National Oceanography Centre
Cruise Report No. 62
M.Y. Angra Pequena

30 June – 9 July 2019

Pemba Channel (Tanzania)

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DOCUMENT DATA SHEET

AUTHOR	*PUBLICATION DATE*
PAINTER, S. et al.	2019

TITLE
M.Y. *Angra Pequena*, 30 June – 9 July 2019. Pemba Channel (Tanzania)

REFERENCE
Southampton, UK: National Oceanography Centre, Southampton, 46pp. (National Oceanography Centre Cruise Report, No. 62)

ABSTRACT

Sustainable Oceans, Livelihoods and food Security Through Increased Capacity in Ecosystem research in the Western Indian Ocean (SOLSTICE-WIO) is a Global Challenges Research Fund (GCRF) project. As part of its work in Tanzania an oceanographic survey of the Pemba Channel was undertaken in June 2019 during the early stages of the South East monsoon. The survey combined traditional hydrographic measurements with plankton and biogeochemical observations at 40 stations throughout the channel to obtain updated information on the local oceanography and pelagic ecology within the wider project objective of understanding environmental controls on the small pelagic fishery of these waters. The fishery is a major source of protein for local communities and faces numerous threats to its longevity with inadequate environmental information widely perceived to be detrimental to fisheries management decision making. The cruise focussed upon a limited suite of measurements pertinent to upper ocean biogeochemical characterisation and successfully completed sampling at all stations. The resulting dataset is believed to be among the most detailed datasets collected to date from these waters.

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Preface

Data presented in this Cruise Report are provisional and should not be used or reproduced without permission. Further details can be obtained from the originators (see Scientific Reports) and in due course the full data set will be lodged with the British Oceanographic Data Centre (www.bodc.ac.uk).

ACKNOWLEDGMENTS

Working in the coastal waters of Tanzania proved to be a highly enjoyable and memorable experience and would not have been possible without the involvement and support of several highly determined individuals. We are particularly grateful to Sofia Alexiou (NOC, U.K.) for the herculean effort of managing the complex logistics associated with this fieldwork, to Dr. Jean Harris and Wild Oceans (http://wildtrust.co.za/wildoceans/) for being willing to bring the M.Y. *Angra Pequena* into Tanzanian waters and we thank the Master and crew of the M.Y. *Angra Pequena* for their excellent assistance and consistent good humour throughout the cruise.

This cruise was conducted as part of the Sustainable Oceans, Livelihoods and food Security Through Increased Capacity in Ecosystem research in the Western Indian Ocean (SOLSTICE-WIO) programme (www.solstice-wio.org), a four-year collaborative project funded through the UK Global Challenges Research Fund (GCRF) under NERC grant NE/P021050/1.

M.Y. *Angra Pequena*

Science party and crew of the M.Y. Angra Pequena

Backrow (left to right): Salome Shayo, Angelina Michael, Faizel Baker, Darwood Van Wyk, Cobus Smit.
Middle row (left to right): Kevin Van Rensburg, Nicky Faro, Afrika Masuku, Margaux Noyon, Stuart Painter, Jean Harris, Louis Wilmot
Front row (left to right): Sofia Alexiou, Mtumwa Mwadini, Baraka Sekadende, Brian Godfrey, Ally Said Moh'd, Sanele Dlamini.

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PAINTER, Stuart (Principal Scientist)	National Oceanography Centre, U.K.
SEKADENDE, Baraka	Tanzanian Fisheries Research Institute
SHAYO, Salome	Tanzanian Fisheries Research Institute
MOHAMEED, Ally Said (Observer)	Zanzibar Maritime Authority

SHIP'S PERSONNEL

WILMOT, Louis,	Master
SMIT, Cobus	1st Mate
MASUKU, Afrika	2nd Mate
BAKER, Faizel	Chief Engineer
FARO, Nicky	2rd Engineer
DLAMINI, Sanele	3nd Engineer
VAN RENSBURG, Kevin	Foredeck
VAN WYK, Darwood	Chef

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ABSTRACT

Sustainable Oceans, Livelihoods and food Security Through Increased Capacity in Ecosystem research in the Western Indian Ocean (SOLSTICE-WIO) is a Global Challenges Research Fund (GCRF) project. As part of its work in Tanzania an oceanographic survey of the Pemba Channel was undertaken in June 2019 during the early stages of the South East monsoon. The survey combined traditional hydrographic measurements with plankton and biogeochemical observations at 40 stations throughout the channel to obtain updated information on the local oceanography and pelagic ecology within the wider project objective of understanding environmental controls on the small pelagic fishery of these waters. The fishery is a major source of protein for local communities and faces numerous threats to its longevity with inadequate environmental information widely perceived to be detrimental to fisheries management decision making. The cruise focussed upon a limited suite of measurements pertinent to upper ocean biogeochemical characterisation and successfully completed sampling at all stations. The resulting dataset is believed to be among the most detailed datasets collected to date from these waters.

1. INTRODUCTION

SOLSTICE-WIO is a UK GCRF funded project that combines traditional research with capacity development and research impact activities. It operates across three case studies located in Kenya, South Africa and Tanzania, with each case study focused upon a different, and nationally significant, aspect of fisheries food security. As part of the Tanzanian case study a short research cruise was undertaken within the Pemba Channel, a deep-water channel separating the island of Pemba from mainland Tanzania (**Figure 1**), to obtain updated or baseline observations of the hydrography and ecology of the region as a step towards understanding the susceptibility of the local small pelagic fishery to environmental fluctuations. Previous research efforts in the region have typically been limited to the shallow water areas around Unguja (Zanzibar) and Mafia Islands or on the narrow continental shelf near Dar es Salaam, with the deeper slope and off shelf waters sampled only within the context of larger international research projects such as the South African led African Coelacanth Ecosystem Programme (ACEP) or the Norwegian Nansen programme. The Western Indian Ocean in general, and much of coastal East Africa in particular remains poorly sampled. SOLSTICE-WIO thus provided an opportunity for collaborative research in this data sparse region with scientists from the Tanzanian Fisheries Research Institute (TAFIRI; Dar es Salaam), the Institute of Marine Science (IMS; Unguja), Nelson Mandela University (NMU; South Africa) and the National Oceanography Centre (NOC; UK) combining efforts to study these waters.

The Zanzibar archipelago (~5-7°S, 39.5°E) consists largely of the semi-autonomous islands of Unguja and Pemba which lie off the coast of Tanzania in the tropical waters of the Western Indian Ocean. Unguja Island is separated from the mainland by the shallow (~40 m deep) Zanzibar Channel whilst Pemba Island is separated by the deep water (~800 m) Pemba Channel that is believed to have separated Pemba Island from mainland Tanzania since the Miocene (~15 Ma). The regional circulation of this part of the Western Indian Ocean is strongly influenced by both the seasonality of the Indian monsoon and the East African Coastal Current (EACC). The EACC flows northwards along the coastline of Tanzania year-round with the core of the EACC lying seaward (i.e. east) of the Zanzibar archipelago. During the Southeast monsoon (SEM), which runs from May to October, the EACC is accelerated by strong south easterly winds reaching speeds of 1.5-2 m s^{-1}. Whilst the EACC core and the majority of its associated transport lies offshore, a limb of the EACC is known to pass through the Pemba Channel bringing waters from the equatorial Indian ocean close to the Tanzanian coast. Scant information exists about local hydrographic and biogeochemical changes or even parameter distributions during the SEM but deep surface mixed layers and nutrient poor waters are widely reported and largely based on data that can be several decades old.

The objectives for the cruise were to map the large-scale gradients in hydrography, chlorophyll, inorganic nutrient and particulate concentrations, phytoplankton and zooplankton distributions.

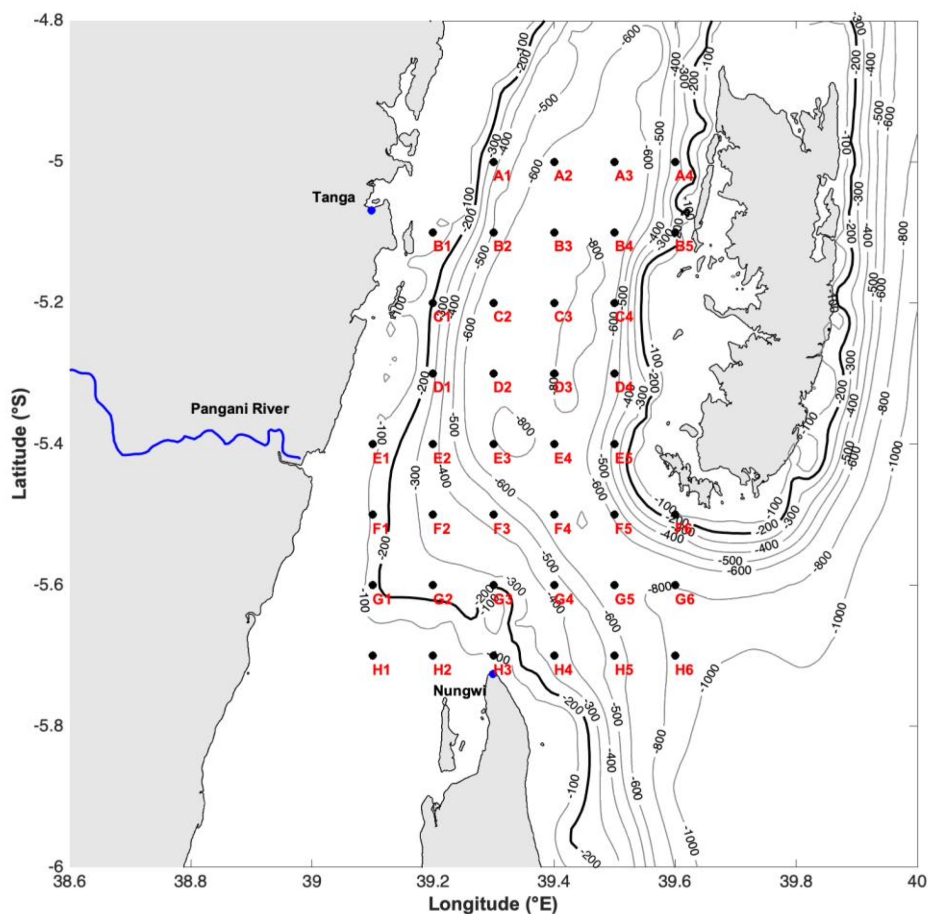

Figure 1: Map showing the cruise work area and position of CTD stations (red dots). The thick black line represents the 200 m bathymetric contour.

2. CRUISE NARRATIVE

PSO's Diary

Saturday June 29th (Day 180)

Mobilisation of the R.V. *Angra Pequena* began with the arrival of the science party throughout the morning and the setup of equipment. As weather conditions were good and setup was quick we departed Stonetown harbour late in the afternoon to begin the ~10 hour transit to the most northerly transect and first station (A1) for a planned 7 am arrival.

Sunday June 30th (Day 181)

The first day of science and as expected we encountered a few difficulties with the deployment of the CTD and the zooplankton bongo nets. Much of the first day was wisely spent learning how best to work from the *Angra Pequena* and how to safely work with the Palfinger crane and winch. A decision to swap the steel cable on the winch for a Dyneema rope was made that both allowed for faster operation of the winch but also extended the depth of sampling from 400 m to over 500 m (current speed permitting). Two stations (**A1** and **A2**) were successfully completed with CTD profiles, water collection, and vertical and oblique bongo net hauls. Adjustment to the movement of the vessel incapacitated most of the science party throughout the first day.

Monday July 1st (Day 182)
After a peaceful night, the science party was fit to proceed and 4 stations were completed throughout the day. We arrived at station **A3** around 08:00 and commenced CTD profiling, net hauls and water collection before moving on to station **A4**. At station A4 a technical hitch with the closure of Niskin bottles meant a second repeat profile was required, which was successful. We then proceeded south to line B and station **B5** (~13:30) before moving west to station **B4**. Science activities were halted after this station due to the need to safely navigate to a safe anchorage site off the coast of Pemba in daylight hours.

Tuesday July 2nd (Day 183)
Overnight we discussed the best approach for completing the survey and decided that a nominal 7am start each day would provide the most time each day for science. Sunrise was around 06:30 and sunset around 18:30, providing a nominal 12 hours working day but time to find safe anchorage was also factored into this daylight window.

We arrived at station **B3** for 7am, and commenced work. After completion we steamed westwards to station **B2** and then **B1**, where all work was completed without incident. We completed transect B by ~13:30 and moved south to Transect C and stations **C1** and **C2**. As several of the westernmost stations were in shallower waters they were completed quickly. We steamed eastwards back to Pemba for anchorage overnight.

Wednesday July 3rd (Day 184)
We began the day at station **C4** completing the station by 08:55. Very strong currents were experienced along the eastern side of Pemba Channel which lost us time as the ship repositioned after each activity back to the nominal sampling position for each station. The strong currents also meant that the maximum sampling depth of the CTD and of the bongo nets varied considerably between stations. Extra ballast was added to the CTD frame to compensate. We proceed to station **C3** arriving ~10:00. After this station we proceeded southwest to station **D1** and **D2**, before heading back to Pemba where we steamed slowly up and down the coast overnight.

Thursday July 4th (Day 185)
Today we arranged for Danny Gill (NOC) to join us to acquire photo and video footage for the SOLSTICE MOOC. Danny was transferred to the *Angra Pequena* by the glider team who were operating out of Mkoani and using the boat *Huntress* for their activities. Weather conditions were not ideal and a large swell made conditions difficult but we proceeded to station **D4** arriving ~09:15 and thereafter commenced our routine sampling with the CTD, bongo nets and water collection. The glider team were also operating very close to this station so this will be a particularly interesting point of comparison later on. We moved on to station **D3** arriving ~11:30 before heading back to station **E5** thus allowing an early finish and the retransfer of Danny back to Pemba Island via the glider team.

Friday July 5th (Day 186)
Weather conditions improved overnight and the swell had largely dissipated. We began the day (07:00) at station **E4** which was completed without incident by 08:30. We proceeded to complete Transect E reaching station **E1** at ~13:00, before heading south to station **F1**, which was completed by ~15:00. Safe anchorage for the night was identified on the western side of Pemba Channel.

Saturday July 6th (Day 187)
A busy day today. We started the day at station **F2** and headed east to complete Transect F and station **F6** by ~16:00.

Sunday July 7th (Day 188)
Weather conditions continued to improve as we now entered the most challenging section of the survey. The waters between Unguja and Pemba Islands can be particularly rough and therefore unworkable as they are exposed to the open Indian Ocean and to interaction of the

EACC with local bathymetry. This region is locally notorious given the loss of several vessels including the inter-island ferry in 2011 and prior to the cruise our chances of working here were often the focus of much discussion. Fortunately, weather conditions were excellent so we pushed ahead to complete the easternmost stations of Transects G and H. We began at station **H6**, then moved northwards with the current to station **G6**. At station **G5** two CTD casts were undertaken to allow collection of water from depths deeper than the standard bottle firing depths we were using. We finished the day at station **H5** before anchoring off a small island to the east of Unguja.

Monday July 8th (Day 189)

Today we sampled stations at the northern tip of Unguja. The Nungwi region is particularly prone to bad seas as the bathymetry rises sharply but we found very favourable conditions. We started at station **H4** moved northwards to station **G4** before reaching station **G3** at 10:45. On the transit from G3 to H3 we undertook some additional CTD profiles (no water collection) as this region has been unsuccessfully sampled in previous years by larger vessels than the *Angra Pequena*. The water depth shoaled very quickly on the transit south from station G3 towards station **H3** such that the nominal position of station H3 was deemed to be too shallow to sample safely and the station was moved approximately 800 m northwards to maintain a minimum water depth of 50m. Despite the good weather a large swell was encountered suggestion a bathymetric influence. We finished the day at station **H2** before anchoring overnight off Nungwi.

Tuesday July 9th (Day 190)

The final day of science and we were left with 3 shallow stations to complete. We began the day at station **G2**, quickly moved to **G1** and completed the survey at station **H1** before heading back to Stonetown arriving ~15:00. Upon arrival some of the science party immediately disembarked.

Wednesday July 10th (Day191)

Final demobilisation of the R.V. *Angra Pequena* occurred around midday once permission to enter the port of Stonetown was secured from the Port Authorities. The remaining science party disembarked.

3. SCIENTIFIC REPORTS

CTD Operations – *Brian Godfrey, Mtumwa Mwadini*

A Seabird 19+ CTD system coupled to a stainless steel SBE55 rosette sampler fitted with 6 x 6L niskin bottles was provided by NMU for the cruise. The rosette system was further equipped with PAR (Satlantic), turbidity (WET Labs ECO-NTU), chlorophyll fluorescence (WET Labs ECO-AFL/FL) and dissolved oxygen (SBE43) sensors with niskin bottle closure controlled via an autofire module, which automatically closed bottles based on pre-determined depths (pressures). As we did not have real time data visualisation during the cruise and as our primary motivation was upper ocean biogeochemical parameters we sampled at standard depths of 150, 100, 75, 50, 25 and 5 m.

Standard depths were adjusted only at stations where the bottom depth was less than 150 m. A total of 44 CTD casts were completed during the cruise (**Table 1**) and the CTD system worked reliably with only minimal complications. Data processing was not possible at sea and will be undertaken after the cruise.

Station	Cast (No)	Date	Day of Year	Time LOCAL (GMT+3)	Time GMT	Decimal Latitude [˚S]	Decimal Longitude [˚E]
A1	2	30/06/2019	181	10:07	07:07	4.9993	39.2991
A2	3	30/06/2019	181	15:03	12:03	4.9926	39.4023
A3	4	01/07/2019	182	08:33	05:33	4.9976	39.5049
A4	6	01/07/2019	182	11:00	08:00	4.9999	39.5978
A4(02)	7	01/07/2019	182	12:01	09:01	4.9990	39.5997
B5	8	01/07/2019	182	13:30	10:30	5.0988	39.6050
B4	9	01/07/2019	182	15:40	12:40	5.0840	39.5030
B3	10	02/07/2019	183	07:26	04:26	5.0904	39.4001
B2	11	02/07/2019	183	09:39	06:39	5.1013	39.2996
B1	13	02/07/2019	183	12:07	09:07	5.1026	39.1993
C1	14	02/07/2019	183	14:04	11:04	5.1994	39.1917
C2	15	02/07/2019	183	16:32	13:32	5.1946	39.2979
C4	16	03/07/2019	184	07:41	04:41	5.1925	39.5046
C3	17	03/07/2019	184	10:09	07:09	5.2042	39.3950
D1	18	03/07/2019	184	13:33	10:33	5.3042	39.2001
D2	20	03/07/2019	184	15:17	12:17	5.2961	39.2976
D4	21	04/07/2019	185	09:27	06:27	5.2994	39.4992
D3	22	04/07/2019	185	11:49	08:49	5.3014	39.3979
E5	23	04/07/2019	185	15:07	12:07	5.3962	39.4992
E4	24	05/07/2019	186	07:25	04:25	5.3994	39.4016
E3	25	05/07/2019	186	09:36	06:36	5.4056	39.3019
E2	26	05/07/2019	186	11:19	08:19	5.4032	39.1996
E1	27	05/07/2019	186	13:14	10:14	5.4022	39.1016
F1	28	05/07/2019	186	14:34	11:34	5.5031	39.1003
F2	29	06/07/2019	187	07:09	04:09	5.5027	39.2011
F3	30	06/07/2019	187	08:45	05:45	5.5061	39.3012
F4	31	06/07/2019	187	10:52	07:52	5.5004	39.4059
F5	32	06/07/2019	187	13:06	10:06	5.5057	39.5022

F6	33	06/07/2019	187	15:06	12:06	5.4997	39.5981
H6	34	07/07/2019	188	07:25	04:25	5.6912	39.5968
G6	35	07/07/2019	188	09:20	06:20	5.6045	39.6016
G5	36	07/07/2019	188	11:31	08:31	5.6001	39.4994
G5 (02_deep)	37	07/07/2019	188	13:09	10:09	5.5960	39.4522
H5	38	07/07/2019	188	14:57	11:57	5.7054	39.5012
H4	39	08/07/2019	189	07:20	04:20	5.7023	39.3983
G4	40	08/07/2019	189	09:02	06:02	5.6011	39.4021
G3	41	08/07/2019	189	10:51	07:51	5.6001	39.3012
G3N	43	08/07/2019	189	12:28	09:28	5.6337	39.2998
G3S	44	08/07/2019	189	13:11	10:11	5.6644	39.3017
H3	46	08/07/2019	189	13:40	10:40	5.6952	39.3000
H3(2)	47	08/07/2019	189	14:01	11:01	5.6939	39.3007
H2	48	08/07/2019	189	15:19	12:19	5.6984	39.1990
G2	49	09/07/2019	190	07:40	04:40	5.6021	39.1988
G1	50	09/07/2019	190	09:15	06:15	5.6025	39.0991
H1	51	09/07/2019	190	10:37	07:37	5.7028	39.0992

Table 1: Final position of stations / CTD casts.

Salinity Sampling – Brian Godfrey, Mtumwa Mwadini

A total of 46 salinity samples were collected for sensor calibration purposes throughout the cruise. These will be analysed as soon as possible after return to NOC.

Station	CTD cast	Niskin	Depth	Salinity Bottle
B5	8	1	150	695
		3	75	696
B4	9	1	150	697
		3	75	698
B3	10	1	150	699
		3	75	700
B2	11	1	150	701
		3	75	702
B1	13	1	150	703
		3	75	704
C1	14	1	150	705
		3	75	706
C2	15	1	150	707
		3	75	708
C4	16	1	150	709
		3	75	710
D1	18	1	150	711
		3	75	712
D2	20	1	150	713
		3	75	714
D3	22	1	150	692
		3	75	715
E4	24	1	150	716
		3	75	717
E2	26	1	150	718
		3	75	719
F1	28	1	125	720
		3	75	721
F3	30	1	150	722
		3	75	723
F5	32	1	150	724
		3	75	725
G6	35	1	150	726
		3	75	727
G5 (02)	37	1	400	728
		2	350	729
		3	300	730
		4	210	731
		5	160	732
		6	75	733
G2	49	1	150	734
		3	75	735

G1	50	1	75	736
		3	35	737
H1	51	2	50	738
		4	25	739

Table 2: List of salinity bottle samples

CTD Data Processing – *Stuart Painter*

CTD data processing was not possible during the cruise and was addressed afterwards. Data was processed via the bespoke CTD data processing system ‘Mexec’ which is a set of Matlab and shell scripts developed by scientists at the National Oceanography Centre. Mexec is a system for processing, quality control and calibration of CTD data and is based entirely around NetCDF file formats.

SeaBird Data Processing

SeaBird Data Processing was restricted to four stages for compatibility with other cruises using mexec. As the CTD system used during this cruise (SBE 19+) contained an auto-fire module (AFM) some minor changes to constants and/or coefficients were required compared to the typical processing undertaken for a SBE 911+ CTD system.

Data Conversion – This was run with the hysteresis correction for oxygen and ensuring conductivity was in units of mS/cm (n.b. The hysteresis correction can also be handled directly in mexec in the script mctd_02b.m – see below. If this option is followed then it is essential that the hysteresis correction is not applied here).

Align CTD – using a value of 5 sec (as advised by Seabird) to advance oxygen and temperature relative to P.

WildEdit – Pass 1 (2 s.d., 500 scans), Pass 2 (10 s.d. 500 scans)

Cell Thermal Mass - using standard SeaBird recommendations for 19+ systems of alpha=0.04 and 1/beta=8.0 for the single primary conductivity channel.

Translate - Convert from binary to ascii format.

At this point all data files were transferred to Mexec.

Mexec processing

To begin, a set of ascii template files were created containing a full list of all variables and their units required in the final CTD and bottle data files. These template files are used to generate blank mexec NetCDF files and it is important that the names of variables and their units are consistently adhered to across different file types. For consistency with the mexec requirements a cruise number of AP06 was created (to signify *Angra Pequena* June cruise). These template files were created based on previous cruises and initially included

sam_AP06_varlist.csv A list of variables coincident with sampling stops on the up cast (e.g. temp, salinity, nitrate, alkalinity etc). This was modified to include bottle chlorophyll measurements and additional nutrients (e.g. NO_2^-)

ctd_AP06_renamelist.csv A list of all variables in the CTD profile data streams

dcs_AP06_varlist.csv A list of variables related to sampling times, positions etc

After creation of the template files the following processing scripts were run. Note that many of the processing scripts were modified to suit the requirements of this cruise. For instance, there was no navigation NMEA data stream against which to cross reference for positions etc and winch information was not recorded. The CTD data processing thus followed a minimalistic approach.

ctd_all_part1_solstice.m: This is a batch script which calls the following mexec routines

msam_01_solstice.m: which creates an empty sample file of name sam_AP06_NNN.nc based on the template file sam_AP06_varlist.csv.
(Input : sam_AP06_varlist.csv; Output : sam_AP06_NNN.nc)

mctd_01_solstice.m: reads in and converts raw 4Hz SBE19 data (in ascii format) into netcdf format. A workaround routine to add the station position to the file header was implemented in this script due to the lack of a navigation file to cross reference against.
(Input : 24Hz SeaBird data; Output : ctd_AP06_NNN_raw.nc)

mctd_02a_solstice.m: renames some variables in the raw input file.
(Input : ctd_AP06_NNN_raw.nc; Output : ctd_AP06_NNN_raw.nc)

mctd_02b_solstice.m: This script can replicate and apply the oxygen hysteresis correction that can also be implemented in the seabird software. The user must choose whether to include or omit the hysteresis correction. For AP06 the oxygen hysteresis correction was applied in the seabird software and omitted in the script mctd_02b_solstice.m.
(Input : ctd_AP06_NNN_raw.nc; Output : ctd_AP06_NNN_24hz.nc)

mctd_03_solstice.m: averages the 24Hz data to 1Hz and calculates derived variables (e.g. salinity, potential temperature etc)
(input : ctd_AP06_NNN_24hz.nc; Output : ctd_AP06_NNN_1hz.nc
ctd_AP06_NNN_psal.nc)

mdcs_01.m: creates an empty file based on template file (dcs_AP06_varlist.csv) which will later hold info on start and end of up and down casts
(Input : dcs_AP06_varlist.csv; Output : dcs_AP06_NNN.nc)

mdcs_02.m: Identifies the deepest datapoint in a CTD profile and adds this information (time, scan number) to the dcs file
(Input : dcs_AP06_NNN.nc; Output : dcs_AP06_NNN.nc)

At this point the user must manually obtain the first and last good data points in each CTD profile. This is done via

mdcs_03g_solstice.m: which is a graphical interface that allows the user to choose the first and last good points of data in the downcast and upcast respectively. After both points have been identified the scan numbers are saved to the dcs file. Generally, the first good data point is the shallowest data point after the CTD has soaked and all pumps are on, and the last good data point is the last data point for which there is good oxygen, salinity, temperature and conductivity data. The SBE19+ CTD system used on this cruise is a pumped system and the

start and stop points were selected based on the shallowest depth after an initial soaking or on the last available good oxygen measurement.
(Input : ctd_AP06_NNN_psal.nc; Output : dcs_AP06_NNN.nc)

ctd_all_part2_solstice.m: A second batch script which calls a variety of mexec routines including

mctd_04_solstice.m: extracts downcast data using information in dcs file and averages to 2db intervals
(Input : ctd_AP06_NNN_psal.nc; Output : ctd_AP06_NNN_2db.nc)

mdcs_04_solstice.m: This script should add the positions of profile start, bottom and end points from the navigation file into the dcs file. As there was no navigation file for this cruise this script was modified to read in and use a table of start, bottom and end positions recorded by the bridge duringthe cruise.
(Input : dcs_AP06_NNN.nc; Output : dcs_AP06_NNN.nc)

mfir_01.m: create an mexec NetCDF file with info from SeaBird bottle (.bl) files. This script only runs if bottles were closed on the CTD cast. Script omitted for CTD casts 014 and 015 (Stations G3N and G3S) as no bottles were fired on these casts.
(Input : Seabird bottle (.bl) file; Output : fir_AP06_NNN.nc)

mfir_02.m: add time from CTD file to firing information file. Script omitted for CTD casts 014 and 015 (Stations G3N and G3S) as no bottles were fired on these casts.
(Input : : fir_AP06_NNN.nc; Output : fir_AP06_NNN_time.nc)

mfir_03_solstice.m: Locate and extract CTD data from the upcast at bottle firings and paste this into the fir file. Script omitted for CTD casts 014 and 015 (Stations G3N and G3S).
(Input : fir_AP06_NNN_time.nc; Output : fir_AP06_NNN_ctd.nc
ctd_AP06_NNN_psal.nc)

mfir_04_solstice: Paste CTD data from fir file into sample file
(Input : : fir_AP06_NNN_ctd.nc; Output : sam_AP06_NNN.nc)

mctd_rawedit.m: This is a graphical interface which allows you to remove spikes in temperature, conductivity and oxygen. All editing is performed on the raw data files (ctd_AP06_NNN_raw.nc) but a backup is made first (ctd_AP06_NNN_raw_original.nc) and the edited file saved as ctd_AP06_NNN_raw_corrected.nc.
(Input : ctd_AP06_NNN_raw.nc; Output : ctd_AP06_NNN_raw_original.nc
ctd_AP06_NNN_raw_corrected.nc)

Once edits are complete it is necessary to re-run some of the early stages of processing to correct derived variables accordingly. This is done by running the batch script

Smallscript_solstice.m: This batch script reruns

mctd_02b_solstice, mctd_03_solstice, mctd_04_solstice, mfir_03_solstice and mfir_04_solstice to propagate any edits of profile data for data spikes back through all subsequent files. Additionally it was modified to also run
msam_oxykg_02.m which converts CTD oxygen from units of ml/l to µmol/L and µmol/kg. The latter conversion is based on calculation of density using combined sets of sensor data if applicable i.e. upsal1, utemp1, upress and upsal2, utemp2, upress.
(Input: sam_AP06_xxx.nc; Output: sam_AP06_xxx.nc)

and

msam_02.m which calculates the following residuals required for calibration.
botsal – upsal
botsal – upsal1
botsal – upsal2
botoxy (µmol/l) – uoxygen (µmol/L)
botchl – fluor
(Input: sam_AP06_xxx.nc; Output: sam_AP06_xxx_resid.nc)

Bottle sample data
A separate ascii file was created for each CTD cast and for each bottle sample data type (i.e. salinity, nutrients, chlorophyll etc). The format of the ascii file is dependent upon the data type, for example, the salinity file format looks like the standard output file from the salinometer (i.e. a file with the same number of header lines), whilst the nutrient file consists of several columns of data (one for each nutrient) and a data quality flag. Ascii files were created with a common naming convention e.g. sal_AP06_xxx, nut_AP06_xxx and chl_AP06_xxx.

Salinity
msal_01_solstice.m: convert the ascii salinity file into NetCDF and recalculate bottle salinity to account for any instrument offset during the measurement of salinities. If no standards are provided with bottle salinities in the file this routine will ask you for the salinometer bath temperature and whether you want to apply a conductivity ratio offset. In this case the offset was set to zero as bottle salinities were previously calibrated against standard seawater (batch P162) during analysis in the NMF calibration lab. Batch P162 has a recognized conductivity of K=0.99983 in single ratio or 1.99966 in double.
(Input : ascii csv file e.g. sal_AP06_NNN.csv; Output : sal_AP06_NNN.nc)

msal_02.m: paste the bottle salinity data into the relevant sample file
(Input : sal_AP06_NNN.nc; Output : sam_AP06_NNN.nc)

Nutrients
mnut_01_solstice.m: Read in a csv ascii file containing nutrient data and convert to NetCDF. Script was modified from previous version to accommodate additional nutrients.
(Input : ascii csv file e.g. nut_AP06_NNN.csv; Output : nut_AP06_NNN.nc)

mnut_02.m: paste the bottle nutrient data into the relevant sample file
(Input : nut_AP06_NNN.nc; Output : sam_AP06_NNN.nc)

Chlorophyll Fluorescence
mchl_01.m: Read in a csv ascii file and convert to NetCDF.

(Input : ascii csv file e.g. chl_AP06_NNN.csv; Output : chl_AP06_NNN.nc)

mchl_02.m: paste the bottle chlorophyll data into the relevant sample file
(Input : chl_AP06_NNN.nc; Output : sam_AP06_NNN.nc)

Oxygen
No oxygen measurements were made during this cruise.

Conductivity Calibration
A set of residual values were generated by running the script
msam_02.m: This script calculates a series of residual values between bottle samples and CTD sensor measurements to aid the calibration process. The standard version of this script was modified to generate

1) bottle salinity – CTD salinity (Channel 1)
2) bottle Chl – CTD fluorescence

(Input : sam_AP06_NNN.nc; Output : sam_AP06_NNN_resid.nc)

Subsequently it was decided to derive bottle conductivity and the salinity ratio

3) bottle conductivity – CTD conductivity (Channel 1)
4) bottle salinity / CTD salinity (Channel 1)

Residual files were appended together (using mapend.m and a file list samfile_list_resid.txt) to create a single master file. The master file was examined in a series of plots (mplotxy) to identify outlier values in the residual variables (particularly No. 3 above), which were removed from sequential versions of the master file using either mdatpik or mplxyed.

The calibration of the single Seabird conductivity channel to the salinometry results revealed a good agreement. A plot of conductivity difference against station number (i.e. time) revealed no drift with time, indicating the sensors was stable.

SeaBird claim that the correct in-situ calibration for their conductivity sensors is a linear function of conductivity with no offset. Plots of conductivity difference against conductivity added support to this and therefore the calibration coefficient A calculated as

$$conductivity = A*(\ primary\ conductivity)$$

where

$$A = \frac{\sum Cond_{bot} Cond_{ctd}}{\sum (Cond_{ctd})^2} = \frac{\overline{Cond_{bot} Cond_{ctd}}}{\overline{(Cond_{ctd})^2}}$$

Coefficient A was determined to be 0.99999713. Corrected Seabird conductivities were calculated through application of coefficient A to the primary conductivity channel. All derived variables (e.g. salinity, potential temperature etc) were then recalculated.

Residual conductivity differences calculated as bottle conductivity – corrected Seabird conductivity were typically better than ±0.003 mS/cm but some scatter was
present within the data. The mean residual was calculated as 0.00 mS/cm and the standard deviation was 0.008616. Final salinity offsets, derived from calibrated conductivities, are shown in **Figure 2**.

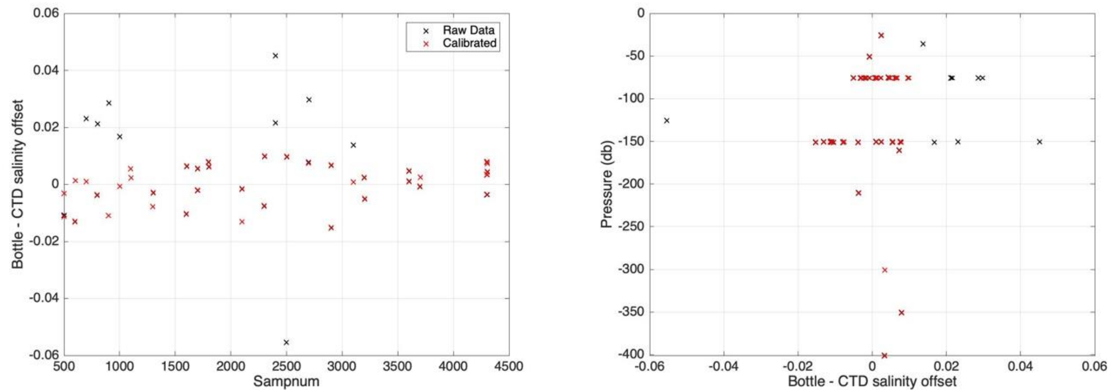

Figure 2: Summary of CTD salinity calibration. Panel a) temporal salinity residuals pre- (black) and post- (red) calibration. Panel b) vertical (pressure) residuals pre- and post-calibration.

Fluorescence Calibration

The linear regression between the WET Labs fluorometer (ECO-AFL/FL; in µg/l) and measurements of bulk chlorophyll-a concentration determined by acetone extraction and fluorometric analysis produced a regression equation of

$$y = 0.9937 * CTDfluor + 0.0971$$

where y = corrected chlorophyll fluorescence concentration (µgl/l).

This calibration equation was acquired after exclusion of a number of outliers, identified either by a large negative residual or by a residual >±0.2 µg/l.

The typical range of post-calibrated residual values (i.e. corrected Wetlabs chlorophyll fluorescence concentration – bottle measurements) was ±0.1 µg/l but the majority of observations were better than ±0.05 µg/l (**Figure 3**). The mean residual after calibration was 0.00 µgl/l with a standard deviation of 0.05 µg/l.

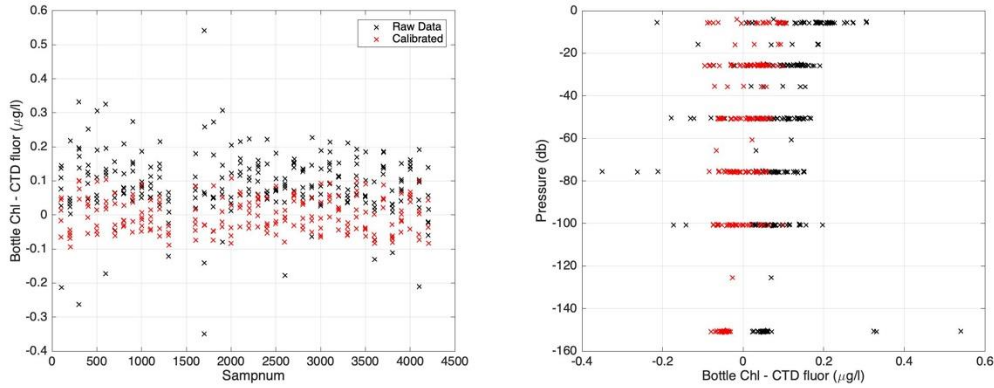

Figure 3: Summary of CTD fluorescence calibration. Panel a) temporal fluorescence residuals pre- (black) and post- (red) calibration. Panel b) vertical (pressure) residuals pre- and post-calibration.

Oxygen Calibration

No oxygen measurements were made during the cruise. At the time of writing it has not been possible to calibrate the dissolved oxygen data from the CTD oxygen sensor beyond the manufacturers calibration. Efforts continue to develop a provisional calibration using dissolved oxygen climatology's.

Final data files

During CTD data processing the raw CTD datafiles were renamed in a sequential manner to aid processing. However, this has resulted in a complicated naming convention which is detailed in **Table 3** below. All final calibrated data files in netcdf or ascii format are named as per the new input file names (e.g. ctd_AP06_xxx) or in the case of bottle sample files sam_AP06_xxx.

CTD Station	Original File Name	New Input File Name	Original File Name	New Input File Name
A1	A1.002.cnv	ctd_AP06_001.cnv	n/a *See note* [1]	ctd_AP06_001.bl
	See note [1]	ctd_AP06_001.ros[1]		
A2	A2.003.cnv	ctd_AP06_002.cnv	A2.003.bl	ctd_AP06_002.bl
	A2.003.ros	ctd_AP06_002.ros		
A3	A3.004.cnv	ctd_AP06_003.cnv	A3.004.bl	ctd_AP06_003.bl
	A3.004.ros	ctd_AP06_003.ros		
A4	A4.2.007.cnv	ctd_AP06_004.cnv	A4.2.007.bl	ctd_AP06_004.bl
	A4.2.007.ros	ctd_AP06_004.ros		
B1	B1.013.cnv	ctd_AP06_005.cnv	B1.013.bl	ctd_AP06_005.bl
	B1.013.ros	ctd_AP06_005.ros		
B2	B2.011.cnv	ctd_AP06_006.cnv	B2.011.bl	ctd_AP06_006.bl
	B2.011.ros	ctd_AP06_006.ros		
B3	B3.010.cnv	ctd_AP06_007.cnv	B3.010.bl	ctd_AP06_007.bl
	B3.010.ros	ctd_AP06_007.ros		
B4	B4.009.cnv	ctd_AP06_008.cnv	B4.009.bl	ctd_AP06_008.bl
	B4.009.ros	ctd_AP06_008.ros		

B5	B5.008.cnv	ctd_AP06_009.cnv	B5.008.bl	ctd_AP06_009.bl
	B5.008.ros	ctd_AP06_009.ros		
C1	C1.014.cnv	ctd_AP06_010.cnv	C1.014.bl	ctd_AP06_010.bl
	C1.014.ros	ctd_AP06_010.ros		
C2	C2.015.cnv	ctd_AP06_011.cnv	C2.015.bl	ctd_AP06_011.bl
	C2.015.ros	ctd_AP06_011.ros		
C3	C3.017.cnv	ctd_AP06_012.cnv	C3.017.bl	ctd_AP06_012.bl
	C3.017.ros	ctd_AP06_012.ros		
C4	C4.016.cnv	ctd_AP06_013.cnv	C4.016.bl	ctd_AP06_013.bl
	C4.016.ros	ctd_AP06_013.ros		
G3N	CTD_043.cnv	ctd_AP06_014.cnv	n/a	n/a
G3S	CTD_044.cnv	ctd_AP06_015.cnv	n/a	n/a
D1	D1.018.cnv	ctd_AP06_016.cnv	D1.018.bl	ctd_AP06_016.bl
	D1.018.ros	ctd_AP06_016.ros		
D2	D2.020.cnv	ctd_AP06_017.cnv	D2.020.bl	ctd_AP06_017.bl
	D2.020.ros	ctd_AP06_017.ros		
D3	D3.022.cnv	ctd_AP06_018.cnv	D3.022.bl	ctd_AP06_018.bl
	D3.022.ros	ctd_AP06_018.ros		
D4	D4.021.cnv	ctd_AP06_019.cnv	D4.021.bl	ctd_AP06_019.bl
	D4.021.ros	ctd_AP06_019.ros		
E1	E1.027.cnv	ctd_AP06_020.cnv	E1.027.bl	ctd_AP06_020.bl
	E1.027.ros	ctd_AP06_020.ros		
E2	E2.026.cnv	ctd_AP06_021.cnv	E2.026.bl	ctd_AP06_021.bl
	E2.026.ros	ctd_AP06_021.ros		
E3	E3.025.cnv	ctd_AP06_022.cnv	E3.025.bl	ctd_AP06_022.bl
	E3.025.ros	ctd_AP06_022.ros		
E4	E4.024.cnv	ctd_AP06_023.cnv	E4.024.bl	ctd_AP06_023.bl
	E4.024.ros	ctd_AP06_023.ros		
E5	E5.023.cnv	ctd_AP06_024.cnv	E5.023.bl	ctd_AP06_024.bl
	E5.023.ros	ctd_AP06_024.ros		
F1	F1.028.cnv	ctd_AP06_025.cnv	F1.028.bl	ctd_AP06_025.bl
	F1.028.ros	ctd_AP06_025.ros		
F2	F2.029.cnv	ctd_AP06_026.cnv	F2.029.bl	ctd_AP06_026.bl
	F2.029.ros	ctd_AP06_026.ros		
F3	F3.030.cnv	ctd_AP06_027.cnv	F3.030.bl	ctd_AP06_027.bl
	F3.030.ros	ctd_AP06_027.ros		
F4	F4.031.cnv	ctd_AP06_028.cnv	F4.031.bl	ctd_AP06_028.bl
	F4.031.ros	ctd_AP06_028.ros		
F5	F5.032.cnv	ctd_AP06_029.cnv	F5.032.bl	ctd_AP06_029.bl
	F5.032.ros	ctd_AP06_029.ros		
F6	F6.033.cnv	ctd_AP06_030.cnv	F6.033.bl	ctd_AP06_030.bl
	F6.033.ros	ctd_AP06_030.ros		
G1	G1.050.cnv	ctd_AP06_031.cnv	G1.050.bl	ctd_AP06_031.bl
	G1.050.ros	ctd_AP06_031.ros		
G2	G2.049.cnv	ctd_AP06_032.cnv	G2.049.bl	ctd_AP06_032.bl
	G2.049.ros	ctd_AP06_032.ros		
G3	G3.041.cnv	ctd_AP06_033.cnv	G3.041.bl	ctd_AP06_033.bl

	G3.041.ros	ctd_AP06_033.ros		
G4	G4.040.cnv	ctd_AP06_034.cnv	G4.040.bl	ctd_AP06_034.bl
	G4.040.ros	ctd_AP06_034.ros		
G5	G5.036.cnv	ctd_AP06_035.cnv	G5.036.bl	ctd_AP06_035.bl
	G5.036.ros	ctd_AP06_035.ros		
G6	G6.035.cnv	ctd_AP06_036.cnv	G6.035.bl	ctd_AP06_036.bl
	G6.035.ros	ctd_AP06_036.ros		
H1	H1.051.cnv	ctd_AP06_037.cnv	H1.051.bl	ctd_AP06_037.bl
	H1.051.ros	ctd_AP06_037.ros		
H2	H2.048.cnv	ctd_AP06_038.cnv	H2.048.bl	ctd_AP06_038.bl
	H2.048.ros	ctd_AP06_038.ros		
H3	H3.2.047.cnv	ctd_AP06_039.47	H3.2.047.bl	ctd_AP06_039.bl
	H3.2.047.ros	ctd_AP06_039.47		
H4	H4.039.cnv	ctd_AP06_040.cnv	H4.039.bl	ctd_AP06_040.bl
	H4.039.ros	ctd_AP06_040.ros		
H5	H5.038.cnv	ctd_AP06_041.cnv	H5.038.bl	ctd_AP06_041.bl
	H5.038.ros	ctd_AP06_041.ros		
H6	H6.034.cnv	ctd_AP06_042.cnv	H6.034.bl	ctd_AP06_042.bl
	H6.034.ros	ctd_AP06_042.ros		
G5(02_deep)	Sal.037.cnv	ctd_AP06_043.cnv	Sal.037.bl	ctd_AP06_043.bl
	Sal.037.ros	ctd_AP06_043.ros		

Table 3: Summary of CTD data file final naming convention.

[1] A dummy .ros and .bl file were created for A1 (ctd_AP06_001) as these were not created at the time of data collection

Bulk and Size-Fractionated Chlorophyll – *Baraka Sekadende, Angelina Michael, Stuart Painter*

Sampling for bulk chlorophyll measurements was undertaken at all stations and from all niskin bottles. 250 ml of seawater was filtered through a 25 mm GF/F before pigment extraction in 90% acetone over a subsequent 18-24 hour period. Sample fluorescence was measured on a calibrated Turner Trilogy fluorometer and converted to true chlorophyll concentrations using the following calibration equation factoring in sample volume, extraction volume and any corrective factors.

$$\text{True chlorophyll (mg m}^{-3}\text{)} = \text{measured fluorescence (RFU)} \times 0.13$$

Sampling for size-fractionated chlorophyll measurements was also undertaken at all stations and from all niskin bottles (**Table 4**). Three size fractions were routinely used for size-fractionated measurements. These were 2, 10 and 20 µm. In each case a 250 ml sample of seawater was filtered through a 25 mm polycarbonate filter of the required pore size before pigment extraction in 90% acetone over a subsequent 18-24 hour period. Sample fluorescence was measured as for bulk measurements.

Preliminary results indicate that 80% of total chlorophyll was located in the picoplankton size fraction (in this case 0.7-2 µm; **Figure 4**) and that maximum chlorophyll concentrations on any given profile were typically in the range 0.2-0.6 mg m^{-3}.

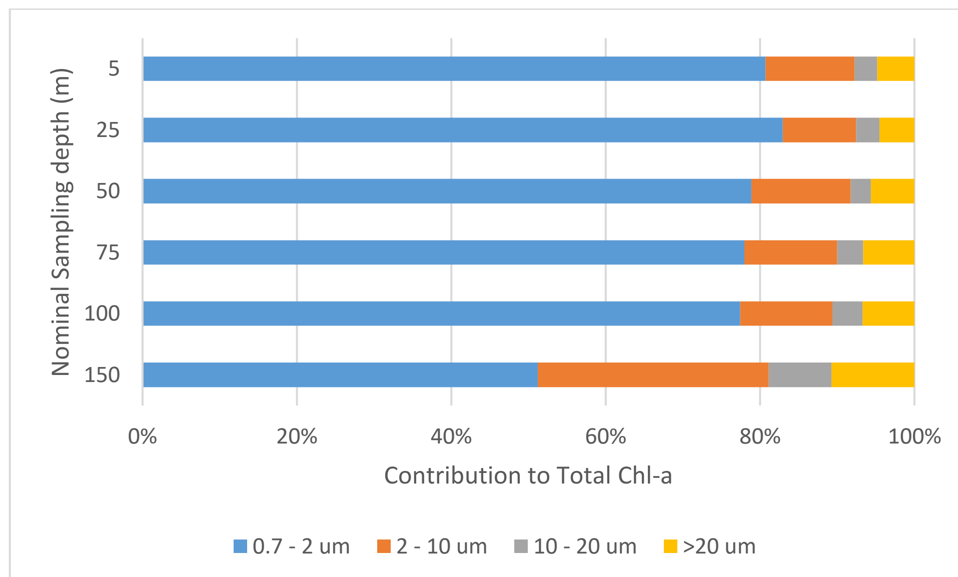

Figure 4: Provisional contribution to total Chl-a by size fraction

Station	Niskin Bottle Sampled	Bulk Chl-a	Size-fractionated Chl-a
A1	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
A2	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
A3	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
A4	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
B1	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
B2	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
B3	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
B4	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
B5	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
C1	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
C2	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
C3	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
C4	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
D1	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
D2	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
D3	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
D4	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
E1	1,2,3,4,5	yes	2 µm, 10 µm, 20 µm
E2	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
E3	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
E4	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
E5	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
F1	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
F2	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
F3	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
F4	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
F5	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
F6	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
G1	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
G2	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
G3	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
G4	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
G5	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
G6	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
H1	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
H2	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
H3	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
H4	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
H5	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm
H6	1,2,3,4,5,6	yes	2 µm, 10 µm, 20 µm

Table 4: Summary of chlorophyll sampling

Particulate Organic Carbon/Nitrogen – *Baraka Sekadende, Angelina Michael, Stuart Painter*

Particulate organic carbon and nitrogen samples were collected at all stations and from all niskin bottles (**Table 5**). 1 L of seawater was typically filtered onto 25 mm pre-ashed (450ºC, >6 hours), GF/F filters before the filter was oven dried at 40-80ºC overnight. Once dry the filter was placed in a 2.5 ml cryovial for shipment back to the UK for analysis. Samples will be analysed for C, N and isotopic content as soon as possible.

Station	Niskin Bottle Sampled	Volume filtered (L)
A1	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
A2	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
A3	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
A4	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
B1	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
B2	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
B3	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
B4	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
B5	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
C1	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
C2	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
C3	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
C4	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
D1	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
D2	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
D3	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
D4	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
E1	1,2,3,4,5	1, 1, 1, 1, 1
E2	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
E3	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
E4	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
E5	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
F1	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
F2	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
F3	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
F4	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
F5	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
F6	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
G1	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
G2	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
G3	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
G4	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
G5	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
G6	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
H1	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
H2	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
H3	1,2,3,4,5,6	1, 1, 1, 1, 1, 1

H4	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
H5	1,2,3,4,5,6	1, 1, 1, 1, 1, 1
H6	1,2,3,4,5,6	1, 1, 1, 1, 1, 1

Table 5: Summary of POC/PON sampling

Phytoplankton – *Baraka Sekadende, Angelina Michael, Mtumwa Mwadini*

The (micro) phytoplankton community will be assessed after the cruise from both surface water samples and from subsurface water collected via CTD (**Table 6**).

At each station a 5L niskin bottle was hand lowered over the side of the vessel to a depth of ~3 m. The collected water was then poured into a 20 µm phytoplankton net to concentrate any larger phytoplankton cells. A second surface sample (bucket) was then collected and poured into the same net before the net was washed and the concentrated samples poured into an amber glass bottle and preserved with 1-2 ml of Lugol's iodine.

An integrated sample of (micro)phytoplankton was also obtained by pouring any unused water from the CTD through a 20 µm phytoplankton net. Samples collected in this manner consist of variable and unmeasured water volumes but concentrate water from the 6 CTD standard sampling depths (150, 100 75, 50, 25 and 5 m) resulting in an intertied sample. The net was gently washed and the concentrated sample poured into an amber glass bottle and preserved with 1-2 ml of Lugol's iodine.

Analysis of the samples will be jointly undertaken after the cruise by staff from TAFIRI and IMS.

Station	Niskin Bottles Sampled for Integrated sample	Surface Niskin (5L)
A1	1,2,3,4,5,6	yes
A2	1,2,3,4,5,6	yes
A3	1,2,3,4,5,6	yes
A4	1,2,3,4,5,6	yes
B1	1,2,3,4,5,6	yes
B2	1,2,3,4,5,6	yes
B3	1,2,3,4,5,6	yes
B4	1,2,3,4,5,6	yes
B5	1,2,3,4,5,6	yes
C1	1,2,3,4,5,6	yes
C2	1,2,3,4,5,6	yes
C3	1,2,3,4,5,6	yes
C4	1,2,3,4,5,6	yes
D1	1,2,3,4,5,6	yes
D2	1,2,3,4,5,6	yes
D3	1,2,3,4,5,6	yes
D4	1,2,3,4,5,6	yes
E1	1,2,3,4,5	yes
E2	1,2,3,4,5,6	yes
E3	1,2,3,4,5,6	yes
E4	1,2,3,4,5,6	yes
E5	1,2,3,4,5,6	yes
F1	1,2,3,4,5,6	yes
F2	1,2,3,4,5,6	yes
F3	1,2,3,4,5,6	yes
F4	1,2,3,4,5,6	yes

F5	1,2,3,4,5,6	yes
F6	1,2,3,4,5,6	yes
G1	1,2,3,4,5,6	yes
G2	1,2,3,4,5,6	yes
G3	1,2,3,4,5,6	yes
G4	1,2,3,4,5,6	yes
G5	1,2,3,4,5,6	yes
G6	1,2,3,4,5,6	yes
H1	1,2,3,4,5,6	yes
H2	1,2,3,4,5,6	yes
H3	1,2,3,4,5,6	yes
H4	1,2,3,4,5,6	yes
H5	1,2,3,4,5,6	yes
H6	1,2,3,4,5,6	yes

Table 6: Summary of phytoplankton sampling

Coccolithophore Sampling – *Baraka Sekadende, Angelina Michael, Stuart Painter*

The Pemba Channel region has previously been shown to host a diverse community of coccolithophores dominated by *Gephyrocapsa oceanica*. To confirm this, samples were collected for identification and enumeration of the coccolithophore community.

At each station a single surface water sample (5 m depth) was collected from the CTD niskin bottle and 500 ml was filtered onto a 25 mm 0.8 µm polycarbonate filter (**Table 7**). Filters were oven dried and stored in petrislides and will be analysed at a later date by scanning electron microscopy. At some stations an additional or alternative depth was also sampled.

Station	Niskin Bottle Sampled	Nominal Depth (m)	Volume filtered (L)
A1	1	150	0.5
A2	6	5	0.5
A3	6	5	0.5
B1	6	5	0.5
B2	6	5	0.5
B3	6	5	0.5
B4	6	5	0.5
B5	6	5	0.5
C1	6	5	0.5
C2	6	5	0.5
C3	2	100	0.5
C4	6	5	0.5
D1	6	5	0.5
D2	6	5	0.5
D3	6	5	0.5
D4	6	5	0.5
E1	6	5	0.5
E2	6	5	0.5
E3	6	5	0.5
E3	3	75	0.5
E4	6	5	0.5
E5	6	5	0.5
F1	6	5	0.5
F2	6	5	0.5
F3	6	5	0.5
F4	6	5	0.5
F5	6	5	0.5
F6	6	5	0.5
G1	6	5	0.5
G2	6	5	0.5
G3	6	5	0.5
G4	6	5	0.5
G5	6	5	0.5
G6	6	5	0.5
H1	6	5	0.5
H2	6	5	0.5

H3	6	5	0.5
H4	6	5	0.5
H5	6	5	0.5
H6	6	5	0.5

Table 7: Summary of Coccolithophore sampling

Zooplankton *–Margaux Noyon, Salome Shayo*

Sample collection

Zooplankton was collected at each station (**Table 8**) using two different Bongo net tows equipped with different mesh size:

- 1 vertical bongo net with 63 µm mesh size down to 100 - 150 m
- 1 oblique bongo net with 200 µm mesh size down to 200 m

The 63 µm bongo nets were deployed to a variable depth depending on the distribution of the Chlorophyll *a* (Chl *a*) at each station. This depth usually corresponded to either the deep Chl *a* maximum when present, or down to the thermocline.

The bongo net of 200 µm mesh size was deployed down to 200 m, or to about 10 m from the bottom in shallower areas, and towed obliquely to the surface.

Both nets were equipped with a flowmeter and a depth sensor (Star-Oddi). The depth sensor was only read after the cast as no electronic winches were available on the RV Angra Pequena. Due to strong currents, estimation of the depth was not always easy, especially with the 200 µm bongo net that was sometimes deployed shallower or deeper than the 200 m depth planned (min depth = 145 m; max depth = 259 m). The depth and the volume filter being known, it might be possible to take that into account later in the interpretation of the data.

Station	Date	Oblique Bongo Net 200µm			Vertical Bongo Net 63µm		
		Dip #	Lat (DD.DDDD)	Long (DD.DDDD)	Dip #	Lat (DD.DDDD)	Long (DD.DDDD)
A1	30/06/2019	1	-4.99243	39.30415	1	-4.99733	39.30137
A2	30/06/2019	2	-4.98605	39.40508	2	-4.99692	39.40263
A3	01/07/2019	3	-4.99193	39.50230	3	-4.99967	39.50078
A4	01/07/2019	4	-4.99675	39.59870	4	-5.00033	39.60018
B5	01/07/2019	5	-5.10228	39.59922	5	-5.10132	39.59835
B4	01/07/2019	6	-5.07360	39.50495	6	-5.09275	39.50038
B3	02/07/2019	7	-5.09530	39.40120	7	-5.10002	39.40002
B2	02/07/2019	8	-5.09377	39.29935	8	-5.09827	39.29985
B1	02/07/2019	9	-5.09882	39.19755	9	-5.09875	39.19938
C1	02/07/2019	10	-5.19897	39.20160	10	-5.20232	39.20232
C2	02/07/2019	11	-5.18643	39.30080	11	-5.19992	39.30070
C4	03/07/2019	12	-5.18580	39.49492	12	-5.20653	39.49408
C3	03/07/2019	13	-5.17412	39.39408	13	-5.19742	39.39778
D1	03/07/2019	14	-5.30180	39.20160	14	-5.30233	39.19972
D2	03/07/2019	15	-5.29678	39.30302	15	-5.29933	39.30068
D4	04/07/2019	16	-5.28870	39.49867	16	-5.29618	39.49887
D3	04/07/2019	17	-5.28073	39.39847	17	-5.29850	39.39885
E5	04/07/2019	18	-5.38860	39.49272	18	-5.39685	39.49903
E4	05/07/2019	19	-5.39507	39.39433	19	-5.39768	39.39993
E3	05/07/2019	20	-5.39283	39.29442	20	-5.39538	39.30000
E2	05/07/2019	21	-5.39815	39.19437	21	-5.39897	39.19793
E1	05/07/2019	22	-5.39987	39.09897	22	-5.40028	39.10088

F1	05/07/2019	23	-5.50032	39.09675	23	-5.50238	39.09863
F2	06/07/2019	24	-5.50002	39.19802	24	-5.49928	39.19965
F3	06/07/2019	25	-5.49592	39.29487	25	-5.49963	39.29538
F4	06/07/2019	26	-5.49080	39.39898	26	-5.49885	39.40310
F5	06/07/2019	27	-5.49307	39.49440	27	-5.49400	39.49755
F6	06/07/2019	28	-5.49687	39.59337	28	-5.49673	39.59685
H6	07/07/2019	29	-5.69593	39.59547	29	-5.69453	39.60082
G6	07/07/2019	30	-5.59213	39.59963	30	-5.59353	39.59808
G5	07/07/2019	31	-5.59389	39.49202	31	-5.59690	39.49617
H5	07/07/2019	32	-5.70140	39.49458	32	-5.69473	39.49510
H4	08/07/2019	33	-5.69713	39.39737	33	-5.69905	39.39827
G4	08/07/2019	34	-5.59250	39.39167	34	-5.59640	39.39802
G3	08/07/2019	35	-5.59873	39.30187	35	-5.59958	39.30068
H3	08/07/2019	36	-5.69222	39.30130	36	-5.69335	39.30153
H2	08/07/2019	37	-5.70098	39.19705	37	-5.69713	39.19848
G2	09/07/2019	38	-5.59758	39.19705	38	-5.60012	39.19983
G1	09/07/2019	39	-5.59848	39.09928	39	-5.60057	39.10015
H1	09/07/2019	40	-5.69820	39.09948	40	-5.70028	39.10015

Table 8: Summary of collected zooplankton samples

Sample processing:

One of the 63 µm bongo net sample was preserved in formaldehyde (4% final concentration) while the other one was used to measure dry biomass of the 63 to 200 µm fraction. For the later, the fraction was filtered onto pre-weight filter papers and oven dried at 80˚C for 24h on the ship. 80˚C is slightly higher than what is usually done (60˚C) but this was a compromise for the use of the oven (nutrient samples needed to be pasteurised at 80˚C).

Both 200 µm bongo net samples were preserved in formaldehyde (4% final concentration).

Planned laboratory processing:

- The 63 µm preserved samples will be settled into a graduated cylinder for 24 to 48h to determine the settled volume. They will then be split into two fractions: less than 200 µm and more than 200 µm. The lower fraction will be counted under the microscope while the above 200 µm will be scanned using a ZooScan (M. Noyon, NMU in collaboration with SAEON who owns the instrument). Only some of the microzooplankton organisms present in the less than 200 µm fraction will be counted, depending on the composition, due to time constraints (maybe only juveniles copepods, nauplii and/or Oithona spp.)
  This is not the priority of SOLSTICE and will be done later on. Most likely after the timeframe of the SOLSTICE project.
- The 63 to 200 µm dry weight fraction will be weighted back at NMU (M. Noyon).
  Done by end of August 2019
- The fish larvae will be picked out from both 200 µm samples and will be sent to KMFRI for identification (James Malumwa). The density of fish larvae being naturally low, it is important that both nets are used to increase number of occurrences for the identification work.

Fish larvae will be isolated by September 2019 but the timeframe for the identification work is to be confirmed once discussed with James Malumwa.

- Both 200 µm samples will be settled into graduated cylinders for 24 to 48h and used as replicates. This will give a rough and quick idea of the biomass at all the stations
  One net done during the workshop at IMS (July 2019). The second net will be done by September 2019
- One of the 200 µm bongo net will be counted to species level when possible (S. Shayo, TAFIRI). Each sample will be split into a sub-fraction containing about 100 adult Calanoid copepods, and the sub-fraction will to be counted. ***SOLSTICE deliverable.***
- The second 200 µm bongo net will be split until it contains about 1000 to 1500 particles and will also be scanned using the Zooscan back at NMU (M. Noyon, in collaboration with SAEON who owns the instrument).
  This is not the priority of SOLSTICE and will be done later on. Most likely after the timeframe of the SOLSTICE project.

<u>Deadline and possible output within the SOLSTICE timeframe:</u>

Main output/activity	**Date**	**Description**
Cruise	July 2019	Samples collection
Zooplankton workshop	10 days July 2019	Settling volume, preparation/split of the samples to be counted, start counting zooplankton samples and agree on the level of taxonomy
Lab processing	Mid July to end October 2019 (15 weeks)	All the samples counted (S. Shayo, TAFIRI). 40 samples in total: 1 week for the 1st sample, 3 samples/week on avg for 13 weeks ~ 39 samples
Data analyses	Nov-Dec 2019	Statistical & multivariate analyses. Is there enough for a paper?
Preliminary draft	End Dec 2019	All figures; bullet points of a draft paper highlighting the structure and the main findings; comparison with other studies in oligotrophic areas
Advanced draft	Dec - March 2020	Draft with text, results and discussion written. Enough to be able to share with other scientists of the project at the final workshop, Zanzibar.
First full draft	April - May 2020	Full draft to be sent to co-authors for comments
Submission of the manuscript	July to Sept. 2020	Submission window to the special issue

Table 9: Timetable for analysis and writeup

Output: One manuscript on the zooplankton composition in the Pemba Channel and its link with environmental parameters – Leader S. Shayo

Nutrients -– *Mtumwa Mwadini, Baraka Sekadende, Angelina Michael, Stuart Painter*

It was not possible to measure nutrient concentrations during the cruise, and concerns over the logistical difficulties of freezing and transporting samples after the cruise provided insurmountable. We thus employed a pasteurization method to preserve liquid samples for storage and transport. At each station seawater was collected into sterile 50 ml centrifuge tubes and into 200 ml Nalgene bottles (**Table 10**). Both sets of samples were then baked in an oven at 80°C for a minimum of 2 hours before the samples were stored in the dark.

To minimise potential sample loss duplicate nutrient samples were collected. One set of samples (200 ml nalgene bottles) will be transported to IMS (Stonetown, Zanzibar) after the cruise for analysis, and the second set (50 ml centrifuge tubes) will be returned to the NOC (Southampton, UK). After both sets of samples have been analysed a final nutrient dataset will be produced.

Station	Niskin Bottle Sampled	NOC 50 ml	IMS 200 ml
A1	1,2,3,4,5,6	yes	yes
A2	1,2,3,4,5,6	yes	yes
A3	1,2,3,4,5,6	yes	yes
A4	1,2,3,4,5,6	yes	yes
B1	1,2,3,4,5,6	yes	yes
B2	1,2,3,4,5,6	yes	yes
B3	1,2,3,4,5,6	yes	yes
B4	1,2,3,4,5,6	yes	yes
B5	1,2,3,4,5,6	yes	yes
C1	1,2,3,4,5,6	yes	yes
C2	1,2,3,4,5,6	yes	yes
C3	1,2,3,4,5,6	yes	yes
C4	1,2,3,4,5,6	yes	yes
D1	1,2,3,4,5,6	yes	yes
D2	1,2,3,4,5,6	yes	yes
D3	1,2,3,4,5,6	yes	yes
D4	1,2,3,4,5,6	yes	yes
E1	1,2,3,4,5	yes	yes
E2	1,2,3,4,5,6	yes	yes
E3	1,2,3,4,5,6	yes	yes
E4	1,2,3,4,5,6	yes	yes
E5	1,2,3,4,5,6	yes	yes
F1	1,2,3,4,5,6	yes	yes
F2	1,2,3,4,5,6	yes	yes
F3	1,2,3,4,5,6	yes	yes
F4	1,2,3,4,5,6	yes	yes
F5	1,2,3,4,5,6	yes	yes
F6	1,2,3,4,5,6	yes	yes
G1	1,2,3,4,5,6	yes	yes
G2	1,2,3,4,5,6	yes	yes
G3	1,2,3,4,5,6	yes	yes
G4	1,2,3,4,5,6	yes	yes

G5	1,2,3,4,5,6	yes	yes
G6	1,2,3,4,5,6	yes	yes
H1	1,2,3,4,5,6	yes	yes
H2	1,2,3,4,5,6	yes	yes
H3	1,2,3,4,5,6	yes	yes
H4	1,2,3,4,5,6	yes	yes
H5	1,2,3,4,5,6	yes	yes
H6	1,2,3,4,5,6	yes	yes

Table 10: Summary of nutrient sampling

4. INSTRUMENTATION REPORTS

CTD System Configurations – *Brian Godfrey*
A single CTD system was prepared for the cruise consisting of a 6-way stainless steel frame system and the initial sensor configuration was as follows:

Sea-Bird 19plus underwater unit, s/n 4624
Sea-Bird temperature sensor, s/n 4624, Count (primary)
Sea-Bird conductivity sensor, s/n 4624, Frequency 0 (primary)
Sea-Bird strain gauge pressure sensor, s/n 4624, Count (primary)
Sea-Bird 55 Carousel 6 position pylon, s/n

The auxiliary input initial sensor configuration was as follows:

Sea-Bird 43 dissolved oxygen sensor, s/n 3745
SAtlantic PAR sensor, s/n 1163
WET Labs ECO-AFL/FL fluorometer, s/n FLNTURT-5075
WET Labs, ECO-NTU transmissometer, s/n FLNTURT-5075

<u>Appendix A:</u> Configuration files
<u>Stainless steel CTD frame:</u>
Date: 29/06/2019
Instrument configuration file: SBE19plus_4624.xmlcon
Configuration report for SBE 19plus CTD

Frequency channels suppressed : 0
Voltage words suppressed : 0
Computer interface : RS-232C
Deck unit : No
Scans to average : 1
NMEA position data added : No
NMEA depth data added : No
NMEA time added : No
NMEA device connected to : No
Surface PAR voltage added : No
Scan time added : No

1) Count, Temperature

Serial number : 4624
Calibrated on : 02 March 2019
A0 : 1.23011713e-003
A1 : 2.64685967e-004
A2 : -1.51417244e-007
A3 : 1.57752939e-007
Slope : 1.00000000
Offset : 0.0000

2) Frequency 0, Conductivity

Serial number : 4624
Calibrated on : 02 March 2019
G : -1.04913904e+000
H : 1.45506285e-001
I : -1.88539648e-004
J : 3.51743133e-005
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Count, Pressure, Strain Gauge

Serial number : 4624
Calibrated on : 26 February 2019
PA0 : 8.70969911e-001
PA1 : 2.63281351e-003
PA2 : 2.07386164e-011
PTEMPA0 : -4.95786216e+001
PTEMPA1 : 5.78923742e+001
PTEMPA2 : -7.63822733e-001
PTCA0 : 5.23769622e+005
PTCA1 : 2.84263995e+001
PTCA2 : -6.02086986e-001
PTCB0 : 2.51225000e+001
PTCB1 : -1.90000000e-003
PTCB2 : 0.00000000e+000
Offset : 0.000000

4) A/D voltage 0, Oxygen, SBE 43

Serial number : 3745
Calibrated on : 28 February 2019
Equation : Sea-Bird
Soc : 3.5922e-001
Offset : -0.5039
A : -4.8763e-003
B : 2.4797e-004
C : -3.3211e-006
D0 : 2.5826e+000
E : 3.60000e-002
Tau20 : 1.1700e-000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

5) A/D voltage 1, PAR/Logarithmic, Satlantic

SerialNumber : 1163
Calibrated on : 10 Apr 2019
a0 : 1.0200e+000
a1 : 8.0468e-001
lm : 1.3589e+000
Multiplier : 1.0000e+000

6) A/D voltage 2, Fluorometer, WET Labs ECO-AFL/FL

Serial number : FLNTURT-5075
Calibrated on : 19 March 2019
Scale factor : 1.50000000e+001
Vblank : 0.0570

7) A/D voltage 3, Turbidity Meter, WET Labs, ECO-NTU

Serial number : FLNTURT-5075
Calibrated on : 19 March 2019
ScaleFactor : 38.000000
Dark output : 0.061000