RV *Investigator* Voyage Summary

Voyage #:	**IN2018_V04**		
Voyage title:	Constraining external iron inputs and cycling in the southern extension of the East Australian Current.		
Mobilisation:	Hobart, Tuesday, 11 September 2018		
Depart:	Hobart, 1300 Tuesday, 11 September 2018		
Return:	Hobart, Monday, 08 October 2018		
Demobilisation:	Hobart, Monday, 08 October 2018		
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Voyage Summary

Scientific objectives

The East Australian Current (EAC) is a major western boundary current that moves southward along the eastern margin of Australia. This current is climatically and biologically important as it exercises control over heat and nutrient distribution. The EAC is nutrient depleted to the north, but as it travels south, it entrains iron from a variety of sources – including riverine, sediment resuspension, eddies, lateral exchange of shelf waters, frontal jets and atmospheric dust inputs thereby elevating the concentration of dissolved iron. When the EAC reaches its southern extent, it breaks up to form eddy-like structures that become incorporated into the Subtropical Front (STF). The STF forms the boundary between warmer nutrient-depleted subtropical water and cool nutrient-rich Southern Ocean water. The waters southwest of Tasmania are nutrient-rich but depleted in dissolved iron, which is a typical characteristic of High Nutrient Low Chlorophyll (HNLC) regions within the Southern Ocean. In springtime, large phytoplankton blooms can be seen associated with a mingling of nutrient-depleted EAC waters with nutrient-rich, but iron depleted Southern Ocean waters in the vicinity of the STF east of Tasmania. Therefore, changes to the EAC caused by climatic shifts will have implications on elemental cycling, production, and local climate. We will assess the relationships between production and nutrient supply in the modern ocean while simultaneously improving our interpretations of past ocean records from the region.

The aims of this voyage are to:

- Assess the sources of external iron to the southern extension of the EAC
- Compare and contrast the biogeochemistry of EAC waters with HNLC waters located southwest of Tasmania;
- Determine the role of 'new' (externally sourced iron) versus 'recycled' iron in regulating springtime productivity across the STF;
- Test the sensitivity of neodymium and thorium isotope sedimentary records to local sedimentary processes;

Supplementary Project: Seabirds

The project seeks to quantify the distribution and abundance of seabirds and marine mammals at sea around Australia using standardised seabird survey protocols. Dedicated observers will collect real-time data on seabirds observed within 300m transect during daylight hours while the vessel is underway. Incidental observations will be collected while the vessel is stationary. The data collected will be compatible with previous seabird at sea surveys conducted around Australia and farther south, allowing for analyses and assessments to be extended by the current surveys. The distribution of seabirds at sea is strongly linked with oceanographic features such as convergences that concentrate prey at densities that allow for efficient foraging by seabirds. Our surveys on the voyage will link with oceanographic investigations to identify the types and strengths of oceanographic features at which we observe different species of seabirds that utilise different methods of feeding (surface seizing, diving etc). No dedicated ship time is required for the seabird surveys. Surveys are conducted by observers while the vessel is underway during daylight hours.

Voyage objectives

This primary objective of the voyage is to characterise the sources and biogeochemical cycling of iron and associated nutrients and their impact on productivity southwest, southeast and northeast of Tasmania. This required various deployments of the following equipment to meet the scientific objectives of the voyage:

TRIAXUS: Triaxus will provide high-resolution real-time data acquisition on upper ocean (5-200 m) physics (mixed layer depth) and biology (chlorophyll fluorescence, transmissivity). These datasets complement those obtained from underway sampling (including nutrient concentrations, bio-optics and Fast Repetition Rate Fluorometry (FRRF, a measure of phytoplankton 'health').

CTD sampling: Profiles of temperature, salinity, and oxygen through the upper ocean at transit stations and full ocean depth at process stations. Water samples collected with the 36-bottle rosette will be analysed on board for salinity, oxygen, nutrients. LADCP data will also be collected from the CTD deployments.

TMR and ISP sampling: An autonomous 12 bottle trace metal-clean rosette (TMR) system and 6 *in situ* pumps (ISPs) will be used to collect trace element and isotope samples in dissolved and particulate phases. Clean sampling and analytical container laboratories will allow for shipboard processing, experiments and some near real-time analyses of iron at sea. The majority of the analyses will take place ashore after the voyage using sophisticated instrumentation not suited for shipboard use.

In situ primary production: Primary production experiments will be conducted at each process station. The experiments will require radiolabeling samples with ^{55}Fe and ^{14}C in the Radiation van and then incubated in the deck-board incubators.

Incubations: Some incubations may be conducted at each process station. The experiments will require the changes in light, nutrient and or trace metal conditions. Samples will then be incubated in the deck-board incubators or the ones in the dry lab.

EZ Net: The EZ net provides the means to obtain stratified samples over the water column, for example between 100 and 200m. In contrast, conventional bongo nets provide no means to control the depth strata that are sampled. Stratified sampling for mesozooplankton provides invaluable detail on diel vertical migration (capturing the daytime deep water residing animals), and/or the presence of seasonally – migrating mesozooplankton – that characterise subantarctic waters but not subtropical. Given the nature of this voyage, the EZ net would provide a great opportunity to characterise differences in the spring mesozooplankton communities across the subtropical convergence and the relative strength of diurnal migration. This would be a major step up in our knowledge base and would add to the detailed characterisation of the spring condition in these water masses.

Multicorer deployment: Surface sediment cores (0 to 30 cm) will be collected on and off the Tasmanian shelf and at the three process stations. Cores will be evaluated for integrity upon recovery, sectioned inside a nitrogen-filled glove bag, and centrifuged to extract pore fluid for trace metal and rare-earth analysis.

Kasten gravity corer: Longer sediment cores (0 to 4 m) will be collected at the three process stations. Cores will be evaluated for integrity upon recovery and subsampled for shore-based analyse. These will complement multicorer deployments. We hope to obtain one core at each of the process stations. Core barrels will 4 m in length.

Supplementary Project: Seabirds

The observations on this voyage will complement existing data from the survey area collected between 1980 and 2005. These earlier data were collected from Antarctic Division research and resupply voyages. The early data were collected between Tasmania and the Antarctic, and the spatial and temporal overlap between current voyage and previous efforts allow integration of the data sets. Seabird observations will commence immediately following departure and continue while the vessel is underway and during daylight hours. At least one student will be on the seabird team, allowing for their training in seabird observation protocols. Incidental observations of marine mammals, marine debris and kelp masses at sea will be recorded consistent with previous surveys.

Results

The results presented below follow the objectives of the voyage outlined above and were generally associated with the equipment deployed to meet those objectives.

TRIAXUS: A number of Triaxus tows were conducted during the voyage. The tows provided detailed information on upper water column biogeochemistry. The results look very interesting and will complement the underway sampling. Appendix Figure 2 highlights some of the Triaxus data.

CTD sampling: Water column sampling: Depth profiles for dissolved oxygen, temperature, salinity and fluorescence were logged via *in situ* instruments during 25 deployments at 12 stations using a 36 Niskin bottle (12L) CTD rosette. Unfiltered seawater subsamples were taken from multiple depths on all casts for shipboard nutrient measurements and for cross-calibration of dissolved oxygen and salinity measurements (MNF). Seawater samples were taken to reconstruct nutrient profiles and investigate physical water mass attributes in addition to information pertaining to marine biota and bacterial composition. The resultant information from these samples will support research projects across a multitude of disciplines including seabird distributions, ocean acidification research and investigation into primary production.

Primary samples: Seawater samples were taken at multiple depths on 14 casts, for shore-based POC/PON analysis and shipboard chlorophyll *a* measurements, shipboard Flow cam measurements and LIFT Fast Repetition Rate Fluorometry, shipboard Flow cytometry and shore-based DNA analysis, shore-based 15N measurements, shore-based biogenic silica measurements.

TMR and ISP sampling: Dissolved and particulate concentrations of iron and other trace metals were collected and will be measured at lower vertical resolution (because the methods are more time-consuming). That said, they will also provide estimates of trace metal supply into the upper ocean.

Water column sampling: Water-column trace metal samples were collected during 18 deployments at 12 stations using a dedicated trace-metal rosette with 12 modified Niskin bottles (10 or 12 L); subsampling was conducted in a clean van. On all casts bottles were first sub-sampled for shipboard Fe(II) analysis (0.2 µm filtered seawater; H. Aflenzer, UTAS), shipboard H2O2 analysis (unfiltered seawater, P. Latour, UTAS), and shipboard nutrient analysis (unfiltered seawater, MNF). From all depths, filtered seawater (0.2 µm) was collected for shore-based analysis of total dissolved trace elements and stable isotope composition.

Ancillary samples for offline filtration of trace metal particle samples were collected from the upper 150 m at the following stations: TS5(TMR1), TS6(TMR2), TS8(TMR5), PS3(TMR11), TS2(TMR13), PS2(TMR15), TS1(TMR16), PS1(TMR17). Filtered seawater samples for Cu(I) analysis were collected from the upper 200 m at the following stations: PS3(TMR11), PS2(TMR15), TS1(TMR16), PS1(TMR17). Filtered seawater samples for analysis of Cr and Ni stable isotope composition and Cr speciation were collected at the following stations: TS8(TMR6), PS3(TMR11, Cr redox samples collected from conventional CTD rosette), PS2(TMR14, TMR15), PS1(TMR17, TMR18).

Particulate sampling: Water-column particle sampling was conducted at 4 stations (TS8, PS3, PS2, and PS1) during 7 deployments using 6 modified McLane pumps with 2 filter heads; each pump was loaded with (1) acid-cleaned 142 mm 0.2 µm Supor filter and (1) pre-combusted 142 mm GFF filter. Subsampling was conducted in a clean van. Supor filters were divided in half for future shored-based analysis for trace metal concentrations and stable isotope composition; GFF filters were subsampled for shore-based POC/PON analysis and δ15N analysis.

Eighteen trace metal rosette casts were analysed for dissolved iron (II) (dFe(II); filtered) and hydrogen peroxide (H2O2; unfiltered). In situ observations of dFe(II) and H2O2 concentrations were made, with the latter being an indicator for the decay for dFe(II) over time. Furthermore, atmospheric trace metals and rain samples were collected as part of Morgane Perron's project entitled under the aspect of 'Natural iron fertilisation of oceans around Australia – linking terrestrial dust and bushfires to marine biogeochemistry'.

In situ primary production: Four 'simulated in situ' 14Carbon / 55Iron uptake incubations (IS 1-4) were completed during the voyage, one at each process station and one at Transit Station 9 (total of 336 samples). For each incubation, six 310 mL samples were prepared from water collected pre-dawn from 4 depths (15 – 70 m) using the trace metal rosette (TMR). The samples were incubated with tracer amounts of 55Fe (0.2 nmol L-1) and 14C (15 µCi) in six light-attenuating mesh bags (simulating light levels from which the water samples were collected) at ambient seawater temperature (~10-20 °C) in the deckboard incubator for 24 hrs. The samples were then processed as follows: 2 size-fractionated (0.2, 2.0 and 20 µm porosity 47 mm polycarbonate (PC) filters), washed with TiEDTA citrate solution to remove extracellular iron and hence determine intracellular Fe:C ratios, 2 size-fractionated without the TiEDTA citrate wash to determine both intra- and extracellular Fe, 1 total (> 0.2 µm; no TiEDTA citrate wash), and 1 dark 'control' (> 0.2 µm no TiEDTA citrate wash). 14C and 55Fe incubations were also conducted at the final sampling point of the two Mn/Fe/H2O2 deckboard experiments. All 14C/55Fe-labeled samples were size-fractionated (0.2, 2.0 and 20 µm) and washed with TiEDTA citrate solution.

Incubations: A number of incubation experiments were undertaken during the voyage: 1) An incubation experiment with the overall aim of examining the impacts of reactive oxygen species (ROS) on phytoplankton growth was conducted. In parallel to the assessment of H2O2 along the transect, phytoplankton cultures were incubated in the Northern and in the Southern area of the voyage. Different treatments for limitation and stress observations were applied: Manganese, iron and H2O2 and combinations were added to investigate the effect of H2O2, considering peroxide as a reactive oxygen species on carbon and iron uptake. The experiments lasted from 5 to 8 days.

An 8-day shipboard incubation experiment was conducted to investigate the biogeochemical cycling of copper (Cu), iron (Fe), zinc (Zn) and silicon (Si) under a range of light conditions: Dark (Bag 1), ambient light (Bag 2 and 4) and UV filtered light (Bag 3). The experiment was sampled every 48 hours for a number of parameters, including POC:PON, biogenic silica, silicon isotopes, particulate metals, dissolved metals, chlorophyll a, FRRF, flow cytometry, flow cam and nutrients.

EZ Net: The EZ net was deployed at PS03 and PS02 to compare day and night distribution of zooplankton and draw conclusions for the active carbon transport during their diel vertical migration (DVM). Samples for detailed community composition were preserved in formaldehyde and will be analysed at IMAS after the cruise. For the same reason, different depths were sampled with the Bongo net (200, 150, 100 and 50 m to surface, respectively) at all three process stations to compare different sampling methods. Animals from each depth of both nets were frozen for POC/PON and lipid analyses at -80˚C.

To complement deployments of the EZ net the Bongo net was also used to collect animals in the upper 150 m of the water column for incubation experiments. Faecal pellet production rate could be calculated at PS03, though we had difficulties of algae contaminating the samples, which limited the number of copepods suitable for our experiments. At PS02 and PS01, the sinking rate of dead zooplankton, the main contributors to the marine carbon flux at this early stage of the phytoplankton bloom, was calculated using the SETCOL approach. Also, the bacterial decomposition rate of carcasses was estimated by measuring the oxygen decline around carcasses over 48 hours.

Multicorer deployment: A total of 7 multicores deployments were attempted on IN2018_V04 between 4 sites. 3 of the 7 deployments were successful resulting in the collection of 13 cores. Multi-core samples are primarily being targeted for paleoclimate and element cycling studies. Specifically, pore waters from the multi core have been designated to evaluate the sediments as a potential source of rare earth elements (REEs) and iron(II) to the overlying water column. Additionally, pore waters are being used to evaluate the cycling of emerging metal isotope paleoproxies during early diagenesis. Sediments are being analysed for REEs, trace metals, radiolarian content, and sedimentation rate.

MC04 and MC05 (table 1 in the appendix) were both considered failed deployments, however, ~500cc of sediment was recovered in 1 tube during each deployment. This recovery allowed us to determine the reason for failure (sediment too hard for multi-core penetration) and sediment composition. MC04 consisted of red clay, forams (10-20%), and was determined to be radiolarian rich using smear slides. MC05 was foram dominated calcareous ooze as expected from nearby KC03.

Kasten gravity coring: Seven Kasten Core operations took place at four sites during IN2018_V04. A 4m core barrel was used for all attempts. Four operations successfully returned sediment cores (Appendix Table 1). Sampling intervals and sequence were determined upon measuring the retrieved core length and ranged from 5cm intervals (KC03) – 6cm (KC02) intervals. In addition to the above samples, bulk sediment samples were taken from KC02 and KC06 and two small u-channel samples.

An archive record of each Kasten core was collected in large (10cm x 10cm) and small (2.5cm x 2.5cm) u-channels for storage at Geoscience Australia to be used for XRD and Magnetic Susceptibility measurements. Samples taken from Kasten Cores during IN2018_V04 will be used for radiolarian based palaeoclimatic reconstructions, neodymium/strontium isotope analysis, organic-bound N isotope composition (10 cc sample) as well as Cr, Fe, Ni, Zn, Cd stable isotope composition (15-20 cc sample).

<u>Supplementary Project: Seabirds</u>

More than 8,000 birds from more than 30 species were recorded during the survey. Approximately 12-13 hours of observations were made each day, comprising transit and stations. Observations commenced at sunrise and continued to sunset, depending on light conditions. In addition, records of marine mammals (cetaceans and seals) were also undertaken. All survey data will be submitted to GBIF later in 2018 or early 2019 once data checking has been completed.

Voyage Narrative

All times in the Voyage Narrative are relative to local shiptime, i.e. UTC + 10 hours.

Tuesday 11 September

We departed Hobart at 1 pm which was ahead of schedule. Due to unfavourable weather conditions south of Australia, at Process station 1, the decision was made to head northward to Transit station 5.

Wednesday 12 September

After an overnight transit to Transit station 5, we arrived at around noon in ~1700 m of water. The CTD was deployed to 1500 m and samples collected for nutrients, biogenic silica, Chlorophyll a, POC/PON, flow cytometry, DNA, nitrogen isotopes and dissolved oxygen. Following the CTD cast, the Kasten corer was deployed. A 40 cm of sediment was collected. Below 40 cm there was a hard basement layer, which stopped full penetration of the corer. The trace metal rosette was then deployed to collect trace metal samples between 0 and 1500 m. Finally, the multicorer was deployed and 3 short corers collected. These cores were sectioned, and pore water samples collected for rare-earth, trace metal, and iron isotope analysis. Visual and microscope analysis of the sediment revealed an abundance of foraminifera within the cores.

During our transit to and from this site, the FIRe instrument has been collecting underway data to determine the photosynthetic health of the resident phytoplankton population.

Thursday 13 September

After transiting for ~12 hours, we arrived at Transit station 6 at around 6 pm. The CTD was deployed to 1500 m and samples collected for nutrients, biogenic silica, Chlorophyll a, POC/PON, flow cytometry, DNA, nitrogen isotopes and dissolved oxygen in the upper water column. The trace metal rosette was then deployed to collect 1L trace metal samples between 0 and 1500 m. Additional samples were taken for peroxide and iron(II) analysis. The CTD was then redeployed at 10 pm. Samples were collected from 10 m off the bottom (~4500 m) and throughout the water for salinity, temperature and nutrients.

Friday 14 September

The deep water CTD cast was followed up with the deployment of the trace metal rosette. Samples were collected between about 4500 and 1500 m. These samples were collected into 1L bottles for metal isotope analysis. Additional samples were taken for peroxide and iron(II) analysis.

After approximately a 12-hour transit we arrived at Transit station 7. This station was located in a warm core eddy. The CTD was deployed to 1500 m and samples collected for nutrients, Chlorophyll a, POC/PON, flow cytometry, biogenic silica, DNA, nitrogen isotopes and dissolved oxygen in the upper water column. The fluorescence trace from the CTD showed a deep mixed layer (~200 m). Preliminary nutrient results also showed a step in the concentration profile at 500 m, perhaps indicating the base of the warm core eddy?

Saturday 15 September

The trace metal rosette was then deployed to collect 1L trace metal samples between 0 and 1500 m along with samples for peroxide and iron(II) analysis. The CTD was then redeployed at 10 pm. Samples were collected from 10 m off the bottom (~4500 m) and throughout the water for salinity, temperature and nutrients. There were a few issues with the spooling of the CTD cable onto the CTD winch which resulted is some loss of time. Due to time constraints, a deep-water trace metal cast was not undertaken. Around 9 am we left the site and steamed to Transit Station 8.

We arrived at Transit Station 8 at around 7 pm. The CTD was deployed to 1500 m and samples collected for nutrients, biogenic silica, Chlorophyll a, POC/PON, flow cytometry, DNA, nitrogen isotopes and dissolved oxygen in the upper water column. The fluorescence trace from the CTD profile showed a shallow mixed layer (0-25 m) followed by a significant step in the fluorescence signal at 25-30 m. The trace metal rosette was deployed after the CTD, and 2L samples were collected between 0 and 1500 m metal isotope analysis.

Sunday 16 September

Sampling at Transit Station 8 continued with the deployment of a deep CTD. This was sampled for nutrients etc. Following retrieval of the CTD, the trace metal rosette was deployed to collect water for a primary production experiment and to set up an incubation experiment. However, the rosette failed. It seemed that the TMR battery was flat even though it had been discharged and recharged a day earlier. Six in-situ pumps were deployed between 40 and 500 m for two hours from 6 am. Filter samples were collected for trace metal, POC/PON and isotope analysis. The last operation at this site was the deployment of the trace metal rosette to 4000 m. Samples were collected for metal, peroxide and iron(II) analysis.

After arriving at Transit Station 9 at around 23:30 pm, the trace metal rosette was deployed to 1500m. There were some issues with wire angle as the rosette drifted under the vessel.

Monday 17 September

The trace metal rosette was recovered and sampled for trace elements. The CTD was then deployed to 1500 m and sampled for the usual parameters of interest – nutrients, biogenic silica, Chlorophyll a, POC/PON, flow cytometry, DNA, nitrogen isotopes and dissolved oxygen – upon retrieval. The trace metal rosette was redeployed to collect water for a primary production and incubation experiments. A deep CTD followed the trace metal rosette deployment and reached a depth of ~ 4750 m. There was quite a strong upper ocean current with the ship moving at ~2 knots. The trace metal rosette was deployed to 4000 m, and samples were collected for metal, peroxide and iron(II) analysis. After all operations were finished, the Triaxus was deployed. It went into the water at around 4:30 pm. It took time to set it up to undulate between 5 and 200 m. The optimum tow speed was 8 knots, and the optimal wire out was between 1150-1200 m. The decent/ascent speed of 1.0m/s worked okay. Sometimes the 1.45-ton tow strain was reached. This was reduced by going slower or changing the decent/ascent rate. The data streams temperature, salinity, fluorescence, dissolved oxygen and nitrate were all good. However, about 2 hours into the tow the nitrate sensor (SUNA) stopping sending back data.

Tuesday 18 September

Triaxus was retrieved at around 4 am and the redeployed at 6 am. However, the primary oxygen and salinity sensors had stopped working so Triaxus was pulled from the water. We continued steaming southward. At around 3 pm Triaxus was redeployed and towed until we reached transit station 4.

Wednesday 19 September

Triaxus was retrieved around 3 am and CTD operations began at 4 am. The CTD was then deployed to 1500 m and sampled for the usual parameters of interest – nutrients, biogenic silica, Chlorophyll a, POC/PON, flow cytometry, DNA, nitrogen isotopes and dissolved oxygen – upon retrieval. At 6 am the trace metal rosette was deployed. The rosette reached a depth of around 4200 m. Samples were collected for trace metal analysis. There was an issue with the rosette battery going flat during the cast resulting in the loss of two depth samples. This is the second time that this has happened and might indicate a faulty battery. A deep CTD followed the trace metal rosette deployment and reached a depth of ~4750 m. The deep CTD was sampled for nutrients, dissolved oxygen and salts. The final deployment of the day was trace metal cast to 1500 m. The rosette worked okay after being recharged. We left transit station 4 at 16:30.

Thursday 20 September

We arrived at Process station 3 at around 4 am. The trace metal rosette was deployed to collect water for a primary production experiment. These experiments were aimed at determining the rates of iron and carbon uptake by phytoplankton. At 5 am we mapped a newly undiscovered underwater volcanic plateau rising to a depth of between 3500 to 2300 m for a suitable site to core with the Kasten corer. On the northern side of the plateau, a suitable area was identified, and the Kasten corer deployed at 8 am. A 3.2 m long core was recovered from a water depth of 3348 m. The top of the core seemed to be intact, and there were various laminations throughout the core. A top-core smear slide indicated the presence foraminifera, diatoms and radiolaria, in addition to a significant amount of clastic and quartz material.

The EZ was deployed at 12.15pm and towed for about 1 hour before the conducting cable holding the EZ net failed. The EZ was recovered thanks to a safety cable. Zooplankton samples were recovered from 200, 150 and 100 m. Samples from 50 and 10 m were not recovered due to cable failure. The trace metal rosette was deployed at 2 pm down to a depth of 1250 m and sampled for trace metals. The CTD was deployed at 4 pm to 1500 m and sampled for nutrients, biogenic silica, Chlorophyll a, POC/PON, flow cytometry, DNA, nitrogen isotopes and dissolved oxygen. The multicorer was deployed northern side of the plateau at the same site as the Kasten corer. Four 20-40 cm cores were recovered. Cores were sectioned and sampled for porewaters and isotope analysis.

Friday 21 September

Bongo nets were deployed to between 0 and 100 m. Zooplankton samples were collected, animals collected and incubated. A deep CTD followed the Bongo nets. This was deployed to around 4800m and sampled for nutrients, biogenic silica and silicon isotopes. At 7 am the tow fish was deployed, and trace metal clean seawater was pumped into four 200 L incubation bags. Samples were also collected for trace metals, silicon isotopes, and biological parameters. The six ISP were deployed to 500 m. Filter samples were collected for trace metal, POC/PON and isotope analysis. The multicorer was deployed northern side of the plateau in deep water 4700+ m of water. All six core tubes came back full of mud (~50 cm). Cores were sectioned and sampled for porewaters and isotope analysis.

Saturday 22 September

Following the multicorer the plateau north of the deep-water site was swath mapped. The plateau was similar to the one further south reaching depths of around 2500 m. It appeared rocky hard with little sediment on top of the plateau. On its northern flanks, there appears to be soft sediment at ~3500 m. At 5 am a deep-water ISP cast was deployed to 1000 m. Samples were collected for trace metal, isotope and POC/PON analysis. At 10.30 am a shallow (1500 m) CTD was undertaken. Bongo nets were deployed to between 0 and 100 m at 12 pm. Zooplankton samples were collected, animals collected and incubated. A deep trace metal rosette cast (4500 m) was undertaken at 2 pm. The battery failed on this deployment with no bottles firing. We left Process station 3 swath mapping along a southward track across the seamounts.

Sunday 23 September

We arrived at transit station 3 at 8am. The CTD was deployed to 1500 m sampled for nutrients, biogenic silica, Chlorophyll a, POC/PON, flow cytometry, DNA, nitrogen isotopes and dissolved oxygen. The trace metal rosette was deployed at 10 am after the CTD and 1L samples were collected between 0 and 1500 m. A deep CTD followed the shallow trace metal rosette cast. The weather deteriorated so a deep trace metal cast was not undertaken.

Monday 24 September

At 6am the CTD was deployed to 1500 m sampled for nutrients, biogenic silica, Chlorophyll a, POC/PON, flow cytometry, DNA, nitrogen isotopes and dissolved oxygen. The trace metal rosette was deployed at 8 am after the CTD. Upon retrieval, at around 10 am, the rosette frame hit the ship and 7 bottles were broken. The bottles were removed from the rosette frame and the 5 unbroken bottles sampled for trace metals. A deep CTD followed the trace metal rosette deployment. Again, Triaxus was not deployed.

Tuesday 25 September

At 6 am the CTD was deployed to 1500 m sampled for nutrients, biogenic silica, Chlorophyll a, POC/PON, flow cytometry, DNA, nitrogen isotopes and dissolved oxygen. A deep CTD followed the shallow cast. Bongo nets were deployed to between 0 and 200 m at 12 pm. After the Bongo nets the seafloor structures were mapped for a suitable Kasten coring site.

Wednesday 26 September

At 4 am the ANU trace metal rosette was deployed to collect water for a primary production experiment. These experiments are aimed at determining the rates of iron and carbon uptake by phytoplankton. A 6 am the six ISPs were deployed to 500 m. Filter samples were collected for trace metal, POC/PON and isotope analysis. Two Bongo net casts down to 150m were undertaken to collect zooplankton. This was followed by an EZ net tow down to 200m at 12 pm. At 2 pm the ANU trace metal rosette was deployed to collect water down to 1500 m for trace metal and isotope analysis. At 5:30 pm the Kasten corer was deployed to collect a sediment core from a small caldera at 3,670 m. A 3.2 m core was recovered. The sediment material was quite sloppy. Samples were collected for XRF, magnetic susceptibility, and isotope analysis. This was followed by an EZ net tow down to 200 m.

Thursday 27 September

The multicorer was deployed northern side of the plateau in deep water 4900+ m of water. One core tube came with a small amount of mud (~10 cm). At 6 am the ANU trace metal rosette was deployed to collect water down to 4500 m. Samples were collected for metal, peroxide and iron(II) analysis. Bongo nets were deployed to between 0 and 200 m at 11 am to collect copepods for carbon production experiments. At 1 pm six ISPs were deployed to 1000 m. Filter samples were collected for trace metal, POC/PON and isotope analysis. The multicorer was deployed at 6 pm to collect sediment cores from a small caldera at 3,670 m. However, the tubes came back with only a small amount of mud (~10 cm). A CTD to 1500 m followed the multicorer at 10 pm.

Friday 28 September

At 12 am Bongo net deploys to between 0 and 200 m. A 4 am we left Process station 2 tow Triaxus at 7-8 knots. At around 12:30 pm Triaxus was retrieved due to an issue with the system.

Saturday 29 September

At 9.30 am the CTD was deployed to 1500 m sampled for nutrients, biogenic silica, Chlorophyll a, POC/PON, flow cytometry, DNA, nitrogen isotopes and dissolved oxygen. At 11 am the ANU trace metal rosette was deployed to collect water down to 1500 m for trace metal and isotope analysis. All further casts were halted after this due to rough weather conditions.

Sunday 30 September

Transit day to the SOTS site.

Monday 1 October

At 10.30 am the CTD was deployed to 1500 m sampled for nutrients, biogenic silica, Chlorophyll a, POC/PON, flow cytometry, DNA, nitrogen isotopes and dissolved oxygen. Bongo net casts down to 150m were undertaken to collect zooplankton. The trace metal rosette was deployed, and samples collected between 0 and 1500 m. At 7 pm the CTD was deployed and samples collected between 0 and 4500 m. Samples were collected for POC, HPLC pigments, alkalinity, DIC and the usual suite of CTD samples. At 10.30 Bongo net were deployed to 200m to collect zooplankton.

Tuesday 2 October

At 1 am six ISPs were deployed to 500 m. Filter samples were collected for trace metal, POC/PON and isotope analysis. At 4 am the ANU trace metal rosette was deployed to collect water for a primary production experiment. The Kasten corer was deployed at 6 am but failed to obtain a core. This was followed by Bong nets and then a shallow CTD (300 m) to collect particles for silicon isotope analysis. The Kasten corer was deployed again but failed to obtain a core. The ANU trace metal rosette was deployed to collect water down to 4500 m metal and isotope analysis. All further casts were halted after this due to rough weather conditions. The area around process station 1 was mapped to find suitable coring sites.

Thursday 4 October

Six ISPs were deployed at 6:30 am to 1000 m. Filter samples were collected for trace metal, POC/PON and isotope analysis. After a transit of about 2 hours the Kasten corer was deployed at ~3 pm and return 2.8 m of core. The core shows defined changes in colour and likely represents at least 1 to 2 interglacial-glacial cycles. At 8 pm Triaxus was deployed.

Friday 5 October

Triaxus was retrieved at 8 am and the multicorer deployed at 9.30 am. Unfortunately, the multicore failed. The fish was deployed at 1 pm and clean seawater collected for experiments ashore. 6.15 pm the Kasten corer was deployed. A 3.6 m core was collected. The core has lots of layering. The multicorer deployed at 11 pm unfortunately it failed for a second time. The problem was the same as the earlier in the day where by one of the corer tubs was shaken out of its holder thereby obstructing the corer.

Saturday 6 October

At 4 am we left Process station 1 to head home. Triaxus was deployed upon leaving the site. At 5 am it was retrieved due to a loose sensor. At 6 am it was redeployed. We continued steaming during the day.

Sunday 7 October

Triaxus was retrieved at 11.30am.

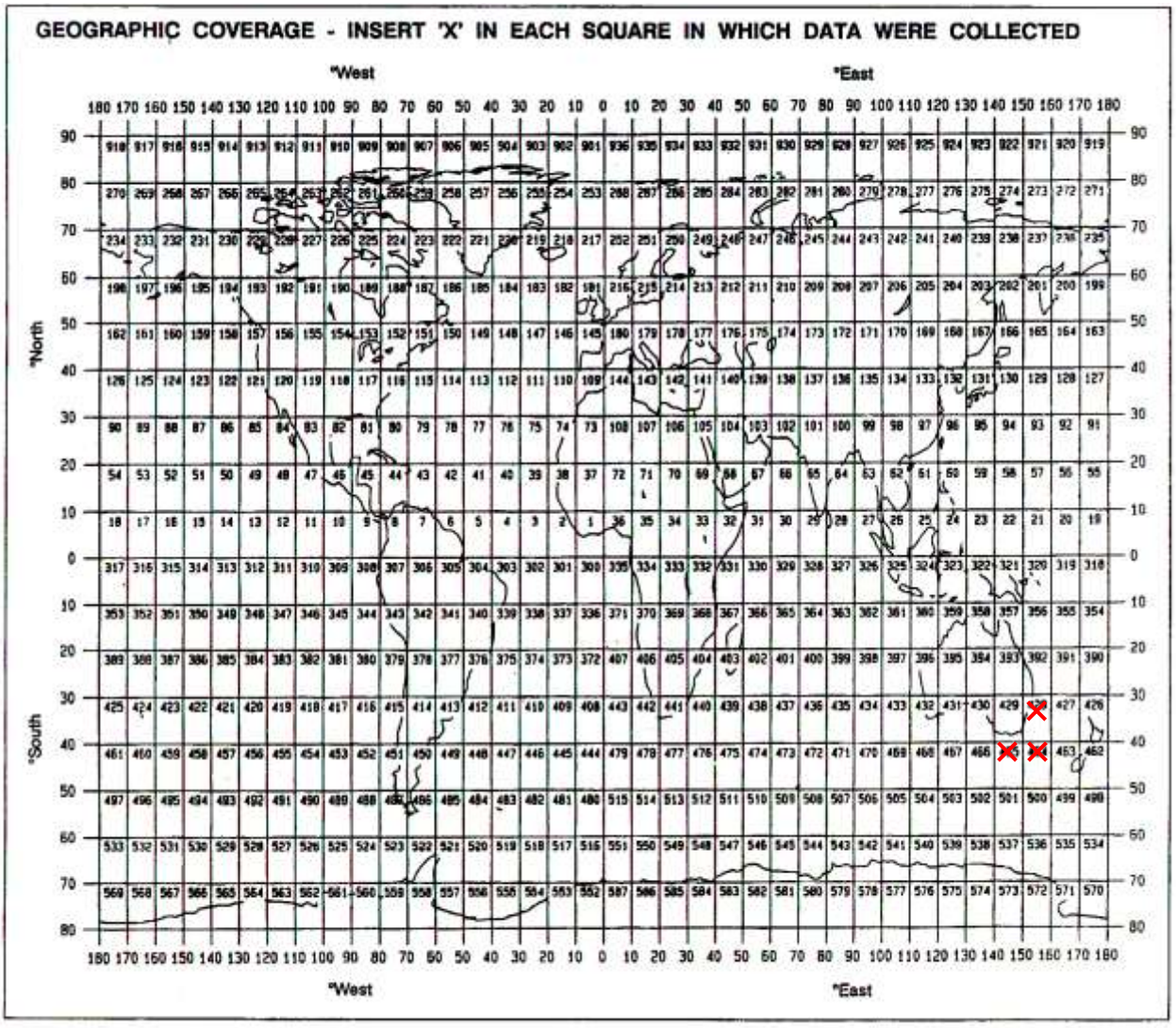
Summary

Overall IN2018_V04 has been a scientific success. We managed to complete all most all of the operations that were outlined in the voyage plan. We were able to sample at all of the stations listed in the voyage plan. We met the scientific objective of the voyage which was to sample the southern extension of the EAC during the annual springtime phytoplankton bloom. Along the voyage track, we were also able to collect water column and surface water samples and make underway measurements to understand the special and temporal variability of the springtime phytoplankton bloom. We also collected cores from the three process stations thereby providing us with a window back into the past when conditions were similar and different from the present day. Overall the voyage was highly successful.

Marsden Squares

Move a **red "x"** into squares in which data was collected

× × ×



Summary of Measurements and samples taken

Item No.	PI see page above	NO see above	UNITS see above	DATA TYPE Enter code(s) from list at Appendix A	DESCRIPTION
1	R. Strzepek	4	stations	B01	Size-fractionated (0.2, 2.0, and 20 µm) primary productivity and iron uptake measurements (n = 336) were made at 4 stations (Transit Station 9 and Process Stations 1 -3) on seawater samples collected using trace metal rosette at four depths (15 - 70 m).
2	M. Ellwood	12	stations	H30, H32	Filtered (0.2 µm) seawater samples (n=212) collected using trace metal rosette; full-depth profiles for shore-based analysis of trace element concentrations and stable isotope composition
3	M. Ellwood	4	stations	H30, H32	Particle samples (n=42) collected onto 0.2 µm Supor filters using McLane pumps in the upper 1000 m for shore-based analysis of trace element concentrations and stable isotope composition
4	M. Ellwood	4	stations	B71	Particle samples (n=42) collected onto GFF filters using McLane pumps in the upper 1000 m for shore-based analysis of POC/PON
5	M. Ellwood	8	stations	H30	Particle samples (n=48) collected onto 0.2 µm PCTE filters by offline filtration of seawater collected from trace metal rosette in the upper 150 m for shore-based analysis of of trace element concentrations
6	M. Ellwood	4	stations	H30	Filtered (0.2 µm) seawater samples (n=24) collected using trace metal rosette from the upper 200 m for shore-based analysis of Cu speciation
7	H. Heynderickx	12	stations	H10, B07, B08	Filtered (0.2 µm PES filter) seawater samples (n=104) collected using CTD rosette; photic zone profiles for shore-based DNA analysis of bacteria and phytoplankton interactions
8	H. Heynderickx	3	stations	H10, B07, B08	Filtered (1.2 µm PES filter) seawater samples (n=24) collected using CTD rosette; photic zone profiles (8depths) for shore-based DNA analysis of bacteria and phytoplankton interactions
9	H. Heynderickx	12	stations	H10, B02	Seawater samples (n=104) collected using CTD rosette ; photic zone profiles (8depths) processed with a flow cytometer on board
10	Helene Aflenzer, Pauline Latour	18	TMR cast	H30	Vertical profiles of dissolved iron(II) and H2O2 concentrations were measured directly after water collection from all the TMR casts (shallow + deep) using a Flow Injection Analysis (FIA) system.

Item No.	PI see page above	NO see above	UNITS see above	DATA TYPE Enter code(s) from list at Appendix A	DESCRIPTION
11	Helene Aflenzer, Pauline Latour	40	filters	M71	Aerosol samples were collected on filters in the aerosol lab under trace metal conditions. These filters are brought back to IMAS for further analysis (ICP-MS).
12	Helene Aflenzer, Pauline Latour	1	event	M90	A single rain sample was collected in trace metal conditions at TS4. Several treatments were applied (filtration and acidification, only acidification, frozen at -80°C). Further analysis will be done on land (ICP-MS). Dissolved iron(II) and H2O2 concentrations were also measured onboard in rain sample.
13	Helene Aflenzer	2	cores	G04	Dissolved iron concentrations were measured (FIA) from 11 porewater samples collected from two multicores.
14	Pauline Latour, Robert Strzepek	2	TMR	B01, B02, B08	Primary productivity and iron uptake measurements (n = 144) were made at 2 stations with different spiking and incubation times. Seawater collected at 15m was used to incubate phytoplankton for 5 days (prim prod. Cast 1) and 8 days (Process Station 2) and different treatments were administrated (Fe, Mn, H2O2 and combinations). Radiolabelled elements (C, Fe) were added 24h before the end of the experiment for uptake measurements. Samples for Fast Repetition Rate fluorometry (FRRF) and flow cytometry were also collected (n = 96 and 48, respectively).
15	Svenja Halfter	3	stations	B09	Zooplankton samples were taken in the upper water column (down to 200 m) at the three process stations, using a Bongo (Process station 1-3) and an EZ net (Process station 2-3). Zooplankton was either used for incubation experiments or preserved in formaldehyde or frozen in -80C.
16	Svenja Halfter	3	stations	B71	Water from the CTD was filtered for PON/POC analyses of the following depths at the three process stations: 5, 50, 100, 150 and 200 m.
17	Svenja Halfter	3	stations	B72	Water from the CTD was filtered for lipid analyses of the following depths at the three process stations: 5, 50, 100, 150 and 200 m.
18	Svenja Halfter	3	stations	B07	Water from the CTD was taken for analyses of bacteria numbers of the following depths at the three process stations: 5, 50, 100, 150 and 200 m.
19	R. Strzepek	12	stations	H10, B02, B08	Seawater samples (n = 120) collected by CTD rosette for flow cytometry (preserved with 2% glutaraldehyde), Flow Cam microscopic analysis, and FRRF.
20	R. Strzepek	4	TMR	B02, B08	Seawater samples (n = 16) collected by trace metal rosette for flow cytometry (preserved with 2% glutaraldehyde), Flow

Item No.	PI see page above	NO see above	UNITS see above	DATA TYPE Enter code(s) from list at Appendix A	DESCRIPTION
					Cam microscopic analysis, and Fast Repetition Rate fluorometry (FRRF).
21	R. Strzepek	20	Days	H71, B02	Surface water intake measurements of phytoplankton active fluorescence with FIRE FRRF; 1 sample / 10 seconds.
22	K. Lawler	4	Cores	G04	Kasten cores retrieved with 4 m core barrel. Sampled onboard for future analyses including radiolarian based palaeoclimatic reconstructions (Lawler), neodymium/strontium isotope analysis (Abbott), Trace metal and nitrogen stable isotope analysis (Janssen) and XXX (Chase).
23	D. Janssen	4	stations	H30, H32	Particle samples (n=42) collected onto 0.2 µm Supor filters using McLane pumps in the upper 1000 m for shore-based analysis of trace element concentrations and stable isotope composition.
24	D. Janssen	4	stations	H30, H32	Filtered (0.2 µm) seawater samples (n=66) collected using trace metal rosette; full-depth profiles for shore-based analysis of trace element concentrations and stable isotope composition
25	D. Janssen	4	stations	H30	Filtered (0.2 µm) seawater samples (n=66) collected using trace metal rosette and CTD Rosette; depth profiles for shore-based analysis of Cr redox speciation
26	D. Janssen	4	stations	H32, B71	Particle samples (n=42) collected onto GFF filters using McLane pumps in the upper 1000 m for shore-based analysis of 15N in organic-bound nitrogen.
27	D. Janssen	12	stations	H32, H75	Filtered (0.2 µm) and unfiltered seawater samples (n=179) collected using CTD Rosette for H. Ren (Taiwan U.); depth profiles for shore-based analysis of 15N.
28	S. Andrew	12	Stations	B02	Seawater samples were collected from the CTD rosette and filtered onto Whatman GF/F filters for chlorophyll a extraction. Samples were taken from 8 depths within the upper 300m. (n=112)
29	S. Andrew	12	Stations	B71	Seawater samples were collected from the CTD rosette and filtered onto Whatman GF/F filters for POC/PON analysis. Samples were taken from 8 depths within the upper 300m. (n=112)
30	M. Ellwood	4	underway	D90	Three discreet Triaxus tows and one multi-stop tow from PS1 to the Tasmanian shelf
31	M. Ellwood		underway	H71	Underway seawater water system was used to record primary seawater parameters during the voyage.
32	E. Woehler	8500	Seabirds	B25	Seabird observations collected between sunrise and sunset on every day of cruise. Almost 8500 individuals recorded from more than 30 species. All data are geo-referenced and

Item No.	PI see page above	NO see above	UNITS see above	DATA TYPE Enter code(s) from list at Appendix A	DESCRIPTION
					will be lodged with GBIF in 2018 or early 2019 following processing and checking.
33	Prayna Maharaj, Riteshma Devi	8	days	B02, B71, B08, H22, H24, H25, H76, H26, H30, H32	An 8 day shipboard incubation experiment was conducted to investigate the biogeochemical cycling of copper (Cu), iron (Fe), zinc (Zn) and silicon (Si) under a range of light conditions: Dark (Bag 1), ambient light (Bag 2 and 4) and UV filtered light (Bag 3). The experiment was sampled every 48 hours for a number of parameters; POC/PON, chlorophyll a, nutrient analysis, dissolved and particulate metal isotopes, biogenic silica and silicon isotopes.
34	Riteshma Devi	11	stations	H10	Seawater samples were collected from the CTD rosette and filtered onto PCTE filters for BSi/Si isotope analysis.
35	Riteshma Devi	22	events	H11	Seawater samples were collected from the Underway system and filtered onto PCTE filters for Si isotope analysis.

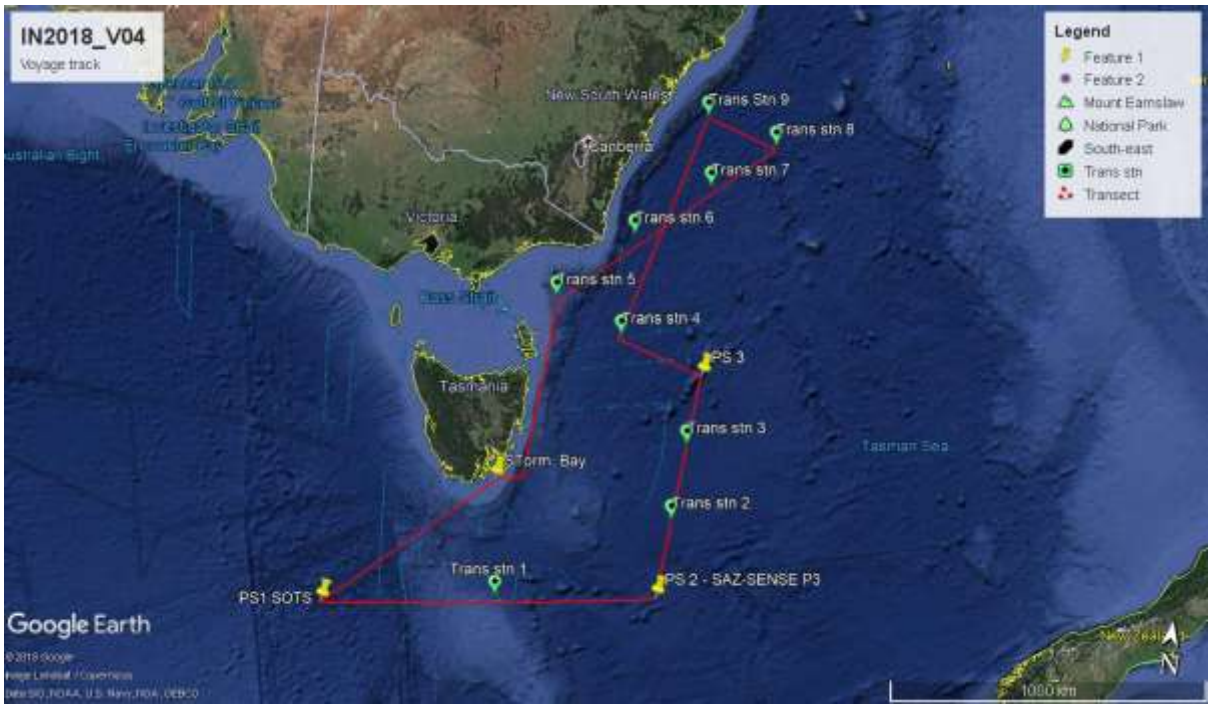
Curation Report

Delete section if not applicable.

Item #	DESCRIPTION
1.	Water and particle samples collected from the TMR and ISPs will be returned to the ANU for chemical analyses. Samples are consumed by analyses.
2.	Some water and sediment core samples collected from the Kasten and multicores will be returned to the ANU for chemical analyses and then discarded following quarantine protocols.
3.	Kasten core archive samples will be archived at Geoscience Australia.
4.	Primary water and sediment core samples collected from the Kasten and multicores will be returned to Macquarie University for chemical analyses and then discarded following quarantine protocols.
5.	SEABIRDS. All data will be lodged with GBIF in 2018 or early 2019 once data checking completed.

Track Chart

Figure showing the area of operation for IN2018_V04.



Personnel List

	Name	Organisation	Role
1.	Max McGuire	CSIRO MNF	Voyage Manager
2.	Rod Palmer	CSIRO MNF	SIT Support
3.	Trevor Goodwin	CSIRO MNF	SIT Support
4.	Amy Nau	CSIRO MNF	GSM Support
5.	Bernadette Heaney	CSIRO MNF	GSM Support
6.	Francis Chui	CSIRO MNF	DAP Support
7.	Steve van Graas	CSIRO MNF	DAP Support
8.	Cassie Schwanger	CSIRO MNF	Hydrochemist
9.	Stephen Tibben	CSIRO MNF	Hydrochemist
10.	Kendall Sherrin	CSIRO MNF	Hydrochemist
11.	Jay McGlashin	CSIRO MNF	Triaxus support
12.	Shanon Palmer	CSIRO MNF	Field Operations
13.	Mark Lewis	CSIRO MNF	Field Operations
14.	Michael Ellwood	ANU	Chief Scientist
15.	Pamela Barrett	ANU	TMR/ISP sampling
16.	Robin Grun	ANU	TMR/ISP sampling
17.	Prayna Maharaj	ANU	TMR sampling / Incubations
18.	Riteshma Devi	ANU	CTD sampling
19.	Sarah Andrew	ANU	CTD sampling
20.	Hanneloor Heynderickx	University of Otago	CTD sampling
21.	Svenja Halfter	UTAS	Zooplankton
22.	Phil Butterworth	UTAS	Zooplankton
23.	Robert Strzepek	UTAS	Primary production
24.	April Abbott	Macquarie University	PI – Mulitcorer sampling/Kasten coring
25.	Hannah Kumar	Macquarie University	Mulitcorer sampling
26.	Hannah Wilson	Macquarie University	Mulitcorer sampling
27.	Annabel Payne	Macquarie University	Mulitcorer sampling
28.	Kelly-Anne Lawler	Macquarie University	Kasten coring
29.	Dave Janssen	Uni of Bern	TMR/ISP sampling
30.	Helene Aflenzer	UTAS	Iron(II) aerosols
31.	Pauline Latour	UTAS	Peroxide chemistry
32.	Eric Woehler	Birdlife Tasmania	Piggyback PI – Bird watching
33.	Kelly Woolerton	Birdlife Tasmania (AusIndustry Innovation Program)	Bird watching
34.	Ms Zhichun Liu	Birdlife Tasmania (IMAS)	Bird watching

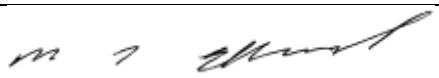
Marine Crew

Name	Role
Adrian Koolhof	Master
Gurmukh Nagra	Chief Mate
Andrew Roebuck	Second Mate
Samuel Edwards	Third Mate
Christopher Minness	Chief Engineer
Samuel Benson	First Engineer
Michael Sinclair	Second Engineer
Damien Wright	Third Engineer
Shane Kromkamp	Electrical Engineer
Gary Hall	Chief Caterer
Emma Lade	Caterer
Adrian Hughes	Chief Cook
Paul Stanley	Cook
James Hogg	Chief Integrated Rating
Peter Taylor	Integrated Rating
Daniel Morse	Integrated Rating
Dennis Bassi	Integrated Rating
Roderick Langham	Integrated Rating
Matthew Schmierer	Integrated Rating
Paul Langford	Integrated Rating

Acknowledgements

The science team are grateful to the MNF and ASP personnel for their excellent support at sea. The crew had to contend with some challenging conditions during some of the TMR, Triaxus, ISP, Kasten corer and multicorer recoveries and we are grateful for their efforts. We are also grateful to the MNF support staff for their wonderful efforts with regards to the mapping of the coring sites, the running of the Triaxus, deployment and maintenance of the Kasten corer and multicorer and for computational support at sea. Finally, the chief scientist would like to acknowledge support from the master Adrian Koolhof.

Signature

Your name	Michael Ellwood
Title	Chief Scientist
Signature	
Date:	7 October 2018

Appendix

Table 1: Core operations during IN2018_V04

Core	Site	Latitude (°S)	Longitude (°E)	Depth (m)	Core length* (cm)	# of cores	Initial Desc.
KC01‡	TS5	39°08.55	149°04.65	1673	n/a	--	Calc. ooze
MC01	TS5	39°08.53	149°04.66	1675	31	3/4	Calc. ooze
KC02	PS3	40°17.54	153°30.38	3347	323	--	Calc. ooze
MC02	PS3	40°17.42	153°30.39	3349	32	4/4	Calc. ooze
MC03	PS3	40°07.54	153°26.69	4882	60	6/6	Pelagic Clay
KC03	PS2	45°56.35	153°37.84	3920	312	--	Calc. ooze
MC04‡	PS2	45°56.03	153°31.4	4889	n/a	0/6	Clay/foram
MC05‡	PS2	45°56.27	153°37.83	3678	n/a	0/4	--
KC04‡	PS1	47°01.06	141°44.31	3177	n/a	--	Calc. ooze
KC05‡	PS1	47°01.54	141°44.92	3166	n/a	--	Calc. ooze
KC06	PS1	46°50.79	141°17.83	4069	277	--	Calc. ooze
MC06‡[1]	PS1	46°50.79	141°17.8	4068	n/a	0/4	--
KC07	PS1	46°48.21	142°15.15	4474	364	--	Calc rich clay
MC07‡[1]	PS1	46°48.18	142°15.18	4478	n/a	0/6	--

* Core length is exclusive of core catcher sediment for Kasten core, average core length for multi-core

‡ Unsuccessful coring operation

Number of cores = successful/tubes loaded

[1] Mechanical issue (core tube dislodged and jammed mechanism)