Australia's National Science Agency

Integrating modern techniques with traditional plankton taxonomy

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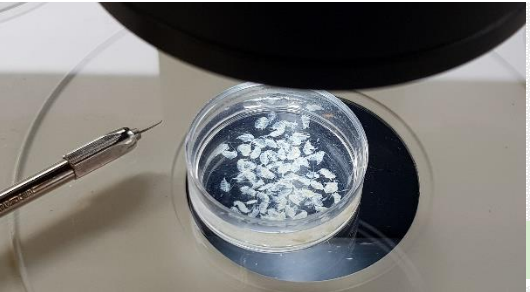
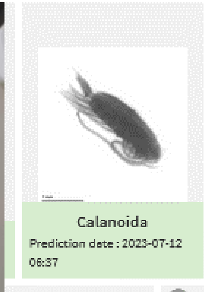
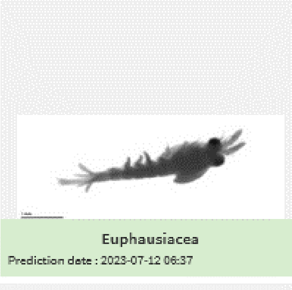
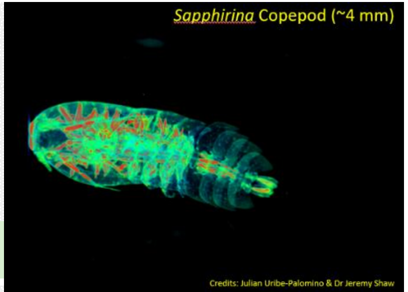
ICES-PICES 7th Zooplankton Production Symposium, March 2024









Biological Ocean Observer

shiny.csiro.au/BioOceanObserver

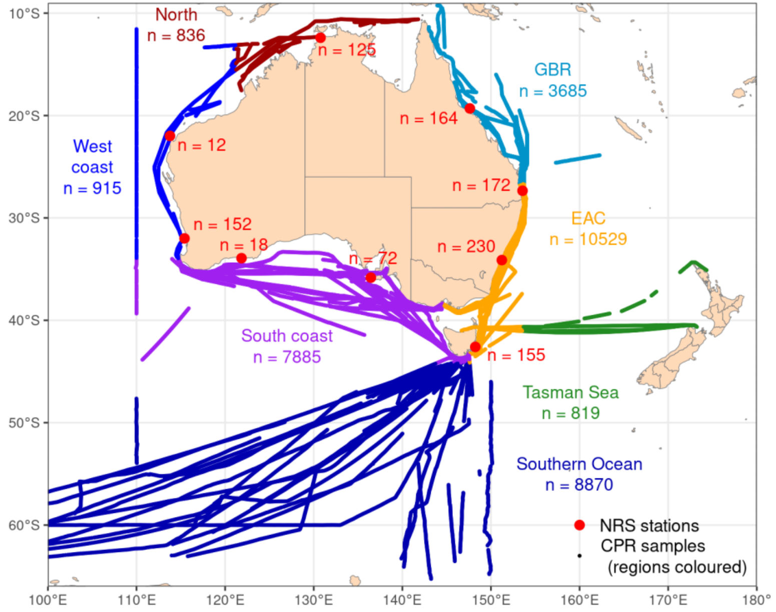
planktonr

planktonteam.github.io/planktonr

IMOS Integrated Marine Observing System

CSIRO Plankton Survey: our history

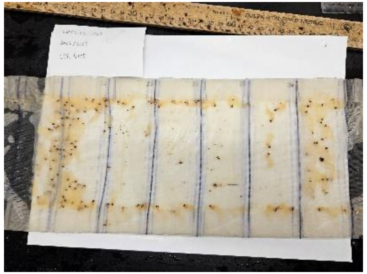
Integrated Marine Observing System (IMOS)
plankton data, 2007-2024



aodn.org.au

National Reference Stations

- ~650, 000 zooplankton counted



Australian Continuous Plankton Recorder Survey

- ~950, 000 zooplankton counted

1. Traditional taxonomic identification

Pros

- Quantitative
- Abundance & biomass
  - Sex and lifestage: male, female, juvenile
  - Size range
  - Functional groups: carnivore/herbivore

Cons

- Specialist skills, consistency
- Expensive, time consuming
- Many phyla can not identify to species

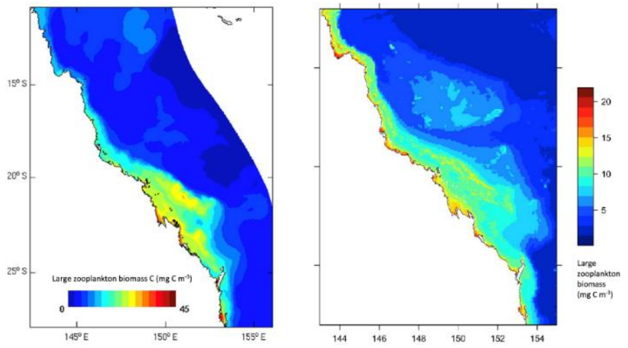





Plankton diversity and abundance data

- Count data: robust, quantitative, abundance and biomass
- Used in ecosystem assessments
- Integrated with remote sensing chla for model validation
- Analysis of long-term changes

➢ Global zooplankton trends (Anthony Richardson: S06 Wednesday 9.30am)
➢ Time series (Claire Davies: S06 Thursday 11:30am)
➢ Plankton indicators in ecosystem assessments (Frank Coman: S06 Thursday 11:45am)
➢ Distributions and trends (Ruth Eriksen: S07 Tuesday 5:15pm)



eReefs model (Large Z)   CPR GLM (Large Z)

Validating biogeochemical model (eReefs) using large zooplankton

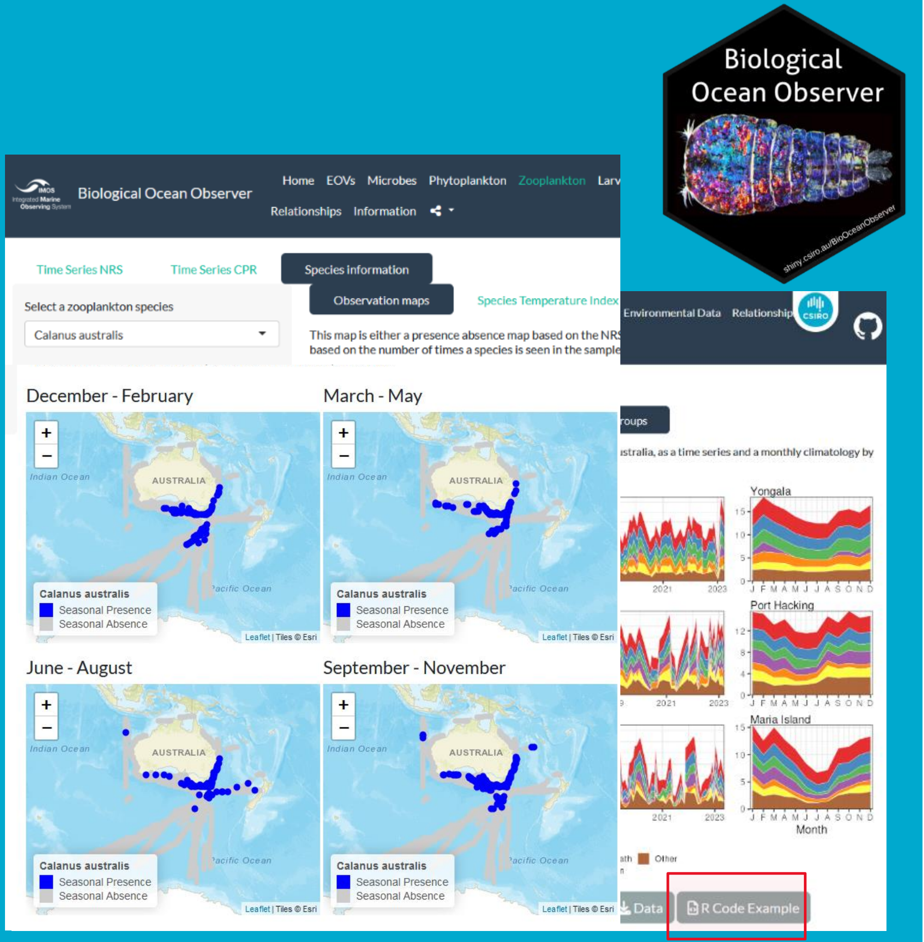
Skerratt et al. (2019) *J Marine Systems*

Advances in data visualisation: BOO

IMOS Biological Ocean Observer:

- IMOS data: NRS, CPR, molecular, long time series mooring biogeochemical products
- An interactive web page making our data accessible and interoperable
- Users from skilled analysts to the general public.

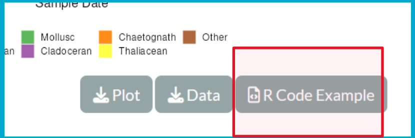
➢ Claire Davies and Jason Everett W02, S06 & poster sessions



https://shiny.csiro.au/BioOceanObserver/

Data visualisation: planktonr

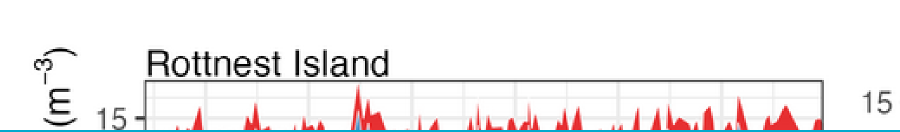
- R code
- Functions to access data directly from AODN
- Functions for wrangling and plotting, tweak to your requirements
- More complex analysis functions: STI, CTI, distribution maps, simple modelling, remove outliers
- Aid to FAIR data - accessible, reproducible
- Vignettes provide a training tool




```r
FGz <- pr_get_FuncGroups(Survey = "NRS", Type = "Z") %>%
  dplyr::filter(StationCode %in% c("ROT", "MAI"))

p1 <- planktonr::pr_plot_tsfg(FGz, Scale = "Actual")
p2 <- planktonr::pr_plot_tsfg(FGz, Scale = "Actual", Trend = "Month") +
  ggplot2::theme(axis.title.y = element_blank())

p1 + p2 +
  patchwork::plot_layout(widths = c(3,1), guides = "collect") &
  theme(legend.position = "bottom")
```



https://github.com/PlanktonTeam/planktonr

2. Molecular studies/eDNA

Pros

- Reveals hidden diversity (e.g. larval crustaceans, bivalves hard to ID by microscopy)
- Verified databanks due to DNA analysis of adults in some phyla
  - commercial species
  - benthic or pelagic adults in museum collections (e.g echinoderms, crustaceans, fish)

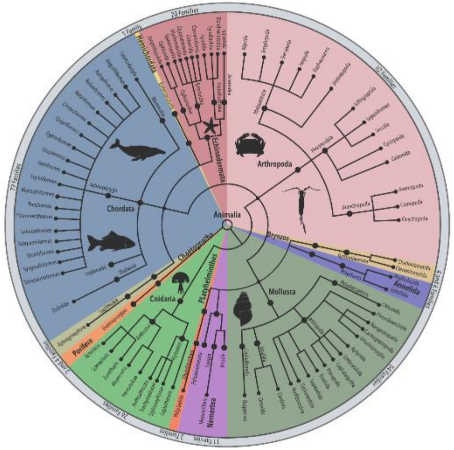
Cons

- Presence data not abundance, currently not quantitative
- Designing primers is challenging for >20 phyla
- Requires expert taxonomic ID for verified specimens, esp. for species with entirely planktonic lifecycle
- Errors in genetics databanks, we are helping fix
- Few larval collections in museums so not a target of metabarcoding initiatives
- Most zooplankton samples preserved in formalin

Molecular studies on NRS samples

- Co-developing molecular techniques for species-level identification
  - Is a copepod leg sufficient?
  - Can you extract the tissue and leave the carapace for ID if results indicate further taxonomic investigation is required?
- IMOS molecular data included in the Biological Oceanography Observer

- Molecular techniques provide valuable indices from plankton time series (Berry et al. 2019, 2023)
- Can highlight impacts of marine heatwaves on pathogens (*Vibrio*) on the Great Barrier Reef (Doni et al. 2023)



Berry et al. (2023)
Diversity & Distributions
DNA metabarcoding
n=90 samples; nearly 300 families
Much greater species diversity, but no abundance data

3. Size-spectrum, optical scanning techniques and machine learning

Zooscan, Flowcam, Laser Optical Plankton Counter, flow cytometry

Pros

- Abundance, specimen size, biomass data

Cons

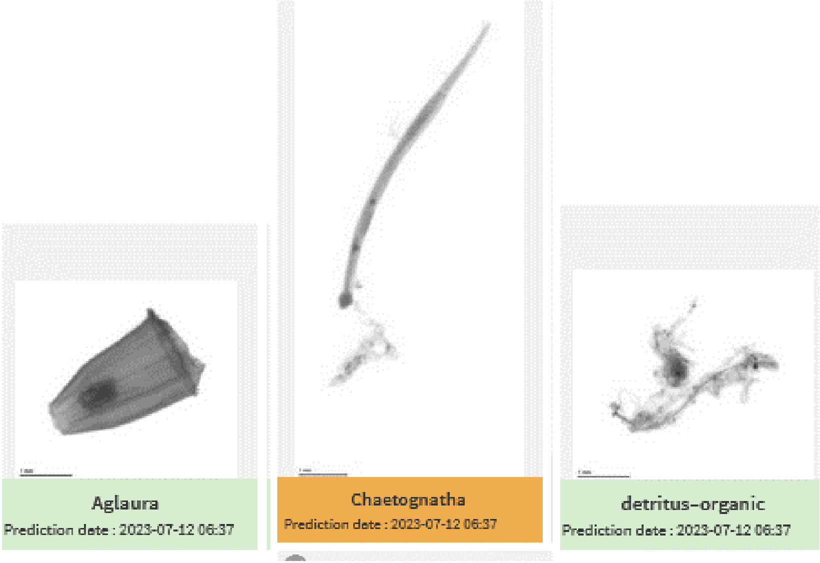
- Identifying functional groups
- Biodiversity lower due to taxonomic resolution
- Viewing angle, specimens cannot be manipulated
- Requires training library of taxonomically validated images for predictions
- Requires specialist coding knowledge to develop machine learning regime
- Flow cytometry for phytoplankton included in the Biological Oceanography Observer

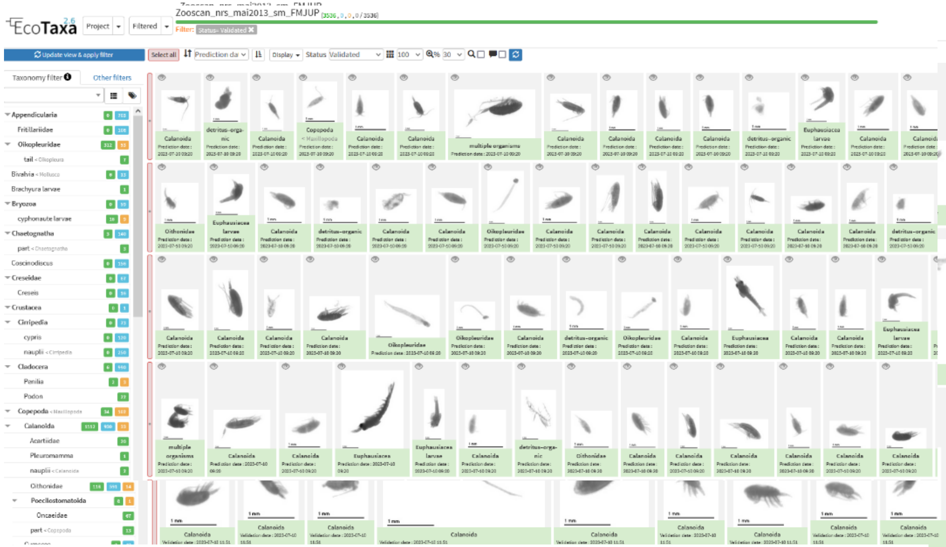
Zooscan

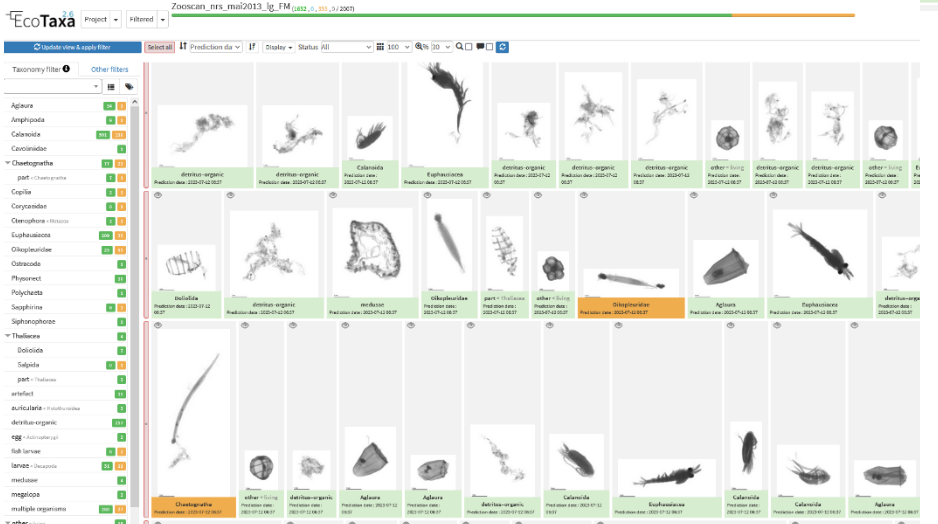
- Zooplankton net samples
- Time intensive to set up sample
  - Separating large fraction >1mm
  - Subsampling by volume
  - Ensuring space between specimens
- Provides data for size spectra, counts and taxonomic information
- Software updates over time

Ecotaxa

- Powerful, able to predict many images rapidly
- Requires a training dataset/library to create predictions
- Requires taxonomists to verify predictions
- Problems catagorising multiple specimens in an image







4. Micro CT scanning

X-ray computed tomography (XCT)

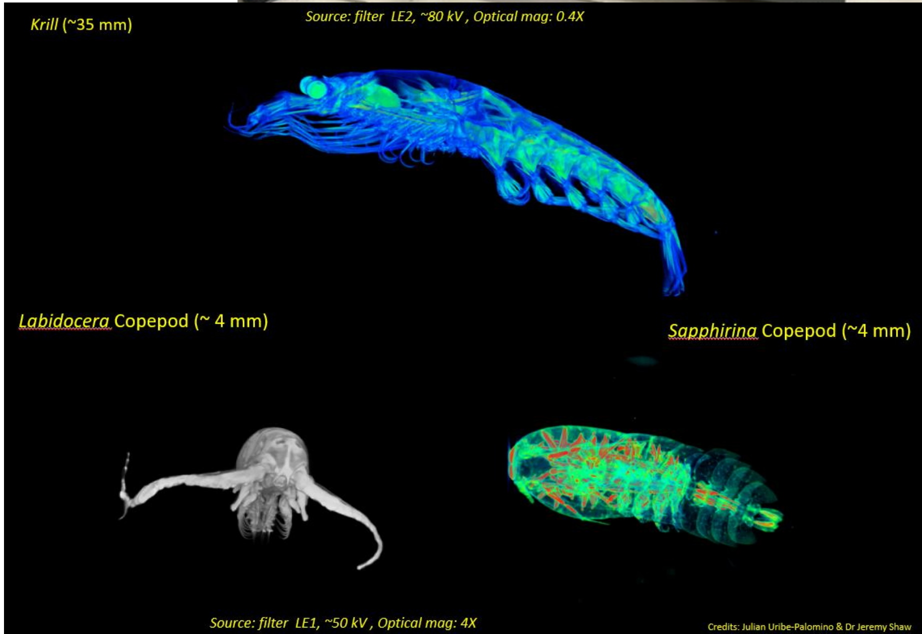
Pros

- 3D visualisation
- Ability to highlight internal structures
- Useful for training AI machine learning (in the future)

Cons

- Time intensive to set up specimens to ensure coating allows external visualisation of key body parts required for ID
- Requires high level training
- Still investigating soft/hard specimens and what size and resolution in possible
- Post processing time intensive

➢Julian Uribe Palomino S04 1:45pm Thursday



Integrated approach to zooplankton observation

- Microscopy will continue to provide the backbone for many plankton observing systems because it can provide abundance estimates for many individual species

- But microscopy has major limitations, so need to integrate plankton data with:
  - Molecular genetics
  - Size based techniques (FlowCytometry, FlowCam, Laser Optical Plankton Counter, ZooScan)
  - Machine learning and AI
  - Bioacoustics

- These techniques require the microscopy data to validate their molecular, bioacoustics, imaging or size-based approaches
- We are doing this work with collaborators within CSIRO and outside
- Rapidly evolving technology, software and integration of machine learning means the future of plankton research is exciting!

Acknowledgments

- Australia's Integrated Marine Observing System (IMOS) – IMOS is enabled by the National Collaborative Research Infrastructure Strategy (NCRIS).
- CSIRO, the Marine National Facility and the Ships of Opportunity that tow the CPR
- Australian Antarctic Division and the Southern Ocean CPR program
- All the members of the CSIRO plankton team

Thank you

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