spatio-temporal coverage. Using the GLOBEC dataset, an average of the first 10 meters for stages CV and CVI was calculated corresponding to the depth of the CPR sampling. CPR and GLOBEC time series were then standardised using their respective minimum

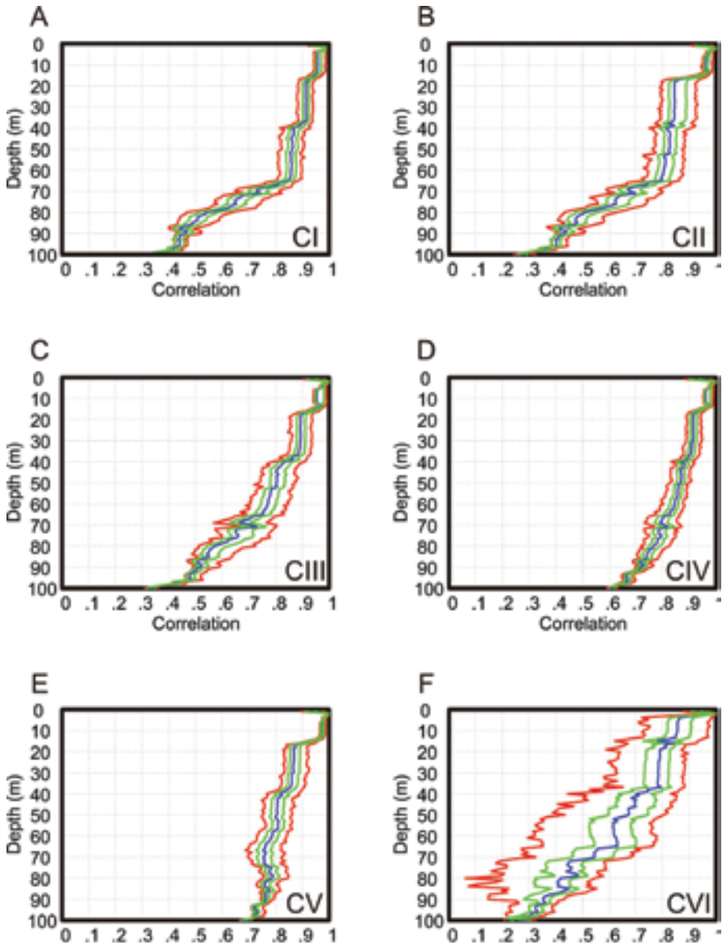


Figure 17. Pearson correlations between the abundance of each copepodite stage of *C. finmarchicus* at 1m and all other depths from 0 to 100 meters (every one meter). For each copepodite stage, 10,000 simulations were performed (see methods). The minimum (left red line), maximum (right red line), 5th (left green line), 50th (median; blue line) and 95th (right blue line) percentiles of simulated correlations are shown

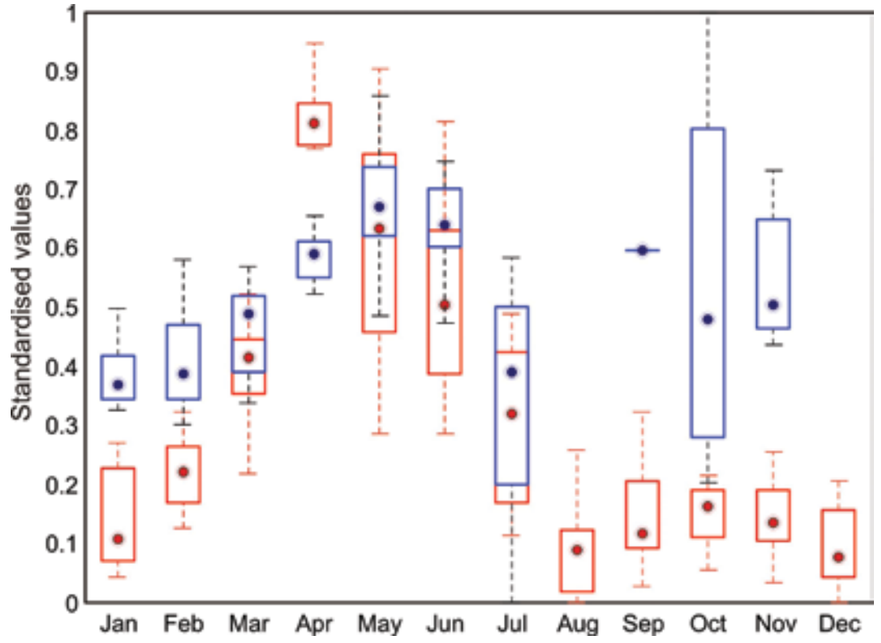
Despite methodological differences, both CPR and GLOBEC samplings give a similar picture of the abundance of *C. finmarchicus*

and maximum values (i.e.(X-min)/(max-min)) and were represented in Figure 18 using a boxplot. On each box, the central mark is the median and the edges of the box are the 25th and 75th percentiles. The whiskers extend to the most extreme data points.

The monthly averaged abundance of *C. finmarchicus* was calculated using both CPR and GLOBEC data set for the common period 1995-2000 (Fig. 18). While CPR data offer a relative constant number of samples for each month, the time series calculated using GLOBEC data was divided in three parts: (1) from January to July where all 2-hour periods were sampled, (2) from September to November where respectively only 1/12, 4/12 and 7/12 steps of 2-hour periods were covered and (3) August and December for which there are no samples. Considering exclusively months with a sufficient amount of samples (i.e. January to July), the pattern from both datasets were remarkably similar ($r = 0.8$; $p = 0.03$; $df = 5$). From January to February, abundances estimated from the CPR were lower than those assessed from GLOBEC. We found the same underestimation from September to November, although the interquartile differences were higher; suggesting a large variability in the abundances mainly related to sampling differences.

A direct comparison of the seasonal variation of adult *C. finmarchicus* abundance in the Georges Bank area from 1995 to 2000 showed that despite their methodological differences, both CPR and GLOBEC samplings give a similar picture of the abundance of *C. finmarchicus* (Fig. 18). Both surface diel and seasonal patterns in the abundance of the calanoid remained positively correlated ($p<0.05$) with patterns of abundance down to 100m for all copepodite stages (Fig. 17). The vertical distribution of all copepodite stages of *C. finmarchicus* was maximal above the thermocline for all months of the year (Fig. 16). Such results were also found in the North Sea (i.e. near the Shetland) by Williams & Lindley (1980) and in the Celtic sea by Williams & Conway (1980). In the North Sea, Williams & Lindley (1980) showed that *C. finmarchicus* copepodite stages CI to CVI were mainly distributed above 25 meters with a thermocline around 10m (their figure 1a). In the Celtic Sea, the study described the vertical distribution of all copepodite stages and showed that total abundance of *C. finmarchicus* was consistently above 25m (Williams & Conway, 1980); their figures 5 and 6).

Figure 18. Boxplots of the monthly standardised abundance of adult *Calanus finmarchicus* for both CPR (in blue) and GLOBEC (between 0 and 10m; in red) in Georges Bank. On each box, the central mark is the median, the edges of the box are the 25th and 75th percentiles, and the most extreme horizontal lines extend to the most extreme data points not considered outliers.



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Williams, R. and Conway, D. V. P. (1980) Vertical distribution of *Calanus finmarchicus* and *C. helgolandicus* (Crustacea: Copepoda). Marine Biology, 60, 57-61.

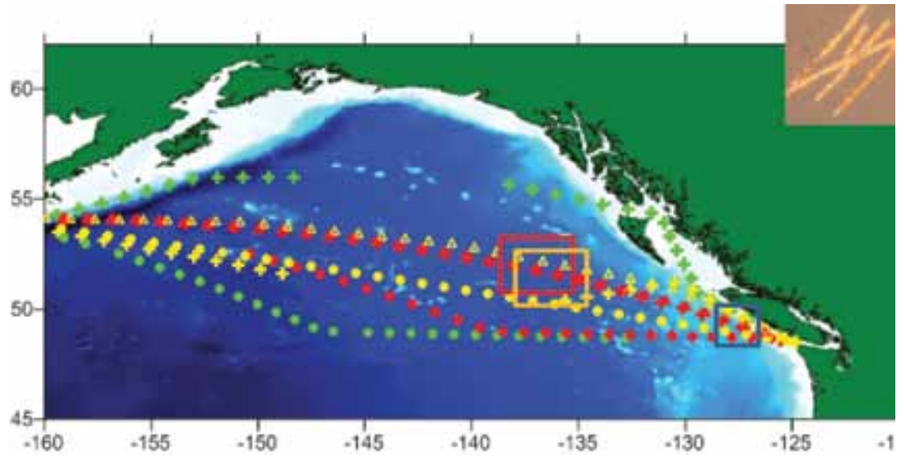
Williams, R. and Lindley, J. A. (1980) Plankton of the Fladen Ground During FLEX 76 III. Vertical Distribution, Population Dynamics and Production of *Calanus finmarchicus* (Crustacea: Copepoda). Marine Biology, 60, 47-56.

Pseudo-nitzschia partitioning in the Pacific Ocean

Rowena Stern and Sonia Batten

The harmful algae *Pseudo-nitzschia* genera occurs regularly in the North West (NW) Pacific coast, causing marine mortalities and economic burdens in shellfish industries. Toxin contents vary in the different 30 plus species and even in populations within species. The only accurate way to identify these algae is by genetics. Metagenomic analysis of nine CPR samples from 2002 to 2008 revealed 79 different genotypes of a *Pseudo-nitzschia* that showed geographic partitioning into centrally occurring versus Canadian coastal types. Furthermore, 2008 was an anomalously cold year and exhibited different *Pseudo-nitzschia* types, including a newly identified species recently identified from a similar region of the Pacific NW coast by Lundholm *et al*. (2012).

Figure 19. *Pseudo-nitzschia* large ribosomal subunit (Lundholm *et al.* 2002) clade I (blue square) and clade II type (red square) distributions from genetic analysis of CPR archive samples. Orange square indicates the new *Pseudo-nitzschia* type from an unusually cold spring in 2008.



Long-Term Trends in Calcifying Plankton and pH in the North Sea

Abigail McQuatters-Gollop

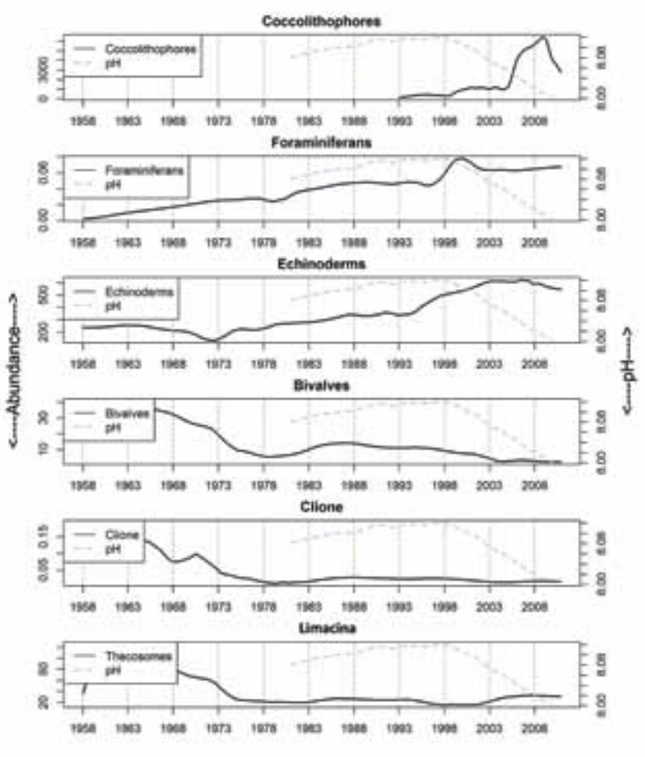
Anthropogenic carbon dioxide emissions are changing ocean chemistry at an unprecedented rate. As the ocean absorbs carbon dioxide, the pH of marine waters is decreasing; this process is known as 'ocean acidification'. It is currently unclear how ocean acidification is affecting the plankton.

We know that there are large differences between responses of organisms to increasing levels of CO_2 in seawater, even between strains of the same species. Calcifying taxa are widely predicted to be adversely affected, since ongoing acidification is rapidly lowering the calcium carbonate saturation state of surface waters. Most investigations into the effects of decreasing pH on planktonic organisms have taken place in short-term laboratory, or mesocosm, experiments, with a focus on the physiological effects of pH change. Very little information is available about the impacts that ocean acidification is having, or might have, on the abundance of calcifying plankton. Uniquely, the CPR survey data offers a long term (80 year) database of the abundance of plankton, which can be explored in relation to environmental factors including pH, temperature and nutrients.

Relationships between the time-series of six calcifying plankton groups (foraminifera, coccolithophores, echinoderm larvae, bivalve larvae, the mollusc *Clione limacina*, and the Thecosome *Limacina helicina*) routinely found on CPR samples and pH were explored in a highly biologically productive and data-rich area of the central North Sea (Fig. 20). The long-term trends show that abundances of foraminifera, coccolithophores, and echinoderm larvae have risen over the last few decades while the abundances of bivalves and thecosomes have declined. pH appears to have been declining since the mid 1990s but there was no statistical connection between the abundance of the calcifying plankton and the pH trends (Fig. 20). If there are any effects of pH on calcifying plankton in the North Sea they appear to be masked by the combined effects of other climatic (e.g. temperature), chemical (nutrient concentrations) and biotic (predation) drivers at this time.

Monitoring programmes such as the CPR are crucial for establishing baselines and recognising futures changes in the plankton which may be linked with ocean acidification. Complementary reliable datasets on environmental parameters are also needed in order to understand ecological responses to climate- and anthropogenic- driven changes in the sea.

Figure 20. Long-term trends in the abundance of calcifying plankton between 1958 and 2010. The trends were estimated using Friedman's super-smoother in which abundance is modelled as a function of long-term trend



Read more: Beare, D., McQuatters-Gollop, A., van der Hammen, T., Machiels, M., Teoh. S.J., *et al*. (2013) Long-Term Trends in Calcifying Plankton and pH in the North Sea. PLoS ONE 8(5).

Seasonal change in acclimatised respiration rate of *Temora longicornis*

Claudia Castellani

The spatial and temporal changes in abundance and diversity we observe in the plankton are inextricably linked to how each species is adapted and responds to changes in its environment. Therefore, knowledge of the physiological traits and limits characterising the species is key to understanding the mechanisms determining its occurrence and predicting its persistence, particularly under a climate change scenario. For instance, respiration is a fundamental trait of organisms and represents the main energy loss pathway within ecological systems. Hence, as the most abundant and diverse aquatic metazoans, marine copepods play an important role, through their respiration, in shaping the structure and dynamics of food-webs and the flow of carbon in the ocean. Despite its importance, published data on in situ respiration rates of copepods are scarce. Moreover, the methods adopted by previous investigators to measure respiration have often been inadequate as most studies have disregarded the effect of the nutritional condition and acute temperature exposure on copepod metabolism. Since metabolism-temperature coefficients, such as Q10, used in ecological models, are derived from data in the literature, it is crucial to test for biases in the method adopted by published studies to measure respiration. Thus, here we investigate the seasonal changes in in situ respiration rates of the copepod *Temora longicornis*, a small copepod which often dominates coastal zooplankton communities in the North Atlantic. We then compared in situ respiration rates of this species with rates we measured in laboratory experiments on copepods maintained under optimal feeding conditions and different temperature exposure regimes (i.e. acute and acclimated). Our results showed that under field conditions *T. longicornis* respiration rate increased significantly with copepod body weight, its reproductive rate, food availability (as Chlorophyll-a) and temperature (Fig.21). Moreover, the mean temperature coefficient we obtained for copepod acclimatised in the field (Q10 = 1.75) was significantly lower than those obtained for copepod maintained under optimal feeding conditions either acclimated (Q10 = 2.05) or acutely (Q10 = 2.41) exposed to changes in temperature in the laboratory (Fig. 21). Therefore, we conclude that seasonal changes in *T. longicornis* respiration rate are not simply determined by body mass and temperature as argued by several investigators, but that it also reflects copepod nutritional and reproductive condition. We also argue that predictive ecological models using fixed thermal coefficients values (e.g. Q10= 2-3) may overestimate copepod respiration, particularly under ambient conditions limiting growth and reproduction. Our findings have important implications for the calculation of carbon flow in marine food-webs and for understanding how zooplankton responds to changes in global temperature.

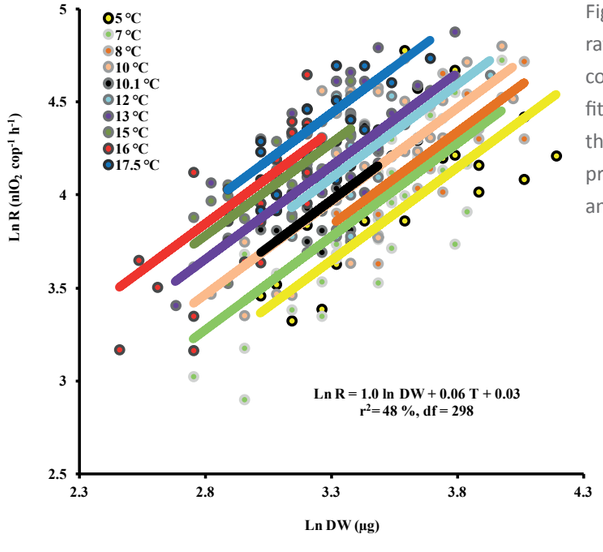
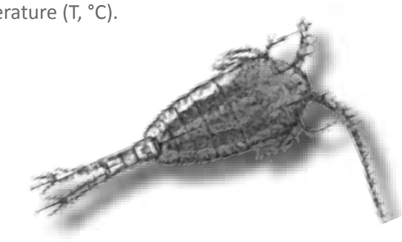


Figure 21. Scatter plot of ln-transformed respiration rate (ln R, nlO_2 cop^{-1} hr^{-1}) of *T. longicornis* versus copepod dry weigh (ln DW, µg). The lines represent fitted values for each temperature obtained from the multiple regression between ln R, ln DW, egg production rates (ln EPR+1), Chlorophil-*a* (ln Chl) and temperature (T, °C).



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

Climate variability and its implication on the planktonic prey (Copepod) – predator (Chaetognath) relationship in the North Sea ecosystem

KK Kusum, NIO India

In the marine ecosystem, zooplankton play a pivotal role in the structuring and regulation of the pelagic food web and in controlling the fate of vertical flux of carbon from surface to the deep ocean. The zooplankton community forms a vital functional component in the pelagic food chain as they efficiently transfer the organic matter produced by the autotrophic (phytoplankton) and heteroptrophic (bacterioplankton) component to higher trophic levels exploitable by man. As they encompass a diverse array of heterogeneous organisms with varied feeding guilds, the relative dominance of each taxa within the zooplankton community and also the prey–predator relationship existing between them have wide implications on the food web structure and also on the vertical flux of organic matter in the marine ecosystems. In the pelagic realm, among the plankton community, chaetognaths are considered as a major carnivorous zooplankton taxa and copepods constitute the dominant taxa which they preferentially feed upon. Hence, a long-term monitoring of the prey – predator relationship existing between these two predominant taxa is crucial in the better understanding of the variability occurring in the pelagic food web in response to climate changes. In the North Sea, studies on zooplankton population dynamics and their responses to changes in the biotic and abiotic variables have been a focus of significant research programmes, of which the majority of the studies have been focused on the impact of climate changes on the dominant zooplankton taxa, copepoda. Chaetognaths, despite being predominant carnivorous zooplankton taxa and a key component in the North Sea food web, have not received much research attention in their long term variability and abundance pattern. Hence, in the present study, we aimed to assess the variability of the major carnivorous zooplankton taxa Chaetognatha during the period of 2000 – 2010 and also evaluated the influence of their major prey, copepods on their abundance pattern.

Chaetognaths, despite being predominant carnivorous zooplankton taxa have not received much research attention in their long term variability and abundance pattern

The results of the study revealed a prominent temporal variability in the abundance and also in the interrelationship among the two major prey- predator zooplankton taxa in NE Atlantic Ocean during the study period. The abundance of the chaetognath community in the North Sea over the years exhibited a remarkable variability in accordance with the size structure and availability of copepods. A decreasing trend was noticed in the abundance pattern of the chaetognath community in accordance to that of the small copepod community. From 2007 – 2010 and also in the year 2000, a shift in the copepod community structure was observed where abundances of large copepods dominated over the small copepods. Although during the period a higher abundance was observed in the large copepod community, a corresponding increase was not prominent in the abundance pattern of chaetognatha as compared to 2002-2003, which in turn suggests their size selective predation behavior. Though both small copepods and chaetognaths exhibited a similarity in their trend, the respective abundances showed an inverse pattern during most of the years which might be due to the size selective predation pressure on the small size copepods. Earlier studies suggesting copepods as being the major prey of the chaetognath community in the North Sea region and the higher incidence of the smaller size category of copepods in the gut content of the epipelagic chaetognaths further corroborates our findings.

In general, a remarkable variability in the zooplankton community structure and trophodynamics was observed in the North Sea ecosystem. A shift in the copepod community dominance from a small size class to large has occurred in the ecosystem and it in turn had a strong influence on the chaetognath feeding and abundance pattern. The peaks in the abundance of the chaetognath community of the North Sea mostly occurred succeeding the peaks in the small copepod abundance. Though prey-predator relationships in the marine ecosystem is mostly determined by the allometric diameter size of the predators mouth and the prey size, any change occurring in the habitat leading to the change in the abundance of either prey or predator can alter the feeding relationship between different organisms in the food chain and ,in turn, might lead to alterations in the pelagic food web and the productivity and biogeochemical cycling in the marine ecosystem. As hydro-climatic changes in this region during this period have been reported, the consequences of this variability on the biological components need to be comprehensively studied to have a better understanding of the changes occurring in the prey-predator relationship.

One year of WaMS

Rowena Stern and Antony Walne

Results of one year of sampling from 2011-2012 across the English Channel using the automated Water and Microplankton Sampler (WaMS) have revealed an astonishing variety of organisms and over 100,000 unique types of plankton. Work is ongoing here, but of interest were harmful dinoflagellates (one sample was almost entirely represented by a single dinoflagellate bloom), diatoms and haptophytes, parasitic fungi and zoonotic apicomplexa, amoeba and Cnidaria, two of which are suspected as invasive, but require further investigation.

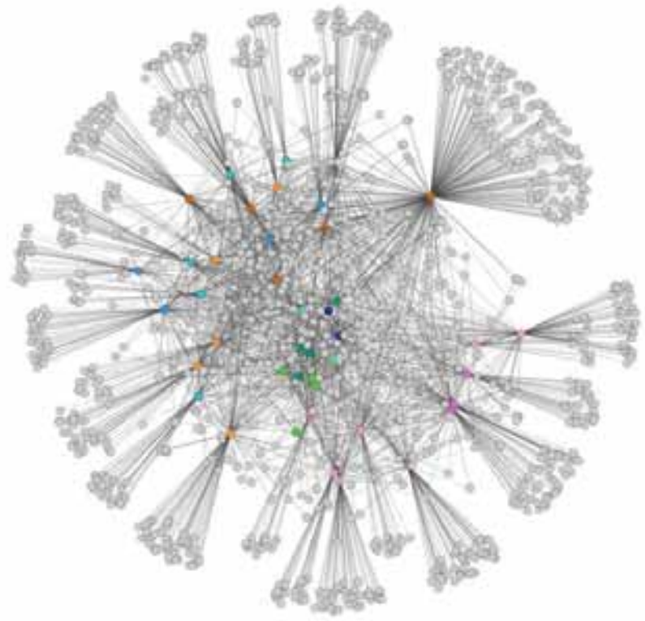


Figure 22. OTU network showing how OTUs are connected to their respective samples. Each grey circle represents a unique taxa (OTU). Those on the outside of the network are specific to a sample, whereas those in the centre are common to many samples. Samples are coloured thus: blue= winter, green=spring, pink=summer, orange=autumn. The more central the samples are in the network, the more OTUs they have in common with other samples.

Viruses in CPR samples

Rowena Stern, Irene Cano-Cejas, Cefas and Declan Schroeder, MBA.

Sea water is a vehicle to viral transmission in the marine environment as has been shown by numerous viral bath studies. Moreover, some studies have pointed out that plankton could be an environmental reservoir of fish and shellfish viruses. The detection of fish and shellfish viruses in the marine environment is crucial to develop reliable policies and could be beneficial for further epidemiological studies. The purpose of this study was to test for viral presence in formalin-preserved CPR samples. Both DNA and RNA were extracted following standard techniques and the quality measured. Due to the potentially fragmented nature of the DNA and RNA extracted, a small DNA region (V9 region of the eukaryote SSU rRNA marker) was used to test the quality of the genome extracted. Then a battery of tests for DNA and RNA viruses were performed by specific PCR and qPCR. Initial results showed the presence of a Salmonid Alpha Virus (SAV) -like genome in one sample. Detection of White Spot Syndrome Virus (WSSV) was suspected by qPCR although more studies are required to confirm this. The CPR sample archive is a resource dating back to 1958 and is available to exploit. These promising results may help our understanding of the spread of both viral and other pathogens and their possible reservoirs associated within the plankton community. Thus the CPR can be used for hindcast environmental DNA (eDNA) surveys to assist with detection of marine viruses.

A typical marine virus

The Transboundary Water Assessment Project

Sonia Batten

SAHFOS has been involved in the GEF funded, UNEP implemented, TWA-Project since its development phase and we are now mid-way through the first assessment. The project has 5 components from watersheds through LMEs to the ocean, and SAHFOS is a partner in the Open Ocean component, managed by the IOC. The TWA-P arose out of the need for a global baseline assessment of the status and changing condition of transboundary water systems (most systems extend across or beyond national jurisdictions) resulting from human and natural causes, which will allow the GEF and others to set science-based priorities for financial resource allocation. It's hoped that the institutional and partnership framework established in the first project will facilitate future periodic assessments. Through GACS we were invited to contribute zooplankton indicators and we determined that metrics of abundance (mesozooplankton abundance) and community structure (represented by mean Copepod Community Size CCS) would be most important and tractable. GACS efforts during 2013 focused on assimilating the different survey data into one database for such global analyses and these metrics were then able to be submitted to TWA-P at the end of the year. The focus through 2014 will be writing the assessment report. Here is an extract of some of the data for 4 regions of approximately similar latitude, from 4 CPR surveys (Fig. 23). Analyses are only in the earliest stages, but we see some intriguing patterns. The general hypothesis is that under a warming ocean we would expect to see a move towards smaller species, and so a decline in average CCS. However, in the eastern North Atlantic which has the lengthiest time series the opposite is apparent, with a clear trend towards larger species over time (note that the methodology isn't sensitive to changes in size within a species, since one length represents one species throughout the time series). The western North Atlantic has two periods of first larger then smaller communities, with closer to average sizes during the last decade. The time series from the North Pacific are much shorter. The eastern North Pacific data show a relationship with SST, with the cold years of 2000-2002 and 2008 onwards having generally larger species (large subarctic species favoured by cool conditions), while the warm years of 2004-2006 and the 1997/98 El Niño year were biased towards smaller species. Eastern and western Pacific show different patterns, not unexpected since the dominant mode of climate variability (the Pacific Decadal Oscillation) has an opposite expression east versus west. The two Pacific time series are not entirely opposite in phase but there is no correlation between them. What is clear from this preliminary view is that there is not one global story – local (or at least basin-scale) processes will be important in understanding the patterns. Thanks to Sanae Chiba (JAMSTEC, Japan) and Chris Melrose (NOAA, USA) for making available the western Pacific and western Atlantic data, respectively.

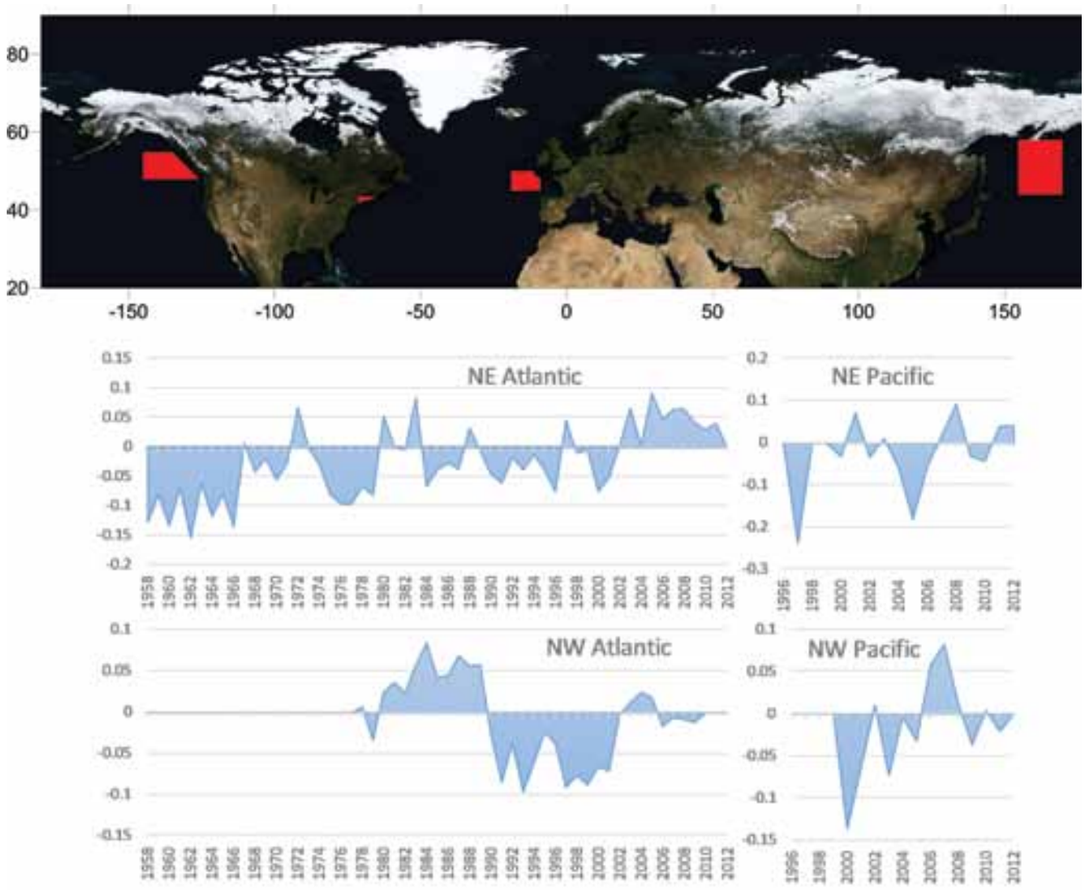


Figure 23. Annual mean anomalies of Copepod Community Size for 4 regions of the Northern hemisphere (see map above) sampled by CPRs: Northeast Atlantic Standard Area E5, the Gulf of Maine in the western North Atlantic, the western Pacific subarctic gyre and the oceanic Northeast Pacific. Anomalies are based on Log^{10} monthly anomalies of CCS (mm), averaged for the whole year. When anomalies are <0 the copepod community was smaller than average, when >0 the copepods were larger than average.

Metagenomics reveal Bacteria associated with North Sea copepod

Rowena Stern, Marianne Wootton, Jennifer Skinner and Declan Schroeder MBA

A *Calanus* copepod from the A route was found to have ten bacteria phyla types associated with it, mostly Proteobacteria and Verrucomicrobia - the latter a recently described group that exist in association with animals and protists. Several potentially zoonotic bacteria (which can infect zooplankton) formed a large proportion of found sequences, some being thermo-sensitive which may provide new temperature ranges of these organisms. A smaller proportion belonged to Rickettsiaceae and Clostridiales, some species of which are potentially infective agents borne by arthropods, which require further investigation. Many bacterial types were obligate anaerobes or extremophiles that may live in the gut or have washed out and stuck to the copepod. Cold to polar associated bacteria, such as *Sphingomonas sp.*, were also identified, indicative of the environmental conditions when sampled.

Figure 24. Normalised relative abundance of taxa found on a copepod from the North Sea by metagenomic sequencing (adapted from MG-RAST). Note: the majority are bacteria, although fragments of diatom genome were also found that may have stuck to the surface or were ingested.

Net Community Production in the North Atlantic

Clare Ostle, University of East Anglia

Net Community Production (NCP) is equivalent to the rate of organic carbon export from the surface ocean to the ocean interior. The metabolic state of a system can be defined by NCP, with autotrophic systems occurring when gross primary production is greater than respiration, and heterotrophic systems occurring when respiration is greater than primary production. Quantifying how this rate varies with plankton community structure is crucial in determining regional metabolic states and their role in the global carbon sink.

Data were collected in the North Atlantic on board MV *Benguela Stream* between December 2011 and March 2013.

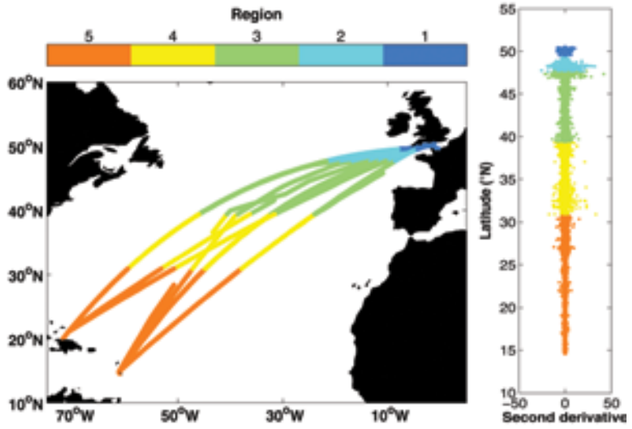


Figure 25. Ship tracks divided into biogeochemical regions 1 to 5, defined by peaks in the second derivative of sea surface temperature, density and Chl-*a*.

The sample area was divided in to five biogeochemical regions based on peaks in the second derivative of sea surface temperature, density and satellite derived Chl-a (Fig. 25). Monthly estimates of NCP for each region were determined from a simple 1D model based on abiotic parameters and the dissolved oxygen inventory. These data are presented in Figure 26 alongside the mean monthly abundance of 5 key phytoplankton groups obtained from the CPR survey.

These measurements show that all five regions are predominantly autotrophic with different phytoplankton groups influencing the metabolic state at different stages during the season. Our annual estimates of NCP agree with those derived from studies which use argon/oxygen ratios or oxygen isotopes which are often more expensive and labour intensive methods. The mean seasonal NCP was also compared with estimates of NCP calculated using dissolved inorganic carbon measurements. These two independent methods followed the same regional trend and were not significantly different in magnitude. The next steps in this study are to statistically investigate the relationships between oxygen and carbon dioxide cycling and the plankton community structure.

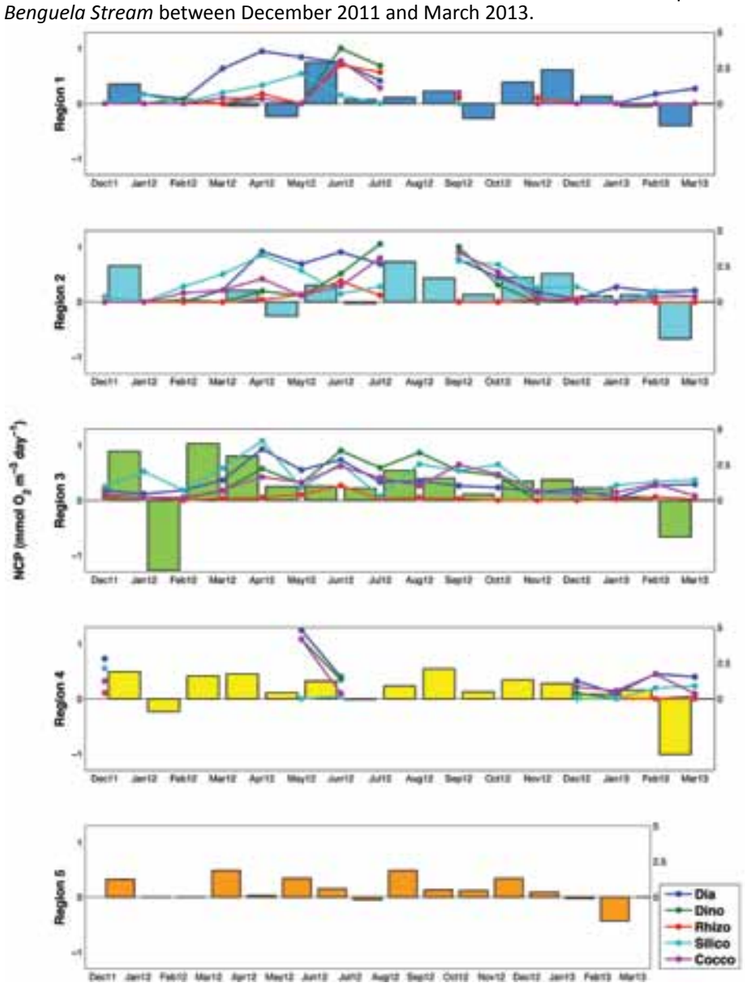


Figure 26. Coloured bars represent monthly NCP within each biogeochemical region given in mmol O_2 m^{-3} d^{-1} plotted on the left y-axis. The coloured lines represent co-located mean monthly abundance ($log^{10}(x+1)$) of Diatoms (blue), Dinoflagellates (green), *Rhizosolenia* (red), Silicoflagellates (cyan), and Coccolithophores (purple) plotted on the right y-axis. Regions 4 and 5 are missing CPR values as the CPR is towed on this route between 40°W and 0°W.

This study is the first to report NCP for these five regions in the North Atlantic Ocean, and shows that there was surprisingly little difference in the magnitude and seasonal variability in NCP between regions. This contrasts with global circulation models and highlights the need for improved global coverage of in situ data and an improved mechanistic understanding of why the two approaches differ. The method developed in this study is simple and cost effective (in terms of personnel time and shipboard space requirements), which is therefore applicable for use on volunteer observing ships, and ideally suited to provide the required global coverage of in situ NCP data.

Marine ecosystem response to the Atlantic Multidecadal Oscillation

Martin Edwards

There has been a well documented trend in global temperature, which has been rising almost linearly over the past few decades. In addition to this, there are a number of important natural oscillations in our climate that continue to occur. Of particular interest in the North Atlantic is the natural cycle known as the Atlantic Multidecadal Oscillation, AMO, which has a multidecadal periodicity of ~60-80 years. Until now the impact of this cycle on marine ecosystems was relatively unknown.

SAHFOS researchers have investigated the biological impact of the (AMO), which has been overlooked in the past but was thought responsible for multidecadal changes in the marine life of the North Atlantic from plankton to fish. There were three main findings from the study. Firstly, that the AMO is far from a trivial presence against the backdrop of external temperature warming in the North Atlantic. Secondly, it accounts for the second most important macro-trend in North Atlantic plankton records, responsible for habitat switching (regime shifts) over a multidecadal scale, and explains the mechanism for the Russell Cycle in the English Channel. Thirdly, the fortunes of various fisheries stocks in the North Atlantic over a multidecadal scale have been influenced by trends in the AMO.

During the 20th century, there have been two AMO warming periods, which at first seem identical in their hydro-biological impact, but now it is apparent that there is a fundamental difference between the two periods, with the current warming phase increasingly influenced by the monotonic trend in the Northern Hemisphere Temperatures (NHT). The redistribution of warm Atlantic water further northward post 1995 coupled with the NHT trend is coincident with the rapid climate warming of the Arctic seen over the same period. A fundamental question that then arises, but still remains elusive, is when will the current warm phase of the AMO begin to decline (2025 based on 60 year cycle) and will it be significant enough to trigger habitat switching in the North Atlantic and associated shelf seas, or will external climate warming override this natural signal?

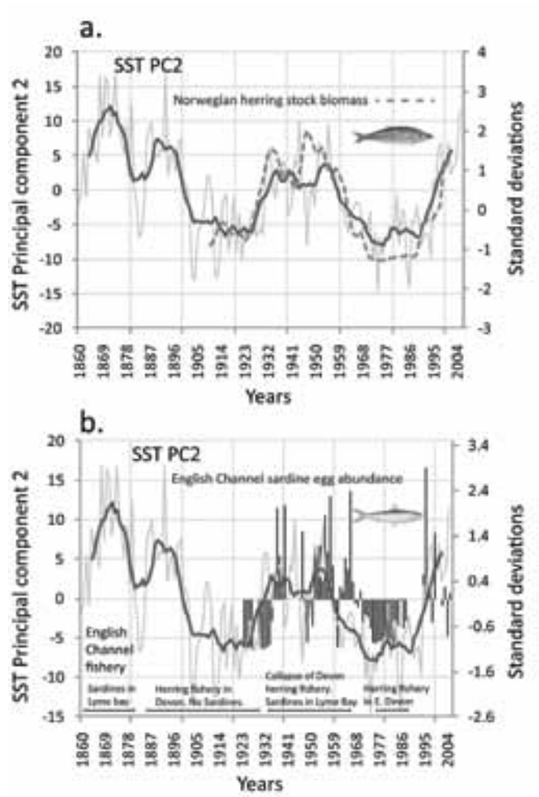


Figure 27. Long term changes in fish abundance (a, Norwegian herring. b, English Channel Sardine egg) in relation to SST, the second most important trend

Read more: Edwards, M., Beaugrand, G., Helaouët, P., Alheit, J., & Coombs, S. (2013). Marine ecosystem response to the Atlantic Multidecadal Oscillation. PLoS ONE, 8(2).

CPR indicators of jellyfish blooms

Priscilla Licandro

In recent years jellyfish outbreaks have been increasingly reported all over the world and a rise in their occurrence has been hypothesized as a consequence of anthropogenic impact and hydroclimatic variability. To verify whether indeed this is true, it is necessary to identify where, when and which jellyfish species are mainly blooming in the ocean.

The CPR Survey is the monitoring programme that covers the greatest spatial (tens to thousands kilometres) and temporal (monthly to multidecadal) scales. It therefore offers a unique opportunity to monitor jellyfish blooms, which are events usually occurring over distances of tens to hundreds of kilometres and for which large-scale methods of data collection are needed.

To monitor jellyfish blooms, CPR samples collected during 2009-2012 in the North Atlantic were visually re-analysed and those fully covered in jellyfish tissue and nematocysts were classified as records of jellyfish swarm events. Those new CPR estimates of bloom events (Fig.28) showed that jellyfish tend to swarm in all seasons, inshore and offshore across the whole North Atlantic basin (Licandro *et al*., in press). Genetic analysis of CPR jellyfish material identified blooms of small hydrozoans as well as of relatively big scyphomedusae. In particular, different species of colonial siphonophores and holopelagic cnidarians such as *Pelagia noctiluca* were swarming inshore and offshore from summer to late autumn.

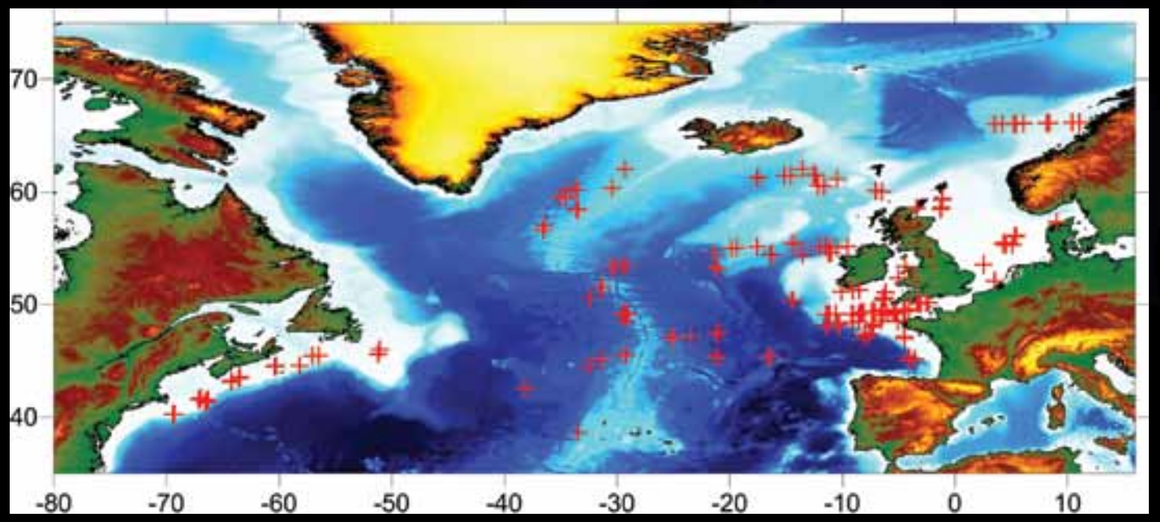


Figure 28. Jellyfish swarms recorded by the CPR in 2009-2012 (from Licandro *et al*., in press).

Read more: Licandro, P. , Blackett , M., Fischer, A., Hosia, A., Kennedy, J., Kirby, R., Raab, K., Stern, R. & Tranter P. Biogeography of jellyfish in the North Atlantic, by traditional and genomic methods. ESSD (in press).

Fellowship Award

NERC KE Fellowship: Interpreting and targeting NERC-funded research outputs to inform and influence marine policy

Abigail McQuatters-Gollop

In 2013 I was awarded a three-year NERC Knowledge Exchange (KE) Fellowship, which will support me in further developing my involvement, and therefore raising the profile of SAHFOS, GACS and the CPR survey, in the UK, EU and international policy spheres. My fellowship has three objectives:

1. **To integrate CPR research and data into the UK and European decision-making process.**
2. **To interpret and translate policy needs and scientific research.**
3. **To identify new impact-generating applications for CPR data and research.**

I will be carrying out these objectives in a variety of ways: through direct involvement with policy boards and working groups, through targeted speaking engagements, via non-technical publications, and networking. One aspect I am particularly excited about is the opportunity to work with our Global GACS partners to look at how all of the CPR surveys are used to support decision making in their own regions.

Although I am only a few months into my fellowship, I have already attended four UK and EU policy meetings, presented SAHFOS policy research at two international conferences, provided feedback to Defra, JNCC, MCCIP and OSPAR on monitoring and research priorities, attended two KE networking events, and created Plankton and Policy, a website established to disseminate my fellowship work (//planktonandpolicy.wordpress.com/). The ICES Annual Science Conference in Reykjavik, Iceland, was a particular highlight as I had the opportunity to present my CPR-policy work in a session focusing on providing and using data for policy needs. This session generated some fascinating discussions on biological datasets and how scientists communicate with decision makers.

I am very grateful for NERC's and SAHFOS's support for my fellowship work.

Sunset at the Harpa Centre, Reykjavik, venue of the 2013 ICES Annual Science Conference.

Education and Outreach

Clare Buckland

During 2013, SAHFOS staff undertook a number of educational, outreach and KE events. These involved running practical workshops, giving presentations and attending events. SAHFOS was also ably assisted by a couple of work experience students through the year.

As in previous years, an Introductory Zooplankton Identification workshop for undergraduate marine biologists from the Plymouth University was undertaken. The course was attended by 17 students who were introduced to plankton taxonomy via a presentation and then a two hour practical microscope session. Here the students were able to experience zooplankton specimens from the English Channel and practice their taxonomic identification skills. The same course was run at the University of Leicester, after an invitation from Professor Paul Hart. The students use this course as preperation for attending a summer field trip to Madeira. During which it forms an invaluable introduction to the identification skills required to complete their course.

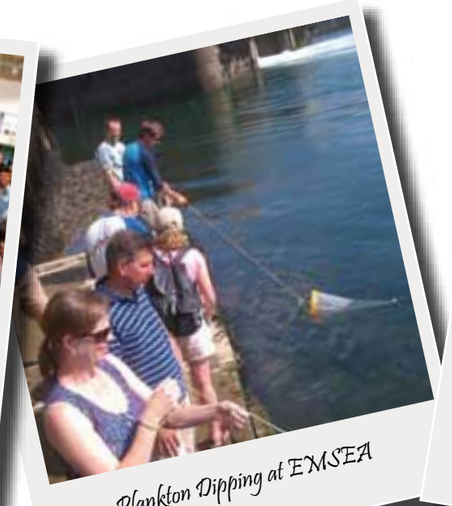
Throughout the year a number of SAHFOS staff gave presentations to the general public, students and school children. These included an evening lecture at Kelly College in Tavistock to teaching staff and thirty Year 12 students, a talk at the European Marine Science Educators Association (EMSEA) conference (at Plymouth University) to 100 international delegates about the educational resources SAHFOS provides through the Life Adrift web site. Also, SAHFOS hosted this year's Plymouth University MRes students for a morning in September. Clare Buckland, Tony Walne and Rowena all gave presentations to the students about plankton, SAHFOS science and recent research using the water sampler.

Events attended in 2013 began with the annual National Science and Engineering Week at the Plymouth City Museum and Art Gallery. Nature's Inventions was a collaborative event with Plymouth Marine Laboratory, Plymouth University and Plymouth City Museum and Art Gallery, and was designed to demonstrate how the earth's flora and fauna have inspired or given rise to some of our best technical advances. The event was visited by 588 school children and the general public between 19th-23rd March and we received excellent feedback from our questionnaires. SAHFOS staff joined the MBA and other wildlife organisations to carry out a 24 hour biological survey of Looe in Cornwall. The aim was to sample, identify and record as many species as possible in a 24 hour period. Everything from marine organisms to insects, to trees and birds were identified between Sunday 23rd – Monday 24th June. The Sunday was spent sampling plankton from the shore along Looe River and out to Looe Island by boat at various points of the tide. In the samples were found a relatively low diversity of organisms, primarily composed of amphipods, mysiids, calanoid copepods, shrimp, rotifers, diatoms, harpacticoids. Where possible these were identified to species and added to the BIOBLITZ database along with the data from other surveys going on at the same time. BIOBLITZ events have proved very effective as public outreach activities, bringing together science and learning in the same activity. On the Monday morning SAHFOS carried out plankton sampling and identifying activity for a group of students from Looe Community College. During the summer, staff assisted at another local event, the Wembury Marine Festival at Wembury Beach, Devon. The event was attended by around 100 people throughout the day with many visiting the SAHFOS plankton stand inside the Wembury Marine Centre. Staff and work experience students displayed a live plankton sample collected from Plymouth Sound onto a large screen and carried out activities for the younger children. Later in the year SAHFOS hosted an Artist's Workshop in the MBA Resource Centre. This outreach event played an important part of the Laboratory on the Hoe project with the MBA (www.mba.ac.uk/nmbl/projects/history/125laboratory). Local artists were invited to come along and experience the beauty and form of plankton through a microscope. The attendees found the afternoon's activities fascinating and were all very keen to display their respective works on the project website. Everyone felt that this was an important aspect of bringing science and art closer together.

Our work experience personnel joined SAHFOS at the beginning of August. Clare Marshall took on the post of Research Assistant and populated our CPR bibliography with publication abstract information for the entire bibliography. Clare then used this information to produce word clouds for each decade of published CPR research. The word clouds showed a clear definition in research subject area from 1936 – 2012 (see page 54). Stephanie Davis joined us as an Assistant Education Officer for 2 weeks. Stephanie designed and produced additional education resources for the Life Adrift web pages and designed an animated slideshow of some of Alister Hardy's photographs from his time working in Lowestoft and out at sea. This animated slideshow can be viewed via the SAHFOS website.

Introductory Zooplankton Workshop for undergraduates

European Marine Science Educators (EMSEA) Conference



Plankton Dipping at EMSEA

National Science and Engineering Week at the Plymouth City Museum

Plankton Dipping as part of the Bioblitz Survey

SAHFOS stand at Wembury Marine Festival

Science and Policy Update

Abigail McQuatters-Gollop

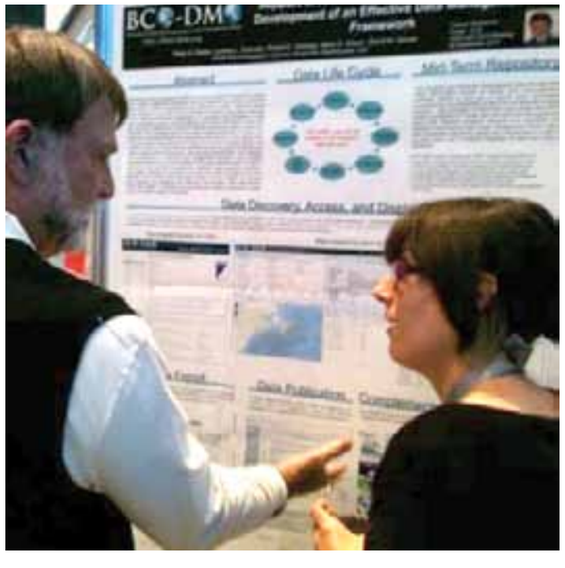
Policy drivers influence research at SAHFOS and an important aim of the organisation is to use CPR data and the expertise of SAHFOS scientists to deliver evidence-based advice to policy makers and ecosystem managers.

SAHFOS continues to hold a place on the UK Marine Monitoring and Assessment Strategy (UKMMAS) Healthy and Biologically Diverse Seas Evidence Group (HBDSEG), 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 2013 SAHFOS expertise and CPR data also contributed to policy-relevant products for the following UK, European and international bodies: Defra, Scottish Natural Heritage, the Marine Climate Change Impacts Partnership (MCCIP), OSPAR, the European Marine Observation and Data Network (EMODNET), ICES and the USA National Science Foundation.

SAHFOS science is directly influencing UK and European marine policy. Abigail McQuatters-Gollop 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), the objective of which is to achieve Good Environmental Status in European waters by 2020. In 2013 SAHFOS, along with five other UK plankton dataset holders, received funding from Defra for the development and delivery of the pelagic indicators and targets proposed last year. This research and development project takes the indicators 'from microscope to assessment' and provides the opportunity to conduct a truly integrated assessment of the plankton in UK waters. In 2014 the teams efforts will focus 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. At the European level, the OSPAR Pelagic Habitats Team had three regional indicators approved for continued development. As in the UK, the CPR is essential to informing these indicators.

This year Abigail was awarded a competitive 3-year NERC Knowledge Exchange Fellowship entitled 'Interpreting and targeting NERC-funded research outputs to inform and influence marine policy' (see page 49) . The fellowship, centred around the CPR survey, will fund her to focus on the aforementioned policy work as well as to actively participate in MCCIP, the ICES Working Group on Biodiversity (WG BIODIV) and exploiting the policy relevance of the GACS. In 2013 Abigail was invited to speak about the MSFD implementation process and the CPR's use as a policy tool at multiple meetings and conferences including the Coastal and Estuarine Research Federation biennial conference in San Diego. Additionally, she co-developed, co-chaired and co-convened the Prospectus for UK Marine Observations, held at the Royal Society. This unique meeting celebrated the UK's role in observing the oceans. SAHFOS director Prof Nick Owens delivered the keynote address and chaired the discussion panel; several talks mentioned the uniqueness and importance of the CPR.

Two new European projects in which SAHFOS has key science-to-policy roles were funded in 2013: INTERREG Promoting Effective Governance of the Channel Seas (PEGASEAS) and the European Marine Observation and Data Network Biology project (EMODNET Biology 2). In addition, SAHFOS staff play active roles in the UK's National Marine Biological Analytical Quality Control Scheme (NMBAQC) which provides a source of external quality assurance for laboratories engaged in the production of marine biological data. David Johns has recently accepted the position of NMBAQC Chair and Astrid Fischer continues to act as the NMBAQC Technical Secretary (see page 35). Assessments, talks, and project roles such as these provide a mechanism to transfer scientific information to decision makers and facilitate the evidence-based development of monitoring programmes and policy measures. These activities also increase the profile of the CPR dataset and SAHFOS research.



Abigail Mc-Quatters-Gollop at ICES Annual Science Conference. Photo credit: Ingeborg de Boois

Data requests and availability

David Johns

SAHFOS routinely records almost 800 taxonomic entities, including phytoplankton and zooplankton, many to species level (and some with lifestage information). Data are available for most taxa from 1958, with the remaining taxa available from subsequent time periods.

One of the advantages of the time series is the ability to respond to scientific questions, whilst keeping the series methodology intact, and thus new taxa have been added (and continue to be added) as research questions change, and new areas are investigated. In a similar manner, all SAHFOS samples are stored in Plymouth, allowing the archive to be utilised as new research methods become available.

During 2013, we received over 80 data request, our highest number so far. The majority of these requests came from the UK, as well as Belgium, Canada, Denmark, the Faroes, France, Germany, Italy, The Netherlands, Norway, Russia and the USA. Many of these requests are from researchers who have used and published CPR data previously, as well as a number of under- and post-graduate students. The data have been used in projects as diverse as fisheries modelling and model validation, remote sensing comparisons, whale distributions, seabird foraging, genetic studies and time series analysis.

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, we can provide assistance and reports for commercial ventures.

Contact David Johns (djoh@sahfos.ac.uk) for further information.

Third International Marine Phytoplankton Workshop

Gemma Brice and Claire Taylor

SAHFOS are delighted to be joining forces once again with The Marine Biological Association to run and host the 3rd International Marine Phytoplankton Taxonomy Workshop. The course will be held from 7th July – 18th July 2014 at our Citadel Hill Laboratories.

We are very pleased to be again welcoming back Prof Carmelo Tomas and Dr Diana Sarno; with us since the first workshop, and Dr Karen Steidinger and Dr Ian Probert returning for their second successive workshop as our international experts. The workshop is aimed at all those working in the marine phytoplankton field and will cover classification and taxonomy of the major marine microalgal groups. In addition, there will be a substantial practical element which will encompass a range of Methodologies and Techniques including: Sampling, Settling and Slide Preparation, Cell Counting, Isolation, Microscopy and Culturing.

Preparations for this workshop have been well under way by Gemma Brice and Claire Taylor during 2013 in order to ensure another successful workshop for the upcoming year. We look forward to another busy but fruitful summer!

Eight Decades of Change

Clare Marshall and Clare Buckland

634 abstracts from CPR publications between 1926 and 2010 were exported from our bibliography to produce word clouds for each decade of the CPR survey. The word clouds demonstrate diagrammatically how CPR data has changed in use over the decades.

1930's

1940's

1950's

1960's

1970's

1980's

1990's

2000's

In the early days of the Survey the key words that were found in CPR publications indicate an inclination towards descriptions of methods, developing distribution information for plankton and providing fisheries information. By the 1950s and 1960s there was a shift towards the Atlantic, oceanic distributions, changes in species and larval descriptions indicating the Survey's expansion into oceanic habitat's. In the 1970s and 1980s we can see that the words fluctuations, abundance, seasonal, annual and temperature were being used regularly suggesting links between environmental factors and biota. In the last 20 years of the Survey, the word clouds are dominated by the words data, changes, biomass, zooplankton species and abundance with inclusions of words like spatial, carbon, patterns and long-term. The study illustrates how a changing marine environment has steered the application of the CPR survey results to understand and monitor these changes.

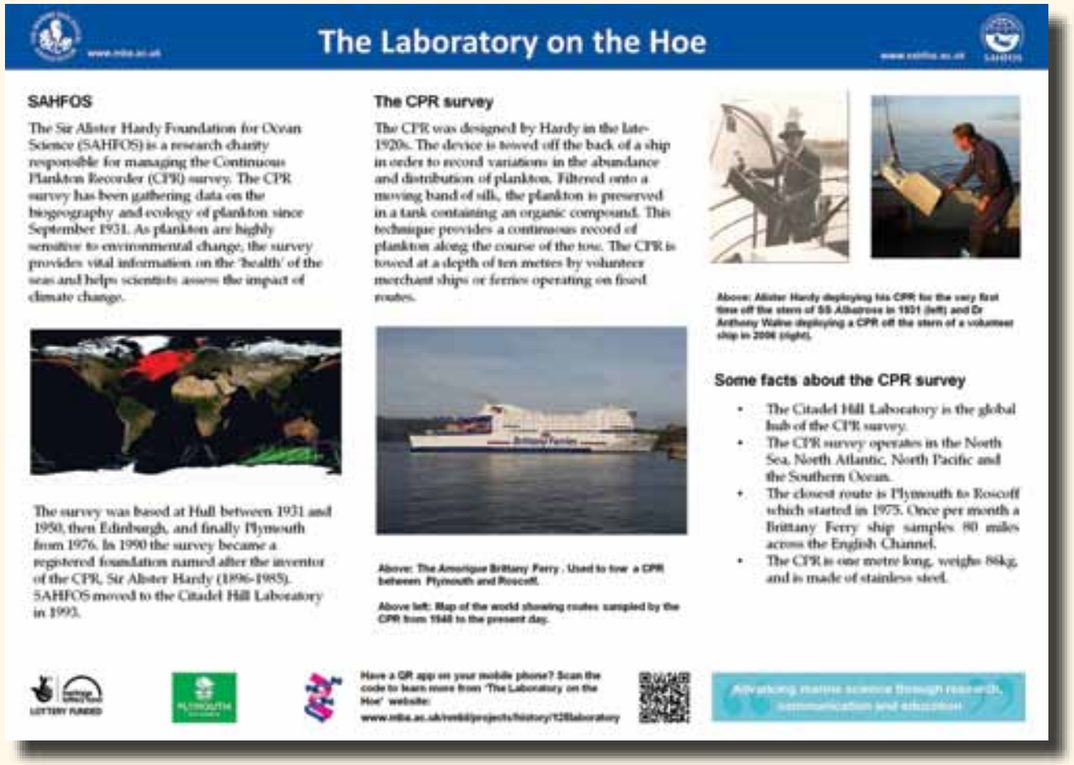
The Laboratory on the Hoe

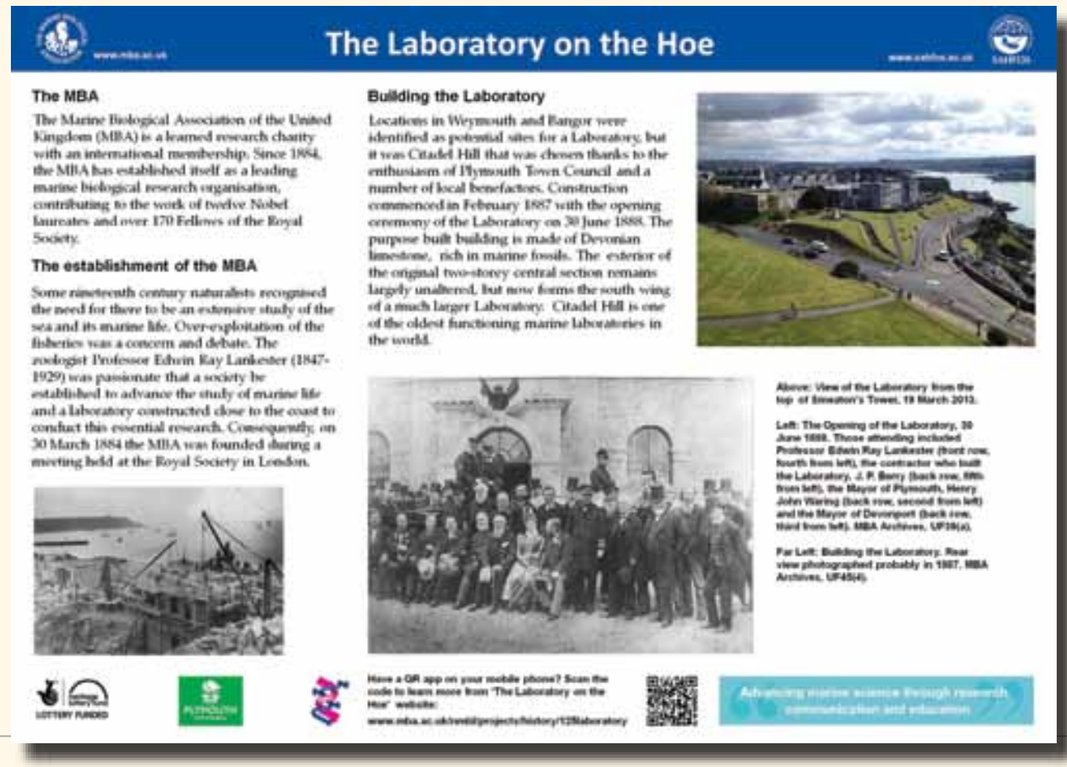
Clare Buckland

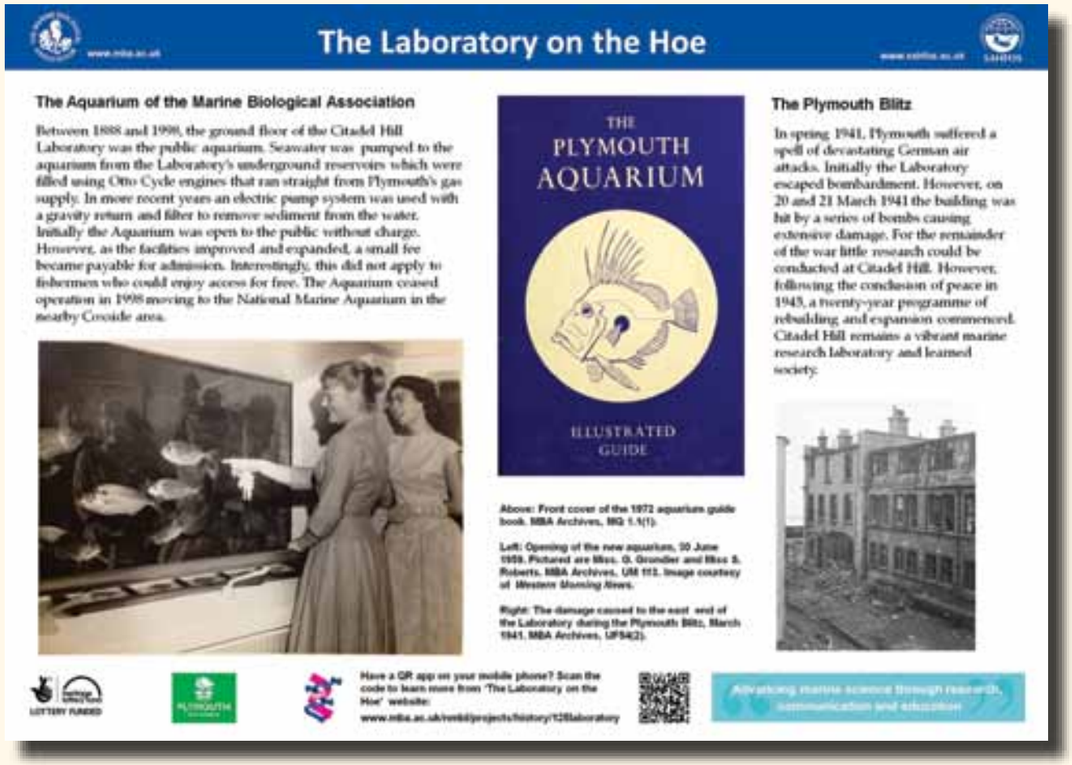
In February 2013, SAHFOS worked alongside the MBA on a project financed by the Heritage Lottery Fund which will mark 125 years since the opening of the Citadel Hill Laboratory on Plymouth Hoe. This project is in partnership with the MBA, Plymouth City Museum and Art Gallery, the Plymouth and West Devon Record Office, and the South West Image Bank.

To mark this auspicious anniversary the partnership delivered several activities, which included historical, scientific and art projects. SAHFOS provided its support and commitment to the project by carrying out 2 public lectures, running an artist's workshop and providing information and images for 2 separate exhibitions about the history and significance of the CPR science and Sir Alister Hardy. SAHFOS also contributed to the project website by providing plankton photographs (taken by Stuart Queen) and information for public outreach boards and the projects book.

The interpretation panels are located surrounding the Citadel Hill laboratories. Since their introduction they have been popular with visitors to the area.







Social Media

Abigail McQuatters-Gollop, Clare Buckland, Rob Camp, Gemma Brice, Alec Colebrook-Clark

The huge rise in social media usage has driven SAHFOS to increase its online presence. Over the past few years, SAHFOS has done this through our chosen platforms of Twitter, Google+, Facebook, Flickr and Youtube. A team from SAHFOS share the responsibility of posting updates through the different applications, and all staff contribute to possible news items. The content for each of the applications is different so that our users have a wide range of interesting topics – what we post varies from either our own news, or relaying relevant information from other users.

The SAHFOS website has received over 32,000 visits since May 2012, resulting in over 109,000 page views, of which 60% of the visits during this period are new. The SAHFOS website seems to be responding to the use of social media with a visible increase in number of views. The SAHFOS education web site was launched under the name of Life Adrift in September. This has received over 3,000 visits, 89% of them being new. It is also worth noting that Life Adrift has managed over 4,700 page views, this is notable as the entire Life Adrift website is a single page.

The SAHFOS Facebook page has been 'liked' by 132 people since it was launched in February 2013 and on average we post a news item on Facebook every 2-3 weeks. Our posts range from photographs and descriptions of interesting plankton species found on CPR routes to recently published papers. We also post information about talks, presentations, events and our staff attendance at conferences around the world. The posts are seen by between 100- 500 people from the global scientific community, students, interested public and previous SAHFOS staff. People who follow our page can also share our information with all of their friends, extending our reach and increasing engagement. Facebook also provides an invaluable link between our website and Twitter with many SAHFOS news items being 're-tweeted' by followers from around the world.

After a trial period during 2011 and 2012, SAHFOS began formal use of our @SAHFOS Twitter account in 2013. The account is managed by Abigail McQuatters-Gollop, with help from Gemma Brice, and supplemental tweeting by our Director, Nick Owens. @SAHFOS has a total of 573 followers, who give us a potential reach of over 500,000 people. In other words, if @SAHFOS tweets and every one of our followers retweets the original tweet to their followers, that piece of information will reach over half a million people! To date we have tweeted 946 times and 352 of those tweets have been retweeted. With social media, success is measured by engagement. In the Twitterverse, engagement takes places both through retweets (mentioned above) and mentions, which happen when a Twitter user mentions (or tags) @SAHFOS in a tweet. From 3rd November 2010 to 6 December 2013 @SAHFOS has been mentioned a total of 524 times by other Twitter users. The more @ SAHFOS engages with other users, the more retweets and mentions we will receive.

During 2013 @SAHFOS established our #StarPlankton endeavour, which is managed by Gemma Brice. Each week Gemma selects a 'star' plankton about which she releases three interesting facts, accompanied by a photo of our star, during the week. These are some of our most popular tweets, and nearly every single #StarPlankton tweet is retweeted.

Flickr is an image and video hosting website, widely used by photographers and bloggers to host images they embed in blogs and social media. Photos and videos can be accessed from Flickr without the need to register an account, and the site offers users the ability to either release their images under certain common usage licences or label them as "all rights reserved". Currently, SAHFOS images allow other users to freely share, copy and redistribute SAHFOS material providing they give appropriate credit, provide a link to the license, and indicate if changes were made. They may not use the material for commercial purposes. Due to the 1TB of free storage available, the site is useful in providing access to high resolution images that are too large to upload to Twitter or Facebook, but can be linked to on these platforms whilst residing on Flickr. The SAHFOS Flickr account was set up after demand for international photo sharing after the Plankton 2011 Conference and has continued growing since. To date, SAHFOS has uploaded 164 images which have been viewed nearly 10,000 times.

PUBLICATIONS LIST 2013

SAHFOS staff in bold

*Associated Researchers/ Research Fellows/ PhD Students

Alheit, J., **Licandro, P.**, Coombs, S., Garcia, A., Giráldez, A., Santamaría, M. T. G. and Tsikliras, A. C., 2013. Atlantic Multidecadal Oscillation (AMO) modulates dynamics of small pelagic fishes and ecosystem regime shifts in the eastern North and Central Atlantic. Journal of Marine Systems 111-112: 263-268.

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Beare, D., **McQuatters-Gollop, A.**, Hall- Spencer, J., van der Hammen, T., Machiels, M. and Teoh, S.J., 2013. Long- term trends in calcifying plankton and pH in the North Sea. PLoS ONE, 8: e61175. DOI: 10.1371/journal.pone.0061175.

Beaugrand, G.*; **McQuatters-Gollop, A.**; **Edwards, M.**; Goberville, E. 2013. Long-term responses of North Atlantic calcifying plankton to climate change. Nature Climate Change, 3 (3). 263-267.

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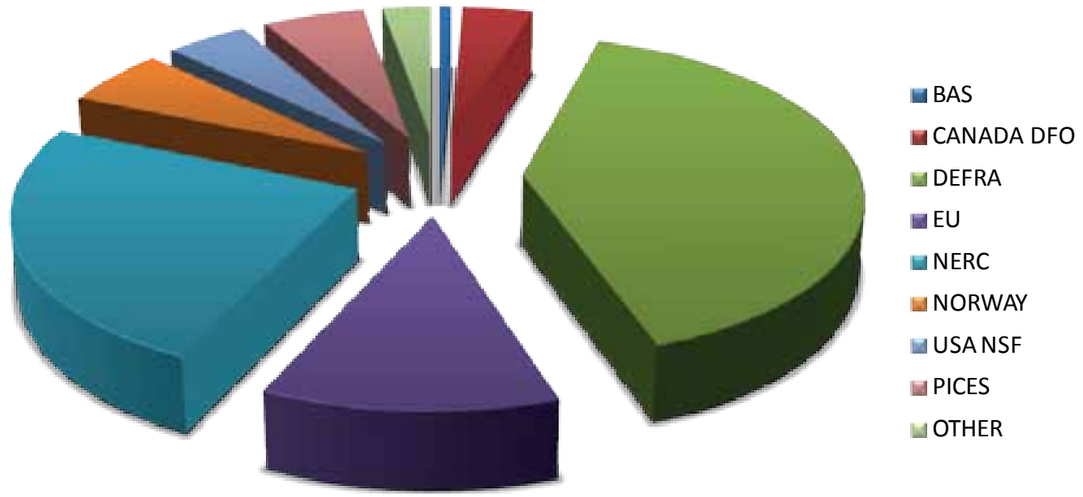
Appendices

Appendix A. Financial Summary



The principal sources of funding for 2013 are broadly derived from grants and contract income from primary funding organisations and research and academic organisations.

Primary funding organisations provide support funding to enable the general operation of the CPR Survey. In 2013 these were: UK Natural Environment Research Council (NERC), UK Department of Environment, Food and Rural Affairs (Defra) and the National Science Foundation U.S. (NSF).

Research and 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 2013 these were: Exxon Valdez Oil Spill Trust, North Pacific Research Board, Dept of Fisheries and Oceans Canada, British Antarctic Survey, European Union, European Environment Agency, Institute of Marine Research Norway, the Marie Curie Institute, Scottish Natural Heritage, Nexen Oil and others.

Total incoming resources for 2013 have increased during the year and together with other income from charitable activities, are reported at £2,141,087 (2012 £1,758,543).

Resources expended for 2013 had reduced during the year, resulting in net incoming resources of £370,665 (2012 net outgoing resources of £76,753).

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 2013

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	2014 Tows
A-	*Hildasay* From March 2010	Chartered by Serco NorthLink Ferries, Scotland from Seatruck Ferries, Heysham.	Freight ro-ro *Hildasay* towed monthly from February to December between Lerwick, Shetland and Aberdeen. 12 tows were completed with 1914 nm towed.
AT	*Horizon Kodiak* From March 2004	Horizon Lines LLC, Charlotte, North Carolina, USA and Tacoma, WA, USA.	Containership *Horizon Kodiak* towed monthly between Tacoma, Washington State and Anchorage, Alaska from April to September. 18 tows were completed with 7143 nm logged.
BA, BB, BC, BD	*Benguela Stream* From January 2008	Seatrade NV, Groningen, Netherlands. Charterers: Geest Line Ltd, Fareham, England.	*Benguela Stream*, a fast refrigerated cargo ship completed four consecutive tows every 28 days from 40º West to Portsmouth, UK. 47 tows were completed with 20967 nm towed.
C-	*Petunia Seaways* From August 2006 *Ficaria Seaways* From July 2006	DFDS Seaways, Copenhagen, Denmark.	*Petunia Seaways* towed between the Humber and Gothenburg in January, February and April. 3 tows were completed with 1016 nm towed. *Ficaria Seaways* towed monthly between the Humber and Hanstholm Lighthouse, NW Denmark from May to December. 8 tows were completed, with 2854 nm towed.
D-, DA, EA, EA	*Atlantic Companion* From May 2008	Atlantic Container Line, Gothenburg, Sweden.	*Atlantic Companion*, a large ro-ro container ship, towed the E route between Norfolk, VA / New York, Halifax, Nova Scotia and south of Cape Race, Newfoundland from January to July and September to December. *Atlantic Companion* also towed the DA and D routes every five weeks from January to July and September to December. This is between 33°W and 7°15'W to the north or south of Ireland en route to Liverpool depending on the prevailing North Atlantic weather. 40 tows were completed with 18076 nm towed.
HE	*Clipper Point* From July 2012	Chartered by DFDS Seaways from Seatruck Ferries Ltd, Heysham, UK.	*Clipper Point* towed between the Elbe and Humber from January to April then October to December 2013. 7 tows were completed with 1922 nm towed.
IB & SB	*Sophia* From December 2011	Chartered by MacAndrews Ltd, London from Peter Doehle Schiffahrts KG, Haren/ Ems, Germany.	Containership *Sophia* towed each month except for November in 2013 from the IB route 46°N, Biscay to 53°N, Irish Sea. She also towed the SB route each month except April and November from Lisbon or Setubal to Leixoes then 46°N in Biscay. 27 tows were completed with 9863 nm towed.
IN	*Norbay* From May 2004	P&O Ferries (Irish Sea) Ltd, Larne, Northern Ireland.	The *Norbay* towed every month in 2013 between the Liverpool Bar light buoy and Dublin. 11 tows were completed with 870 nm towed.
KC	*Norrland*	Chartered by Sea-Cargo, Bergen, Norway from Brise Schiffahrt, Hamburg, Germany	This new monthly route between Immingham and Tananger was started in February 2013 by the ro-ro *Norrland*. 11 tows were completed with 3936 nm towed.
LG	*Ficaria Seaways* *Petunia Seaways*	DFDS Seaways, Copenhagen, Denmark.	*Ficaria Seaways* towed between west of Rotterdam and Gothenburg from January to April 2013. 4 tows were completed with 1826 nm towed . *Petunia Seaways* towed May to July 2013. 3 tows were completed with 1290 nm towed.
LR & V-	*Selfoss* From September 2000	Eimskipafelag, Reykjavik, Iceland.	The *Selfoss* towed from January to March and May to December 2013 between the Humber and Sule Skerry off Northern Scotland to 18°W. 21 tows were completed with 8755 nm towed.
M-	*Sea Cargo Express* From September 2012	Sea Cargo A/S Bergen, Norway.	*Sea-Cargo Express* has towed monthly between Aberdeen and Tananger from January to December. 12 tows were completed with 3085 nm towed.
NI	*Skogafoss* From April 2013	Chartered by Eimskip, Reykjavik, Iceland from W. Bockstiegel Maritine Service, Emden, Germany.	*Skogafoss* restarted monthly tows in April between Iceland and Sortland, Lofoten, Norway. 17 tows were completed with 6725 nm towed.
OAS	*James Clark Ross* January/February 2013	British Antarctic Survey. Natural Environment Research Council.	The RRS *James Clark Ross* towed 3577 nautical miles between 51°S and 63.5°S and 25° to 57.6°W during January and February on the Ocean Acidification South cruise. 37 tows were completed with 3439 nm towed.
PR	*Armorique* From March 2009	Brittany Ferries, Roscoff, France.	The *Armorique* towed from Roscoff to Plymouth each month from January to October. 11 tows were completed with 992 nm towed.
PR	*Bretagne* Nov/Dec 2013	Brittany Ferries, Roscoff, France.	The *Bretagne* took over and did the November and December tows. 2 tows were completed with 185 nm towed.
R-	*Flandria Seaways* from July 2000	DFDS Seaways, Copenhagen, Denmark.	*Flandria Seaways* towed monthly CPRs between the Hook of Holland and the Shipwash Bank. 11 tows were completed with 943 nm towed.
SA	*Encounter* From April 2012 to May 2013 *Energizer* From July 2013	Chartered by MacAndrews Ltd, London. Managed by Confeeder Shipping, Rhoon, Netherlands.	Containership *Encounter* towed from Bilbao to Land's End from February to May. 4 tows were completed with 1715 nm towed. The *Energizer* resumed towing monthly from July to December. 6 tows were completed with 2610 nm towed.
SF	*Pharos SG* From March 2011	Owners: Byron Marine Ltd, Southampton, England. Charterers: Government of South Georgia & South Sandwich Islands, Stanley, Falkland Islands.	*Pharos SG*, the South Georgia Fisheries Protection Vessel, completed five sets of eastbound double tows from Stanley to South Georgia in March, May, July, October and December 2013. 10 tows were completed with 3562 nm towed.
ST	*Green Frost* From November 2008	Green Reefers AS, Bergen, Norway.	The *Green Frost* towed monthly between the North Cape of Norway and Svalbard from April to December. 9 tows were completed with 3741 nm towed.
TARA	*Tara* From June 2013	Tara Expeditions.	The French research schooner *Tara* towed CPRs for 3915 nautical miles over 36 legs between the Faroe Islands, Tromso, Murmansk, Dudinka, the Franz Josef Islands, then from Pevek to Tuk, Ilulissat, Greenland and Quebec Province. The Arctic circumpolar passage was completed from June to the end of October 2013.
VJ	*Skaubryn* From May 2013	Chartered by Seaboard International Shipping Company, from Doriko Ltd, South Korea.	Ro-ro ship, *Skaubryn* completed three sets of seven 500nm tows each in May, July and September 2013 between Vancouver Island and Hokkaido, Japan. There were 21 tows totalling 10442 nm.
Z-, ZB, ZC	*Reykjafoss* *Westerkade*	Chartered by Eimskip, Iceland from Reider Shipping BV, Winschoten, Netherlands.	Z route: towed by *Reykjafoss* of Reider Shipping, Netherlands from January to June from Newfoundland to Reykjavik. From June the tow direction was reversed to ensure that the Grand Banks are sampled to the east of Newfoundland. In October 2013 the route was restarted by the *Westerkade* with monthly tows

North Atlantic tow routes and ships of 2013

Selfoss
Eimskip
LR route: Immingham to Sule Skerry
V route: Sule Skerry to SE Iceland

Skogafoss
Eimskip
NI route: E Iceland to Sortland

Hildasay
Serco Northlink Ferries Ltd
A route: Lerwick Shetland to Aberdeen

Sea Cargo Express
Sea-Cargo
M route: Aberdeen to Tananger

ST

Green Frost
Zahl Transport
ST route: Svalbard to North Cape

NI

V

Norrland
Sea-Cargo
KC route: Immingham to Tananger

A

M

KC

C

LR

HE

LG

IN

IB

PR

R

D

Z

Sophia
MacAndrews Ltd
IB route: Biscay to 53°N

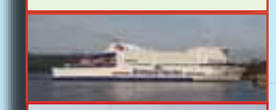
Norbay
P&O Ferries Ltd
IN route: Dublin to Liverpool

Ficaria Seaways
DFDS Seaways
C route: Humber to Hanstholm

Petunia Seaways (& Freesia Seaways)
DFDS Seaways
LG route: Humber to Gothenburg
C route: Humber to Hanstholm

Atlantic Companion
Atlantic Container Line
D and DA route: 33°W to 7°W and Liverpool

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

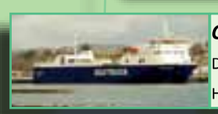


Encounter (& Energizer)
MacAndrews Ltd
SA route: Bilbao to Lands End

SA

SB

B



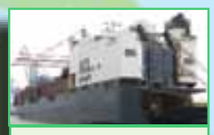
Clipper Point
DFDS Seaways
HE Route: Cuxhaven to Immingham

Flandria Seaways
DFDS Seaways
R route: Hook of Holland to Shipwash Bank

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.

Atlantic

Reykjafoss & Westerkade Eimskip
Z routes: Reykjavik to east of Newfoundland



Atlantic Companion
Atlantic Container Line
E routes: Norfolk VA to south of Cape Race

Benguela Stream
Seatrade NV, Geest Line
B Routes: Portsmouth to 40°W

Sophia
MacAndrews Ltd
SB route: Lisbon to Leixoes then 46°N

Z

ZB

ZC

EA

EB

BA

BB

BC

BD

NI

V

A

LR

D

IB

PR

SA

SB

Tara
Tara Expeditions
Arctic Circumpolar

Arctic

Global tow routes and ships of 2013

Southern Ocean

SF

OAS

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

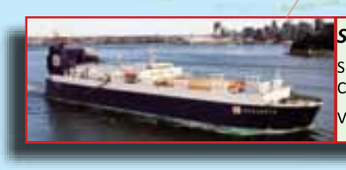
James Clark Ross
British Antartic Survey
OAS route: 37 tows around Southern Ocean

Pacific

Horizon Kodiak
Horizon Lines LLC
AT route: Anchorage Alaska to Tacoma Washington State

VJ

AT



Skaubryn
Seaboard International Shipping Company
VJ route: Vancouver to Hokkaido Japan

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