2 March 2020

Cruise Science Report: TN376 R/V Thompson
25 January – 3 March, 2020

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Cruise narrative

Cruise track overview

This cruise was loaded in Cape Town, South Africa, beginning 22 January, 2020 and departed Cape Town on 25 January. The cruise track took us southeast from Cape Town for our first shakedown station at 38o35'S x 024oE, a station which was ultimately cancelled due to heavy weather conditions. Two days out of Cape Town, the coupler between the ship's number 3 main engine and generator broke. This meant that the ship only had one main engine, with associated generator, plus two smaller engine/generators for all power needs. With the loss in redundancy, this meant that we had to cut our cruise plans short, in order to stay within several hundred miles of Durban, SA, such that the ship could go in for repair once a replacement coupler could be found. This also meant that we had to abandon the planned meridional transect that was to be done on this trip, since the travel to the ship yard, the repair, and return to the next station took over a week of sampling out of the cruise, and our proximity to Durban (and long distance from the Crozet Islands) meant that we couldn't possibly accomplish the meridional transect and make it to Mauritius within the UNOLS ship schedule. We are now trying to get this leg added onto the ship schedule for next year's cruise.

Given the above engine issues, we therefore decided to stay within the Agulhas meander system, an area that is part of the Great Calcite Belt (Balch *et al.*, 2016), known for massive coccolithophore-rich, (and PIC-rich) frontal boundaries and eddies. This evidence goes back to the NASA SeaWiFS ocean color sensor in the late 1990's and the NASA MODIS mission from 1998 to the present (Fig. 1 shows the average austral summer PIC concentration for the region of the Southern Indian Ocean, as detected by the NASA MODIS Aqua sensor). These averages are for all austral summer seasons between 2002-2018.

Given the constraints described above, we focused on sampling (and re-sampling) two features, a filament of the Aghulas and south subtropical fronts and a cyclonic eddy spun off from these frontal boundaries in the preceding December. The actual cruise track (plus the planned original cruise track with meridional transect are overlaid in Fig. 1. For the first leg of the cruise (white overlay in Fig. 1), we focused on a region within one of the meanders which had shown persistent elevated PIC over a mesoscale meander, a feature that was over 80,000 km^2 (400km long and 200 kilometers wide). We surveyed the feature zonally and meridionally with the video plankton recorder (VPR), then repeated the same transects with CTD sections (doing 12-depth water sample profiles for chlorophyll, nutrients, dissolved oxygen, particulate inorganic carbon (PIC), particulate organic carbon (POC), biogenic silica (BSi), quantitative coccolithophore counts and quantitative FlowCAM samples (for enumeration of algal classes, cell volumes, and slope of the particle-size distribution function). We also performed carboy experiments in each feature. In this, and all subsequent feature surveys, the Morton lab drew trace-metal clean surface water using a surface water sampler for carboy experiments to be incubated on board the ship under simulated *in situ* conditions. All carboy experiments involved incubation of trace-metal-clean surface water, collected by a novel surface sampler that was, for the first time, deployed laterally away from the ship while steaming at a few knots speed ("Big Jon Scientific Surface Sampler"). It maintains a distance of 10-15m from the ship as it steams, insuring no trace metal contamination from the ship's hull. The carboy experiments involved triplicate incubations of untreated control water plus five treatments with a)10% dilution with deep SAMW water, b) 12µM trace metal-clean nitrate, (c) 5µM trace metal-silicate, (d) 4nM of iron and (e) 4nM of iron+5µm of silicate. The carboys were then sampled daily for 4-5 days while being incubated under surface light conditions in an on-deck incubator, with temperature maintained at *in-situ* surface conditions. The carboys were sampled daily by the Balch group for chlorophyll, nutrients, PIC, POC, biogenic silica, quantitative coccolithophore counts and quantitative flow cam samples (for enumeration of algal classes, cell volumes, and slope of the particle-size distribution). Photosynthetic parameters were also measured in the carboy experiments by the Brownlee group using a PAM fluorometer (Water PAM, Walz, Germany). Ph.D. student, Julia Middleton (Ph.D. student of Dr. Tristan Horner, WHOI) performed experiments on barite formation in all the features studied in this expedition.

We started the second leg of the cruise (yellow cruise track overlay, Fig. 1), heading for an eddy that we had observed since December using PIC and altimetric satellite remote sensing (from the point that the eddy had pinched off from the Agulhas/Southern Subtropical frontal regions). This eddy formerly had contained more PIC (based on higher remote sensing reflectance) and now the coccolithophore

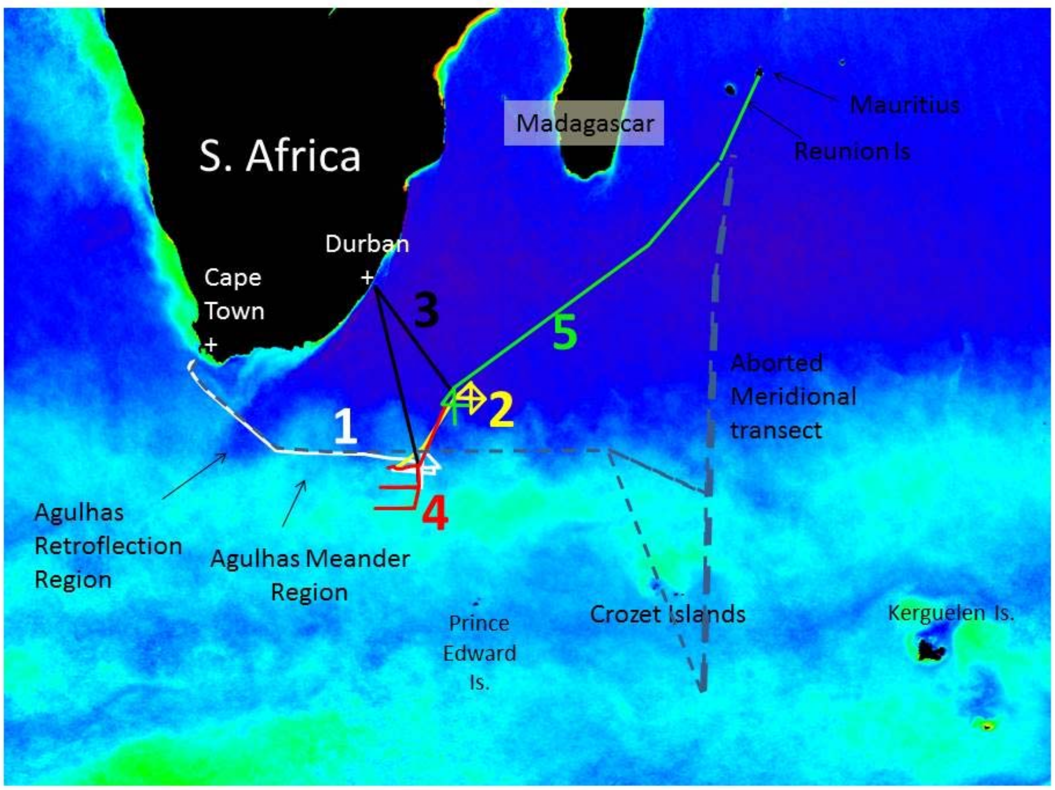

Fig. 1-Average PIC concentration in the SW Indian Ocean/Southern Ocean as detected by MODIS Aqua. Note how the elevated PIC reflects the Agulhas Retroflection and Agulhas meander system. This is the austral summer season average for the Aqua sensor for years 2002-2018. The cruise track of TN376 is shown with numbered, colored lines corresponding to the five cruise legs. The original planned cruise track is shown with a grey dashed line and the aborted meridional transect is shown with a thick grey dashed line.

concentrations appeared to be waning. For both the filament and eddy, the altimetric and PIC products showed good coherence with the oceanographic structures, suggested that these would be good study sites to examine the conditioning of SubAntarctic Mode Water by coccolithophores and other resident phytoplankton species. We sampled for another carboy experiment in this eddy, deployed a 10m sock drifter in the eddy center on 8 February, 2020, in order to follow the eddy feature in our absence, then stopped all science and headed for Durban for the ship repair (leg 3; grey thick cruise track in Fig. 1). The repair was complete by the evening of 13 February, 2020 and the ship subsequently set sail from Durban, to head back to the filament that we had studied in Leg 1 (which was now showing increased PIC levels; Leg 4; red cruise track, Fig. 1). We performed another deck carboy experiment in the filament, conducted VPR and CTD surveys, and we performed a deep CTD cast for nutrient and carbonate chemistry, then re-occupied the eddy that we had studied prior to Durban (Leg 5; orange cruise track, Fig. 1), surveyed with both VPR and CTD casts, performed yet another carboy experiment, recovered the drifter. We performed two more deep casts (072.01 and 073.01) in transit to Mauritius.

Detailed Leg Summary

Leg 1; Transit from Cape Town, S.A., zonal transect through Agulhas meander system, and sampling of a coccolith-rich filament; CTD stations 1-17, VPR tows 1-7; trace metal casts 1, 3, 5, 6, 7, 8, 12 and 17; 0800h, 25 January- 0222h, 4 February, 2020. (Fig. 1 white line)

For this leg, we transited across the Agulhas Meander system, beginning with a station in the Agulhas Retroflection eddy (station 2), criss-crossing the Agulhas, Southern Subtropical Fronts with VPR and underway bio-optical systems running, and performed full CTD water casts (stations 2-4). This line of stations crossed into the end of our filament of interest, which showed (with the Acoustic Doppler Current Profiler (ADCP), cyclonic circulation around a zero-velocity core of this frontally-embedded eddy. Station 5 was situated in the western interior side of this eddy. This was where we collected water for our first carboy experiment and also performed a trace metal cast consisting of nine Niskin X samplers deployed on a Kevlar line. After collecting seawater for the carboy experiment, the VPR was deployed and towed for the entire west-to-east section, then north-to-south section through the center of the eddy. The same sections were then visited (in reverse) for CTD casts. Daily productivity casts to measure photosynthesis and calcification, plus trace metal casts were run at stations 1, 3, 4, 5, 6, 7, 8, 12, and 17. The carboy experiment for this feature was run from surface water taken at station five. Measurements of photosynthetic variables were made underway and at stations 1-17. These included photosynthetic efficiency and rapid light curve data. An imaging PAM system (PSI, Cz) was also used to obtain cell type-specific photosynthetic efficiency data (see Brownlee group report for more details of imaging PAM and measurements made). Filter/freeze/transfer (FFT) preparations were made for qualitative viewing of surface and fluorescence maxima phytoplankton assemblages (400x magnification bright-field, polarized microscopy and epi-fluorescence using 480nm and 530nm excitation) viewing at stations 5,6,7,8, 12, and 17. Barite precipitation measurements were performed at station & in this feature.

Leg 2; Transit to eddy feature and its survey; CTD stations 18-25; VPR tows 8-9; trace metal casts 18, 20, and 23; 0222h,4 Feb.-1400h, 8 Feb., 2020 (Fig. 1; yellow line)

This leg of the cruise involved sampling a cyclonic eddy roughly centered at 35^o 53'S and 37^{o}38'E. We first did a full 195 kilometer east-to-west VPR survey, towed it from the east end of the eddy to the northern end of the eddy followed by a complete VPR section (163 kilometers) from north to south. The area of this PIC-enhanced, elliptical eddy was about 25,000 km^2. Productivity and trace metal casts were performed at stations 18, 20, 23 and the water for a second carboy experiment was collected from station 18 (eddy interior). Measurements of photosynthetic variables were made underway and at stations 18-25. FFT preparations were made for semi-quantitative viewing of surface and fluorescence maxima phytoplankton assemblages (400x magnification bright-field, polarized microscopy and epi-fluorescence using 480nm and 530nm excitation) viewing at stations 18, 23, and 25. Barite precipitation measurements were performed at station && in this feature. A 10m-sock drogue equipped with a satellite Argos transmitter was deployed in the eddy center prior to our departure for Durban as a means to track the feature in our absence.

Leg 3; science stopped and ship diverted for engine repair; 1400h, Feb. 8, with science sampling resumed at 1726h, 16 February. (Fig. 1; thick, black line)

All overboard sampling at Leg 2 stopped on 8 February for the steam back to the port of Durban for engine repairs. Only the carboy experiments were sampled during the two-day transit to the port but given that we had a temperature-controlled seawater incubator, the carboy experiments could be maintained at their *in situ* temperatures for the duration of the multi-day experiment. The engine repair work in Durban was completed by the evening of 13 February, after which the ship sailed for station 26 to resample the first filament that we had sampled in Leg 1.

Leg 4; Re-sampling the meander filament and transit to first deep CTD; CTD Stations 26-53; VPR tows 10-12; trace metal casts 28 and 39; 0347h,16 Feb. - 0418h, Feb. 20, 2020 (Fig. 1; red line)

The ship proceeded to re-sample the meander filament by performing three east-to-west, VPR sections across the feature, followed by three CTD sections made immediately afterwards across the same lines, from west-to-east. Those sections were made zonally at 41o30', 40o30'S and 39o30'S and had lengths of 222km, 222km and 167km, respectively, such that they adequately sampled the cross-section of the feature. Beginning with station 27, we alternated each CTD full-water cast with a "trip on the Fly" water cast. These later casts were used only to sample DIC and nutrients and served to provide grfeater resolution sections across the features. This pattern of Ctd sampling was continued for the remaining feature surveys. Following the completion of each VPR and CTD zonal leg, the VPR was towed to the next zonal leg. Productivity/TM casts were made at stations 28, 39 and 50, near the mid-points of the filament. The carboy experiment in this feature was run using water from station 28. Measurements of photosynthetic variables were made underway and at stations

26,28,30,32,34,35,37,39,41,43,44,46,48,50,52. FFT preparations were made for semi-quantitative microscopy viewing at stations 28, 29, 30, 39, 42, and 50. Barite precipitation measurements were performed at station && in this feature.

Leg 5; Re-sampling Eddy 3, Deep water casts, transit to Mauritius; CTD Stations 54-73; VPR tows 13-14; trace metal casts 50, 56, and 70; 0418h, Feb. 20 – 0800h, March 3, 2020. (Fig. 1; green line)

From leg 4, we proceeded to re-sample the cyclonic eddy, originally sampled in leg 2. On the way, we made the first deep CTD cast to sample for nutrients, oxygen and carbonate chemistry down to the sea floor (4500m). The eddy re-sampling consisted of a 163km west-to-east VPR tow followed by a 203km east to west CTD section. Heavy seas forced us to cancel the west-most CTD station. The ship then proceeded to the north eddy station with all weather decks secured. Again, heavy sea-states made deployment of the VPR impossible, so we performed the north-to-south CTD section but had to call off some of the middle CTDs from that section due to heavy seas. The drogue had spiraled about 100km from eddy center by this point, so the ship broke from the N-S line to recover it, after which the interior eddy stations (that had been skipped due to weather) were re-sampled under safer sea states, finally arriving at the southern eddy station, #71 at 1853h on 2/24/20. At this point, the VPR could finally be re-deployed to tow the entire south-to-north eddy survey transect. Two productivity/trace-metal stations were run in the eddy at stations 56 and 70. (The carboy experiment was sampled at station 56. Measurements of photosynthetic variables were made underway and at stations 54,56,58,60,62,64,66,68,70,71. FFT preparations were made for semi-quantitative microscopy viewing at stations 56 (east eddy interior) and 70 (eddy center). Barite precipitation measurements were performed at station && in this feature. We performed a deep, 24-bottle, cast for nutrients, oxygen and dissolved inorganic carbon chemistry 183km NE of the eddy (34.42^{o}S x 38.04^{o}E; depth 5217m), sampled to 5200m. The last station of the cruise was a 24-bottle deep cast at 27^{o} 24.5' S 049^{o} 49.33' E for freons, nutrients, temperature, salinity, PIC, POC, biogenic silica, coccolithophore and coccolith abundance, dissolved oxygen and dissolved inorganic carbon chemistry. The purpose of this cast was to examine water ages of SAMW, examine the stoichiometry of the changes in the chemistry from assumed preformed levels, and to provide comparative values for the meridional transect to be performed next year.

Overview of preliminary findings

The VPR sections, done concurrently with the surface underway optical and hydrographic measurements, demonstrated that peak backscattering [b_b] (and acid-labile backscattering [b_b'], a good proxy of PIC concentration) and chlorophyll fluorescence were found in cold, low salinity, oxygenated water. Seawater with the density characteristics of SAMW (σ_θ between 26.5 and 27.1) shoaled within the features at depths ranging from 100 -550m depth. The potential vorticity (PV) of these waters had low to moderate values (50-100 x10^{-12} m^{-1} s^{-1}); depending on the PV criteria used to describe the SAMW pycnostad, this water is technically not SAMW but appears to be capped off by a surface-warmed layer. It is, however, close to fulfilling the definition with a number of the observed PV values between 50- 100 x10^{-12} m^{-1} s^{-1}. Subsequent mixing of this cooled water during austral winter would inject this water into the SAMW layer (see McGillicuddy report for more detail of this).

The acid-labile backscattering (directly correlated to PIC concentrations) was elevated in the centers of each feature, contributing up to 50% of the total backscattering. The on-board microscopy using the filter-freeze-transfer technique (see Balch lab section later in this report) which confirmed that the elevated acid-labile backscattering was originating from plated coccolithophores and their detached coccoliths, not some other carbonate biomineralizer (e.g. foraminifera). The phytoplankton assemblage in both the surface and fluorescence maximum depths of the features was dominated by a surprisingly diverse assortment of coccolithophore species (as well as detached coccoliths), not just *Emiliania huxleyi*. For example, the species observed in the shipboard light microscopy were: *E. huxleyi*, *Acanthoica quattrospina*, several species of the genus *Syracosphaera (*both holo- and heterococcolith forms such as *S. ossa* and *S. pulcra)*, *Discosphaera tubifera*, *Rhabdosphaera clavigera*, *Michaelsarsia elegans*, *Saturnulus helianthaformis*, *Papposphaera* sp., *Pappomonas* sp., *Calciosolenia* murrayi and *Helicosphaera* sp.. More exact identifications of these will be determined following scanning electron microscopy ashore, as well as quantitative abundance estimates using polarized microscopy coccolithophore counts, post-cruise. This diversity is consistent with previous Great Calcite Belt observations in the Indian sector of the Southern Ocean (Smith *et al.*, 2017). Secondarily, the assemblage also contained surprising numbers of several species of dinoflagellates, both armored and unarmored. In some stations from the feature interior, cyanobacteria (*Synechococcus*) appeared to roughly co-vary with the coccolithophore abundance, and were relatively abundant (based on epifluorescence microscopy using 530nm excitation). Diatoms were almost non-existent in most samples. The only samples where there was any abundance of diatoms was in the middle of the frontal filament during its second sampling (stn 39) in the fluorescence maximum at 47m depth. For an example of the phytoplankton assemblage from the center of the filament, showing bright-field (all cells), polarized birefringence (highlighting calcium carbonate); blue epifluorescence (showing eukaryotic cells containing chlorophyll; green epifluorescence (showing fluorescent cyanobacteria) (see Fig. 2).

Nutrient concentrations in these features typically showed low nitrate, phosphate and silicate concentrations in the surface layers except in the zonal section of the filament (the furthest south sampling of the cruise in leg 4). There, the surface nitrate and silicate concentrations were elevated above background. A this moment, we don’t yet know if nitrate was limiting in the Redfieldian sense. However, in the carboy experiments, the only enhanced growth of phytoplankton (as indicated by increasing chlorophyll concentrations over the multi-day experiments) were observed in the nitrate and SAMW augmented treatments and nitrate concentrations were depleted to background within a few days. Thus, the phytoplankton populations (as quantified by chlorophyll a) showed distinct signs of nitrogen limitation whereas there was no effect of iron, silicate or iron plus silicate augmentations in any of the experiments. Future evaluation of the photophysiology data (PAM fluorometry and single cell PAM fluorescence imaging) will reveal the control of algal photophysiology and photosynthetic efficiency by nutrients and trace metals (Fig. 3).

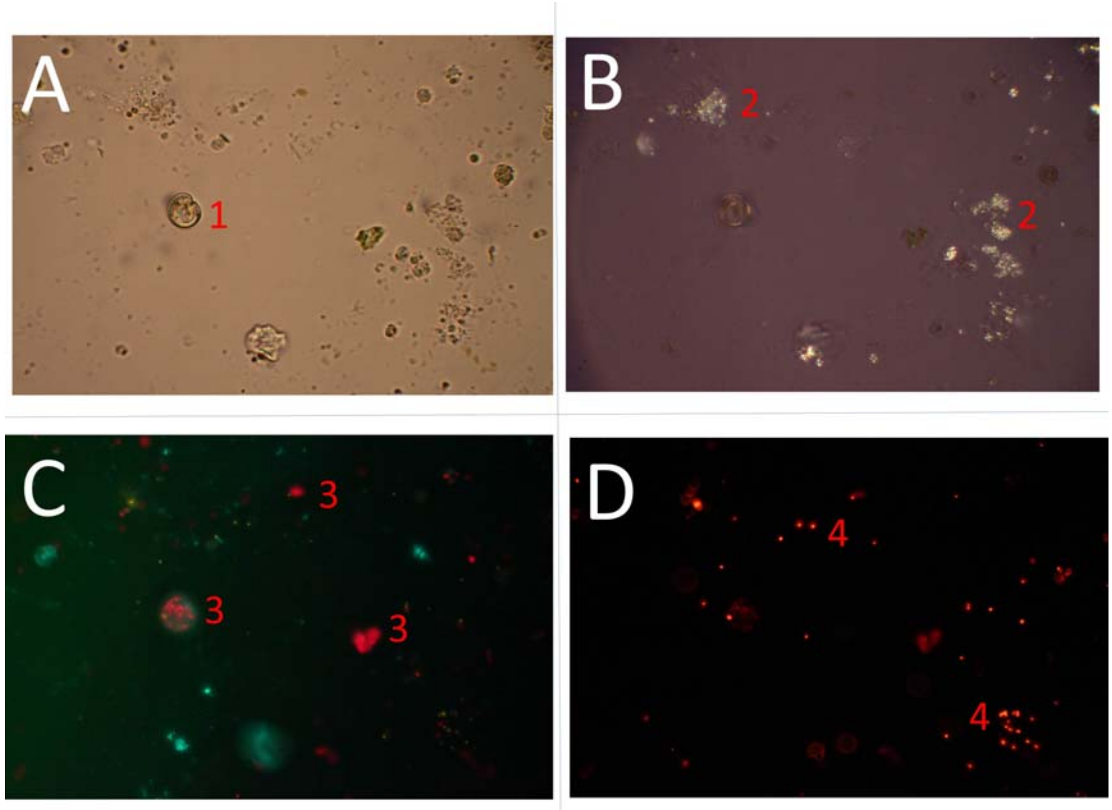

Fig. 2- Example of four micrographs of the same microscope field at 400X magnification. These images were made from a 250mL seawater sample filtered on a 0.4um-poresize, 25mm diameter, polycarbonate filter. The slide was prepared using the Filter-Freeze-Transfer technique (Hewes and Holm-Hanson, 1983). These photos were photographed using (a) brightfield illumination, (b) polarized light illumination showing irefringent calcium carbonate particles as white particles against the darker background, (c) chlorophyll fluorescence by photosynthetic eukaryotes (epi-fluorescence microscopy with 490nm excitation) and d) epifluorescence microscopy by photosynthetic prokaryotic algae (Synechococcus) under 530nm excitation. Numbered particles designate 1)-dinoflagellate, 2)-coccolithophores, 3)-photosynthetic eukaryotes containing chlorophyll and 4) *Synechoccus* cyanobacteria. This field did not contain diatoms but they were present in other fields of the same sample. The dimensions of the field are 281mm x 187.5mm. This method is semi-quantitative and allows approximate particle concentrations to be estimated.

In this cruise, we had the remarkable opportunity to observe the continuous formation of rich coccolithophore populations within the energetic Agulhas meander system, the formation of a PIC-enhanced cyclonic ring, and the subsequent demise of the resident algal population within the semi-enclosed cyclonic ring over time. Regarding the conditioning of SAMW water by the resident phytoplankton, there is little doubt that the water south of the Southern Subtropical and SubAntarctic Fronts (in the filament) was the site of active coccolithophore growth and dinoflagellate growth. We hypothesize that his growth was sustained over the course of our observations in the same manner that phytoplankton experience continuous growth in a chemostat. The filament feature actually became brighter with coccolithophore reflectance during the period of the cruise.

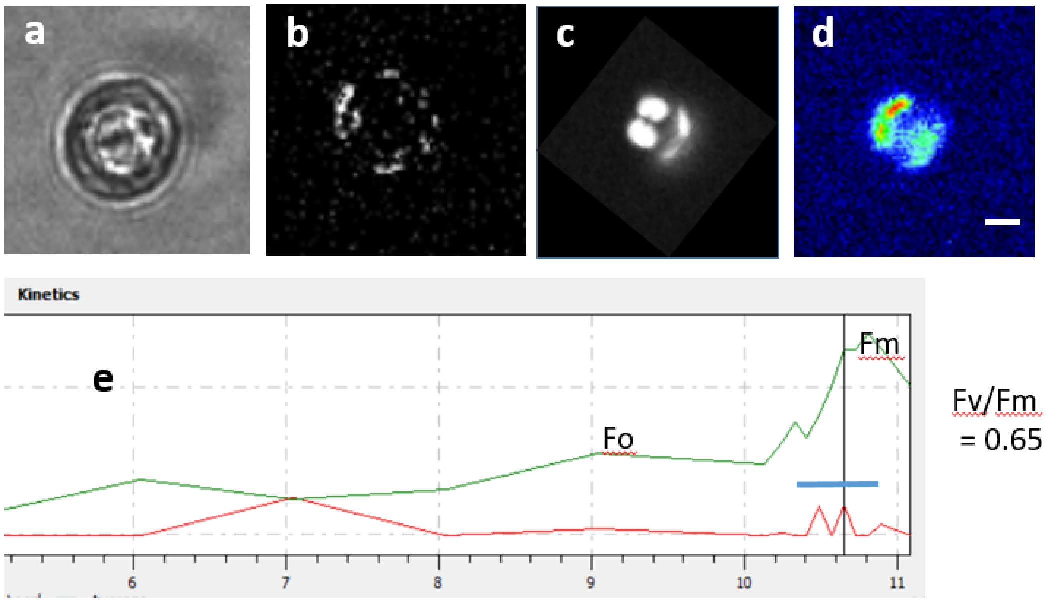

Fig. 3 Single cell PAM fluorescence imaging of a calcifying coccolithophore. a) Bright filed image, b) polarized light image of external coccoliths , c) chlorophyll fluorescence, d) Maximum chlorophyll fluorescence image following a saturating light pulse, e) fluorescence plots of dark-adapted state, Fo and following a saturating light pulse, Fm (blue bar in e). The cell was from a surface underway sample taken at 16:00 h on 01.31.2020. Bar in d) = 10 µm

The water that appeared to be supporting this growth was cold, low salinity water, probably upwelled or advected into the region from further south of the filament.

From the survey and re-survey of the semi-enclosed eddy, we hypothesize that the cyclonic eddy phytoplankton populations were behaving more like a batch culture approaching stationary phase, with a phytoplankton population in significant decline. Satellite imagery demonstrated that the reflectance of the feature was decreasing over time, even though the eddy was still observable using satellite altimetry. The fluorescence maximum at eddy center descended from 54m to 82m depth between first and second samplings, separated by a 2.5 week period. The levels of backscattering (both total and acid-labile) also decreased as this phytoplankton assemblage was “crashing”. Post-cruise, as we work up all the biogeochemical samples, we will determine the full extent that these mixed coccolithophore and dinoflagellate populations conditioned the DIC and nutrient chemistry prior to its subduction during the ensuing winter. At this juncture, however, this “proto-SAMW” water appears to have been significantly conditioned by coccolithophores and dinoflagellates. Any conditioning of SAMW by diatoms (in the Sarmiento et al. sense (Sarmiento *et al.*, 2004)) appears to have already happened further south, with the consumption of all the silicate. What we have observed in this cruise is the next level of conditioning by the coccolithophores and dinoflagellates before the long transit of SAMW north from the Southern Ocean towards the equator.

Ship’s Data

The R/V Thompson’s underway surface sampling system collects a huge amount of data, beyond the scope of this report. However, some of the data sets gathered routinely during the cruise were: ADCP current velocity profiles, bathymetric measurements using the ship's multibeam system, meteorogical data and underway surface water properties (e.g. temperature, salinity, fluorescence) and pCO_2.

Acknowledgements- We would like to thank Captain Russ DeVaney, officers and crew of the *R/V Thomas G. Thompson*. The engine coupler issue was a major challenge for the ship's crew and scientists alike, and the fact that we were still able to accomplish the surveys of the two eddies in this trip (which was two thirds of the proposed work) is a real testimonial to the seamanship and "can-do" attitude of the ship's crew in this emergency situation. The University of Washington marine technicians that accompanied us (Elizabeth Ricci and Jennifer Nomura) provided excellent oversight of all deck operations and utmost safety at all times, Scripps chemists John Ballard and Zac Anderson were indispensable for the accurate measurement of oxygen, nutrients and salts. Norman Kuring (NASA Goddard Space Flight Center, Greenbelt, MD) provided us with regular basin scale (as well as high resolution) MODIS imagery before, during and after Thompson 376 to help us locate features. All the members of the ship operations office at the University of Washington are to be thanked for the immense organizational and logistical tasks associated with the planning a cruise of this size as well as working through the mechanical challenges that we faced (Robert Kamphaus, Meegan Corchoran, Loren Tuttle, Croy Carlin and others too numerous to mention here). Without their help, we could have never have completed this important work. Primary support of the National Science Foundation for this project is gratefully appreciated.

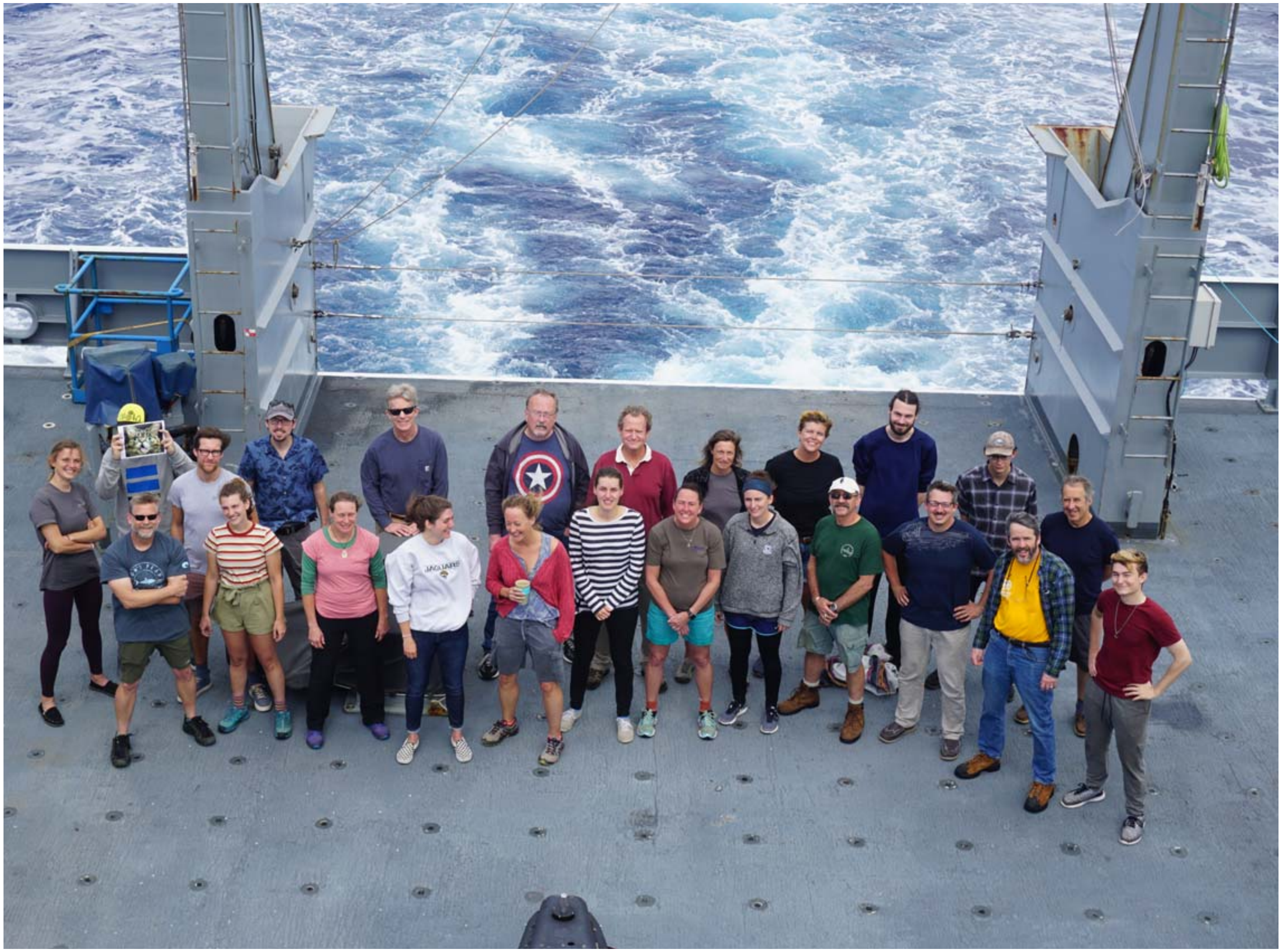

Fig 3- Science party of TN376 (front left to right) Loren Hearn, David Drapeau, Sydney Greenlee, Judith Murdoch, Kristy Dick, Rebecca Garley, Daniella Sturm, Marcy Train, Shannon Burns, Phil Altalo, Pete Morton, Barney Balch, Colin Fischer. (Back row, left to right) Matthew Enright, Zachary Anderson, John Ballard, Dennis McGillicuddy, Bruce Bowler, Fred Thwaites, Sara Rauschenberger, Julia Middleton, Joose DeVries, Andrew Hirzel, Colin Brownlee

Table 1- Science party participants of *R/V Thompson* and their affiliations/roles.

First Name	Last Name	Institution	Position
Phil	Alatalo	Woods Hole Oceanographic Inst. Woods Hole, MA, USA	Research Associate
Zachary	Anderson	Bermuda Inst. Of Ocean Sciences, Prince George, Bermuda	Marine Tech /ODF
William	Balch	Bigelow Laboratory for Ocean Sciences, East Boothbay, ME, USA	Chief Scientist/ Principal Investigator
John	Ballard	Scripps Inst. Of Oceangraphy, La Jolla, CA US	Marine Tech/Chemist
Bruce	Bowler	Bigelow Laboratory for Ocean Sciences, East Boothbay, ME, USA	Senior Res. Assoc.
Colin	Brownlee	Marine Biological Assn of the UK, Plymouth, UK	Principal Investigator
Shannon	Burns	Univ. South Florida, Saint Petersburg, FL, USA	Research Technician
Joost	de Vries	Marine Biological Assn of the UK, Plymouth, UK	Ph.D. Student
Kristie	Dick	Florida State University, Tallahassee	Undergrad Student
David	Drapeau	Bigelow Laboratory for Ocean Sciences, East Boothbay, ME, USA	Senior Res. Assoc.
Matthew	Enright	Bermuda Inst. Of Ocean Sciences, Prince George, Bermuda	Research Specialist
Colin	Fischer	Bigelow Laboratory for Ocean Sciences, East Boothbay, ME, USA	Research Technician
Rebecca	Garley	Bermuda Inst. Of Ocean Sciences, Prince George, Bermuda	Senior Res. Assoc.
Sydney	Greenlee	Colby College, Waterville, ME, USA	Undergrad Student
Lauren	Hearn	Florida State University, Tallahassee	Undergrad Student
Andrew	Hirzel	Woods Hole Oceanographic Inst. Woods Hole, MA, USA	Graduate Student
Dennis	McGillicuddy	Woods Hole Oceanographic Inst. Woods Hole, MA, USA	Principal Investigator
Julia	Middleton	Woods Hole Oceanographic Inst. Woods Hole, MA, USA	Graduate Student
Peter	Morton	Florida State University, Tallahassee	Principal Investigator
Judith	Murdoch	University of Otago, New Zealand	Research Technician
Jennifer	Nomura	Univ. Washington	Marine Tech
Sara	Rauschenberg	Bigelow Laboratory for Ocean Sciences, East Boothbay, ME, USA	Res. Assoc.
Elizabeth	Ricci	Univ. Washington	Marine Tech
Daniela	Sturm	Marine Biological Assn of the UK, Plymouth, UK	Ph.D. Student
Fred	Thwaites	Woods Hole Oceanographic Inst. Woods Hole, MA, USA	Senior Res. Assoc.
Marcia	Train	Long Island School, Maine	Teacher at Sea

Table 2- Summary of scientific deck operations performed during *R/V Thompson* #376.

Deck Operation	Number or duration of operations
1. CTD with 24x10L Niskin bottle samples; Full water casts (all biogeochemical variables,Nutrients, bottle oxygens, bottle salts)	53
2. CTD “trip on fly” casts for nutrients, salts	20
3. Trace metal casts using 5L TM clean Niskin bottles; Kevlar line	17
4. Trace metal-clean samples of surface water for carboy experiments	4
5. Underway DIC samples	
6. Underway surface samples for Chl, POC, PIC, BSi, FlowCAM, coccolith microscopy	95
7. Underway samples for photosynthetic parameters	
8. Number days for drogue deployment	18
9. VPR tows	14
10. Number of CTD casts with DAVPR	68
11. Samples processed for PAM photosynthesis properties from CTD casts	
12. Calcification/Productivity casts	16
13. Days continuous underway inherent optical property measurements	27.4
14. Days continuous bow mounted apparent optical measurements (daytime hours only when solar azimuth >20o)	27.4
15. Four-five-day Deck carboy experiments	4
16. Aerosol Samples for airborne particulate matter	27

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