Project	AtlantOS – 633211
Deliverable number	D8.17
Deliverable title	POGO-AtlantOS collaboration on ocean products
Description	development of methodologies and sampling protocols
Work Package number	WP 8
Work Package title	Societal benefits from observing/information systems
Lead beneficiary	AWI
Lead authors	Karen Wiltshire, Eva- Maria Brodte
Contributors	Annette Wilson, Peter Lemke, Rainer Knust, Karin Lochte
Submission data	19 March 2019
Due date	31 December 2018
Comments	Deliverable report was delayed because previous scheduled training expeditions were cancelled. This last expedition within the deliverable as now scheduled to June 2019.The international interest was overwhelming with about 800 applications and therefore the reviewing process for choosing the right scholars was delayed from December to late February Now after re notification by the scholars the deliverables can be reported

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement n° 633211.

Stakeholder engagement relating to this task*

WHO are your most important stakeholders?	☐ Private company If yes, is it an SME ☐ or a large company ☐? ☐ National governmental body x International organization ☐ NGO x others Please give the name(s) of the stakeholder(s): Young researchers and their home institutions , research institutions of teaching faculty: Universidad de Magallanes Institute of Natural Sciences, Sakarya University Universidad Lisboa Pontificia Universidad Católica de Chile Utrecht Univercity MARE-FCUL Ruđer Bošković Institute Earth System Science Interdisciplinary Center (ESSIC) Max-Planck-Institut für Marine Mikrobiologie National University of Ireland, Galway Instituto de Meteorología de Cuba Aarlborg University University Of Ghana, Marine and Fisheries Science Department
WHERE is/are the company(ies) or organization(s) from?	x Your own country x Another country in the EU x Another country outside the EU Please name the country(ies): South Africa, Cuba, Germany, Brazil, Greece, Nigeria, Philippines, Kenya, Mexico, Bangladesh, Ghana, Mauritius, Trinidad Tobago, Portugal, Argentina, Chile, USA, Ireland, Denmark
Is this deliverable a success story? If yes, why? **If not, why?**	x Yes, because the interest in the programme was enormous and the number of applications very high. The public press (Deutsche Welle, DW) will report during the expedition ☐ No, because …..
Will this deliverable be used? **If yes, who will use it?** **If not, why will it not be used?**	x Yes, by school kids, the public, the scholars / trainees ☐ No, because …..

NOTE: This information is being collected for the following purposes:

1. To make a list of all companies/organizations with which AtlantOS partners have had contact. This is important to demonstrate the extent of industry and public-sector collaboration in the obs community. Please note that we will only publish one aggregated list of companies and not mention specific partnerships.
2. To better report success stories from the AtlantOS community on how observing delivers concrete value to society.

*For ideas about relations with stakeholders you are invited to consult D10.5 Best Practices in Stakeholder Engagement, Data Dissemination and Exploitation.

Table of Contents

1. Executive summary

The AtlantOS WP8.8 targeted products address societal benefits in several areas by training early career scientists, promoting an international network and by addressing the public with outreach activities related to the UN Sustainable Development Goals e.g. Goal 4: Quality education, Goal 5: Gender equality, Goal 13: Climate action, Goal 14: Life below water, Goal 17: Partnerships for the goals.

Education founded on a well-managed mix of interests and needs in the field of oceanography and marine science is more imperative than ever in order to secure earths´ future oceans as a sustainable resource. To strengthen the intercultural competences and general communication skills, an ocean training programme on board large research vessels was created to provide early career scientists hands-on training in the set-up and operation of scientific instrumentation and equipment. The trainees were taught how to acquire and process marine water samples, sample analyses, and on how to interpret data results. A best practice training programme manual will also developed. In general, the main aim of this initiative was focused on training ocean experts to address the sustainability of our global ocean, promoting excellence and moral sounding and a good sense of international gender equality facilitation and networking. To strengthen the POGO AtlantOS collaboration and to gain a real synergetic benefit, training scholarships on board the RV Polarstern were embedded in the NoSoAT / SoNoAT programme and single internships with sea going experience were provided to early career researchers.

2. Introduction

This report provides information on an oceanographic training programme onboard large research vessels developed by the POGO-ATLANTOS initiative. Conducting training on big research vessels encourages participants to learn multidisciplinary approaches and encourages them to move out of their comfort zone.

Over the four years of the AtlantOS project, a total of 15 scholarships were awarded to scientists from 14 countries; emerging ocean countries in the Atlantic and/or in cooperation with emerging ocean countries (Table 1). The POGO AtlantOS programme trained ocean experts on how to address sustainability issues in our global ocean, by promoting excellence and moral sounding and a good sense for international gender equal facilitation and networking. Trainees were taught to acquire and process marine samples, sample analyses, how to interpret the data collected and to apply best practice used in land based laboratories. In general, the aim was to train ocean experts on how to address sustainability

of the global ocean, promoting excellence. International gender equality and networking were an important component of the programme. To strengthen the collaboration of POGO with AtlantOS and to gain a real synergetic benefit, the funded scholarships trained on board the RV Polarstern, embedded in the NoSoAT / SoNoAT with more scholars expected to join the programme in June 2019. In 2019, the SoNoAT scholars will take part in a training cruise aboard the RV Polarstern with a pre-cruise workshop planned in Punta Arenas, Chile. The programme is very popular, for example, a total of 769 applications were received for the 2019 cruise (SoNOAT2019) for the five available scholarships.

Table 1: Successful applicants awarded POGO-AtlantOS scholarships

Name	**Country of citizenship**	**programme / expedition**	**Additional outcome /take home product**
Scientist 1	South Africa	PS120 / SoNoAT2019	Expedition blog
Scientist 2	Cuba	PS120 / SoNoAT2019	Expedition blog
Scientist 3	Germany	PS120 / SoNoAT2019	School teaching Germany
Scientist 4	Brazil	PS120 / SoNoAT2019	Expedition blog
Scientist 5	Greece	PS120 / SoNoAT2019	School teaching Greece
Scientist 6	Brazil	MSM60 Go-SHIP cruise	Best practice / Product development GLODAP2
Scientist 7	Nigeria	PS102 / NoSoAT2016	Expedition blog
Scientist 8	Philippines	PS102 / NoSoAT2016	Expedition blog / video
Scientist 9	Kenya	PS102 / NoSoAT2016	Expedition blog / video
Scientist 10	Mexico	PS102 / NoSoAT2016	Expedition blog / video
Scientist 11	Bangladesh	PS102 / NoSoAT2016	Expedition blog
Scientist 12	Nigeria	PS95 / NoSoAT2015	Expedition blog / own project on board
Scientist 13	Ghana	PS95 / NoSoAT2015	Expedition blog / own project on board
Scientist 14	Mauritius	PS95 / NoSoAT2015	Expedition blog / own project on board
Scientist 15	Trinidad Tobago	PS95 / NoSoAT2015	Expedition blog / own project on board

3. General scope of the Use Case T8.8 POGO-AtlantOS collaboration on ocean products

Activities in AtlantOS Task 8.8 were carried out by the Alfred Wegener Institute. The POGO activities, especially the NF-POGO Centre of Excellence within AtlantOS focused on the organization of oceanographic expeditions and training workshops.

An educational design for a shipboard training was developed. Activities included publishing a funding call and reviewing the submitted applications. To identify successful applicants, an approved strict

criteria scheme was followed, taking gender balance, regional balance and the quality of the applicant into account. A teaching booklet and teaching material were developed along with an online evaluation procedure to assess the training programme once complete. This year's expedition SoNoAT training cruise aboard the RV Polarstern was combined with a pre-cruise workshop in Punta Arenas, Chile.

An outreach and literacy concept addressing different kind of audiences was developed and included lectures and interviews for / with school kids in Ireland, Germany, UK, and Japan, and a social media campaign on Twitter, Instagram, facebook and institutional webpages.

4. Target Users for the Use Case

The target users are, after publication of the training concept, international operating institutions who can use the transferable training programme framework developed to conduct shipboard training using the developed blueprint of the teaching booklet as well as the soon to be published "Best Practice Bulletin". Target users for the Outreach material include school classes, young scientists, and the general public. Outreach material is used to highlight the need for education and networking, and to communicate the importance of marine and climate science when addressing global issues.

5. Literature review of user needs

Best practice examples and manuals for shipboard training onboard a big research vessel are rare which leads us to the planned publishing of our educational concept in a Best Practice Bulletin.
Scholars and teachers (faculty) were asked to evaluate the concept developed in the POGO-AtlantOs collaboration and to provide feedback in order to improve the training approach. This ongoing feedback by each training activities led the teaching booklet in its current format. In general the training approach was evaluated as very useful by teachers, home institutes, scholars and crew on board. Finally evaluation and results from the last training cruise in June 2019 will be published within the "Best Practice Bulletin".

6. Targeted Products

List of Products

- Teaching booklet SoNoAT2019
- Cruise report PS102
- Cruise report PS95

The teaching booklet from the SoNoAT2019 training (see Appendix 1) and the cruise reports from the NoSoAT2015 and NoSoAT2016 are available online: https://www.awi.de/en/about-us/sites/helgoland/visiting-scientists/centre-of-excellence-nf-pogo/sonoat/reports-dates.html.

An example of a successful outreach campaign is the video footage of the NoSoAT2016 training on board the Polarstern. More video footage is planned for the next training cruise SoNoAT2019.

Examples of educational videos produced:

- Scholars give a short introduction on life on board a research vessel and explain the benefits of the educational hub: https://youtu.be/S8_h2ep96TM .
- Scholars working on an ocean literacy project interview Professor Peter Lemke who explains the climate system: https://youtu.be/I-tR9i1FKfA.

A 2019 cruise is planned, from Stanley to Bremerhaven, that will cover a large geographic range and will transit from temperate to sub-tropical marine regions. As with all POGO-AtlantOS training cruises, during the 2019 cruise, participants are expected to learn the principles of oceanographic, meteorological, atmospheric and tropospheric interactions and their impacts on climate. Work on-board will focus on active learning and hands-on, applied research techniques, supported by a suite of background lectures, exercises and presentations. Participants will gain hands-on training in the set-up and operation of scientific instrumentation and equipment, acquisition and processing of samples and analysis and interpretation of the respective data. In addition, participants will gain an understanding about climate processes, simple climate modelling, data crunching and statistics (Fig. 1).

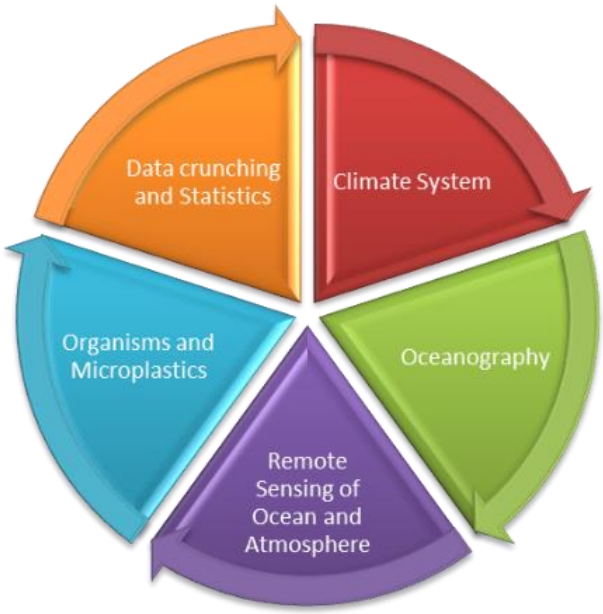


Figure 1: Rotation scheme depicts activities scholars follow aboard the POGO-AtlantOS research cruises.

Data collected on the cruises allow the young scientists to categorise regional oceanic and atmospheric patterns and identify biogeographic provinces in the Atlantic. The practical work is supported by on-board lectures, discussions, practical exercises, data workup sessions and peer-led presentations focused on enabling interpretation of the respective data.

On the cruises, the scholars are actively involved in providing material for Outreach activities and conducting ocean campaigns. The aim is to increase the global awareness of climate and ocean issues as well as capacity development worldwide. Target audiences of the outreach activities prepared by the scholars include:

A. schools (kids and teachers)

B. students and young scientists worldwide

C. general public

D. politicians

The Programme tweeting campaign includes

A. A general twitter campaign starting with the opening of the first call

B. Picture of the day, chosen at meetings after dinner, published daily with one keyword on Twitter and Instagram, starting on the first day of each cruise

C. Post-expedition tweets follow the homeward journey of the scholars.

All scholars are introduced to “official” tweeting protocols. In general, the expedition is addressedas #SoNoAT, implementing Atlantos, Nippon and POGO with handles (@) and #NF_PogoCofE.

Local schools are contacted (Pre-cruise: a short skype interview, Invitation to the school to prepare cups we will take down to the deep) and join the same schools after the cruise (Post cruise) to talk about the young researchers experience in their home countries and / or to involved schools

Within the format “From Ocean Experts to Ocean Translators” the researcher will provide short clips explaining

A. Microplastics in the Oceans,

B. Why should we care about the Oceans,

C. Weather and climate, D How to get oceanographic data (CTD, etc.),

D. Write your own song and perform it.

7. Summary

In summary, the POGO-AtlantOS initiative has helped to:

- facilitate the interaction between emerging ocean countries along the Atlantic Seaboard and ocean research institutes in Europe
- Expand a network of young researchers
- Implement the scholars’ expertise in science and outreach / ocean literacy.
- Provided views in modern ocean science infrastructures to develop “take home” sampling protocols and to the develop assessments of “tool necessities” for specific applications

Appendix 1: Teaching booklet

South North Atlantic Training Transect SoNoAT 2019

Course content
RV Polarstern - PS 120
Stanley - Bremerhaven
02 June - 29 June 2019

Inhalt

South North Atlantic Training Transect 2019 SoNoAT 2019 on RV Polarstern PS 120

02 June 2019, Stanley, Falklands - 29 June 2019, Bremerhaven, Germany

1. Introduction

The Atlantic Training Transect (NoSoAT and SoNoAT) is a biennial training survey that brings together International participants through collaboration between the Alfred Wegener Institute (AWI), Partnership for Observation of the Global Oceans (POGO) and funded through the Nippon Foundation and ATLANTOS. The scientific programme in 2019 is based on Ocean and Climate interactions and is designed to provide participants with a thorough insight into the fundamental principles of our changing climate.

The cruise from Stanley to Bremerhaven will cover an enormous geographic range and will transit from temperate to sub-tropical regions. During the transect, participants will be trained in the principles of oceanographic, meteorological, atmospheric and tropospheric interactions and their impacts on climate. Work on-board will focus on active learning and hands-on, applied research techniques, supported by a suite of background lectures, exercises and presentations. Participants will gain hands-on training in the set-up and operation of scientific instrumentation and equipment, acquisition and processing of samples and analysis and interpretation of the respective data. In addition, participants will receive training in understanding climate processes and simple climate modelling and data crunching and statistics.

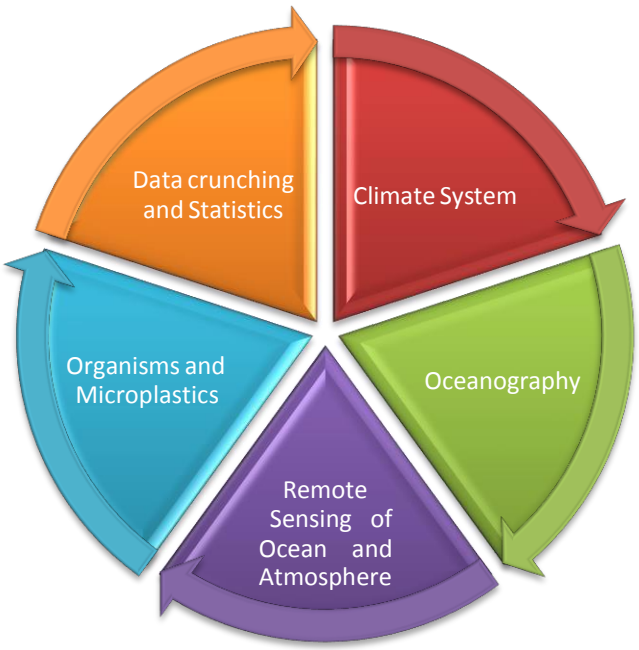


Figure 1: Rotation scheme

These data will allow us to categorise regional oceanic and atmospheric patterns and identify biogeographic provinces of the Atlantic. The practical work will be supported by on-board lectures, discussions, practical exercises, data workup sessions and peer-led presentations which will enable interpretation of the respective data.

The course outline will provide an overview of the course schedule and details of those organising, lecturing and participating in the survey. A list of recommended literature and

background reading is included. If you have any queries, please do not hesitate to contact us. We hope that you will find your time on-board the RV Polarstern enjoyable, instructive and career enhancing. We look forward to meeting you in Bremerhaven.

2. SoNoAT Participants

SoNoAT participants will include a total of up to 16 lecturers and 25 students, the names and affiliate institute of which are listed below.

2.1 Instructors

Table 1: Names and affiliations of teachers / instructors

No.	Name	On-board Position	Area of Expertise	Institute
1	Karen Wiltshire	chief scientist	Oceanography	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung Meeresforschung
2	Peter Lemke	Route planning	Climate science	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung
3	Eva Brodte	Knowledge / Technology Transfer and Outreach activities	Capacity development / Scientific Outreach	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung
4	Kristine Carstens	Oceanography	Practical Oceanography	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung
5	Peter Croot	Oceanography	Oceanography	National University of Ireland Galway
6	Jan El Kassar	Remote Sensing	Remote sensing	Freie Universität Berlin
7	Santiago Gasso	Remote Sensing	Remote sensing	ESSIC-UMD/NASA
8	Mara Gomez	Organisms and mircoplastics	Phytoplankton	MARE-FCUL
9	Clynton Gregory	Oceanography	Oceanography/Data Analyses	National University of Ireland Galway
10	Anneke Heins	Organisms and mircoplastics	Microbiology	Max Planck Institute for Marine Microbiology, Bremen, Germany
11	Therese Keck	Remote Sensing	Remote sensing	Pandata GmbH
12	Inga Kirstein	Organisms and mircoplastics	Microplastics	AAU, Aalborg, Denmark
13	Sandi Orlic	Organisms and mircoplastics	Microbiology / FISH	Institut Ruđer Bošković, Zagreb, Croatia
14	Fiona Beckmann	Communication	Science communication	POGO secretariat
15	Mirco Scharfe	Data crunching and statistics	Oceanography	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung
16	Eberhard Sauter	Knowledge / Technology Transfer and Outreach activities	Science and Knowledge Transfer	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung

2.2 Scholars

These participants has been chosen by a reviewing panel out of 796 applicants from 88 nationalities.

Table 2: Names and affiliations of scholars

No.	Name	Country of Citizenship
1	Marufa Ishaque	Bangladesh
2	Angela Patricia Palomino Gaviria	Colombia
3	Yoania Povea Pérez	Cuba
4	Vincent Valentin Scholz	Germany
5	Anjana Aravind	India
6	Emma Kilcoyne	Ireland
7	Ahmad Hussein Mohamed	Kenya
8	Felaniaina Lantovololona	Madagascar
9	Gay Amabelle Go	Philippines
10	Sian Seymour	South Africa
11	Evelina Emanuel Wabike	Tanzania
12	Yohan Didier Louis	Mauritius
13	Lucas de la Maza	Chile
14	Lorena Neira-Ramírez	Colombia
15	Hassan Al-Najjar	Palestinia
16	Ibrahima Diack	Senegala
17	Emmanuel Brempong	Ghana
18	Ximena Aguilar	México
19	Merrisa Naidoo	South Africa
20	Stacy Ballyram	Trinidad
21	Graciela Stefani Peña Ramirez	Argentina
22	LUCIANA SHIGIHARA LIMA	Brazil
23	Debra Ramon	Israel
24	Thodoris Karpouzoglou	Greek
25	Juan Carlos Farias Pardo	Brazil

3. Group Rotations for SoNoAT 2019

Survey participants will be divided into groups of five which will rotate between the five main disciplines:

1. Climate System

2. Oceanography

3. Remote Sensing of Ocean and Atmosphere

4. Organisms and micro plastics

5. Data crunching and Statistics

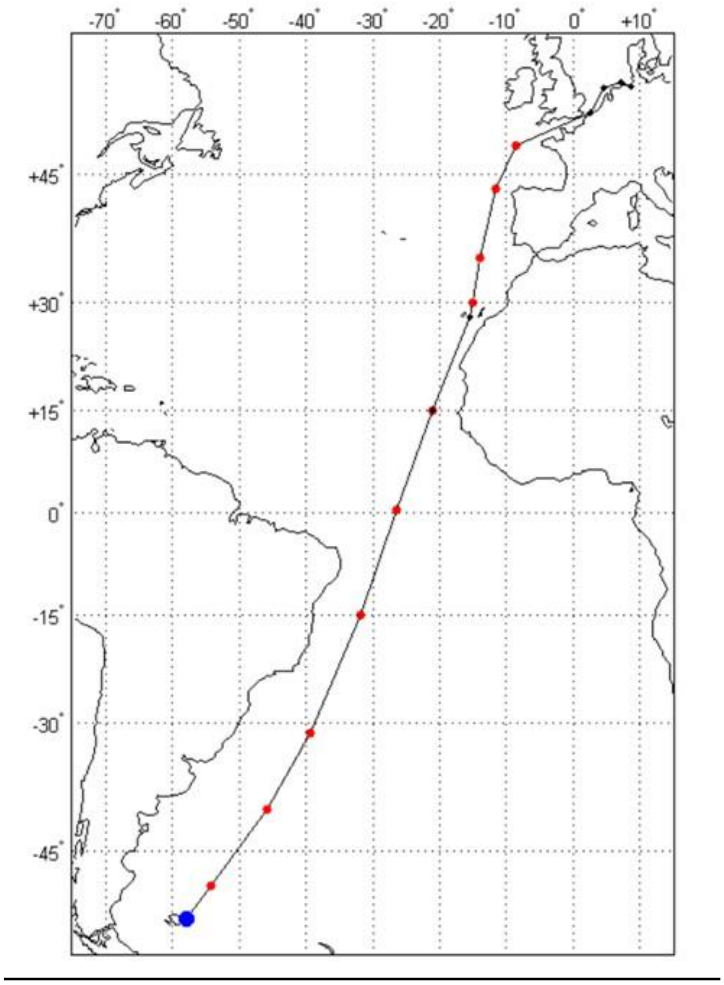


Figure 2: General route of the PS120

Each group rotation (Table 1) will last 4-5 days and include an average of two stations per rotation (a total of ~10 stations). At the end of each rotation students will have a project day set aside to work on preparing that evenings presentation and on individual projects. The timing of project days is flexible and will of course be dependent on station positions.

Table 3: Draft on-board schedule and rotating scheme of groups

Start Rotation Date	No of days	Modules				
		Climate system	Oceanography	Remote Sensing	Organisms & Microplastics	Data crunching & statistics
28.-29.May		Arrival Punta Arenas, Chile				
30. -31. May	1,5	Workshop Punta Arenas, sorting of groups				
01. June		Flight Punta Arenas – Mount Pleasant, Falklands				
01.June		Bus Mount Pleasant – Stanley, Falklands				
02. June	1	On board Stanley				
03. June	1	Settling in , unpacking gear and lab set up already in groups				
03. -07. June	5	Group1	Group2	Group3	Group4	Group5
08.-12. June	5	Group5	Group1	Group2	Group3	Group4
13. -17. June	5	Group4	Group5	Group1	Group2	Group3
18. – 22. June	5	Group3	Group4	Group5	Group1	Group2
23.-27. June	5	Group2	Group3	Group4	Group5	Group1
27. June	1	Packing of gear, samples, lab clean up, cruise report, reports				
28. June	1	Packing of gear, samples, lab clean up, cruise report, reports				
29. June		Arrival Bremerhaven , Germany				
29. June		Disembarkation; welcome venue AWI				

4. Course Content

The course focuses on the five main disciplines listed below:

1. Climate System

2. Oceanography

3. Remote Sensing of Ocean and Atmosphere

4. Organisms and Microplastics

5. Data crunching and Statistics

4.1. Climate System

Topic Lead: Prof. Peter Lemke

“Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased.”

This statement in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) in 2013 is based on a wide variety of climate observations and model simulations. The present characteristics of the climate system are a product of a long-term evolution determined by external forcing (sun, volcanoes) and internal interactions within the climate system, which is composed of atmosphere, ocean, cryosphere, land surfaces, and the marine and terrestrial biosphere. Until 250 years ago, the interference of man was small, and climate variations were a product of natural processes and interactions alone.

Since the beginning of industrialisation the composition of the atmosphere, especially the concentrations of greenhouse gases like carbon dioxide and methane, have significantly increased. In addition, the character of the land surface has been largely modified through

land-use and land-cover change through human activities. Part of the observed global warming during the past 100 years is attributed to these anthropogenic impacts.

This course provides the evidence of climate variations on all time-scales, and presents an introduction to the physics of the climate system, with a special focus on atmosphere, ocean and ice. Exercises will deal with specific climate processes and with the energy balance of the Earth and other planets. Matlab programs will be provided to study these effects in detail.

Subtopic: Observations of the water isotopic composition in near-surface atmospheric vapour and surface ocean

The project involves isotopic analyses of near-surface atmospheric water vapor and of surface ocean water aboard RV Polarstern. Continuous in situ observations of water vapour in the air are automatically conducted using a laser spectrometer, controlled and maintained by a scientist and the responsible group (Climate system) on board. In addition, daily sea water samples (30 mL bottles) are taken from the permanently installed 6 m sea water inlet by a scientist and the responsible group (Climate system) on board and stored in a cold place. They do not require the use of any chemical. The water isotopic composition of these sea water samples is later measured in the isotope laboratory in Potsdam.

4.2 Oceanography

Topic Lead: Prof Karen H. Wiltshire and Prof Peter Croot

Aim: To introduce the scholars to different sampling concepts, sampling planning, sampling techniques, sampling devices, measurement techniques and accuracy, and common oceanographic instrumentation.

Content: This Module is a combination of three intensive training sessions of approximately 1.5 hours duration on Deck and in the Lab. These sessions will be directly associated with real sampling, both underway and on station.

What to expect:

• This Module requires a high level of discipline and safety at all times and especially while sampling and on deck. All narcotics including alcohol cannot be imbibed under 8 hours before deck or lab work. Here it is important to note that the rules are the same as for driving a vehicle.

• The scholars will be expected to work in teams of 5 persons. Each person will have to take over a responsibility e.g: Persons will be deemed responsible for safety of the team on deck, safety of the team in the lab., data logging, sampling coordination, handover to next team.

• Scholars will be expected to work in shifts, potentially long hours and also at night and as the sampling stations might require this.

Suptopic: Deployment of Argofloats (BSH) - Module Lead Mirco Scharfe

Argo is an international program that uses profiling floats to observe temperature, salinity, currents, and, recently, bio-optical properties in the Earth's oceans; it has been operational since the early 2000s. The real-time data it provides is used in climate and oceanographic research. A special research interest is to quantify the ocean heat content (OHC).

The Argo fleet consists of almost 4000 drifting "Argo floats" (as profiling floats used by the Argo program are often called) deployed worldwide. Each float weighs 20–30 kg. In most cases probes drift at a depth of 1000 metres (the so-called parking depth) and, every 10 days, by

changing their buoyancy, dive to a depth of 2000 metres and then move to the sea-surface, measuring conductivity and temperature profiles as well as pressure. From these, salinity and density can be calculated. Seawater density is important in determining large-scale motions in the ocean. Average current velocities at 1000 metres are directly measured by the distance and direction a float drifts while parked at that depth, which is determined by GPS or Argos system positions at the surface. The data are transmitted to shore via satellite, and are freely available to everyone, without restrictions.

http://www.argo.net

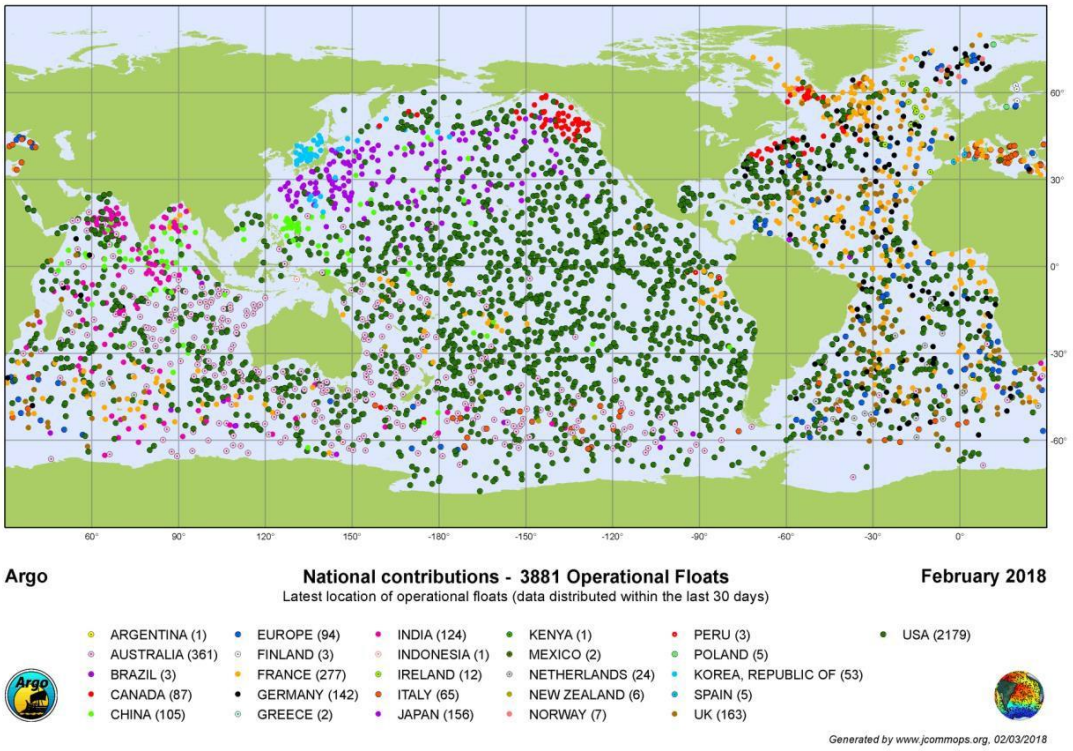


Figure 3: Coverage of Argo floats in the oceans (source: www.jcommops.org, 02/03/2018)

During the PS120 cruise we will deploy Argo floats for the Federal Maritime and Hydrographic Agency of Germany (German: Bundesamt für Seeschifffahrt und Hydrographie, BSH).

Subtopic: Equipment and Instruments in Oceanography - Module team: Clynton Gregory, Kristine Carstens

a. CTD sensor packages and rosette Sampling

b. Underway- CTD

c. Expendable Bathythermographs (XBTs)

d. Thermosalinograph/Ferrybox Underway Measurements & Sampling

Subtopic: Marine Technologies / Marine Research Instruments – Eberhard Sauter

The module will provided additionally to the practical, hands–on application in the other modules an overview of underwater research gear and performance of measurements, like

Wire-driven gear such as nets, corer, samplers, underwater platforms such as AUVs, ROVs, gliders, floats, landers, moorings, observatories and new developments.

Subtopic: Assessing Climate Change in the Atlantic Ocean - Module team: Prof Peter Croot (NUI Galway), Clynton Gregory (NUI Galway)

Physical Oceanography

This set of activities will be based around the planning, acquisition and analysis of CTD data collected at stations along the expedition track between Port Stanley and Bremerhaven.

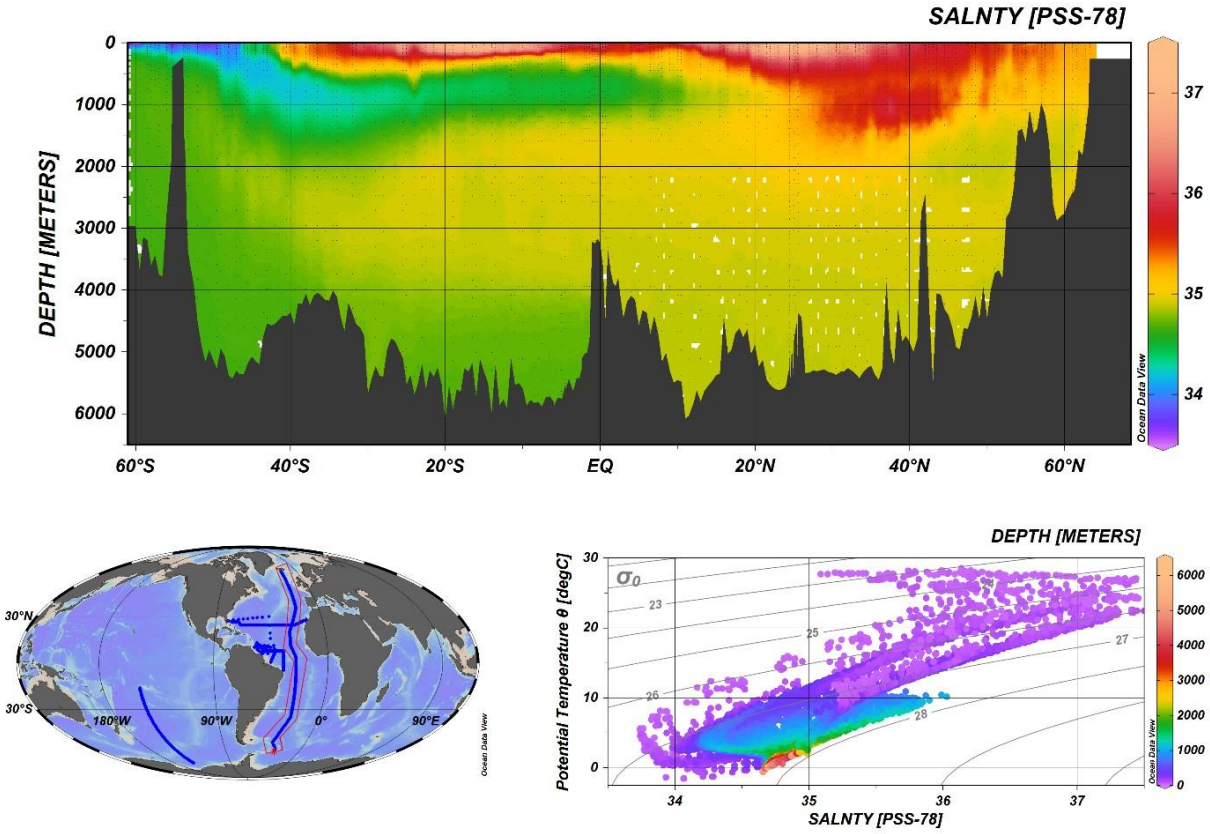


Figure 4: Salinity in the Atlantic ocean along the A16 line (data: Carina database v1.2 for ODV).

CTD planning, operation, sample and data collection

Several hours prior to arriving on station, students will be introduced to the basics of CTD operation on the RV Polarstern. They will learn how to identify the different sensors on the CTD rosette and how to set and check a Niskin bottle prior to deployment. Students, with the help of the module coordinators, will plan their bottle sampling strategy on the upcast, prior to deployment, based on the expected locations of the different water masses anticipated to be encountered at that location. All deck and winch room operations during deployment will be explained to the students prior to beginning the station and they will be taught the basic operations of the Seabird CTD software, the event logger on the Polarstern and the AWI's ManageCTD program for post processing of the data into ODV. Students will also take water samples for dissolved gases, nutrients and phytoplankton from the Niskin bottles for use in other sections of this module. At the completion of the station the students will clean the CTD and reset the Niskins in anticipation of the next deployment.

XBT deployment and data retrieval

Students will learn how to setup for an XBT deployment from a moving ship, including communicating with the ship's crew for a safe and successful release of the XBT probe. The students will also learn how to download the data and to load it into oceanographic software such as ODV. Previously we have also deployed an underway CTD from the Polarstern, if time and conditions allow this may also be performed during this expedition. XBT deployment are anticipated at this stage to be a daily event, but will depend on the availability of XBTs and sea conditions.

Water mass identification

Students will be introduced to the basics of water mass identification using T, S and O_2 for the main water masses found along the expedition track. Salinity measurements for CTD calibration made onboard. Focus will be on following AABW and AAIW north, the increase in NADW as we move north in the SW Atlantic and its reduction in the Eastern Basin of the Atlantic, and the appearance of MOW in the later part of the transect.

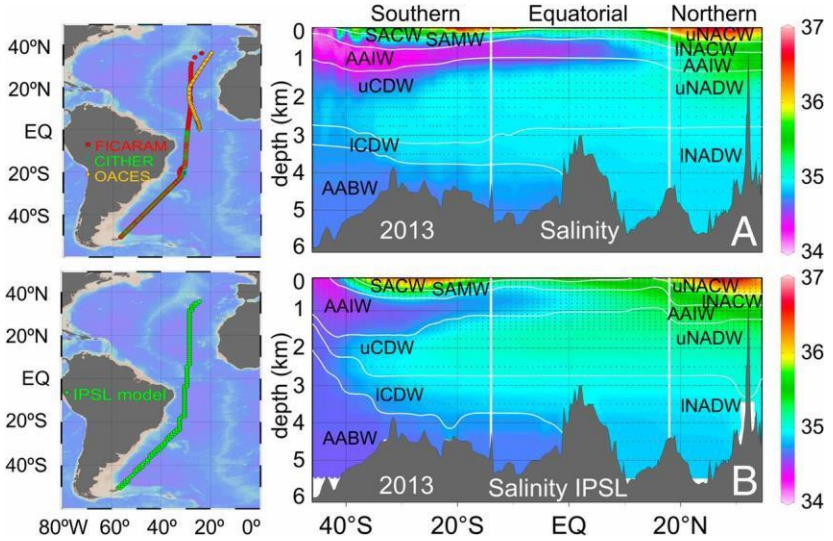


Figure 5: Water masses identified in the Atlantic Ocean (Ríos *et al.*, 2015).

Ocean Heat Content

Combining data obtained during this expedition with that from previous expeditions for the same locations, students will examine changes in the oceanic heat content of the water column to examine the evidence for an increase in temperature in surface and intermediate waters of the Atlantic. ***This work will also crosslink with related themes in the climate module***.

Chemical Oceanography

In this module students will be introduced to basic concepts pertaining to the carbon system in the ocean and undertake some shipboard measurements as part of their training.

Carbon system parameters

In this section of the module students will be introduced to the carbon system in the ocean and undertake measurements of some carbon system parameters in the water column.

Measurement of 2 of the 4 carbon system parameters (pCO_2, pH, DIC and TALK) allow calculation of the other 2 via programs such as CO_2SYS (Lewis and Wallace, 1998). Recent acidification in the Atlantic (Ríos *et al.*, 2015).

Spectrophotometric pH measurement

Recent advances in technology have enabled high precision measurements of pH using spectrophotometry to be made at sea (Bellerby *et al.*, 2002; Byrne and Breland, 1989; Clayton and Byrne, 1993; Douglas and Byrne, 2017; Soli *et al.*, 2013; Yang *et al.*, 2014). Students will be asked to discuss some of the uncertainties in this approach (Yang *et al.*, 2014; Yao *et al.*, 2007) and to discuss the distribution of pH along the A16 line in the Atlantic (Figure 2) and recent work examining anthropogenic induced changes in pH in the Atlantic (Woosley *et al.*, 2016).

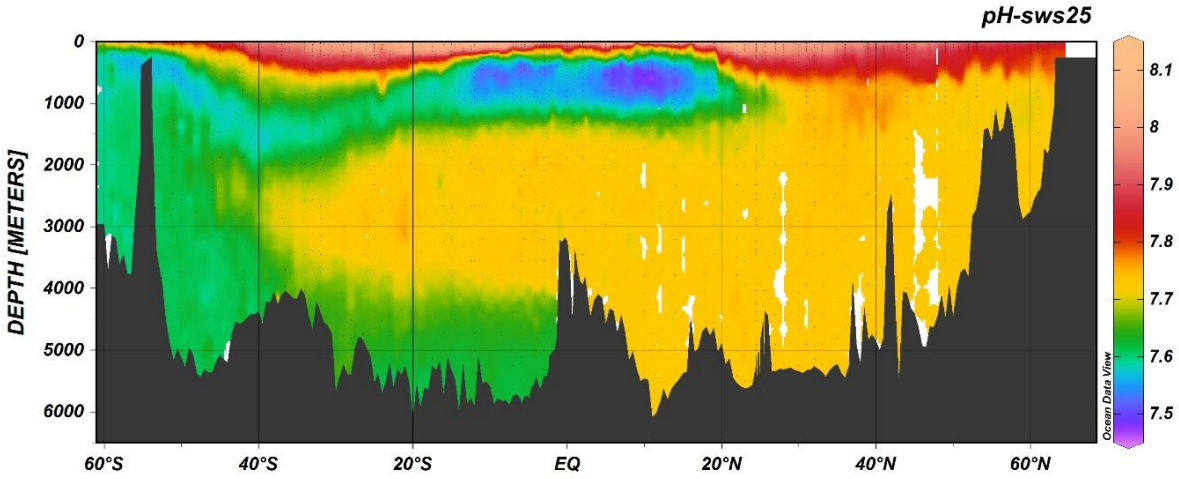


Figure 6: Calculated distribution of pH in the Atlantic ocean along the A16 line (data: Carina database v1.2 for ODV).

Spectrophotometric measurement of carbonate concentration

Utilizing the direct determination of carbonate in seawater by its Pb complex, the concentration of carbonate can be measured in the water column by spectrophotometry after the addition of $PbCl_2$ (Byrne and Yao, 2008; Easley *et al.*, 2012; Patsavas *et al.*, 2015; Sharp *et al.*, 2017). Students will determine the concentration of carbonate in samples taken from a full depth CTD cast and compare their direct measurements to values calculated from consideration of alkalinity and TCO_2 values from earlier WOCE and GO-SHIP expeditions along the A16 line in the Atlantic (Figure 3).

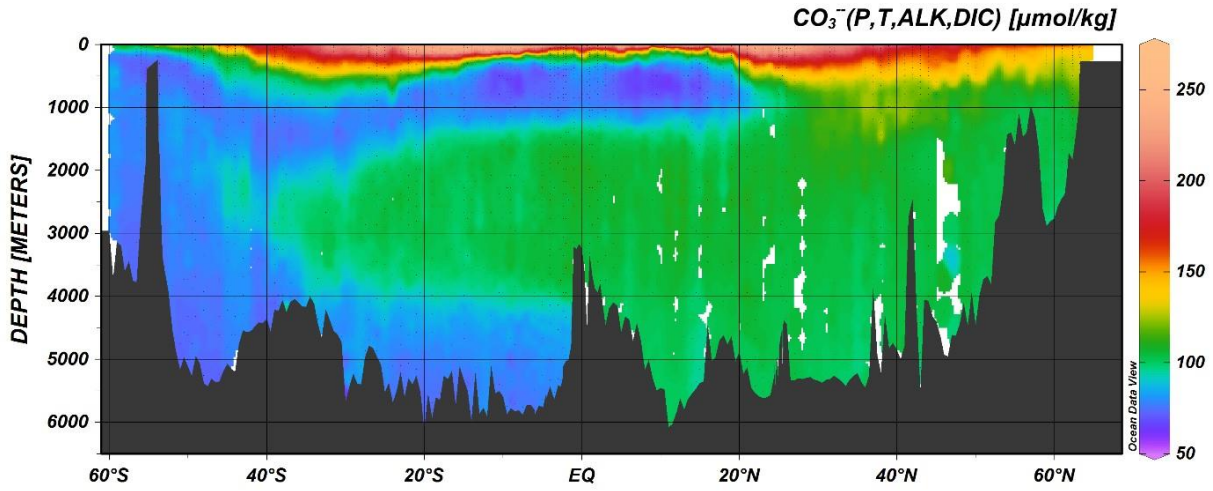


Figure 7: Calculated distribution of carbonate in the Atlantic ocean along the A16 line (data: Carina database v1.2 for ODV).

Students will then use their carbonate data to estimate the aragonite and calcite saturation states throughout the water column (Figure 4). This data will be used to develop the idea of saturation states and carbonate preservation in the deep ocean and the impact of ocean acidification on the ocean.

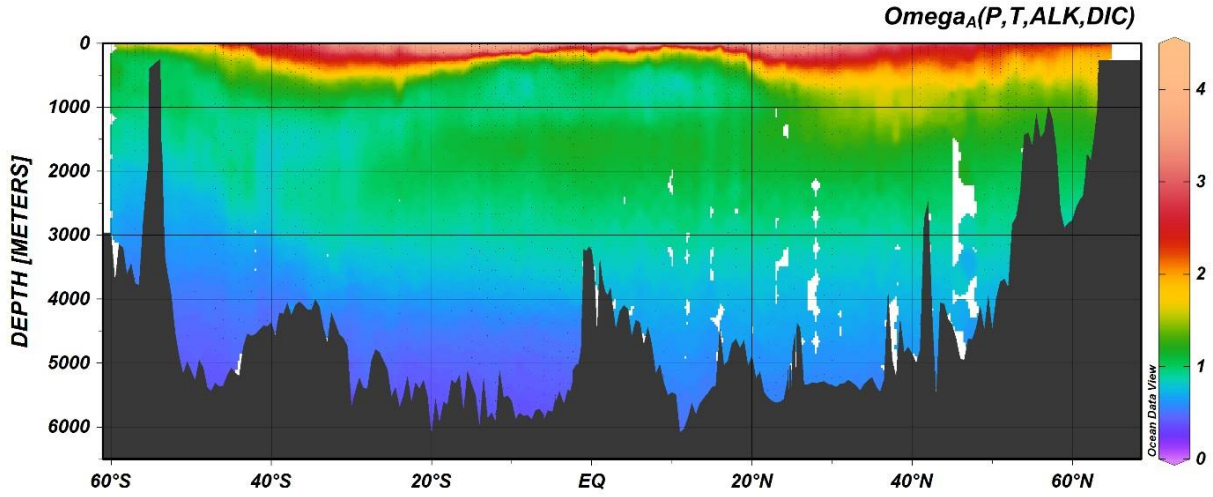


Figure 8: Calculated aragonite solubility in the Atlantic ocean along the A16 line (data: Carina database v1.2 for ODV).

Nutrient analysis

Measurement of nutrients in the water column will help to identify water masses and highlight differences between the northern and southern gyres of the Atlantic. Sample would be measured onboard directly using either a nutrient analyzer or by small volume manual sampling (as commonly carried out at NUI Galway). In this section of the module students will learn about the N and P cycles and the Redfield ratio (Redfield, 1934; Redfield *et al.*, 1963).

Nitrite and Nitrate

Nitrite is detected and analyzed by formation of a red pink colour upon treatment of a NO2−-containing sample with the Griess reagent (Griess, 1858). When sulfanilamide is added to nitrite (figure 5) a diazonium salt is formed. This the reacts with the azo dye agent (N-alpha-naphthyl-ethylenediamine) to form a pink coloured complex. This diamine is used in place of the simpler and cheaper alpha-naphthylamine because this latter is a potent carcinogen and

moreover the diamine forms a more polar and hence a much more soluble dye in acidic aqueous medium.

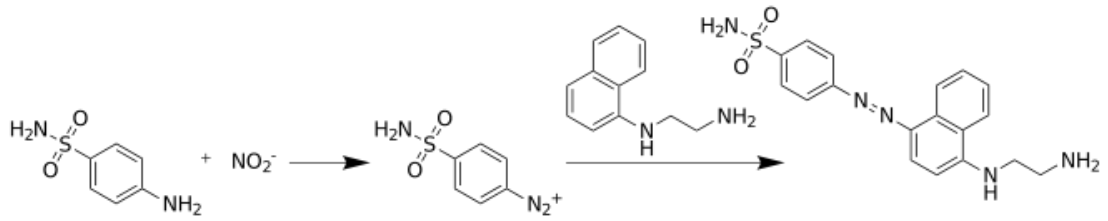


Figure 9: The Griess reaction

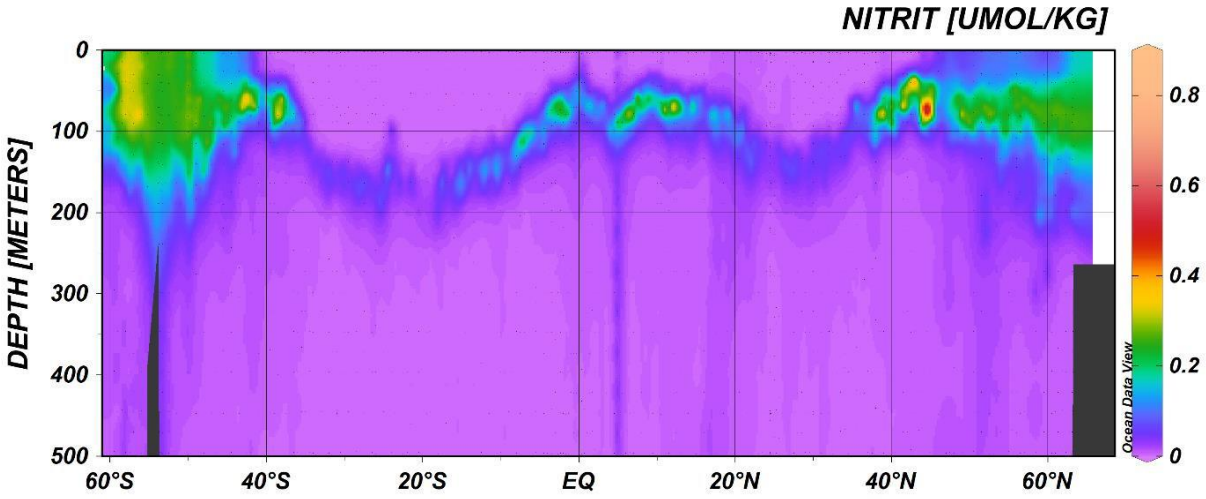


Figure 10: Nitrite distribution in the Atlantic Ocean along the A16 line (data: Carina database v1.2 for ODV).

Reactive nitrate is converted into nitrite by reduction with V(III) (García-Robledo *et al.*, 2014; Schnetger and Lehners, 2014) and subsequent determination using a modified version of the Griess reagent.

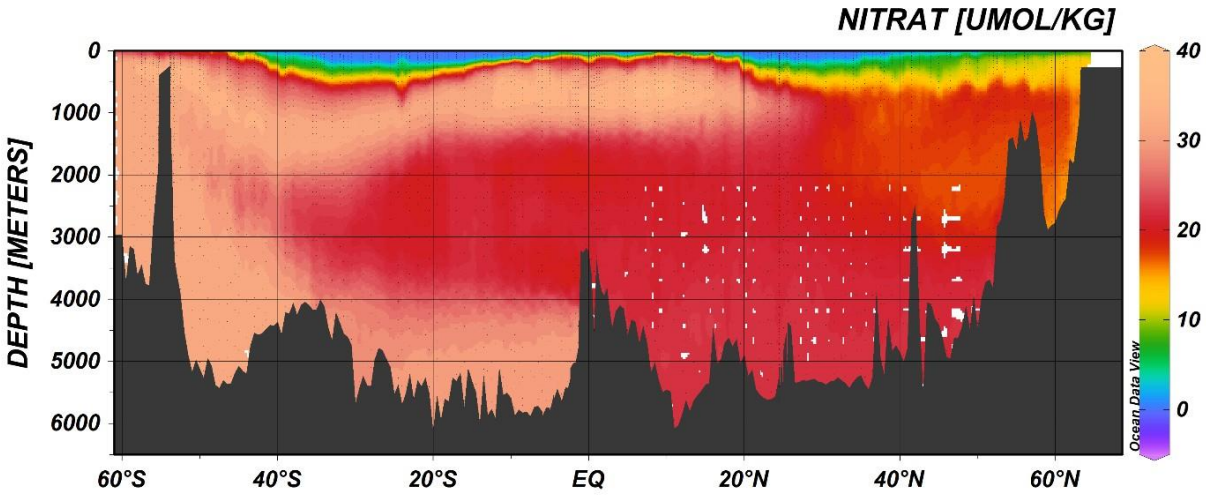


Figure 11: Nitrate distribution in the Atlantic Ocean along the A16 line (data: Carina database v1.2 for ODV).

Phosphate

Reactive phosphate is determined using a modified version of the Murphy and Riley (1962) technique. This involves formation of a yellow phosphomolybdate complex followed by

reduction to a molybdenum blue compound using ascorbic acid. The method uses a single mixed-reagent solution.

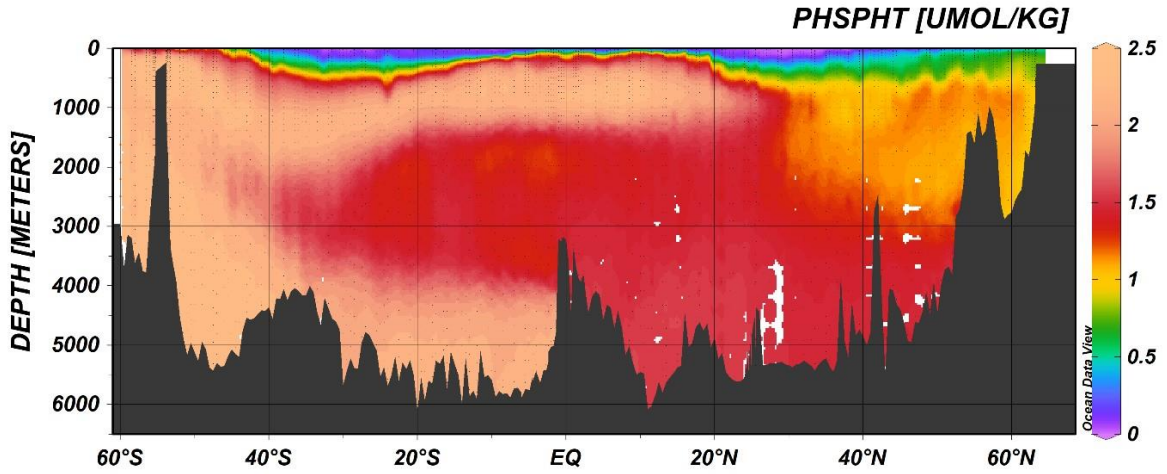


Figure 12: Phosphate distribution in the Atlantic Ocean along the A16 line (data: Carina database v1.2 for ODV).

Air/Sea Gas exchange - Trace Gas analysis

In this part of the module students will be introduced to the concepts of Air/Sea gas exchange and will learn how to take samples for dissolved gases in seawater. Discrete samples will be taken from the Niskin bottles on the CTD rosette as for usual gas (e.g. O_2, CO_2) sampling and collected in gas tight Labco Exetainers (12 mL). One set of samples will be analyzed onboard using a O_2 spot optodes, the remaining samples will be preserved with a small amount of $ZnCl_2$ and then stored until returned to Galway for later analysis on a Membrane Inlet Mass Spectrometer (MIMS) (Krogh and Gill, 2014). Students will be sent the data post expedition to include in a follow up report (Nemcek *et al.*, 2008; Tortell *et al.*, 2011; Tortell *et al.*, 2012).

O_2/N_2 and O_2/Ar

The exetainer samples will be analyzed on a MIMS for their O_2/Ar ratios as a measure of net community production (Kaiser *et al.*, 2005; Li and Cassar, 2016). The data for O_2 will be compared to that measured directly in the water column via the CTD's oxygen sensor (Figure 8) and the samples measured at sea with the optodes.

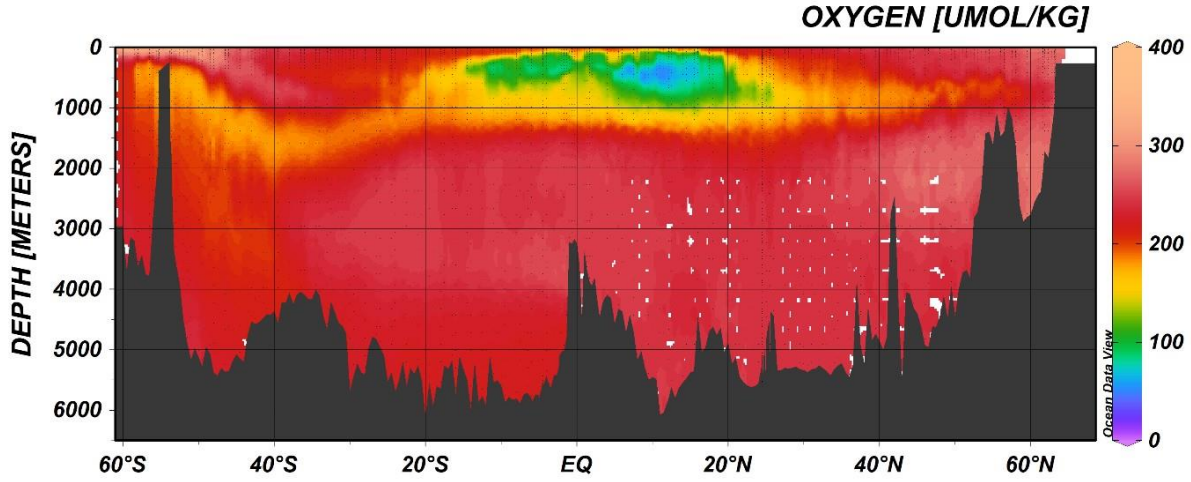


Figure 13: Oxygen concentration in the Atlantic Ocean along the A16 line (data: Carina database v1.2 for ODV).

Climate relevant gases - CO_2 ($\delta^{13}C$) and DMS

Samples for CO_2 and DMS will also be analyzed on the MIMS (Nemcek *et al.*, 2008; Tortell *et al.*, 2011; Tortell *et al.*, 2012) and the data made available to the students for inclusion in their final post expedition reports.

Biological Oceanography

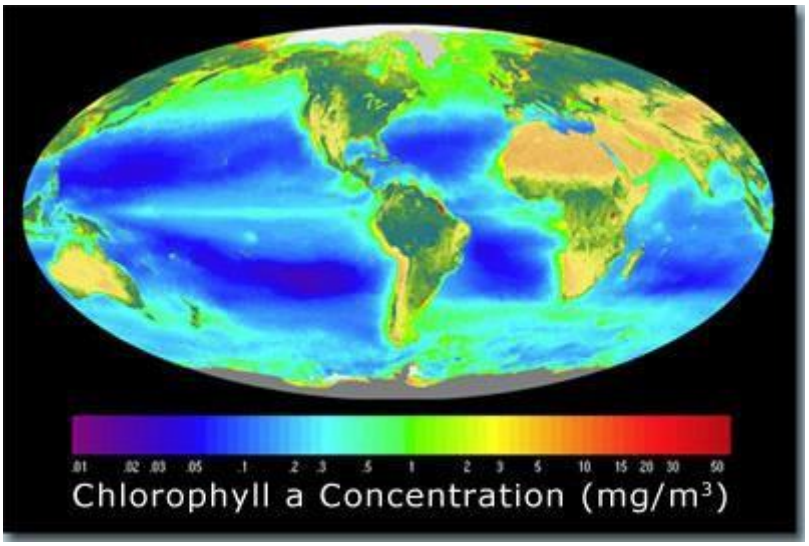


Figure 14: Global average Chlorophyll a concentrations as determined by remote sensing. (Source http://www.gma.org/herring/biology/distribution/comparing_oceans.asp).

The biological aspects of the oceanographic module will bring together the physical and chemical drivers of oceanic productivity to allow the students to interpret the different biological environments they will encounter during the expedition. In particular the students will learn about the contrasting phytoplankton communities found in the high productivity zones in the high latitudes and equator versus that which exists in the low productivity oligotrophic gyres. Aspects of this work will link with related themes in the remote sensing modules.

Flow Cytometry analysis

Students will be introduced to the basic operation of a flow cytometer and learn how to interpret the specific scattering and fluorescence characteristics of different algal types, in particular for the dominant picoplankton species *Prochlorococcus* and *Synechococcus* (Flombaum et al., 2013). Water samples obtained from the Niskin bottles of the CTD will be analyzed on a flow cytometer for the abundance of pico and nanoplankton using standard protocols (Marie *et al.*, 2001).

Coccolithophorids

Where possible the abundance of coccolithophorid species in the water column will be made for samples from the CTD (von Dassow *et al.*, 2012). This data the students will use to assess the impact of the carbonate concentration and/or aragonite/calcite saturation state on the abundance of these algal species.

Hyperspectral Particulate Absorption

Water samples from Niskin bottles will be filtered using a 25 mm Whatman GF/F for measurement of the particulate absorption spectrum (Mitchell, 1990). The part of the module is designed to complement work that will also be performed in the remote sensing module.

Schedule and Summary of Learning Outcomes

Proposed Schedule

The schedule proposed below is only indicative due to the nature of the timing of the CTD stations being determined by ship operations and liable to occur at any time of day or night during the period of the 5 days of the module.

Day 1:

1.1 Introduction to the CTD (Croot, Gregory & von Dassow) – 2 hours
1.2 XBT deployment (Gregory) – 30 minutes
1.3 Water mass identification (Croot) - 1 hour
3.1 Introduction to Flow Cytometry (von Dassow) – 1 hour

Day 2:

1.1 Pre-deployment planning for CTD station (Croot) – 2 hours
1.2 XBT deployment (Gregory) – 30 minutes
2.1.1 Introduction to the measurement of ocean pH (Croot) – 1 hour
2.1.2 Carbon system measurements at sea (Croot) – 1 hour
3.2 Importance of coccolithophorids to ocean systems (von Dassow) – 1 hour

Day 3:

1.1 CTD deployment at station (Croot, Gregory & von Dassow) – 5-6 hours
1.2 XBT deployment (Gregory) – 30 minutes
Measurement of water samples (Croot, Gregory & von Dassow) – 4 hours

Day 4:

1.2 XBT deployment (Gregory) – 30 minutes
1.4 Ocean heat content (Croot) – 1 hour
2.2 Importance of the Redfield ratio (von Dassow) – 1 hour
2.3 Air/Sea Gas Exchange (Croot) – 1 hour

Day 5:

1.2 XBT deployment (Gregory) – 30 minutes
Module exit briefing (Croot & von Dassow) – 2 hours

Learning Outcomes

Physical Oceanography

- Planning and Operation of a CTD rosette system
- Identification of water masses by θ/S properties
- Ocean circulation as drivers of biogeochemical cycles and primary productivity

Chemical Oceanography

- Understand the key aspects of the Carbon system in the ocean
- Calculate saturation states for aragonite and calcite
- Liebig's law and nutrient limitation

Biological Oceanography

- Redfield ratios
- Ecumenical hypothesis

Climate change

- Basics of ocean acidification and deoxygenation
- Heat content of ocean

Survey planning and operation at sea

Health and Safety at Sea

Student reports, evaluations and assessments
Students will be required to submit a report on this module prior to leaving the ship, this will take the form of a short report detailing the pre-planning and execution on station of the CTD cast, the results they found and an interpretation of their findings in the context of previous work at the same or nearby locations.

4.3 Remote Sensing of Ocean and Atmosphere

Topic Lead: Dr Therese Keck, Santiago Gasso, Jan El Kassar

Passive optical earth observation with spaceborne (satellites), airborne (planes) or field remote sensing instruments is the contactless measurement of the atmosphere and the ocean (and land). By measuring Earth's radiation at the top-of-the atmosphere from the visible to near infrared electromagnetic spectrum, we can turn it into geophysical information related to oceanic and atmospheric constituents such as algae, atmospheric aerosols and thermodynamical states (e.g. temperature, salinity, atmospheric water vapour). Satellites have been observing the Earth for more than 40 years, a period of data gathering long enough for using these tools for climate evaluation and monitoring. In addition, with the current explosion of Earth observing satellite deployments (from nano to car-sized satellites), it is imperative that future scientists learn about them and how to make use of their observations.

The course gives an introduction to remote sensing, satellites and sensors, atmosphere and ocean color. We start with the concepts of satellite instruments like Ocean and Land Color Imager (OLCI -- https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-olci) and products for ocean colour (e.g. phytoplankton -- https://oceancolor.gsfc.nasa.gov/l3/) and aerosols (https://modis-atmos.gsfc.nasa.gov/products/aerosol). Computer exercises with the satellite data visualisation and calculation software SNAP (Sentinel Application Program- http://step.esa.int/) and the aerosol transport software HYSPLIT (https://ready.arl.noaa.gov/HYSPLIT.php) enhance and illustrate your understanding of physical processes in the atmosphere-ocean system.

Additionally, you learn measuring with in situ optical sensors for ocean colour (Ramses and Hamamatsu) and aerosols (Microtops). You will conduct daily spectral measurements and analyse the results (blue-green ratio, algae algorithms, aerosol) with programming language Python.

The aim of the course is a first exposure to measurement techniques and advantages/obstacles in optical remote sensing focused on ocean colour and aerosols.

List of student projects (draft titles):

Each student must prepare a report/short paper of approx. 10 pages including some literature research and current issues / ship measurements / Atlantic Ocean relevant parts. To be submitted end of cruise to receive a participation certificate for the floating school.

1. Observing algae density in the upper ocean layer from South-West to North-East Atlantic Ocean in June
2. Match-up study along the transect: satellite derived data and in situ / laboratory measurements (with SNAP?)
    i. Chlorophyll concentration (blue-green ratio RAMSES + laboratory measurements, maybe satellite)

ii. Sea surface temperature (Ferrybox/bucket/XPT + satellite data)
iii. Reflectance/radiance (RAMSES + satellite)

3. Microtops aerosol analysis along the transect compared to climatological average
4. Estimation and comparison of aerosol mass concentration from remote sensing and from model (Hysplit)

4.4 Organisms and microplastics

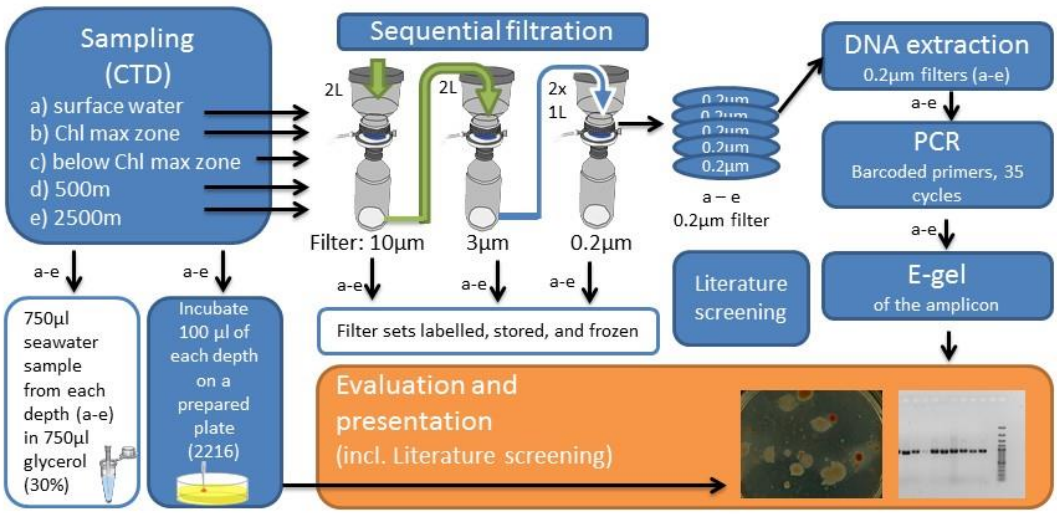
Topic Lead: Inga Kirstein, Anneke Heins, Dr. Sandi Orlic, Mara Gomes

4.4.1 Microbiology and Molecular Ecology (eDNA & FISH)

Anneke Heins (Max Planck Institute for Marine Microbiology, Bremen, Germany), Sandi Orlić (Institut Ruđer Bošković, Zagreb, Croatia)

The students will take water samples with the CTD (or alternatively surface water with a bucket) and filter it sequentially through a pore size of 10µm, 3µm and 0.2µm. Filters containing the smallest size fraction (3µm to 0.2µm) will be processed on the ship, beginning with DNA extraction, followed by a PCR with barcoded primers and a subsequent gel electrophoresis of the amplicons. We assume ten sampling stations with the CTD and plan to sample a) the surface water, b) the Chl max zone, c) water directly below the Chl max zone, d) in 500 m, and e) in 2500 m. Unfiltered seawater (750 µl) from each depth will additionally be stored in 750 µl glycerol (30%) and frozen, 100 µl will by plated to observe CFU growth. With 25 students in total, each one will extract and visualize the DNA of two filters. Members of each group will decide which depth they want to work with (a, b, c, d, or e) and will present the results in their final report. At every depth, where the samples for the eDNA, samples (filters) for FISH will be collected. This will allow to compare the results between these two approaches. Different FISH probes will be used, like general one for bacteria (Eub I-III) or for Gammaproteobacteria (Gam42a) and other more specific as for Sar11 group.

Overview E DNA project



4.4.2 Assessing Microplastics in the Atlantic Ocean

Inga Vanessa Kirstein (AAU, Aalborg, Denmark)

This module will be based around the planning, sampling, and analysis of microplastics collected along the expedition track between Port Stanley and Bremerhaven. To address the abundance, distribution, and composition of microplastics, sub-surface water samples will be taken by using on-board pumps and underway pipe system of the RV Polarstern. Two sampling procedures will be carried out during the PS120. Firstly, at the sampling stations, seawater will be filtered directly through cascade of 300 µm followed by 10 µm stainless steel filters in a closed steel filter system to prevent contamination and aim for small microplastics (< 20 µm). Secondly, on a daily basis, seawater will be filtered through geological sieves (bottom: 0.02 mm, centre: 0.1 mm and top: 0.3 mm mesh) enabling the filtration of a higher volume of water, as well as size fractionizing of the sample. For this second sampling, the collected material will be subsequently filtered through 10 µm stainless steel filters. All filter meshes from both sampling will be stored at -20°C for later polymer analysis in the laboratory. Since bigger plastic items are fragmented over time, we expect to find increasing amounts of microplastics with decreasing particle size. Collected microplastic samples will undergo sample preparation and afterwards characterized using µFT-IR in the home laboratory at University of Aalborg, Denmark.

4.4.3 Phytoplankton communities distribution along the Atlantic

Mara Gomes (MARE-FCUL)

This module will deal with the ecology and distribution of phytoplankton communities thriving in the Atlantic Ocean. For this purpose, different approaches will be performed: characterization of phytoplankton populations through pigment analysis; estimation of phytoplankton cells abundance quantitatively; and obtainment of highly resolved biooptic chlorophyll-*a in situ* measurements. Additionally, to understand the potential role of Saharan dust as a nutrient fertilizer for marine phytoplankton in the Atlantic Ocean, identification and counting of biogeochemically relevant coccolithophores will be done. Since the methodologies used for the above-mentioned analysis require very specific instrumentation, this module will consist mainly in sampling data for further analysis on land.

Proposed Schedule

Timeline Module 4.4: The schedule proposed below is only indicative due to the nature of the timing of the CTD stations being determined by ship operations and liable to occur at any time of day or night during the period of the 5 days of the module.

		Day 1											Day 2											Day 3											Day 4											Day 5										
	Time	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
E-DNA	Lecture/Seminar																																																						
	Sampling CTD																																																					
	Filtration																																																					
	DNA extraction																																																					
	PCR																																																					
	Gel electrophoresis																																																				
FISH	Lecture/Seminar																																																				
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	FISH Part 1																																																				
	FISH Part 2																																																				
	Microscopy																																																				
	Data analysis																																																				
Phytoplankton	Lecture/Seminar																																																				
	Sampling CTD																																																				
	Pigments																																																				
	Sahara dust																																																				
	Abundance																																																				
	Phytooptics																																																				
Mp	Lecture/Seminar																																																				
	Sampling Station																																																				
	Sampling Transect																																																			
Literature/Report writing																																																				

Day 1:

eDNA & FISH

Introduction eDNA & FISH – 1 h

Sample taking from the CTD: 5L per sample for 5 depths: 30 min

Filtration (CTD): 60 min/ student, CTD dependent!

ALTERNATIVE: Filtration (surface water): 75 min/ student. Not CTD dependent.

Assessing Microplastics in the Atlantic Ocean

Introduction “Plastic in the Ocean”– 30 minutes

Introduction “Sampling procedures and contamination prevention” 1 h

Microplastic sampling (continuous sampling, filtration time depending on the matrix)

Phytoplankton communities distribution along the Atlantic

Introduction “Phytoplankton communities distribution along the Atlantic” – 30 min

Introduction “Effects of Saharan dust on the coccolithophore communities” – 30 min

Sampling taking from CTD: surface (10L), 25m (5L), DCM (10L), 100m (5L), 150 m (5L)

Filtration for HPLC - 60 min (2 depths)

Filtration for Coccolithophores - 120 min (5 depths)

Fixing samples with lugol - 5 minutes

Calibration of ACs instrument - 60 min

Day 2:

eDNA & FISH

Lecture on FISH + first part of the FISH protocol – 2 h

DNA extraction: 2-3 h/ student

PCR active: 20 min/ student, PCR passive: 4:30 h

Assessing Microplastics in the Atlantic Ocean

Microplastic sampling (continuous sampling, filtration time depending on the matrix)

Phytoplankton communities’ distribution along the Atlantic

Calibration of ACs instrument - 60 min

ACs continuous sampling + HPLC filtering (not CTD dependent) every 4 hours for calibration

Day 3:

eDNA & FISH

Potential of FISH (lecture) + second part of the FISH protocol – 4 h

Gel electrophoresis: 1:10 h

Assessing Microplastics in the Atlantic Ocean

Seminar “Microplastic – Does size really matter?” – 30 minutes

Microplastic sampling (continuous sampling, filtration time depending on the matrix)

Phytoplankton communities distribution along the Atlantic

Sampling taking from CTD: surface (10L), 25m (5L), DCM (10L), 100m (5L), 150 m (5L)

Filtration for HPLC - 60 min (2 depths)

Filtration for Coccolithophores - 120 min (5 depths)

Fixing samples with lugol - 5 minutes

Calibration of ACs instrument - 60 min

ACs continuous sampling + HPLC filtering (not CTD dependent) every 4 hours for calibration

Day 4:

eDNA & FISH

Microscopy – 1,5 hours

Assessing Microplastics in the Atlantic Ocean

Microplastic sampling (continuous sampling, filtration time depending on the matrix)

Phytoplankton communities’ distribution along the Atlantic

Calibration of ACs instrument - 60 min

ACs continuous sampling + HPLC filtering (not CTD dependent) every 4 hours for calibration

Day 5:

eDNA & FISH

Data analysis 1,5 hours

Assessing Microplastics in the Atlantic Ocean

Seminar “What happens next? Microplastic analysis” – 30 minutes

Microplastic sampling (continuous sampling, filtration time depending on the matrix)

Phytoplankton communities’ distribution along the Atlantic

Calibration of ACs instrument - 60 min

ACs continuous sampling + HPLC filtering (not CTD dependent) every 4 hours for calibration

Learning Outcomes

eDNA & FISH

- Importance and diveristy of bacteria in the water column
- Sampling planning
- Advantages and risks of both approaches

Microplastics

- Plastic as an environmental contaminant and its potential implications
- Planning microplastic sampling
- Understanding potential contamination risks/sources
- Sampling of microplastic of different size fractions using different filtration approaches

Phytoplankton communities

- Role of phytoplankton communities in the Earth system
- Shifts in phytoplankton biomass and composition along the Atlantic
- Factors driving phytoplankton changes
- Importance of discrete water sample pigment and absorption measurements to develop and validate optical inline methods and (global and regional) algorithms on satellite data

Student reports, evaluations and assessments

Students will be required to submit a report on this module prior to leaving the ship including the general background, aims, methods, results and discussion. Since students will not have the chance to analyse the samples of the subtopics 4.4.2 and 4.4.3 on board, the report will include a detailed outlook on this subtopics instead of a results and discussion section.

4.5 Data Crunching and Statistics

Topic Lead: Mirco Scharfe (AWI) and Clynton Gregory (NUIG

The focus of this module is on the analysis of (long-term) data describing the intra-annual, inter-annual and spatio-temporal variation in the marine environment. Long-term data (observations, modelled data) are of central importance in climate and environmental research for the detection of trends and for identification of drivers of change. Ocean and shelf seas systems are characterized by high natural variability, e.g. strong fluctuations in environmental conditions in successive years. Knowledge about the range of fluctuations of parameters / processes is essential for the assessment of changes. Shifts or change points in the properties of biological, chemical and physical time series or climate indices (e.g. Fig. 1), for example, may be an indicator of persistent or temporary change (`states`) in the related ecosystem (function) or climate system.

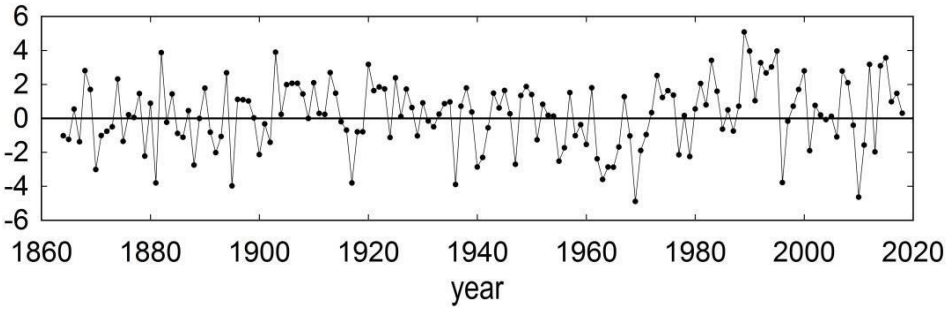

Figure 15: DJFM NAO Index 1864-2018, station based (after Hurrel)

Data source: https://climatedataguide.ucar.edu/climate-data/hurrell-north-atlantic-oscillation-nao-index-station-based

Based on exemplary training data sets with a regional focus on the North Atlantic and North Sea we are investigating characteristics of temporal developments as well as methods for testing on changes in the respective properties of time series (e.g. mean, variance). Knowledge about changes in such properties is also of great importance regarding the general applicability of different statistical procedures (trend tests, comparison of mean values, distribution of values etc.).

Practical applications are made using the R platform of statistical computing. An overview about the extent of R-based analysis tools with a focus on data manipulation and time series analysis is given. Basic steps are represented including the choice and implementation of different analysis packages. The handling of data sets will be demonstrated as well as the use of line-oriented commands Examples are provided including the verification of the particular approach adopted to a specific question.

Learning aim

The goal is to provide basic knowledge about the analysis of marine and climatological time series (data sets) and to increase the awareness regard to the validity of results obtained. The students will be prepared to develop and apply own approaches analysing change in marine systems.

Preliminary schedule

Introduction (lecture I)

- Overview of the North Atlantic system and the North Sea
- Fluctuations - large-scale relationships
- Spatial and temporal variability of drivers
- Exemplary ecosystem responses
- Sources of observational data
- Use of meteo-marine hindcast / forecast simulations

Value of time series (lecture II)

- Time series – what can we learn from them?
- Comparability of time series
- Features of marine and climatological time series
- Quality and validity of data sources

Pre-analysis of time series (lecture III)

- Characteristics of time series
- Homogeneity of time series
- Applicability of statistical methods
- Data transformations
- Decomposition of time series
- Dealing with gaps
- Combinations of observational and modeled data

Techniques (lecture IV)

- Measures of differences and associations between data sets
- Correlations, causality and statistical power
- Reliability (interpretation) of results

Approaches (lecture V)

- Change point analysis
- Frequency analysis
- Trend analysis
- Time series models
- Empirical Orthogonal Functions (EOFs)

Software based analysis (lecture VI)

- Introduction to R
- Installation of packages
- Finding functions – presentation of different packages
- Manipulation of data
- Practical applications

Evaluation

The POGO students have to submit a report on this module. The report will be composed of questions related to lecture content and results of the individual application of R packages to selected questions (submission deadline: end of cruise).

4.6 Knowledge / Technology Transfer and Outreach activities

Topic Lead: Prof. Dr. Eberhard Sauter, Eva Brodte

The outreach activities and group dynamics onboard will be supported by ALL scholars parallel and partly overlapping to the group rotating scheme.

Knowledge / Technology Transfer

The lectures will also deal with the science and society interaction and stakeholder-specific communication, the conversion of money into knowledge and of knowledge into money, respectively; (in)dependence / integrity of science

Outreach activities

Within the outreach activities we will address different audiences, like A) schools (kids and teachers), B) students worldwide and former as well as future potential scholars, C) general public, D) politicians. We aim for increasing the global awareness of climate and ocean issues as well as the capacity development worldwide.

Twitter campaign

The tweeting activities will include a) a general twitter campaign starting with opening of the first call, b) Picture of the day, chosen at meetings after dinner, publish daily with 1 keyword on Twitter and Instagram, starting first day of the cruise and c) post-expedition tweets: follow the ways back home of the scholars. The scholars will be introduced in “official” tweeting protocols. In general, the expedition will be address expedition as #SoNoAT, implementing Atlantos, Nippon and POGO with handles (@) and #NF_PogoCofE

Pre-cruise:

Get in contact with involved schools, a short skype interview, Invitation to the school to prepare cups we will take down to the deep

Post cruise:

Some scholars are invited to give talks about their experience in their home countries and / or to involved schools

From Ocean Experts to Ocean Translators

Part 1 Asked a scientist (continued …) Short clip explaining...

With teams of five (at least two speakers, two filmmaker and cutter, a board to be painted and a lot of ideas) – we will request choose of topic with application and emphasis the will to participate in outreach activities :A Microplastics in the Oceans, B Why should we care about the Oceans, C Weather and climate, D How to get oceanographic data (CTD, etc), E Write your own song and perform it, Part 2: Joined project with four schools: getting classes directly involved

Group dynamics and soft skills

The scholars will be training in problem solving approaches, we have some group dynamic exercises and we will conduct a climate role play.

5. Key Online Resources

Some key online resources are listed below. All participants will also receive an invite to join the course Dropbox which will contain digital copies of some of the references listed below and others. Please note these references are for background and reference material for projects but please do browse through them in advance of the cruise and try to bring a copy on-board for reference. Reference books will be present on-board.

5.1 Climate Systems

- IPCC Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (WG1AR5) Fact Sheet http://www.ipcc.ch/report/ar5/wg1/docs/WG1AR5_FactSheet.pdf
- IPCC Working Group I (WG1AR5) Brochure Http://www.ipcc.ch/report/ar5/wg1/docs/WG1AR5_FAQbrochure_FINAL.pdf

- IPCC Working Group I (WG1AR5) Summary For Policy Makers
  http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_SPM_FINAL.pdf
- IPCC Working Group I (WG1AR5) Technical Summary
  http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_TS_FINAL.pdf
- IPCC Working Group I (WG1AR5) Technical Summary Supplemental
  http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/supplementary/WG1AR5_TSSM_FINAL.pdf

5.2 Oceanography Resources

Announced via email

5.3 Remote Sensing

Introduction to optical ocean remote sensing (C. Mobley, ongoing):
http://www.oceanopticsbook.info/
Focus on chapters “Light and Radiometry” and “Optical Constituents of the Ocean”

IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, free at .https://www.ipcc.ch/report/ar5/wg1/ . Suggested chapters Observations: Atmosphere and Surface Chapter 2, OBSERVATIONS: Ocean : Chapter 3, OBSERVATIONS Clouds and Aerosols: Chapter 7

Interactions between Mineral Dust, Climate, and Ocean Ecosystems by Santiago Gassó Vicki H. Grassian Ron L. Miller. https://doi.org/10.2113/gselements.6.4.247, https://www.researchgate.net/publication/260631578_Interactions_between_Mineral_Dust_Climate_and_Ocean_Ecosystems

Harnessing remote sensing to address critical science questions on ocean-atmosphere interactions. Neukermans, G., Harmel, T., Galí, M., Rudorff, N., Chowdhary, J., Dubovik, O., Hostetler, C., Hu, Y., Jamet, C., Knobelspiesse, K., Lehahn, Y., Litvinov, P., Sayer, A.M., Ward, B., Boss, E., Koren, I. and Miller, L.A., 2018.. Elem Sci Anth, 6(1), p.71. DOI: http://doi.org/10.1525/elementa.331 , free at

Surface ocean-lower atmosphere study: Scientific synthesis and contribution to Earth system science Brévière, E.et al.(2015) Anthropocene, 11, http://dx.doi.org/10.1016/j.ancene.2015.11.001 or http://www.solas-int.org/files/solas-int/content/downloads/Resources/Breviere%20et%20al.%202015.pdf

Ocean-Atmosphere Interactions of Gases and Particles by P. S. Liss et al. , free online book https://link.springer.com/book/10.1007/978-3-642-25643-1

5.4 Organisms and micro plastics

5.5 General Websites

- Intergovernmental Panel on Climate Change Reports
  http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml
- Pangea online repository for numerical data containing a wealth of biological, chemical and physical data sources (including data roughly along our route)
  http://pangaea.de

- Global ocean data assimilation experiment: https://www.godae.org
- NOAA Ocean Education Resources http://oceanservice.noaa.gov/education/kits/currents/lessons/currents_tutorial.pdf
- Encyclopaedia of Earth http://www.eoearth.org/view/article/154990
- Global Carbon Project http://www.globalcarbonproject.org/carbonbudget/15/presentation.htm

6. Software for Pre-installation

Participants should bring their own laptops if possible with the following software pre-loaded. If you have any problems procuring, a laptop please just let us know and we can provide you with one. If you have any problems loading the software we will have technicians present at the introductory Punta Areanas.

6.1 Software for Oceanography

- Ocean Data View (ODV) is a free oceanographic data exploration and visualisation package. To download to your laptop please log in at http://odv.awi.de. You will need to register to create an account from where you can proceed to download the latest version of ODV. 24
- SBE Data Processing is used for processing water column data from CTD casts: http://www.seabird.com/software/SBEDataProcforWindows.htm. Then go to "download from FTP site" which bring you here: ftp://ftp.halcyon.com/pub/seabird/OUT/SeasoftV2/SBEDataProcessing/ Pick: SBEdataprocessing_win32_v7_23_2.exe

6.2 Software for Remote Sensing of Oceans & Atmosphere

Additional information will be sent separately. Please download and install:

- SNAP
  - … is a mighty satellite data visualisation and calculation tool
  - http://step.esa.int/main/download/
  - Please download the "Sentinel Tool Box" (SMOS not necessary) for your operating system (OS): Windows, Linux or Mac
- Anaconda
  - … is a collection of Python packages that are usually used by scientists
  - https://www.anaconda.com/download/
  - Please download Anaconda 3.7 for your OS
- PyCharm
  - … is a program that supports displaying and programming Python
  - https://www.jetbrains.com/pycharm/download/
  - Please download the "Community" version for your OS
- HySplit model
  - … is a model to simulate aerosol transport in the atmosphere
  - https://ready.arl.noaa.gov/HYSPLIT.php

6.3. Software for Outreach acitivites

If you have smart phone please download the following App

- Stop motion studio (free version)
- Any video and audio app you like

7. Assessment for SoNoAT 2019

Reports for modules

See separate modules description.

Cruise Report

Students will divide themselves up into discipline specific working groups (WG) based on their preferred area of interest. Teams will work-up and interpret data collected and write a short report on each section.

8. Meetings & Presentations

On-board cruise meetings will be held every evening after dinner. These will include weather reports from the RV Polarstern's resident meteorologist, updates as to our position and the schedule for the following day.

Please note that all participants will give a short PowerPoint presentation on themselves and their current research topic. Presentations are limited to 10 minutes. If you are also taking samples on the cruise for your own personnel research please also include details. Presentations will be scheduled for the evening after dinner.

9. Instructor Biographies

Prof Karen Wiltshire

Karen Wiltshire is the Vice-Director of Alfred Wegener Institute for Polar and Marine Research and Head of Biological Station Helgoland and Wadden Sea Station Sylt. She is also a Professor of Marine Geosciences at Jacobs University Bremen and AWI Head of PACES TOPIC “COASTS”. Prof. Wiltshire is also the chair of Partnership for Observation of the Global Ocean (POGO) and coordinates the NF-POGO Centre of Excellence in Oceanography, Helgoland.

Prof. Wiltshire gained her Doctor of Philosophy from the University of Hamburg, and held positions at the Institute of Chemistry, Geethacht; the Gatty Marine Laboratory, University of St. Andrews; the Max Planck Institute of Limnology, Germany; and the University of Kiel before joining the Alfred Wegener Institute for Polar and Marine Research. Some of her main interests are research questions related to phytoplankton pigment physiology, and the factors determining species composition and long-term changes in phytoplankton at a regional scale. A study on the links between bacterial succession and succession of their algal substrates which she co-authored was published in Science.

Prof Peter Lemke

Peter Lemke studied physics in Berlin and Hamburg. He received his PhD in 1980 and his Habilitation in 1988 in meteorology from the University of Hamburg, when he was employed at the Max-Planck-Institute for Meteorology. After two years as a PostDoc at Princeton University he was a professor at the University of Bremen and the University of Kiel. Since February 2001 he is a Professor of Physics of Atmosphere and Ocean at the University of Bremen. At the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven he was the head of the Climate Sciences Research Division until his retirement at the end of September 2014. He continues to work on the observation of climate processes in atmosphere, sea ice and ocean and their simulation in numerical models for the polar components of the climate system. Since 2009 he is the head of the Climate-Initiative REKLIM (Regional Climate Change) of the Helmholtz Association (HGF), in which nine centres of the HGF and nine universities are collaborating. Peter Lemke has participated in nine polar expeditions with the German research icebreaker “Polarstern”. On six expeditions he acted as chief scientist.

In 1991 he received the German Polar Meteorology Award (Georgi-Preis) and in 2005 he became an Honourable Professor of the China Meteorological Administration, Beijing. In 2010 he received the Bayer Climate Award. In 2013 he was appointed as Member of the German Advisory Council on Global Change.

Since more than 30 years he served on many national and international committees on polar and climate research. From 1995 to 2006 he was a member of the Joint Scientific Committee

for the World Climate Research Programme and served as its chair from 2000 to 2006. He was the Coordinating Lead Author for Chapter 4 (Observations: Changes in Snow, Ice and Frozen Ground) of the IPCC Fourth Assessment Report published in 2007. IPCC was awarded the Nobel Peace Prize together with Al Gore in 2007. For the Fifth Assessment Report of the IPCC published in 2013 Lemke worked as Review Editor of Chapter 4 and as Lead Author of the Technical Summary.

Dr Eva Brodte

Eva studied biology and geography at the Universities Düsseldorf and Bremen and received her PhD in Marine Biology from the University of Bremen. She gained wide experience in different fields of marine science with a focus on ecology and physiology of fish, benthic invertebrates and zooplankton, as well as anthropogenic impacts on marine environments (environmental impact assessments) and habitat mapping. At the Leibniz Institute for Baltic Sea Research, Warnemünde and the University of Rostock Eva Brodte coordinated a joint interdisciplinary project on the Services of Sediments in the Baltic Sea (SECOS) in the frame of the German Coastal Research Agenda. Currently she is the responsible coordinator for the guest science programme at the AWI-BAH and AWI-Sylt and the scientific coordinator of the NF-POGO Centre of Excellence.

Kristine Carstens

Kristine Carstens is an experienced technical assistant, responsible for quality management and measuring nutrients, salinity and pigments for the long term data series Helgoland Roads and transects. Since her employment in 2002, she also set up the FerryBoxes and is continuously developing them further.

Prof. Peter Croot, NUI Galway

Peter Croot is a Marine Biogeochemist and is established Professor of Earth and Ocean Sciences at NUI Galway, Ireland. Peter's work is centered on the biogeochemical cycling of elements in natural waters, and his main research focus is on the underlying role of chemical speciation and kinetics on key processes in the aquatic environment. In particular he is interested in the mineral-water interactions that occur when aerosols (continental dust, volcanic ash) are deposited to the ocean surface, and how this impacts phytoplankton production and ocean chemistry. His research typically combines small scale laboratory and field observations coupled with satellite observations over larger temporal and spatial scales to gain insight on all aspects of these phenomena.

Peter completed his PhD studies in the chemistry department at the University of Otago (Dunedin, New Zealand). This was followed by post-doctoral studies at WHOI (USA), Gothenburg University (Sweden) and at the NIOZ (Netherlands) with faculty positions at IFM-GEOMAR (Germany) and PML (United Kingdom) before coming to Galway in 2012. Peter has published over 90 peer-reviewed papers and has extensive sea-going experience in 15 major oceanographic expeditions (>600 days at sea), including 4 iron enrichment experiments, ranging from the Southern Ocean/Antarctica to the Tropical Pacific and Atlantic.

 **Jan El Kassar**

Jan El Kassar studied meteorology at the Freie Universität Berlin (FUB) and received his Bachelor and Master degree there. During his semester as an Erasmus student in Bergen, Norway, he got invested in the remote sensing of oceans and poles and started working on ocean color and sun-induced chlorophyll fluorescence retrieved with the MERIS instrument aboard ESA's satellite ENVISAT. Since spring 2018 he is a PhD student at the Institute of Space Sciences (WeW). While still conducting research on polar phytoplankton dynamics and physiology his main focus now lies on the retrieval of total columnar water vapor over land in the visible and near-infrared spectrum with MERIS and its successors OLCI on Sentinel 3a and b.

 **Santiago Gasso**

Dr. Santiago Gassó works as a research scientist at the NASA's Goddard Space Flight Center and the University of Maryland. He has more than 15 years of experience working in observational studies of aerosols, clouds and their interactions using a combination of satellite detectors. As part of the science team of NASA's OMI, MODIS and VIIRS satellite sensors, he has contributed to the development and analysis of the algorithms used by these instruments to detect atmospheric aerosols. In addition to these operational oriented activities, he carries out independent research in a number of subjects. They include dust impacts in marine biology, aerosol transport at high latitudes and volcano effects on clouds. He developed expertise on observations of aerosol generation and transport processes in high latitudes with focus in South America. He has been a collaborator and Co-I in internationally funded projects to survey and monitor dust activity in Patagonia and Alaska. He made and published the first dedicated satellite and modeling studies of dust activity in Patagonia and Alaska. During 2014-2017, he was part of the High Latitude Dust and Cold Environment Network (www.hlccd.org), a working group supported by The Leverhulme Trust (UK). More recently he joined the Science Steering Committee of the Surface-Ocean Low Atmosphere Study (SOLAS), a Future Earth sponsored international program dedicated to the promotion of interdisciplinary initiatives involving atmosphere-ocean aerosol exchanges. Also, he developed an interest in studying volcanoes through a discovery he made in 2006. He found that low levels volcanic activity (non-explosive passive degassing activity VEI<2) can be detected in cloudy conditions by studying the change

in properties in nearby water clouds. The discovery provides an excellent opportunity for studying aerosol-cloud interactions as well as provides a way to detect volcanic activity in cloudy conditions. Santiago Gassó, Ph: (301)614-6244; ESSIC-UMD/NASA

 **Mara Gomez**

Master student of Marine Sciences at Faculty of Science of University of Lisbon and a research fellow at the Marine and Environmental Science Centre (MARE-ULisboa). Started the academic path in University of Aveiro in Portugal, where she did a Marine Science Bachelor and focused her final project on physical oceanography linking hydrodynamics with sediment transport. Her master thesis is focused on complementary tools for aquaculture management, namely remote sensing and in situ data for Sines region (Portugal). Currently makes part of PiscisMOD Project where she is responsible for sampling, processing and analysing collected samples for environmental monitoring of water quality in the vicinity of aquaculture units in Sines. Her interests focus on phytoplankton dynamics, ocean colour remote sensing and water quality assessment for aquaculture management.

Clynton Gregory

I am a Marine Scientist at NUI Galway, Ireland, focusing on oceanography and biogeochemistry. My research ranges from the influences of submarine groundwater and its effects on Phytoplankton community structures, bloom rates and Harmful algal blooms to deep sea physical and chemical processes and shelf circulation and its controls on harmful algal blooms. My interests however extend to all aspects of marine science from deep sea oceanography to near shore coastal estuarine systems.

 **Anneke Heins**

Anneke finished her studies in 2016 at the University of Oldenburg with a Master of Science (Biology) and a Master of Education (Biology and Art). She focused on the marine environment and gained field experience during campaigns in Egypt, Turkey and a semester abroad in Kalmar, Sweden. During her Bachelor thesis she analyzed and described the nematocysts and reproduction mechanisms of the upside-down jellyfish Cassiopea andromeda and published the results in 2015. In her Master thesis she described the statolith development of Sanderia malayensis, utilizing micro-computed tomography, scanning electron microscopy, calcein staining, energy-dispersive X-ray spectroscopy, and 3D image reconstruction. After presenting the results at the 5th International Jellyfish Bloom Symposium in Barcelona she published them in 2018. Both theses were realized in cooperation with scientists from the Senckenberg

Institute in Hamburg, where Anneke continued working as a scientific assistant after graduation. Currently she is employed as a PhD student at the Max Planck Institute for Marine Microbiology. Aspects of her topic include isolation and cultivation of heterotrophic bacteria, DNA extraction and sequencing, as well as catalyzed reporter deposition-fluorescence in situ hybridization (CARD-FISH) and genome assembly and annotation.

 **Therese Keck**

Therese started to study meteorology and physics in Karlsruhe, Germany, and continued her studies at Freie Universität Berlin in Berlin. She worked as a student assistant at Institute for Space Sciences and satellite remote sensing of the earth quickly became the focus of her interest: Therese wrote her bachelor's thesis about influence of aerosols on modelled radiation vector and her master's thesis about different snow states and how to retrieve them from remotely sensed emissivity. During her PhD years, Therese worked in the field of ocean colour and radiation transport modelling and gained experience in optical water measurements. In 2015 and and 2016, she participated the Polarstern Floating School PS95 and PS102 and taught "Remote Sensing". Currently, she is employed at Pandata GmbH in Berlin.

 **Inga Kirstein**

Inga studied in the Bachelor and Master programme "Water Science: Chemistry, Analytics, Microbiology" at the University Duisburg-Essen, Germany. In parallel to her studies, she joined as a student assistant the group of Aquatic Biotechnology, in the Biofilm Centre and the group of Organic Functional Materials of the Faculty of Physics. Using an interdisciplinary approach combining physics, analytical and microbiological tools, Inga worked on scalable photobioreactors for algae for her bachelor's thesis and on the nutrition optimization of thermophilic and halophilic cyanobacteria for her master's thesis. Inga then moved to Helgoland to conduct her PhD project "It`s all about the base - Marine biofilms in the plastic age". There, she developed strong skills in experimentation with microbial marine biofilms colonizing plastics, working with analytical and molecular biological tools. In 2014, she contributed to a two-weeks research cruise on the RV Heincke in the North Sea to collect microplastic samples. Currently, Inga is employed as a scientist at the University Aalborg, Denmark and works on the quantification and qualification of microplastics in marine and drinking waters.

 **Dr. Sandi Orlic**

PhD University of Zagreb; Postdocs: KU Leuven (Belgium) and Cavanilles Institute for Biodiversity and Evolutionary Biology (Spain); current affiliation: Ruđer Bošković Institute

Zagreb Croatia; field of interests: microbial ecology of aquatic ecosystems; 35 international per reviewed articles; leader or collaborator on national and international projects; participated as a co-organizer of the summer school of the Max Planck Institute for Marine Microbiology, held in Rovinj (2013) on molecular methods (Marine molecular microbial ecology) and was the President of the Organising Committee of the 15th Symposium of Aquatic Microbial Ecology (SAME 15) in Zagreb (Croatia). Till now have led 2 PhD students and 3 in course. In 2015 was elected as an Associated Faculty Member International Max Planck Research School of Marine Microbiology; since 2015 is representative of Republic of Croatia in the JPI «Healthy and Productive Seas and Oceans» Management Board (EU);
Cruise time: 17.12.2015-28.01.2016. R/V Sonne UltraPac Expedition; scientist, cheif scientist T.Ferdelman MPI, Bremen.

 **Prof. Dr. Eberhard J. Sauter**

Since 2008 Eberhard heads the Technology Transfer Office of the Alfred Wegener Institute for Polar and Marine Research (AWI) in Bremerhaven, Germany. With a background in multidisciplinary deep-sea and polar research, including numerous seagoing expeditions in polar and coastal regions with focus on the exchange of matter between seafloor and water column, he came to knowledge and technology transfer via own contributions to underwater technology development. Today he works at the interface between science and industry, catalyzing the introduction of innovative, environmentally compatible technologies and services. One of his main interests is the balance between usage and conservation of marine and polar systems. Eberhard is Honorary Professor for Marine Technologies at the University of Applied Sciences Bremerhaven.

 **Dr. Mirco Scharfe**

Environmental Scientist (Postdoc) at the Alfred-Wegener Institute. He has a PhD from the University of Hamburg (2013). Employment: 1998-2000: Hydraulic engineering office Dr.-Ing. Gebler, Karlsruhe; 2001-2003 and 2007-2011: Helmholtz Zentrum Geesthacht, Institute for Coastal Research; 2012 to date: Alfred-Wegener Institute. Research interests: Hydro-climatic conditions of the North Sea system; Long-term variation of phytoplankton and hydro-chemical conditions in coastal seas; Experience in time series analysis and the assessment of parameter interactions using statistical/modelling approaches.