Science Briefing for eXXpedition Round Britain 2017

Projects as of 8/3/2017: 1 - 11

1. **Observations of Plastic Pollution at Sea.**

Materials: ice chests, air bubblers, 3 brass sieves, squirt bottles, plastic pipettes, large petri dishes, tweezers, toothbrushes, magnifying glasses, labels, large and small glass jars, scintillation vials (white caps), alcohol, scotch tape, permanent marker, bucket, large aluminum roasting trays (for sorting), dissecting microscope (optional), camera, tablet or phone for MDT, datasheets

Protocols:(A) 5 Gyres (modified) Manta Trawl Sampling for Plastic;
(B**)** Marine Debris Tracker (MDT) http://www.marinedebris.engr.uga.edu/

Background: The UN Environment Program has declared that marine plastic debris is a global problem on par with climate change. One challenge is the urgent need to fill data gaps in our understanding of the sources, types, distribution, fate, and effects of marine plastics. Citizen scientists can contribute to the understanding of the distribution of plastics through visual identification of macroplastics i.e. material > 5 mm, and microplastics i.e.> 1 mm < 5 mm (top and middle sieves).
Objective: to quantify macro- micro-plastic on the sea surface along the U.K coast.
Methods: We will use two methods for collecting macro- and micro-plastic data. The first method uses a sea surface Manta trawl (see protocol 'A') that guest crew will deploy daily to collect small pieces of plastic. Rigging and training for the trawl will take place on board Sea Dragon (SD). The second method uses visual observations and the MDT app to record floating debris. Details on methods are described in the protocols. It is recommended that there are 1 or 2 devices (tablet, phone, computer) with the MDT app on them available to guest crew members at all times.
Results: Data collected and input to the MDT app will be automatically uplinked, mapped and publicly available. Data collected from the trawl will be sent to 5 Gyres and included in publicly available databases. Note that we will add the trawl data at a later time when the final full counts have been made using various methods. Scientists studying patterns of distribution and sources of plastic debris will use these data in various analyses.

Duties of on-board guest crew scientists (hereafter, crew scientists) (2): The crew scientists will be responsible for assuring that the MDT app is downloaded on a couple of guest crew devices and that these are readily available for use throughout each leg of the trip. They will teach the crew how to use the MDT app and continuously encourage them to make

observations. They will make crew assignments during the trawl to prepare for trawl plastic collection, processing of samples, on-board or on-shore analysis of samples both visually and possibly by microscope (note that there is a dissecting microscope on board SD and that it has a video camera which can also take still photos as well as project to the flat screen in the salon; you may need Diana's assistance to hook up), preservation of samples, and storage of materials and supplies when not sampling. They are also responsible for assuring that the data from plastic collection is recorded in datasheets and photographed (both plastic bits and datasheets as backup copy). It could be tricky to keep track of the plastic bits coming from specific sieves in specific trawls with multiple trawls and processing of samples spanning days and involving lots of hands. You will need to figure out a strategy that works for you. There will be two ice chests to put up to two trawl contents in remove most of the living material immediately. If going to hold trawl sample over, use the air bubblers and add a little fresh sea water periodically; try and not keep unprocessed longer than 48 hrs, shorter if starts to smell. Photographs need to be sent to the mission scientist (D Papoulias) at the end of each voyage leg.

1a. **Microplastic Analysis of Samples (< 1 mm, ≥ 0.333 mm)**

Principal Investigator: Winnie Courtene-Jones, Scottish Association for Marine Science (SAMS). She will analyze the bottom sieve material from trawl samples. Please see specific notes in Protocol A

Winnie Courtene-Jones (Winnie-courtene-jones@sams.ac.uk) joined the Scottish Association for Marine Science (SAMS) in 2015 to commence a PhD researching microplastic pollution in the deep sea ecosystem. Her research interest focuses on the transport, long-term fate and sequestration of marine plastics, specifically microplastics, in the environment. Winnie says: I am so excited to be involved with the work of eXXpedition and the round-UK mission. Being based on the west coast of Scotland, the Scottish leg of the trip is particularly pertinent to me and I will be analyzing samples from the smallest (1 - 0.333 mm) size fraction of microplastics collected. From these data I wish to assess the relative abundances of microplastics in close proximity to 'urbanised' areas (Clyde Sea, Inverness, Edinburgh) and see how these concentrations relate to less populated areas (outer Hebrides, north coast of Scotland). Additionally, microplastics will be analysed by Fourier transformation infrared (FT-IR) spectroscopy which enables the determination of the polymer types floating in the sea surface. This work will be linked to the underlying hydrodynamic ocean processes which may distribute microplastics geographically.

Duties of crew scientists are to ensure collection of bottom sieve material into glass jars, be sure that the jar contents contains alcohol to prevent growth, jars are labelled correctly and stored safely.

1b. **Microplastic Analysis of Samples (> 1 mm)**

Principal Investigator: Dr. Mark Hartl, Heriot-Watt University, https://www.hw.ac.uk/schools/energy-geoscience-infrastructure-society/staff-directory/mark-g-j-hartl.htm He will analyze the top and middle sieve material from trawl samples. Please see specific notes in Protocol A. Working with Winnie, he intends to analyse the size fractions to describe the distributions of different sizes and polymers.

2. **Plastic Nurdle Collection for "The Great Nurdle Hunt"** **http://www.nurdlehunt.org.uk/**
Contact: Madeleine.Berg@fidra.org.uk

Materials: zip-loc plastic bags, permanent felt marker, tweezers, magnifying glass, datasheet, camera, scotch tape.
Protocols: (see below)

Background: Nurdles are small plastic pellets about the size of a lentil. Countless billion are used each year to make nearly all our plastic products but many end up washing up on shores. Spills and mishandling by industry can mean nurdles end up at sea. Our planet's oceans are now accumulating nurdles in worryingly large numbers. New nurdles are washing up on Scottish shores but there is little information on where they are coming from or how widespread the problem is. Findings from The Great Nurdle Hunt will help FIDRA show the local plastics industry the extent of the nurdle pollution on our shores.
Objective: Quantify nurdles in Manta trawl samples and on beach cleans during the eXXpedition Round Britain voyage and provide samples and data to FIDRA as part of their program.
Methods: Nurdles are hard to spot! They are very small (3 – 5 mm diameter) and most are clear or white but they become yellow over time. Occasionally you find coloured pellets. Use tweezers to remove the nurdles from the Manta trawl or beach sample. Count then store nurdles in a labeled Ziploc bag. Take a picture of the bag with its label (Date, GPS location, trawl number or beach sample, number of nurdles) and showing nurdle contents. It is important to be able to cross-reference the bag with, the trawl number to be able to provide travel speed, time trawling, wind direction and sea conditions. Remember to also include the nurdle counts in the total count of plastic retrieved in the trawl sample.

Various nurdle types

Results: Your findings are really important to FIDRA as they have very little off-shore information. They are collecting evidence to show the local plastics industry the extent of the pollution. FIDRA will map the location of the nurdles you collect and upload the information you provide to their website.

At the end of a voyage leg, crew scientists will be responsible for providing the labeled bags of nurdles to on-board Mission Lead Sue Weaver and sending the photographs to Mission Scientist.

3. ‘Nano’-Plastic Sampling

Materials: hand pump and tubing with check valve installed on inlet end, scissors, permanent marker, masking tape, distilled water, polycarbonate 0.6 micron pore 47 mm diam., labels, scotch tape, vacuum pump, filtering apparatus, aluminum foil, Ziploc bag, tweezers, datasheet, blue nitrile gloves
Protocols: (C) Filter sampling instructions
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Objective: Characterize and quantify ‘nano’-plastic particles operationally defined as < 0.333 mm, in the sea off the UK coast to understand the distribution and fate of plastic in our oceans**.**
Methods: See Protocol C for details on methods. Generally, water will be pumped through a filter that will collect the micron and sub-micron sized particles. The filters will be sent to two different laboratories for analysis of numbers, and polymer composition and comparison of methodology.
Results: Testing of filtration device for collecting microplastic particles < 0.333 mm, characterization of these particles in coastal surface waters, and comparison of two different methods FT-IR Raman and scanning electron microscopy for characterizing these particles.

Crew scientists should ensure that filters are properly labelled, well-wrapped in aluminum foil, you can keep the two separately wrapped filters together with masking tape, then put all in zip locs for the trip. Store in refrigerator.

3a. Use of Scanning Electron Spectroscopy to Count and Characterize ‘Nano’ Plastic

Principal Investigator: Mario Meier, Particle-Vision

Mario is co-founder of a small start-up called “Particle Vision” (www.particle-vision.ch) and designated CEO of an enterprise called FUB (www.fub-ag.ch; unfortunately the English versions of the sites aren’t really updated). Both companies are doing environmental monitoring. Among others, a main topic for them is air pollution (mainly aerosol particles). To fulfil the needs of their customers they developed methods for analyzing particles with light and scanning electron microscopy. They are interested in determining if their methods could work for particle pollution in water (including micro-plastic) as well. They are able to characterize particles morphologically and chemically with sizes from 0.1 µm to 100 µm automatically. One topic of interest they might investigate is pollution due to tyre wear. They know quite well the morphological and chemical fingerprint of tyre wear and it is likely that we will find such particles in aquatic environments. They would like to know if their methodology using scanning electron microscopy can be applied to measuring microplastic pollution.

3b. Scientist for second analysis to be determined.

4. **Body Burden Analysis – Mercury**

Principal Investigator: Oksana Lane, Biodiversity Research Institute, Portland, ME USA
http://www.briloon.org/about-us/bri-staff/science-directors/oksana-lane-m-s

Materials: Paper envelopes, 1 per sample. 1 large manila envelope to contain everything. Masking tape to wrap around hair. Scissors. Waiver forms. Hair Mercury Datasheet, nitrile gloves for collector, alcohol to clean scissors.
Protocols: (D) Hair Collection for Mercury Analysis

Background: We are all exposed to mercury from multiple sources: food, power plants, mine waste, hydrocarbon exploration and burning, dental fillings, personal care products, medical equipment, vaccines, etc. There are 3 principal forms of mercury but organic methyl mercury is the most toxic. As a neurotoxic chemical methyl mercury has been associated with effects on cognition, movement, and behavior. Children are especially vulnerable and can be exposed through maternal transfer of the chemical to the fetus. Methyl mercury is principally formed biologically by organisms that convert or methylate elemental mercury. The major source of methyl mercury for humans and top predators is through the aquatic food chain. For humans this means fish consumption. In the body, mercury partitions into various tissues: blood, organs, hair, nails, etc. The body excretes inorganic mercury in urine, but methylated mercury tends to be the principal form found in hair. The hair samples collected on this expedition will be measured for total mercury (a much simpler, cheaper analysis than that of methyl mercury) but because the majority of this total mercury (inorganic + methyl + elemental) is in the methyl form, it is an excellent indicator of methyl mercury in our body.
Objective: Provide a unique opportunity for guest crew to know how much mercury is in their bodies, in order to facilitate their understanding and communication about sources contaminated with mercury, exposure to and effects of mercury on humans, fish and wildlife.
Methods: The guest crew scientist or her designee will organize hair collection. Hair will be collected voluntarily from guest crew on board. Samples may also be collected from individuals from coastal communities during the expedition (limit the number to max. of 10 per community). A waiver will need to be signed by each participant. Information to be collected with the sample includes: gender, age, residence & travel in the last year (where you may have been exposed), and amount of fish consumed (i.e. servings per month). Standard protocol for the collection of human hair samples is to be followed to obtain the highest quality samples.
Results: Oksana will analyze these samples as time and resources permit (this is a courtesy analysis). It may take several months before the sample analysis is completed. Your results will be emailed to you along with summary and explanatory information. Oksana will also use these results in her general analysis of trends in mercury contamination and to identify possible hot spots of mercury contamination. Individuals will use the information to inform their health decisions and communicate about environmental mercury contamination. See folder **eXXpedition Science Results 2014 – 2016** for summarized data from past voyages.

The crew scientists of each voyage leg are responsible for ensuring that the hair samples are collected along with the waivers and the necessary dietary and travel information and that the entire package is delivered to a Mission Lead Sue Weaver.

5. **iNaturalist Observations**

Principal Investigator: Tegan Mortimer

iNaturalist allows people who are out exploring nature to add their georeferenced images of fish and wildlife to a database, almost like a biodiversity "scavenger hunt. http://www.inaturalist.org/people/exxpeditiongirls is the site where eXXpedition has begun a collection of observations of marine life and birds from previous voyages and will continue with the Round Britain voyage. All participants are encouraged to log/provide their geo-referenced sightings/photos of fish and wildlife to Tegan who will input them to iNaturalist.

6. Identification of the Species Colonizing Microplastic

Principal Investigator: Bonnie L. Brown, PhD., Professor and Interim Chair, Dept. Biology, Virginia Commonwealth University, USA
http://bonnie-brown-vcuegl.squarespace.com

Materials: DNA/RNA lysis tubes, DNA/RNA shield, distilled water, Instant Ocean, squirt bottle, clean rinsed forceps (aka tweezers), labels, scotch tape, blue nitrile gloves, datasheet
Protocols: (E) Procedure for Collection and Preservation of Genomics Samples

Background: Metagenomics uses DNA extracted from the organisms in a sample to obtain the taxonomic composition of a complex environmental sample and it also can tell us about the functional potential of those organisms. Also using RNA, instead of just DNA, a metatranscriptome could tell us the actual function as opposed to functional potential.
Objective: Metagenomic analysis of the oceanic plastisphere will define the taxa that comprise plastic-attached communities. Taxonomic identification is necessary to define the microecosystems that exist on marine plastics, which in turn allows us to estimate the potential larger ecosystem effects of plastic particles.
Method: Using whole genome (a.k.a. shotgun) sequencing, we expect to identify polyzoa, protists, chlorophytes, cyanobacteria, heterotrophic bacteria, archaea, pathogens, and other organisms attached to the plastic particles.
Results: Metagenomic analysis will allow us to identify the potential for transport of harmful algal blooms (HABs) among trophic zones (benthic HABs have been found on floating plastic). Sequence reads will reflect microbial function and metabolic pathways that the communities express (xenobiotic biodegradation, chemotaxis, light harvesting) and allow us to estimate effect on oceanic biogeochemical cycling (nitrogen fixation, denitrification, phosphate metabolism, iron transport). Genes detected will predict the degree to which plastics serve as a collector of pathogens (e.g., Vibrio) and allow us to estimate xenobiotic degradation, virulence, and pathogenicity. Lastly, metagenomic analysis will provide part of the data needed to estimate the potential for synergistic toxic effects on organisms that consume the particles (ingestion of both virulent organisms and the leaching of hazardous chemicals such as PBDEs).

Good references for the application of metagenomic analysis to understand the marine plastisphere:
http://msystems.asm.org/content/1/3/e00024-16
http://pubs.acs.org/doi/abs/10.1021/es401288x
http://onlinelibrary.wiley.com/doi/10.1111/1574-6941.12409/abstract
http://onlinelibrary.wiley.com/doi/10.1111/1574-6941.12408/abstract

Crew scientists must ensure proper and careful collection of samples, labelling of vials, and storage in freezer. I would suggest that after a trawl you collect 5 – 10 pieces of plastic immediately for this work. Count the pieces and note on datasheet. The remainder of the trawl can be sorted by crew or on-shore with citizens. BE CAREFUL NOT TO CONTAMINATE WITH YOUR DNA! KNOW AND UNDERSTAND PROTOCOL VERY WELL.

7. Analysis of sub-tidal sediments in harbours for Microplastic

Principal Investigator: Richard Thompson, PhD and Megan Ross

Materials: mini Van veen grab sampler, labels, permanent marker, aluminum foil, small aluminum trays, blue nitrile gloves, camera, wear cotton/wool clothing, masking tape, datasheet

Protocols: (see below)

Background: Microplastics are ubiquitous in coastal sediments. Quantities may range from 2 to 30 particles per 250 ml of sediment. The original sources for the microplastic are not well understood because of complex transport mechanisms and unknown fragmentation rates (Law and Thompson, 2014). A key objective is to establish hot spots of contamination. Here we will focus on harbours which seem likely places of accumulation because they are sheltered facilitating sedimentation, they have high human usage and are often associated with heavy loadings of larger debris.

Objective: to quantify microplastics in harbor sediments at select locations around the UK to describe contrasting conditions of microplastic contamination.

Methods: We will target collection of sediments while stationary in harbours. Sediment will be collected with a hand operated grab lowered to the sea bed. The grab will be rinsed in water and checked to ensure it is clean prior to sampling. Those undertaking the sampling will wear cotton clothing and be positioned downwind of the sampling activity. Five replicate samples will be collected from the same general location in each harbour. Each replicate sample will be of at least 50 mL of sediment. Allow the water to drain from the sampler then sample will be stored in airtight clean sampling vessels (small glass jars; if there are not enough use the larger ones) and will be transferred and sealed in these as soon as the samples are collected. The containers must be clearly labelled, see the datasheet. A photo of the location should be taken and unique details of the photo also recorded on the datasheet.

Samples will be returned to Plymouth University for microplastic analysis after the voyage is competed.

Results: The results gathered from this survey will provide preliminary data on the distribution and abundance of microplastic in UK harbor sediments.

Crew scientists will be initially trained by Megan Ross on how to deploy the sampler. You will be responsible for making sure the sampler is NOT LOST (eXXpedition will have to replace it and it is expensive, so follow the guidelines you will be provided to ensure a safety rope is attached etc.), that it is cleaned well before and after use, the samples are well labeled (you can write directly on the tin foil 'lids' (easier before you cover the tray; but also put a label inside the tray as an extra precaution), and stored safely and properly. You will need to figure a way to keep track of the photos that accompany the samples!

8. Analysis of Coastal Waters for PFOS and PFOA

Principal Investigator: Rakesh Kanda, PhD, Brunel University, London
www.brunel.ac.uk/people/rakesh-kanda

Materials: Stainless steel bucket or pump, high density polyethylene (HDPE) bottles with HDPE lined caps, permanent markers, DO NOT WEAR GLOVES, datasheet
Protocols: (see below)

Background: Perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) are a subset of the polyfluorinated alkanes (PFC) group of chemicals used for applications such as surface treatment and as waterproofing agents. These compounds are highly persistent and bioaccumulative and exposure to them has been linked to several health concerns including endocrine disruption effects, harm to the immune system and liver toxicity. In December 2002, PFOS was classified as persistent, bioaccumulative and toxic (PBT) by the OECD. Consequently the European Parliament placed a restriction on marketing and use of PFOS and its salts and Environmental Quality Standards of inland and other surface waters and in biota were set. A number of studies have shown exceedances in River's across Europe. There are limited data on levels of these compounds in coastal waters.
Objective: to measure PFOS concentrations in UK estuary/coastal waters.
Methods: Sampling will be carried out to avoid contamination during sampling. Sample can only be collected in specific containers of high density polyethylene (HDPE) material to avoid sorption of PFOS/PFOA to the container. Sample caps must have HDPE liners. PTFE sampling devices must be avoided. Fill stainless steel bucket (give it one very good rinse with seawater) directly with water by lowering over the edge of ship. DO NOT RINSE THE BOTTLES PROVIDED BY KANDA LAB. Label bottles with permanent marker thus: eXX RB17, date, time, GPS position and site (i.e., coast between x port and y port, or if in a harbor the name of the harbor). Store in a cool safe place out of sunlight. In the Kanda laboratory, samples will be extracted following addition of labelled (PFOS and PFOA) international standards using solid phase extraction. The SPE cartridges will be eluted using solvent and analyzed using liquid chromatography-tandem mass spectrometry (LC-MS/MS). For LC-MS/MS identification 1 precursor ion and 2 daughter ions are monitored.
Results: The data collected by eXXpedition will be used to monitor the temporal trends of PFOS concentrations as a result of actions following implementation of the Stockholm Convention in estuary/coastal waters.

Crew science leads are responsible for making sure bottles are properly labelled and stored. Please tell Mission Leader Sue Weaver where bottles are stored at end of Leg.

9. Analysis of microplastic in the digestive system of mussels

Principal Investigator: Jeanette Rotchell, PhD. University of Hull
https://www.researchgate.net/profile/Jeanette_Rotchell/publications

Materials: small plastic boxes – be sure there are lots of big holes in lids, nitrile gloves, datasheet, permanent marker

Protocols: (see below); NOTE: no permit is needed to collect mussels for personal use; Dr. Rotchell is in possession of a permit from her University to handle and kill mussels in her laboratory a copy of this permit is in the binder that Diane Reid will have on-board which contains all permissions.

Background: The aim of this project is to examine the extent and impacts of microplastic contamination in the marine mollusc *Mytilus edulis* and is part of larger studies that are being conducted in Dr. Rotchell's laboratory.

Methods: This will be investigated by collecting mussels from wild populations for chemical analyses to detect microplastic particles in their digestive tracts. In each harbor 20 live mussels should be collected along with some seaweed and put into a labelled plastic box (date, gps location, harbor name). Put boxes in the refrigerator lid needs holes until shipment to the Rotchell laboratory which we would like to do in batches at a couple of ports along the way. Live mussels will be delivered to Dr. Rotchell's laboratory where mussels will be sacrificed with a lethal dose of MS222 in order to dissect the gut which will be placed in preservative. Microplastic particles will be removed from the gut, counted and described under a microscope.

Results: The work aims to provide important baseline information on microplastic presence in tissues in a commercially important species. The work will be of relevance to shellfisheries industry and UK regulatory authorities such as CEFAS/DEFRA/EA.

Co-PI: Christopher Green, PhD Brunel University, **London (http://www.brunel.ac.uk/people/christopher-green)** will collaborate with Jeanette to identify the type of plastic found in the digestive tracts using FT-IR Raman.

Crew scientists are responsible for ensuring that the mussels are collected, boxes are properly labelled, and stored in refrigerator. You will periodically ship the boxes to the Rotchell laboratory using the company TNT using her account number which crew member Lynne Braham has.

10. Measuring Potential Airborne Microplastics

Principal Investigator: Stephanie Wright, PhD. research fellow at King's College, London https://kclpure.kcl.ac.uk/portal/en/persons/stephanie-wright(06e7b1c7-2725-4437-96bf-dabc12b00e1b).html

Materials: sampling data sheet, sampling calendar**,** SKC DPS System (pump, charging unit and plug, tubing, sampling head, PM10 inlet, stainless steel mesh filter support, rain cover, mounting bracket), stainless steel forceps, 47 mm and 37 mm pre-weighed PFTE filters and their corresponding pre-labelled petri dishes (for sample storage). aluminum foil, blue nitrile gloves, labels, scotch tape, permanent marker, plastic Ziploc bag.
Protocols: see Protocol G: Measuring Potential Airborne Microplastic

Background: Microplastics are a recognized marine pollutant, but they may also be in the air. For example, sea surface microplastics may become airborne during wave breaks or windy episodes. Microplastics on a beach may be wind-transported in the same way as dust and sand. This is important for human health, as we breathe air. Thus, inhalation may present a direct exposure route to this potentially harmful contaminant.
Methods: A portable particulate monitoring system will be used to sample particulate matter (PM) ≤10 µm aerodynamic diameter. This system pumps air through an inlet at 10 L/min. The 'unwanted' size fraction is retained on 37 mm PFTE filters, whilst the PM10 size fraction is retained on 47 mm PFTE filters. The system should be secured on the front of the boat (e.g. on the bow sprit) out of the way but easily accessible for daily maintenance. Blank reference samples will need to be collected periodically throughout the trip..
Results: The plastic will be counted and identified using FT-IR Raman spectroscopy. This study will provide information about air-borne microplastic in areas where people are working along the coast of the UK. Currently, very little information is available.

Crew scientists are responsible for ensuring that the air collector is secured at the front of the boat (see instructions), that the container does not get wet or is dried out if it does, the monitor's batteries will need to be recharged nightly and filter removed, labelled with date and stored in original box. Tell Mission Scientist Sue Weaver where samples are stored.

11. Measuring Plankton Abundance and Microplastics

Principal Investigator: The Sir Alister Hardy Foundation for Ocean Science (SAHFOS; https://www.sahfos.ac.uk/) and Richard Thompson, PhD.

Materials: all provided by SAHOS including CPR (Continuous Plankton Recorder), filters, color chart, Secchi disc, dilute ethanol, datasheets, scotch tape, permanent marker
Protocols: (F) CPR and Secchi Disc Methods

Background: SAHFOS is an internationally funded independent research non-profit organisation responsible for the operation of the Continuous Plankton Recorder (CPR) Survey. As a large-scale global survey, it provides the scientific and policy communities with a basin-wide and long-term measure of the ecological health of marine plankton. Established in 1931, the CPR Survey is the longest running, most geographically extensive marine ecological survey in the world. It has a considerable database of marine plankton and associated metadata that is used by researchers and policy makers to examine strategically important science pillars such as climate change, human health, fisheries, biodiversity, pathogens, invasive species, ocean acidification and natural capital.

Our focus on the ocean plankton is important. Plankton sustains life on this planet by producing almost half the oxygen we breathe; it is the planet's second lung. From a socio-economic context, it has been estimated that the annual gross marine product (GMP), akin to a country's gross domestic product (GDP) is approximately US$2.5 trillion which would rank the ocean as the world's 7th largest economy. Much of that economy is driven by the plankton, without which the earth would be warmer, breathless, more acidic and devoid of charismatic megafauna; a global recession would be certain. The CPR Survey is of global importance in progressing our understanding of natural variability and human-induced changes in our oceans. It is used by scientists, policy makers and environmental managers across the world. Over the last eight decades the purpose of the survey has co-evolved with changing environmental policy, from purely monitoring plankton distributions to addressing and providing indicators for major marine management issues, ranging from fisheries, harmful algal blooms, biodiversity, pollution, eutrophication, ocean acidification and climate warming.

Results: Never has the impact of SAHFOS' science been so relevant. There are significant challenges ahead for the planet if we are to achieve the goals set out in the recent, and historic, international agreement at COP21, namely to keep global warming below 2°C. SAHFOS monitors the pulse of the oceans through the plankton and contributes to the significant scientific effort that advises political decisions on a global scale.

Crew scientists are responsible for being trained by Megan Ross on the proper use of the instruments and collection of the plankton density and secchi data, and preservation and storage of the samples.