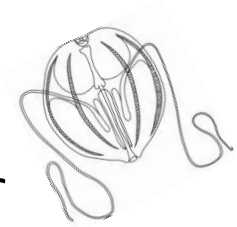
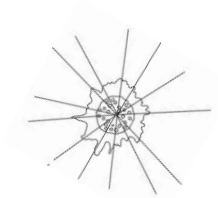
Issue 12
March 2019

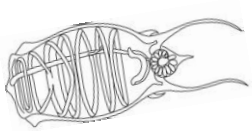
IMOS Integrated Marine Observing System

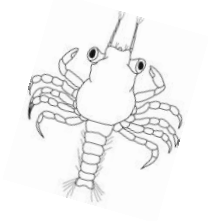


IMOS Australian Plankton Survey 2018 Annual Newsletter



The Australian Continuous Plankton Recorder Survey & National Reference Stations





We have now towed
200,000 km and this is
5 times around the Earth!

National Reference Stations

NRS

684 zooplankton samples counted
643 biomass samples counted
604 phytoplankton samples counted

480,462 zooplankton counted
213,176 phytoplankton counted

CPR

21,678 Phytoplankton Colour Index segments counted
6,015 zooplankton segments counted
5,624 phytoplankton segments counted

108,390 nautical miles towed
145 trips processed

665,986 zooplankton counted
59,219 phytoplankton counted

Directors report I am proud to open our Newsletter summarising our activities in 2018. It was a busy and successful year for us. I will just point to the highlights here, many of which are expanded upon later in the newsletter.

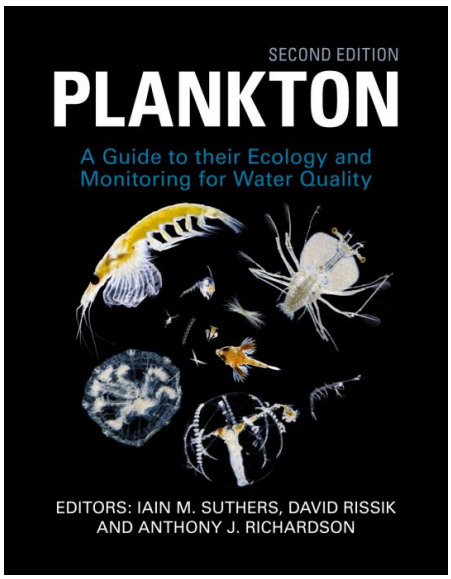
In terms of plankton analysis, we continue to collect and count thousands of IMOS plankton samples each year. We have now towed CPRs over a distance equivalent to five times around the Earth. I'd like to thank all the Team for the huge effort in shipping logistics, sampling, counting and databasing, which all comes together to produce the high quality IMOS plankton data. I don't think there is a better plankton team in the world!

In terms of publications, I would like to highlight only a few here. Tina Berry – a PhD student in the Mike Bunce lab at Curtin University and co-supervised by Olly Berry at CSIRO and me – published the longest-ever eDNA study. The paper is entitled *Marine environmental DNA biomonitoring reveals seasonal patterns in biodiversity and identifies ecosystem responses to anomalous climatic events*. Tina used the eDNA of copepods to provide insights into ocean health, seasonal patterns in biodiversity, and impacts of marine heatwaves. Nice work Tina!

Another noteworthy publication is that by Jenny Skerratt entitled *Simulated nutrient and plankton dynamics in the Great Barrier Reef (2011-2016).* A special mention for Claire Davies for facilitating this, The paper included an assessment of the plankton fields in the eReefs model against observed phytoplankton and zooplankton data from the NRS and CPR surveys. Of note is the strong agreement spatially between the eReefs zooplankton biomass and that modelled from observed IMOS NRS and CPR data combined with historical data. This and other model assessment work was facilitated through the Zooplankton Ocean Observations and Modelling (ZOOM) Task Team. It is hoped that the IMOS plankton data will be increasingly used in similar model assessments in the future.

New Plankton book

See page 11 for details…



Available now via CSIRO publishing:
https://www.publish.csiro.au/book/7808/

The final paper I will mention is that by James Smith (formerly UNSW) entitled *A database of marine larval fish assemblages in Australian temperate and subtropical waters*, it brought together historical fish larval data with data that has been collected over the past few years piggybacking on the IMOS infrastructure. Iain Suthers (UNSW) and Ana Lara-Lopez (UTas) and I have championed the fish larval work, with support from IMOS. In the next phase of IMOS, the IMOS Larval Fish subfacility has now been funded. This long-term monitoring of fish larvae will be incredibly valuable for providing a fisheries-independent measure of changes in distribution and abundance of many commercial and non-commercial species. Well done Iain and Ana for your motivation and persistence.

And thanks to the students who have helped bring the IMOS data to life. Dr Ryan Heneghan has just been awarded his PhD in mathematics at UQ for a thesis entitled *Improving zooplankton realism in size spectrum models: implications for energy flow in food webs and fisheries production*. Using both modelling and empirical approaches, this work shows that oligotrophic systems have similar trophic efficiencies to eutrophic systems, counter to conventional wisdom, and a consequence of changes in zooplankton functional groups across the world's oceans. Congratulations Ryan on a fascinating piece of work, with major theoretical and applied implications. Phil Dyer (UQ PhD student) presents ongoing work on the biogeography of plankton around Australia on Page 24 of the newsletter. He is supervised by David Schoeman (University of the Sunshine Coast), Roland Pitcher (CSIRO) and me, and he plans to use his approach globally to assess the representivity of the Global Marine Protected Area network for protecting pelagic biodiversity. Finally, I'd like to point you to the article by Max Campbell on Page 25. Max obtained 1st Class Honours in Biology at UQ (supervised by David Schoeman and me) with a comparative analysis of macroecological relationships. Max used 10s of thousands of CPR samples from around the world and generalised linear mixed modelling to test whether copepod size declines with temperature.

I would also like to mention the Plankton Book that our Team was heavily involved in. It is the second edition of *Plankton: A Guide to their Ecology and Monitoring for Water Quality* by CSIRO Publishing. It is an introductory to intermediate level book for students and researchers interested in understanding more about phytoplankton and zooplankton, including their identification. From my perspective, two sections that are particular interesting and informative are the Fun Facts in Chapter 1 (e.g., plankton in the movies, plankton driving our automobiles and plankton inspiring engineering and architecture, the 19 different ways that plankton interacts with humans from impacts (positive and negative) on human health to their use in aquaculture (in Table 1.1). I'd like to highlight Ruth Eriksen's role in Chapter 6 on Marine Phytoplankton, Julian Uribe for the stunning zooplankton images in Chapter 8 on Marine Zooplankton, and Anita Slotwinski for the professional line drawings of specimens in Chapter 8. We are proud of Chapter 8, which is a guide to the major groups of marine zooplankton – it is almost 1/3 of the book in length – and is packed full of tips and tricks for plankton identification. A signed copy of the book was presented to Tim Moltmann, IMOS Director, at the Annual Planning Meeting in Brisbane in February 2019. Many of the inputs in the book were possible because of the contribution of IMOS to plankton research in Australia. If you are interested in further details or purchasing the book, see page 11.

Table of Contents

Above: Anthony Richardson and Iain Suthers signing the plankton book.

Above: Anthony Richardson, Tim Moltmann and Iain Suthers.

Finally, I represented AusCPR at the annual GACS (Global Alliance of CPR Surveys) meeting in Plymouth (UK) in November 2018. This is an important meeting to keep up-to-date with the latest developments in CPR surveys globally and to make sure we are maintaining "best practice". I am now the Chair of GACS and we are having our next meeting in November 2019 in Australia – the first time outside Europe. We have secured some funding from POGO to help with this. I look forward to welcoming the GACS community to Australia later in the year!

Yours in plankton,
Anthony

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.

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.

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.

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.

Anita Slotwinski

Position: Plankton Biologist
Location: CSIRO, Brisbane, Queensland
I analyse CPR & NRS samples. I also manage the project website, communication materials, and the zooplankton species reference collection. My research interests are in marine plankton ecology, environmental change and species response and photomicroscopy. In my spare time I enjoy time with family & friends, photography, gardening and exploring nature.

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.

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.

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.

James McLaughlin

Position: Marine Biologist/ Biogeochemist
Location: CSIRO, Floreat, Western Australia
My job is helping to expand the survey into WA waters and the analysis of phyto- and zooplankton samples. I have been with CSIRO for 5 years and work 10% of my time with AusCPR. My research interests include marine phytoplankton dynamics and ecology, benthic and pelagic primary production, and ocean acidification. I enjoy spending time with my family, travelling and keeping tropical aquarium fish.

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.

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.

Contact Information

Visit the AusCPR website
http://imos.org.au/auscpr.html

Visit the NRS website
http://imos.org.au/anmnnrs.html

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Further team contact details
http://imos.org.au/cpr_staff.html

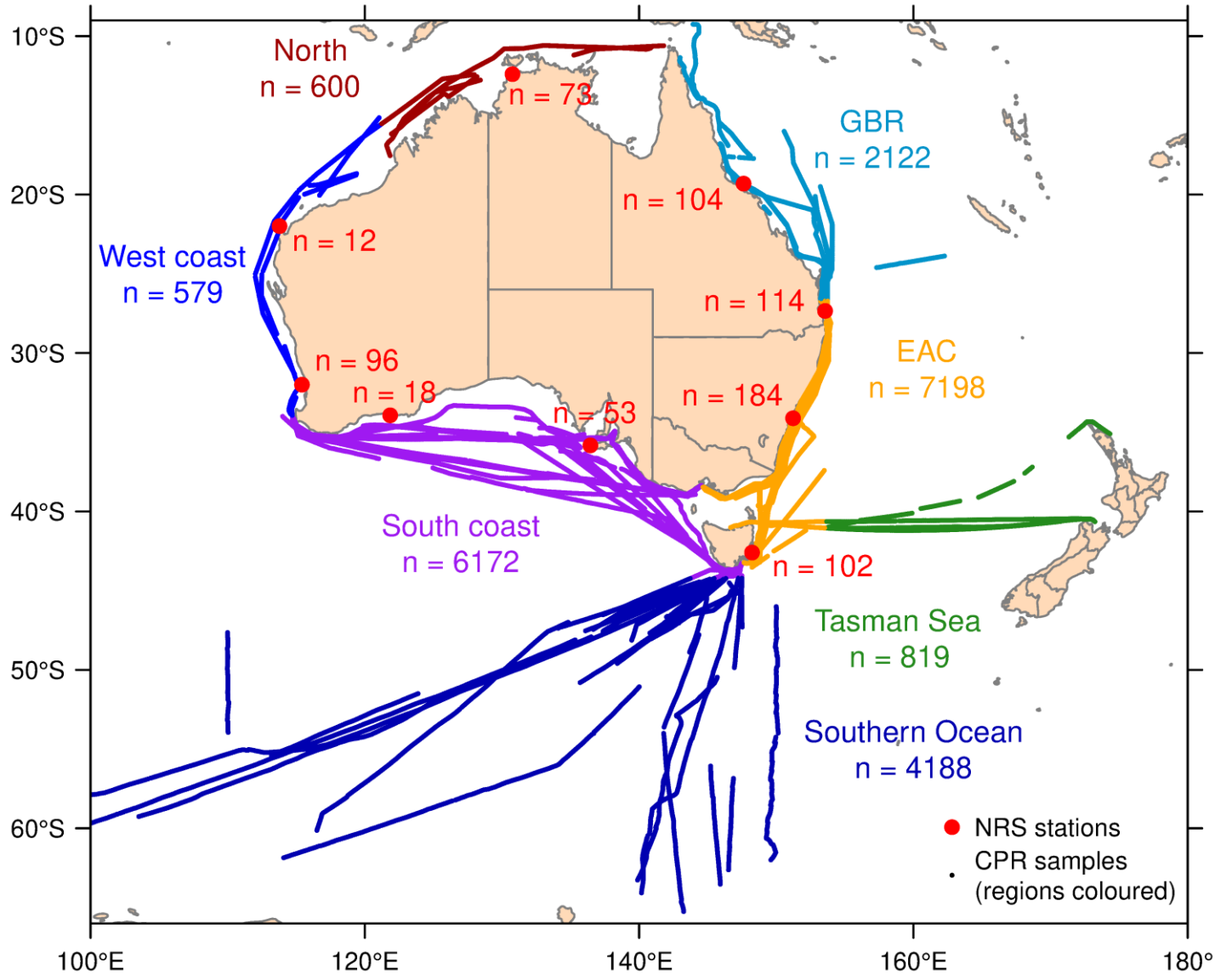
Social media

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

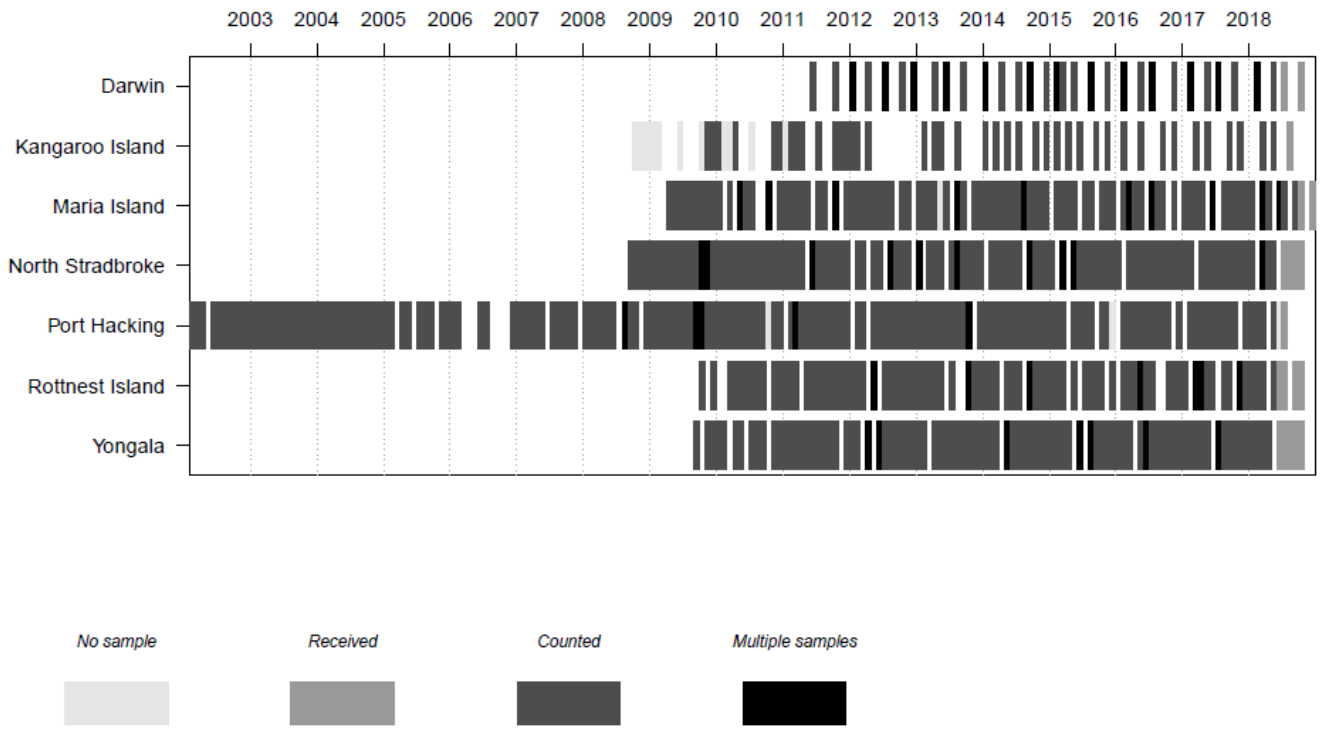
Integrated Marine Observing System (IMOS) plankton data, 2007–2018



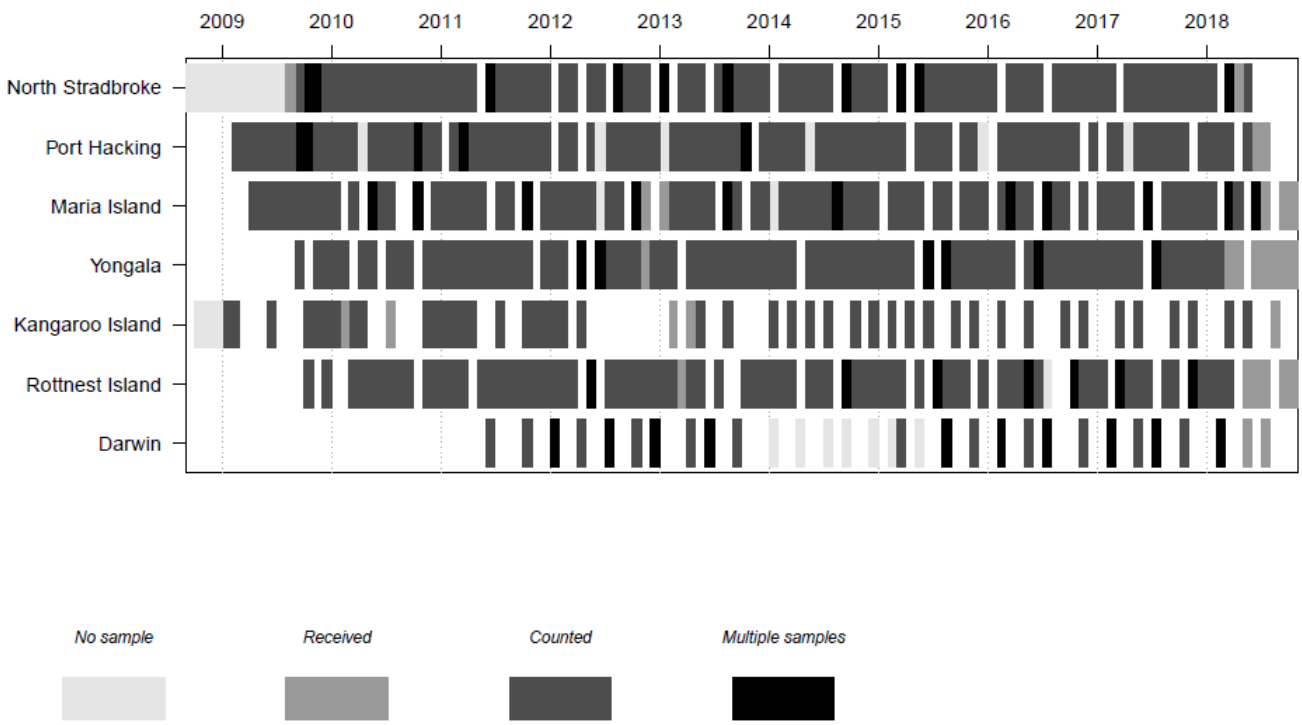
The route from Melbourne to Adelaide is one of our longest-running routes and traverses the productive upwelling waters of the Bonney upwelling system..

Our Southern Ocean routes are towed in collaboration with the SCAR SO-CPR Sruvey 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.

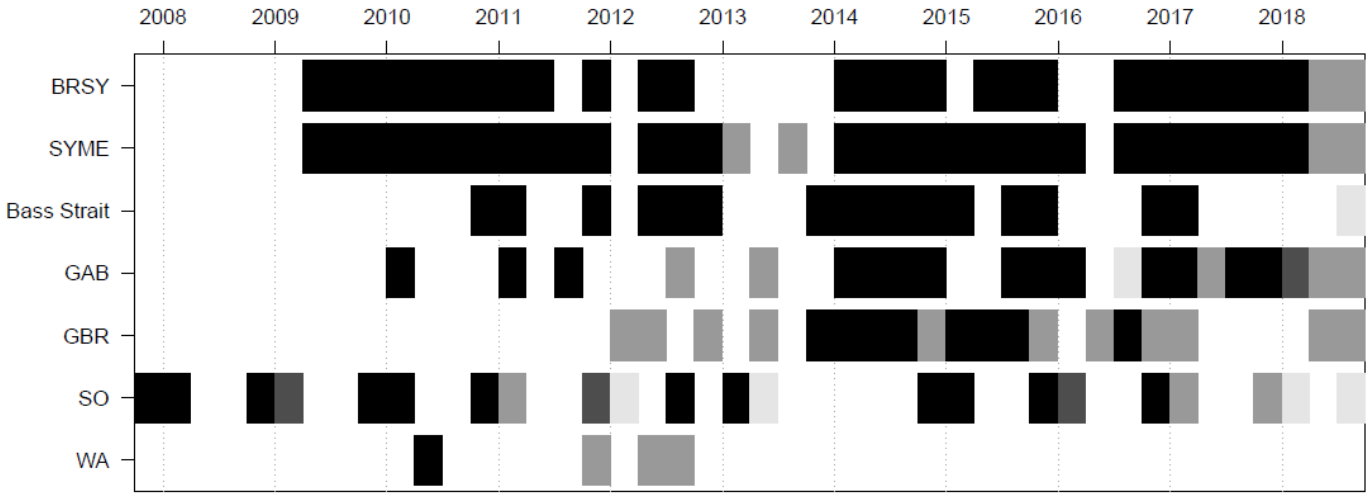
National Reference Stations Zooplankton Progress -26-02-2019



National Reference Stations Phytoplankton Progress 26-02-2019



Australian Continuous Plankton Recorder Progress 26-02-2019



** Please note the GBR route replaces the GAB*

Shipping

Mark Tonks

The eastern and southern Australian coastal waters continue to be sampled by two Wallenius Wilhelmsen ships, the *Tonsberg* and *Salome*, between the ports of Brisbane, Port Kembla, Melbourne and Adelaide. Since the commencement of sampling with this company in July 2016, combined both vessels have completed over 50 CPR tows covering more than 14,000 nm. We continue to be incredibly impressed with the support they provide to our plankton survey.

In October 2018 we provided a summary report to Captain Sunil Dhowan (Head of Port and Cargo Operations – Oceania) to present to a Global Head of Operations meeting in the United States. This report provided information on the number of tows and distance towed by each Wallenius Wilhelmsen vessel, indications of seasonal plankton biomass and Phytoplankton Colour Indices and outlined the five most abundant zooplankton and phytoplankton taxa sampled on their route. Further to this, Captain Dhowan nominated their company into the 'Environmental Category' of the 2019 Lloyds Daily Cargo News Awards. He hopes that this will help inform the Maritime Industry that shipping lines can assist in environmental initiatives.

The inner Great Barrier Reef route between Cairns and Gladstone is now being sampled by the Rio Tinto ship *RTM Wakmatha*. Negotiations began with Rio Tinto in July 2017 to tow a CPR in this region. After numerous logistical discussions, and a lengthy tow point design and fabrication phase sampling finally commenced in June 2018. Since the initial tow a further two tows have been conducted in September 2018 and January 2019.

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)

We continue to do our monthly sampling at the North Stradbroke Island National Reference Station. It takes us 90 minutes to reach the site from the Manly Marina where our research vessel 'Scylla' is berthed.

On site

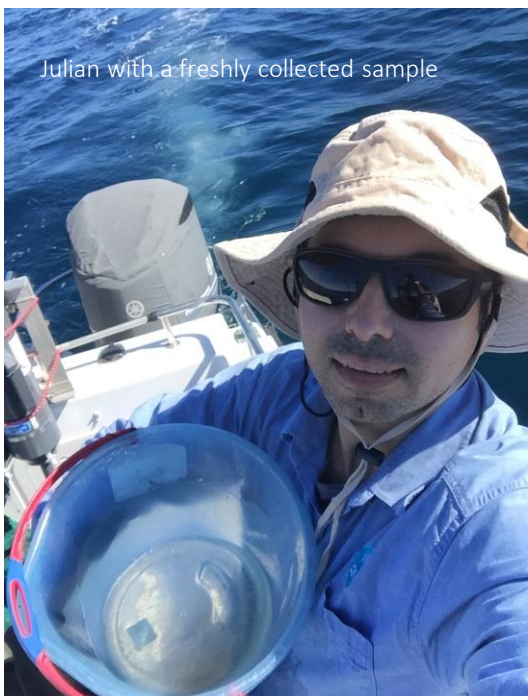
- we deploy a secchi disc to measure turbidity;
- deploy a CTD to record salinity and temperature profiles from the surface to 55 meters
- collect three discrete plankton samples with a drop net (sampling the water column to 55 meters);
- sample water at discrete depths using Niskin bottles (57m, 50m, 40m, 30m, 20m, 10m, surface) and
- complete two 7 minute fish larval tows (samples are combined).

View of the boat and niskin bottles

Preparing the plankton net for deployment

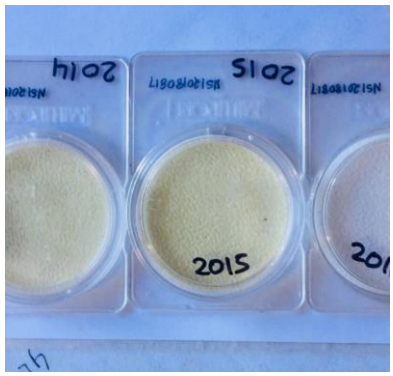
Julian and Mark winding up the secchi disk after measuring turbidity

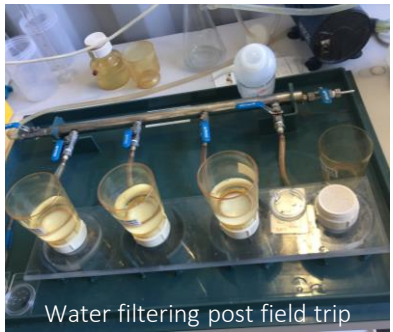
The deployed plankton net before sinking down



Julian with a freshly collected sample

Much gelatinous material found in this sample





Water filtering post field trip

Microbial genetic plankton samples

Brisbane Lab Update

Frank Coman

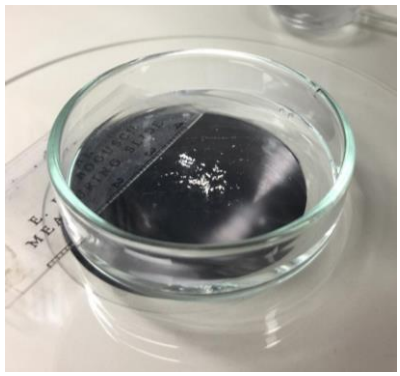
The staff at our Brisbane laboratory have again been concentrating on collecting and analysing samples from both AusCPR and the National Reference Stations (NRS), but this year we have also needed to spend some time relocating to a new site. From 2011 until March this year we had been based at the Ecosciences Precinct at Dutton Park, but in March 2018 we moved our offices and laboratory to the Queensland Biosciences Precinct which is located on the University of Queensland campus. Most of our sampling equipment for both the AusCPR and National Reference Station projects is still located at the Ecosciences building. It did not take long to settle into the new offices and laboratories, with minimum disruption to our sample processing.

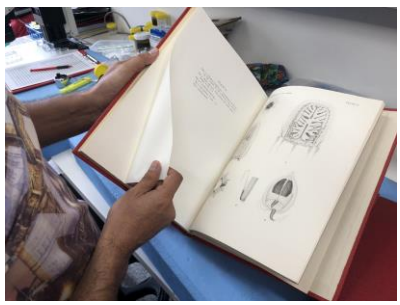
Mark has continued to be involved in other field work projects. In June Mark and Julian from the Brisbane laboratory, along with Claire from Hobart all assisted on a field trip to ground truth the data from remote sensing work being conducted around Heron Island. The three of them spent time driving boats and diving along transects around the Island in June. Mark and Frank also took part in the mid-year Torres Strait Lobster dive survey for 2 weeks in July, and Mark is again participating in the next pre-season survey through November. Mark also has to spend a considerable amount of time preparing for these trips as he has taken over the responsibility for the logistics of the field trips.

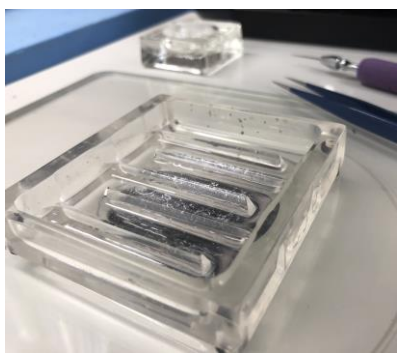
Just prior to the Heron Island field trip Claire and Jason Everett were in Brisbane to work with Anthony on using IMOS plankton data for other modelling projects. Claire and Jason returned again in October to continue this work. Some of the results will be used in the up-coming Status and trends report. Anthony and Ruth have also been working hard on this report, but in the background Anita has done a great job of sorting out the logistics of getting everyone together for the main workshops required to complete the report. Felicity also visited Brisbane in February 2018 to attend an R-course and also was able to spend some time to run the staff at the Brisbane laboratory through the workings of a LUCID key.

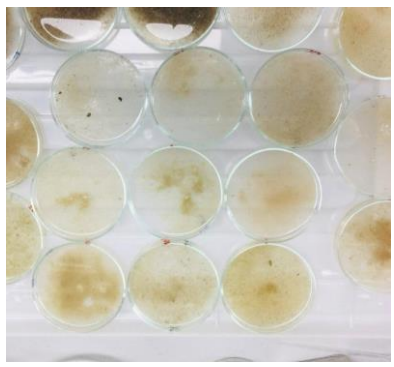
Over the last year Micheli Duarte continued to spend some time in the laboratory most weeks working through the ichthyoplankton samples collected at the North Stradbroke Island National Reference Station. In July Tony Miskiewicz visited our laboratory to assist Micheli with some larval fish identifications. Tony was very generous with his time, and his extensive knowledge was extremely helpful.

Several of Anthony's students have however been working with our data from both the NRS samples and AusCPR for their theses. Ryan Heneghan has recently completed his PhD









using data to look at marine trophic pathways, Max Campbell has completed his Honours year concentrating on temperature indices and zooplankton, and Phil Dyer is continuing with his PhD using Gradient Forest Models to examine bioregionalisation of pelagic communities around Australia.

Micheli and Phil both made presentations at the CSIRO Oceans and Atmosphere mini symposium in May, and Anthony also made a presentation about the Status and Trends of Australia's Open Oceans.

The AusCPR work based from Brisbane has continued well this year, with both the Salome and the Tonsberg collecting samples between Brisbane and Fremantle for us over the last year. We have also begun collecting samples from the Great Barrier Reef, between Gladstone and Cairns, from the Rio Tinto ship Wakmatha. At present it looks like all these ships will be working on their current routes for some time into the future, so it will be great to have some stability on the shipping front for a while.

Sampling at the National Reference station at North Stradbroke Island has continued successfully. Since the last newsletter we have only missed one month of sampling in June 2018 due to bad weather. Mark Tonks, Julian Uribe-Palomino, Kinam Salee and I continue to be the regular crew, and we have also received plenty of help from other staff and students who have been visiting the laboratory. Sampling procedures have remained the same throughout the year, but it looks like we will be making some slight changes to the way we sample for ichthyoplankton beginning in 2019.

Julian attended an advanced copepod identification course in Italy in October, and also took the opportunity to visit a laboratory in Portugal to learn more about the identification of decapod larvae. I think there will be a more extensive report on Julian's trip elsewhere in the newsletter, but I know that Julian learned a lot from the course and enjoyed catching up with fellow copepod enthusiasts from all round the world.

Another highlight for the year for Julian was the publication of the description of a new species of jellyfish, which was named *Melicertissa antrichardsoni*. As we are coming close to finishing up for 2018 Anthony is over in Plymouth attending the annual GACS meeting. We are also getting close to completing our contributions to a new plankton book entitled Plankton, A guide to their ecology and monitoring for water quality 2nd edition, soon to be published by CSIRO publishing. Anthony is an editor and has contributed to several chapters, and Anita has recently been working hard on the index, but the major contribution from the Brisbane team was the production of Chapter 8. We hope the new edition of this book will prove useful to many plankton researchers, students and enthusiasts.

Hobart Update

Felicity McEnnulty

Claire has participated in field sampling at the IMOS Maria NRS several time this year, and they have only missed one sampling event (due to bad weather/boat unavailability due to motors upgrade).

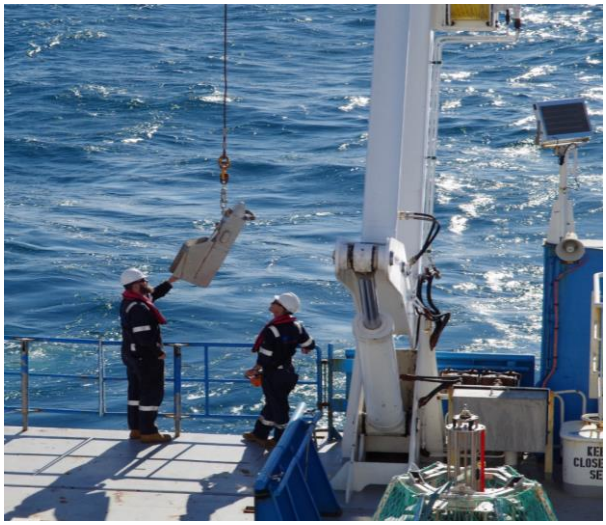
RV Investigator has towed the CPR several times for us this past year including down the east coast of Australia in May (Transit IN2018_T02, led by Professor Gustaaf Hallegraeff) and to the Southern Ocean Time Series (SOTS) station at 47 degrees South in March and August (IN2018_V02 and IN2018_V07 led by Tom Trull).

Ruth joined IN2018_T02 to undertake a comparison of CPR samples and surface underway samples from Brisbane to Hobart, also sampling at the Port Hacking and Maria Island National Reference Stations. This was a great opportunity to take images of live phytoplankton from tropical through to temperate waters (see Figure) . The underway samples have been analysed by UTAS student Brad Paine, who did a great job, and recently submitted his Marine Research report "Species Diversity and Abundance of Surface Phytoplankton along a Late Autumn Transect (INV2018-T02) from Brisbane to Hobart". The accompanying CPR samples will be analysed now the lab is up and running again (see later). Ruth and Gustaaf worked with several STEM teachers as part of the "Investigator Educator on Board" program, and it's pleasing to see there has been a lot of marine science research undertaken on Investigator being taught as part of the curriculum following the voyage.

We appreciate our collaboration with the Australian Antarctic Division who collected 4 CPR tows between Hobart and 47 degrees South in the 2017/18 season and who have already collected 2 tows for us during the 2018/19 season towing on *RV Aurora australis*.

In the lab, we had a large tree fall against the building in May during a wild storm and a flood in the lab due to an incident with the sprinkler system in August but luckily only the stand-alone fume hood was damaged and has now been fixed. Despite this excitement we have continued counting samples identifying all the IMOS NRS phytoplankton samples and the NRS Maria Island samples as well as CPR tows from Hobart to SOTS, Hobart to sub-Antarctic and sub-Antarctica to Hobart.

The team continues to train to update their skills. Felicity did the UQ R course in February. Felicity and Ruth demonstrated the use of Lucid keys on several trial groups (*Tripos* phytoplankton and *Sapphrinia* copepods) to the Brisbane team from what they learnt on the October 2017 course. Ruth attended the International Polar Diatoms Workshop at the McBride Diatom lab in Iowa, USA in August, presenting her research on tintinnids that agglutinate particles and diatoms to their lorica (see more on tintinnids in another article this issue). Felicity spent a week in August at the Australian Antarctic Division with John Kitchener from the Southern Ocean CPR for QA/QC of identifications and data, and discussion about CPR sampling.



Above: CPR being deployed from Investigator (image G. Hallegraeff, IMAS)

Claire's publication on the database of Chlorophyll *a* data in Australia was published on 20 Feb 2018. It has 48 authors who contributed data. Davies, C. H. *et al.* (2018). A database of chlorophyll a in Australian waters. Nature Scientific Data 5:180018 DOI: 10.1038/sdata.2018.18. The data citation is Davies et al. Australian Ocean Data Network http://dx.doi.org/10.4225/69/586f220c3f708 (2017).

We have participated in the following workshops, conferences and meetings over the past year. Ruth and Claire attended the IMOS Annual planning meeting held in Hobart late February and all attended an associated IMOS ZOOM meeting. *Claire, Ruth and Felicity attended the Hobart CSIRO Connect workshop with the rest of the Hobart site.* Claire, Felicity (talks) and Ruth (poster) presented at AMSA in Adelaide in July 2018. Ruth prepared a poster for ACOMO 2018 based on the taxonomic work we have been doing with *Tripos.*

Felicity and Julian manned a stall at the Australian Antarctic Festival held in Hobart in August showcasing our CPR and plankton work, speaking to many school children and the general public over 5 days. Claire and Ruth with Anthony ran a Status and Trends Workshop in Hobart in September looking at IMOS data. It was attended by CSIRO, AIMS, SARDI, UNSW, UTAS, UWA and Curtin University. The aim of the workshop is to develop a publication which will provide easy access to some of the most interesting and significant observations from the IMOS program. Felicity attended the Marine Biological Specimens - Data Discoverability and Accessibility Workshop, co-hosted by the NESP Marine Hub and AODN in Hobart looking at how to ensure taxonomic data is available from researchers and museums to modellers and analysts.

Continued on next page…

Claire has been working with Jason Everett (UNSW) and Anthony on IMOS data products including several meetings in Brisbane (June, November) as a result of the IMOS ZOOM meeting outcomes.

We have improved our connectivity and now have data on the cloud which is accessible at a greater speed and a virtual machine that allows us to access specialist software e.g. Lucid) from either site and also manage our new image catalogue. We have continued with QC of the data and update changes to species name as they are changed in WORMS or on advice from experts.

Some of the amazing diversity of live phytoplankton taken during the Investigator voyage from Brisbane to Hobart (images G. Hallegraeff and R. Eriksen).

An *Oithona plumifera* copepod from MAI20180920. It is an image composed of a stack of 16 photos done with Helicon 3D viewer software by Felicity McEnnulty.

New Book - PLANKTON: A Guide to Their Ecology and Monitoring for Water Quality

Healthy waterways and oceans are essential for our increasingly urbanised world. Yet monitoring water quality in aquatic environments is a challenge, as it varies from hour to hour due to stormwater and currents. Being at the base of the aquatic food web and present in huge numbers, plankton are strongly influenced by changes in environment and provide an indication of water quality integrated over days and weeks. Plankton are the aquatic version of a canary in a coal mine. They are also vital for our existence, providing not only food for fish, seabirds, seals and sharks, but producing oxygen, cycling nutrients, processing pollutants, and removing carbon dioxide from our atmosphere.

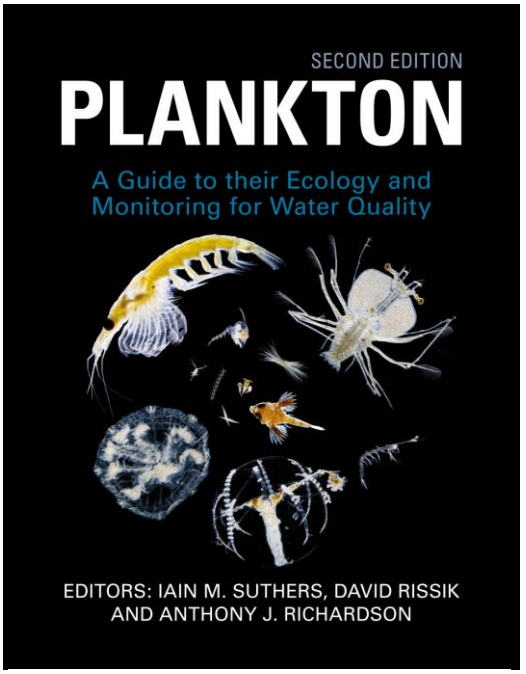
This Second Edition of *Plankton* is a fully updated introduction to the biology, ecology and identification of plankton and their use in monitoring water quality. It includes expanded, illustrated descriptions of all major groups of freshwater, coastal and marine phytoplankton and zooplankton and a new chapter on teaching science using plankton. Best practice methods for plankton sampling and monitoring programs are presented using case studies, along with explanations of how to analyse and interpret sampling data.

Plankton is recommended for teachers and students, environmental managers, ecologists, estuary and catchment management committees, and coastal engineers.

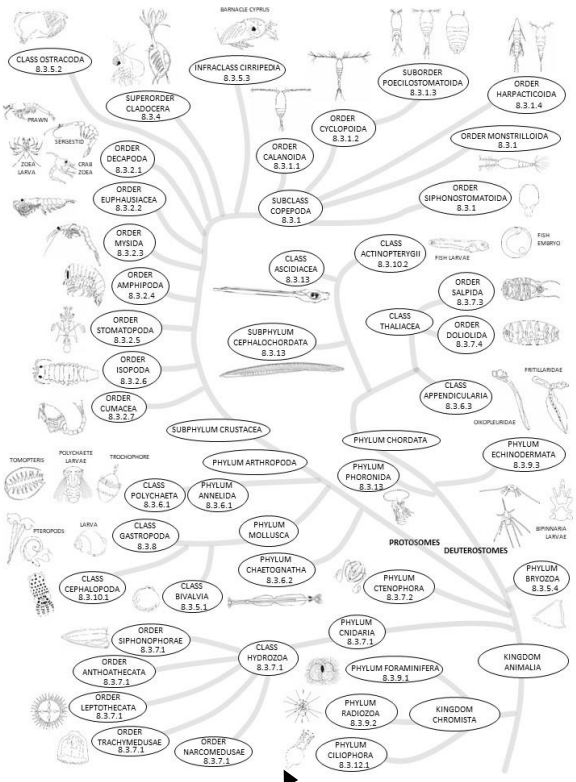
Features:

- Fully revised and expanded edition with a new chapter on teaching science (K-12 and tertiary studies) using plankton
- Covers all major freshwater, coastal and marine phytoplankton and zooplankton groups and provides a list of up-to-date references
- Explains the role of plankton in aquatic ecosystems and its usefulness as a water quality indicator
- Describes best practice methods for plankton sampling and monitoring programs using case studies
- Demonstrates how to analyse and interpret the results of sampling programs

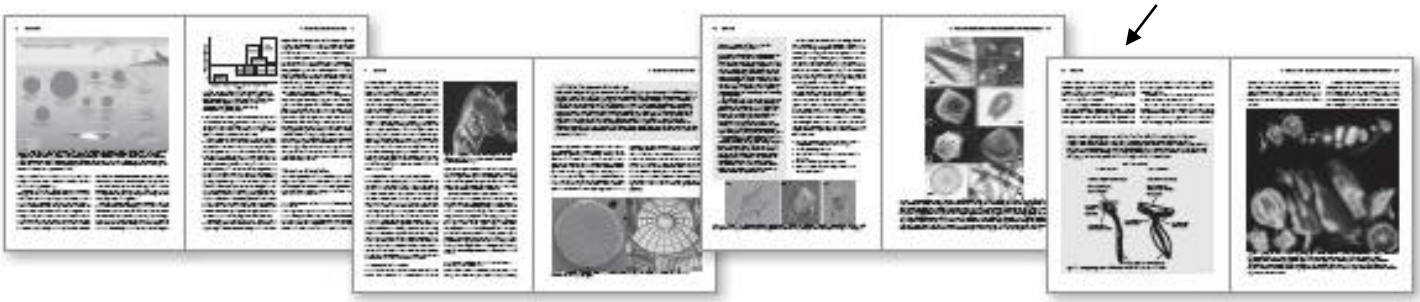
We welcome any feedback and the Team would like to hear what people think of the new updated edition. Please feel free to get in touch.



Available now
via CSIRO publishing:
https://www.publish.csiro.au/book/7808/



these are some of the sample pages



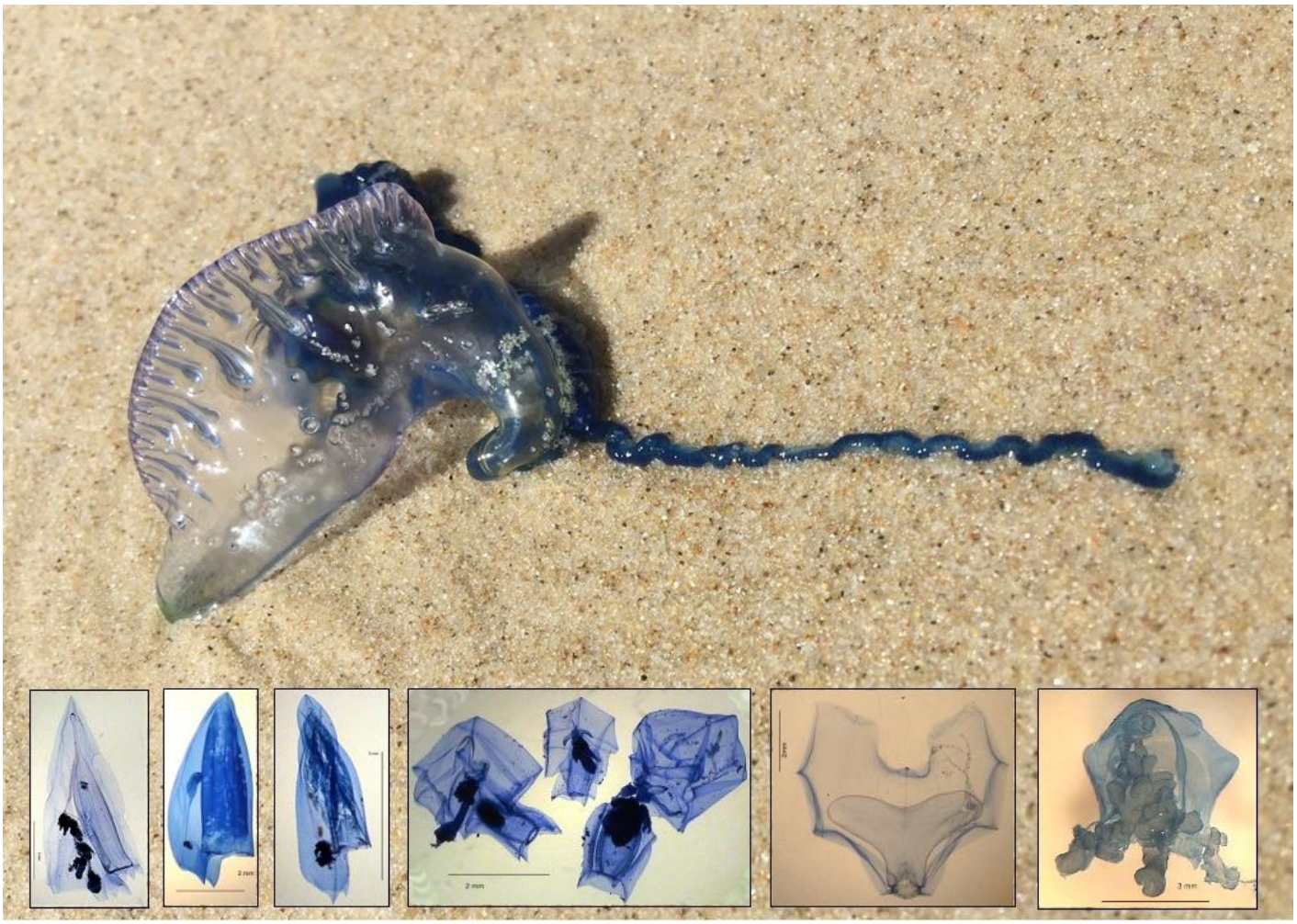
Siphonophores from surface waters of the Colombian Pacific Ocean

Julian Uribe-Palomino

Siphonophores are a particular group of 'jellyfish' that can form very long colonies, making them some of the largest marine organisms in the world (more than 20m in length). A very well know example of them is the Portuguese man-of-war or blue bottles.

Siphonophores can be found in every ocean from the surface to practically every depth as well, and considering their carnivorous nature, these animals can impact in other communities such as copepods, other microcrustaceans and also fish larvae. What is known of these organisms in tropical waters is very limited. We published a paper early in 2018, addressing for the first time the changes in the composition, distribution and abundances of siphonophores of the hyponeuston, following information collected in research cruises in the Colombian Pacific Ocean from 2001-2004.

We found a relationship between the abundances of these organisms and the presence of fish eggs and copepods from some sectors of the study area. Better studies of the water column are needed to get better understanding of the whole community in tropical equatorial waters. The paper describing the details and findings of this research can be found in the can be found at this link: https://doi.org/10.1017/S0025315417002065



Above: Common siphonophores with worldwide distribution.

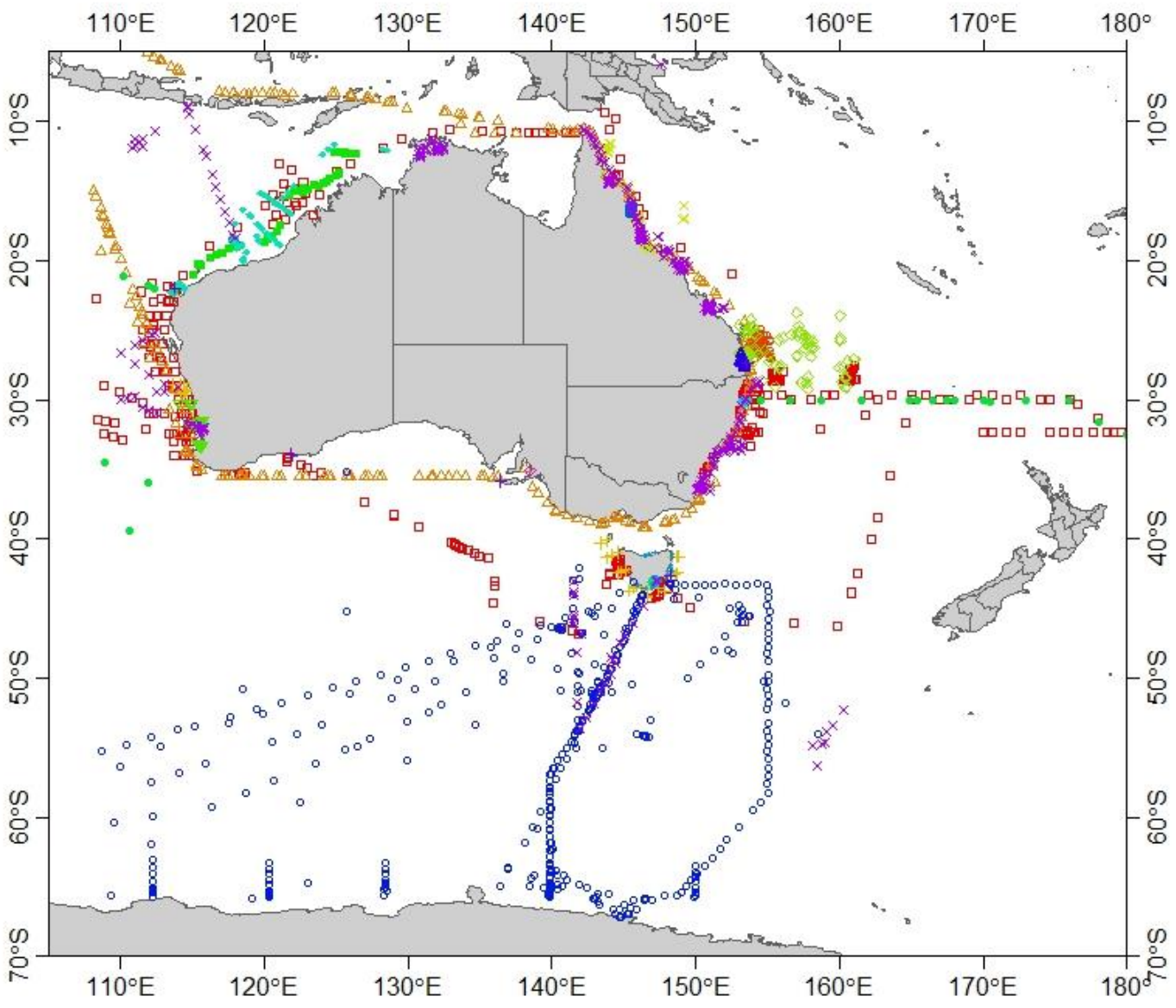
A Database of Chlorophyll a in Australian waters

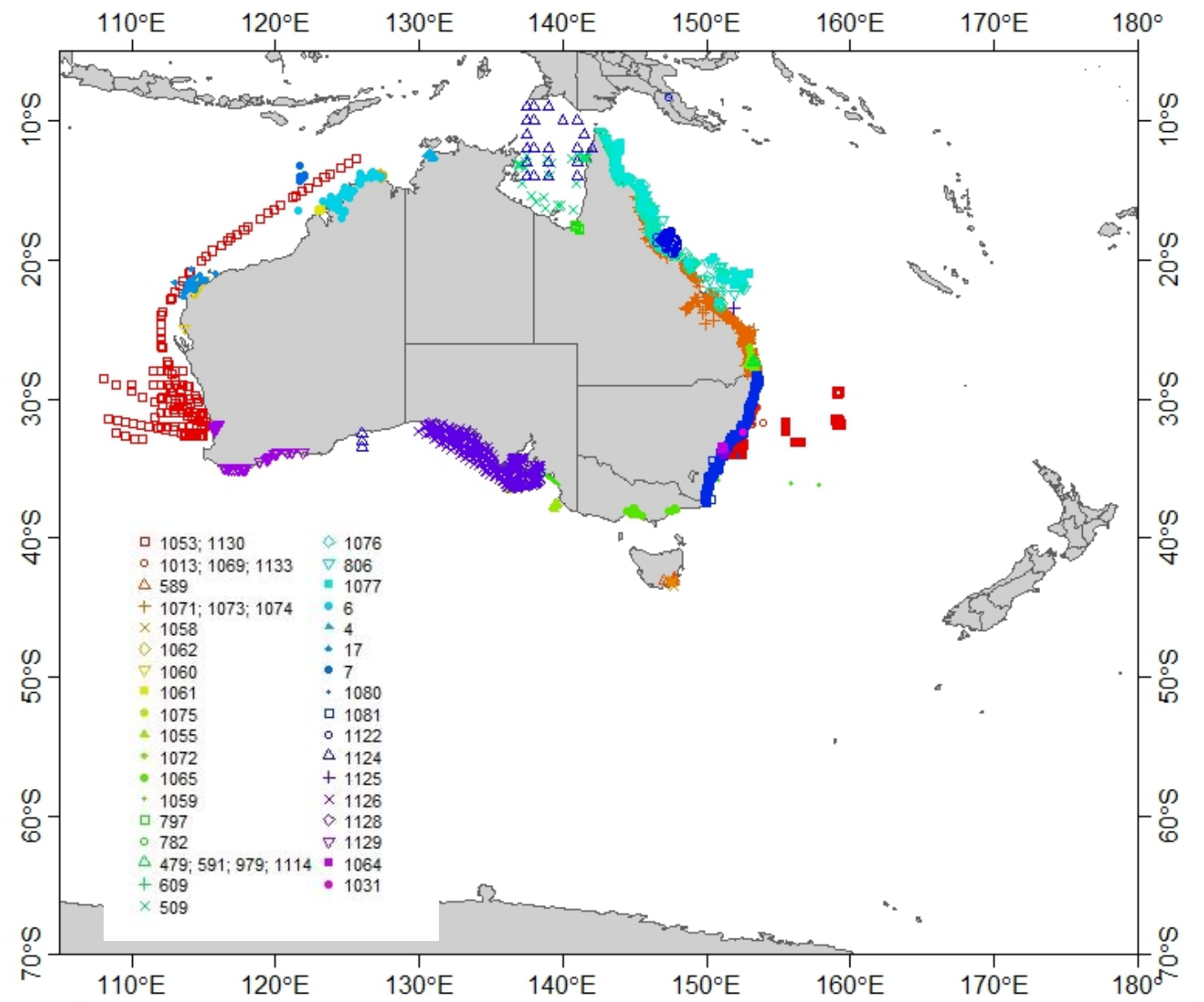
Claire Davies

The team published the chlorophyll *a* database in Scientific Data in February 2018 with the data freely available through the AODN. This was the result of a collaboration of 50 researchers from many different agencies and universities around Australia. Over 170,000 records were collated dating back to 1965. Many of the samples link to the data in the Australian Phytoplankton Database (Davies et al. 2016) and the Australian Zooplankton Database (Davies et al. 2014) that we published previously.

Chlorophyll *a* is present in all photosynthetic phytoplankton species and is widely used as a proxy for estimating phytoplankton biomass. Chlorophyll *a* analysis has the advantage that it accounts for the nano and pico plankton in samples which are underestimated when analysing plankton samples through light microscopy. The data can also be used for water quality and ecosystem state studies, such as the Ecosystem Health Monitoring Program in Moreton Bay, Queensland where high chlorophyll *a* values could indicate a eutrophic system with elevated nutrients from terrestrial run off or be indicative of phytoplankton blooms.

The following figures show the locations of the data collated and the distribution between the different methods used to determine chlorophyll *a* concentrations.

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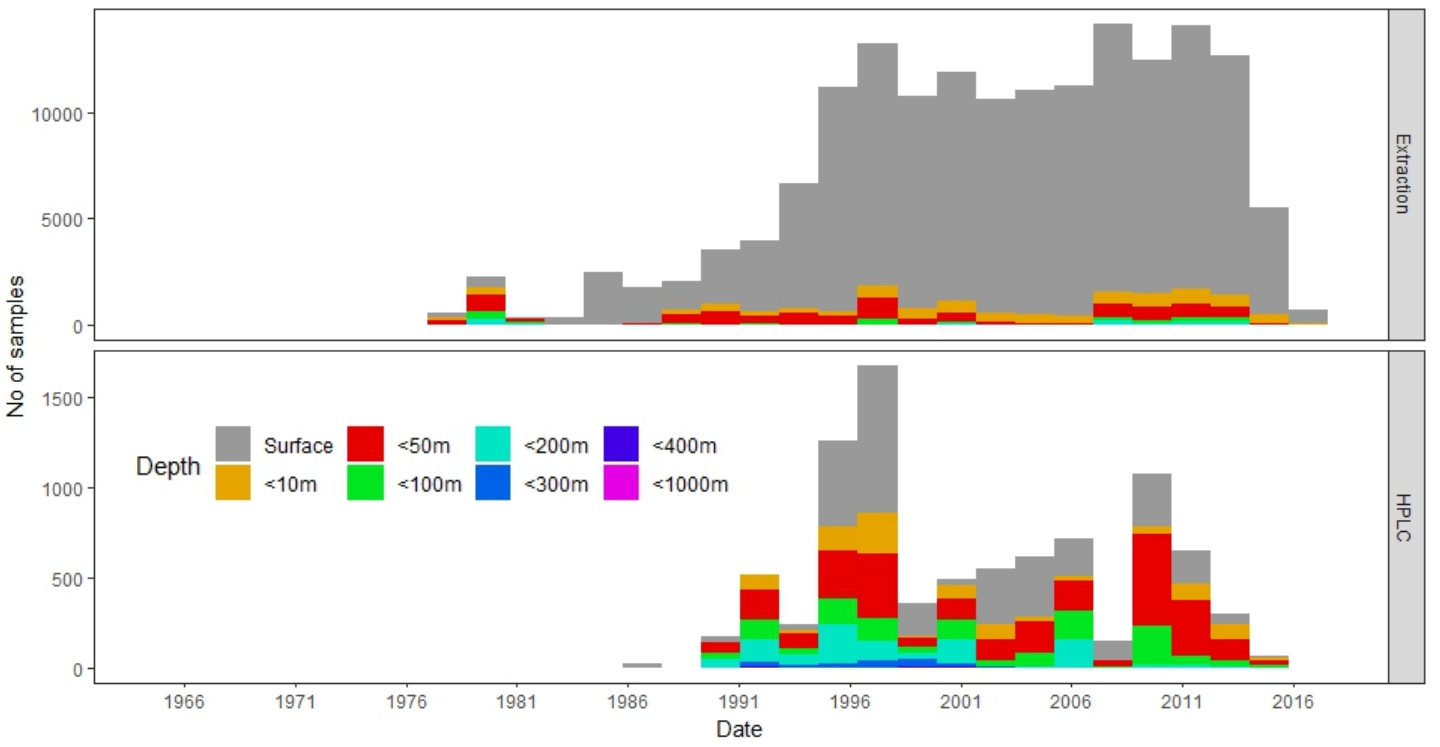
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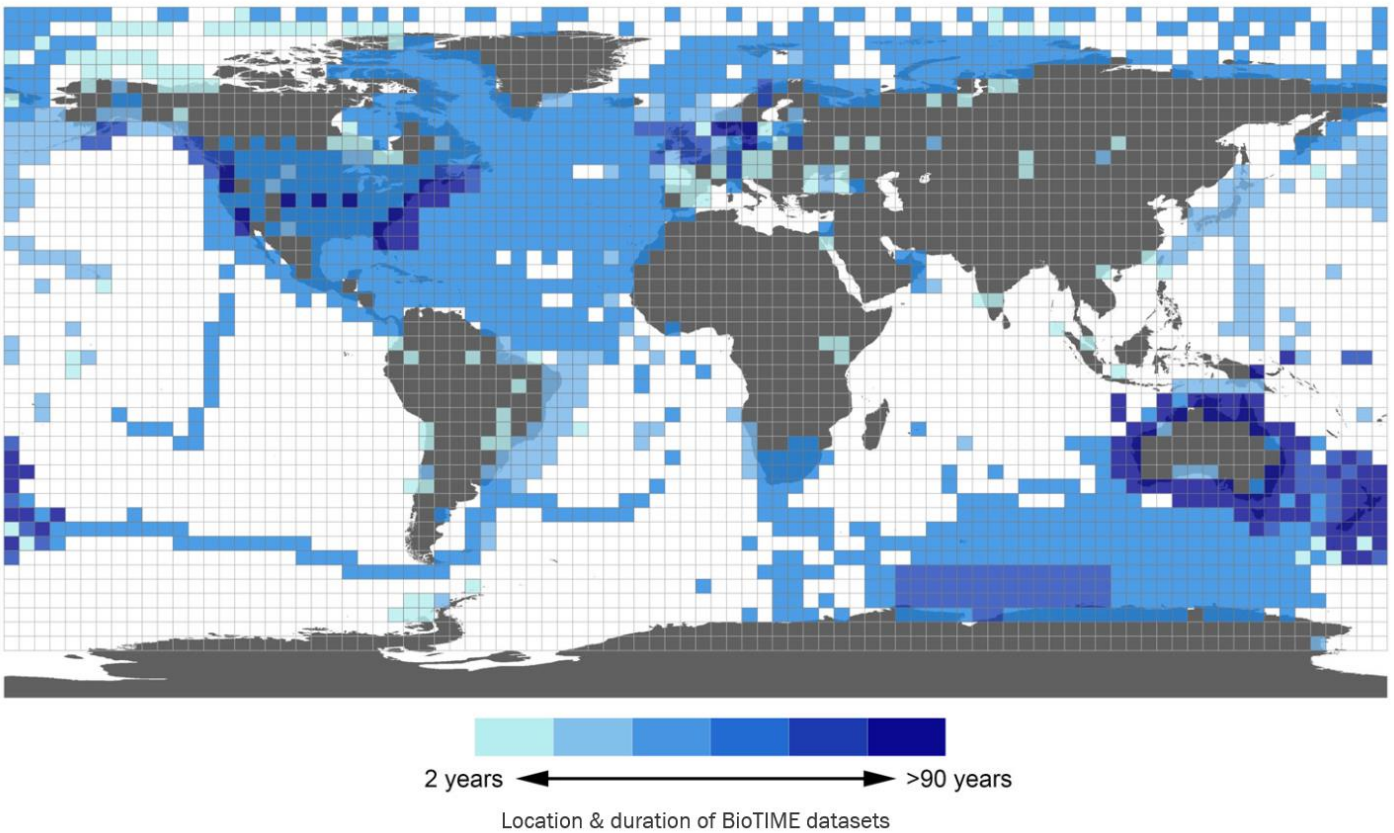
BioTIME: a database of biodiversity time series for the Anthropocene

Claire Davies

The Australian Phytoplankton Database and the Australian Zooplankton Database contributed to a publication that is believed to be the largest assemblage level biodiversity time-series database currently available, https://onlinelibrary.wiley.com/doi/full/10.1111/geb.12729. The paper was published in Global Ecology and Biogeography with a static version of the database being deposited in figshare. It was led by the BioTime Team based at the University of St Andrews. The project built on the database used in Dornelas et al. 2014 and included all the raw data. The database includes nearly 9 million species abundance records, from 1874 to the present, from assemblages consistently sampled for a minimum of 2 years, which need not necessarily be consecutive. In addition, the database contains metadata relating to sampling methodology and contextual information about each record. The motivation for this project was to enable users to quantitatively analyse temporal trends in species or assemblages through a community led, freely available database. This data paper should be a useful resource for scientists, managers and policy makers and potentially invaluable input to regional and global assessments, such as the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Further information about this database can be found here www.synergy.st-andrews.ac.uk/biotime/biotime-database/.

Dornelas, M., Gotelli, N. J., McGill, B., Shimadzu, H., Moyes, F., Sievers, C., & Magurran, A. E. (2014). Assemblage time series reveal biodiversity change but not systematic loss. Science, 344(6181), 296-299.



Above: The BioTIME database quantifies biodiversity change in nearly 400 ecosystems from around the world, that have been monitored over time.

From: Dornelas M, Antão LH, Moyes F, Bates, AE, Magurran, AE, et al. BioTIME: A database of biodiversity time series for the Anthropocene. *Global Ecol Biogeogr.* 2018; 27:760 - 786. https://doi.org/10.1111/geb.12729

Tintinnid diversity at the National Reference Stations

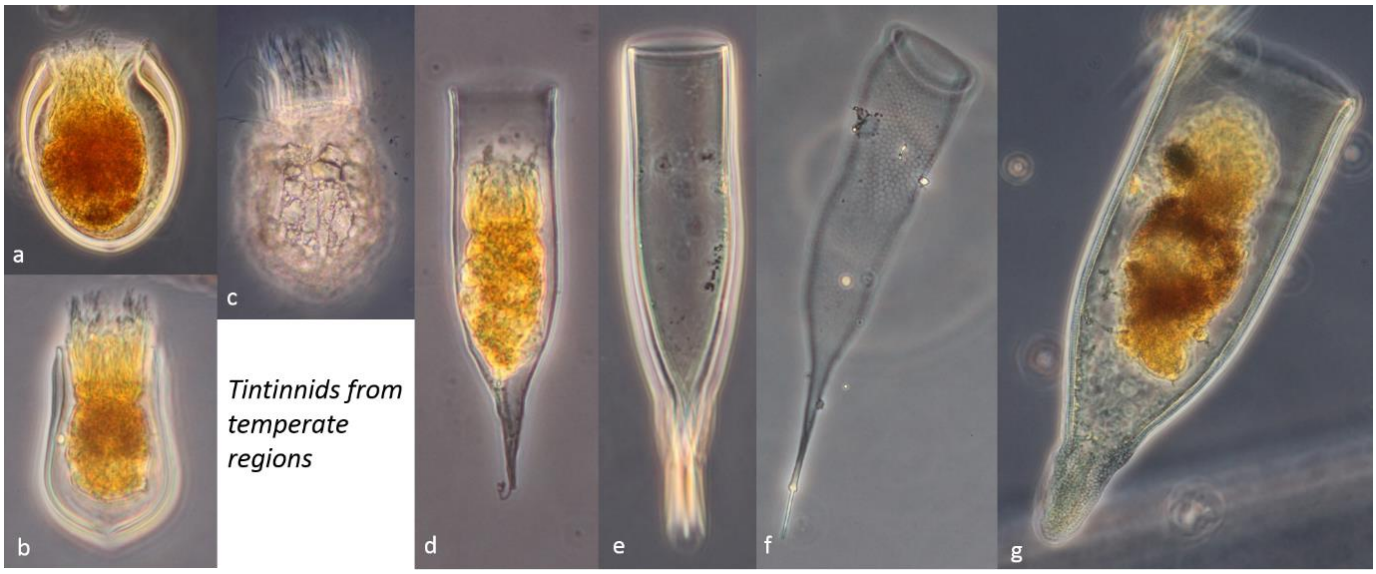
Ruth Eriksen and Julian Uribe-Palomino

Tintinnids are among some of the most intriguing micro-zooplankton (20 -200 µm) we find in our daily work on NRS samples. Tintinnids are ciliates that build unique vase-shaped shells called lorica. The name of the group is derived from latin for "small tinkling bell", but has also been linked to the protective armour worn by Roman soldiers (Dolan and Pierce, 2013).

The shape, size, structure and complexity of the lorica is the main morphological feature we use to distinguish between species, although it is not entirely reliable and there is much variability within species. Some lorica are hyaline (clear), others are agglutinated (covered in inorganic or organic particles). Tintinnids that agglutinate sand or mineral particles are much more likely to be dominant in coastal areas, while hyaline species are more common in open waters. The lorica is largely made of proteins, and certain species may form cysts, in response to unsuitable environmental conditions (Alder, 1999). Some tintinnid loricae are well preserved in marine sediments and can be used as indicators of ecological conditions in the same way as dinoflagellate cysts and forams.

Tintinnids at the NRS may be captured in both the phytoplankton (Niskin bottle) and the zooplankton (net tow) samples, and the more robust forms are well-preserved in the CPR tows. Tintinnids are delicate, and sensitive to physical disturbance and thus identifications are often made on empty lorica, as the resident ciliate has performed an "emergency-eject" operation. Normally the ciliate is attached to the lorica via a small umbilicus, remnants of which may be visible on the empty lorica. Images below include some of the diversity of these intriguing micro-zooplankton.

a) Codonellopsis note agglutinated particles on the bowl b) *Salpingella* c) *Rhabdonella* d) *Tintinnopsis* e) *Acanthostomella* f) *Amphorides* g) *Epiplocylis* h) *Dadayiella* i) *Codonella* (images R. Eriksen and J. Uribe Palomino; d, e and g are empty lorica)



a) Undella sp. 01 b) *Undella* sp. 02 c) *Codonellopsis* d) aff. *Rhabdonella* e) *Parundella* f) *Xystonella* g) not identified (images R. Eriksen and J. Uribe Palomino; e-f are empty lorica)

References

Dolan, J.R., Pierce, R.W. 2013. Diversity and distributions of tintinnds. In: Dolan JR, Montagnes DJS, Agatha S, Coats WD, Stoecker DK, editors. The biology and ecology of tintinnid ciliates: models for marine plankton. West Sussex: Wiley-Blackwell. p. 214-243.

Alder, V.A., 1999. Tintinnoinea. In: South Atlantic zooplankton (ed. D. Boltovskoy), Vol. 1, Backhuys Publishers, Leiden, pp. 321-384.

Taxonomy of the dinoflagellate genus Tripos in Australian waters

Ruth Eriksen and Claire Davies

The four sub-genera of the genus *Tripos* a) *Tripoceratium* b) *Ceratium* c) *Amphiceratium* and d) *Poroceratium* (Images from the National Reference Stations a-c) R. Eriksen, d) J. Uribe Palomino).

In collaboration with our colleague Professor Gustaaf Hallegraeff at IMAS, we have been working extensively on a revision of the marine dinoflagellate genus *Tripos* Bory de Saint-Vincent*, 1823* (previously *Ceratium*). We presented aspects of this work this year at AMSA and ACOMO (see articles this issue).

The genus *Tripos* is very diverse; there are four distinct sub-genera (see above figure), with over 150 species documented globally. In Australia and the Southern Ocean, more than 50 species have been reported, with occasional high biomass blooms of *Tripos fusus*, *T. furca*, and *T. muelleri* a feature of estuaries and in-shore waters. Off-shore, *Tripos* rarely contribute significantly to biomass, yet they are widely reported to be useful indicators of the movement of water masses.

There is considerable plasticity in the morphology of many species, which may or may not be of taxonomic significance, resulting in confusion and uncertainty around spatial distribution and abundances. We reviewed over 100 years of species-level data, primarily from the IMOS plankton NRS and CPR surveys and data collated in the Australian Phytoplankton Database (Davies et al, 2016) to identify a sub-set of species with unambiguous records that may serve as indicators of water masses, and therefore potentially show decadal changes in distribution linked to environmental drivers. In the course of the review, we developed a Lucid key (dichotomous and matrix) to clarify identification of this important genus for new and experienced microscopists.
The Lucid key extends the work we have been doing for many years on species reference sheets and should be a great way to share both the biogeographical and taxonomic information we generate through IMOS.

From: Davies, C.H., Coughlan, A., Hallegraeff, G., Ajani, P., Armbrecht, L., Atkins, N., Bonham, P., Brett, S., Brinkman, R., Burford, M., Clementson, L., Coad, P., Coman, F., Davies, D., Dela-Cruz, J., Devlin, M., Edgar, S., Eriksen, R., Furnas, M., Hassler, C., Hill, D., Holmes, M., Ingleton, T., Jameson, I., Leterme, S.C., Lonborg, C., Mclaughlin, J., Mcennulty, F., Mckinnon, A.D., Miller, M., Murray, S., Nayar, S., Patten, R., Pritchard, T., Proctor, R., Purcell-Meyerink, D., Raes, E., Rissik, D., Ruszczyk, J., Slotwinski, A., Swadling, K.M., Tattersall, K., Thompson, P., Thomson, P., Tonks, M., Trull, T.W., Uribe-Palomino, J., Waite, A.M., Yauwenas, R., Zammit, A., and Richardson, A.J. (2016). A database of marine phytoplankton abundance, biomass and species composition in Australian waters (vol 3, 160043, 2016). *Scientific Data* 3.

Two new species of micro-medusa from Australian waters

Julian Uribe-Palomino

In the southern Queensland, and in particular Moreton Bay we are used to finding jellyfish the size of big oranges after a windy summer day. They are known as blue blubber (*Catostylus mosaicus*) however, there are several species of jellyfish that don't grow bigger than a few centimetres or even millimetres.

Many species of zooplankton, including jellyfish, often may go unnoticed due to their minuscule size. As part of our research we collect, preserve and identify these tiny creatures and sometimes describe new species.

In 2018, two new species of tiny full grown jellyfish (of around 2 mm diameter) were described by Julian Uribe-Palomino and Dr Lisa-ann Gershwin, from samples collected at the IMOS National Reference Station (NRS) Yongala and Moreton Bay respectively by Julian Uribe-Palomino and Dr Lisa-ann Gershwin in 2018.

The smallest of the described species *Paralovenia yongalensis*, was named for the location it was found, Yongala, an area south-east of Townsville where the *SS Yongala* was shipwrecked in 1911 and several lives were lost. This wreck area is now recognised as one of the best diving spots in the world besides the Great Barrier Reef.

Melicertissa antricharsoni is the second newly described species and constitutes the smallest species within this genus. This species has been found only in Moreton Bay and very recently at NRS-North Stradbroke Island. This species was name after Professor Anthony Richardson, one of our researchers at CSIRO and a passionate academic who has supported the study of plankton in Australian waters and actively promote the importance of research in plankton worldwide.
For detailed descriptions of these newly discovered species visit : https://doi.org/10.3897/zookeys.783.26862.

Figure 1. Lateral view of the two new species of micro-medusae. A *Paralovenia yongalensis* Gershwin & Uribe-Palomino, 2018 and B. *Melicertissa richardsoni* Uribe-Palomino & Gershwin, 2018 (The umbrella has contracted dorsally exposing the gonad and the manubrium).

AMSA 2018 – Canyons to Coast

Felicity McEnnulty

The annual Australian Marine Sciences Association (AMSA) conference "Canyons to coast" was held in Adelaide in July 2018. Three Hobart staff presented 2 talks and a poster:

- Estimates of Zooplankton Biomass in Australian Waters
McEnnulty et al 2018

- Ecology of the Dinoflagellate Genus Tripos in Australian Waters
Davies et al 2018

- Taxonomy of the Dinoflagellate genus Tripos in Australian waters
Eriksen et al 2018

Claire also presented in the workshop "How to access and use IMOS data for your research, organised by Craig Steinberg aimed at making students aware of the data available from IMOS.

Claire also participated in a scientific diving meeting.

Next year the AMSA conference will be held in Fremantle from 7-11 July 2019 and will feature a plankton symposium run by Anthony Richardson.
http://amsa19.amsa.asn.au/

Abstract: Ecology of the Dinoflagellate Genus Tripos in Australian Waters

Claire H. Davies , Frank E. Coman, Ruth S. Eriksen , Felicity McEnnulty , Mark Tonks , Anthony J. Richardson , Anita S. Slotwinski , Julian Uribe-Palomino, Gustaaf Hallegraeff

Australian researchers and policy makers have access to two significant phyto-and zooplankton datasets, through the IMOS-funded National Reference Stations (NRS) and the Continuous Plankton Recorder (AusCPR) surveys.With over 10 years of consistently sampled and measured species-level data, it is nowpossible to address issues ranging from taxonomic rigour to the ecology and phenology of plankton on anAustralia-widescale.Using the morphologically distinctdinoflagellate genusTripos(previously Ceratium)as an example, wereviewed IMOSobservations of >45Tripospecies against the historical observations during the period1940 to 1990sbyTaylor, Wood, Huisman and Hallegraeff, clarifying the important diagnostic features and spatial and temporal distributions.Using these confirmed distribution data we then used a statistical modelling approach to understand drivers of distributions of each species. This tests the concepts of warm water (T. biceps, T. dens, T. falcatus,etc), cosmopolitan (T. fusus, T. muelleri, T. furca),cold water (T. lineatus)or putativedeep "shade flora"(T. gravidus, T. cephalotus,T. praelongus,T. ranipes) species against real environmentdata and can be used as a tool to projectthe likely effects of climate change on distribution.

AMSA 2018 – Canyons to Coast, continued….

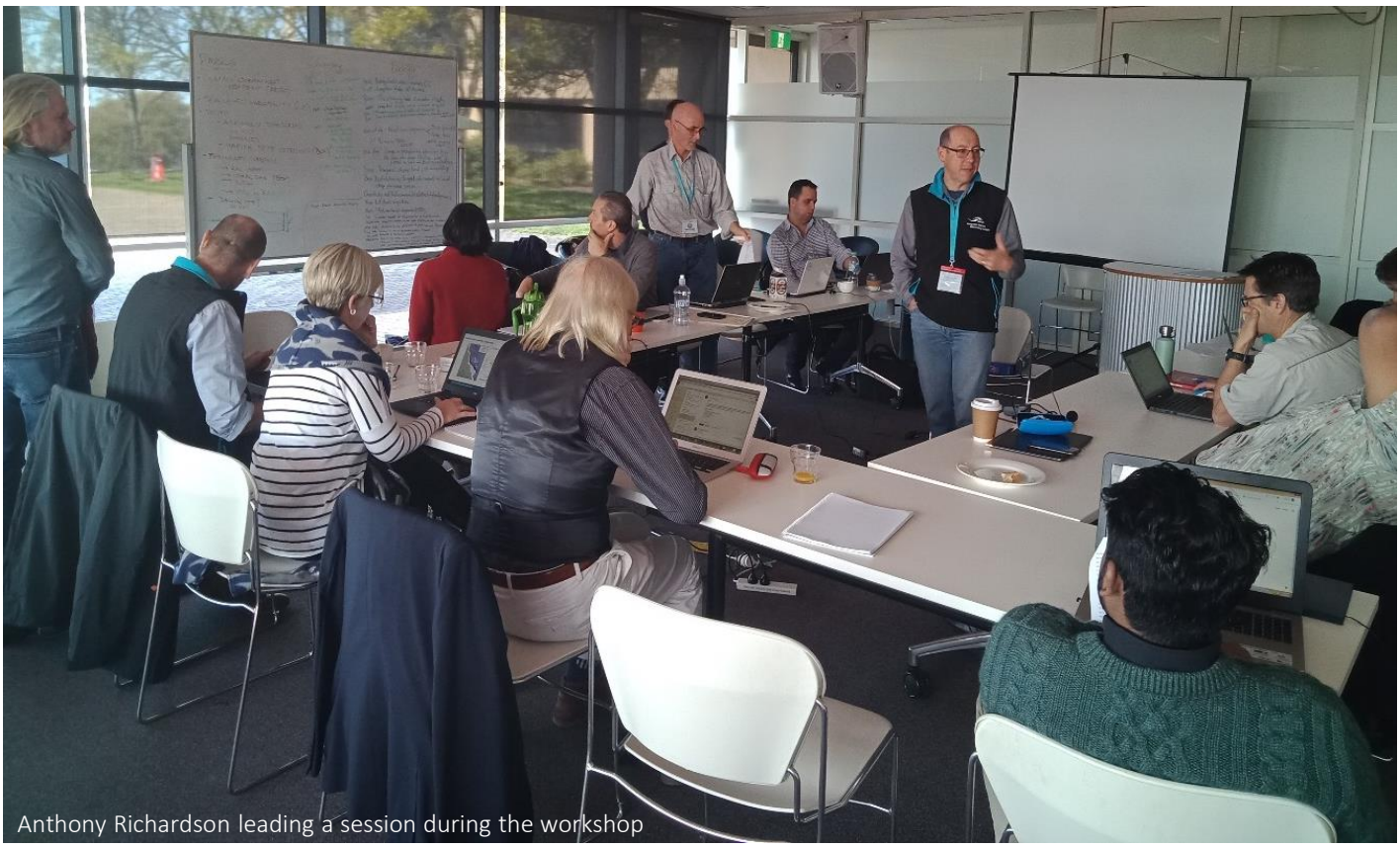
Abstract: Estimates of Zooplankton Biomass in Australian Waters

Felicity R. McEnnulty, Frank E. Coman , Claire H. Davies , Ruth S. Eriksen , Mark Tonks , Anthony J. Richardson, Anita S. Slotwinski , Julian Uribe-Palomino

There is currently no map or national product of zooplankton biomass around Australia. Zooplankton estimates are needed for validating nutrient-phytoplankton-zooplankton models and ecosystem models, and for understanding energy transfer from phytoplankton to fish. Here we compile 13,951 zooplankton observations from nets, Continuous Plankton Recorder (CPR) and Laser Optical Plankton Counter (LOPC) data to generate the first zooplankton biomass maps around Australia. We used generalised additive models based on a suite of environmental variables including sea surface temperature, chlorophyll-a, salinity, time of day and season. We adjusted for biases associated with different sampling types (nets, CPR or LOPC) and tow types (vertical, horizontal, oblique). To assess confidence in the data, we compared zooplankton biomass maps generated independently from nets, CPR and LOPC. We found that zooplankton biomass was strongly related to environmental variables. We also built regional models for each marine management bioregion in Australia. This work will provide Australia-wide and regional nutrient phytoplankton-zooplankton models and ecosystem models with a product useful for assessing zooplankton biomass.

State and Trends of Australia's Oceans – An assessment of our pelagic environment

Ruth Eriksen



Anthony Richardson leading a session during the workshop

A new activity we are undertaking is to lead and co-ordinate the first iteration of a new pelagic environment assessment report for Australia's marine environment. The report focuses on time-series that encompass the physical (e.g., temperature, salinity, boundary currents), chemical (e.g., nitrogen, phosphate, silicate, pH, aragonite saturation), and biological (e.g., archaea, bacteria, phytoplankton, zooplankton, mid trophic levels and fish) components of the pelagic environment. The report extends the successful "Plankton 2015" report by going beyond biological indicators, and will be a web-based product, allowing users to access underlying data included in the analyses.

To achieve this we have invited a working group of experts across a range of scientific disciplines and experience to work with meaningful time-series of ecosystem indicators that describe the state and trends of the pelagic environment. The "STAR Task Team" will analyse and synthesise datasets collected using a suite of observing platforms including remote sensing, microscopy, bottles, ocean sensors, molecular techniques, bioacoustics and animal tracking.

The Task Team is supported by CSIRO and by IMOS, enabling a series of face-to face meetings to discuss, develop and synthesise contributions from our experts. The first meeting was held in Hobart in October, and we were very impressed with the ideas for contributions and linkages between participants. Each participant is encouraged to go back to their own research and organisational networks to facilitate more contributions to increase the strength and relevance of the assessment. The AODN attended the first meeting, and made valuable contributions to the discussions around data access and implications for future iterations.

The STAR Task team is overseen by a Steering Committee comprising Tim Moltmann (IMOS, Chair), Dr Karen Evans, Dr Nic Bax and Dr Dave Smith (CSIRO) who will provide oversight and review. The next meeting of the Task Team will take place in Brisbane, immediately prior to the IMOS Annual Planning Meeting.

Trichodesmium Workshop Hobart

Claire Davies

Trichodesmium is an important nitrogen fixing cyanobacteria that is prevalent in tropical Australian waters. *Trichodesmium* is believed to fix 60 -80 TgN annually which equates to 30-80 % of the global nitrogen fixation and it is also predicted to increase in abundance with climate change. Claire, Ruth and Jenny Skerratt hosted a *Trichodesmium* workshop in July in Hobart. The aim of the workshop was to get observationalists, remote sensors and modellers in the same room to talk about *Trichodesmium* to work out data gaps, common problems and ways to collaborate better to a common goal. The 24 workshop participants came from CSIRO, AIMS, private industry and the Australian Navy, all of whom have been working on or are interested in *Trichodesmium*. All the participants were highly enthusiastic and not only did we get a better understanding of methods used to investigate the occurrences and drivers of *Trichodesmium* but an even better outcome was the exchange between these three groups.

There will be some notable outcomes with cross discipline collaborations:

- A process to collect live *Trichodesmium* samples to trial culturing the Australian strains and to determine the genetic code and the species found in Australian waters
- A manuscript on assessing biogeochemical models and satellite data against observations using GAMs to compare the relationships of *Trichodesmium* to environmental variables.
- Observations from navy ships of *Trichodesmium* blooms added to the hourly weather observations and made available where the data is not classified.

Following on from this workshop Anthony gave a presentation at ACOMO in October to demonstrate the methods and some preliminary results from the work we are progressing for the manuscript. We have been comparing outputs from the eReefs model and the satellite remote sensing algorithms with the statistical models of the observational data collected through the IMOS plankton surveys. So far the data indicates that:

- There are higher abundances inshore than offshore along GBR
- There is a peak in abundance in autumn and spring off Townsville
- There is an increase in abundance off Townsville, and potentially along entire GBR?

Participation at Pint of Science Event: Fortune-telling Oceans, Tiny & Powerful

Julian Uribe-Palomino

Last May 2018 the Plankton Team was invited to present some of our work at Pint of Science. The event started in 2012 in UK as an initiative to connect people to science, since then, the event called previously 'meet the researchers' became more and more popular and these days is a yearly event happening in more than 300 cities in 21 different countries.

Pint of Science gave us the unique opportunity to talk to people about a microscopic world that is usually invisible, the kind of environment that is only revealed using microscopes, fancy technology and sometimes, believe it or not, satellites.

As humans we don't often feel connection to things that we can't see or feel, however, nature 'hides' a lot of 'stuff' working quietly in the background (just like the apps in our smart phones) that allow us to live on this planet. Plankton is one of those amazing things.

During our presentation at Pint of Science we explored the definition of plankton, the variety of these tiny creatures, their power and significance, and why us humans should care about plankton.

https://pintofscience.com.au/event/fortune-telling-oceans

Australian Antarctic Festival

Julian Uribe-Palomino

During the Australian Antarctic Festival last August in Hobart, the Plankton Team had the chance to talk to locals, tourists and school students about our plankton research in the Southern Ocean and Australian coastal waters.

We introduced plankton, discussed the importance of plankton to the planet and how humans benefit from their existence. We also showcased the Continuous Plankton Recorder (CPR) demonstrating how we collect plankton samples, ongoing research that contributes to a national long term monitoring program.

We also had the chance to captivate the public with live phytoplankton collected fresh from the CSIRO wharf on the Derwent River, collected every morning throughout the festival. The community had the opportunity to view specimens collected from the sea floor, fishes from the National fish Collection and different instruments used for sampling on voyages on board of the *Investigator* or the *Aurora Australis* vessels.

Above: Images of Felicity McEnnulty and Julian Uribe Palomino running our stand at the Australian Antarctic Festival.

PhD: Modelling Marine Communities to Produce the First Global Data-Driven Bioregionalisation and Inform Conservation

Phil Dyer

The vast size of the marine biosphere makes comprehensive biological sampling impossible, and the available survey data is patchy in time and space. To help meet the need for reliable information about the patterns of biodiversity in the oceans, I am building large-scale, data-driven and biologically-informed bioregionalizations. The bioregionalization could be used to support conservation planning and marine research. To build the bioregionalization, I am investigating statistical approaches to bring together high-resolution, remote-sensed environmental data with biological samples from a wide range of surveys, covering microbes, plankton and fish.
Copepods in particular are excellent for mapping out bioregions in a data driven way. Copepods are found everywhere, are much easier to speciate than microbes, and can be sampled more reliably and consistently than fish or large invertebrates. The AusCPR, NRS and SOCPR datasets will be invaluable for building the bioregions, particularly in the pelagic ocean. The copepods will probably provide the majority of the information for a pelagic bioregionalization. The microbial data, fisheries data and additional plankton data from the AusCPR, NRS and SOCPR data will help refine and reinforce the bioregionalization.

The statistical technique Gradient Forest shows a lot of promise for building the large-scale bioregionalizations because it is capable of combining unrelated surveys with relatively few assumptions. Gradient Forest generates a set of functions that give the expected "species compositional turnover" between two sites when the environmental conditions at each site are known. I use the set of functions to generate maps showing areas of similar biology, and cluster the maps into bioregions.

The three maps here show patterns of biodiversity in copepod distributions (Figures 1 and 2), and patterns of biodiversity considering copepod, phytoplankton and fisheries data together (Figure 3). Figure 1 is a continuous compositional map, similar colours indicate similar biology. Figures 2 and 3 have been divided up into bioregions, areas of similar biology. 50 bioregions are shown, which explains most of the structure in the data while still being readable.
Figures 1 and 2 show two dominant trends in copepod assemblage distributions. The first is temperature, creating a clear north south pattern in assemblage distribution. Distance from the coast is the other visible trend, as coastal processes add nutrients and create habitats that are not available in deeper water. Dividing the space up into 50 bioregions (Figure 2) makes these trends easier to see, as well as showing how the strong circumpolar current creates long narrow bands of habitats. Adding in phytoplankton and fisheries data (Figure 3) creates a smoother map with the same general trends. As more datasets are added, noise from each dataset is balanced by information from other datasets.

I am continuing to work on ways of finding an appropriate number of bioregions given the data, and how best to apply the Gradient Forest technique over very large scales, up to global in scope.

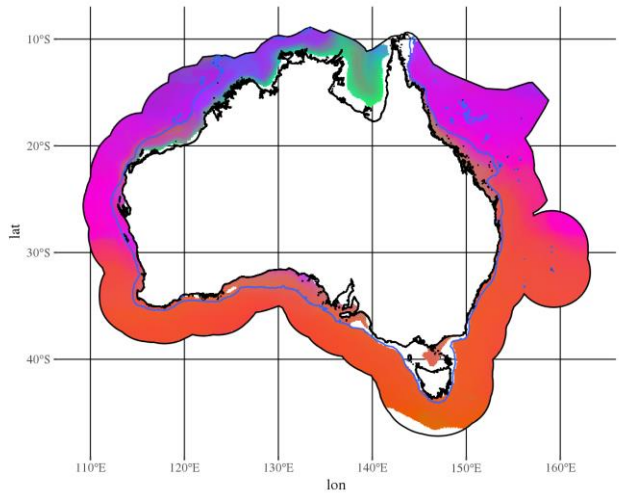


Figure 1: Copepod composition map around the Australian Exclusive Economic Zone. Similar colours between points indicate a similar species set.

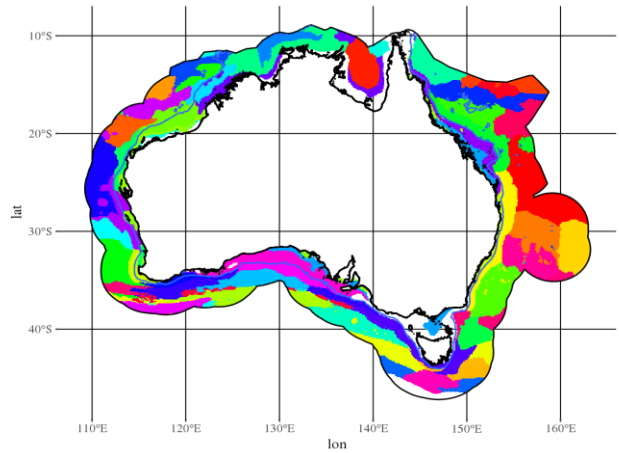


Figure 2: Copepod bioregions map. 50 bioregions are shown, which balances explanatory power with simplicity.

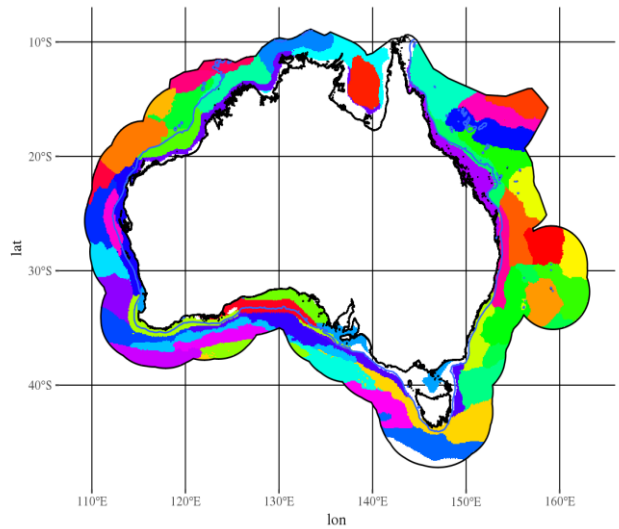


Figure 3: Bioregion map combining phytoplankton, copepods, and fisheries data on pelagic species. 50 bioregions are shown, which balances explanatory power with simplicity

Honours Project: Testing macroecological hypotheses that drive community structure of zooplankton in the global ocean

Max Campbell

Ecology is often criticised for lacking general rules which describe our global environments. Testing large-scale patterns can help uncover, describe and offer valuable insights into these unifying rules. Ideally, a better understanding of these rules can help us interpret the current distribution of our global biodiversity, and make better decisions as we face issues such as climate change. For my honours project, I used the IMOS AusCPR data in combination with other CPR surveys (North Atlantic, North Pacific and Southern Ocean) to test three large-scale ecology patterns using zooplankton: 1. increased copepod size with decreased temperature, 2. increased food-web efficiency in more productive areas of the ocean, and 3. the average thermal preference of the zooplankton community matches ambient temperature. To do this I used several metrics to capture zooplankton community attributes, and modelled how these attributes varied across environmental gradients.

The AusCPR data provided a unique opportunity to test my three patterns. Using the spatial coordinates and time of CPR samples, I was able to match individual samples with estimates of sea surface temperature and chlorophyll-a from satellite data. The AusCPR survey spans these environmental gradients very well having samples extending from the northern Great Barrier Reef to well into the Southern Ocean. Further, these analyses required comprehensive information about the diet and size of the zooplankton taxa. Luckily this information was available in the detailed metadata of the AusCPR, or could be obtained with the guidance of zooplankton experts Anthony Richardson, Claire Davies and Frank Coman. I would like to extend a big thanks to the IMOS team who facilitate such wonderful opportunities for doing some seriously fun data science!

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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

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Visit the AusCPR website at
http://imos.org.au/auscpr.html

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