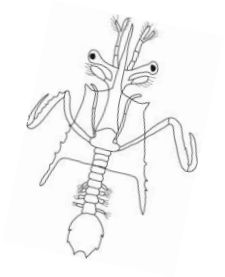
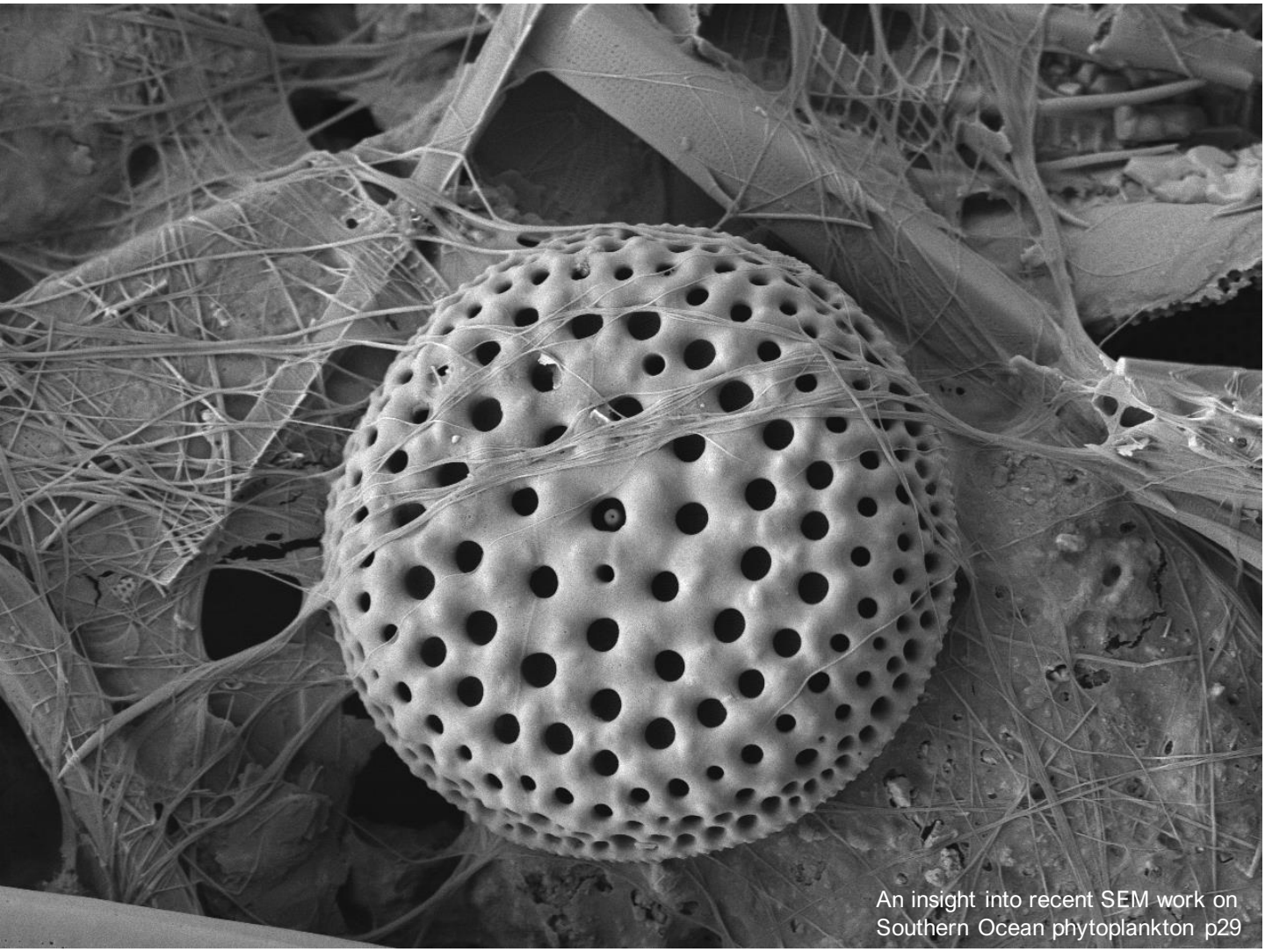
Issue 14
October 2022



IMOS Integrated Marine Observing System

IMOS
Australian Plankton Survey



An insight into recent SEM work on Southern Ocean phytoplankton p29

Continuous Plankton Recorder

31,457 Phytoplankton Colour Index segments counted
7,384 zooplankton segments counted
10,656 phytoplankton segments counted

157,285 nautical miles towed
199 trips processed

898,592 zooplankton counted
166,763 phytoplankton counted

National Reference Stations

910 zooplankton samples counted
908 biomass samples completed
832 phytoplankton samples counted

606,659 zooplankton counted
348,086 phytoplankton counted

WELCOME BACK

Welcome to our latest IMOS plankton newsletter. We missed the newsletter last year. It has been a difficult last 2 years for everyone with the pandemic. We know we have been lucky in Australia, but it has still taken its toll. I'd like to thank our IMOS Plankton Team – they have worked incredibly hard to keep on top of the workload during lockdowns. A special shout-out to Tonka and Frank for ensuring our Continuous Plankton Recorders are still sampling the oceans despite the challenges faced by the shipping industry.

Earlier in the year the IMOS Plankton Team got the opportunity to improve their taxonomic skills in a **LUCID workshop**. **Matt Taylor** and **Mike Rickerby** from LUCID presented the workshop in Brisbane where Anita, Julian and Frank were present, while Claire, Felicity, Fiona and Ruth attended online from Hobart. The workshop covered both LUCID keys and Fact Sheet Fusion. The workshop was very useful and introduced many features and solutions that were new. Mark and Matt made the workshop both informative and easy to follow. It was the first time they had combined a live and online workshop and were happy with the results and thus plan to deliver more this way. We look forward to putting the lessons from the workshop into practice to produce practical keys for a variety of plankton groups.

Something else we have been busy with was contributing to **Australia's State of Environment Report**. This opportunity was a consequence of our contributions to the **IMOS State and Trends of Australia's Oceans Assessment Report** (https://www.imosoceanreport.org.au/). Thanks to **Claire**, **Ruth**, **Wayne Rochester**, **Jason Everett**, **Gustaaf Hallegraeff**, Paloma Matis, and Iain Suthers for the collaboration and analysing the plankton data, and thanks to **Kerry Swadling** and **Penny Ajani** for reviewing our contributions. It is great to see the uptake of IMOS plankton data into ecosystem assessments.

I'd like to take this opportunity to highlight some of our recent papers. For example, we have published one in ***Ecography*** (and with the front cover too!) by **Max Campbell** (Campbell *et al.* 2021). Max did an Honours degree supervised by me, and Dave Schoeman at University of the Sunshine Coast. This is a great product of the **Global Alliance of CPR Survey (GACS)** community, with 32 GACS authors from around the world, including all the AusCPR team. The paper tests **Bergmann's Rule**, which posits that species are smaller in warmer areas (e.g. tropical sun bears are smaller than polar bears). Max tested Bergmann's Rule on copepod data from CPR surveys around the world (n=97,830 samples and 388 species). In support of Bergmann's Rule, Max found that body size decreased by 45.1% across the global temperature range, and that this could translate to a ~7.3% decline in copepod biomass under the high emissions warming scenario by 2100. No one has ever considered this before and these findings suggest a likely reduction in fisheries and carbon sequestration in the future.

Congratulations also to **Julian Uribe** on his paper describing the discovery of a **new species of ciliate from Moreton Bay** (Uribe-Palomino *et al*. 2021). The ciliate is epiphytic on the huge diatom *Palmerina ostenfeldii* and the paper formally describes and genetically characterizes it as *Vaginicola collariforma* sp. nov. Interestingly, the diatom had evolved folds where the ciliate attaches, so is not parasitic on the diatom. Observations suggest that rotational movement of the large *Palmerina ostenfeldii* cells driven by the ciliates may enhance exposure of chloroplasts to light and promote diffusive uptake of nutrients.

Also, well done **Felicity McEnnulty**, who led a collaboration of 25 scientists **synthesising Australia 's data on zooplankton biomass** (McEnnulty *et al.* 2020). She assembled 49,187 zooplankton biomass records from around Australia, stretching back to the 1930s. This dataset is an important contribution to initiatives to make historic data more available. We are using the zooplankton data to develop global maps of zooplankton biomass and to track long-term changes in zooplankton biomass.

I also wanted to mention the innovative work by **Charlie Hinchliffe** and **Iain Suthers** on **larval fish distribution in the East Australian Current** (Hinchliffe *et al.* 2021). This paper brought together **IMOS NRS fish larval data** with cruise data to show that the during summer when the East Australian Current is strongest, fish larval richness and abundance peaks in the south, but both peak in the north at all other times of year when the current weakens. They also showed that where the East Australian Current separates from the coast in NSW is a zone of marked changes in fish larval abundance and richness. This work highlights the importance of the IMOS time series for fish larvae – it's very disappointing that it is being discontinued because of funding cutbacks.

I also wanted to highlight our work on using **zooplankton data for ecosystem model assessmen**t. **Barbara Robson** (ex CSIRO, now AIMS) led a paper on **validation of the zooplankton component of eReefs** (Robson *et al.* 2020). **Claire Davies** was involved and has been excellent at showcasing IMOS plankton data. There was also a paper by **Ryan Heneghan** (QUT) on the **Zooplankton Model of Size Spectra** (ZooMSS), which is a global ecosystem model that predicts the global distribution of fish catches now and in the future under climate change (Heneghan *et al.* 2020). IMOS data were a key dataset in the validation of ZooMSS.

I also wanted to showcase the paper by **Penny Ajani**, with **Claire Davies**, **Ruth Eriksen** and myself, on **impacts of global warming on the PHB NRS** (Ajani *et al.* 2020). I think the coolest thing is that the Community Temperature Index, which reflects the temperature preference of the phytoplankton community, increased over time since the 1930s to the present. It is great to see the IMOS dataset put in context of the historical plankton data that Claire Davies has assembled over the years.

And finally, a paper led by **Claire Davies** described **changes in the zooplankton community along 110ºE transect as part of the second International Indian Ocean Expedition** (Davies et al. 2022). They found that as ocean temperature increased from south to north along the transect, zooplankton abundance and diversity also increased. The dominant copepod species preferentially fed on microzooplankton, although microzooplankton such as the mixotrophic Rhizaria, were consistently high.

I hope everyone will have a better year in 2023. Thanks once again Anita for your hard work editing the newsletter.

Anthony

References

Ajani PA, Davies CH, Eriksen RS, Richardson AJ (2020) Global warming impacts phytoplankton at a long-term Pacific Ocean coastal station. *Frontiers in Marine Science* 7: 576011. 11 pp

Davies CH, Beckley LE, Richardson AJ (2022) Copepods feeding on microzooplankton and Rhizaria dominate secondary producers in the oligotrophic Indian Ocean. *Deep Sea Research Part II* 202: 105136. 11 pp

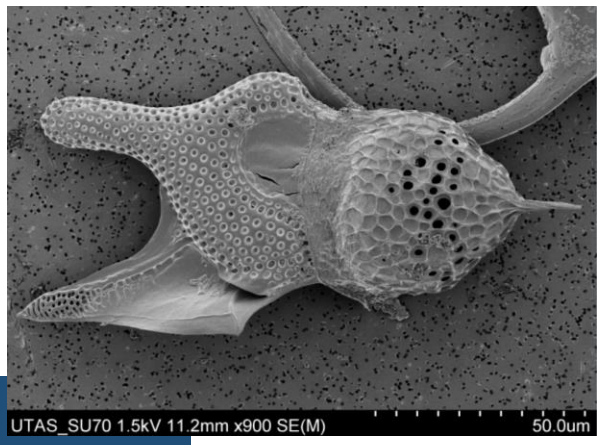
Heneghan RF, Everett JD, Blanchard J, Sykes P, Batten SD, Edwards M, Takahashi K, Suther IM, Blanchard JL, Richardson AJ (2020) A global size-spectrum model that resolves zooplankton community composition. *Ecological Modelling* 435: 109265. 18 pp.

Hinchliffe C, Smith JA, Everett JD, Falster DS, Lara-Lopez A, Miskiewicz AG, Richardson AJ, Schilling HT, Suthers IM. Larval fish distribution in a changing western boundary current (2021). *Reviews in Fish Biology and Fisheries*. https://doi.org/10.1007/s11160-021-09647-x

McEnnulty FR, Davies CH, Armstrong AO, Atkins N, Coman F, Clementson L, Edgar S, Eriksen RS, Everett JD, Koslow JA, Lønborg C, McKinnon AD, Miller M, O'Brien T, Pausina S, Uribe-Palomino J, Rochester W, Rothlisberg PC, Slotwinski A, Strzelecki J, Suthers IM, Swadling KM, Tonks ML, van Ruth P, Young JW, Richardson AJ (2020) A database of total zooplankton biomass in Australian marine waters. *Scientific Data* 7: 217. 9 pp

Robson BJ, Skerratt J, Baird ME, Davies C, Herzfeld M, Jones EM, Mongin M, Richardson AJ, Rizwi F, Wild-Allen K, Steven A (2020) Enhanced assessment of the eReefs marine models for the Great Barrier Reef using a four-level model evaluation framework. *Environmental Modelling and Software* 129: 104707. 15 pp.

Uribe-Palomino, J, Gastineau R, Richardson AJ, Wade NM, Whittock L, Hallegraeff GM (in press, 1/3/2021) New observations on the large hemidiscoid diatom *Palmerina ostenfeldii* and its symbiotic ciliate *Vaginicola collariforma* sp. nov. from subtropical Australian waters. *Diatom Research*



SUBMIT A CAPTION

Team member Ruth Eriksen captured this amazing image of a tintinnid eating a *Histioneis* on the IOE voyage. This 'one in a million' capture deserves a fitting caption. Submit your entry to anita.slotwinski@csiro.au and we will publish the entries in the next newsletter.

Dr Jason Evertt (UQ, UNSW and CSIRO O&A), Dr Ruth Eriksen (O&A) and Mark Underwood (NCMI) at the One Ocean-Our Future launch in Sydney.

ONE OCEAN, OUR FUTURE, AUSTRALIAN NATIONAL MARITIME MUSEUM

Jason D. Everett, Ruth Eriksen, Frank Coman, Emily Jateff and Anthony J. Richardson
Original article from Marine Matters

It started with a plankton biologist and a marine archaeologist sharing a love of plankton on an RV Investigator voyage, and it ended with a Continuous Plankton Recorder (CPR) permanently hanging in the Australian National Maritime Museum in Sydney as part of the ***One Ocean, Our Future*** exhibition.

Emily Jateff, a marine archaeologist and Curator, Ocean Science & Technology at the Australian National Maritime Museum, was onboard the RV Investigator in 2018 from Brisbane to Hobart when she stepped in to help Ruth Eriksen. Ruth, a phytoplankton taxonomist with the IMOS Plankton Team at CSIRO was towing the CPR and sampling plankton from the ships underway system. Emily would often join Ruth and Gustaaf Hallegraeff for live imaging sessions on the microscope. The photo of the living foraminifera, which adorns the base of the CPR exhibit, was taken by Ruth and Emily at one of these sessions.

Emily fell in love with the CPR, and all the plankton it sampled, and on this voyage the seeds were sown for a 60- year old unused CPR to make its way to the Australian National Maritime Museum. There it has been professionally curated as a permanent acquisition, and a part of the One Ocean, Our Future exhibition.

The first CPR was towed over 1300 miles in Antarctic waters in 1925–1926 by Sir Alister Hardy. This device was then modified and has remained relatively unchanged since the 1930s. Since then it has been towed over millions of miles, and collected plankton from around the world. The samples collected by the Global Alliance of CPR surveys (GACs), of which the IMOS Australian Plankton Survey is a part, are used in a range of ways, including to improve taxonomic knowledge, understand phenology, fisheries and climate change.

Within IMOS the CPR is towed by commercial shipping partners who volunteer their crew to take charge of the deployment and retrieval while at sea. The samples are then transported to Hobart and Brisbane where they are sorted, counted and identified by the IMOS Plankton Team. *Read more here*

Anthony Richardson

Position: Leader IMOS Australian Plankton Survey
Location: CSIRO, Brisbane, Queensland

I manage the CPR project, I help secure funding, guide research directions, develop relationships with other plankton surveys, and support and develop CPR staff. My research interests are marine climate change ecology, plankton ecology, pelagic ecosystem dynamics, and ecosystem modelling. In my spare time I love to spend time with my family.

Anita Slotwinski

Position: Plankton Biologist
Location: CSIRO, Brisbane, Queensland

I analyse CPR & NRS plankton samples. I also manage the project website, communication materials, the zooplankton species reference collection and contribute to developing taxonomic material.
My research interests are in marine plankton ecology, environmental change and species response. I also enjoy photomicroscopy and expanding our photographic catalogue of Australian zooplankton.

Claire Davies

Position: Plankton Biologist
Location: CSIRO, Hobart, Tasmania

My job includes identifying and counting CPR and NRS samples. I also manage the NRS and CPR databases, and am a boat driver for SE NRS sampling. My research interests include plankton ecology, climate change impacts and the feeding dynamics between zooplankton and megafauna. In my spare time I spend as much time in and out of the water as possible.

Felicity McEnnulty

Position: Plankton Biologist
Location: CSIRO, Hobart, Tasmania

I analyse CPR and NRS samples, am involved in data collation and quality control and contributing to publications and presentations. My research interests include plankton ecology, deep-sea invertebrates, introduced marine species and Antarctic marine invertebrates and fishes.

Fiona Scott

Position: Phytoplankton Biologist
Location Australian Antarctic Division, Hobart

I analyse CPR samples from the Southern Ocean including data collection and photomicrography at both Light- and Electron Microscope levels. My research interests include ecology of phytoplankton and other protists as well as biogeography and systematics of Australian marine macroalgae.

Frank Coman

Position: Deputy Leader
Location: CSIRO, Brisbane, Queensland

My role involves liaising with ships that tow the CPR, the management of the North Stradbroke Island NRS sampling, zooplankton sorting of IMOS NRS samples, and plankton analysis of CPR samples. I am interested in plankton biology and ecology, climate change impacts on marine ecosystems and aquaculture. In my spare time I play sport, enjoy fishing, camping and photographing Australian wildlife.

James McLaughlin

Position: Marine Biologist/ Biogeochemist
Location: CSIRO, Perth, Western Australia

My job is helping to expand the survey into WA waters and provide logistical support to the CPR team in WA. I have been with CSIRO for 13 years. I am lead of the Coastal Vegetation and Sediment Team here in Perth. My research interests include marine phytoplankton dynamics and ecology, benthic and pelagic primary production, and factors that enhance or limit photosynthesis.

Julian Uribe-Palomino

Position: Plankton Biologist
Location: CSIRO, Brisbane, Queensland

My role involves analyses of plankton samples, operational tasks, data collection and quality control and contributing to publications and presentations. I am interested in biological oceanography, environmental modelling, biogeography, remote sensing and GIS.

Karl Forcey

Position: Technical Officer
Location CSIRO, Brisbane, Queensland

I am helping the survey by working on the integration of marine instrumentation to CPR projects, data recovery and quality control, maintenance and repair of CPR units and technical advice. My research interests include underwater video systems, oceanographic instrumentation and AUV's gliders and other emerging technologies.

Mark Tonks

Position: Experimental Scientist
Location: CSIRO, Brisbane, Queensland

My tasks include liaising with shipping companies, including owners, agents and crew to ensure that CPR sampling is maintained, and counting NRS and CPR zooplankton samples. I also have a coxswain's certificate and drive our research vessel to the NRS site where I then assist with plankton and water sampling. My research interests include plankton ecology, bycatch sustainability and fish and crustacean ecology. I also enjoy playing a variety of sports.

Ruth Eriksen

Position: Plankton Biologist
Location CSIRO, Hobart, Tasmania

I analyse CPR and NRS samples, and am involved in data collation and quality control and contributing to publications and presentations. My research interests are phytoplankton ecology and taxonomy, phytoplankton physiology and response to contaminants, tintinnid ciliates and temperate and sub-Antarctic phytoplankton community dynamics.

Sarah Pausina

Position: Plankton Biologist
Location CSIRO, Brisbane, Queensland

I work in the lab analysing plankton samples from Australian waters and contribute to the reference material we use for taxon identification. Occasionally you'll find me in the field helping with sample collection. Broadly, my background is in marine ecology, and I am particularly interested in zooplankton dynamics and water quality.

Wayne Rochester

Position: Quantitative Ecologist
Location CSIRO, Brisbane, Queensland

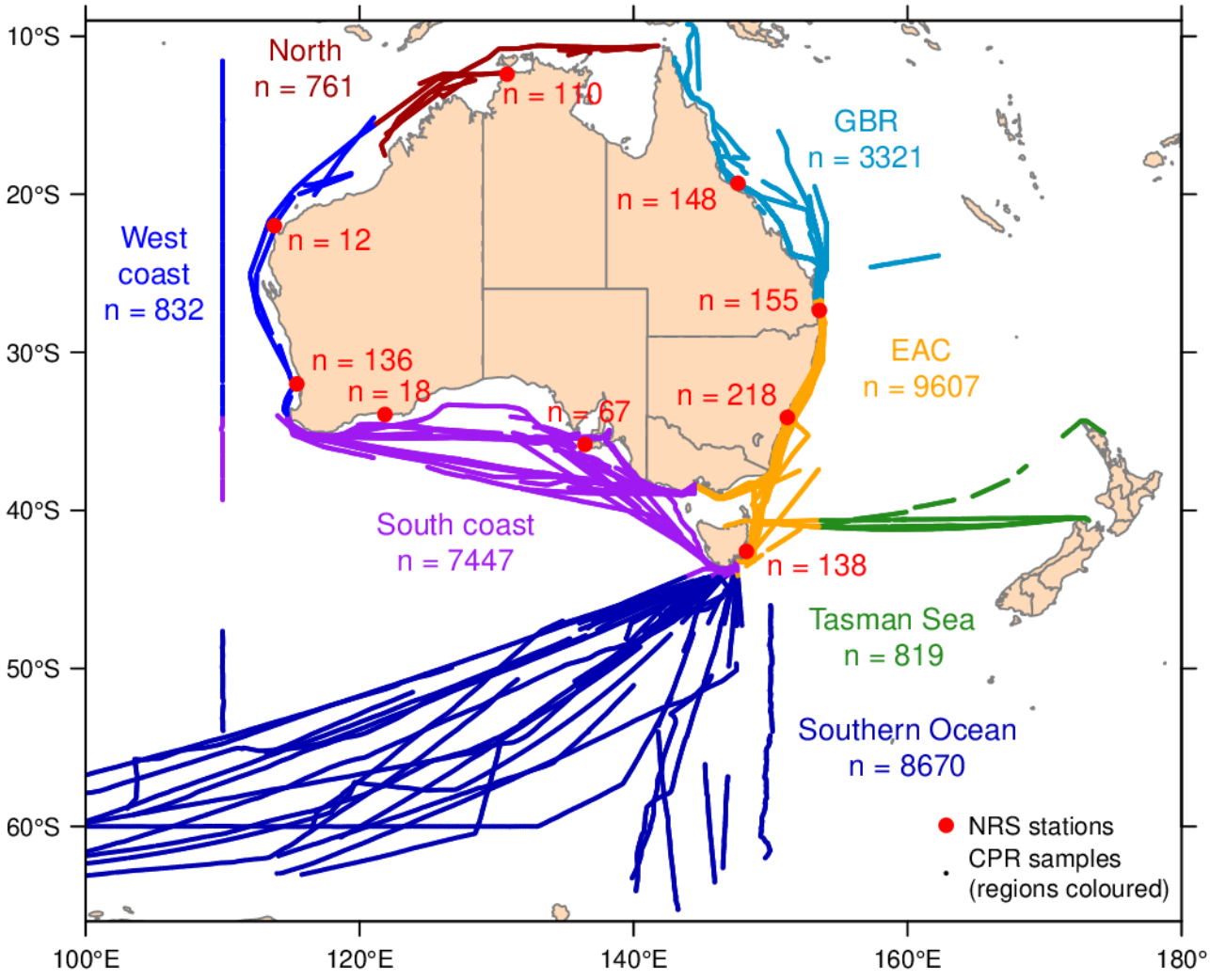
I help the survey by the analysis of plankton data for ecosystem health assessment. My research interests are quantitative ecology, spatial ecology and natural resource management.

The EAC route is towed quarterly from Brisbane to Melbourne and follows the southward-flowing warm-water East Australia Current. This region is forecast to warm more than anywhere else in the Southern Hemisphere this century.

The National Reference Stations are sampled monthly.

The Great Barrier Reef (GBR) route is towed seasonally from Gladstone to Cairns in the GBR lagoon. Long-term observations on the GBR, such as those by the CPR, will help support management of the healthy reef

Integrated Marine Observing System (IMOS) plankton data, 2007–2022

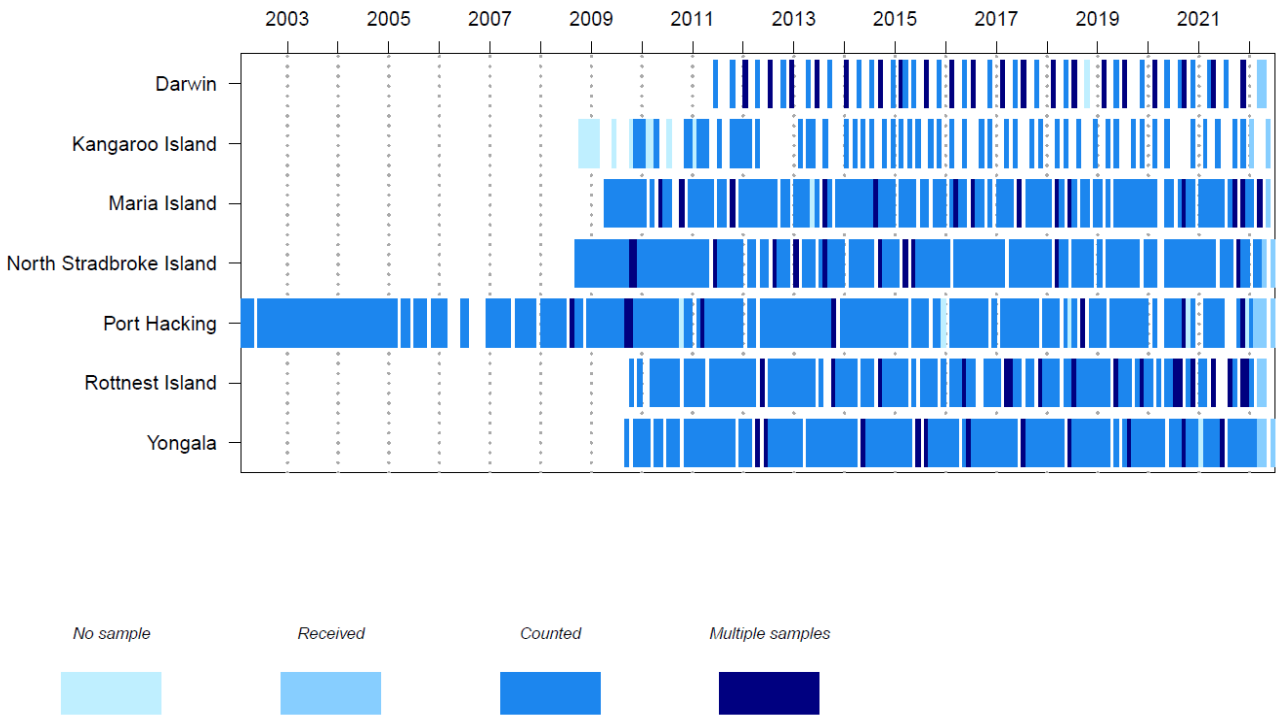


The route from Melbourne to Adelaide is one of our longest-running routes and traverses the productive upwelling waters of the Bonney upwelling system..

Our Southern Ocean routes are towed in collaboration with the SCAR SO-CPR Survey based at the AAD. Together with the EAC route, the Southern Ocean sampling provides an almost continuous transect running from warm tropical to polar waters.

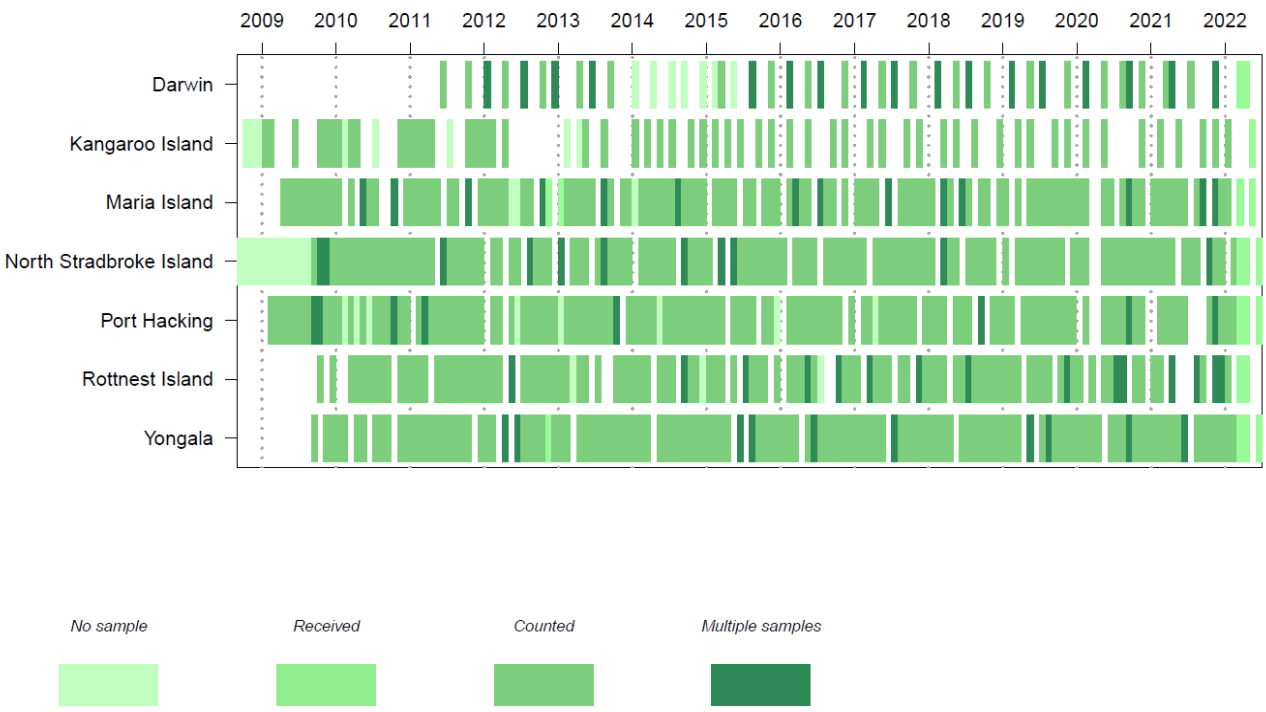
National Reference Stations Zooplankton Progress

NRS zooplankton progress - 2022-07-26

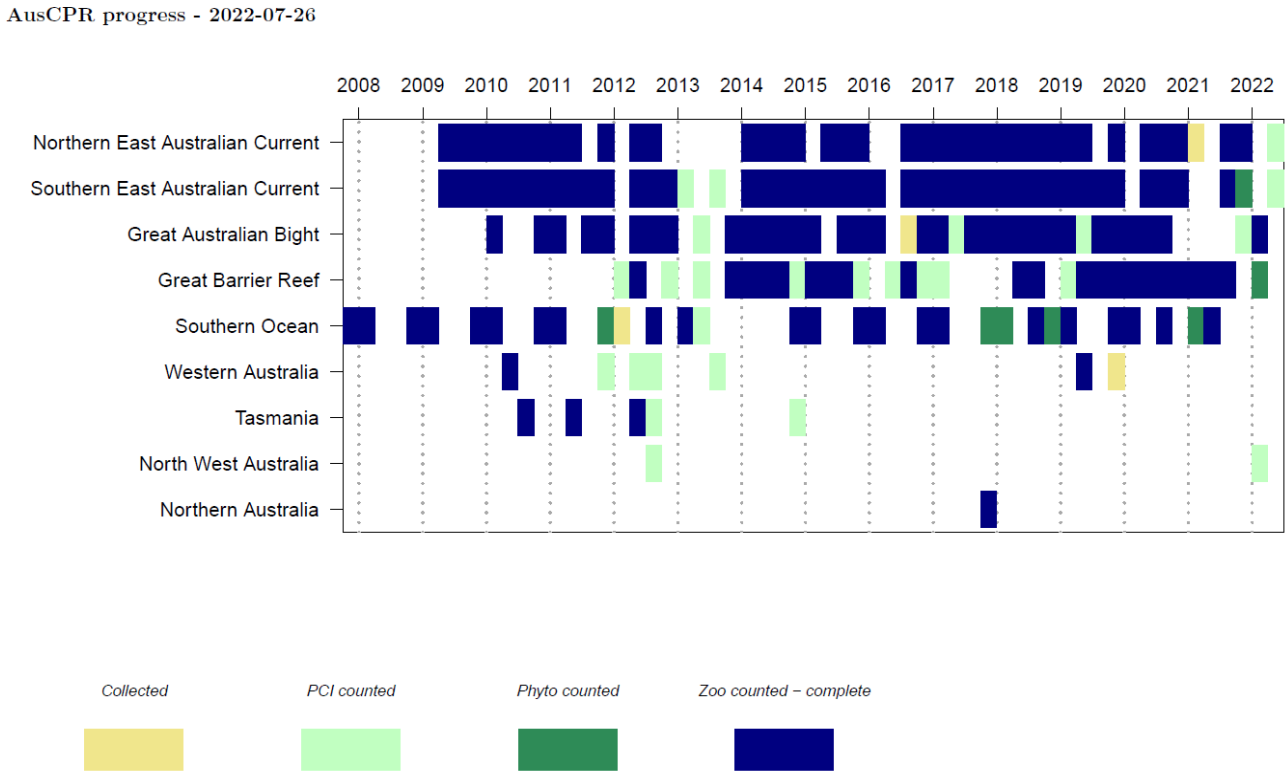


National Reference Stations Phytoplankton Progress

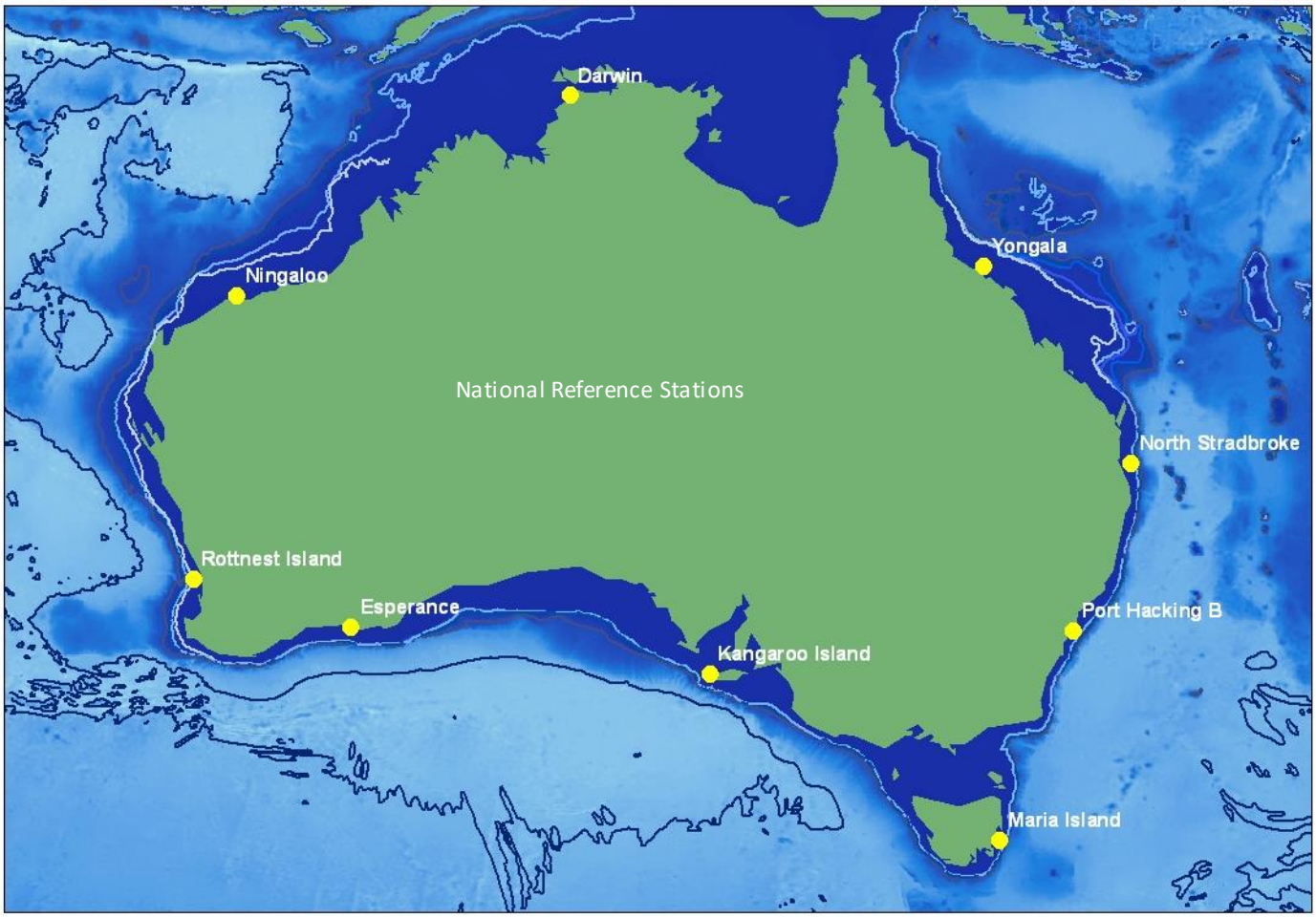
NRS phytoplankton progress - 2022-07-26



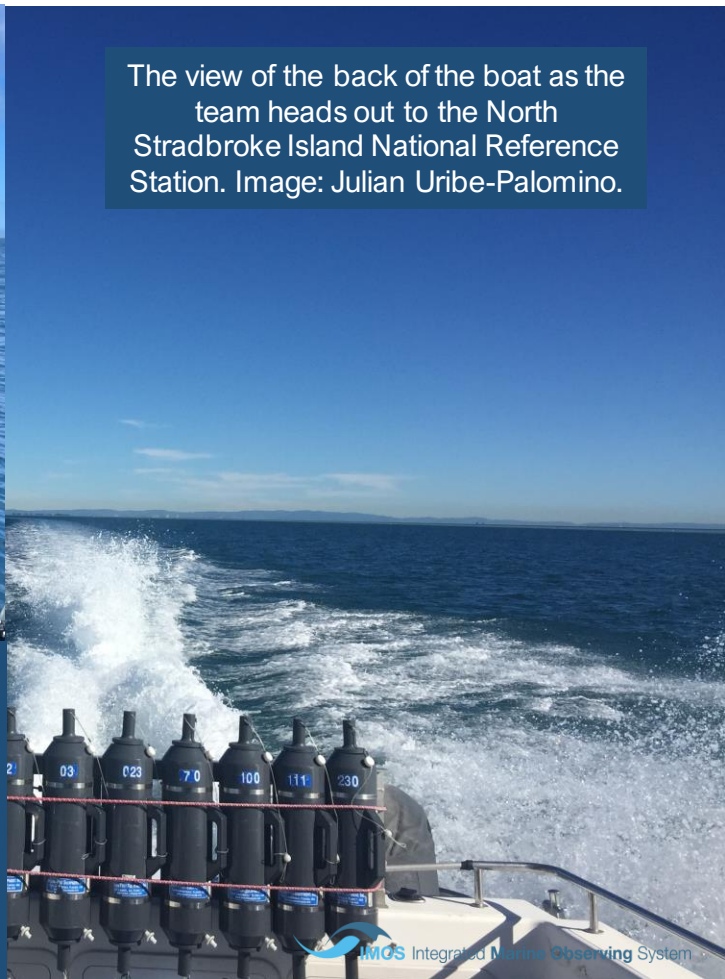
Australian Continuous Plankton Recorder Progress



IN THE FIELD – NATIONAL REFERENCE STATIONS SAMPLING



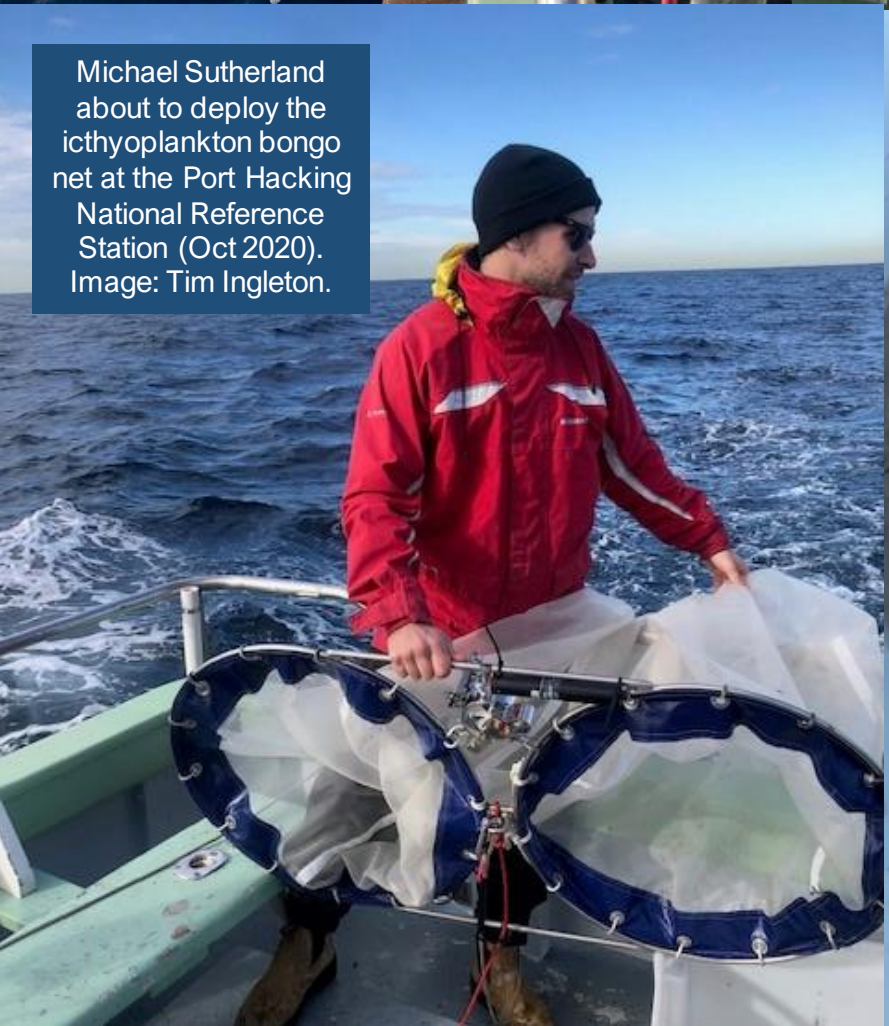
Dion Frampton with over 4 litres of small salps in the larval fish net, Maria Island National Reference Station. Image: David Kruse.



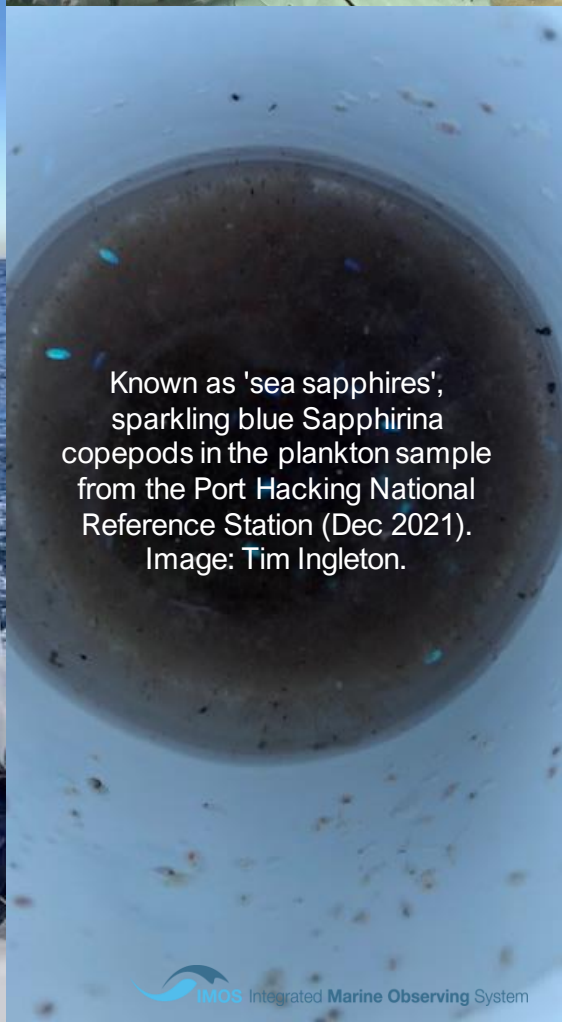
The view of the back of the boat as the team heads out to the North Stradbroke Island National Reference Station. Image: Julian Uribe-Palomino.

Plankton sampling at the Port Hacking National Reference Station (Feb 2021). Image: Tim Ingleton.

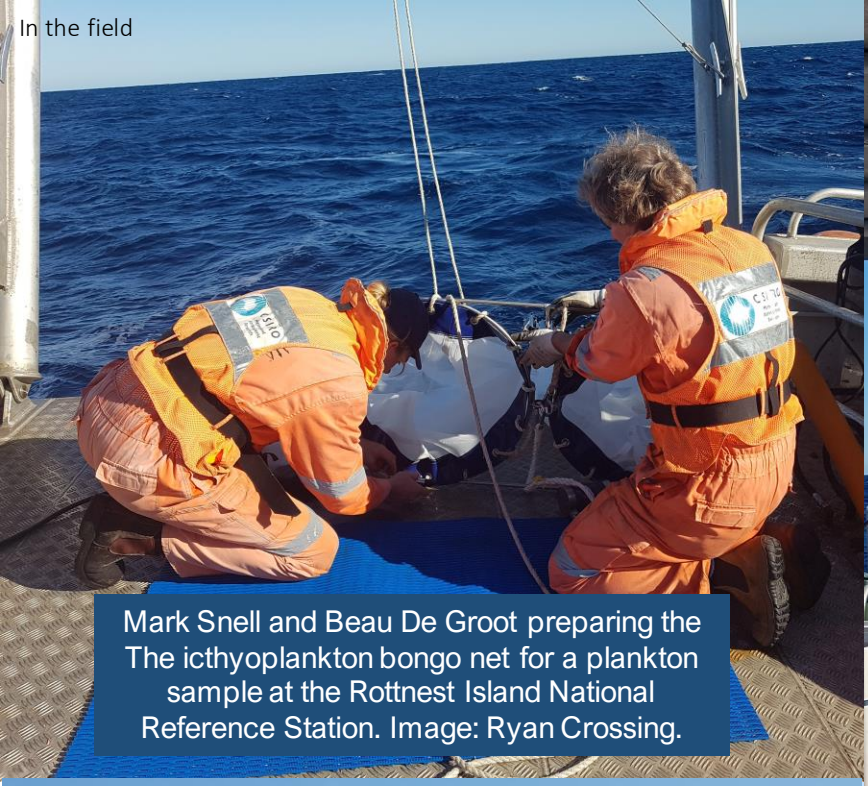
Plankton sample at the Port Hacking National Reference Station (Feb 2021). Image: Tim Ingleton.



Michael Sutherland about to deploy the icthyoplankton bongo net at the Port Hacking National Reference Station (Oct 2020). Image: Tim Ingleton.

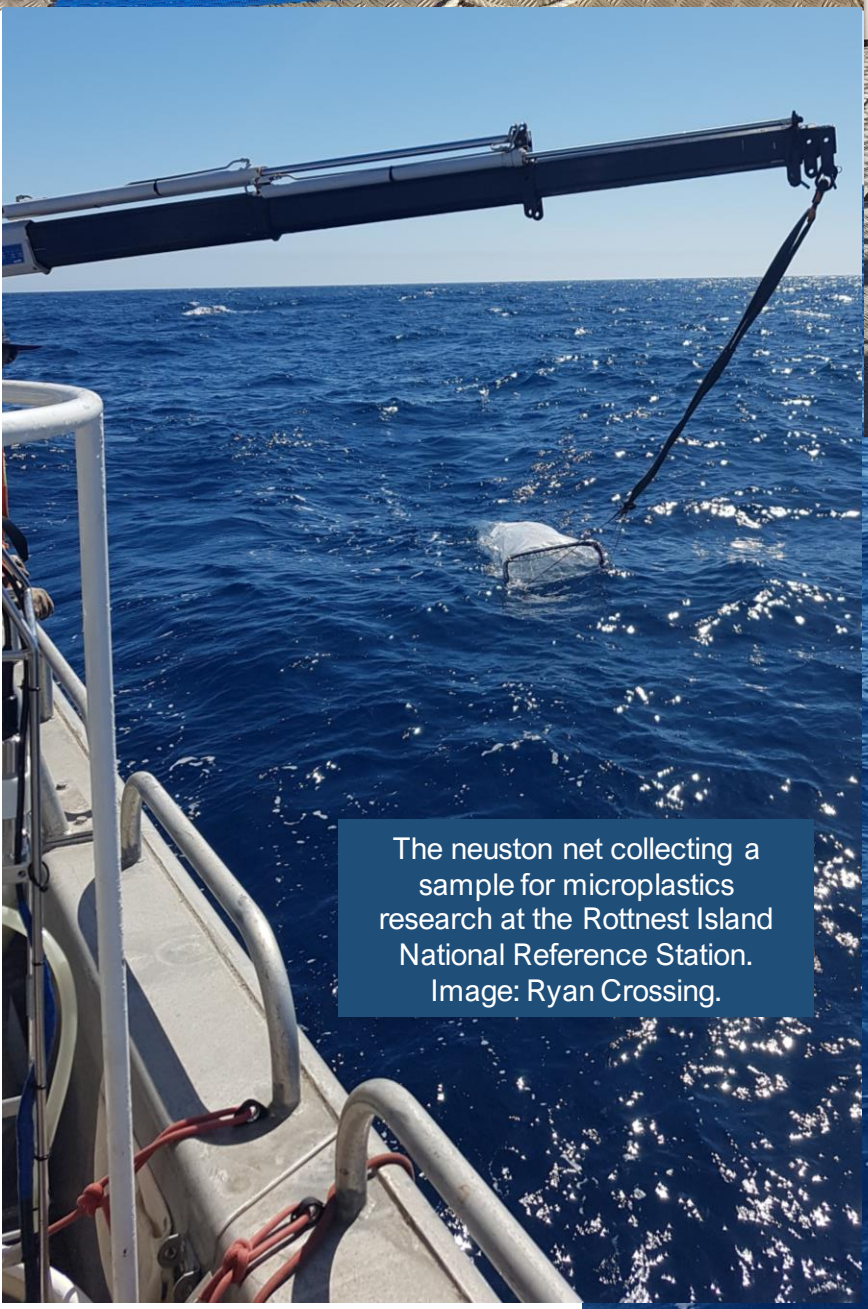


Known as 'sea sapphires', sparkling blue Sapphirina copepods in the plankton sample from the Port Hacking National Reference Station (Dec 2021). Image: Tim Ingleton.

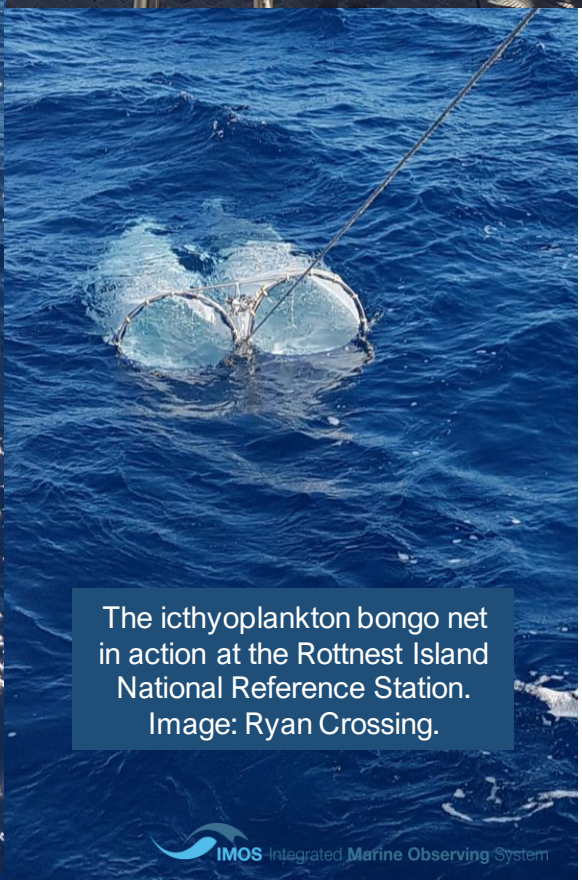


Mark Snell and Beau De Groot preparing the The icthyoplankton bongo net for a plankton sample at the Rottnest Island National Reference Station. Image: Ryan Crossing.

The icthyoplankton bongo net being deployed for a plankton sample at the Rottnest Island National Reference Station. Image: Ryan Crossing.



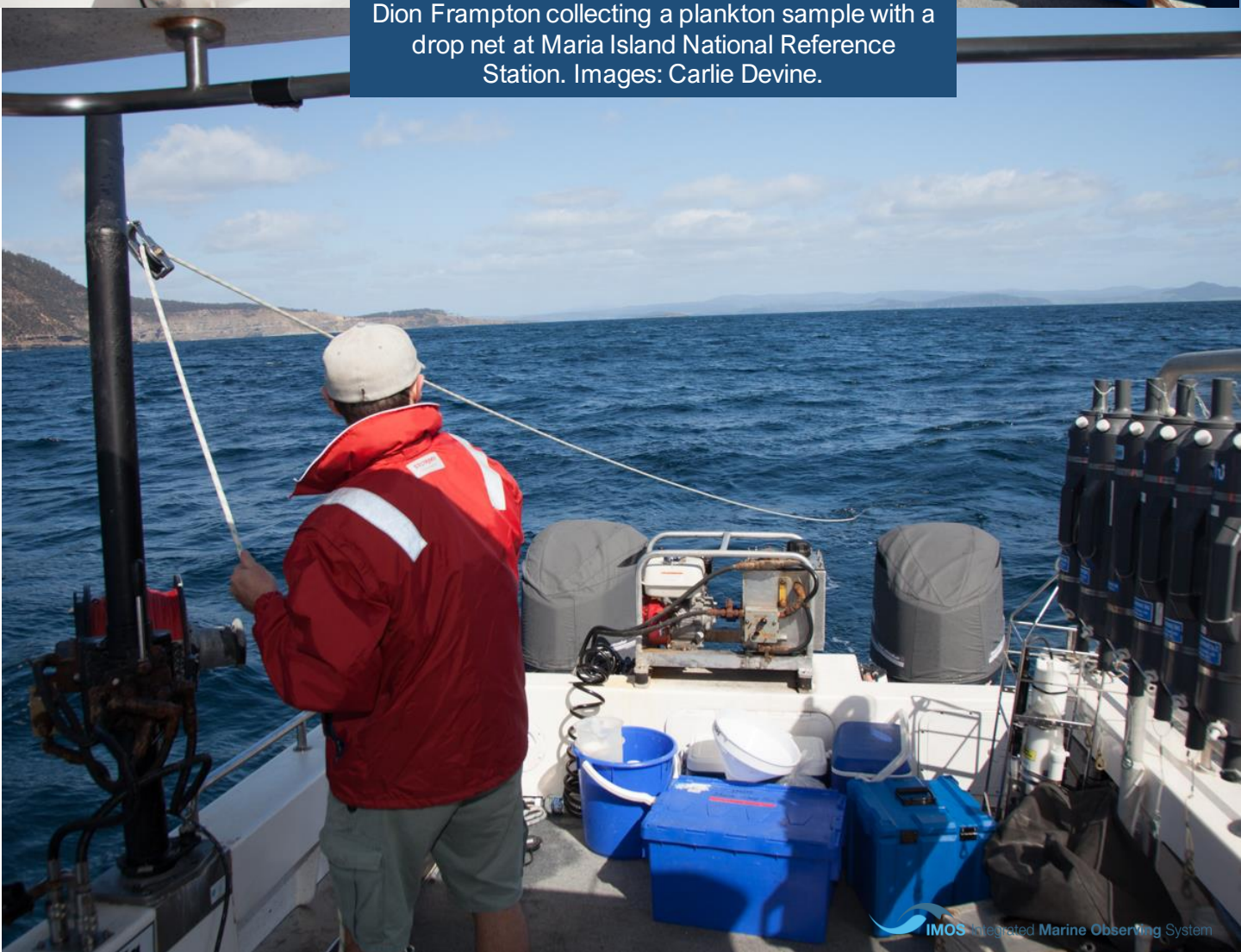
The neuston net collecting a sample for microplastics research at the Rottnest Island National Reference Station. Image: Ryan Crossing.



The icthyoplankton bongo net in action at the Rottnest Island National Reference Station. Image: Ryan Crossing.

The first trip performed at the Yongala National Reference Station after the COVID 2020 lockdowns. John Luetchford from the Oceanographic Tech team is using the A-Frame to launch the niskin bottle for a water sample at depth, instead of the hydrographic winch, to allow social distancing on deck. The Yongala NRS buoy is in the background. Usually the team at Yongala NRS use the small boat *RV Apollo*, but because of issues of maintaining social distancing the first COVID trip on 22 April 2020 was carried out on the AIMS vessel RV Cape Ferguson.
Image: Irena Zagorskis

Dion Frampton collecting a plankton sample with a drop net at Maria Island National Reference Station. Images: Carlie Devine.



Plankton sample collected with a drop net at Maria Island National Reference Station. Images: Carlie Devine.

SHIPPING

Mark Tonks

The *Wallenius Wilhelmsen* roll-on/roll-off ships, *Tonsberg* and *Salome* continue to tow CPRs through eastern and southern Australian coastal waters between the ports of Brisbane, Port Kembla, Melbourne and Adelaide. Both vessels have completed a combined 77 CPR tows covering more than 23,000 nautical miles. Captain Sunil Dhowan (Head of Port & Cargo Operations, Oceania), Captain Roman Rossa (Brisbane Port Operations Manager), Captain Patrick Lobo (Fremantle Port Operations Manager) and the crews of the ships involved, continue to provide excellent logistical support.

A *Tonsberg* crew member filling the CPR cassette with preservative prior to deployment.

Thanks to their efforts we continue to maintain an extremely high level of sample return with associated metadata. We'd also like to acknowledge the efforts of Mark Wilson, Mark Snell and James McLaughlin (CSIRO, Perth) for collecting and freighting CPR cassettes from Fremantle to Brisbane.

The Rio Tinto ship, *RTM Wakmatha* continues to tow CRPs along the inner Great Barrier Reef between Cairns and Gladstone. This ship travels regularly between Weipa and Gladstone carrying bauxite for Gladstone's alumina refineries. Since their initial CPR tow in June 2018, a further 9 tows (at approximately 3-month intervals) have been completed up until December 2020. In total, over 3000 nautical miles have been sampled. We thank Rio Tinto and the *Wakmatha* crew, particularly Chief Officer's Robert Spencer-James and Jack Miller for their assistance.

SHIP NAME	OPERATOR	LENGTH	DEAD WEIGHT
MV Tonsberg	Wallenius Wilhelmsen	265 m	41820 tonnes
MV Salome	Wallenius Wilhelmsen	265 m	43878 tonnes
RTM Wakmatha	Rio Tinto Shipping	236 m	89605 tonnes

Images: MV Tonsberg (Dexter), MV Salome (Mick Prendergast), RTM Wakmatha (all from www.marinetraffic.com)

RV Investigator departs Hobart for the Southern Ocean. Image: Thomas Moore.

1:100 dilution of phytoplankton net placed under the underway line for a few minutes. Image: Ruth Eriksen.

FROM THE HOBART PLANKTON LAB

Felicity McEnnulty

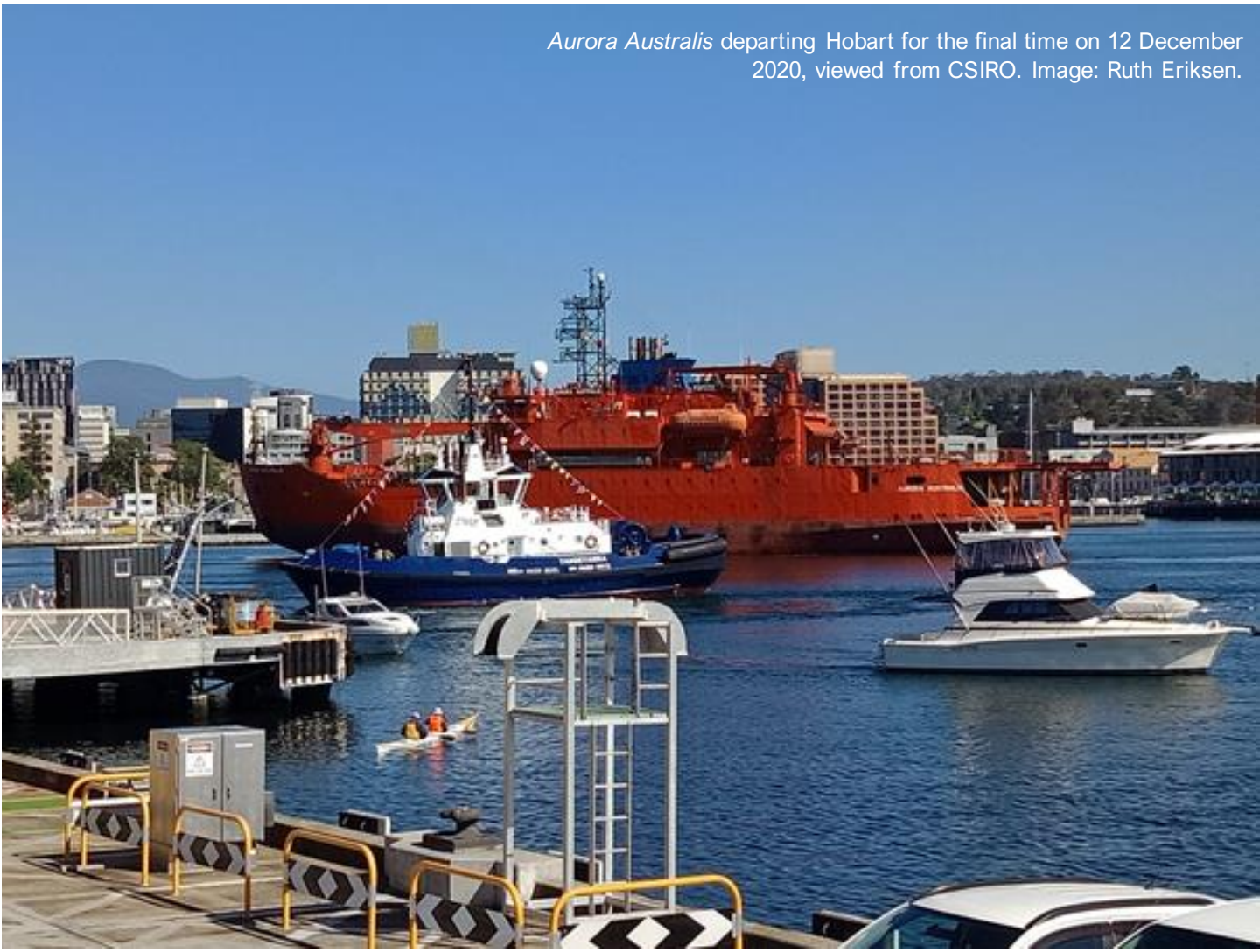
Field sampling at the Maria Island NRS station was interrupted by COVID-19 and bad weather but the field team still managed ten successful sampling trips this year. Claire worked in the lab in March through to June while Tasmania was under COVID restrictions and powered through identifying phytoplankton and zooplankton samples from her 2019 IIOE voyage, and also worked up NRS phytoplankton samples from around Australia. Ruth worked from NSW and Felicity worked from home during this period on data management and the development of species identification tools and information sheets.

Since June we have all been back in the lab, identifying plankton from the NRS stations, AusCPR tows and the northern tows from Tasmania to 47 degrees south collected for us by the SOCPR at the Australian Antarctic Division. The *RV Investigator* cruise to the Southern Ocean Time Series (SOTS) mooring was delayed from March until August, during which they collected us our annual Tasmania to SOTS CPR tow.

A close-up of one of the juvenile Calanidae species. Image: Ruth Eriksen.

Ruth went on the IN2020_V10 cruise in November 2020 to conduct sea trials and testing of scientific equipment, study deep water properties in Storm Bay and map habitats in the Huon Marine Park. Sampling for nutrients, pigments, and optical properties of the water column occurred in some dense blooms of Calanidae copepods. These were mostly *Calanus australis* juveniles with some *Neocalanus* juveniles also represented. They were identified from the NRS MAI larval fish tows that also sampled the bloom, many of the copepods later washed up in Marion Bay, Tasmania.

Zooplankton accumulating in the in-line filters for the underway sampling line on the *Investigator*. Image: Ruth Eriksen.



Aurora Australis departing Hobart for the final time on 12 December 2020, viewed from CSIRO. Image: Ruth Eriksen.

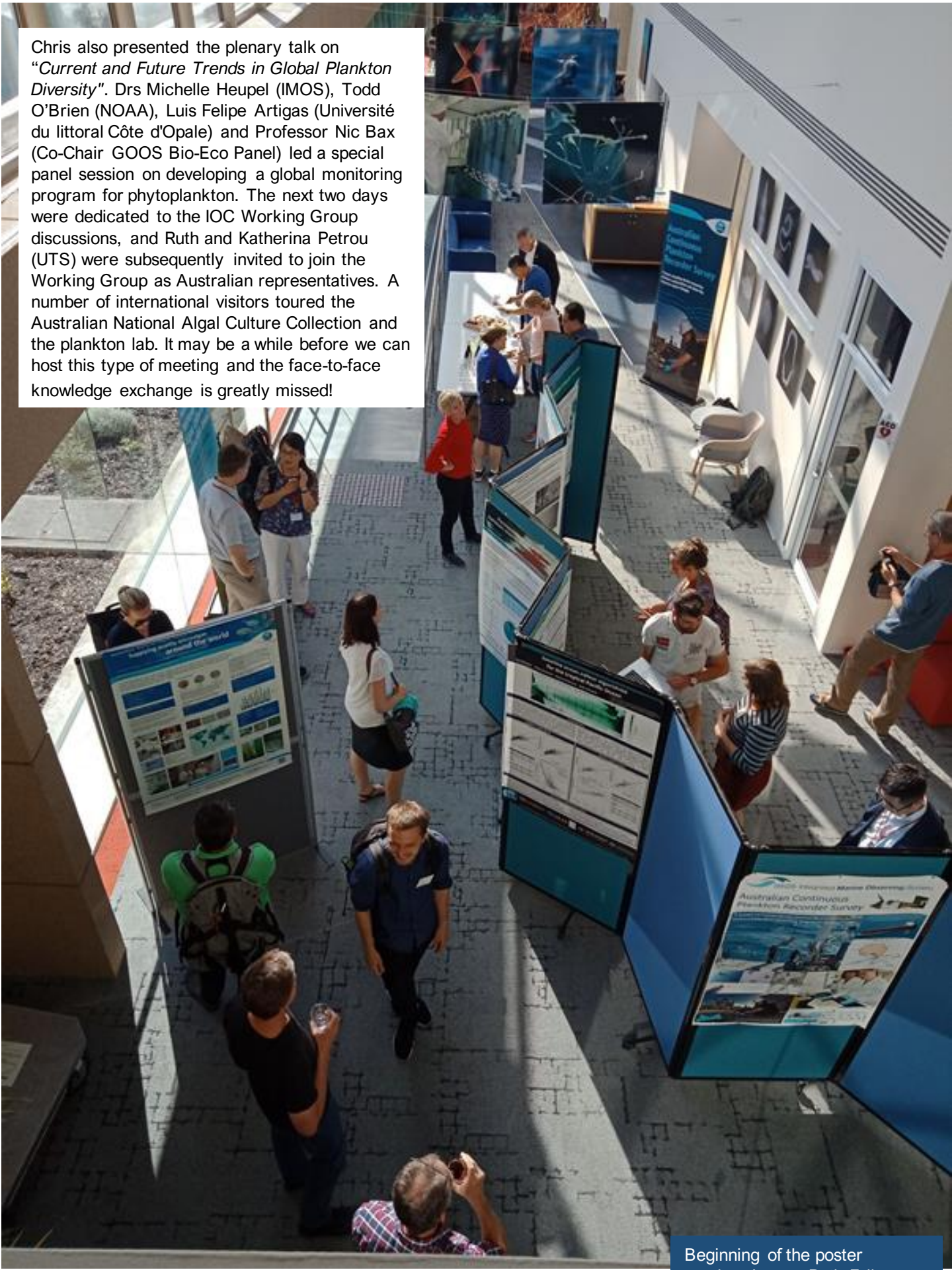
In other news, we bid final farewell to the icebreaker *Aurora Australis* as she left Hobart after 150 Antarctic trips! The "orange roughy" has been a familiar sight in Hobart for 30 years, and she has heralded the Antarctic resupply seasons as we watched her come and go each year from the Hobart waterfront. In fact, Ruth's first job was with the inaugural Hydrochemistry team on *Aurora*, joining for her second voyage and she has since spent more than a year of sea-time doing marine science on *Aurora* in the intervening years. A large group of people and an impressive fleet of watercraft joined to wave her off, a few tears were shed amongst past expeditioners. The *Aurora* will be replaced by the $398 million RSV *Nuyina*, named after a Tasmanian Aboriginal word for southern lights.

Julian visited from the Brisbane lab in January to work out methodology for molecular analyses using ethanol preserved NRS zooplankton samples with Sharon Appleyard in the genetics lab.

Julian was also able to join us for the IOC Trends PO Working Group public symposium "Saving Our Seas" which was held in Hobart in pre-COVID days when it was possible to host an international meeting on phytoplankton.

Ruth worked with Peter Thompson, Karlie McDonald, Anusuya Willis and Jess Melbourne-Thomas to host the Cutting Edge Science Symposia, of which the highlight was an evening talk by Professor Chris Bowler (CNRS France and Scientific Coordinator of the Tara Oceans program) on the behind the scenes wonders of the Tara Oceans expeditions entitled "*The Tara Ocean Foundation - exploring to understand, sharing for change*" https://oceans.taraexpeditions.org/en/m/about-tara/les-expeditions/tara-oceans/ .

Chris also presented the plenary talk on "*Current and Future Trends in Global Plankton Diversity*". Drs Michelle Heupel (IMOS), Todd O'Brien (NOAA), Luis Felipe Artigas (Université du littoral Côte d'Opale) and Professor Nic Bax (Co-Chair GOOS Bio-Eco Panel) led a special panel session on developing a global monitoring program for phytoplankton. The next two days were dedicated to the IOC Working Group discussions, and Ruth and Katherina Petrou (UTS) were subsequently invited to join the Working Group as Australian representatives. A number of international visitors toured the Australian National Algal Culture Collection and the plankton lab. It may be a while before we can host this type of meeting and the face-to-face knowledge exchange is greatly missed!



Beginning of the poster session. Image: Ruth Eriksen.

Speakers and guests at the *Saving Our Seas* CSIRO Cutting Edge Symposium held in Hobart January 2020, as part of the Trends PO Working Group meeting. Image: Carlie Devine CSIRO.

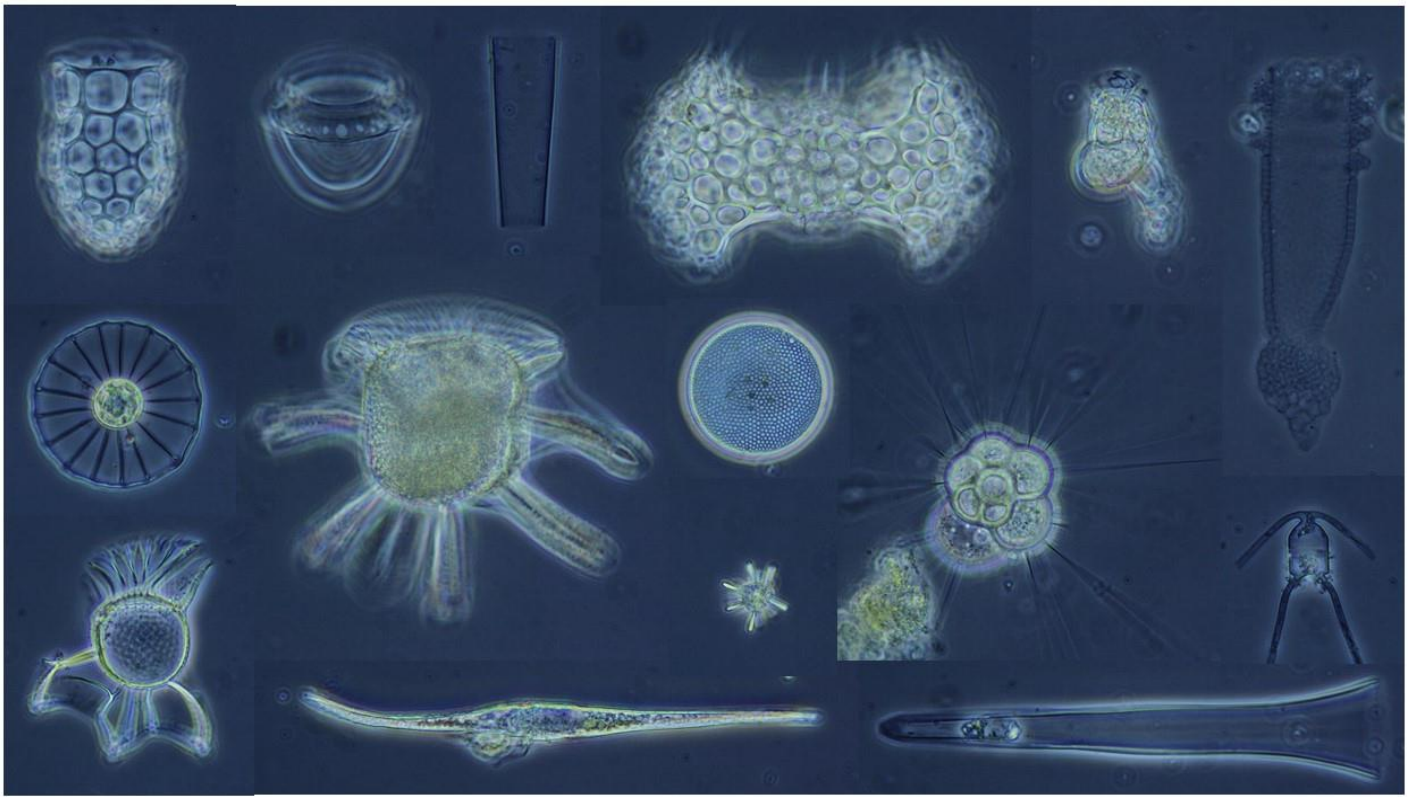
https://studyoverseas.soton.ac.uk/

Madeline Anderson completed her stay as a Visiting Scientist with us, which was part of her "Study Abroad" exchange from the University of Southampton. Madeline had to complete an independent research project for her degree and so she analysed the phytoplankton samples from the International Indian Ocean Expedition (IIOE2) voyage in May last year. This voyage retraced part of the historic first International Indian Ocean Expedition completed some 60 years earlier and aimed in part, to document biodiversity changes that have occurred in this part of the world's oceans in the intervening decades (see last newsletter). Madeline photo documented, measured and counted the *Tripos* in the phytoplankton net samples collected at 20 stations along the 110°E transect. She submitted a thesis in May titled "Abundance, Diversity and Biogeography of the Dinoflagellate Genus *Tripos* (Bory de Saint-Vincent, 1823) in the Southwestern Indian Ocean during the Austral Autumn.". We hope to use the basis of Madeline's work, together with our analysis to prepare a manuscript for the upcoming special issue in DSR2 dedicated to IIOE2. Recent news from Madeline is that she has applied to do a taxonomic-based PhD with the British Antarctic Survey, we are thrilled that she will continue to apply her keen eye and enthusiasm to marine biodiversity research!

www.imas.utas.edu.au

Brad Paine (IMAS) worked with us for a couple of months to examine the phytoplankton on the CPR silks from the *RV Investigator* transit voyage IN2018_T02 (PI, Gustaaf Hallegraeff), which Ruth participated in 2018. Brad worked on the underway samples that accompany the CPR tows as part of his undergraduate research project, and more recently completed his honours on dinoflagellate cysts from long-cores collected at PHB and MAI on the same voyage.

Claire, Julian and Ruth organised samples and taxonomic advice for an Honours student looking at the genetics of single cells of *Tripos* species. Melissa Elliman intended to use cells collected from Port Hacking, North Stradbroke and Maria Island NRSs, but COVID prevented many samples from being collected. She then supplemented her specimens from *Tripos* separated out from the IIOE2 voyage Claire went on in 2019. So those samples have proved useful yet again. Melissa also tested the *Tripos* Lucid key being developed in our team and her experience provided some useful feedback for improvements. Melissa was completed her studies at UTAS, supervised by Anasuya Willis of the Algal Culture group at CSIRO, Hobart. Her thesis was titled 'Defining *Tripos* species (Dinophyceae, Alveolata) from Australian coastal waters' and she is in the process of preparing a manuscript of the same title.



Above: Compilation of images from phytoplankton net samples from the IIOE2 voyage in 2019. Thanks to Peter Thompson, Martina Doblin and Peta Vine for samples. Image: Ruth Eriksen.

Australia-New Zealand Plankton Network

Helen Bostock (University of Queensland) and Ruth Eriksen (CSIRO Oceans and Atmosphere)

We would like to seek Expressions of Interest for researchers and students interested in being part of a Aus-NZ plankton network (modern or fossil plankton). We are interested in knowing what plankton taxa researchers and students are working on to develop a database of researchers and identify gaps in plankton skills and knowledge for this region. The aim of such a network is to share ideas, papers, expertise and samples (where suitable) and undertake a review of the current research on plankton in this region. When restrictions allow, we would like to hold some training workshops to develop the next generation of plankton researchers. We hope that this could become an action under the UN Decade of the Ocean which has a focus on sustainable oceans and training up future ocean scientists. If you are interested in being involved then please fill out the google form linked below.

Click here to access the survey
or go Australian/New Zealand Plankton community survey (google.com).

FROM THE BRISBANE PLANKTON LAB

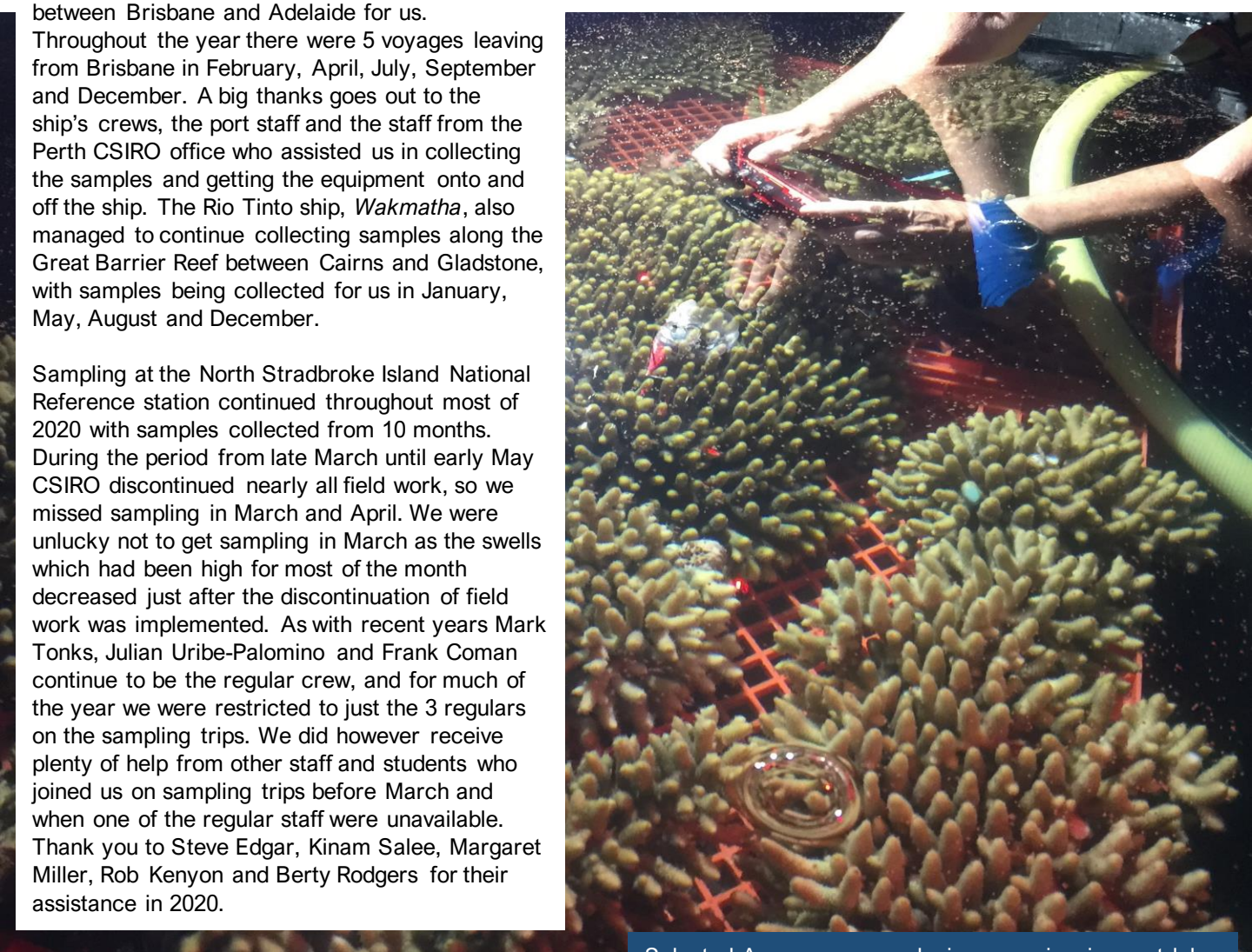
Frank Coman

With the events of 2020 some expectations had to re-evaluated and just managing to meet deliverables for many projects became more difficult than in any normal year. Having said that, throughout the year we have managed to meet the objectives of both IMOS projects, which are the focus of most of the team members in Brisbane. Throughout the whole of 2020 Julian, Mark and Frank have continued to work at QBP, keeping busy in the laboratory. Anita was working home for a period, but returned to the lab in July, Anthony continued to work from home for the second half of 2020. Importantly for our IMOS work sampling continued uninterrupted for AusCPR, and there was just a 2-month break in the NRS sampling.

Both the *Wallenius Wilhelmsen* ships, the *Salome* and the *Tonsberg* continued to collect samples between Brisbane and Adelaide for us. Throughout the year there were 5 voyages leaving from Brisbane in February, April, July, September and December. A big thanks goes out to the ship's crews, the port staff and the staff from the Perth CSIRO office who assisted us in collecting the samples and getting the equipment onto and off the ship. The Rio Tinto ship, *Wakmatha*, also managed to continue collecting samples along the Great Barrier Reef between Cairns and Gladstone, with samples being collected for us in January, May, August and December.

Sampling at the North Stradbroke Island National Reference station continued throughout most of 2020 with samples collected from 10 months. During the period from late March until early May CSIRO discontinued nearly all field work, so we missed sampling in March and April. We were unlucky not to get sampling in March as the swells which had been high for most of the month decreased just after the discontinuation of field work was implemented. As with recent years Mark Tonks, Julian Uribe-Palomino and Frank Coman continue to be the regular crew, and for much of the year we were restricted to just the 3 regulars on the sampling trips. We did however receive plenty of help from other staff and students who joined us on sampling trips before March and when one of the regular staff were unavailable. Thank you to Steve Edgar, Kinam Salee, Margaret Miller, Rob Kenyon and Berty Rodgers for their assistance in 2020.

Prior to the lockdown period staff from Brisbane were able to do some travelling. Julian visited the CSIRO laboratories in Hobart in January to work on genetic bar coding of copepods, focussing on monstrilloid copepod species. In February Julian travelled to the UK for an internship at the Natural History Museum to learn more about harpacticoids from Ronny Huys. There will be more about these trips elsewhere in the newsletter. Frank travelled to Melbourne in March, along with Claire from Hobart, to attend the final 2-day workshop of the Ready to Lead program.



Selected Acropora spp. colonies spawning in a wet lab tank from Heron Island Research Station HIRS.

Coral gamete bundles released by coral colonies during the spawning season. The bundles are clusters of sperm (white stuff) surrounded by the eggs (pinkish structures). The bundles come to the sea surface after they are released by the coral colony polyps. Image: Julian Uribe-Palomino.

Culture tanks set up for spawning coral. Image: Julian Uribe-Palomino.

Cultured *Acropora spathulata* planula larvae after a few days of spawning. Image: Julian Uribe-Palomino.

Ready to Lead program. Members of the team also participated in several field trips outside the IMOS work in 2020. Mark Tonks spent 3 weeks in the field in February on the Northern Prawn Fishery (NPF) survey in the Gulf of Carpentaria, and 2 weeks in November on the Tropical Rock Lobster (TRL) survey in Torres Strait.

Julian and Mark spent a week on Heron Island in mid-October on a remote sensing ground truthing field trip organised by Tim Malthus. Julian and Mark, along with Frank, returned to Heron Island at the end of November and spent nearly 3 weeks working on the moving corals project being headed by Chris Doropoulos (see images on the next page).

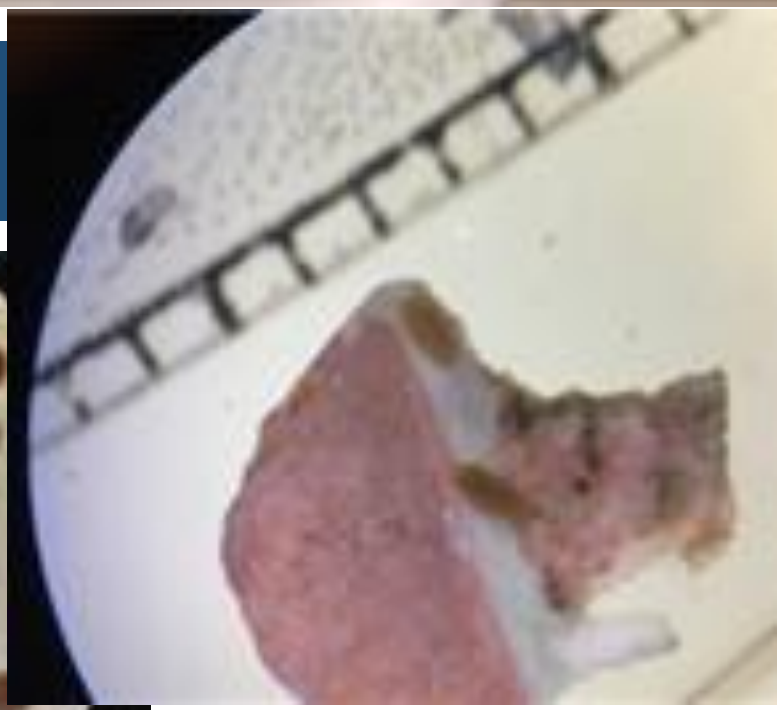
Unfortunately, there were also a couple of events which had to be postponed during the year. The team members from both Brisbane and Hobart had planned to attend a workshop in Brisbane to learn more about creating LUCID taxonomic keys. We are planning to conduct this workshop, either live or online later in 2021. Also, Julian and Anthony from Brisbane and Claire from Hobart were all going to attend the international Copepod conference in South Arica in July. Currently this conference has been postponed until mid-2022.

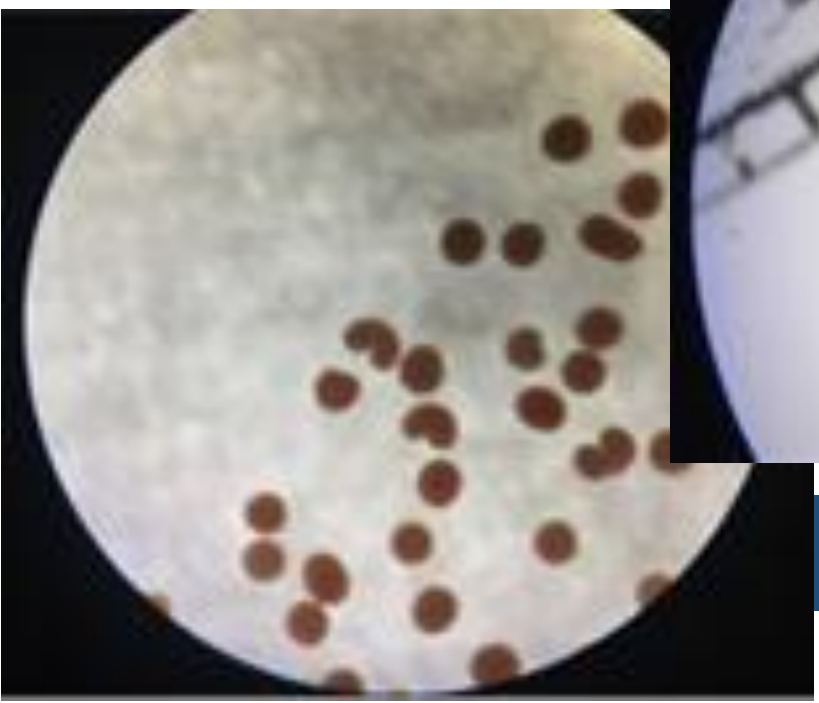
Anthony has continued to encourage students to work with our data to produce ecological and food web models incorporating zooplankton and phytoplankton. We have had few students working in the laboratory this past year.

Despite the difficult year that 2020 has been we have continued to meet our IMOS objectives and to assist with other projects being run from the CSIRO in Brisbane. Hopefully we will be able continue to be successful in 2021 and look forward to adapting to the changing workplace that will be the future for all of us.

Coral larvae under culture after 48 hours of spawning. Image: Julian Uribe-Palomino.

Right: Two planula larvae on a coralline bit. The elongated larvae is looking to settle whilst the flat larvae is already settled and shaped in the typical round shape of a contracted polyp. Image: Julian Uribe-Palomino.

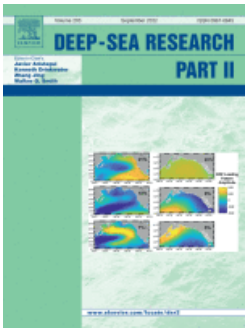




Left: Fertilised eggs of a coral colony going into their first cellular division. Image: Julian Uribe-Palomino.

RECENT PAPERS

Here is a list of new papers the Team has either led or been involved in since the last newsletter. It is so rewarding for us to see the data we collect being used in so many different capacities.



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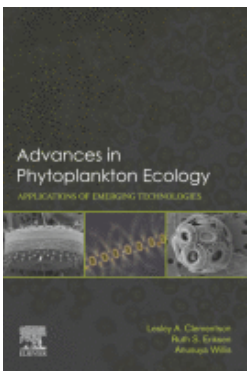

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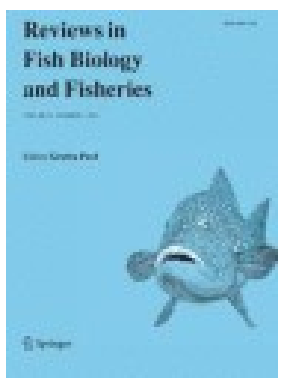

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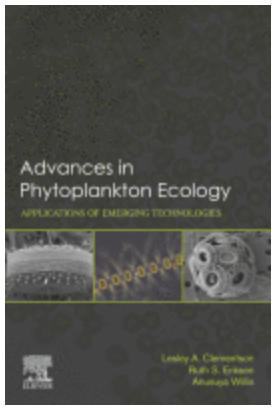

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DATA, PRODUCTS, VISUALISATIONS – THE FUTURE

Claire Davies

We all know that wrangling long term plankton data into neat data products can be tricky, we need to consider things like changes in taxonomy and how to account for absences. Plus we also need to have the skills to turn our manipulated data into science impact. Fortunately, there are now several improvements on the horizon that are going to make interacting with IMOS plankton (and other biological data sources) easier in the future.

BGC database improvements

Since the very beginning of the IMOS funding for the NRS and the AusCPR plankton surveys we have used an Oracle database hosted by the CSIRO data centre to hold our data. We use the database for managing the processing of samples, data entry, quality control, integrating datasets, generating products and serving raw data to the AODN portal. The data base has expanded over the years and now manages all the data from parameters analysed at the NRS, other IMOS plankton streams such as the Southern Ocean Time Series mooring phytoplankton data and the Southern Ocean CPR phytoplankton data.

Whilst, as many of you know, we have had the ability to provide this data in user friendly formats on request, we have struggled to make these available through the AODN. IMOS have recently provided funding to CSIRO and AODN to address this so that these formatted datasets can be made available through the portal. The database team, Claire, Margaret Miller and Steven Edgar will work closely with the AODN to transfer data tables and code to the AODN team. The AODN will then create the data products and serve them through the portal.

AN INSIGHT INTO RECENT SEM WORK ON SOUTHERN OCEAN PHYTOPLANKTON

Fiona Scott

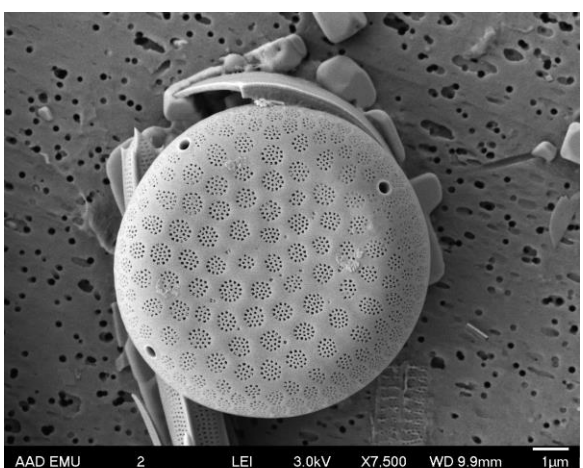
As a sideline to the routine phytoplankton analysis of Southern Ocean CPR silks, I have been making use of the Australian Antarctic Division's Scanning Electron Microscope (SEM) to identify problematic taxa. Overall, the SEM work provides excellent qualitative data – in 'value adding' to information already gleaned from light microscopy – but it is not a realistic method for quantitative analysis of CPR samples.

The benefits of undertaking SEM work include: **1**. I can verify the identification of Southern Ocean phytoplankton to a higher level of classification than by LM only, and then apply the information as I work through subsequent samples. The current total of phytoplankton taxa recorded from S.O. silks is 198. I have obtained LM images of 182 taxa and recently have accumulated SEM images of 117 taxa. Images are in various stages of being uploaded onto the Portfolio image database. **2**. High resolution SEM images can be made available for use in reports/publications in which key taxa or unusual taxa need to be illustrated. **3**. SEM images will be extremely useful in the LUCID identification keys, currently under construction.

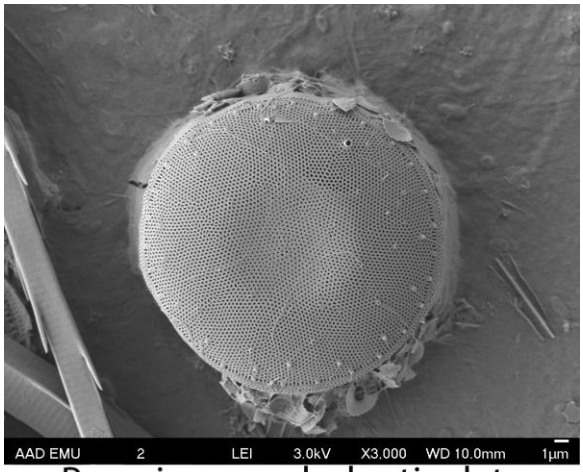
Lumping certain taxa into functional groups is an unfortunate reality of working at the LM level. For example, at x20 magnification I can confidently identify to species level only a small number of 10-20 µm diameter centric diatoms – most I relegate to a 10-20 µmd size class. This functional group may be useable in ecological modelling, however, the real bonus of the SEM work lies in being able to observe changes in taxonomic diversity over both temporal and spatial scales.

I suspect that I could drive people crazy in describing these beautiful organisms, so I have included just a few SEM images of taxa that would be included in this very 10-20 µmd size class.

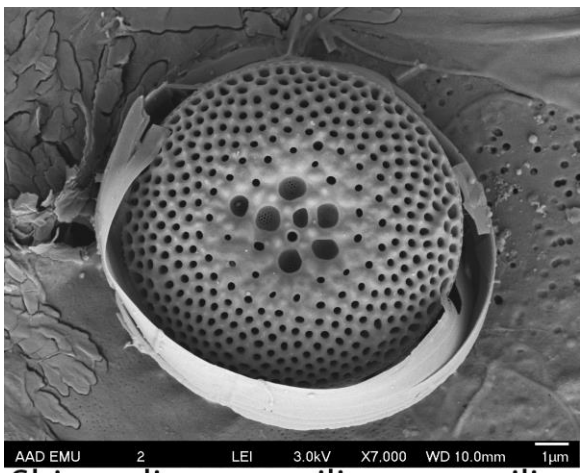
Unfortunately, the SEM at the AAD is currently being decommissioned; luckily, future work can be accommodated at the Central Science Laboratory at the University of Tasmania. The SEM work for Southern Ocean phytoplankton will continue on an ad-hoc basis, as samples are acquired.



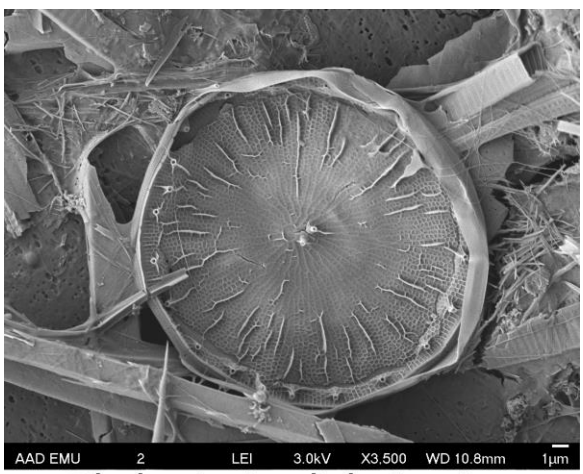
Actinocyclus exiguus



Porosira pseudodenticulata

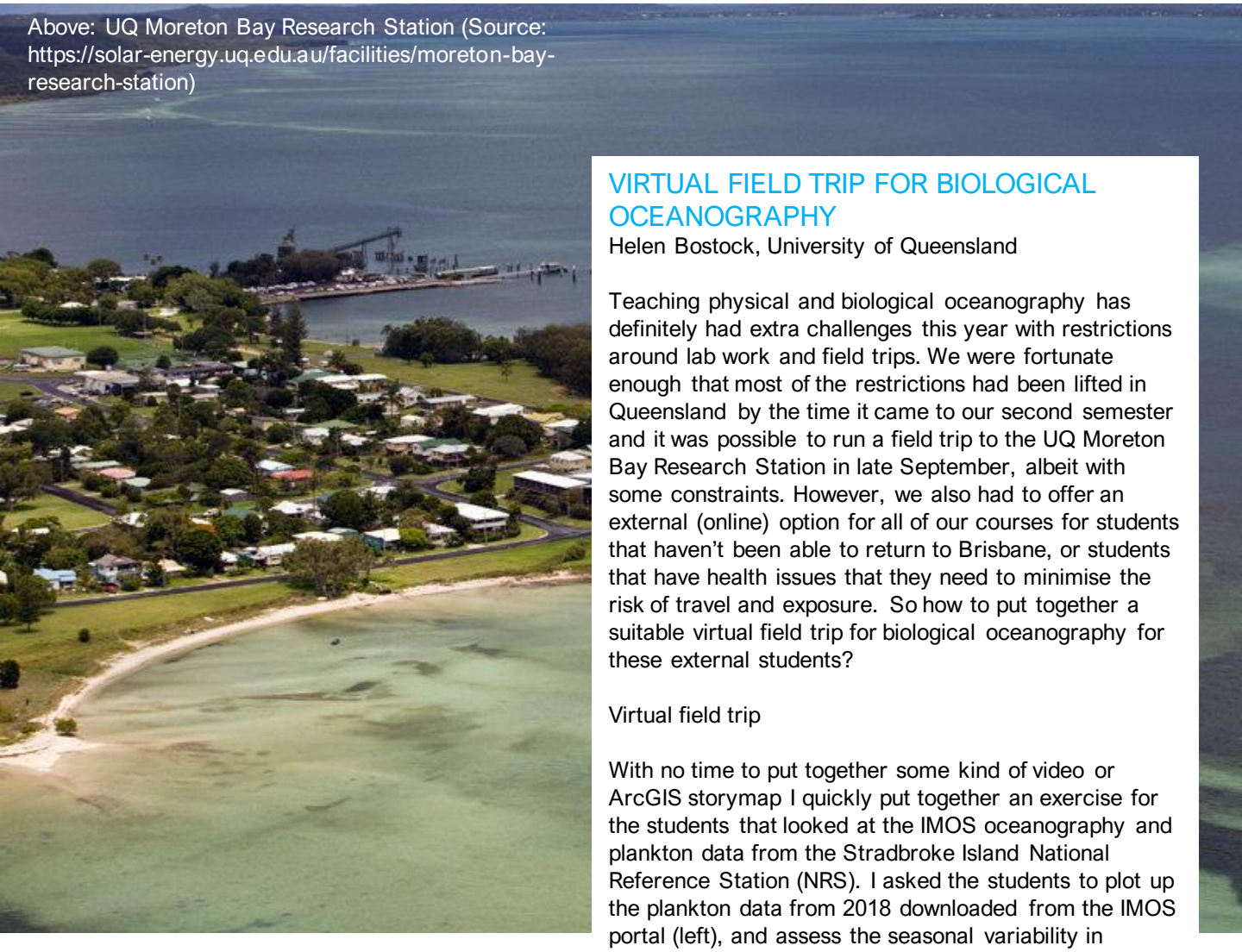


Shionodiscus gracilis var. gracilis



Thalassiosira dichotomica

Thalassiosira frenguellii



Above: UQ Moreton Bay Research Station (Source: https://solar-energy.uq.edu.au/facilities/moreton-bay-research-station)

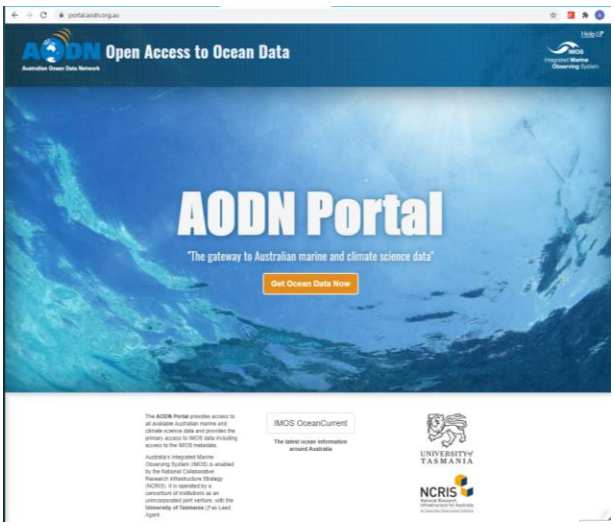
VIRTUAL FIELD TRIP FOR BIOLOGICAL OCEANOGRAPHY

Helen Bostock, University of Queensland

Teaching physical and biological oceanography has definitely had extra challenges this year with restrictions around lab work and field trips. We were fortunate enough that most of the restrictions had been lifted in Queensland by the time it came to our second semester and it was possible to run a field trip to the UQ Moreton Bay Research Station in late September, albeit with some constraints. However, we also had to offer an external (online) option for all of our courses for students that haven't been able to return to Brisbane, or students that have health issues that they need to minimise the risk of travel and exposure. So how to put together a suitable virtual field trip for biological oceanography for these external students?

Virtual field trip

With no time to put together some kind of video or ArcGIS storymap I quickly put together an exercise for the students that looked at the IMOS oceanography and plankton data from the Stradbroke Island National Reference Station (NRS). I asked the students to plot up the plankton data from 2018 downloaded from the IMOS portal (left), and assess the seasonal variability in biological productivity and the dominant taxa and compare this to the oceanographic data collected at the same time (e.g. temperature, salinity, turbidity, chlorophyll data, nutrients, alkalinity and total carbon). The students were then required to compare this data with data from other NRS from around Australia, that had recently been reported in the State and Trends of Australia's Oceans report STAR-Report-March-2020.pdf (imosoceanreport.org.au), and any other published papers that were relevant to the topic. This exercise clearly just scratches the surface of the IMOS Plankton datasets that are available. But I would like to highlight this great resource to lecturers teaching students biological oceanography, providing data for student projects, practicals and even virtual field trips. It would be great to share some of the practical exercises that lecturers have developed using the IMOS plankton datasets for teaching.



Above: The IMOS data portal (https://portal.aodn.org.au/)

I would also like to thank Julian Uribe-Palomino and Jason Everett, who gave excellent lectures and demonstrations to the University of Queensland students, and helped out on the field trip to teach the students skills in sampling and identifying plankton. Their enthusiasm for plankton has recruited a couple of students from this course to undertake internships and research projects. Training up the next generation of plankton researchers!

INTERNSHIP IN HARPACTICOID COPEPODS AT THE NATURAL HISTORY MUSEUM IN LONDON

Julian Uribe-Palomino

Free living marine copepods are one of the most abundant and diverse group of organisms in the Oceans. They have been studied widely however, there is still a lot of things to discover from this fantastic group of animals which are one of the main focuses of the projects our plankton team works in: The Australian Continuous Plankton Recorder and the IMOS-National Reference Stations.

Even though most of the copepods we know about belongs to the orders Calanoida and Cyclopoidea (following the most recent taxonomic update - WoRMS), our knowledge of the copepods from the order Harpacticoida is more limited.

Planktonic Harpacticoids are relatively easy to identify to genus and in some cases to species level however, less is known about the identity of epibenthic harpacticoids that regularly appear in planktonic samples These species might be resuspended by water movements or enter the water column by vertical migration and when they do they temporarily become part of the plankton communities but have not been well studied.

Hintze Hall is one of the most iconic spaces that introduce the general public to one of the most important museums of the world, the Natural History Museum in London. Image: Julian Uribe-Palomino.

Julian Uribe-Palomino at the Natural History Museum in London.

Harpacticoid-like copepods are the second most abundant taxon of benthic communities after Nematodes however, they are highly diverse and globally, their diversity have been underestimated and their taxonomic study has been neglected because there are very few specialists capable of accurate identification of these animals.

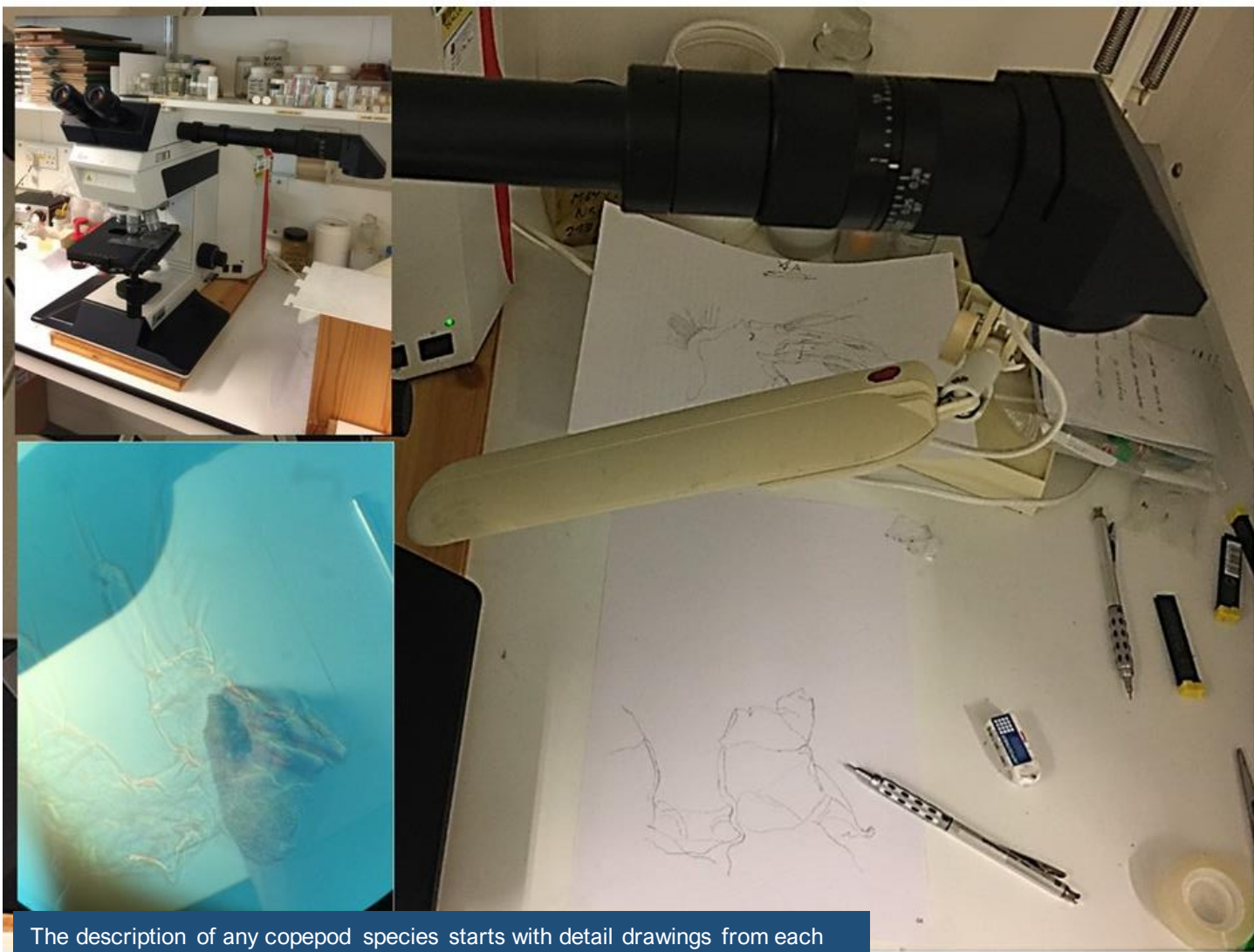
During my internship at the Natural History Museum, under the direction of Professor Rony Huys, I had the opportunity to learn theory and practical techniques that will be the foundation to build better taxonomic skills to be enable me to work with our Australian fauna of harpacticoid-like animals. I learnt that not all the animals that look like harpacticoids belong to this order, there is this another difficult to distinguish order called Canuelloida.

Recent integrated taxonomic work, that included molecular studies, made it possible to confirm clearly distinctions between Harpacticoids and Canuelloids . Even though, it was known for a while that morphological differences among animals clustered as Harpacticoids existed, it is only with these recent studies that the distinctions have been confirmed.

Harpacticoids and Canuelloids are not as easy to identify in comparison to Calanoids or many Cyclopoids. Their morphology is more complex and requires detailed revision. This is one of the difficulties of developing a better understanding of this challenging group of animals and in particular, their diversity that has been broadly underestimated in waters under Australian jurisdiction.

The Australian region has an enormous potential as a source of new species of the already mentioned copepod orders. The identification of possibly new species and a new genus are some of the outcomes of this internship. A whole review of the work done on harpacticoid-like copepods of Australia should be done to have a better understanding of their spatial distribution, ecological role in the marine ecosystems and future work to do with this intriguing group of animals.

Even though all these specimens look very similar almost as the same morphotype, there are clear differences once they are observed carefully. There is at least 3 different species in that samples from Moreton Bay. Image: Julian Uribe-Palomino.



The description of any copepod species starts with detail drawings from each one of the copepod body appendages. This is the intersection between Science and Art. Image: Julian Uribe-Palomino.

Free living Copepods arranged by main orders: Calanoids, Cyclopoids and Harpacticoids. Specimens of this last one order are really hard to ID. Image: Julian Uribe-Palomino.

Besides my main objective of improving my taxonomic skills in marine copepods, I also had the opportunity of meeting researcher Dr Gill Mapstone who has dedicated her life to the study of Siphonophores. I also had the chance to interact with researchers working in diverse fieldsfrom Parasites to deep water corals and I attended seminars where students were getting support from all these professionals working together under the roof of one of the most amazing Museums of Natural History in the whole World.

The Natural History Museum in London is also investing of the digitalization of several collections, a cool video explaining the outreach of this titanic work can be found at this link: https://www.nhm.ac.uk/our-science/our-work/digital-collections.html

Specimens of a new genus found in samples collected in Moreton Bay, North Stradbroke Island. Image: Julian Uribe-Palomino.

BARCODING AS A SUPPORTIVE TOOL FOR TRADITIONAL IDENTIFICATION OF MARINE ORGANISMS

Julian Uribe-Palomino

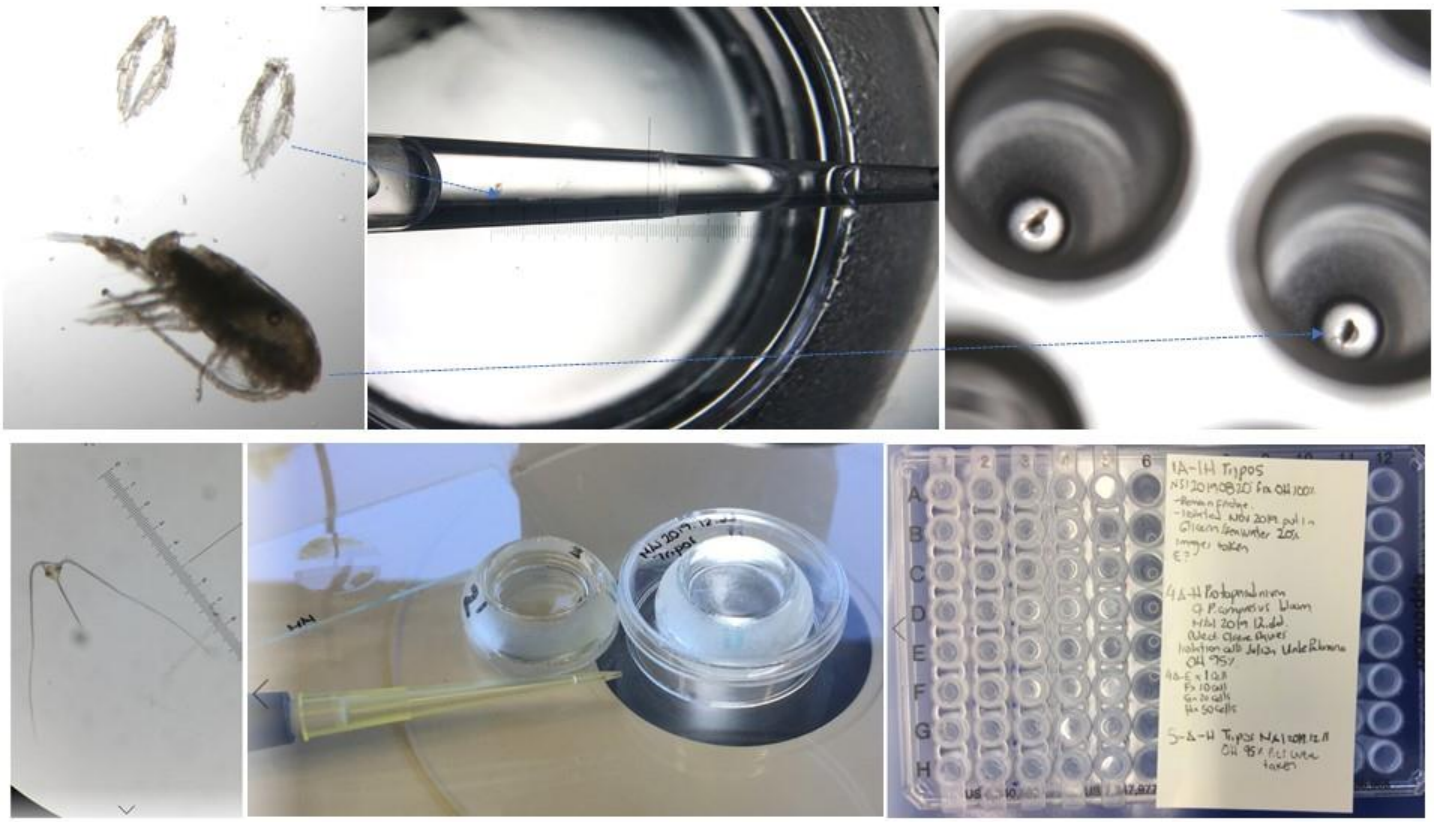
Environmental impact assessments are moving quickly into the implementation of cutting-edge techniques that involve bulk DNA sequencing instead of traditional collection and classification of specimens based on morphological taxonomy. However, a good DNA reference collection of single species-sequences (DNA-Barcode) is required for this molecular approach to be meaningful.

Unlike plants, insects and fish, there are no natural collections of planktonic organisms from Australian waters. Even though there are specimens registered in Australian Museums, that in most of the cases are unique, most (all) of these do not have any DNA barcode linked to them.

Recognising this important issue, our team is willing to start building a local DNA-Barcode library of the most common planktonic marine organisms that we found in our Australian waters, in particular copepods. This library will provide support to metabarcoding studies, providing quality data at a National level to help resolve the identity of several OTUs that already exist but have not been assigned to any particular species.

During January 2019, specimens of some of the most common copepods and specimens of the dinoflagellate genus *Tripos*, found during the analysis of our plankton samples, were isolated from two NRS: North Stradbroke Island and Maria Island. These samples were fixed and preserved in pure ethanol for the purpose of DNA-Barcoding. This molecular approach aims to sequence a highly conserved region of genome (a fragment of a mitochondrial gene subunit denominated as cytochrome c oxidase I or COI for short) to distinguish specimens to species level.

We expect to extend this approach to other difficult to identify planktonic taxa such the larvae of several organisms, including decapods and other crustaceans, some of those of commercial interest. For this project to move forward, we are seeking local and international collaboration to fund the processing of the samples that we able to obtain at the Australian National Reference Stations.



Top line. Copepod Calanoid (*Nanocalanus minor* female). Fifth leg of the specimen was cut and kept for confirmation of the species identity. Body was transferred to Eppendorf tray for further DNA extraction. Appendages were taken for DNA extraction in case of unique specimens and the rest of the body is kept for species Identification. Images: Julian Uribe-Palomino.

Bottom line. Specimen of *Tripos massiliensis* selected from Maria Island for DNA extraction and Eppendorf tray with occupied wells with different *Tripos* species. Images: Julian Uribe-Palomino.

PLANKTON GALLERY

Julian Uribe-Palomino

*Acrocalanus gibber*_intersex_NRS Darwin_10x

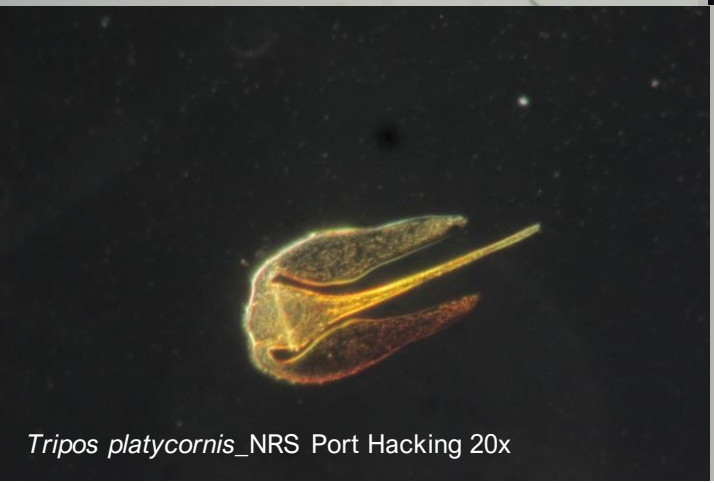
Anomura zoea_AusCPR Cairns to Gladstone_4x

*Urocorycaeus furcifer*_male_NRS Port Hacking_10x

*Ditrichocorycaeus minimus*_male_NRS Darwin_10x

Monstrilloid_female__Heron Island_4x

Caligidae_AusCPR Port Kembla to Melbourne_2x



*Tripos platycornis*_NRS Port Hacking 20x

Oncaea vodjanitskii female & *Oncaea atlantica*_female_NRS North Stradbroke Island_20x

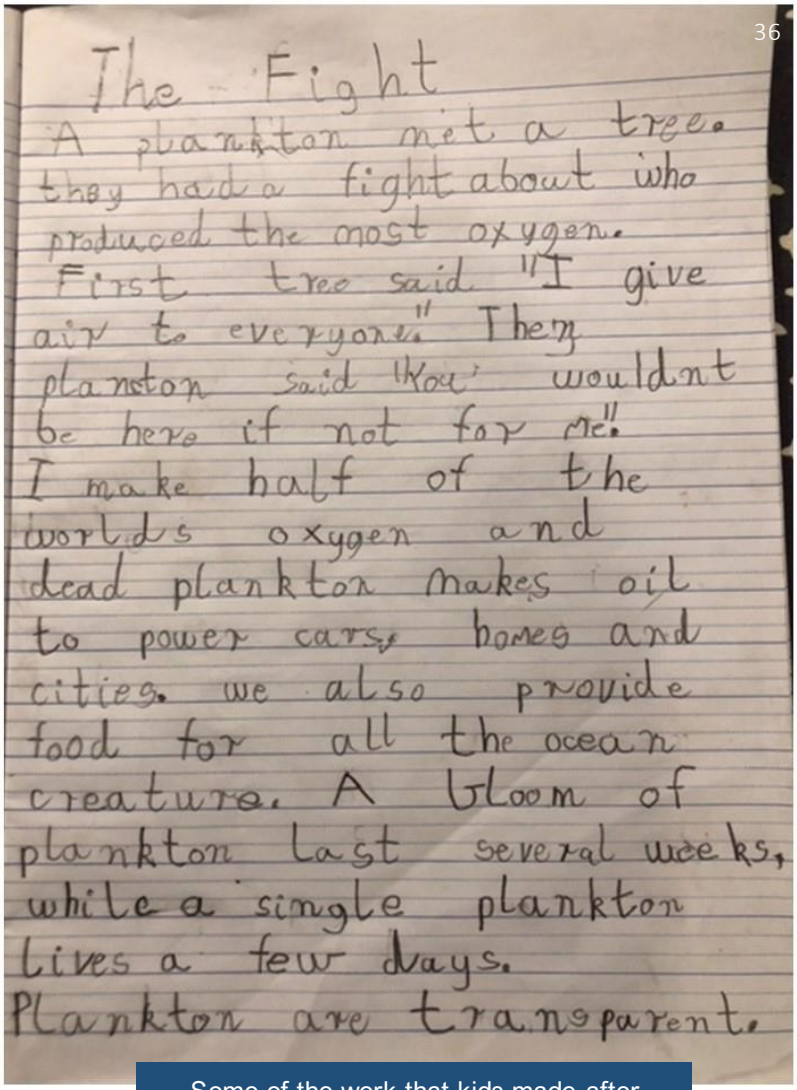
TEACHING PLANKTON IN TIMES OF COVID-19

Julian Uribe-Palomino

Due to restrictions imposed to limit the mobility of people and the possible spread of the COVID-19 virus, many education providers found very difficult to deliver their courses, in particular those requiring practical sessions. This situation gave us the opportunity of reaching members of the general public and university students by using online communication platforms. We had the possibility of going beyond geographical boundaries as it was the first time that we went 'live' online to talk about the invisible world that lays beneath the ocean waters.

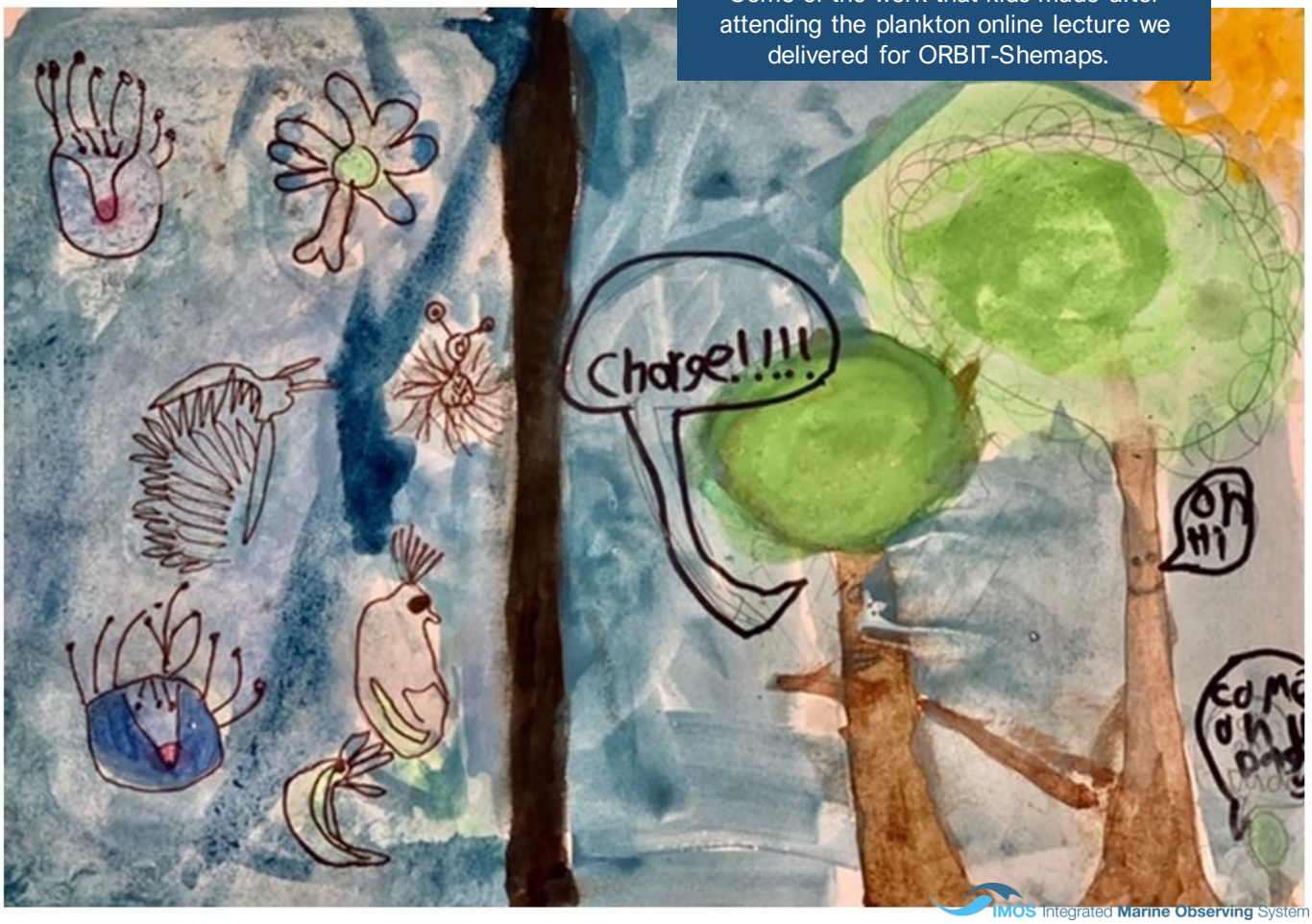
Online Educators from ORBIT by Shemaps (https://learnwithorbit.com) brought us the opportunity to reach kids using their virtual teaching platform last April (2020). This was great opportunity to clarify to kids in particular what plankton is and the impact that these 'creatures' have in our day to day life.

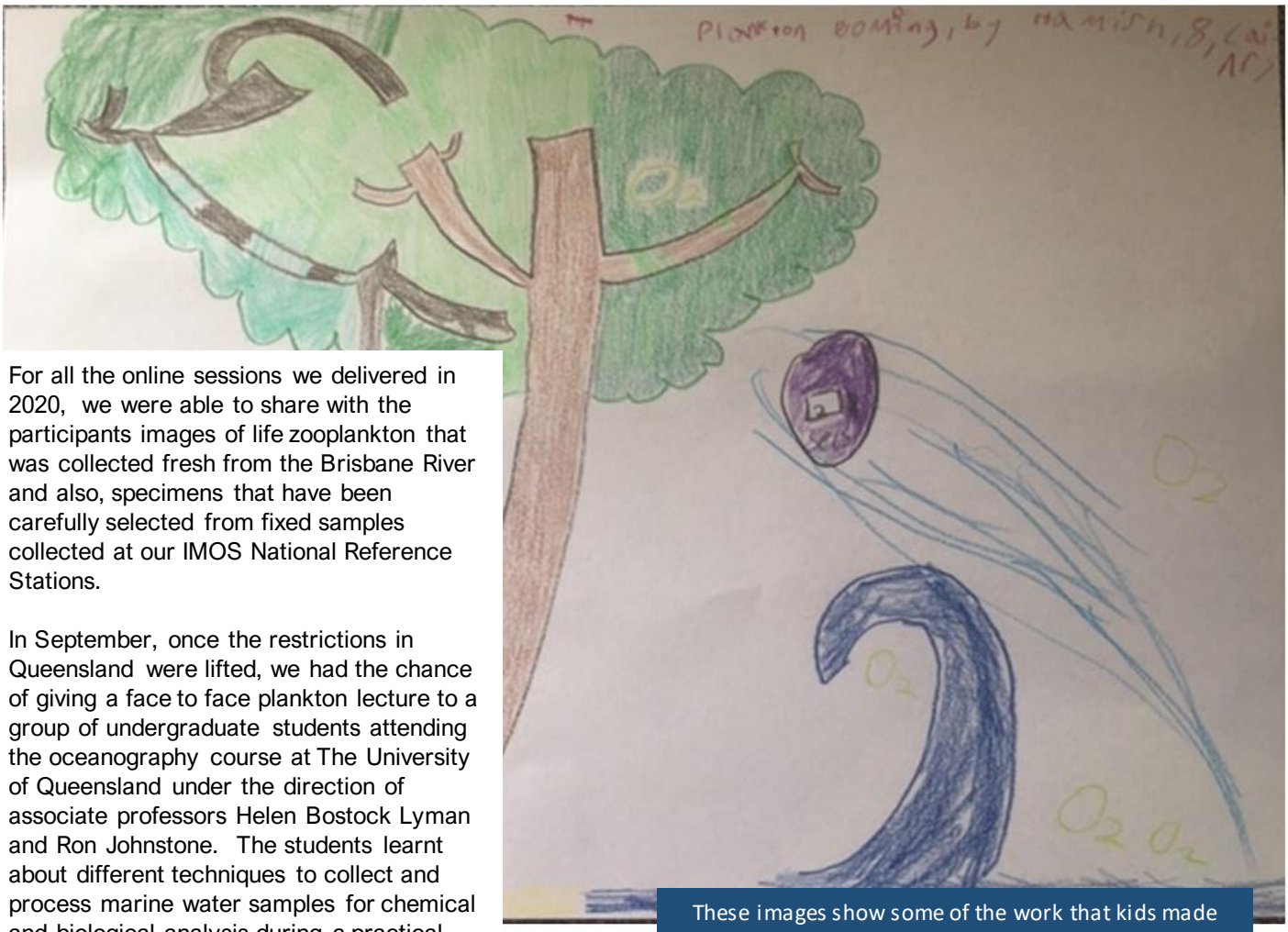
Subsequently in June we delivered an introduction to zooplankton communities to students from the University of Tasmania under the direction of Professor Kerrie Swadling as the students did not have the chance of doing their practical course as usual at Maria Island (TAS).


The Fight

A plankton met a tree. they had a fight about who produced the most oxygen. First tree said "I give air to everyone" Then plankton said "You wouldnt be here if not for me". I make half of the worlds oxygen and dead plankton makes oil to power cars, homes and cities. we also provide food for all the ocean creatures. A bloom of plankton last several weeks, while a single plankton lives a few days. Plankton are transparent.

Some of the work that kids made after attending the plankton online lecture we delivered for ORBIT-Shemaps.



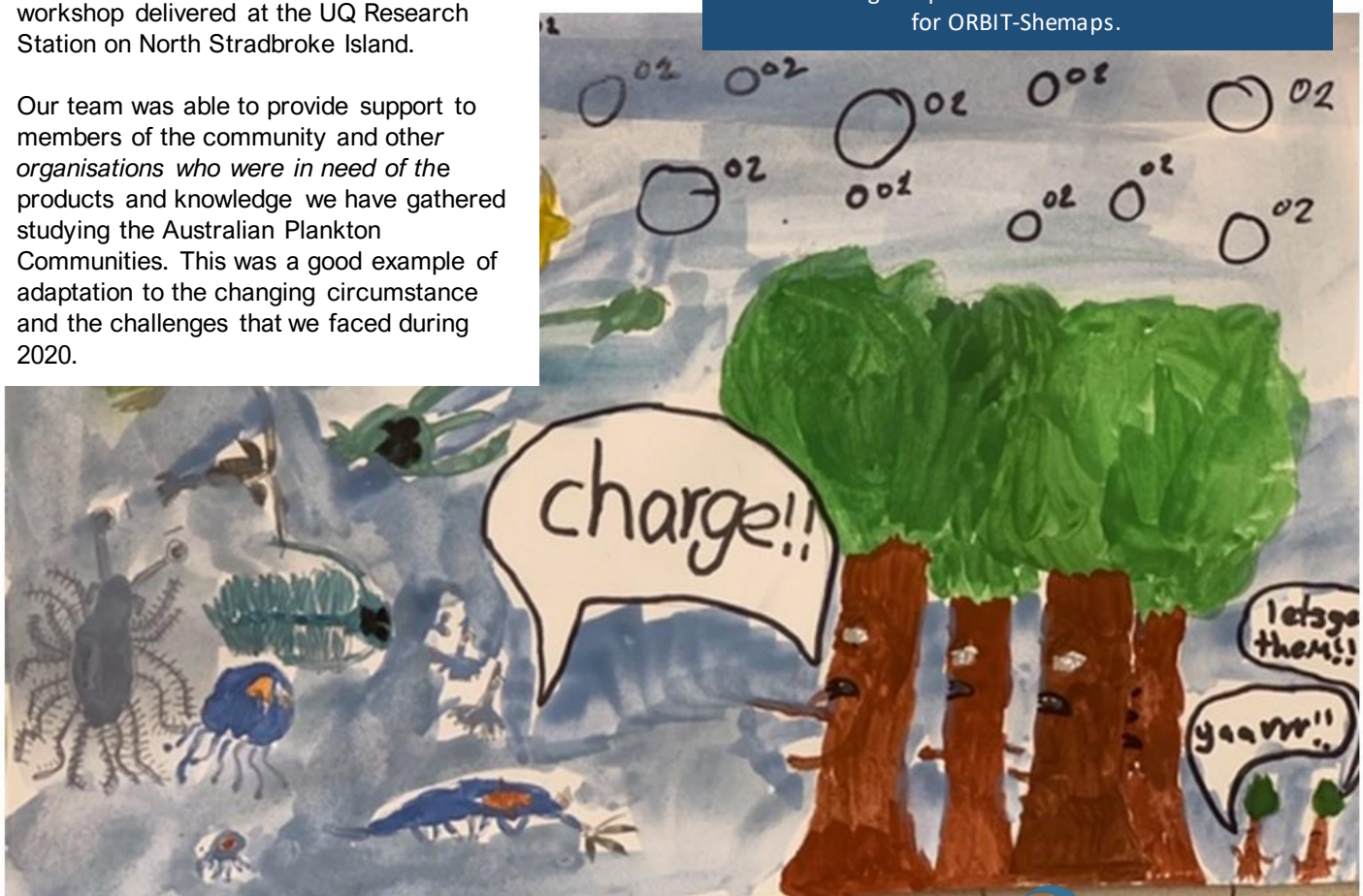


For all the online sessions we delivered in 2020, we were able to share with the participants images of life zooplankton that was collected fresh from the Brisbane River and also, specimens that have been carefully selected from fixed samples collected at our IMOS National Reference Stations.

In September, once the restrictions in Queensland were lifted, we had the chance of giving a face to face plankton lecture to a group of undergraduate students attending the oceanography course at The University of Queensland under the direction of associate professors Helen Bostock Lyman and Ron Johnstone. The students learnt about different techniques to collect and process marine water samples for chemical and biological analysis during a practical workshop delivered at the UQ Research Station on North Stradbroke Island.

Our team was able to provide support to members of the community and other *organisations who were in need of the* products and knowledge we have gathered studying the Australian Plankton Communities. This was a good example of adaptation to the changing circumstance and the challenges that we faced during 2020.

These images show some of the work that kids made after attending the plankton online lecture we delivered for ORBIT-Shemaps.



TESTING BERGMANN'S RULE IN COPEPODS

Max Campbell

Bergmann's Rule states that organisms from the same taxonomic group are generally larger in cooler regions and smaller in warmer regions. This pattern is well documented in many groups; however, it is widely debated whether temperature is the major driver of this pattern because many plausible drivers of size covary with temperature. Spatial gradients in body size are important because body size largely determines the ecology and physiology of organisms, and thus they can provide valuable insights into global biodiversity. In our recent paper "Testing Bergmann's Rule in Marine Copepods" (in press), which is a big collaborative effort among the GACS community (Global Alliance of CPR Surveys) and global CPR surveys, we test which drivers influence Bergmann's Rule in copepods. To do this we used over 100,000 CPR samples (which is the most samples ever used to test Bergmann's Rule), and advanced statistical models to disentangle the correlated drivers of body size. The results of this work have implications for theoretical ecology, ecosystem modelling and for climate change predictions.

This project is an example of how we can use large consistent datasets, that span spatial, temporal, and environmental gradients (such as IMOS datasets), to test important ecological hypotheses. For this project, I was lucky enough to work under the supervision of Anthony Richardson and David Schoeman, whom continuously improved this project over the last three years. I love working on large datasets such as this one because I feel like an explorer travelling into the unknown, with only a well-established hypothesis and a bag full of statistical techniques to help me. I would like to thank the IMOS team and our co-authors for this unique opportunity, and for their invaluable help with this work.

NCRIS National Research Infrastructure for Australia
An Australian Government Initiative

Australia's Integrated Marine Observing System (IMOS) is enabled by the National Collaborative Research Infrastructure Strategy (NCRIS). It is operated by a consortium of institutions as an unincorporated joint venture, with the University of Tasmania as Lead Agent. **www.imos.org.au**

PRINCIPAL PARTICIPANTS

University of Tasmania (Lead Agent) · Australian Government · Australian Institute of Marine Science · Australian Government Bureau of Meteorology · CSIRO · Government of South Australia · SARDI · The University of Western Australia · sims sydney institute of marine science · UTS · The University of Sydney · Macquarie University · UNSW Sydney

SIMS is a partnership involving four universities.

ASSOCIATE PARTICIPANTS

Curtin University · Australian Government Department of Agriculture, Water and the Environment Australian Antarctic Division · Australian Antarctic Program · Deakin University · The University of Melbourne

Visit the AusCPR website https://imos.org.au/facilities/shipsofopportunity/auscontinuousplanktonrecorder

Visit the NRS website https://imos.org.au/facilities/nationalmooringnetwork/nrs

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IMOS acknowledges the Traditional Custodians and Elders of the land and sea on which we work and observe and recognise their unique connection to land and sea. We pay our respects to Aboriginal and Torres Strait Islander peoples past and present

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