Sir Alister Hardy Foundation for Ocean Science

Monitoring the health of the oceans since 1931

2010 Annual Report

The Continuous Plankton Recorder Survey Est. 1931

Passenger Ro-Ro ferry CAP FINISTÈRE

Brittany Ferries, Roscoff, France
SA route
Bilbao to Portsmouth
From October 2010

Containership REYKJAFOSS

Charterers: Eimskip, Reykjavik, Iceland
Owmers: Reidar Shipping BV, Netherlands
Zc, Zb and Z Routes
Newfoundland to Iceland, NW Atlantic
From June 2008

Passenger/cruise Ro-Ro ferry PRIDE OF BILBAO

P&O Ferries, Portsmouth UK,
SA route: Bilbao, Spain to Portsmouth, UK
From: May 2004 to September 2010

Passenger Ro-Ro ferry ARMORIQUE

Brittany Ferries, Roscoff, France
PR route: Plymouth to Roscoff
From March 2009

Containership BBC REYDARFJORDUR

Chartered by Eimskip, Reykjavik
Owners: Phoenix Reederei, Leer, Germany
NI route, 11°30'E to 13°10'West.
Mosjoen, Norway to Reydarfjordur, Iceland
From June 2009 to June 2010

Cargo-Supply ship GREEN FROST

Charterers: Zahl transport A/S, Bodo, Norway
Owners: Green Reefers A/S Bergen
ST route: Svalbard to Tromso
From November 2008

Ro-Ro SKAUBRYN

Seaboard International Shipping Company Ltd
North Vancouver, Canada
VJ Route:- Vancouver to Japan
Via the Aleutian Islands and Bering Sea
From June 2000

Containership HORIZON KODIAK

Horizon Lines LLC, U.S.A.
AT route: N.E. Pacific: Tacoma, Washington State, USA to Anchorage , Alaska, USA
From March 2004

Ro-Ro TOR DANIA

Chartered by DFDS Seaways, Copenhagen, Denmark
Owned Imperial Shipping AB, Gothenburg, Sweden
HE Route: Elbe to the Humber,
From October 2005 to March 2009

Ro-Ro/ Containership ATLANTIC COMPANION

Owners: Atlantic Container Line, Skarhamn, Sweden
E route: New York – Halifax, Nova Scotia to 52°W
D & W routes: 33°W to 7°West from Montreal to Liverpool
From May 2008

Ro–Ro TOR FICARIA

DFDS Seaways, Copenhagen
C route: Humber to off Hanstholm Lighthouse, NW Denmark, en route to Gothenburg.

Containership HELGALAND

Charterers: MacAndrews & Co Ltd, CMA CGM London
Owners: M/S Helga GmbH Co. Jork, Germany
IB and SB routes: Lisbon to Porto and 46°North then Dublin
From February 2010

Ro-Ro NORBAY

P&O Ferries (Irish Sea) Ltd., UK
IN Route - Dublin to Liverpool
Mid Irish Sea
From May 2004

Ro-Ro TOR PETUNIA

DFDS Seaways, Copenhagen, Denmark
LG Route: Humber to Gothenburg via the Skaw, Southern North Sea
From August 2006

Ro-Ro cargo ferry HILDASAY

Charterers: NorthLink Orkney & Shetland Ferries Ltd
Owners: Seatruck Ferries Ltd, Warrenpoint, N Ireland and Heysham, England
A route: Lerwick Shetland to Aberdeen
From March 2010

Refrigerated cargo ship BENGUELA STREAM

Owners: Seatrade Groningen NV, Netherlands.
chartered to Geest Bananas UK Ltd
B route: Mid Atlantic to Portsmouth, UK
From January 2008

Ro-Ro S.C. ABERDEEN

Sea Cargo A/S, Bergen and Stavanger, Norway
M route: Aberdeen to Tananger, Norway
From September 2001

Containership S. RAFAEL

Chartered by Eimskip, Reykjavik
Owners: Briese Shiffahrts GmbH & Co KG. Leer, Germany
NI route: Mosjoen to Reydarfjordur, Iceland From September 2010

Passenger Ro-Ro ferry BRETAGNE

Brittany Ferries, Roscoff, France
PR route: Roscoff to Plymouth
February, November 2010

Containership SELFOSS

Eimskipafelag, Reykjavik, Iceland
LR and V routes: Immingham to Sule Skerry (NW Scotland) and SE Iceland
From September 2000

Passenger Ro-Ro ferry PONT AVEN

Brittany Ferries, Roscoff, France
PR route: Roscoff to Plymouth
December 2010

Ro-Ro S.C. ABERDEEN

Sea Cargo A/S, Bergen and Stavanger, Norway
M Route: Aberdeen to off Stavanger and Tananger, Norway
Northern North Sea.
From September 2001 to February 2010

Ro-Ro MAERSK FLANDERS renamed FLANDRIA SEAWAYS in August 2010

DFDS Seaways, Scheveningen, Holland
R Route: Hook of Holland to the Shipwash Bank, off Suffolk en route to Felixstowe, England.
From July 2000.

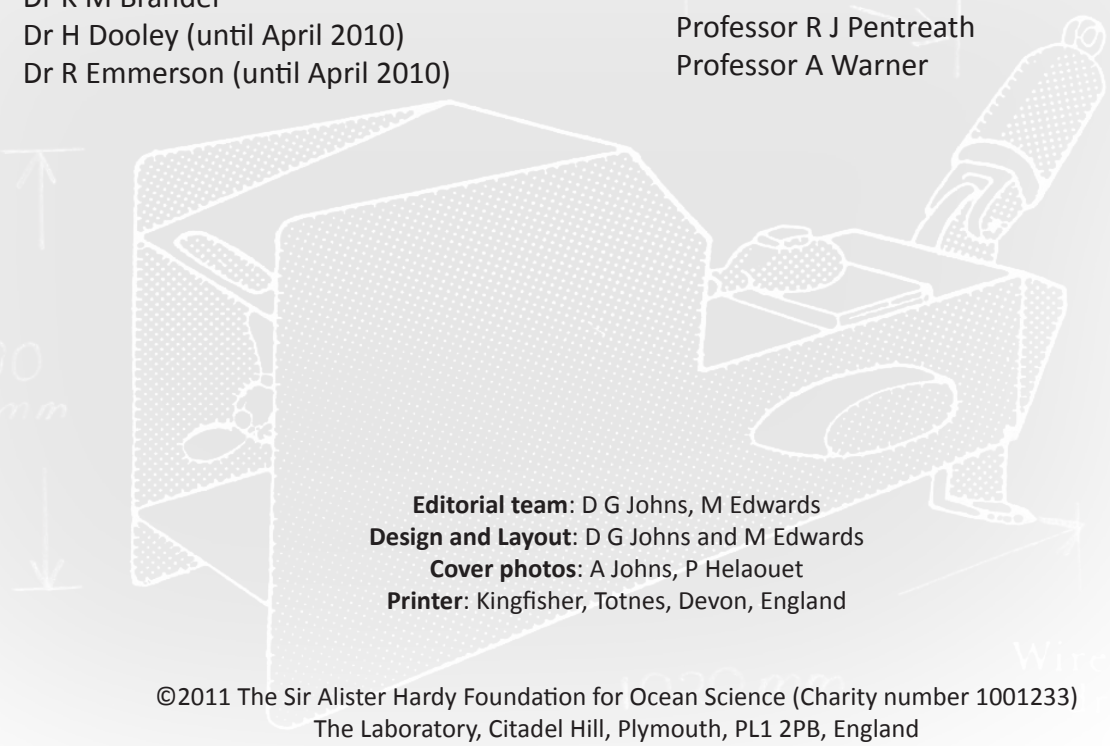
Ro-Ro cargo ferry, HASCOSAY

NorthLink Orkney & Shetland Ferries Ltd
Stromness, Orkney, Scotland, UK
A route: Lerwick, Shetland to Aberdeen
From November 2002 to February 2010

Research vessel CAPE HATTERAS

Duke University, Beaufort, North Carolina, USA
GM route in Gulf of Mexico. Post April 2010 Deepwater Horizon oil spill. Towed October 2010.
From November 2002 to February 2010

Annual Report 2010



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Director's review of the year

Welcome to our 2010 Annual Report in which we outline recent progress at SAHFOS. During the last 12 months, we have maintained our regular survey operations in the Arctic, Atlantic, Pacific and Southern Oceans. We have started planning for an increasingly global perspective for monitoring plankton through working with other countries. During the year, we initiated some new studies in the molecular taxonomy of phytoplankton. We report, with delight, an increase in the use of CPR data by stakeholders during the year. We also identify an increase in our research outputs. During 2010, we have initiated internal actions to improve our QA/QC procedures in order to meet stakeholder requirements. This will involve full documentation of all CPR processes over the coming year. All these activities are designed to strengthen SAHFOS and to ensure we maximise the impact of the resources that we receive. We are grateful to NERC, Defra, BAS, EU, Canada, France, Ireland, the Netherlands and the USA for their ongoing commitment and support in funding the CPR Survey.

While the broad goals of SAHFOS remain to continue to monitor and understand changes in the plankton communities of the North Atlantic, North Pacific, European Arctic and Southern Ocean, our Going Global strategy (see www.sahfos.ac.uk for details) requires an increasingly broader perspective. The environmental factors that cause changes within plankton communities are invariably large-scale and often global in nature. We are therefore embracing the challenges of working at broader scales. We will do this collaboratively by working with other countries. During the year, we were in touch with scientists in Australia, Brazil, Canada, China, Eire, France, Japan, New Zealand, South Africa and the USA, all of whom are interested in working on a global initiative. This will be taken forward in 2011. As part of this global initiative we have continued to work with scientists from South Africa, Namibia and Angola to plan a new CPR survey in the Benguela Current system off western South Africa. Training of technicians from these countries to run the Benguela CPR Survey was carried out early in 2011.

Although SAHFOS has only a small number of research staff, their outputs have increased in 2010 with 57 papers published. Of these, 34 were published in the ISI literature. Some 70% of these involved international co-authorship. The range of publications is also growing. While we continue to publish on inter-decadal plankton variability in relation to global change processes and its relevance for policy issues, staff have produced papers on topics as diverse as an Atlas of Calcifying Plankton (reflecting contemporary interests in ocean acidification), plankton-seabird associations (reflecting multi-trophic level macroecology), volcanic ash fuelling plankton blooms (a consequence of the August 2008 Kasatochi eruptions) through to carbon export by Acantharia (and its role in climate control). It is marvellous to acknowledge the increased breadth of applications that our understanding now achieves.

The number of CPR data requests continues to grow and this demonstrates how SAHFOS engages with a wide range of stakeholders. During 2010, we received 81 requests for CPR survey data. Although most of the data requests were from the UK, we have also provided data to scientists in Australia, Belgium, Canada, China, Denmark, France, Germany, Ireland, Netherlands, Norway and USA. Both the number of requests and the number of countries involved have increased significantly over previous years. It is our intention that we continue to increase the use of our data. We would particularly welcome enquiries from those with whom we have not interacted before.

This year, we are trying a new approach to our Associated Researcher scheme. In this, our staff nominate a smaller number of larger projects in which they wish to develop external collaboration. This process is ongoing and so far we have started three major collaborations. The outputs of the 2010 awards are presented later in this report and demonstrate another way in which CPR data is used for the benefit of the scientific and policy-maker communities.

It is a pleasure to announce that Chris Reid was awarded a Service Medal by ICES in recognition of his role in leading the Editorial Workshop for the Position Paper on Climate Change (EWPPCC) for 2010. SAHFOS staff numbers have increased as we welcomed Dr Rowena Stern and Rebecca Vince. Rowena, who joins us from UBC Canada, is our new molecular taxonomist while Becky, a local Plymothian, has joined on a temporary apprenticeship to help with our administration. No staff left during 2010.

As the coming year is the 80th Anniversary of the CPR Survey, SAHFOS will be hosting an international symposium, Plankton 2011. This will be held in Plymouth on 22nd and 23rd September. The symposium will focus on the causes and consequences of long- term change in aquatic plankton communities. I use this opportunity to extend an invitation to you to join us. Full details are available on www.plankton2011.org.

As I will be leaving SAHFOS in autumn 2011, I would like to say a heartfelt thank you to SAHFOS Council and staff for allowing me to lead SAHFOS during the last 5 years. Together, we have made significant progress and I hope SAHFOS continues to develop well in the future. I wish my successor, and all the staff, “fair winds and following seas” in the years ahead.

Peter Burkill

April 2011

CPR survey Northern Hemisphere

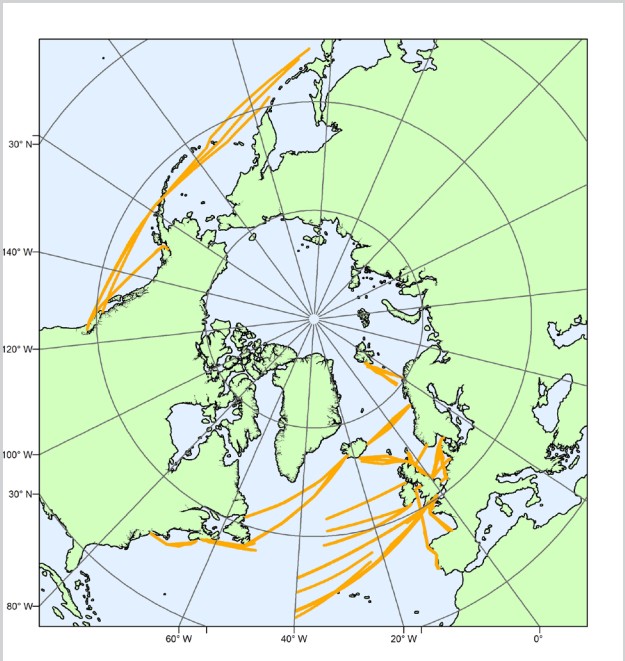


Fig.1. Continuous Plankton Recorder samples taken in the Northern Hemisphere during 2010. During 2010, the CPR survey expanded its operations into Arctic waters with tows from northern Norway to Svalbard.

CPR Survey Operations

Tow logistics and operations

Peter Pritchard, *Operations Manager*

The physical operation of the Continuous Plankton Recorder (CPR) Survey over the past 79 years would not have been economically possible without the generous support of ships, owners, managers, charterers, port operatives and agents. The consistent monthly tows and the assistance from the agents and port operatives in transporting the recorders to and from the vessels are a fine testament to the shipping industry. The international marine, fisheries, meteorological and oceanographic communities are greatly indebted to them.

Ships and companies participating during 2010 are shown in Appendix B. Photographs of the ships are inside the covers. During 2010 the 25 tow ships logged 128,509 nautical miles on 29 routes worldwide. There were 112,360 analysable nautical miles. A total of 5,832,006 nautical miles have been towed to 31 December 2010 by the 296 ships since September 1931.

The overall 87.4% sampling success rate in 2010 illustrates the conscientious, consistently professional work of the CPR workshop team. The team comprises of Lance Gregory, Roger Barnard, Chris Harris and Debbie Cracknell. Eight changes of ships occurred in 2010. February: *Bretagne* on the PR route; *Helgaland* on the IB/SB route; *Tor Dania* on the HE route. March: *Armorique* on the PR route, *Hildasay* on the A route. September: *S.Rafael* on the NI route. October: *Cap Finistere* on the SA route. December: Pont Aven on the PR route.

The tow equipment aboard the ships is subject to a planned maintenance and safety inspection regime complying with the international lifting equipment regulations. (LOLER 1998)

The following geographic areas were monitored by CPRs:

Arctic, North East Atlantic and Norwegian Sea

The ST route between the North Cape of Norway and Svalbard was towed six times from April to December 2010 by the Green Frost. We are indebted to the owners Green Reefers of Bergen and charterers, Zahl Transport of Bodø, Norway. The NI route between Mosjoen, Norway and Reydarfjordur, Iceland was towed by the *BBC Reydarfjordur* from January to June 2010. Unfortunately the ship sustained a major mechanical failure and came off charter. We are indebted to the owners, Phoenix Reederei of Leer, Germany and the charterers, Eimskip, Reykjavik as well as Grieg Logistics Shipping Agency of Mosjoen for assisting the survey. A replacement containership, *S. Rafael* towed the route from September to December 2010 thanks to the kindness of the owners, Briese Schiffahrts of Leer, Germany. This route covers a very important area for plankton monitoring.

Iceland to North America and Europe

The Foundation is greatly indebted to the Hafrannsoknastofnunin (Marine Research Institute) of Reykjavik for the continuous logistical support to the survey. Teresa da Silva and her supervisor Dr Astthor Gislason organise the transfer of the Continuous Plankton Recorders (CPRs) to and from the Z route ship, *Reykjafoss* at Reykjavik. Eimskip Shipping Company of Reykjavik has steadfastly supported the CPR survey since 1933. They have allowed successive ships to tow CPRs from the east coast of the USA to Nova Scotia, Newfoundland and Iceland (E and Z) routes, (*Godafoss, Skogafoss* etc.), and presently, the chartered ship *Reykjafoss*. They also allow the Foundation to tow CPRs on the Immingham to SE Iceland (V) route from the *Selfoss*. The *Reykjafoss* of Reider Shipping BV, Netherlands towed the Z route from Newfoundland to Reykjavik each month during 2010. Their kind assistance and permission is much appreciated.

East Coast of North America

E route: Towed by the ro-ro/containership *Atlantic Companion* between New York, Halifax, Nova Scotia and south of Cape Race, Newfoundland throughout 2010. We are grateful to Atlantic Container Line of Sweden for their professional assistance.

North Atlantic

The *Atlantic Companion* also covered the DA and D routes between 33°West to the north or south of Ireland en route to Liverpool. This depended on the prevailing North Atlantic weather. The refrigerated cargo ship *Benguela Stream* of Seatrade NV towed the B route each month during 2010 from 40° West to Portsmouth, UK. We are grateful to Seatrade NV the managers and the charterers, Geest Bananas (UK) Ltd for their kind assistance.

Pacific

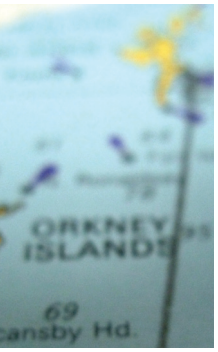
The AT route between Tacoma, Washington State and Anchorage, Alaska was resumed in April by the containership *Horizon Kodiak* of Horizon Lines LLC, USA. Eighteen individual tows were completed to September, with 7242nm logged. The crew of the *Horizon Kodiak* performed running repairs and servicing of the CPRs aboard the ship. A

replacement CPR 180 was sent out in June 2010 after difficulties with CPR 126. Professor Robert Benda of Prince William Sound Community College, Valdez, Alaska with his son Scott Benda looked after the filter cassette unloading, servicing and reloading. The three towed filter cassettes are landed at Anchorage in watertight plastic Peli cases, care of Horizon Lines. Lori Galloway, Pam Moore and their technicians at Horizon Lines, Anchorage organise the airfreight of them to Valdez. After reloading, Robert Benda returns them to Anchorage ready for placing back aboard the ship. The Horizon Lines, Tacoma container terminal shore gang handled the CPRs to and from the ship. Thanks are due to the Ship's Superintendent, Danny Ellis, and Horizon Lines' shore gang plus foremen, Ken Clinton and Vern Poulsen. The continued success of this route is due to the excellent professional co-operation by all of the aforementioned. October 2010, Professor Bob Benda retired from the NE Pacific plankton survey after eight years conscientious and dedicated work. The Sir Alister Hardy Foundation wishes to extend thanks and gratitude for the consistent professional assistance given by Bob and his family to the NE Pacific survey. We wish them all the best for the future, especially with Alaskan wildlife rescue projects, namely bear cubs and eagles.

The VJ route between Vancouver and Japan was towed for three tow sets over May, July, August and September by *Skaubryn* of Seaboard International Shipping Ltd. Each of the three westbound tow sets comprises seven 500 nm tows. At 3500nm this is presently the longest annual route in the CPR survey. 10,132 nm were logged over 21 tows. There were 9,364 analysable nm. This gave 92.4% success. The Brancker XR620 CTD + F unit was successfully run on the three sets of VJ route tows. The above success rate is attributable to the care taken by Dr Sonia Batten, Doug Moore and the CPR team on Vancouver Island. We are indebted to Seaboard and the *Skaubryn* for their continued assistance.

North Sea

The C, HE and LG routes have been consistently monitored each month by ships of the DFDS Tor Line (now DFDS Seaways from August 2010) fleet over many decades. The Survey is greatly indebted for permission to tow CPRs from DFDS Seaways' headquarters in Copenhagen, and for the logistical help from their port offices at Immingham and Gothenburg. *Tor Dania* chartered from Imperial Shipping Gothenburg returned to the HE route in February 2010. DFDS Seaways *Tor Ficaria* and *Tor Petunia* towed on the C and LG routes. *Maersk Flanders* (renamed *Flandria Seaways* in August 2010) towed the R route between the Shipwash Bank and Hook of Holland from July 2000. The continued permission to tow from Norfolk Line, Netherlands and logistical help by Norfolk Line at Dooley Terminal, Felixstowe are much appreciated. The M route, between Aberdeen and Tananger, has been towed each month by the freight ro-ro *S. C. Aberdeen* of Sea Cargo A/S, Bergen. Sea Cargo of Bergen and Aberdeen have very kindly assisted the survey for many years. The A route between Lerwick and Aberdeen was towed each month by the freight ro-ro *Hascosay* of NorthLink Ferries Ltd to February 2010. The replacement ro-ro, chartered from Seatruck Ferries of Heysham, took over the A route from March 2010. We are very grateful for their permission and professional assistance to the survey.



Irish Sea

IB route: (46°North in Biscay to 53°North), off Dublin has been towed by the new ship, *Helgaland* from February to December 2010. The charterers are MacAndrews Ltd of London. The ship is managed and owned by Petra Heinrich, HH Shipping, Jork, Germany. IN route: The *Norbay* of P&O Ferries Irish Sea Ltd, Larne, Northern Ireland consistently monitors the plankton each month between the Liverpool Bar light buoy and Dublin. We are grateful to the ship and P&O Ferries at Gladstone Dock, Liverpool for their professional assistance.

Portuguese and NW Spanish coasts, Bay of Biscay and the Channel.

The *Perseus J* of Jüngerhans Maritime Services, Haren Ems Germany, chartered by MacAndrews Ltd towed the SB route in January, then the ship was repositioned. The SB route is from Cabo da Roca (38°50'N 9°53'West) to Leixoes (41°15'N, 8°58'W). The recorder bodies with the same filter cassette inside were then re launched off Leixoes and towed to 46°North in the Bay of Biscay. The SB route was continued by the Helgaland each month from February to December. SA Route: The *Pride of Bilbao* (P&O Ferries) towed monthly from Bilbao (43° 30'N, 3°10'W), around Ushant to off the Casquets (50°N, 2°20'W) from 2004 to September 2010. The ferry was removed from the route for subsequent sale. We have expressed our gratitude to P&O Ferries and the crews for their consistent professional assistance. This route has enabled comparisons between the National Oceanography Centre's Ferrybox readings and a Brancker XR620 conductivity, temperature and depth sensor fitted in the CPR tails. Sea temperature data were forwarded to the Meteorological Office, Exeter. Brittany Ferries, Roscoff, kindly gave permission for their *Cap Finistère* to commence plankton recorder tows on this route from October 2010. PR route: No ship on the route in January. Brittany Ferries' *Bretagne* towed in February 2010. The *Armorique* then towed each month to October. *Bretagne* towed in November and the *Pont Aven* was fitted for towing in December. We are much indebted to Brittany Ferries for their kind permission and professional assistance.

Taxonomic analysis and database management

Tanya Jonas, *Senior analyst*

Since 1931, the CPR analysis team, more than 100 dedicated individuals, have analysed just over 240,000 CPR samples. The samples are mostly from the North Atlantic and North Sea but, in more recent years, we have expanded regular CPR monitoring into the North Pacific and South Atlantic. In 2010, eighteen team analysts were working in Plymouth; two, Sonia Batten and Doug Moore, in Canada; and three, Sanae Chiba, Tomoko Yoshuki and Yuka Sasaki, in Japan.

CPRs sampled 112,360 nautical miles in 2010. Tows were made in the North Sea, North and South Atlantic and Pacific Oceans with 4945 samples allocated for analysis (Figure 1 and 2). The analysis load was below that of some years as a number of anticipated tows, on the D, DA, EA, EB and ST routes, did not take place. We continue to analyse the samples following standard procedures adopted in 1948 and modified in 1958 (a minor modification to the phytoplankton methodology).

In the North Atlantic, during 2010, we have noted high counts of Goose Barnacle nauplii (*Lepas* spp.) in a large area to the north-east of the Azores; to the west a few unusual isopods occurred. The Ecological Status Report provides more information on these and other unusual findings.

Since the inception of the Pacific tows, the analysis of the samples has been shared between analysts in Plymouth and Vancouver Island. During 2010, 14,755 nautical miles were sampled and 317 samples analysed by the teams in the two laboratories. In the last couple of years, a sister laboratory, at the National Fisheries Research Institute in Yokohama, has undertaken analysis of Pacific samples collected west of the 180° meridian.

During the austral summer of 2009/10, the BAS ship *RRS James Clark Ross* carried out the last few CPR tows in the Scotia Sea for the five-year contract 3QS226/1. There were some technical problems with these last tows so, disappointingly, there was only one tow with samples that could be analysed. The results over the five years were beginning to show some interesting features, particularly frontal systems and the distributions of key taxa. We will continue our collaboration with BAS, but this time we will use the fishery protection vessel *Pharos* (Figure 3) to tow CPRs in alternate months between the Falkland Islands and South Georgia. Uniquely for the region, the plankton samples will be collected throughout the year.

Miles towed and samples analysed since 1931

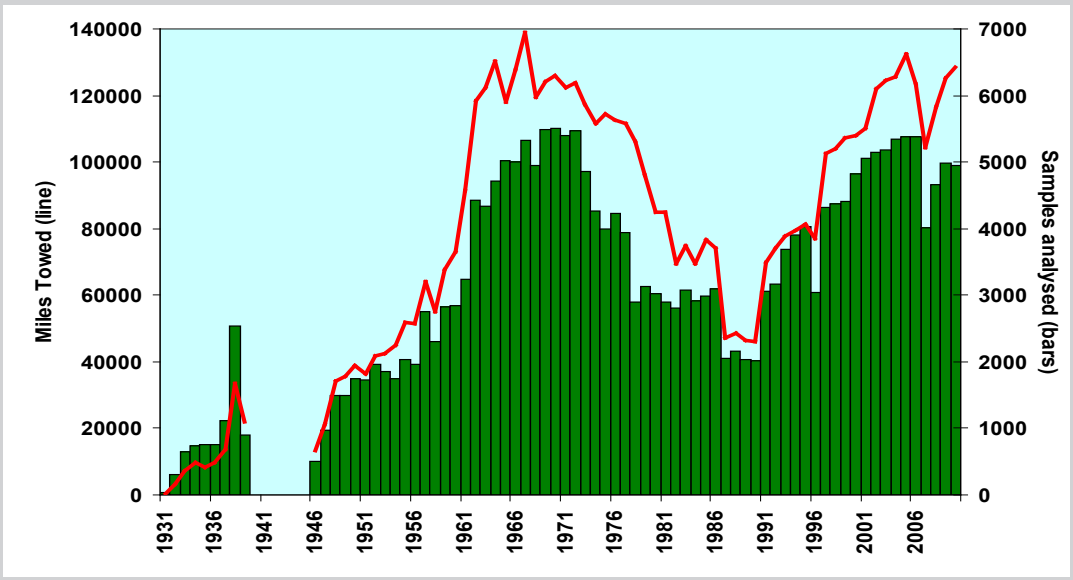


Figure.2.Miles towed and samples analysed since the inception of the Continuous Plankton Recorder Survey in 1931

The CPR Console now provides the user interface to enter CPR data to the database. It enables more information to be stored and when further developed will speed up data processing. The last few years have been quite testing as the team got to grips with the new system.

Training, quality control, quality assurance and procedures

Training for all analysts continues, and in 2010 covered the use of our new microscopes and digital cameras as well as identification of decapods, euphausiids, *Centropages* spp., appendicularians and *Thalassiothrix longissima*. Claudia Castellani and Marianne Wootton attended a three day course on light microscopy organized by the Royal Microscopical Society. Milly Hatton-Brown attended the EDIT-DEST course 'Basics of Taxonomy: describing, illustrating and writing biodiversity' in Sweden. Gemma Brice, Maria Campbell and Milly Hatton-Brown have also received in-house training on Pacific plankton. Marianne Wootton and Claire Wotton passed, with flying colours, the BEQUALM quality assurance phytoplankton identification and enumeration test.

A thorough review of our procedures and quality control measures started in 2010. The review will result in a comprehensive procedures manual to be used by all the sister surveys. The review process has also served as a wonderful training exercise as all analysts have been involved.

New laboratory and equipment

In 2010 we purchased two new microscopes: a dissecting Zeiss Stereo Discovery V8 and compound Nikon Eclipse 80i, both with drawing tubes and attachments for cameras (Figure 4). These have further enhanced the facilities in the taxonomy laboratory set up in 2009.

Towards the end of 2010 the SAHFOS Council agreed to a major refurbishment of the Analysis laboratory and associated offices. After consultations with the designers and technical experts at Sanber, and approval of planning applications, work on the offices started in November. In December, the laboratory area was completely cleared, ready for two months of refurbishment starting in January 2011.The new laboratory will fit SAHFOS for the future, with the best health and safety features, room for one inverted microscope, 11 analysis and five dissecting microscopes.

Technological development: the Water and Microplankton Sampler (WaMs)

Anthony Walne, *Instrumentation*

The water sampler was used in the southern North Sea on the CPR route between Vlaardingen (The Netherlands) and Felixstowe (UK) monthly between March and August 2010. We used a 10 sample WaMS with a seawater switch. Each sample was approximately 100 ml and was retained in a plastic medical reagent bag preloaded with acidic Lugol's iodine.

The CPR samples were analysed in the SAHFOS laboratory in the usual way. The samples from the WaMS were sent to Sweden where they were settled in Utermohl chambers and counted by inverted microscopy by Lars Edler. In July and August the phytoplankton was dominated by the diatom *Rhizosolenia imbricata shrubsoleii* contributing over 95% of the particulate carbon seen in the water samples. At the same time high numbers of the species were seen on CPR samples and the highest value of the Phytoplankton Colour Index was recorded.

One justification for the development of the WaMS was to investigate the contribution it could make to monitoring of Harmful Algal Bloom (HAB) species. Both the CPR and the Water Sampler recorded individuals of the genera *Pseudo-nitschia*, *Prorocentrum* and *Protoperidinium*. The taxa *Gymnodinium* and *Dinophysis* were recorded more frequently by the WaMS than the CPR and this may be because the species tend to be small and non-chain forming. Both samplers recorded the presence of the nuisance species *Phaeocystis* and the CPR had several records of *Noctiluca*. This species was not identified in WaMS samples and this may be due to its delicate nature.

Figure 3. The Falklands Fisheries protection vessel *MV Pharos SG*

Database developments

Darren Stevens, *I.T. Manager*

2010 saw some new developments and changes within the IT team, one of the major changes being the formation of a Citadel Hill IT team, recognising the close collaboration that had been going on for some time between the SAHFOS and MBA IT departments. The virtualisation project at the end of 2009 it was clear that both IT departments had become very interdependent and this was recognised by the Senior Management team with the arrangement of cross-organisational team training.

The SAHFOS website was re-launched in 2010 using an open source .NET based content management system called UMBRACO. This has allowed all staff to update and create web pages, which are then reviewed before being launched onto the website. The intention is to ensure the website becomes far more dynamic, as all staff can now post newsworthy items. This was the completion of work started by Alec Colebrook-Clark as an undergraduate and he was lucky enough to continue working for SAHFOS after graduation in order to complete the task.

Helen Ralph left SAHFOS and the MBA in January 2010 to go travelling around Australia, leaving the position of IT Support Assistant vacant. Alec Colebrook-Clark was in a position to move into the role of IT support but was able to retain some time to continue work on the SAHFOS, FOTO, and PMSEF websites allowing SAHFOS to continue to develop the website.

A highlight of the year was the independent database review conducted by Dr Roy Lowry, Dr Peter Wiebe, Dr Francisco (Tjess) Hernandez and Dr Ann Bucklin. The report of this working group gave clear guidelines on the way forward, with development of the database and advice on what resources would be required in order to achieve these goals. This was a really worthwhile exercise, paving the way for further database development in accordance with the 'Going Global' and 'Going Complete' strategies.

The year rounded off with the launch of a new project to provide a central store for plankton images held by SAHFOS. The software of choice to deliver this objective is Resource Space, an open source digital asset library. This has also allowed us to expand the project, linking it with our Quality Assurance procedures to store procedure documents, as well as providing a central repository for presentations and internal forms. In order to deliver this project, the IT Manager and IT Support Assistant received training in Linux towards the end of 2010, with further training to follow.

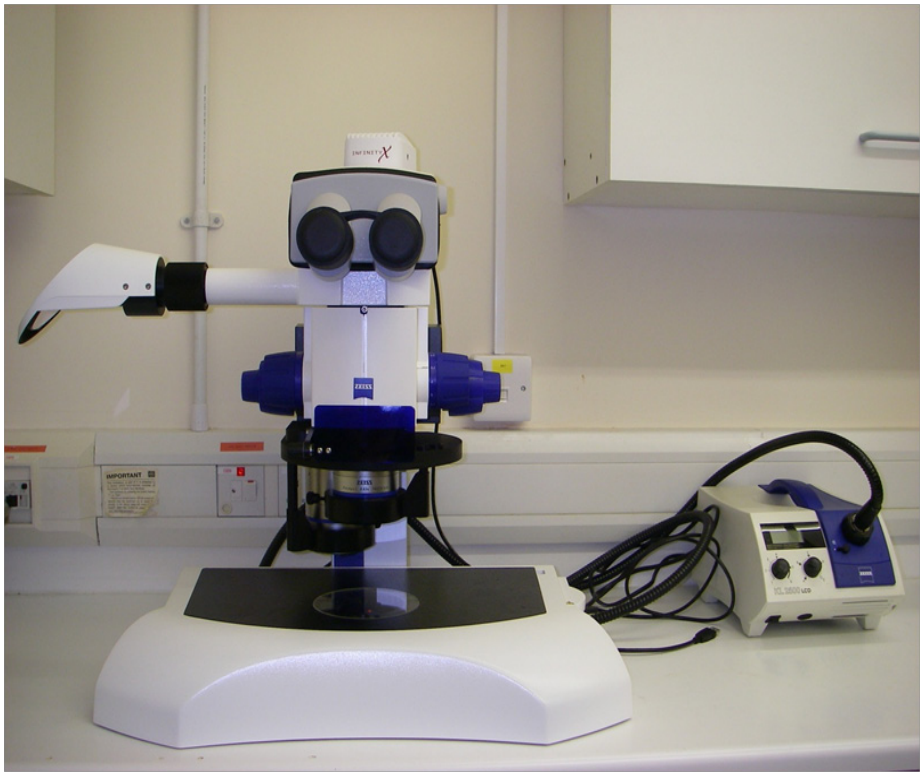


Figure 4. The new Zeiss stereo microscope

Global CPR Network

SCAR Southern Ocean CPR survey

Dr Graham Hosie, *Director of the SCAR SO-CPR survey, Australian Antarctic Division (AAD)*

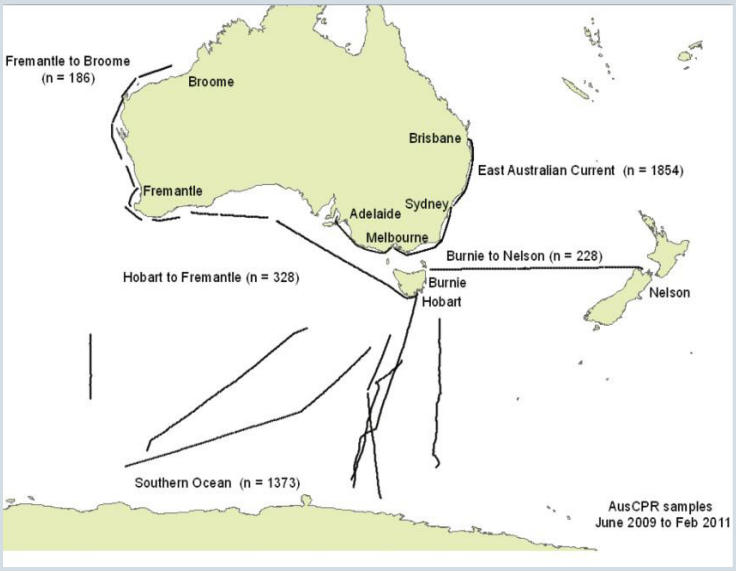
It has been another busy year for the SO-CPR team with the usual series of CPR tows around Antarctica, various workshops to ensure standardisations of our methods and to conduct time-series and biogeographic analysis of the data, plus conference meetings promoting the CPR work. Not surprisingly, the request to use the data grows as recognition of the value of the Southern Ocean CPR data-set grows. All this is happening at a time when the survey is about to celebrate its 20th anniversary.

Field work

The Southern Ocean CPR Survey completed 44 tows from five vessels during the 2009-10 season; November to March. Australia completed 24 tows south and west of Australia from the Australian icebreaker *Aurora Australis*. Japan supplemented this with another 6 tows in the same region from their new icebreaker *Shirase*. New Zealand completed 11 tows between New Zealand and the Ross Sea from the *San Aotea* II (6 tows) and *Tangaroa* (5 tows). Three tows were conducted in the Drake Passage region from the Brazilian vessel *Ary Rongel*. Tows are expected to be conducted annually across Drake Passage and will complement the SAHFOS-led tows around South Georgia further east. This is the main region of krill fishing activity and the results of the CPR tows will be useful for conservation and management of the region. In total 3,176 samples were collected by SO-CPR during the 2009/10 Antarctic season. The 2010/11 is on track to produce a similar number of samples. The addition of the 2009/10 samples increases the data set to approximately 30,000 for more than 230 taxa coupled with environmental data.

Workshops and Data Analyses

The CPR data set was the centrepiece of the Southern Ocean Biogeographic Synthesis workshop in Villefranche-sur-mer, May 2010, convened by the SCAR Marine Biodiversity Information Network (SCAR-MarBIN). The purpose of the workshop was to start the process of developing a new Biogeographic Synthesis Atlas for all marine taxonomic groups (pelagic and benthic) using both historical data and the updated volume of information produced by the Census of Antarctic Marine Life. The new atlas is expected to be a major tool for future Antarctic research, conservation and management of the region. The CPR dataset was used as one of the test data sets for the pelagic realm to develop the methodology and format to apply to other groups. The dataset was selected because of the geographic extent of sampling around Antarctica and because of the CPR's consistency and reliability of sampling. The focus of the analysis was on modelling and predicting distribution patterns of whole zooplankton assemblages around Antarctica, by month and season. The basic approach involves finding relationships between the zooplankton distribution/abundances and the environmental variables that are likely to drive the plankton patterns, e.g. sea surface temperature, salinity, chlorophyll, sea surface height, sea-ice cover, all derived from satellite remote sensing. The distribution patterns of zooplankton assemblages are then modelled and tested against the observed data, based on these relationships. This includes using the satellite observed environmental data to predict zooplankton biogeographic patterns in areas poorly sampled. This analysis of whole zooplankton assemblages builds on the recently published CPR Southern Ocean zooplankton atlas and modelling the circum-Antarctic distribution patterns of the copepod *Oithona similis*. Both the real observation and the modelled biogeographic patterns have shown a number of persistent hot spots of high zooplankton abundance that can be related to foraging zones of higher predators. The analysis started at the Villefranche workshop and concluded at a follow-up workshop in Wellington, June 2010, hosted by the National Institute of Water and Atmospheric Research (NIWA) and the Census of Antarctic Marine Life (CAML).



At the same time, time-series analyses of the dataset have continued using both observed data and modelled patterns to understand the variability and trends being observed in zooplankton distributions, abundances

and composition in relation to the same environmental variables, e.g. temperature, salinity, chlorophyll, sea-ice. One of the aims of the work is to develop a set of species/environmental trend indicators commensurate with those used by SAHFOS. The time-series analysis is also a major contribution to a joint Australia-Japan collaboration on establishing a benchmark on plankton and other pelagic patterns to study future climate change impacts. This is a project supported by dedicated funding from both governments and emanates from a joint statements by Prime Ministers Rudd and Fukuda in Tokyo June 2008, acknowledging the need for enhanced cooperative scientific research in Antarctica to better understand the global impacts of climate change on the region.

A standards workshop was conducted in Tokyo, November 2010, with the primary goal of ensuring we are maintaining the same high standard of species identification, methodology and data quality amongst all participants and laboratories involved with the Southern Ocean CPR Survey. The second aim of the workshop was to discuss future SO-CPR operations and research, and how the Survey can contribute to the global CPR initiative. The workshop was also another step towards building a global CPR network with the active participation of key personnel for various laboratories involved in CPR work in the Southern Ocean, the AAD (Australia), NIPR (Japan), NIWA (New Zealand) and SAHFOS (UK). The participation of SAHFOS's Senior Analyst Tanya Jonas was particularly welcome with her wealth of CPR knowledge. All participants in the workshop are trained to a high standard of methodology and identification of Southern Ocean plankton. While we have endeavoured to maintain that standard between the laboratories, usually through opportunistic visits, the Tokyo meeting provided the first opportunity to bring all key personnel together to exchange our knowledge and expertise, and to ensure our identifications and methodologies are correct through an intensive hands on and interactive workshop. The conclusion of the workshop was that despite the separation of laboratories, there were no errors in the identification of zooplankton; we are maintaining a high standard in methodology and the data are the highest quality possible. The workshop was possible thanks to the support provided by the SCAR Expert Group on CPR Research (EG-CPR) and the National Institute of Polar Research who hosted the meeting, along with real and in-kind support provided by SAHFOS, NIWA, the Australian AusCPR Survey and the AAD.

Meetings

A dedicated CPR session was convened at the SCAR 4th Open Science Conference in Buenos Aires, August 2010, conducted in association with the annual SCAR business meetings. The session was well attended and numerous papers were presented highlighting the scientific achievements of the SO-CPR Survey over the last 20 years. They included the biographic analyses, analysis of long term patterns and trends, and the sudden bloom of pelagic foraminiferans across much of the Southern Ocean and sea-ice zone of eastern Antarctic in the 2004/05 summer season. In that season the foramiferans often represented between 50 to 75% of total zooplankton numbers instead of the usual 5 to 8%. The results of the biogeographic and time-series analyses were also presented at the annual Australian Marine Sciences Association in July 2010 and at the annual NIPR Symposium on Polar Biology in Tokyo, November 2010.

20 years and going strong

The 2010/11 Antarctic field season will see the 20th anniversary of the start of the Southern Ocean CPR Survey. Sir Alister Hardy first used his CPR in the southern Atlantic sector of Antarctica and across Drake Passage during the 1925-27 *Discovery* expedition. After some test tows around Heard Island during the winter (June) of 1990, the Southern Ocean CPR Survey officially commenced at 09:58 GMT on 12 January 1991 when a CPR purchased from Plymouth was deployed from the *Aurora Australis* on route between Mawson and Hobart. At that time the SO-CPR Survey was a genuine one-man-show with just a few tows per year, with only limited support from SAHFOS via telexes, letters and occasional opportunistic visits. After 20 years the survey now involves several nations, with between 50 to 60 tows per year around Antarctica, using more than a dozen vessels, and there is now much more exchange of information and support between Antarctic laboratories and with SAHFOS. The SO-CPR Survey still has a long way to go match the achievements of the SAHFOS based CPR Survey. However, through continued support and interaction between CPR laboratories we hope to emulate that success.

The United States West Atlantic (US-CPR) CPR survey

Dr Jack Jossi, *U.S. Dept. of Commerce, NOAA Narragansett Laboratory, USA*

This, the longest running sister survey, which started in the mid 1970's, uses the same design as SAHFOS and had three routes in operation during 2010. Sampling between Boston and Nova Scotia (route C0) began in 1961 when it was conducted by the CPR staff of the Oceanographic Laboratory, Edinburgh. The US assumed its operation in 1977. Concurrent sampling includes expendable bathythermograph (XBT) and surface salinity measurements. A thermosalinograph (TSG), and a partial pressure of carbon dioxide (pCO_2) sensor are to be installed in early 2011. The second route (B0) extends over the shelf and slope from New York City toward Bermuda, and has been in existence since 1976. Other sampling, extending from New York to Bermuda, includes XBT, TSG, acoustic Doppler current profiler (ADCP), and pCO_2. A third route (N0) covering Narragansett and Mount Hope Bays, and Rhode Island Sound includes monthly sampling using a CPR internal mechanism in an undulating towed vehicle. This route has been conducted since 1998, and includes concurrent measurements of temperature, salinity, oxygen, repetitive rate fluorometry, chlorophyll fluorometry, and optical plankton counting.

Analysis activities during 2010 have focused on the preparation of a series of atlases, the first covering CPR zooplankton across the Gulf of Maine. Included are 1978-2007 baseline abundance conditions in time and space (space = distance along the route); inter-annual variations of seasonality; and inter-annual departures from mean abundance for the 31 most abundant taxa during the baseperiod. Opposing changes in seasonality for two of these taxa are shown in the accompanying figures. For *Centropages typicus*, copepodite stages 4-6 (Figure 4a), the day of maximum abundance occurred between late August to early October in the early 1960s for the three sections of the Gulf of Maine transect, but had advanced to early to late August by 2009. In the case of Decopoda larvae (other than Brachyura) (Figure 4b), the opposite change is seen, at least in the central and eastern sections of the Gulf of Maine. During the early years, the annual maximum abundance for the central and eastern sections occurred during January and February. A fairly steady latening of this annual maximum continued through the series until 2009, when it occurred between late July and late August. Given the large number of species included in the non-Brachyuran category, this change is likely the result of changes in species composition of the CPR samples. We are very grateful for the longstanding support of the officers and crews of the containerships *Godafoss*, *Reykjafoss, Selfoss*, and *Skogafoss* (Eimsipafelag, Reykjavik, Iceland), who by the end of 2010 had towed the CPR 295 times across the Gulf of Maine; of the container ship *Oleander* (Bermuda Container Lines Ltd., Hamilton, Bermuda) who completed the 381st CPR tow in December 2010; and of the research vessels *Cap'n Bert* (University of Rhode Island) and *John Chafee* (State of Rhode Island, DEM) for the 107 CPR tows in Narragansett Bay.

This being my last annual report before retirement in April 2011, I would like to thank all the staff of the CPR surveys, from Edinburgh, to Plymouth, to Nanaimo, to St Lucia, to Narragansett. The resulting plankton time-series are among the longest for this part of the world, and are due in very large part to your help, always offered with generosity, insight, and grace. Keep on towing!

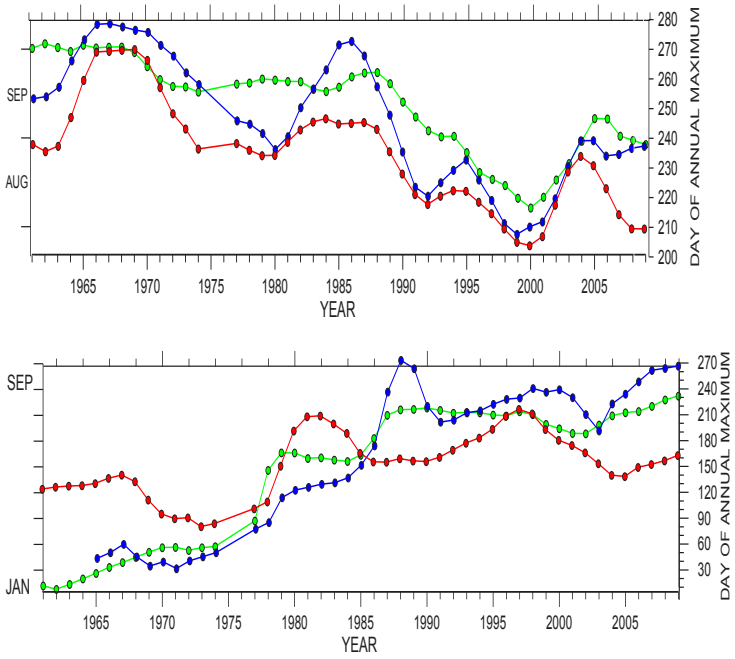


Figure5a (Top) Variations of the day of annual maximum abundance of *Centropages typicus,* copepodite stages 4-6 for the Massachusetts Bay (red), the central Gulf (blue), and the western Scotian Shelf (green) sections of the Gulf of Maine CPR route. 5b (Bottom) Variations of the day of annual maximum abundance of Decapoda (excluding Brachyura) larva for the Massachusetts Bay (red), the central Gulf (blue), and the western Scotian Shelf (green) sections of the Gulf of Maine CPR route.

The Australian Continuous Plankton Recorder (AusCPR) survey

Dr Anthony J. Richardson & Dr Graham Hosie

AusCPR is a joint project of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Australian Antarctic Division (AAD) to monitor plankton communities as a guide to the health of Australia's oceans. AusCPR was initiated in 2008 and forms part of the $US105M Integrated Marine Observing System (IMOS), an initiative of the Australian Government.

AusCPR has expanded considerably since last year and has two areas of operation. The first is in Australian coastal waters. The longest running route is between Brisbane (27°S) and Melbourne (38°S) (since June 2009). This route now runs to Adelaide and is conducted every 2 months. Other routes are towed less frequently, such as across the Tasman Sea to New Zealand and across the Great Australian Bight and up the Western Australian coast. The tow from Australia to New Zealand is conducted in conjunction with hydro-acoustic research into the biomass of mesopelagic mid trophic levels. The second area of operation is in the Southern Ocean south of Australia, in collaboration with the SCAR Southern Ocean CPR Survey based at the AAD (see the Southern Ocean CPR report).

Our focus has been on expansion and data delivery this year, but some interesting science is emerging from collaboration with Prof. Gustaaf Hallegraeff and Dr Lucy Whittock (University of Tasmania) that might be new for CPR surveys globally. In September 2009, following a 10 year drought, the most severe since European settlement, a large dust storm hit the eastern states of Australia. Airports on the east coast of Australia were closed and visibility was <50 m in some areas. Our regular east coast CPR tow, 3 weeks after the event, yielded black silks, appearing as if they were covered in oil. On closer examination with light microscopy, scanning electron microscopy, and through molecular analysis, the cause of the 'black' silks was identified as the fungus *Aspergillus sydowii*. This fungus has been implicated in soft coral disease in the Carribean Sea and is found in dust in the Sahara, but also inhabits freshwater and marine habitats. This extremely cosmopolitan organism covered our silks between Brisbane and Sydney, and was present between Sydney and Melbourne, but has not been seen at any other time since we began our tows in June 2009. Currently we are not sure of the ecosystem consequences of this fungus, but they are under investigation. This example highlights the invaluable insight into unexpected events provided by a regular synoptic plankton survey such as the CPR.

Finally, a brief note about QA/QC. As part of this process, we are building an identification guide for phyto- and zooplankton from the AusCPR survey, which currently has key taxonomic information for identification, and in the future will include distribution maps and seasonal cycles. We have currently completed these for 47 phytoplankton and 211 zooplankton species.

We would like to take this opportunity here to thank all the staff at SAHFOS for their continued support over the past year. In particular, Lance Gregory has provided regular and valuable advice on all things logistical. Finally, we would also like to thank the expanding AusCPR team – Frank Coman, Claire Davies, James McLaughlin, David McLeod, Anita Slotwinski, Joanna Strzelecki and Mark Tonks – who have made AusCPR a reality.

Pacific CPR operations

Dr Sonia Batten, *SAHFOS*

The year saw the last tow by the cargo ship *Skaubryn*, which has towed the great circle VJ route from North America to Japan since the beginning of the Pacific survey. The ship was sold to new owners, but, with Seaboard's generous cooperation we have lined up one of their replacement vessels to undertake the same sampling in 2011 and beyond. Professor Bob Benda and his son Scott, who have been servicing the AT route mechanisms at the Prince William Sound Community College in Valdez Alaska since 2003, asked to step down after 2010. New local technicians will be trained early in 2011 to replace them but we thank them for all their help. Other than that, 2010 was a routine eleventh year of sampling. Funding was adequate, with the consortium contributing about 75% of the costs and SAHFOS making up the remainder.

Sampling was planned to be at the normal level with six AT tows between Cook Inlet and Puget Sound and three VJ tows. The June AT tow failed completely but other tows were successful, with some minor losses because of mechanical issues. The Brancker CTD was fitted to the CPR on the VJ route and returned three full tows of data. A minilogger was fitted to the AT CPR for July onwards.

CPR Research Highlights

Calanus finmarchicus distribution linked to a critical thermal boundary

Dr Pierre Hélaouët, SAHFOS

Among the species identified by the CPR survey, *Calanus finmarchicus* is probably one of the most important components in the North Sea plankton community by being representative of the Atlantic Arctic biome (cold oceanic environment). Therefore, a change in the abundance of that species in the North Sea in favour of its congeneric species (i.e. *C. helgolandicus* adapted to more temperate water masses) may indicate that the subarctic biome has moved northward, potentially having deep repercussions on the food web. For instance, the progressive substitution of *C. finmarchicus* by *C. helgolandicus* has been proved to be the cause of a delay of several months in the timing of occurrence of *Calanus* prey and thus had a repercussion on juvenile cod.

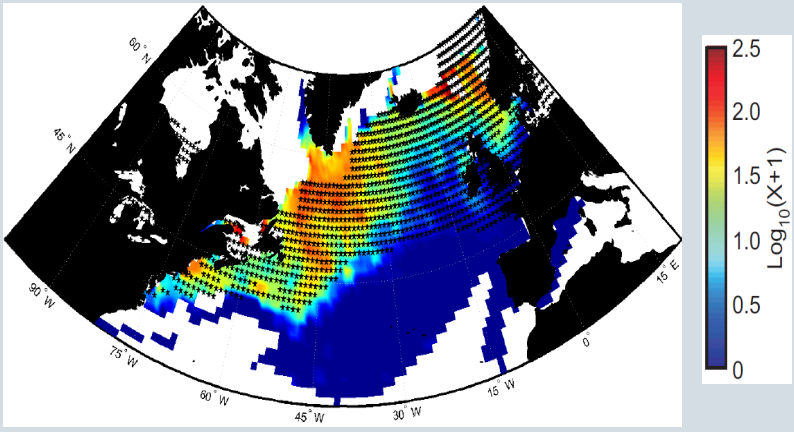


Figure 6. Spatial distribution of *Calanus finmarchicus* in the North Atlantic Ocean

Compared to the south part of the North Sea, the North part is characterized by Sea Surface Temperature lower than 10°C but also by higher concentration in chlorophyll, lower diversity and copepods of greater size. It has been shown that this transitional area coincides with a critical thermal boundary of 9-12°C (Figure 6), which represents a large-scale ecological threshold in the North Atlantic Ocean. If the critical boundary moves northwards with climate warming, it is likely that the associated species will have to follow. This potential sensibility to temperature changes, together with the economic weight of the North Sea, makes this temperate marine environment more important to monitor in a fast changing world.

Figure 7a shows the thermal profile of *C. finmarchicus* for each month. The species has its maximal abundance between April and September at temperatures ranging from 5 to 10°C, thus being comprised in the critical thermal boundary. The calculation of the Z-score, and S respectively the mean and standard deviation of the abundance, shows that the species abundance has its maximum variability within the critical thermal boundary (Figure 7b). This is confirmed by the calculation of the standard deviation on the Z-score (Figure 7c).

The analysis provides compelling evidence that the change in the distribution of *C. finmarchicus* in the North Sea has been the result of a climate induced forcing on the thermal niche of the species.

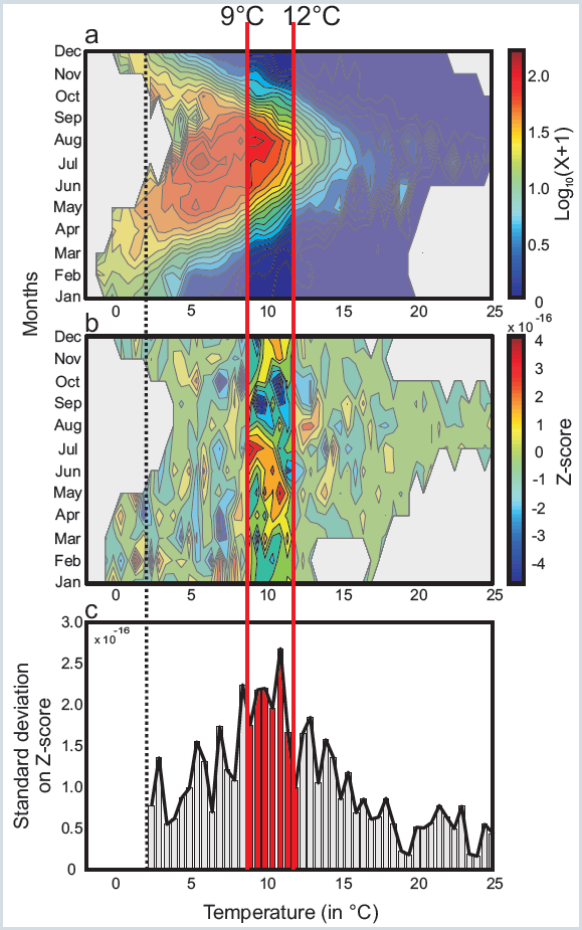


Figure 7. *Calanus finmarchicus* a) Contour diagram of abundance (decimal logarithm) as a function of SST and month of year. b) Z-score performed on the abundance. c) Standard deviation on the Z-score. (a,b,c) Red lines represent the temperature of respectively 9°C and 12°C. (a,b,c) The dashed line represents the limit below which the Standard deviation on the Z-score has not been calculated.

Variation among northeast Atlantic regions in the responses of zooplankton to climate change

Niall McGinty, *Martin Ryan Institute, Galway*

Broad scale climate forcing can interact with local environmental processes to affect the observed ecological phenomena. This causes potential problems of over-extrapolation for results from a limited number of sites or the averaging out of region-specific responses if data from too wide an area are combined. In this study, an area similar in extent to the Celtic Biscay Large Marine Ecosystem, but including off-shelf areas, was partitioned using clustering of satellite chlorophyll (chl-a) measurements. The resulting clusters were used to define areas over which to combine copepod data from the Continuous Plankton Recorder. Following filtering due to data limitations, nine regions were defined with sufficient records for analysis. These regions were consistent with known oceanographic structure in the study area (Figure 8). Boundaries of the shelf regions were found to follow patterns of known water bodies which exist within the shelf sea area while off-shelf partitioning is largely due to the progressively later timing of the chl-a peak moving northward.

Generalised additive models were used to generate smoothed monthly abundance estimates for the adult and juvenile stages of *Calanus helgolandicus* and *C. finmarchicus* as well as the *Para-Pseudocalanus* group. Monthly and long-term variables were allowed to covary and in taxa/regions where this improved model fit, changes in the phenology were calculated. Correlations between variables (annual abundance, sea surface temperature (SST), phenology or central tendency) found that there was a large degree of variability both across regions between taxon and also within each taxa for the species groups (Figure 8). This variability appears to increase with longer time intervals. In almost all cases the central tendency of each taxon were found to be negatively correlated with SST but this relationship becomes more variable when considering multi-annual trends of species annual abundance. The analysis showed that general trends covering ocean scale basins may not be indicative of the trends found at smaller scales. Regions do not track environmental variables in the same way and trends in different regions may not necessarily be correlated. The regions defined here should be thought of as complementary to the larger management regions such as the EU Celtic Seas eco-region. The regions also provide an objective basis for investigations into the long term dynamics of plankton populations and suggest suitable sub regions for deriving pelagic system indicators.

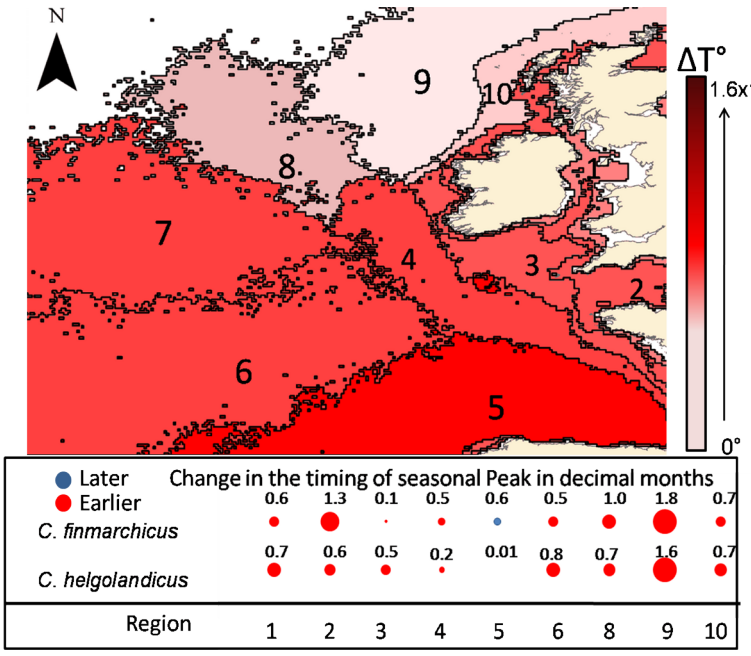


Figure 8. The spatial extent of the ecoregions as defined by the clustering of SeaWiFS chl-a data for the months March to October, 1998-2008. The changes in temperature Δ T for each region are shown by the colour of each region. The changes in the timing of the seasonal peak for the adult *Calanus helgolandicus* and *C. finmarchicus* for the nine ecoregions are found below.

The water sampler in the English Channel

Dr Rowena Stern, *SAHFOS*

As part of the Going Global, Going Complete effort, SAHFOS is co-ordinating trials of a water sampler. The aim of this initiative is to find a method to capture small and delicate plankton that may be lost or under-represented in CPR survey. Researchers at Station Biologique Roscoff have already revealed the abundance and seasonal trends of diverse and important picoplankton communities in the English Channel. As a relatively well-sampled system, that allows for rapid processing of samples, the English Channel has been chosen as a test environment for the water sampler by monthly sampling over a year. The aim is to retrieve a complete coverage of all microbiota, specifically ecologically important ones, such as Harmful Algal Bloom (HAB) species, potential pathogens of plankton. We also want to identify under-represented taxa which are either under-studied or rare, such as heterotrophic nano- and pico-plankton and their role in community dynamics and to map their biogeographical distribution. Under altered climatic conditions, members of rare biospheres may become abundant. We are trialling the use of high-throughput sequencing methods and HAB microarray and combining results with flow cytometric analysis of microbial communities in collaboration with Glen Tarran at PML. This combined approach would provide a holistic picture of plankton ecology in the English Channel. The large ribosomal subunit (LSU) DNA markers were used to probe samples taken at four intervals in the English Channel at an average tow depth of 4 m.

The temperature averaged 13.2˚C ±2˚C. Our molecular analysis from samples taken in November 2010 has already revealed a large variety of organisms not normally found in CPR samples, including a variety of photosynthetic algae and a substantial amount of Ascomycetes fungi. The sequence-capture rate was variable between samples. The results revealed diatom and diatom-like sequences (all from samples 5 and 6) which were quite diverse, with one group most likely being related to the Lithodesmiaceae family. Another group which could not be identified to genus using this DNA marker could be either diatom or *Bolidomonas*-like algae, very small photosynthetic algae that have a DNA sequence similar to diatoms. By contrast, an unknown group of red-algal related species were mostly present in mid-channel samples. A small number of Prasinophyte-related species were retrieved, of primitive green algal lineage.

Previous studies have shown that the English channel is dominated by the tiny (‹2µm) prasinophyte, *Micromonas pusilla* all year so it is likely that the sequences here belong to this species, although no corresponding LSU sequence exists for confirmation. About half of the sequences belonged to ascomycetes fungi these were split into diverse species of unknown identity and a species-related group of DNA sequences, whose nearest relatives are Onygenales, part of the Eurotiomycetes class that can be human pathogens but are also found in soil. Two sequences (2B7, 2E6) showed genus-level similarity to the cosmopolitan Chaetothyriales *Phialophora* and *Exophiala* – these resemble yeast, often with dark pigmentation and are mostly saprophytic or parasitic on the dermis layer of animals. Although molecular methods are not quantitative, analysis of species diversity reveals a diverse range of photosynthetic algae and potentially pathogenic fungal species, many of which could not be identified; this demonstrates a gap in our knowledge even in relatively well sampled marine environments.

The correct identification of HABs is important. Many species actually comprised different populations or even subspecies that have variable abilities to produce toxins. Many HABs such as *Alexandrium*, *Pseudo-nitzschia* and *Dinophysis* cannot be fully identified using morphology alone. Genetic methods may be able to resolve toxin and non-toxin producing species. However, current methods of cloning and sequencing are very laborious, expensive and subject to bias. We are in the process of a trial to identify HABs using microarray - a chip containing thousands of small DNA or RNA probes (25 nucleotides) from a sample. Microarrays can identify multiple species in a short time, but can be less accurate because of the short size of the probes compared to the gold standard of DNA sequencing, for molecular identification. We were interested in whether microarray could identify HAB species using DNA from archive CPR, an unusual application as this test is usually done with freshly purified DNA or RNA. In initial trials, we identified a high intensity phytoplankton bloom from July 1995 off the Brittany coast which corresponded to CPR sample 429SA_19. DNA was extracted and amplified, giving 600bp of the large rDNA (28S) gene. This product was sequenced and additionally tested on an experimental microarray specifically created to detect HABs, designed by Medlin team and Jixen Chen at MBA, described by Metfies et al. 2006. The microarray is designed in a systematic, hierarchical manner, so that several probes ultimately identify a species to family, genus and finally species in many cases. Work is in progress to improve its design. Although the PCR product yield was half as much as required for microarray, all but one of the positive controls worked. Four HAB genera were detected. *Pseudo-nitzchia* predominated but we also found species-level identification for *Dinophysis*, *Alexandrium* and *Karenia* (see Figure 9). These signals are now being verified by DNA sequencing and have confirmed the presence of *Alexandrium tamarense* so far.

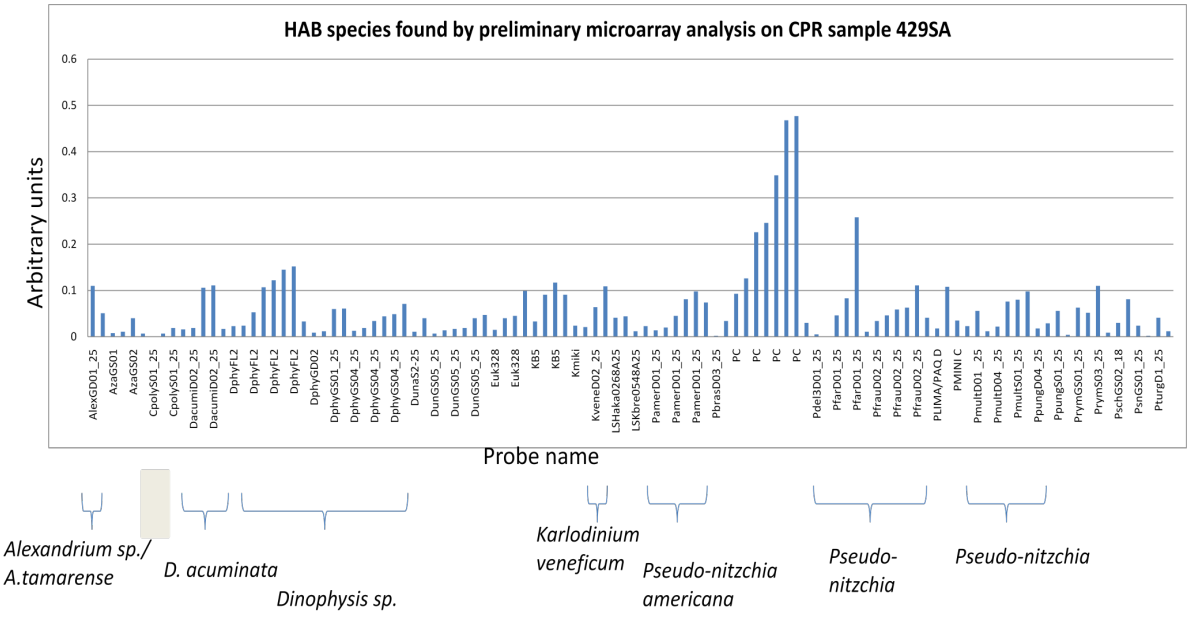


Figure 9. Normalised results of HAB species detection using HAB microarrays.

Generating prey fields for bioenergetic individual-based modelling of larval and early juvenile cod and sandeel in the North Sea

Zeren Gürkan, *DTU Aqua*

Disentangling the processes that take place in early life-stages of fish is crucial for achieving sustainable management of fish stocks under possible environmental changes, e.g., climate change. Bioenergetic Individual-Based Models (IBMs) describing the growth and survival of larval and early juvenile stages of fish, particularly Atlantic cod and lesser sandeel in the North Sea, are being developed at DTU Aqua. The responses to local physical and feeding conditions are particularly emphasized in order to reflect on the direct and indirect climate change impacts. The generic Letcher-type IBM, where prey encounter and physiological processes are parameterized explicitly, was taken as the starting point. The critical/threshold initial patch concentration range for zooplankton prey, identified from the model results, shows that 0.04-0.05 no. zoop./mL and higher prey concentrations ensure high survival probability for sandeel at the early-life stages. Survival probability is very high (0.997) when the initial patch density is higher than 0.047 no. zoop./mL. It is 100 % when the initial patch density is higher than 0.071 no. zoop./mL. The model can be used to gain insight into early-staged sandeel under possible effects of climate change on the ecosystem, e.g., effects on prey parameters. This model can also be applied to early-staged cod in the North Sea where growth data (length-at-age data) for cod larvae are available from 2004 to calibrate and validate the IBM. The hydrodynamic biogeochemical model, ERGOM, which is developed by NERI, provides outputs of physical, chemical and biological conditions in North Sea including bulk zooplankton biomass and these are utilized to form the input conditions to the individual-based model for early-staged sandeel growth and survival in the spatial setting encompassing bio-physical processes. CPR time series data have been used to validate the bulk zooplankton simulations and an agreement has been found between normalised CPR data and model results. Simulated years are 2004-2006 and validation of the spatially explicit model results of sandeel growth and survival will be done using data from 2004. *Calanus helgolandicus* and *C. finmarchicus* outputs from the same model for the same years will be generated and validated by using CPR data. These will form input prey fields in spatially explicit bio-physical IBM for growth and survival of early-staged cod. Simulated years will be 2004-2006 and the validation of the spatially explicit model results of cod growth and survival will be done by data from 2004. When the model runs are completed with the operational spatial setup of the IBMs, they can also be realistically used to assist in understanding susceptibility to direct and indirect climate change impacts, e.g., trophic cascades.

Impact of environmental changes on pteropod distribution and abundance in the north Atlantic and the Mediterranean sea

Samir Alliouane, *CNRS and Université Pierre et Marie Curie, France*

Since the beginning of the industrial period, 250 years ago, the oceans have absorbed about one third of the carbon dioxide (CO_2) emitted into the atmosphere by human activities. This phenomenon has limited climate change but is not without consequences on the oceans. The excess CO_2 increases the total inorganic carbon in seawater and decreases its pH as well as the concentration of carbonate ions which can be detrimental to calcifying organisms such as shelled (thecosomata) pteropods. The aim of this study was to analyze the potential impact of environmental changes, primarily ocean acidification, on the abundance of pteropods (*Cavolinia inflexa*, *Clio pyramidata*, *Creseis* spp. and *Limacina retroversa*) in two time-series: one in the North-East Atlantic (January 1958 to December 2008) using Continuous Plankton Recorder (CPR) data and one in the Northwest Mediterranean Sea (February 1995 to January 2007) using data collected at the point B time-series station in the Bay of Villefranche-sur-Mer.

The selected area in North Atlantic was chosen according to the higher CPR sampling number (15°W–12°E; 44°N–60°N). Cells (1° x 1°) containing at least 200 samples during the 50 years period were used and 3 areas were selected in order to study *Limacina* spp. abundance in details: the North Sea, Eire and France. The abundance of *Limacina* spp. exhibits a decline in each zone with a high significance in North Sea and Eire ($p<0.001$). The larger decrease in *Limacina* spp. population is observed in Eire with a loss of 73 ind. m-3 in 50 years, corresponding to 1.4 ± 0.3 ind. m-3 y-1. In North Sea and France the decrease is about 23 ind. m-3 and 7.6 ind. m-3, respectively, corresponding to annual decreases of -0.46 ± 0.11 ind. m-3 y-1 and 0.15 ± 0.14 ind. m-3 y-1. The decline in *Limacina* spp. population took place in November 1972 in the Eire region and in November 1975 in the North Sea. The population trend seems to have followed a different pattern in the French region with a non-monotonic trend during the same period. Due to the lack of sufficient carbonate chemistry data in the two other areas, the long-term pH trend was only determined for the North Sea. A non significant ($p=0.78$) decrease of -0.0018 ± 0.001 pH unit y-1 is estimated. In this area, the correlation between pH and *Limacina* spp. abundance is not statistically significant ($r=-0.04$; $p=0.16$). The decline of pHT, was similar to that in the North Atlantic (-0,00184 pH unit y-1; $p<0.001$ in Point B and $p=0.78$ in North Sea). In contrast to the North Atlantic, the abundance of pteropod increased in the study period: +0.79 ind. ($p<0.001$) for *C. inflexa*, +0.3 ind. ($p < 0.001$) for *C. pyramidata* and +1.3 ind. ($p<0.001$) *Creseis* spp..

The results of this preliminary analysis suggest that decreased pH does seem to affect pteropod populations. Changes in abundance may be controlled by other environmental factors such temperature. If the decline of abundance in the North Sea (decrease in population) is confirmed, it could lead to a reorganization of the pelagic food web.

NE Pacific 2010 indicators.

Dr Sonia Batten, *SAHFOS*

The end of 2009 saw the development of an El Niño event in the equatorial Pacific, detectable in the NE Pacific, which persisted into spring 2010 but then weakened. By the end of 2010 strong La Niña conditions were evident.
At the time of writing sample analysis is complete for the NE Pacific for the first two sampled months of 2010; April and May. Data for July to September described here are based on the samples analysed in BC, Canada – about 25% of the eventual number to be analysed.

Total mesozooplankton biomass looks as though it will be low in 2010 (Figure 10), perhaps the lowest of the time series once data are finalised. Maximum biomass was recorded in May, as is typical in most years except very cold years (such as 2008) when it has occurred in June. Although the June sampling failed in 2010 the two May samplings were similar in magnitude and very early July sampling had low biomass suggesting that the peak was in May. Timing of the peak biomass for both total zooplankton and the dominant copepod *Neocalanus plumchrus* was well within the range seen in previous years, although the length of the season was relatively short in 2010. Summer community composition looks to be consistent with the cool, and PDO negative conditions, in the second half of the year. Large copepods were relatively dominant and small copepods less so than warmer years (see 2009 annual report for previous years' data).

Temperature data and northwards extent of warm water copepods

Temperature sensors (Vemco minilogger, Chelsea Instrument's Aquapack or Minipak, or a Brancker CTD) have been fitted to many CPRs over the Pacific survey's history. Although any one year has not had extensive instrumented coverage, there were 1,304 samples in the NE Pacific from 2000 to 2009 which have an associated in situ temperature measurement. In work about to be submitted (Batten and Walne in prep) the in situ temperature data were first used to characterise 29 abundant copepod taxa into one of four groups based on their temperature preferences as sampled. A group of 7 warm-water copepods was then further examined to show interannual changes in northwards extension that are likely related to the temperature of the surface ocean. Years that were cold (such as 2007-08) show low or zero abundance of warm water species north of 48°N and they were mostly found in the south only, if at all. Years that were warm, such as 2005, show higher abundances and warm water species continued to be encountered quite far north. Given that the cold-water species showed no such strong relationship with temperature at these latitudes (48° to 58°N), we can expect an increase in copepod diversity in this region under warming conditions, which has implications for ecosystem functioning. Preliminary data for 2010 suggest that there will be a higher number of warm water species than has been found in 2007-2009, probably the result of the El Niño conditions present in the first half of the year.

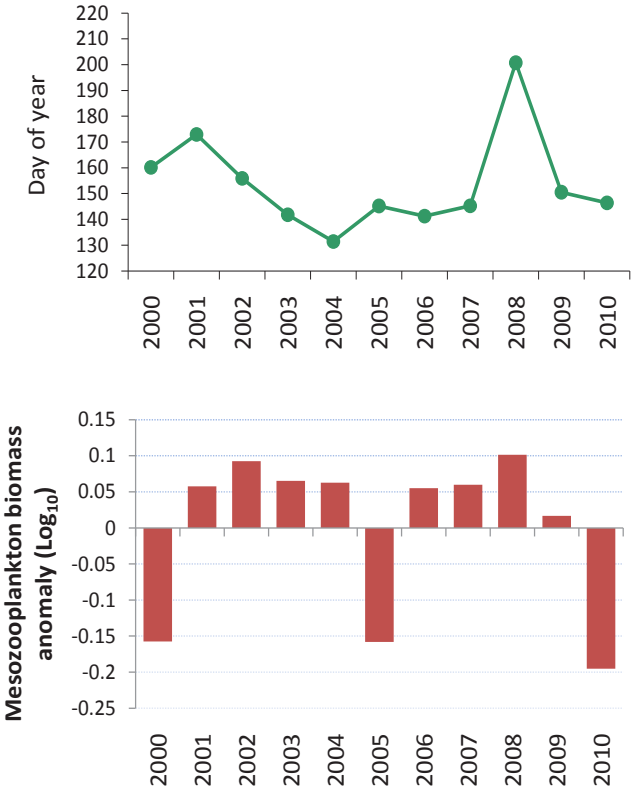


Figure 10. Day of year when peak biomass (defined as the 50% percentile of total integrated biomass) occurred (top) and annual mesozooplankton anomalies (bottom). Data for 2010 are provisional.

An intercomparison of bio-optical techniques for detecting dominant phytoplankton size class from satellite remote sensing

Raitsos D.E., *Institute of Oceanography, Athens, Greece*

In order to improve our understanding of biogeochemical cycling, a new range of multi-plankton biogeochemical models have been developed. To help verify and constrain these models, scientists have recently sought to use satellite data to identify and differentiate between either phytoplankton functional types (PFTs) or phytoplankton size classes (PSCs). In this study, several of these techniques were evaluated against in situ observations to determine their ability to detect dominant phytoplankton size classes (micro-, nano- and picoplankton). The satellite models were applied to a 10-year ocean-colour data series from the SeaWiFS satellite sensor and compared with in situ data (6504 samples) from a variety of locations in the global ocean, of which 5664 measurements from the Continuous Plankton Recorder (CPR) in the North Atlantic were used. Due to the nature of sampling, the CPR is a unique dataset ideally suited for comparison with satellite data (samples are within the 1st optical depth, with each sample offering a more suitable spatial comparison with satellite data when compared with point measurements). Results show that spectral-response, ecological and abundance-based approaches can all perform with similar accuracy. Detection of microplankton and picoplankton were generally better than detection of nanoplankton. Abundance-based approaches were shown to provide better spatial retrieval of PSCs. Individual model performance varied according to PSC, input satellite data sources and in situ validation data types. Uncertainty in the comparison procedure and data sources was considered. Improved availability of in situ observations would aid ongoing research in this field.

Towards understanding the carbon sink created by blooms of coccolithophores in the north Atlantic

Jamie Shutler, *Plymouth Marine Laboratory*

Coccolithophores are phytoplankton that form external calcium carbonate ($CaCO_3$) scales or platelets (coccoliths or liths). This platelet production has the ability to affect the air-to-sea carbon dioxide flux and constitutes a source of sediments which serve as a long-term carbon sink. There are hundreds of different species of coccolithophores which live at a range of depths in the sun–lit layers of the worlds oceans, with one of the most predominant and widely studied species being *Emiliania huxleyi*. In the latter stages of growth these particular phytoplankton shed their coccoliths turning the water a milky or turquoise-white colour. These detached coccoliths are easily discernible from satellite (or Earth observation) ocean colour data due to their ability to reflect and scatter light strongly in the visible spectrum. This unique characteristic within phytoplankton species allows the study of their frequency and distribution by Earth observation.

The accuracy of any Earth observation algorithm needs to be assessed before strong conclusions can be drawn from the resulting data. The lack of a suitably large multi-year in situ dataset has previously limited the evaluation of Earth observation coccolithophore bloom detection algorithms. Here the CPR data from 1998-2009 for the north Atlantic were used to evaluate an Earth observation method developed to detect coccolithophore blooms in time series data. This extensive evaluation, using twelve years worth of CPR data (exploiting a total of 26,738 CPR samples), showed that the Earth observation algorithm correctly identifies coccolithophore blooms 78 % of the time. This result has allowed the environmental drivers behind bloom formation in the north Atlantic to be further investigated, providing the basis for a MSc study. Current work is focusing on studying the spatial distribution of these blooms across the twelve year time series.

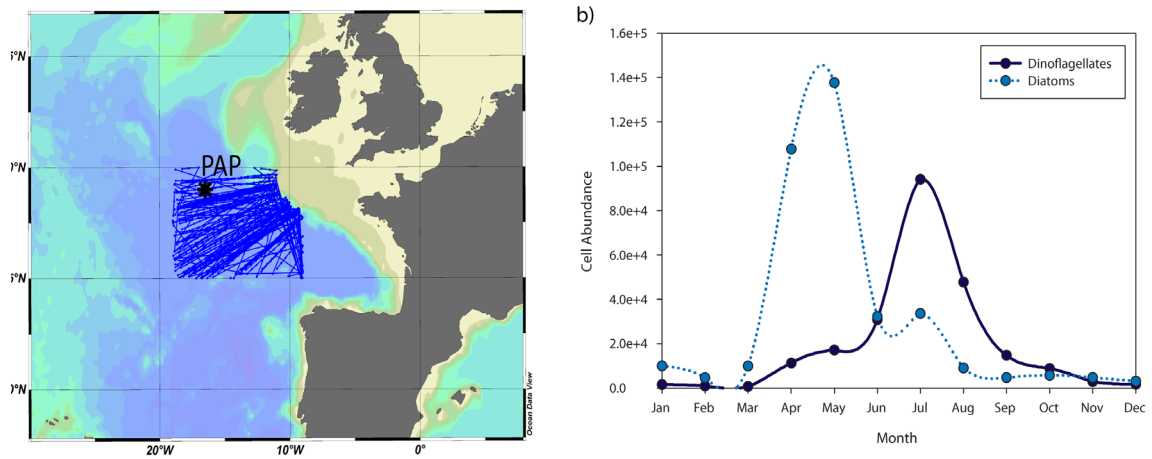


Figure 11. a) CPR towed routes between January 2001 and December 2007 in the waters surrounding the Porcupine Abyssal Plain (PAP) observatory. b) Average seasonal variation of diatom and dinoflagellate abundance (2001-2007).

Investigating and Modelling Seasonal Variations of Dinoflagellates in the North Atlantic using Continuous Plankton Recorder data.

Charlotte Marcinko, *University of Southampton*

Dinoflagellates are complex unicellular organisms that are abundant throughout the World's oceans, whose contribution to global primary production is second only to diatoms. However, dinoflagellates are regularly overlooked as a phytoplankton functional type within ecosystem models, particularly for non-coastal regions. Long-term times-series data providing information on the temporal and spatial variability of different phytoplankton groups are sparse. The CPR survey provides one of very few datasets available to the scientific community that provides data on the abundance and composition of dinoflagellates and allows for the annual cycles of phytoplankton to be resolved due to its consistent sampling throughout the year.

An associate researcher grant was awarded to support research investigating the construction of a model explicitly containing dinoflagellates. Data from the CPR has been used to investigate the typical seasonal variation and composition of the dinoflagellate population in the waters surrounding the Porcupine Abyssal Plain (PAP) Observatory within the North Atlantic (Figure 11a). The results of these analyses have been used in the development and calibration of a simple ecological model which aims to reproduce the seasonal variations of dinoflagellates and diatoms within the PAP region.

A comparison of the typical seasonal variation of dinoflagellates and diatoms for the period 2001-2007 was made (Figure 11b). Results indicated a distinct seasonal succession from a diatom dominated spring bloom to an increased dinoflagellate population during summer months. These data have been combined with nutrient and remotely sensed chlorophyll climatologies for the optimisation of model parameters. Specifically, CPR data were used to constrain the seasonal variations of dinoflagellate and diatom phytoplankton functional types within the model.

Preliminary results have shown that modelled and CPR phytoplankton succession were in good agreement. The model was able to correctly capture the seasonal peak of diatoms from April - May and the seasonal peak of dinoflagellates in July. However, the model failed to fully replicate the seasonal variation of chlorophyll. Maximum chlorophyll from model simulations did not coincide with maximum diatom abundance as expected and instead occurred in June. This was due to an underestimation of diatom biomass within the model. Current work is focused on further model development to improve model to data fit.

SeaWatch SW Project

Russ Wynn, *National Oceanographic Centre*

This project is investigating bio-geophysical controls on the spatio-temporal distribution of migratory marine megavertebrates. The priority is the Critically Endangered Balearic shearwater, but other migratory seabirds as well as basking sharks, ocean sunfish and cetaceans are the focus of intensive monitoring off southwest England. For the fourth year running, effort-based monitoring of all marine megavertebrates was undertaken at Gwennap Head (Cornwall) between 15 July and 15 Oct 2010. A team of experienced volunteer observers helped man the watchpoint for 93 consecutive days, with dawn-to-dusk observations totalling almost 1,000 hours. The team have now collected about 4,000 hours of observational data over the last four years, and there are currently three PhD students and two Masters students working on these data. A key component of this work is the integration of high-resolution multibeam bathymetry data with hydrographic and biological data (e.g. zooplankton sampling) to understand the controls on megavertebrate occurrence. Alice Jones, a PhD student at NOC who is CASE sponsored by SAHFOS, is currently preparing papers on harbourporpoise and Basking Shark occurrence off the southwest UK based on SeaWatch SW data.

Highlights of the 2010 field season at Gwennap Head included record numbers of Balearic shearwaters, with a peak day count of 268 on 18 Sept that equates to about 1% of the world population! It was again a poor year for basking sharks, with peak numbers in September for the fourth year running. An observation of the rare White-beaked and Risso's dolphins in loose association in July was probably unprecedented in Cornish waters.

A field expedition to Mallorca and Menorca in spring 2010 was undertaken in partnership with University of Oxford. A total of 36 light-logging geolocators were deployed on breeding Balearic shearwaters, which will be recovered in spring 2011 and will provide data on the birds' at-sea distribution and behaviour throughout the year. A small number of GPS trackers were also deployed on breeding birds undertaking short foraging trips, and successfully returned fine-scale distribution data. A new PhD student will be recruited to work on these data, and those collected on subsequent expeditions. Further details and all the news from the 2010 field season can be found on the project website http://www.seawatch-sw.org, which has generated over 40,000 hits in the last four years.

Where do all the salmon go? Linking temporal distributions of plankton to isotope records derived from salmon scales

Kirsteen Mackenzie, *University of Southampton*

The marine life of Atlantic salmon and many other commercially important fish has remained a mystery for hundreds of years. Despite extensive research, we still know very little about the feeding locations of salmon. This is a problem as salmon populations are declining sharply and all indications point to the marine phase of life as responsible for these declines, although the reasons are also unclear.

Recent work making use of CPR data has highlighted linkages between ocean climate variations, plankton abundance and salmon populations, but these linkages vary between river stocks, and the mechanisms linking individual populations to climate dynamics are uncertain.

Carbon isotope ratios were measured in salmon scales from historical archives. These archives span several decades, meaning that temporal trends can be investigated for the salmon populations represented by the scale samples. Carbon isotope ratios in salmon scales reflect the growth rate and abundance of primary production, and the extent of carbon export at the base of the food chain.

The CPR dataset is the only record of plankton abundance with sufficient spatial resolution and temporal duration to enable correlation with the patterns seen in salmon isotopes. Determining the links between sea surface temperature, the state of primary production and carbon isotopes in salmon tissues has allowed us to propose the most likely regions of the Atlantic Ocean used by each salmon population as feeding grounds, an example of which is shown in Figure 12a. Using the isotope records to identify feeding grounds, and the CPR dataset for each identified feeding ground, it is possible to analyse the effects that plankton have on numbers of fish returning to UK rivers for populations of different natal origin. Figure 12b shows strong, positive correlation between variations in phytoplankton abundance in the feeding grounds shown in (a) and variations in returning Atlantic salmon abundance. Interestingly, salmon populations correlate more closely with phytoplankton than zooplankton abundances, suggesting strong bottom-up control.

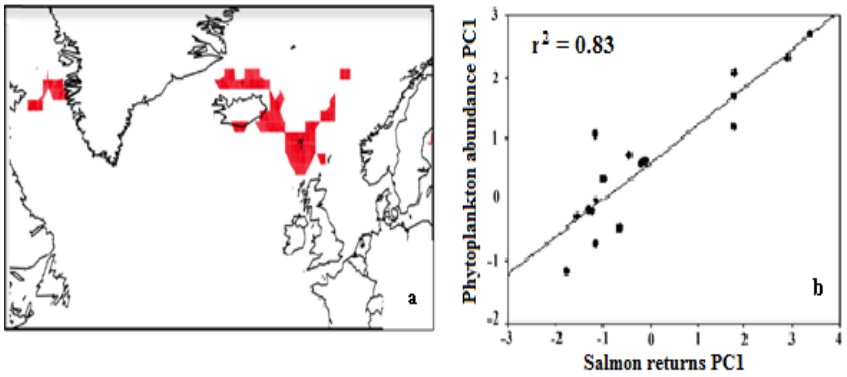


Figure 12. a) Proposed feeding ground for one river's salmon population, based on carbon isotope data; and b) correlation between principal component 1 of the dominant annual phytoplankton species 3 year mean abundance in the red feeding areas from (a), and principal component 1 of annual numbers of salmon returning to England and Wales and our example population.

Identifying linkages between climate, plankton abundance and taxonomic composition and salmon abundance is very important to the conservation of salmon populations. The isotopic approach identifies stock-specific feeding areas, and the CPR data allows tests for bottom-up control on marine mortality on a stock specific basis. The techniques used here, however, can also be applied to many different migratory marine animals, whereby the CPR archives can aid management and conservation across the North Atlantic.

Linking spatial-temporal changes in plankton species to taxonomic and eco-physiological traits

Dr Claudia Castellani, *SAHFOS*

Current research focuses on understanding the spatial and temporal changes in large scale distribution of plankton through combining taxonomic (morphological and genetic) and eco-physiological characteristics of the species. Long-term studies have reported regional differences in the inter-annual trends of abundance of some plankton species. Plankton can be characterised by very different species-specific eco-physiological traits and life strategies. Therefore, long-term changes in abundance and distribution should reflect how each species responds to and/or is affected by changes in biotic and abiotic environmental factors. Recent work in collaboration with colleagues at SAHFOS (M. Wootton, A.J. Lindley) and Dr R.K. Kirby (RSF, Uni. Plymouth, MBA) has investigated the phenotypic and genotypic variations in the planktonic copepod, *Centropages typicus* showing consistent differences in the morphology of the chela of the sexually modified fifth pereiopod (P5) of the male among samples from the Mediterranean, western North Atlantic and eastern North Atlantic.

Although, genetic analysis of the Cytochrome c oxidase subunit I (COI) and of the nuclear rDNA internal transcribed spacer (ITS) tandem array indicated the presence of separation between the Mediterranean and the north Atlantic morph-types we could not find any conclusive evidence of genetic differentiation between *C. typicus* from the western and eastern sites. Therefore, we suggest that breeding experiments would be required to clarify the extent of genetic isolation between *C. typicus* from the different population centres. Further work aims to elucidate the mechanisms which might have given rise to the observed basin scale multi-decadal variability in copepod species in the north Atlantic by combining information on the eco-physiology of the species with abundance data obtained from different database sources including the Continuous Plankton Recorder. The results of this research will be integrated into statistical models such as predictive habitat and IBM models to make predictions on how different species could be affected by future environmental change

Indications of changes in jellyfish populations in European waters

Dr Priscilla Licandro, *SAHFOS*

Swarms of Cnidaria jellyfish have been increasingly reported along the European coasts in recent years, raising general concern as they may cause great problems for fish aquaculture and for tourism. In some regions, for instance the Northeast Atlantic, the analysis of long-term CPR records reveals that cnidarians now persist during the winter months. Similarly, long-term records in the Mediterranean have shown an increased frequency of swarms of Scyphomedusae (e.g. *Pelagia noctiluca*), which since the late 1990s have been annually recorded, while previously *Pelagia* blooms tended to occur only every twelve years and with four years duration. Changes in Cnidaria populations may be more subtle than the mere extension of their period of occurrence.

A study based upon a twenty years time series of Cnidaria siphonophores in the North-western Mediterranean indicates that notwithstanding the overall population (which has not shown significant changes in abundance or occurrence), its composition has undergone significant changes. Indeed a shift in dominance between different species has occurred, following a period of major hydroclimatic changes in the middle-late 1980s. The results of this study suggest that in order to improve our understanding of changes in jellyfish populations, their diversity, as well as their abundance and persistence, needs to be taken into account.

Revealing dispersal behaviour of a pelagic seabird with the help of CPR Survey samples.

Tony Bicknell, *University of Plymouth*

Our ability to track the movements of vagile marine animals has been greatly enhanced with the use of intrinsic biochemical markers, especially when conventional direct methods are impractical due to animal size and/or location. The measurement of naturally occurring stable carbon and nitrogen isotopes in animal tissues provides information that can be used to infer the geographical or ecosystem origin and movements of individual animals. This is based on the fact that isotopic concentrations in tissues reflect those in their food web and that spatial patterns, gradients or differences in these isotope signatures exist in nature. Patterns or gradients are known to exist at broad scales in the marine environment (i.e. inshore versus offshore) but more resolved differences can be identified by directly characterising regions using the isotopic signatures of the ecosystems primary producers or consumers. The CPR survey provides access to such baseline isotopic information for an extensive area of the Atlantic Ocean and we are using these data to help infer the unknown movements of a seabird between distinct regions.

Seabirds forage and migrate over large expanses of the Atlantic Ocean where isotopic differences exist, so the technique can provide valuable insights into their behaviour. The Leach's storm-petrel *Oceanodroma leucorhoa* is a small (~45 g) highly pelagic seabird that breeds on a few isolated offshore islands around Canada (Newfoundland), Iceland and Scotland. The dispersal of young birds away from their natal colonies is believed to maintain a large meta-population within the Atlantic but the mechanism underlying this is unclear. It is thought that birds will prospect at different colonies before making the decision on were to breed but whether these long distant movements are undertaken during or between breeding seasons is uncertain and stable isotope analysis may reveal this behaviour. The stable carbon and nitrogen isotope values in the blood of birds reflect their diet over the past 4-5 weeks. To infer whether the individuals were feeding in the same region they were caught during this period, or recently moved from a different region, the values are compared to baseline regional isotopic signatures. Calanoid copepods collected on CPR Survey routes Z, F and V in June and July 2008 have been analysed to produce regional signatures for Newfoundland, Iceland and Scotland. The copepod samples were isotopically distinct between the ocean regions and these data are currently being used to infer movement of non-breeding Leach's storm-petrels caught on colonies in Scotland and Newfoundland during the 2008 breeding season.

Education and Publications

Education and Outreach activities in 2010

Clare Buckland, *SAHFOS*

The year started with Gemma Brice and Milly Hatton-Brown running a PMSP stand at Association Science Education at Nottingham. This is a European event aimed at teachers and other education providers. Despite treacherous snowy conditions the event was well received; through dressing up in giant plankton costumes and an interactive stand we advised teachers of ways of getting marine science and plankton into the classroom. In February, Clare Buckland visited the Living Coasts at Torquay to run plankton workshops for the general public for 2 days. It was very rewarding to display live plankton from Plymouth Sound and preserved material from the Antarctic. Plankton seminars and workshops were carried out at Ridgeway Community College in March and Plymstock School in July. The students learnt about basic plankton identification, photosynthesis and food chains.

SAHFOS carried out National Science and Engineering Week activities in March at the Plymouth City Museum and Art Gallery - a joint event with Plymouth Marine Laboratory and University of Plymouth. Change: for better or worse? was designed to promote awareness of changes that are occurring in the environment and its knock-on effects to other organisms. School children entered our competition to draw what they thought Plymouth would look like in 1000 years time. The artwork was very inspired and many incorporated what they had learnt at the event into their drawing. The event was very well attended and received by schools and the general public with approximately 700 visitors throughout the week.

As part of National Science Week Gemma Brice went to Paignton Zoo to carry out a workshop entitled Passionate about Plankton. Working with the Torbay Countryside Trust we did eight workshops with secondary school pupils. This involved learning about plankton, searching for it in trays of seawater, looking at SAHFOS samples of plankton from around the globe and then design their own plankton which we marked on floatability, design and a scientific name.

SAHFOS continued with our 'You're Hired' challenges in 2010 to find the most employable 17 year old in Plymouth. Challenges about the importance of plankton were carried out at St Boniface RC School and at Plymouth College by Clare Buckland, Lance Gregory and Linda Horsfield. The city final was held in June at the University of Plymouth and was the best yet. SAHFOS received good media coverage and publicity during the city final.

In March, Coastwise (a group of amateur biologists based in North Devon) visited SAHFOS and took part in a zooplankton training session run by Clare Buckland. They were to commence plankton net sampling over the summer from numerous locations along the North Devon coast.
A seminar about plankton and the CPR survey at the University of Plymouth was held in October. Students were encouraged to sign up for a zooplankton identification course and this was carried out in the MBA Resource Centre a week later. The students found the half day course very interesting and useful as an introduction to basic taxonomy of plankton. Many remarked that they would attend again and encourage their peers to do so.

A number of outdoor marine festivals were carried out in 2010. BIOBLITZ was held on Mothecombe Beach, Devon in June. The event is organised as part of Natural History Museum's OPAL Project and aims to produce a full inventory of species from a certain area in 24 hours. A number of various biological surveys and experts came along and in total 900 species were recorded (105 were plankton/ marine species). The event was a huge success with many members of the general public joining in with the identification of 100s of species. The highlight of the event was a midnight rock pool ramble and SAHFOS overnight plankton sampling. SAHFOS took part in the Blue Mile event in Plymouth in July and Wembury Marine Festival in August at Wembury Beach. Both of these events were well attended by the general public.

SAHFOS was present at the BA Festival of Science at Aston University in Birmingham in September. Plankton workshops were carried out by Clare and Gemma for a number of visiting school groups and the event went well.

SAHFOS Contributions to policy 2010

Dr Abigail McQuatters-Gollop, *SAHFOS*

Since its conception in 1931, the purpose of the CPR survey has evolved with changing environmental policy, from purely monitoring to addressing major marine management issues such as fisheries, harmful algal blooms (HABs), biodiversity, conservation, pollution, eutrophication and climate change impacts. Policy drivers continue to 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 participate in indicator and target development for the Marine Strategy Framework Directive (MSFD), the EU's thematic strategy on the protection and conservation of the marine environment. The aim of the MSFD is to achieve good environmental status (GES) of Europe's seas by 2020 through the monitoring and assessment of ecological indicators towards GES targets. SAHFOS continues to be involved in the UK Marine Monitoring and Assessment Strategy (UKMMAS) Healthy and Biologically Diverse Seas Evidence Group (HBDSEG), which is coordinating indicator development for the UK. In 2010 Charting Progress 2: An Integrated Assessment of the State of UK Seas was published. This report, commissioned by HBDSEG, collated and assessed data and information from UK monitoring initiatives and will contribute toward the MSFD's assessment requirements. SAHFOS led the chapter 'Biological indicators of state: the plankton'. In addition to its involvement in HBDSEG, SAHFOS participated in the Defra-led Good Environmental Status Workshop in October, in which invited experts began drafting indicators and targets to meet the MSFD requirements. SAHFOS is also active in the Cefas/Defra-funded Marine Ecosystem Health Working Group which has provided advice to the UK government on eutrophication indicators for the MSFD. In September 2010, Dr Abigail McQuatters-Gollop was invited to speak about indicator development using heterogeneous datasets at the 8th meeting of the EU's Marine Observation and Data Expert Group (MODEG) in Brussels. The talk stimulated discussion about using CPR indicators for ecosystem assessment at the European level.

As in previous years, SAHFOS contributed expertise to the UK's Marine Climate Change Impacts Partnership (MCCIP) Annual Report Card which assesses climate change impacts on the oceans. SAHFOS also published the 'Atlas of Calcifying Plankton: Results from the Continuous Plankton Recorder Survey'. The atlas, created as part of the EU's European Project on Ocean Acidification (EPOCA), is targetted towards policy makers and provides baseline data for interpreting the possible effects of ocean acidification on marine plankton. As in 2009, SAHFOS research was again highlighted in the EU's high profile Science for Environmental Policy: DG Environment News Alert Service journal. Assessments 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.

In 2010 SAHFOS expertise and CPR data also contributed to policy-relevant products for the following UK, European and international bodies: Defra, Scottish Natural Heritage, OSPAR, the EU, the European Marine Observation and Data Network (EMODNET), ICES, WWF, the American National Science Foundation, and the Canadian Department of Fisheries and Oceans.

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Data requests

For 2010, there were 81 data requests, the highest number received so far.

Data requests have come from Australia, Belgium, Canada, China, Denmark, Eire, Finland, France, Germany, Netherlands, Norway, UK and USA. External researcher's names and affiliations for 2010 data requests are below.

January – Frederick De Laender (Ghent University, Belgium), Samantha Patrick (University of Plymouth, UK), Natalie Ashford-Hodges (Imperial College, UK), Monika Winder (University of California, USA), Teunis Jansen (DTU Aqua, Denmark)

February – Rubao Ji (Woods Hole, USA), Manal Al-Kandari (MBA, UK), Jamie Otero Villar (CEES, University of Oslo, Norway), Todd O'Brien (NOAA, USA)

March – Gustaf Hallegraf (University of Tasmania, Australia), Zeren Gurkan (DTU Aqua, Denmark), Johan Decelle (Roscoff, France), Samir Alliouane (Villefranche, France), ChonyYuan Mao (University of Southampton, UK), Keziah Stott (St. Andrews, UK), Charlotte Marcinko (NOC, UK), Robin Pingree (MBA, UK), Lindsay Rhona Mcpherson (University of Aberdeen, UK), Mary O'Connor (NCEAS, USA)

April – Jamie Shutler (PML, UK), Niall McGinty (Galway, Eire), Kevin Colcomb (MCGA, UK), Johan Decelle (Roscoff, France), Jari Hanninen (University of Turku, Finland), Eric Rehm (University of Washington, USA)

May – Gjert E. Dingsor (IMR, Norway), Victoria Harris (UCL, UK), Dan Pendleton (NOAA, USA), Risa Smith (Environment Canada, Canada), Mel Austin (PML, UK)

June – Chris Lynam (CEFAS, UK), Rabea Diekmann (University of Hamburg, Germany), Todd O'Brien (NOAA, USA), Donna Ham (University of Plymouth, UK), Alan Baudron (University of Aberdeen, UK), Santiago Alvarez Fernandez (IMARES, Netherlands), Sylvie Guenette (Fisheries and Aquatic Centre, Rennes, France), Kristina Raab (IMARES, Netherlands), Valentina Lauria (University of Plymouth, UK)

July – Donna Ham (University of Plymouth, UK), Rob Masefield (CEFAS, UK), Junya Hirai (University of Southampton, UK), Sultan Hameed (Stony Brook University, USA), Dan Pendleton (NOAA, USA)

August – Nick Kamenos (University of Glasgow, UK), Rabea Diekmann (University of Hamburg, Germany), Junya Hirai (University of Southampton, UK), Sophie Pitois (CEFAS, UK)

September - Santiago Alvarez Fernandez (IMARES, Netherlands), Juan Carlos Molinero (IFM GEOMAR, Germany), Carola Wagner (Liebniz Institute, Germany)

October – Charlotte Marcinko (NOC, UK), Graeme Hays (University of Swansea, UK), Andy Kenny (CEFAS, UK), Manal Al-Kandari (MBA, UK), Stephanie Henson (NOC, UK), Paul Harrison (Hong Kong University of Science and Technology, China)

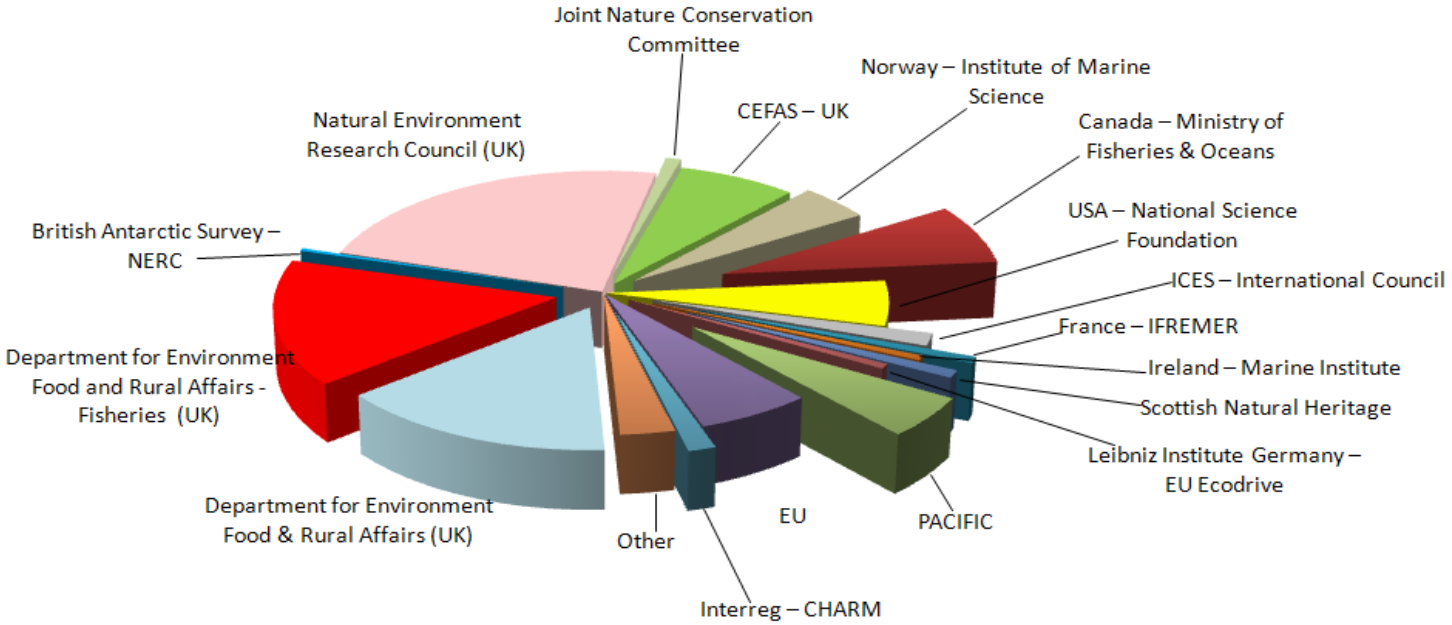
November – Ed Westwood (NOC, UK), Gjert E. Dingsør (IMR, Norway), Iain Suthers (University of New South Wales, Australia), Saeed Sadri (University of Plymouth, UK), Alice Jones (NOC, UK), Samantha Patrick (University of Plymouth, UK), Teunis Jansen (DTU Aqua, Denmark), Kevin Friedland (NOAA, USA), Santi Alvarez Fernandez (IMARES WUR, Netherlands), Dave Mackas (DFO, Canada), Tom Letessier (University of St. Andrews, UK).

December – Shaylon Stolk (University of Glasgow, UK), Chris Nall (University of Bangor, UK), Sophie Pitois (CEFAS, UK), Stephanie Hinder (University of Swansea, UK), Zanda van der Waal (University of Newcastle, UK), Sarah Burthe (CEH, UK).

Appendix A. Financial Summary

The principal sources of funding for 2010 are broadly derived from grants and contract income from Core Funding Organisations and Research & Academic Organisations. Core Funding Organisations provide support funding to enable the general operation of the CPR Survey. In 2010 these were: UK Natural Environment Research Council (NERC) , UK Department of Environment, Food and Rural Affairs (DEFRA) & NOAA. Research & Academic Organisations commission SAHFOS to undertake specific research, or tow specific routes. SAHFOS may also collaborate with other research groups, sometimes under the umbrella of International Organisations. In 2010 these were Exxon Valdez Oilspill Trust, the North Pacific Research Board, Dept of Fisheries & Oceans Canada, British Antarctic Survey, IFREMER France, the European Union, CEFAS, ICES, Institute of Marine Research Norway, and others. Total incoming resources for 2010 have increased during the year and together with other income from charitable activities, are reported at £1,811,804 (2009 £1,790,087). Total resources expended for 2010 has also increased during the year reported at £1,620,762 (2009 £1,428,054), with the result of an overall movement in funds of £191,042 (2009 £362,033).

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 2010

Routes	Towing Vessels	Shipping Company
A-	*Hascosay* *Hildasay*	Northlink Orkney & Shetland Ferries Ltd, Stromness, Orkney, Scotland. To February 2010. Owners: Seatruck Ferries of Warrenpoint and Heysham. Form March 2010. Chartered by NorthLink Ferries
AT	*Horizon Kodiak*	Horizon Lines LLC, Charlotte, North Carolina, USA and Tacoma WA, USA
BA, BB, BC, BD	*Benguela Stream*	Seatrade NV, Groningen, Netherlands. Charterers: Geest Bananas Ltd, Fareham, England
C-	*Tor Ficaria*	DFDS Tor Line, Copenhagen, Denmark
D, DA, EA, EB	*Atlantic Companion*	Atlantic Container Line, Gothenburg, Sweden
GM	*Cape Hatteras*	Duke University, Beaufort, North Carolina, USA (from National Science Foundation, USA)
HE	*Tor Dania*	Chartered by DFDS Seaways AB, Copenhagen from Imperial Shipping AB, Gothenburg, Sweden
IB & SB	*Helgaland* *Perseus J*	Owners: MS Helga GmbH & Co, Jork, Germany Charterers: MacAndrews Ltd, London. From Feb 2010 Chartered by MacAndrews Ltd, London from Jüngerhans Maritime Services GmbH, Haren,Ems Germany. To Jan 2010.
IN	*Norbay*	P&O Ferries (Irish Sea) Ltd, Larne, Northern Ireland
LG	*Tor Petunia*	DFDS Seaways AB, Copenhagen, Denmark
LR & V	*Selfoss*	Eimskipafelag, Reykjavik, Iceland
M	*S C Aberdeen*	Sea Cargo A/S Bergen, Norway
NI	*BBC Reydarfjordur* *S. Rafael*	Chartered by Eimskip, Reykjavik from Phoenix Reederei Bereederungs, Leer, Germany. To June 2010. Owners: Briese Shiffahrts GmbH, Leer, Germany. Charterers Eimskip. From Oct 2010
PR	*Armorique* *Bretagne* *Pont Aven*	Brittany Ferries, Roscoff, France
R-	*Flandria Seaways*	Norfolk Line Ltd, Felixstowe, Norfolk Line BV, Scheveningen, Netherlands,part of DFDS Seaways AB Copenhagen, Denmark
SA	*Pride of Bilbao* *Cap Finistère*	P&O Ferries (Dover) Ltd Brittany Ferries, Roscoff, France
ST	*Green Frost*	Green Reefers AS, Bergen, Norway
VJ	*Skaubryn*	Seaboard International Shipping Company, North Vancouver, British Columbia, Canada
Z-, ZB, ZC	*Reykjafoss*	Chartered by Eimskipafelag, Reykjavik, Iceland from Reider Shipping BV, Winschoten, Netherlands

INVESTOR IN PEOPLE

Sir Alister Hardy Foundation for Ocean Science (SAHFOS) manages the Continuous Plankton Recorder (CPR) survey. SAHFOS is an internationally funded charity operating in the North Atlantic, North Pacific and Southern Ocean

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