IMOS

marinematters

ISSUE 41 | APRIL 2024

Tracking Ocean Changes from Antarctica

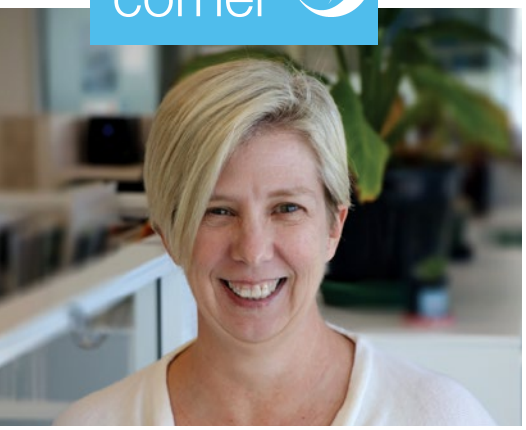
Introducing the new IMOS Coastal Wave Buoys Facility

IMOS and Sea Country Observing Partnerships

Down the sink: following carbon in the Southern Ocean

Clive McMahon, SIMS

director's corner



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.

Welcome to the April 2024 edition of *Marine Matters*

In this first edition of Marine Matters for 2024 you will find a range of updates, including a description of the recent NCRIS funding allocations and how those funds are being applied within IMOS.

This edition takes time to celebrate a range of IMOS achievements including contributions to the State of the Global Climate Report, expansion of the Bonney mooring into a National Reference Station, and an update on the Data Management System being developed by IMOS for the Reef Integrated Monitoring and Reporting Program to support decision making by managers on the Great Barrier Reef. We take a moment to recognise the contributions of women in IMOS as we celebrated the International Day of Women and Girls in Science and congratulate Moninya Roughan and Chari Pattiaratchi on their recent recognition and awards.

There are a number of excellent science updates in this edition as well as information on our work to identify and develop Sea Country Observing Partnerships. This is a really interesting and exciting time for IMOS as we work to expand into new areas and opportunities.

As always, I want to thank everyone who has taken time to contribute and share your stories, updates and information with us. I hope you enjoy this edition of Marine Matters.

Dr Michelle Heupel
IMOS Executive Director

New IMOS Step Change Observing and Data Uplift activities

IMOS submitted a 2023–2027 NCRIS Research Infrastructure Investment Plan (RIIP) Funding proposal in March 2023.

The 2023 Step Change Observing and Data Uplift activities in the IMOS proposal were developed through community consultation and stakeholder engagement to ensure the capacity to create impact, include Indigenous partnerships where possible, and leverage existing IMOS or partner efforts where possible.

In October 2023 IMOS received $37 million for the following activities:

- Step Change Observing
- Data Uplift
- CoastRI consultation

Step Change Observing

Deep Argo Floats – we are investing in Deep Argo Floats to better understand the deep ocean to inform climate and weather.

Ocean Gliders – we are adding additional Ocean Glider deployments to fill gaps in our observing coverage around Australia.

Event Based Sampling – as well as observing marine heatwaves there will be additional Event Based Sampling Ocean Glider deployments to observe river outflows due to floods, marine cold spells and extreme weather events such as tropical storms and cyclones.

eDNA Marine Microbiome Initiative – we will advance the use of eDNA as a marine monitoring and biosecurity tool.

Marine Turtle Observing – we will increase water column observing in Northern Australia by tagging and tracking turtles.

Acoustic Telemetry – we are expanding national acoustic tracking infrastructure into coastal and estuarine areas.

Moorings – we will deliver near real-time data from existing moorings to meet the operational needs of industry and improve forecasting and prediction.

FishSOOP – we will collect water temperature data via partnerships with commercial fishers.

Sea Country Observing Partnerships – we will establish dedicated, co-designed observing of Sea Country with Traditional Owners.

Pacific Linkages and Climate Change – IMOS will support linkages with Pacific Island neighbours.

Data Uplift

Alongside the expansion of IMOS observations there is a need to invest in our ability to deliver more information, not just data.

The Data Uplift activity is designed to:

- Deliver more analysis or model-ready data to ease use.
- Produce integrated datasets to support novel research.
- Ingest high value industry and government datasets to facilitate access.
- Develop data products to translate data into information for non-experts (e.g. Ocean Information Resources).

A data uplift brings additional scope to IMOS to deliver more data products and host additional priority datasets. In conjunction with increased and integrated data assets, tools and products will be developed through the Ocean Information Resources. Tools and products will focus on non-expert users who have a need for information but require assistance to access and fully use IMOS data.

CoastRI

The CoastRI activity funding includes support for consultation to design the program and initial investments in Coastal Wave Buoys and Estuarine Moorings for 2023-2027.

- CoastRI consultation is underway.
- The Coastal Wave Buoys Facility builds on the previous New Technology Proving project and is undergoing initial planning for expansion in 2024.
- Estuarine Moorings will require additional development and meetings in 2024 prior to establishment. ■

2024 IMOS Annual Meeting

The national IMOS community recently gathered in Hobart for our Annual Meeting, an opportunity to update everyone on new elements of the program including coastal observing, emerging technology, enhanced data delivery and First Nations partnerships.

IMOS welcomed a number of keynote speakers including:

- Dr Jerome Aucan from the Pacific Community Centre for Ocean Science (PCCOS) to discuss the needs of the region and their plans for Pacific Islands Global Ocean Observing System (PI-GOOS);
- Scientia Professor Matthew England from the Centre for Marine Science and Innovation at the University of New South Wales presented what ocean observations are needed in a changing climate;
- Manuwuri Forester is an Indigenous Partnerships Coordinator at the Australian Institute of Marine Science (AIMS), she shared her experience in helping Traditional Owners connect with AIMS to access better science and research which will lead to opportunities to merge Traditional Knowledge and Western Science.

View the full agenda and presentations on the IMOS website. ■

Dr Jerome Aucan from the Pacific Community Centre for Ocean Science with IMOS Executive Director Dr Michelle Heupel at the IMOS Annual Meeting.

IMOS and Sea Country Observing Partnerships

As IMOS evolves and grows there is an increasing need to collaborate with First Nations community to ensure we effectively engage with and deliver to all those interested in marine observations to help understand Sea Country.

IMOS honours First Nations people as Australia's first marine scientists and carers of country, and we pay tribute to the Traditional Ecological Knowledge, wisdom, and Indigenous perspectives passed from generation to generation, and successfully applied to sustainable environmental management over thousands of years.

As IMOS evolves and grows there is an increasing need to collaborate with First Nations community to ensure we effectively engage with and deliver to all those interested in marine observations to help understand ocean and Sea Country conditions and how Sea Country is changing.

Through our Sea Country Initiative IMOS is looking to establish linkages, collaborate, and co-design with Indigenous community to deliver ocean and coastal observations on Sea Country.

The initiative encompasses the following key aspects:

- Work in conjunction with and enhance existing IMOS partner connections with Indigenous community, whilst fostering new partnerships with Indigenous community to build mutual respect and understanding, collect data and share knowledge on marine ecosystems, coastal habitats, and Traditional Ecological Knowledge.
- Identify and support Indigenous community priorities and establish clear Indigenous Cultural Intellectual Property (ICIP) protocols for IMOS to protect any sharing or use of Traditional Ecological Knowledge.
- Provide the IMOS Community with guidance and support and foster high levels of cultural competency within the program while ensuring the adoption of CARE principles for Indigenous data governance.
- Develop and implement tools to track, evaluate and improve Indigenous partnerships and engagement within the program and provide the IMOS Office advice which will inform the planning and delivery of future IMOS efforts.

IMOS is seeking to appoint an Indigenous Engagement Officer to meet these objectives. The IMOS Indigenous Engagement Officer will work to enhance and expand the IMOS program through helping identify, develop, and maintain mutually beneficial partnerships with Indigenous community. This will include supporting new initiatives that have high relevance to Indigenous community such as coastal research infrastructure. ■

NEWS

The World Meteorological Organization (WMO) State of the Global Climate report confirms climate change indicators reached record levels in 2023

The WMO released the new report in March ahead of World Meteorological Day.

The State of Global Climate report confirms that 2023 was the hottest year on record and that records were also broken for greenhouse gas levels, surface temperatures, ocean heat and acidification, sea level rise, Antarctic Sea ice cover and glacier retreat.

WMO Secretary-General Celeste Saulo says “Climate change is about much more than temperatures. What we witnessed in 2023, especially with the unprecedented ocean warmth, glacier retreat and Antarctic sea ice loss,” she said.

On an average day in 2023, nearly one third of the global ocean was gripped by a marine heatwave, harming vital ecosystems and food systems. Towards the end of 2023, over 90% of the ocean had experienced heatwave conditions at some point during the year.

With our oceans absorbing significant amounts of atmospheric heat, they play a critical role in global climate and weather. Understanding ocean conditions is vital to predicting and defining current and future weather patterns.

In Australia, IMOS provides essential ocean observations, including physical, biological, biogeochemical and atmospheric measurements, to help understand the state, trends and future conditions of our oceans.

The State of Global Climate report cites publications that use data from a number of IMOS Facilities, including Argo Floats, Expendable Bathythermographs, Biogeochemical and Sea Surface Temperature (SST) Sensors on Ships of Opportunity, Moorings, Acidification moorings, and Satellite Remote Sensing SST products.

This demonstrates the value of the sustained ocean observations IMOS provides, improving our understanding of conditions, species and habitats to support management and protection of our precious marine estate. ■

> *“Climate change is about much more than temperatures.*

IMOS congratulates Professor Moninya Roughan and Professor Charitha Pattiaratchi on their recent awards

Professor Roughan (centre) received the Clarke Medal at Parliament House by Her Excellency the Honourable Margaret Beazley AC KC (left), and Dr Susan Pond President of the Royal Society of New South Wales (right).

Photo: Salty Dingo 2024

Professor Moninya Roughan, leader of the IMOS NSW Moorings sub-Facility, was awarded the prestigious Clarke Medal and Lectureship in Earth Sciences from the Royal Society of NSW.

This accolade is awarded for distinguished research in the natural sciences, conducted in Australia and its territories, across the disciplines of botany, zoology, and geology. Moninya, hailing from the University of NSW Sydney, has made leaps in understanding the dynamics of the East Australian Current, ocean observing and prediction systems, and their impact on continental shelf processes and western boundary current warming.

Professor Charitha Pattiaratchi, leader of the IMOS Ocean Gliders Facility, received the Oceanography Society's Mentoring Award for extraordinary mentoring of early-career marine scientists in developed and undeveloped nations.

Over the course of his career, Chari has developed a world-renowned research and training program for early career researchers and graduate students in coastal oceanography at The University of Western Australia. To date, he has supervised more than 300 people including direct supervision of 277 dissertations. ■

Professor Charitha Pattiaratchi.

International Day of Women and Girls in Science 2024

Meet inspiring women scientists at IMOS.

The United Nations International Day of Women and Girls in Science was on the 11th of February 2024, and we are celebrated some of our inspiring scientists at IMOS who are helping to undertake systematic, sustained and scientifically-robust observations of our vast and valuable marine estate.

We chatted to five women about their role in IMOS, what attracted them to pursue a career in science, the rewards, and advice they might have for girls and young women considering a career in STEM.

Photo: Thea Schneider

Dr Natalia Ribeiro Santos

Who are you, and what's your role in IMOS?
I'm a coffee-loving oceanographer, with a PhD in making elephant seals tell me the secrets of ocean-ice shelf interactions. I am an IMOS Science Officer, and my role is to support the science delivery of the IMOS program. This includes ensuring science planning is optimal, data are used as widely as possible, and that relevant issues are well-researched to inform IMOS processes and decisions, including meeting data standards.

What drew you into the world of science?
I've always been fascinated by the natural world, especially the ocean. As a child, I was endlessly curious and had a passion for learning and writing. While I didn't initially see myself as a scientist, my journey took me down unexpected paths, from teaching to sea exploration. Looking back, I realize that each decision I made was guided by a desire for happiness and fulfillment, ultimately leading me to where I am today.

What's the best part about being a scientist?
The best part is constantly learning something new. In the past, being out on deck used to be my happy place. I would often be at sea on research and merchant vessels as a student, scientist and technician.

What would you say to young girls and women thinking about being a scientist?
Choosing the right mentor or supervisor is crucial in your journey as a scientist. Take the time to speak with previous mentees to ensure compatibility and support. Don't underestimate the power of lifting other women along the way. We can achieve greater success if we actively choose to support each other.

Dr Rebecca Zitoun

Who are you and what is your role in IMOS?
I am Dr Rebecca Zitoun, working as a Science Engagement Officer at IMOS.

What drew you into the world of science?
I always loved spending time both at sea and in the ocean. My fascination with it, the excitement of discovering new things, and the challenge of solving complex problems naturally led me to become a marine scientist. Right now, I can honestly say I'm living my best life. Being able to make a positive impact on the health of our ocean through my work, and getting to teach and share the wonders of the ocean with others brings me a lot of joy and satisfaction.

What's the best part about being a scientist?
As a marine scientist, you're on the frontline, tackling real-world challenges that matter for society. This makes being a scientist incredibly rewarding and fulfilling. And being a marine scientist means wearing many hats! You're not just a scientist; you're a teacher, educator, science communicator, networker, administrator, engineer, and technician, among other things. On top of that, you juggle various tasks – from working in the lab and office to hopping on research vessels and getting hands-on in the field. It's this mix of roles that keeps the job interesting and fun because you're constantly learning something new.

What would you say to young girls and women thinking about being a scientist?
For young girls and women considering a career in science, my advice is simple: become a scientist and don't let anyone dictate what you can or cannot do or achieve. You have the capability to pursue your passion and contribute to the exciting world of science. Embrace your curiosity, challenge stereotypes, and break through any barriers. Your potential is limitless, and the scientific community thrives when diverse voices and perspectives are included. So, go ahead and pursue your dreams in science with confidence and determination!

Photo: Jo Manning

Dr Jessica Benthuysen

Who are you and what is your role in IMOS?
I am a physical oceanographer at the Australian Institute of Marine Science based in Perth. I chair the national committee for IMOS Event Based Sampling, in which we deploy ocean gliders in marine heatwaves and other extreme events.

What drew you into the world of science?
I was fascinated by the power of mathematics and physics to explain patterns in the environment.

What's the best part about being a scientist?
I enjoy the wonder and excitement of discovery, sharing my findings, and the camaraderie of being part of a passionate science community.

What would you say to young girls and women thinking about being a scientist?
A mentor can make a huge difference into shaping your future and I encourage you to reach out to scientists whose work interests you.

Dr Kay Critchell

Who are you, and what's your role in IMOS?
I'm a Lecturer of Oceanography at Deakin University, Victoria. I also run the Sensors on Temperate Merchant Vessels sub-Facility, which means I look after the automatic collection of data on board the Spirit of Tasmania as it goes about its activities through the Bass Strait.

What drew you into the world of science?
The unknown. There are so many things that we don't understand about how the world works. As a scientist, we get to explore those unknowns and move our understanding forward tiny bits at a time.

What's the best part about being a scientist?
The unknown! When you collect data and run an analysis, until you tell someone about what you have found, you are the only person in the whole world who knows that information. To me, that's awesome.

What would you say to young girls and women thinking about being a scientist?
You won't regret it. Even if you try it out and decide against pursuing a career as a scientist, your ways of thinking, problem-solving, and exploring the world will be a valuable addition to whatever you decide to do.

Emma Bowen

Who are you and what is your role in IMOS?
I'm the Facility Manager for the Acoustic Telemetry sub-Facility within IMOS Animal Tracking.

What drew you into the world of science?
I have always loved spending time at the beach and in the ocean, and from a pretty young age I wanted to work in a field that allowed me to make a positive impact on that environment. Marine science seemed like the best way to combine those two things!

What's the best part about being a scientist?
There are lots of good things. One of the best would be helping others learn more about the marine environment with the data we collect, from all over the coastline and a wide range of species. Our team also gets to meet and learn from a diverse range of interesting people, working in the marine environment around the country. Last but not least, my fieldwork is in the ocean, which is pretty special.

What would you say to young girls and women thinking about being a scientist?
Go for it! Don't be afraid to follow your interests or to connect with people who inspire you. You might end up going further than you think! ■

IMOS is improving our data discoverability

The IMOS AODN are working on a project to redesign the AODN Portal and underlying architecture with a focus on usability, discoverability and data uptake.

IMOS provides a wealth of data, which is openly accessible by the marine and climate science community, international collaborators and other stakeholders through our Australian Ocean Data Network (AODN) Portal.

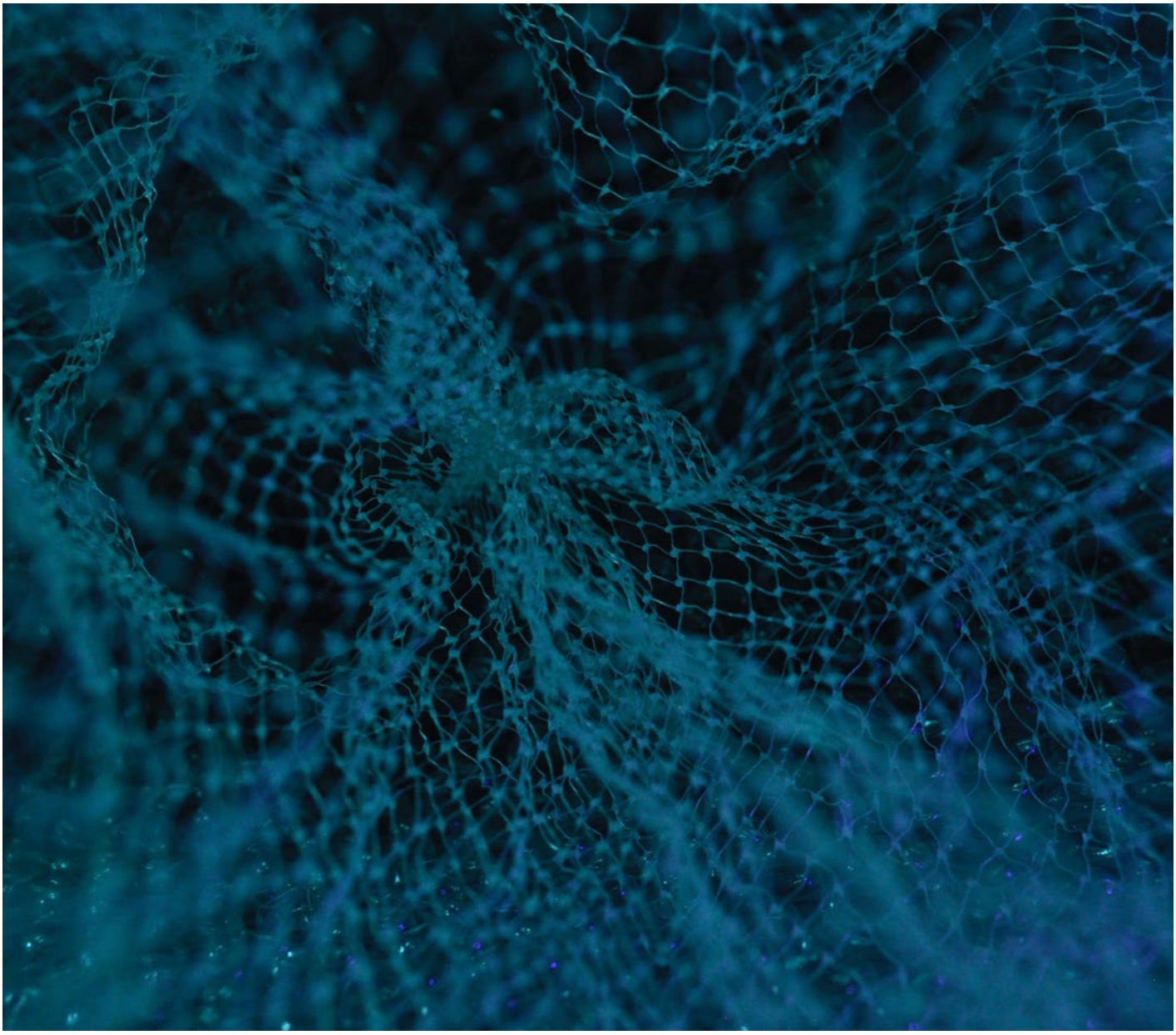
Our team at the IMOS AODN are working on a project to redesign the AODN Portal and underlying architecture with a focus on usability, discoverability and data uptake. The new portal will have interactive map-based exploration capabilities allowing the user to discover IMOS and other marine datasets in their area of interest.

The new data architecture prioritises the discovery of data. Searching for Australia's marine data will be easier in the new portal with a free text 'google like' search, topic search and popular filters.

This project will make it easier to use IMOS-hosted data with basic data previews (gridded, time series, profiles), kick start guides, coding examples, ready to use data that are pre-integrated and in popular formats, and it will improve the extraction of data subsets.

Importantly our new architecture will also simplify data contribution for our partners.

We will keep you informed about the project via updates in the IMOS Bulletin. If you have any questions about the project please contact: Mark Rehbein (mark.rehbein@utas.edu.au) ■



Update from the Great Barrier Reef Data Management System project

IMOS is leading a project to deliver a fit-for purpose Data Management System (DMS) for the Reef 2050 Integrated Monitoring and Reporting Program (RIMReP).

The DMS has now reached over 100 fully processed datasets and is continuing to grow. With access to more than 2,500 different variables, users can explore various datasets related to the human environment, coral reef monitoring, water quality, marine weather, satellite products, geographical and administrative boundaries, and more.

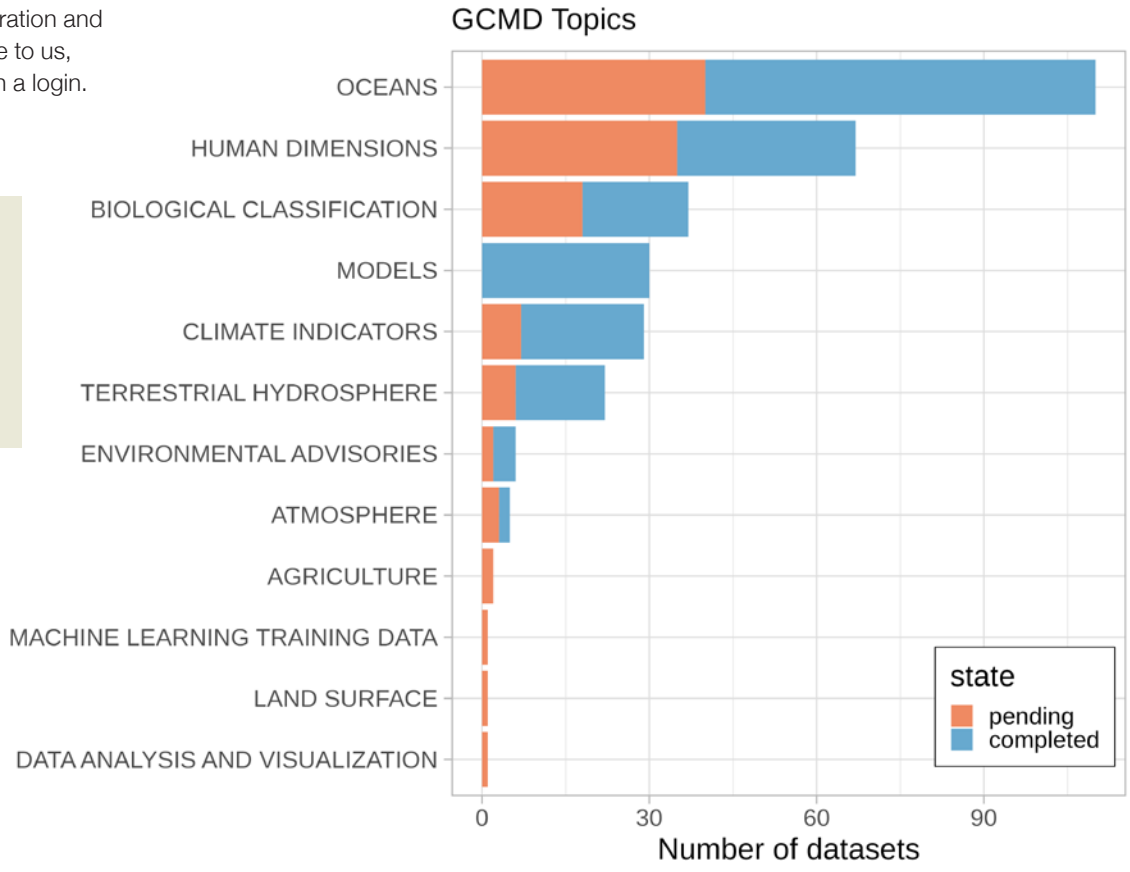
To learn how to interact with the DMS data and metadata services, please visit the public repositories rimrep-examples and rimrep-training. You can download more than 25 working notebooks in Python or R and customize them to fit your research/management data needs. Explore the DMS catalogue using your academic email as your access credential. If your organisation is not a partner of the Australian Access Federation and wants to use the DMS, write to us, and we will provide you with a login.

We recently made the project documentation site available to the public. It provides a technical description of the DMS and guides you through searching for a dataset, setting up your computer with necessary tools, and connecting to and using DMS data and metadata services. If you encounter any issues while using the DMS, you can raise them in the documentation repository. Your feedback can help us improve the system.

Featured data collection: During times of ocean warming, the DMS provides efficient access to several datasets related to sea water temperature, from NOAA's Coral Reef Watch suite of products (like Degree-heating Week, our most popular dataset) to Australian Institute of Marine Science (AIMS) marine weather stations (updated every 10 minutes) and modelled oceanographic and biogeochemical data from eReefs products. NOAA and SSTAARS Sea Surface Temperature climatologies are also available. The DMS team recently developed a Python notebook to extract the maximum value of the Degree-heating Week, from a range of dates and a region. No more "fishing for data": now you can have access to all this data in one single place.

The RIMReP Data Management System is funded by the partnership between the Australian Government's Reef Trust and the Great Barrier Reef Foundation, and the Great Barrier Reef Marine Park Authority with support from the Integrated Marine Observing System.

Currently, the DMS is fully equipped with more than 100 different datasets from coral reef ecosystems to human activities. Number of datasets by Global Change Master Directory (GCMD) Keywords topics.



Introducing the new IMOS Coastal Wave Buoys Facility

IMOS is establishing a national network of wave buoys to help understand the processes and changes driven by waves in the coastal zone.

Australia has one of the longest coastlines in the world and this dynamic intersection between land and sea includes numerous critical ecosystems and infrastructure. Our coastal zone is also where many of us live, work and play. Over 87% of Australians live within 50 kilometres of the coast, with further growth predicted in coming decades.

Climate and human development are changing our coastal systems at an unprecedented rate and more data are needed for planning to avoid or mitigate changes and sustainably manage this precious resource.

IMOS tested wave buoys in the coastal zone through our New Technology Proving capability, and building on the success of that project we are establishing a national Coastal Wave Buoys Facility to provide data essential for understanding the processes and changes driven by waves around our coastlines.

The new IMOS Facility will be led by Professor Ryan Lowe and Dr Mike Cuttler at the University of Western Australia.

“Wave buoys provide ocean measurements critical to research, marine industries, government agencies and service providers,” says Professor Lowe.

“IMOS will be setting up moored wave buoy sites around the country with co-investment from partners. This will create a coordinated national network of wave and temperature observations to meet a wide range of end user and stakeholder needs.”

The data will be used in the development and improvement of models used to predict and forecast hazards which threaten coastal populations, and to understand the impacts of environmental disturbances (such as extreme storm events and marine heat waves) on coastal ecosystems.

This new Coastal Wave Buoys Facility represents one of the initial investments IMOS is contributing to establish the CoastRI program. CoastRI, a cross-NCRIS collaboration, is being developed to provide a national-scale coastal observing and modelling capability for Australia. ■

Photo: Matt Hatcher, University of Western Australia

Coastal wave buoy deployed in coastal waters near Sandpatch, in south-west Western Australia.

Photo: Matt Hatcher, University of Western Australia

The facility will utilise small format wave buoys, which means they are readily deployed and serviced using small vessels in the coastal zone.

Marine Microbiome Initiative: New study reveals marine heatwaves have significant impact on microorganisms

Researchers from CSIRO have demonstrated that marine heatwaves are altering the microorganism communities that form the base of the marine food chain, disrupting coastal ecosystems.

Australia has recently experienced a number of marine heatwaves off the East Coast and Tasmania. They are prolonged oceanic warm water events that can have significant impacts on marine life, including fish, coral reefs and kelp forests.

The effects of marine heatwaves on microorganisms are relatively unknown despite ocean temperature being a major determinant of microbial biogeography and assemblage composition.

The study used data from a long-term effort to observe marine microbiota that IMOS operates with our partner Bioplatforms Australia called the Australian Microbiome Initiative. The Australian Microbiome Initiative is a national bio-resource, providing a central database of marine microbial DNA and bioinformatics.

Approximately 50% of the marine dataset has come from water samples collected annually from the national network of IMOS National Reference Stations. The spatial (which includes locations in all of Australia's important marine bioregions) and temporal scale of the IMOS dataset were invaluable to the study as it allowed a much more robust calculation of environmental optima for individuals.

The study combined molecular and oceanographic datasets to generate indices describing the generalised niche characteristics or environmental preferences of microbial species and assemblages.

The authors examined the marine heatwave at Maria Island in 2015/16 demonstrating how valuable these indices are to distil complex community information into simple metrics to identify and track shifts in microbial and plankton communities (the trophic base) in response to environmental change.

Lead author Dr Mark Brown said the researchers analysed a marine heatwave off Tasmania in 2015/16, an extreme warming event, finding it had significant impacts on microorganisms.

"The marine heatwave transformed the microbial community in the water column to resemble those found more than 1000 km north, and supported the presence of many organisms that are uncommon at this latitude," Dr Brown said.

"This reshaping leads to the occurrence of unusual species, the development of unique combinations of organisms, and can cause cascading effects throughout the ecosystem, including changes in the fate of carbon sequestered from the atmosphere.

"For instance, we observed a shift away from the normal phytoplankton species at this site towards smaller cells that are not easily consumed by larger animals, potentially leading to profound changes all the way up the food chain."

CSIRO principal research scientist Dr Lev Bodrossy said researchers used a new approach to simplify the way they observed tens of thousands of marine microbes.

"This will enable us to evaluate the health of the marine ecosystem and predict how it will change with predicted global warming," Dr Bodrossy said.

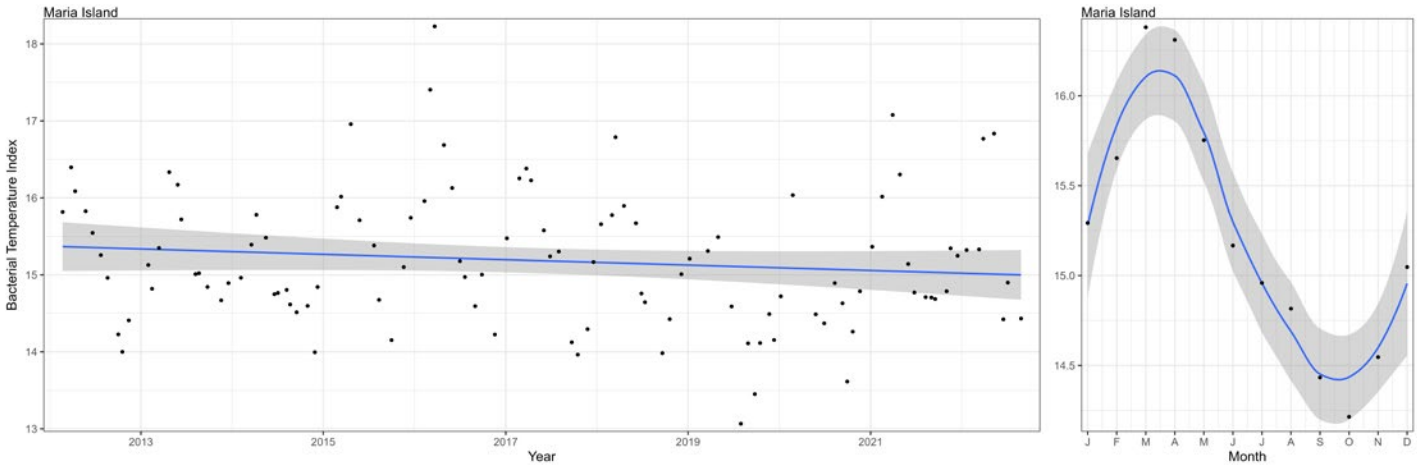
"We'll be able to better predict the future of fish stocks and marine carbon sequestration in different regions of the global ocean."

"Observations like these, especially those done in the open ocean, are difficult to sustain but are crucial for understanding and forecasting the future status of the marine ecosystem," he said.

The community environmental niche indices from IMOS National Reference Stations are available to visualise and download as timeseries (figures and data) via the IMOS Biological Ocean Observer.

The article 'A marine heatwave drives significant shifts in pelagic microbiology' was published in Nature's Communications Biology.

This article is based on a CSIRO media release written by Carla Howarth. ■



A plot (generated from IMOS Biological Ocean Observer) of Bacterial Temperature Index from the Maria Island National Reference Station, as a time series and a monthly climatology averaged across all depths. The Bacterial Temperature Index peaks in 2016 at the time of the Marine Heatwave.

National Mooring Network:
New National Reference Station deployed in Victoria

IMOS has enhanced an existing mooring in the Bonney Coast region to become part of our National Reference Station network.

IMOS has established a network of National Reference Station (NRS) moorings to provide baseline information that is required to understand how large-scale, long-term change and variability in the global oceans are affecting the ecosystems of Australia's coastal seas. The sites include both continuous moored-sensor sampling, and quarterly vessel-based sampling, measuring a wide range of physical, biogeochemical and biological variables.

The National Reference Station Network has consisted of seven sites around the coast of Australia. Three established, long-term sites that existed prior to IMOS (Maria Island, Tasmania, Port Hacking, NSW, Rottnest Island, WA), and four additional sites to cover the distinct regions of Australia's coastal oceans (Darwin, NT, Yongala, QLD, North Stradbroke Island, QLD, Kangaroo Island, SA).

IMOS, with our partners Deakin University and SARDI, have established and maintained a mooring since 2019 in the Bonney Coast region to fill a significant gap in the IMOS observations. Encompassing the shelf waters between Cape Jaffa in South Australia and Cape Otway in Victoria, the Bonney Coast hosts a strong seasonal wind-driven coastal upwelling system that supports one of the most productive marine regions in Australian coastal waters of high ecological and economic importance to South Australia and Victoria.

IMOS has recently upgraded this Victorian mooring to convert it into a National Reference Station site – bringing the network up to a total of eight sites. In early April staff from Deakin University and SARDI serviced the existing Bonney mooring. Whilst at the site, the first quarterly/seasonal NRS water samples were collected to measure a range of biogeochemical and biological variables.

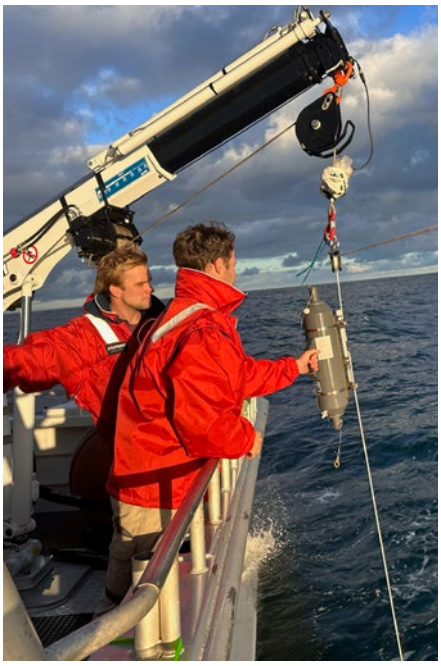
"The upgrade of the Bonney mooring to a National Reference Station broadens the spatial monitoring of our globally unique Great Southern Australian upwelling system beyond the long time series of observations collected by IMOS at the Kangaroo Island National Reference Station since 2008. The collected observations will deepen our knowledge of the response and differences between the major upwelling hotspots located along our southern shelf seas that span across our State borders", says Dr Mark Doubell, SARDI Oceanographer.

By adding this mooring in Victoria IMOS will build on the multi-decadal time series of the physical and biogeochemical properties of Australia's coastal seas we already have collected, with the data able to inform research into ocean change, climate variability, ocean circulation and ecosystem responses.

"In addition, we have never seen Bass Strait busier with extensive decommissioning in the oil and gas sector and an emerging offshore wind industry with close to half of the proposed precincts situated in Bass Strait," says Associate Professor Daniel Ierodiaconou, Marine Scientist from Deakin University.

"From selecting optimal locations for wind farms to planning construction and operations, to decommissioning infrastructure, these decision-making processes rely entirely on ocean observations."

"The Victorian National Reference Station also anchors other sustained observing IMOS does in the region. This includes the following collocated infrastructure: a cross shelf acoustic curtain, coastal wave buoys, ocean acidification monitoring, microplastic sampling and seasonal glider missions," said Associate Professor Ierodiaconou.



Photos: Daniel Ierodiaconou, Deakin University

Deep Water Moorings:
Down the sink: following carbon in the Southern Ocean

Written by Mark Horstman and originally published by the Australian Antarctic Program Partnership.

The Southern Ocean plays a crucial role in the global carbon cycle, responsible for about 40% of the total global ocean uptake of human-induced carbon dioxide emissions.

The IMOS Southern Ocean Time Series (SOTS) site southwest of Tasmania provides a valuable long-term opportunity to explore the variability of the ocean carbon cycle.

The sub-Antarctic zone, where the SOTS site is located, is important for its influence on the exchange of carbon dioxide (CO_2) between the ocean and atmosphere. Recently a compilation of nearly a decade of observations from the SOTS observatory between 2011 and 2022 revealed changes in ocean chemistry resulting from CO_2 uptake, and for the first time, direct measurements of an increase in the magnitude of the ocean's seasonal CO_2 cycle.

Now Xiang Yang, a PhD student with the Australian Antarctic Program Partnership (AAPP) at the University of Tasmania, has extended this SOTS record to cover two decades.

"By combining observations from SOTS with data from satellites, Argo floats and ships, we developed a model to compute the air-sea CO_2 exchange, that extends and fill in gaps in the SOTS records from 2004 to 2021."

"We found that CO_2 partial pressure, or pCO_2, in the surface ocean is increasing faster than in the atmosphere. This means that the SOTS neighbourhood has acted as a net carbon sink in the last 20 years to absorb human-generated CO_2 from the atmosphere," he said.

Mr Yang and his co-authors also explored what drives the CO_2 exchange between air and sea.

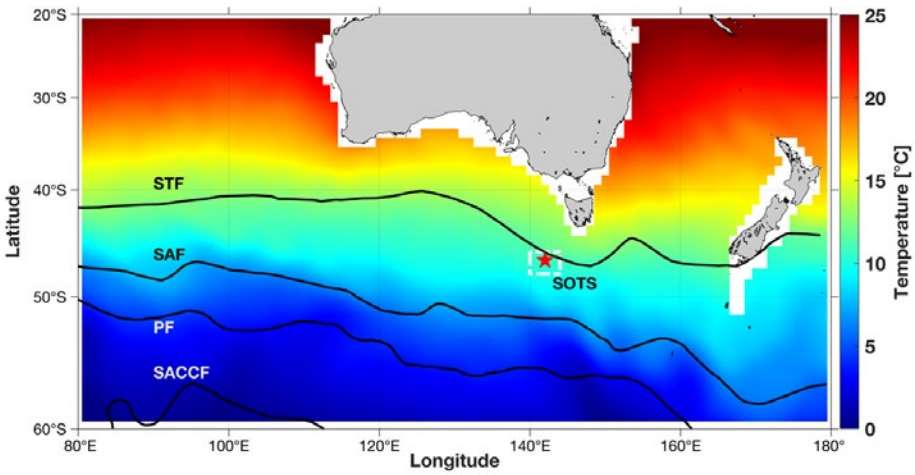


Figure 1: The general location of the Southern Ocean Time Series station (SOTS) is indicated by the red star, and the white polygon represents the study area. Major fronts are the Subtropical Front (STF), the Subantarctic Front (SAF), the Polar Front (PF), and the Southern Antarctic Circumpolar Current Front (SACCF). Climatological surface temperature for the period 2004 to 2021. (plot: Xiang Yang)

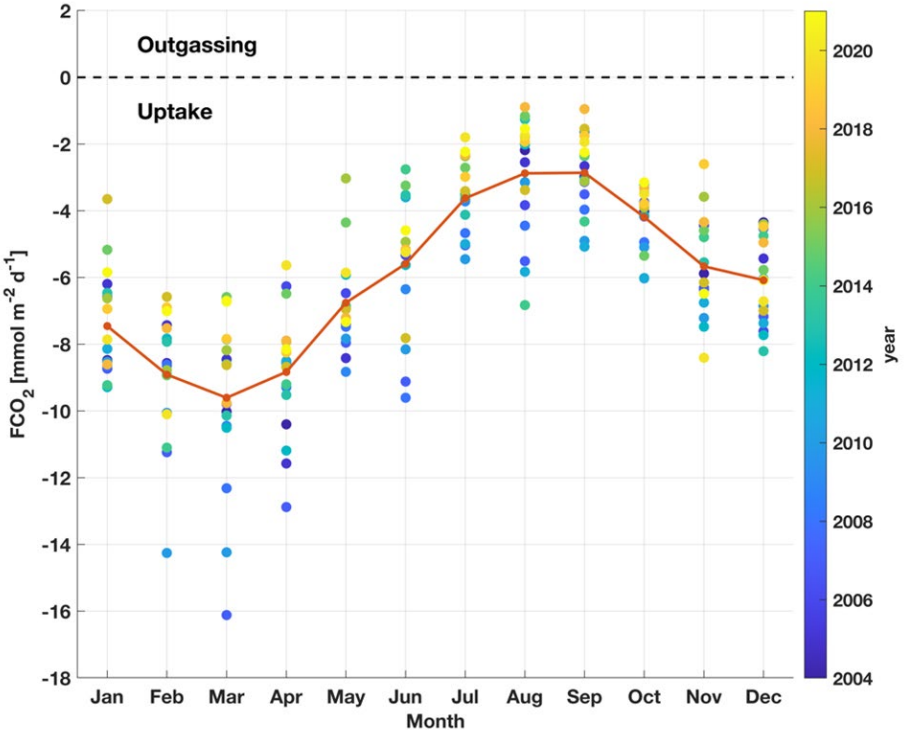
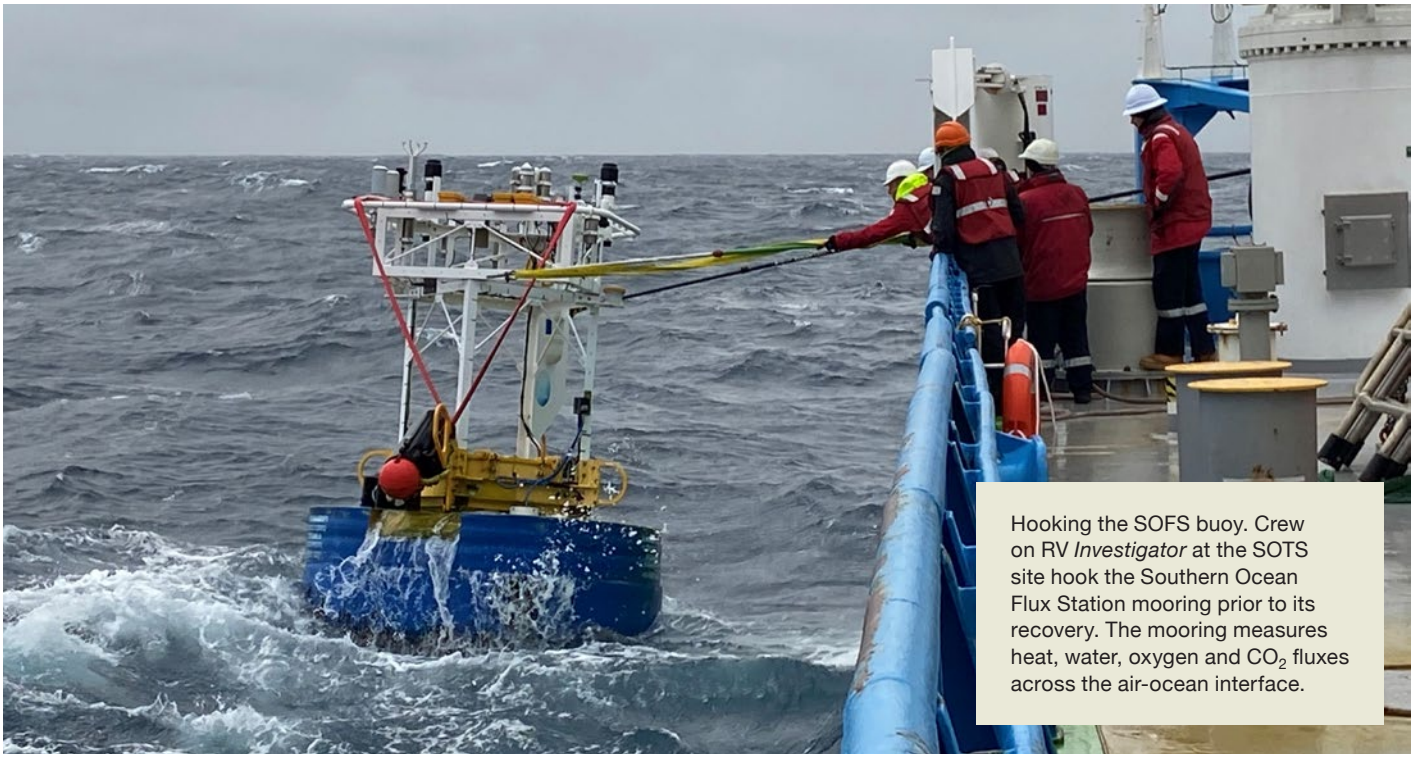


Figure 2: The air-sea CO2 flux (FCO_2) by month, showing the SOTS region acting as carbon sink. Colour scale is blue to yellow from past to present, 2004 to 2021. The orange solid line indicates the average value for each month. Negative values indicate ocean uptake of CO_2. (plot: Xiang Yang)



Hooking the SOFS buoy. Crew on RV *Investigator* at the SOTS site hook the Southern Ocean Flux Station mooring prior to its recovery. The mooring measures heat, water, oxygen and CO_2 fluxes across the air-ocean interface.

Photo: Max McGuire, CSIRO

"The strongest sink period is from February to April, when biological activity predominantly impacts CO_2 as phytoplankton bloom in spring and summer. The movement of water driven by eddies and ocean fronts is mainly responsible for the carbon variabilities in the autumn and winter."

The CO_2 exchange (or 'flux') is highly seasonal. The air-sea CO_2 flux (or FCO_2) is most variable in summer and more stable in winter, but the winter magnitude over the last few years has decreased to near zero.

The study, published in January in the journal Global Biogeochemical Cycles, also looks at the impacts of large-scale climate modes like the Southern Annular Mode (SAM).

"The positive trend of the SAM, when the strong westerly winds of the sub-Antarctic zone contract towards the pole, can slightly increase the ocean uptake of CO_2 by enhancing wind-induced mixing", Mr Yang said.

His ongoing PhD studies continue to investigate carbon pathways, using BGC-Argo floats and sediment trap records from the SOTS site to quantify how much particulate organic carbon has been transferred to the deep ocean from biological activity near the surface.

Read the full paper:

Yang, X., Wynn-Edwards, C. A., Strutton, P. G., & Shadwick, E. H. (2024). *Drivers of air-sea CO_2 flux in the subantarctic zone revealed by time series observations*. Global Biogeochemical Cycles, 38, e2023GB007766.

The IMOS SOTS site is operated through a partnership between IMOS, CSIRO Marine National Facility, CSIRO, Bureau of Meteorology, and the Australian Antarctic Program Partnership (AAPP). IMOS and the CSIRO Marine National Facility are national research infrastructure supported by the Australian Government's National Collaborative Research Infrastructure Strategy (NCRIS). ■

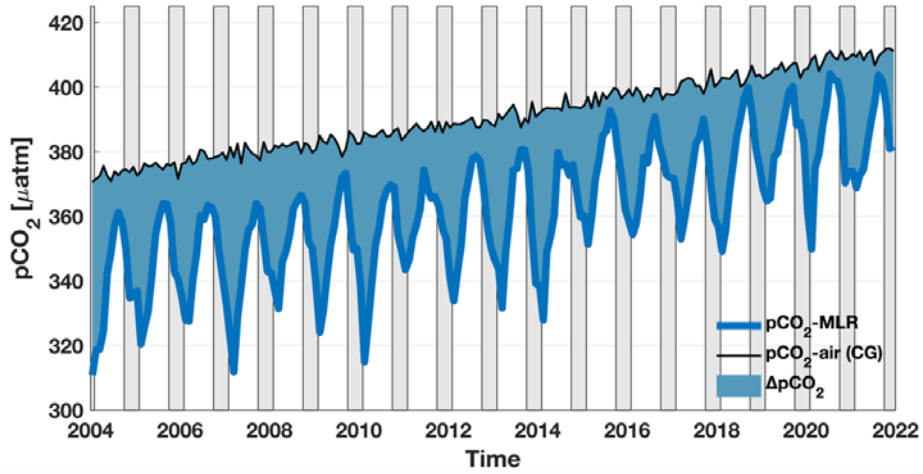


Figure 3: Time series of pCO_2 in the SOTS region. Blue line: p CO_2-MLR is the multiple linear regression model result. Black line: pCO_2-air (CG) is atmospheric pCO_2 measured at the Cape Grim (Tasmania) station. Blue area indicates air-sea CO_2 exchange: ΔpCO_2 is the gradient between pCO_2-MLR and pCO_2 -air (CG), used to calculate FCO_2. (plot: Xiang Yang)

Ocean Gliders, National Mooring Network, Satellite Remote Sensing: What happens when a historic year of rainfall dumps freshwater into the ocean?

Using a combination of observations from IMOS Ocean Gliders, a Mooring, and Satellite Remote Sensing a new study looks at the impact of the 2022 East Australian floods on the ocean.

The oceanic impact of extreme rainfall events in normally 'dry' regions is not well understood, as their effects are challenging to observe.

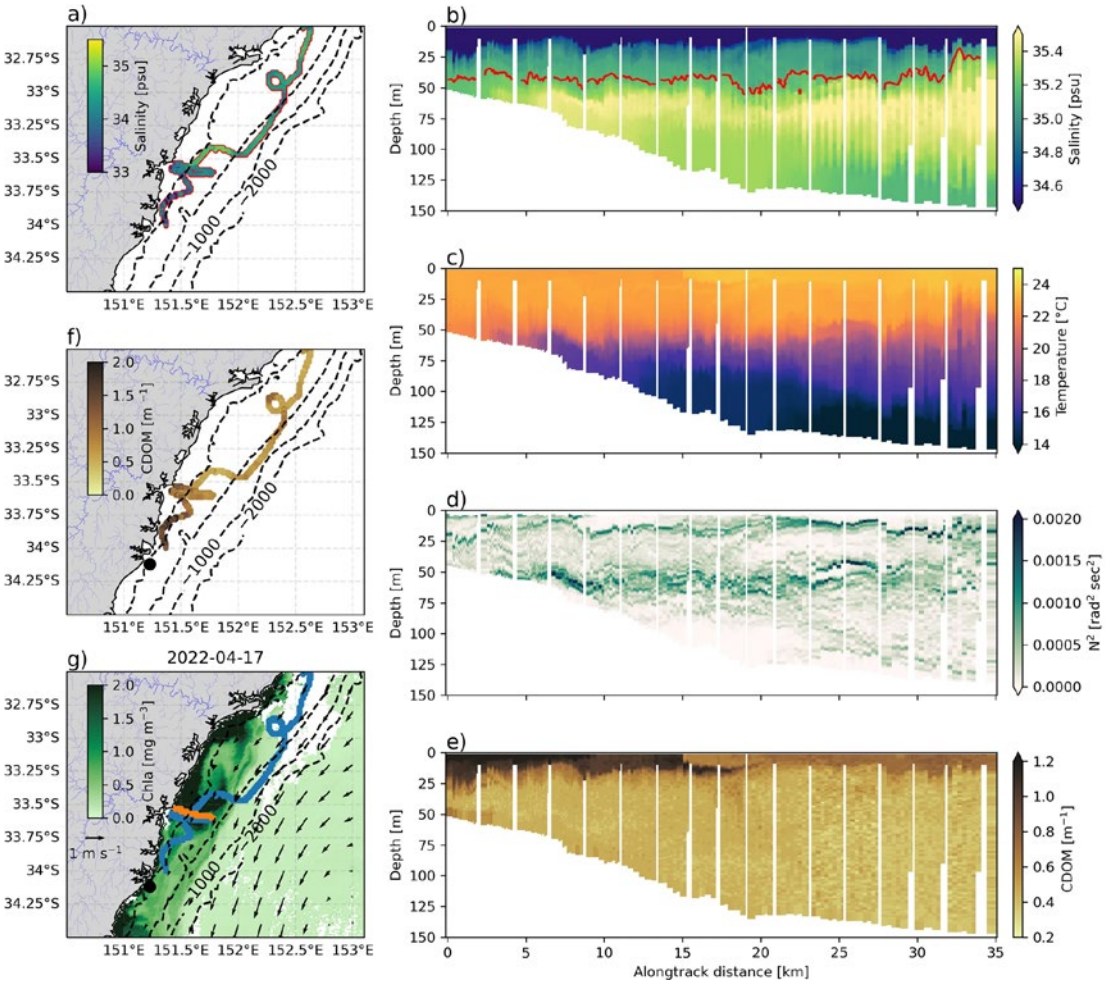
IMOS has been operating a wide range of observing equipment throughout Australia's coastal and open oceans since 2006. Consequently, the productive Hawkesbury shelf region, inshore of the East Australian Current, is one of the best observed western boundary current shelves globally.

The study, led by Neil Malan from the Coastal and Regional Oceanography Lab at the University of New South Wales in partnership with the NSW Department of Climate Change, Energy, the Environment and Water (NSW DCCEEW), used a multi-platform approach leveraging data from IMOS moorings, ocean gliders, satellite data, and estuary monitoring sensors run by NSW DCCEEW to build up a picture of where floodwaters had moved.

Using over a decade of sustained observations of salinity from these platforms the researchers identified and quantified the extent and longevity of extreme freshwater discharge events over the continental shelf. In particular, the research observed the impact of sustained extreme rainfall on the coastal ocean during 2022, the wettest year on record, in contrast with a large rainfall event during 2015, a year of average rainfall.

The IMOS Ocean Gliders revealed that in 2022 extreme low salinity waters extended more than 70 km offshore and persisted for months. The study also observed a previously unseen dynamic for the region during April 2022: a 'double-stacked' stratification, with two layers of fresher water in the upper 50 m of the water column resulting in one salinity stratified layer, and another, deeper, temperature-stratified layer.

Extreme low salinity events are known to be important for species composition of local fisheries as well as detrimental for coastal water quality. Such events and their impacts may become more common as extreme rainfall events are projected to become more frequent in a changing climate. Therefore, it is essential to have comprehensive ocean observations to identify salinity extremes. ■



Case study of April 2022 extreme wet event

a) Glider track with minimum salinity for each profile (colours), and red outline for profiles where extreme low salinity water is present. Cross-shelf sections at 33°S for **b)** Salinity, with the red contour showing the extreme low salinity threshold **c)** Temperature **d)** N^2 and **e)** coloured dissolved organic matter (CDOM). **f)** Shows the glider track coloured by the maximum CDOM value for each profile. **g)** Shows surface maps of daily satellite-derived ocean colour (shading) and geostrophic velocities (vectors), glider tracks are shown in blue, with the cross-shelf section shown in orange. Note that alongtrack distance is in the across-shelf direction.

Image from Malan, N., Roughan, M., Hemming, M. *et al.* Quantifying coastal freshwater extremes during unprecedented rainfall using long timeseries multi-platform salinity observations. *Nat Commun* 15, 424 (2024). https://doi.org/10.1038/s41467-023-44398-2. Shared under a Creative Commons Attribution 4.0 International License.

Animal Tagging: Tracking Ocean Changes from Antarctica

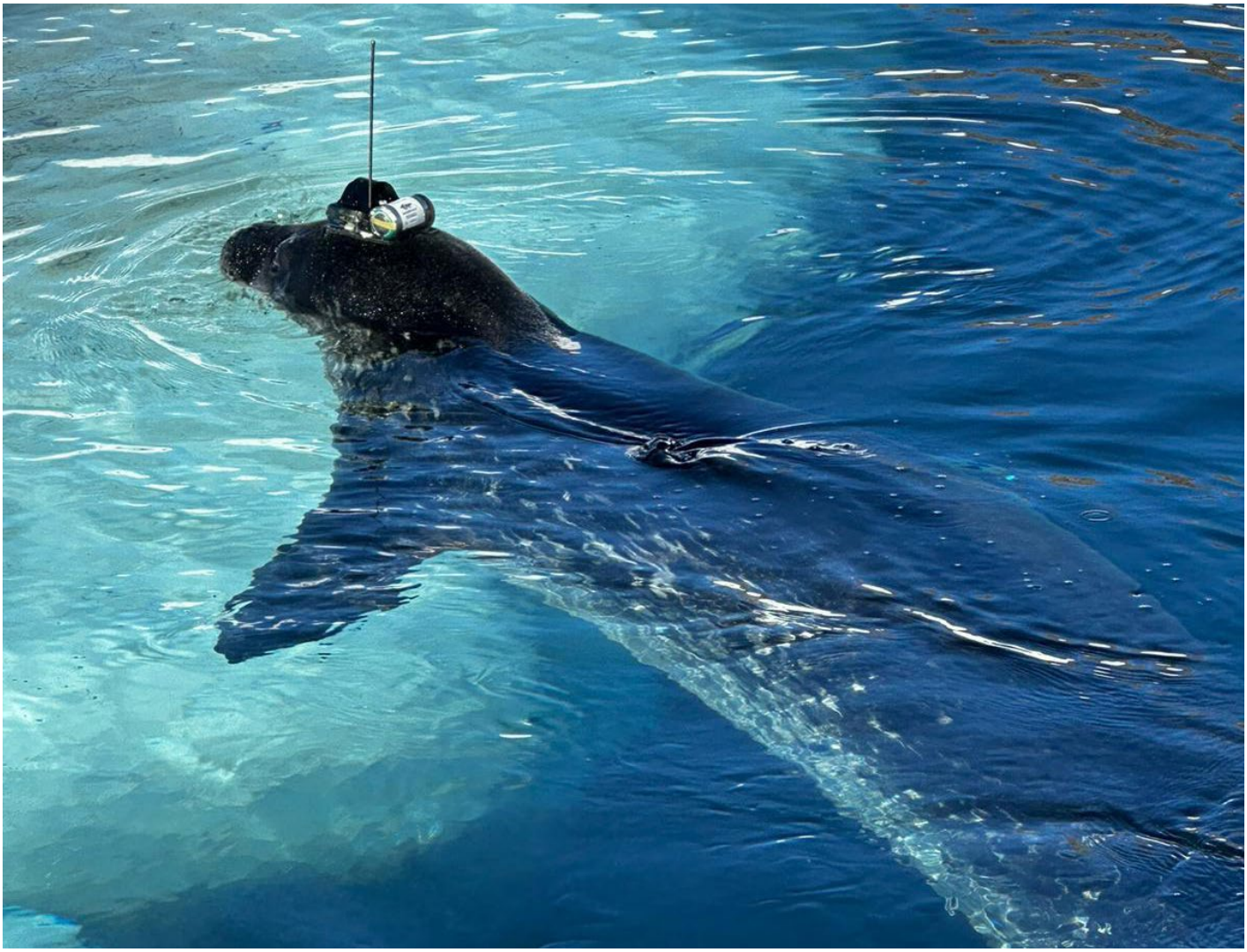


Photo: Clive McMahon, SIMS

Dr. Clive McMahon, from the IMOS Animal Tagging sub-Facility and the Sydney Institute of Marine Science, led a team of dedicated researchers on another expedition down to Antarctica in late January to deploy seal tags.

Teaming up with esteemed colleagues from Laboratoire d'Océanographie et du Climat: Expérimentations et Approches Numériques (LOCEAN) IMOS deployed nine advanced CTD (conductivity-temperature-depth) tags on Weddell seals (*Leptonychotes weddellii*).

This initiative, part of a long-standing collaboration between IMOS Animal Tagging sub-Facility and LOCEAN, is not just about gathering data; it's about piecing together a comprehensive picture of the Antarctic ecosystem. By studying both the water column's physical structure and the seals' behaviour, the team aims to measure biological production in the sea ice zone and its cascading effects through the food web.

This study along the Terre Adélie Coast is especially exciting as it provides a comparison of the region's physical ocean structure and its biology before and after the significant calving event of the Mertz glacier tongue in 2010. The team hypothesise that this event has profoundly influenced the ecological and oceanographic processes along the coast.

The primary goal of the latest expedition was to correlate the foraging behaviour of Weddell seals with hydrographic data from both pre- and post-calving periods to understand how the calving has impacted ice/ocean interactions, primary production, and, ultimately, the seals' feeding performance.

The team left in late January, aboard the French icebreaker, *L'Astrolabe* and returned to Hobart in early March. The seals have since ventured back to the sea, sending daily ocean profiles from around Dumont d'Urville and even reaching Watt Bay, 180 km to the east. These profiles are invaluable, providing critical insights into ocean physics and the seals' at-sea behaviour.

Over the next few months, as the sea ice begins to reform, the seals will deliver a wealth of information as they forage and move around this highly productive region in the far south of the globe.

This article is based on a SIMS news item written by Isobel Lerpiniere. ■

Australian Plankton Survey: IMOS plankton observations highlighted at global zooplankton conference

Written by Claire Davies

More than 315 scientists from 38 countries gathered in Hobart in March 2024 for a major international conference about marine zooplankton, the most abundant and diverse 'eco-influencers' on the planet.

The 7th International Zooplankton Production Symposium (17–22 March) was organised by the North Pacific Marine Science Organisation (PICES) based in Canada, the International Council for the Exploration of the Sea (ICES) based in Denmark, and the Australian Antarctic Program Partnership (AAPP) at the University of Tasmania. CSIRO was a sponsor.

The IMOS Plankton Team, who are operated through our partner CSIRO, attended the Symposium and presented in a range of sessions about IMOS plankton observations and data.

Professor Anthony Richardson, a researcher at CSIRO and University of Queensland and Leader of the IMOS Australian Plankton Survey sub-Facility, was an invited speaker in the session "Applications of time series to track changes in zooplankton communities and impacts on ecosystem structure and function."

Anthony presented what may be the first observational evidence of a clear global decline in zooplankton biomass based on the analysis of 90 years of historical biomass data from around the globe. This data has been painstakingly archived through efforts such as the Australian Zooplankton Biomass Database led by the IMOS plankton team and the NOAA COPEPOD database.

IMOS data were an important contribution to this analysis, as Australia was relatively devoid of zooplankton data prior to when IMOS started collecting observations. Further, the IMOS mandate to make data freely available in useable formats make this type of analysis possible.

Long data sets and a variety of methods mean that time series analysis have gone beyond Latin names and counts. Size, biomass, indices, ratios, and assessment by functional role can give better insights into what is changing and why, and what its likely impact will be in the ecosystem and/or fisheries. Data standardisation and interoperability are key to advancing the field of trait-based approaches and the massive potential of vast image databases. The IMOS datasets were presented at a pre-Symposium workshop on time series analysis by Anthony Richardson (AusCPR and NRS), Luke Brokensha (Southern Ocean CPR) and Ruth Eriksen (Southern Ocean Time Series) and there were many comments around how the IMOS approach to data-sharing was an enviable position to be in and an ideal model for other multi-agency monitoring programs overseas.

Frank Coman presented on a range of indices developed through the IMOS plankton data, EAC index, Community Temperature Index, and how these can aid our understanding of the overall ecosystem and how it is changing. All this information is difficult to decipher without visualisation tools, Claire Davies presented work on the IMOS Biological Ocean Observer and how this can increase uptake by making data more available and accessible. All the IMOS Plankton Team were involved in various poster presentations, equipment displays or the Art Exhibition.

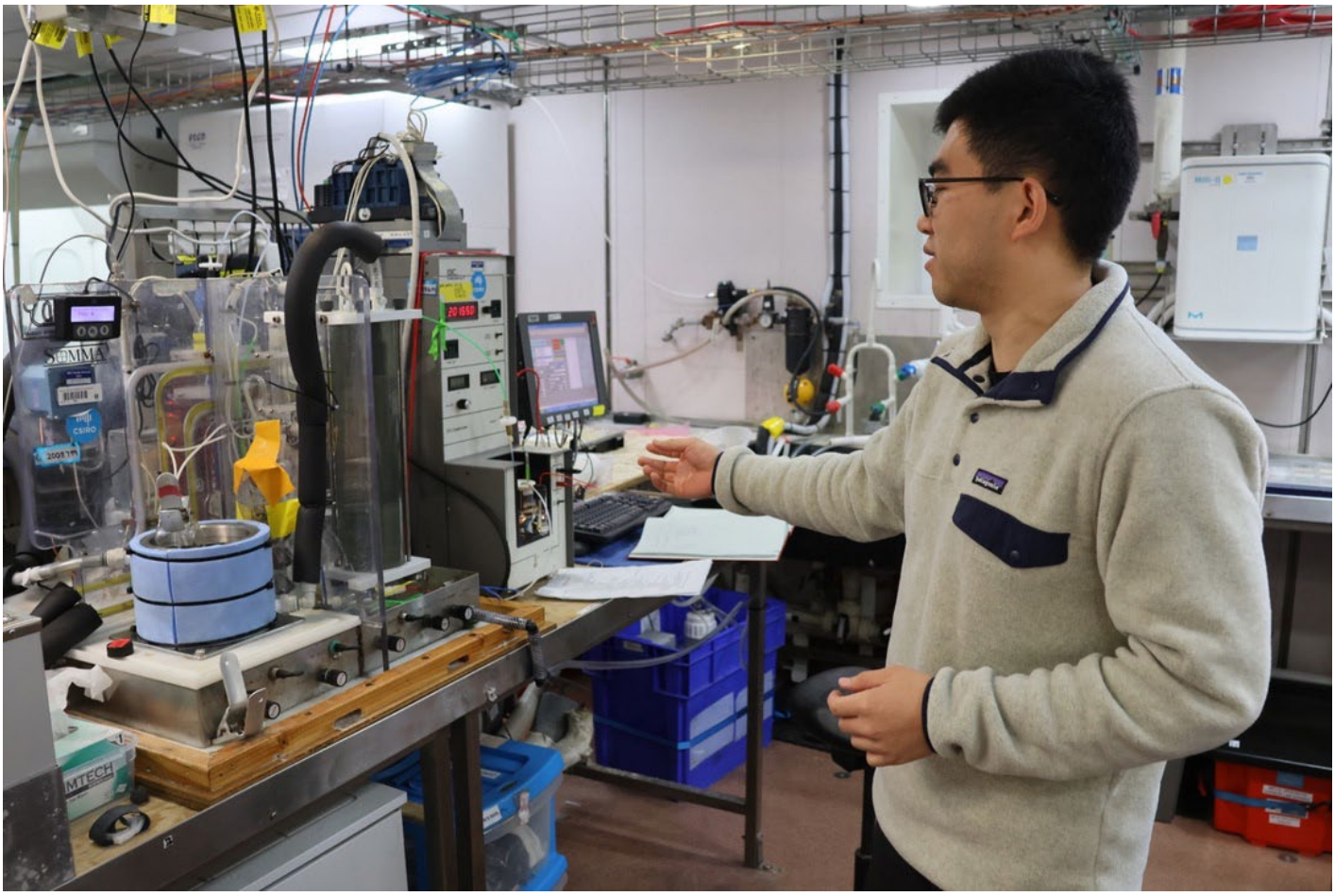
The Conference statement reinforced the urgent need for sustained and enhanced international research efforts and resourcing to build on and support long-term biological time-series as fundamental baselines for assessing the impacts of environmental change on zooplankton. The work by IMOS in Australia will be critical in this endeavour. ■

Photo: Peter W Allen, UTAS

Several hundred attendees of the International Zooplankton Production Symposium, from 38 countries.

Xiang Yang

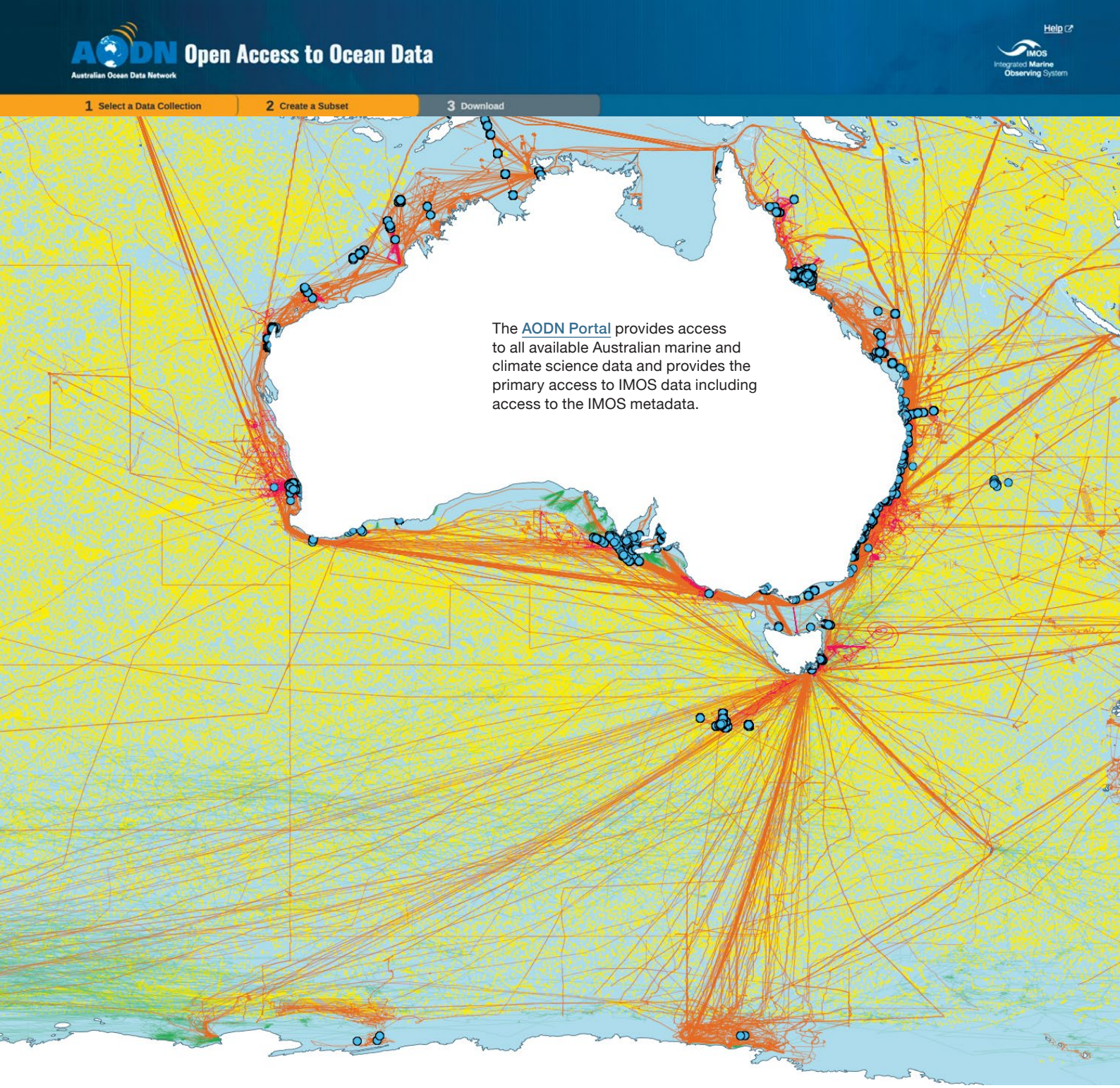
Drivers of Air-Sea CO_2 Flux in the Subantarctic Zone Revealed by Time Series Observations



The subantarctic zone, roughly the mid-latitudes of the Southern Ocean, is an important region for its influence on the exchange of carbon dioxide (CO_2) between the ocean and atmosphere. The Southern Ocean Time Series (SOTS) site southwest of Tasmania gives a great opportunity to explore the variability of the ocean carbon cycle.

By using observations from SOTS, and data from satellites and ships, Xiang developed a model to compute the sea surface CO_2 over the past two decades (2004–2021). It extends and fills in the gaps in the records of SOTS. Xiang found that surface ocean CO_2 is increasing faster than in the atmosphere. The SOTS neighbourhood has acted as a net carbon sink in the last 20 years, to absorb anthropogenic CO_2 from the atmosphere, but its magnitude is weakening. The CO_2 exchange (or 'flux') is highly seasonal. The air-sea CO_2 flux (or FCO_2) is most variable in summer and more stable in winter, but the winter magnitude over the last few years has decreased to near zero.

The impacts of large-scale climate modes like the Southern Annual Mode (SAM) and smaller scale process like eddies were also explored. The positive SAM can slightly increase the ocean uptake of CO_2 by enhancing wind mixing. Biological activities predominantly impact CO_2 in spring and summer. The water mass movement associated with eddies and ocean fronts is mainly responsible for the pCO_2 variabilities in the autumn and winter. ■



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Thanks to: Eduardo Klein Salas, Mark Horstman, Julia Scott, Carla Howarth, Neil Malan, Isobel Lerpiniere, Claire Davies, Xiang Yang, Jodie Van De Kamp.

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.

For more information about IMOS please visit the website www.imos.org.au