highlights 2017-2018

IMOS
Integrated **Marine Observing** System

Photo: Gretchen Grammer, SARDI

Director's Overview

Tim Moltmann
IMOS Director

This Annual Highlights document covers the twelfth year of operation for IMOS as a national collaborative research infrastructure.

Five years ago, the Board approved a decadal strategy (2015-25) setting out a bold vision for IMOS. That by 2025, Australia would have a continuously growing time series of essential ocean variables for marine and coastal environments. A system that would enable cutting edge research on contemporary problems, and provide a scientific basis for informed decision making about Australia's vast and valuable marine estate.

In pursuit of this vision, the IMOS community has successfully built a world class research infrastructure. We have used it very well to date, as evidenced in this 2017–18 Annual Highlights document, and those of previous years.

The ongoing need for IMOS has just been reinforced by the Australian Government, with significant, ongoing funding over the medium to long term. The Federal Budget handed down on 8th May 2018 was a watershed moment in the history of IMOS.

Funding is now secure to 2023, with strong prospects out to 2029 under the Australian Government's investment of an additional $1.9 billion (over 12 years) in the National Collaborative Research Infrastructure Strategy (NCRIS).

At the end of 2017–18, we can therefore be very confident that the Board's 2025 vision is being, and will be achieved.

IMOS functions within the broader national research infrastructure landscape, and it was also pleasing to see additional funding in the Federal Budget for the Marine National Facility (MNF) to fully utilise the research vessel *Investigator*. IMOS and MNF work closely together, and the combination of these investments is great news for Australian marine and climate science.

In this document, we highlight annual science impacts from IMOS infrastructure in four sections – broadscale, backbone, regional and national.

The power of turning broadscale observations into big datasets that validate and reduce uncertainties in ocean remote sensing, modelling and forecasting is highlighted. Collaboration is fundamental to our success but particularly at this scale, and IMOS has become a trusted partner in the national and international programs featured here, as well as in many others.

A key challenge for a national research infrastructure is deciding how to facilitate use and impact at national scale, while managing community pressure to do 'everything, everywhere'. Backbone facilities are providing an increasingly effective mechanism for IMOS to drive national scale use and impact. The examples highlighted here demonstrate how IMOS strategic investments in marine observing and data infrastructure are scaling up and connecting excellent activities underway at regional and local levels.

The social, cultural, economic and environmental importance of Australia's vast marine estate does concentrate in particular regions. IMOS looks to respond to these regional drivers by intensifying its efforts in strategically important locations. The examples highlighted here show how use and impact is being accelerated though this approach.

Highlights from the Australian Ocean Data Network (AODN) and IMOS *OceanCurrent* show how sustained investment in national data and product platforms adds even more value to the broadscale, backbone and regional facility investments highlighted above.

All of the achievements of the past year were underpinned by continued, excellent performance of IMOS operating institutions. The program had 235 milestones for the year, of which 91% were achieved and a further 6% in progress at 30 June 2018. An outstanding effort by all of the scientific, engineering, technical and administrative staff involved in running the program on a day to day basis.

In closing, we would like to acknowledge the outgoing Chair of the IMOS Board, Dr Ian Poiner, who stood down on 30 September 2018. Ian has been Independent Chair since 2011, and the success of the IMOS community over this period owes a great deal to the clear and calm stewardship he has provided. Thank you, Ian.

We hope you enjoy reading this IMOS Annual Highlights document for 2017–18, and thank you for your continued interest and support.

How does IMOS work?

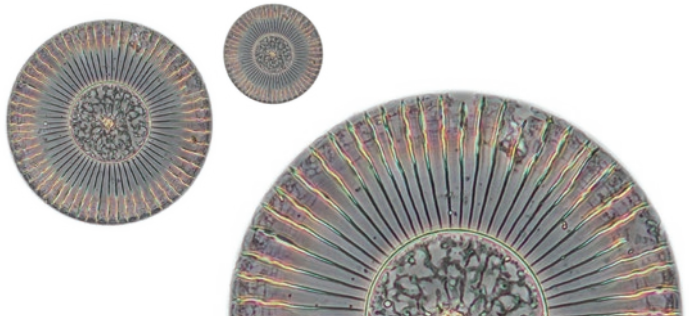
IMOS undertakes systematic and sustained observing of Australia's vast and valuable marine estate. All of its data is openly accessible to the marine and climate science community, international collaborators, and other stakeholders and users in a timely manner. It achieves this through a portfolio of platform-based **Facilities** to acquire the observations, an integrated set of science **Nodes** to design and guide the system, a program-wide focus on **Data** to enable ready access, use and reuse, and a growing number of **Research Partnerships** to drive uptake and impact.

Facilities

IMOS currently has a portfolio of ten Facilities that undertake systematic and sustained observing of Australia's marine environment, across scales (from open ocean, onto the continental shelf, and into the coast), and across disciplines (physics, biogeochemistry, and biology and ecosystems).

The current IMOS Facilities are:

1. Argo Floats
2. Ships of Opportunity
3. Deep Water Moorings
4. Ocean Gliders
5. Autonomous Underwater Vehicles
6. National Mooring Network
7. Ocean Radar
8. Animal Tracking
9. Wireless Sensor Networks
10. Satellite Remote Sensing



Nodes

The Australian marine science and stakeholder community is large, diverse, and dispersed. Nodes provide the means for IMOS to undertake national science and implementation planning, integrated across regions. They identify the major research themes and science questions, and determine what we need to observe, where, when and how. IMOS Node science and implementation plans have continued to be reviewed and developed over a number of years and provide a strong scientific underpinning for IMOS.

Data

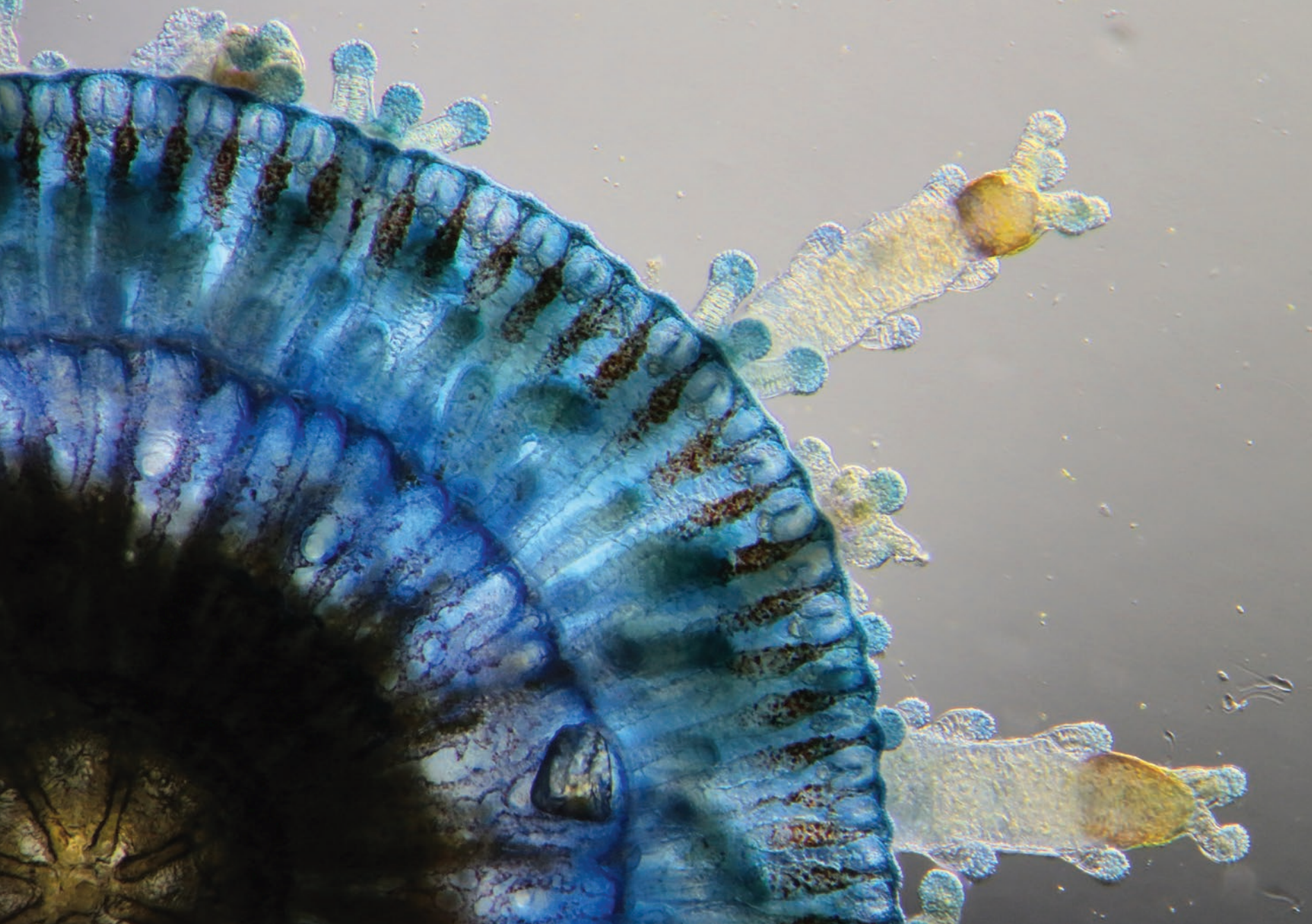
A key element of IMOS is that all observations are turned into quality-controlled Data that can be discovered, accessed, downloaded, used and reused in perpetuity. Datasets and time series are essentially the research infrastructure that is being created and developed. This has been achieved by having a separate Data Facility, the Australian Ocean Data Network (AODN), that is responsible for building and maintaining a national marine information infrastructure. The infrastructure includes a geospatial portal as well as a metadata system, file formats, controlled vocabularies, file storage, servers, web services, and data tools.

Research Partnerships

The societal benefits of investment in IMOS are realized through uptake and use of observations and data to undertake marine and climate science that has relevance and impact. To some extent this emerges quite naturally through the IMOS Facility and Node structure, which is based on broad engagement across the Australian marine and climate science community. However, IMOS must also be explicitly responsive to current and emerging national priorities. Partnerships with major Australian research initiatives that require marine observations and data provide a mechanism for prioritization and focus.

In this document, we highlight science impacts from IMOS infrastructure in four sections – broadscale, backbone, regional and national.

Photos: Julian Uribe-Palomino, CSIRO



Broadscale

Observations from the open ocean are essential for improving our understanding of the ocean's role in climate and for tracking the evolution of climate change on decadal time-scales. Australia's highly variable climate is sensitive to conditions in the surrounding oceans and measurements of the open ocean provide the primary source of information used to anticipate floods and droughts associated with climate modes like El Niño and the Indian Ocean Dipole. Broadscale observations are also critical for ocean prediction on time-scales of days to weeks.

The IMOS broadscale observing infrastructure delivers sustained observations that cover the open ocean, providing researchers with the data to observe, understand and predict the oceans surrounding Australia from the tropics to Antarctica. The ocean is a globally connected system, and marine observing is an international endeavour. The broadscale facilities also provide much of Australia's contribution to the Global Ocean Observing System (GOOS), and related basin-scale coordination efforts in the Southern Ocean, Indian Ocean and Pacific Ocean.

The IMOS broadscale portfolio currently includes:

- Argo profiling floats,
- Satellite Animal Tracking,
- Ships of Opportunity, for physics,
- Ships of Opportunity, for biochemistry and biology and ecosystems, and
- Satellite Remote Sensing, calibration/validation/reception and national products.

2017–18 Impact

New Chlorophyll *a* database for Australia

Chlorophyll *a* is the most commonly used indicator of phytoplankton biomass in the marine environment. It is a simple and cost-effective way to estimate phytoplankton biomass as the chlorophyll a pigment is present in all photosynthetic phytoplankton species.

In Australian waters chlorophyll *a* concentrations are generally lowest in the tropical and subtropical oceanic regions and higher in the Southern Ocean and temperate regions. In coastal zones, the chlorophyll a concentrations can fluctuate greatly as phytoplankton blooms develop, peak and crash.

Concentrations of chlorophyll *a* also vary throughout the oceans with oceanographic features such as upwelling and fronts which drive nutrients towards surface layers and thus enhance chlorophyll *a* levels. In inshore estuaries and bays, high chlorophyll *a* values can indicate the system is eutrophic with elevated nutrient levels from terrestrial run off. Chlorophyll *a* is therefore used in several water quality monitoring programs across the country.

A new database of chlorophyll *a* in Australian waters was published in the Nature journal Scientific Data, and collates 173, 333 chlorophyll *a* records collected since 1965 by researchers, students, government bodies, state agencies councils and databases into a single repository. The Australian Chlorophyll *a* database is freely available through the AODN portal, and includes Chlorophyll *a* data from a number of IMOS Facilities including National Reference Stations moorings, Ocean Gliders, and Ocean Colour.

The data can be used in isolation as an index of phytoplankton biomass, or in combination with other data to provide insight into water quality, ecosystem state, and relationships with other trophic levels such as zooplankton or fish.

National ocean forecasting

Ocean conditions can be unpredictable. This unpredictably creates risk and uncertainty for the maritime and naval industries that rely on the ocean.

The Bluelink partnership (between Defence, CSIRO and the Bureau of Meteorology) addresses this challenge

by using a variety of observational data streams from numerous sources to create a comprehensive suite of ocean forecasts that predict all types of marine weather scenarios, from local beach conditions to oceanic interactions on a global scale.

The Bluelink forecasting systems are routinely assessed against in-situ observations, and includes IMOS data from the Argo Floats, Ocean Gliders, Satellite Remote Sensing and Ocean Radar facilities.

The IMOS Ocean Glider data is extremely important for Bluelink because there are very few other observations available to assess the 3D structure and temporal frequency of models in shelf areas. The vertical resolution provided by the Ocean Glider data is especially useful in this respect. More recently Bluelink started to use IMOS Ocean Radar data, whilst this is still in a preliminary phase, the data will be used to assess the modelled current velocities.

The Bluelink models and forecasts are used by Defence, marine planners, and maritime industry and safety authorities, to help guide their activities at sea and near shore.

Global database of animal tracking data

Polar oceans are poorly monitored despite the important role they play in regulating the Earth's climate system. Marine mammals equipped with biologging devices are being used to fill the data gaps in these logistically difficult to sample regions.

IMOS has been tagging elephant seals since 2011 and contributes this data to the Marine Mammals Exploring the Oceans Pole to Pole (MEOP). MEOP is an international consortium of researchers dedicated to sharing a comprehensive quality-controlled database of oceanographic data obtained in Polar Regions from instrumented marine mammals with users.

A recently published review of the MEOP Consortium highlights the MEOP conductivity temperature depth (CTD) database, which is publicly accessible through the MEOP data portal. The database currently contains 529, 373 profiles, and is also included in major oceanographic databases including the World Ocean Database and the Coriolis Ocean Dataset for Reanalysis.

Collectively, MEOP demonstrates the power and cost-effectiveness of using marine mammals as data-collection platforms that can dramatically improve the ocean observing system for biological and physical oceanographers. It is an excellent example of a multidisciplinary collaboration creating a great output for both the biological and physical communities, and with time should significantly improve the quality of the projections provided by ocean-climate models.

New surface waves product on the way

Surface waves have been identified as a key ocean variable for a range of priority activities within the Australian National Marine Science Plan. Furthermore, the need for surface wave data has been articulated through the Forum for Operational Ocean Oceanography (FOO). IMOS hosts the Forum, an initiative whose goal is to improve the safety and efficiency of marine industries through better decision-making via operational oceanography.

This led to the establishment of a FOO working group, which sought to identify current limitations of the existing Australian surface wave observing platforms to deliver impact, particularly in an operational oceanography context. Wave data was consequently identified as an area of potential growth for IMOS.

In the last year IMOS has established a new Surface Waves Sub-Facility which will gather high quality ocean surface wave data from current and next-generation satellite missions and make it readily available to the Australian marine and climate science community through the AODN Portal.

The Surface Waves Sub-Facility are starting a project that will enhance existing IMOS facilities to deliver global validated, national satellite remotely sensed (SRS) wave products to support ongoing and emerging research and operations in Australia.

With the recent launches of international satellite missions measuring ocean waves there is an emerging need for continued collection, quality control, and distribution of ocean surface wave data to user groups in Australia and also globally.

Photo: Clive McMahon, SIMS

Backbone

Backbone facilities play a central role in IMOS, linking the broadscale to the regional, and providing whole-of-program capability that goes beyond a 'sum of regions' approach.

Within IMOS this manifests in a capability to monitor major boundary currents, such as the East Australian Current. It manifests in the ability to develop long term, high frequency time series to address significant questions, such as uptake of CO_2 in the Southern Ocean, and variability and change in the physical and biogeochemical properties of Australia's coastal seas. Lastly, it manifests in an integrated suite of national facilities to study marine biology and ecosystems, and their interaction with biogeochemical and physical processes. Emphasizing biology and ecosystems in the backbone is a strategic choice. It is based on an assessment that IMOS will make a much greater difference in sustained ecological observing by playing the role of national integrator and aggregator, guided by priorities around bioregional planning and management, assessing the state of the marine environment, and managing long ranging, cross-jurisdiction species, both commercially exploited and threatened/protected.

Photo: Fabrice Jaine, SIMS

The IMOS backbone portfolio currently includes:

- Deep Water Moorings (transport arrays),
- Deep Water Moorings (time series),
- National Reference Station Network (including ocean acidification and passive acoustics),
- Acoustic Animal Tracking, and
- Autonomous Underwater Vehicles (AUV).

Photo: Asher Flatt

2017–18 Impact

Continental-scale data maps a decade of widespread marine species movement

The ability to predict how species will respond to environmental change relies on accurate records of animal movement patterns.

Over the last decade IMOS has established a permanent array of acoustic receivers around Australia. The data has been centralized into a national database made available through the AODN, to foster collaborative research across the user community and quantify individual behaviour across a broad range of taxa.

The data, published in the Nature journal Scientific Data, has tracked the whereabouts of 117 marine species, ranging from sharks and saltwater crocs all the way to sea turtles and dugongs, with distances travelled by the animals ranging from a few to thousands of kilometres.

The database has collected 49.6 million acoustic detections from these tagged animals so far. The data was then validated by developing an open-source, state of the art algorithm that identifies background noise signals and anomalous movements thereby strengthening the quality and re-usability of the dataset.

The data allows researchers to unravel the widespread movements of Australian marine species, and provide insight into the natural habitats, distributions and changing behaviours of these animals in the face of climate change-related issues, such as warming waters, lack of oxygen and ocean acidification, and in response to more immediate anthropogenic activities.

Large scale assessment of benthic communities across marine protected areas

In Australia, networks of Marine Protected Areas (MPAs) have been implemented to represent and conserve the biological diversity of the continent's underwater environments.

In a recent study the IMOS Autonomous Underwater Vehicle was used to map benthic communities in replicate 'no-take' and 'general-use' (fishing allowed) zones within three MPAs along the New South Wales coastline.

The study recorded 92 taxa and 38 morpho-groups across the MPAs. Discovering that the important habitat-forming biota (massive sponges) were more prevalent and abundant in no-take zones, while short ephemeral algae were more abundant in general-use zones.

The AUV allows rapid, simultaneous assessments at multiple spatial scales, and is therefore useful for documenting changes in marine communities and identifying adequate scales to manage them. The study generated a baseline for these benthic communities against which the effectiveness of three large MPAs can be assessed.

The results suggest that even young no-take zones may have positive and potentially important effects on some dominant taxa on these rocky reefs.

A benthic community that supports habitat-formers is typically associated with an ecosystem that is capable of sustaining overall higher species diversity and abundance, which in turn can lead to greater resilience to disturbances related to climate change and other pressures.

Thus, maintaining and promoting no-take zones, as part of an adaptive and strategic marine spatial management plan, is an effective management tool to conserve benthic communities and the services that they provide within and beyond the boundaries of MPAs.

Internal Waves in the East Australian Current

The undersea equivalent to the surface waves that break on beaches, internal waves play an important role in transferring heat, energy, and momentum in the ocean.

Whilst internal waves drive most ocean turbulence, the ways in which they interact with current systems and topography is not well understood.

Using data from the IMOS East Australian Current (EAC) deep water mooring array, a recent study has examined internal waves in the EAC for the first time. The 14-month deployment of seven moorings that make up the array, provided full depth velocity data across the continental slope, as well as temperature observations over the entire water column.

Understanding and describing the processes of internal wave propagation in the complex environment of the EAC is important, and the research found that in total, internal waves account for 5–10% of velocity variance in the core and edges of the EAC, increasing to about 35% at depth and to the east.

The upwelling and turbulent mixing supported by internal waves also plays a significant role in transporting nutrient-rich waters into coastal ecosystems, and therefore more detailed studies using the growing IMOS dataset from the EAC moorings will continue to help us understand this complex and important process.

Photo: Fabrice Jaine, SIMS

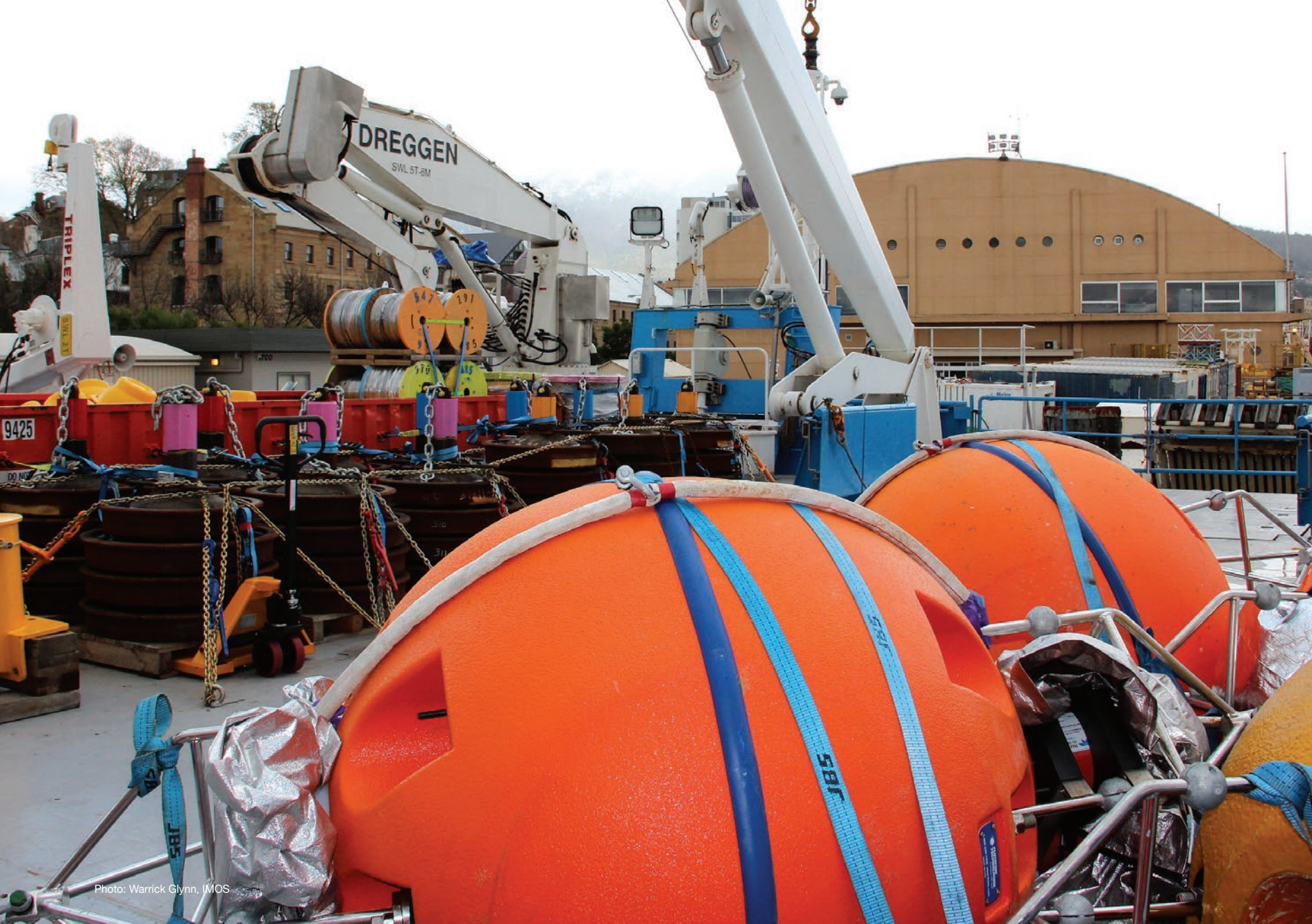


Photo: Warrick Glynn, IMOS

Regional

IMOS invests in Facilities responding to the needs of multiple regions around Australia. This allows for regional intensification of infrastructure in areas of high social, economic, and environmental value.

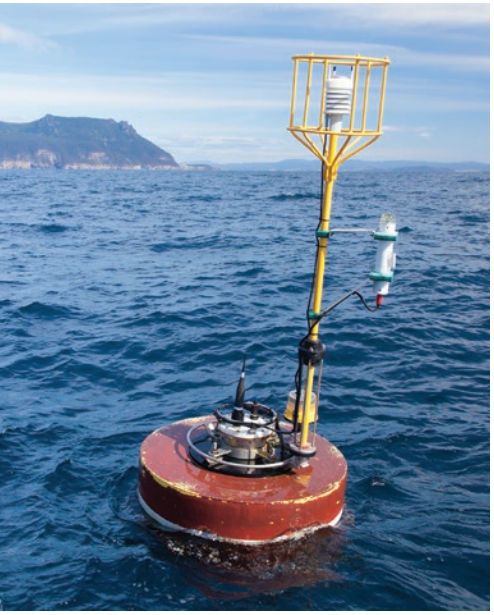


Photo: Carlie Devine, CSIRO

The IMOS regional Facilities undertake measurements of the major boundary currents, and continental shelf and coastal processes in Australian waters. They are aimed at determining the fundamental physics and biogeochemistry of shelf and coastal ocean circulation, and the influence of climate and climate change. These Facilities are collectively contributing an unprecedented level of data in Australian shelf and coastal waters, which in turn is creating new opportunities for modelling, analysis and product development.

The IMOS regional portfolio currently includes:

- Ocean gliders,
- Ocean radar,
- Moorings network (continental shelf and coastal), and
- Wireless sensor networks (Great Barrier Reef).

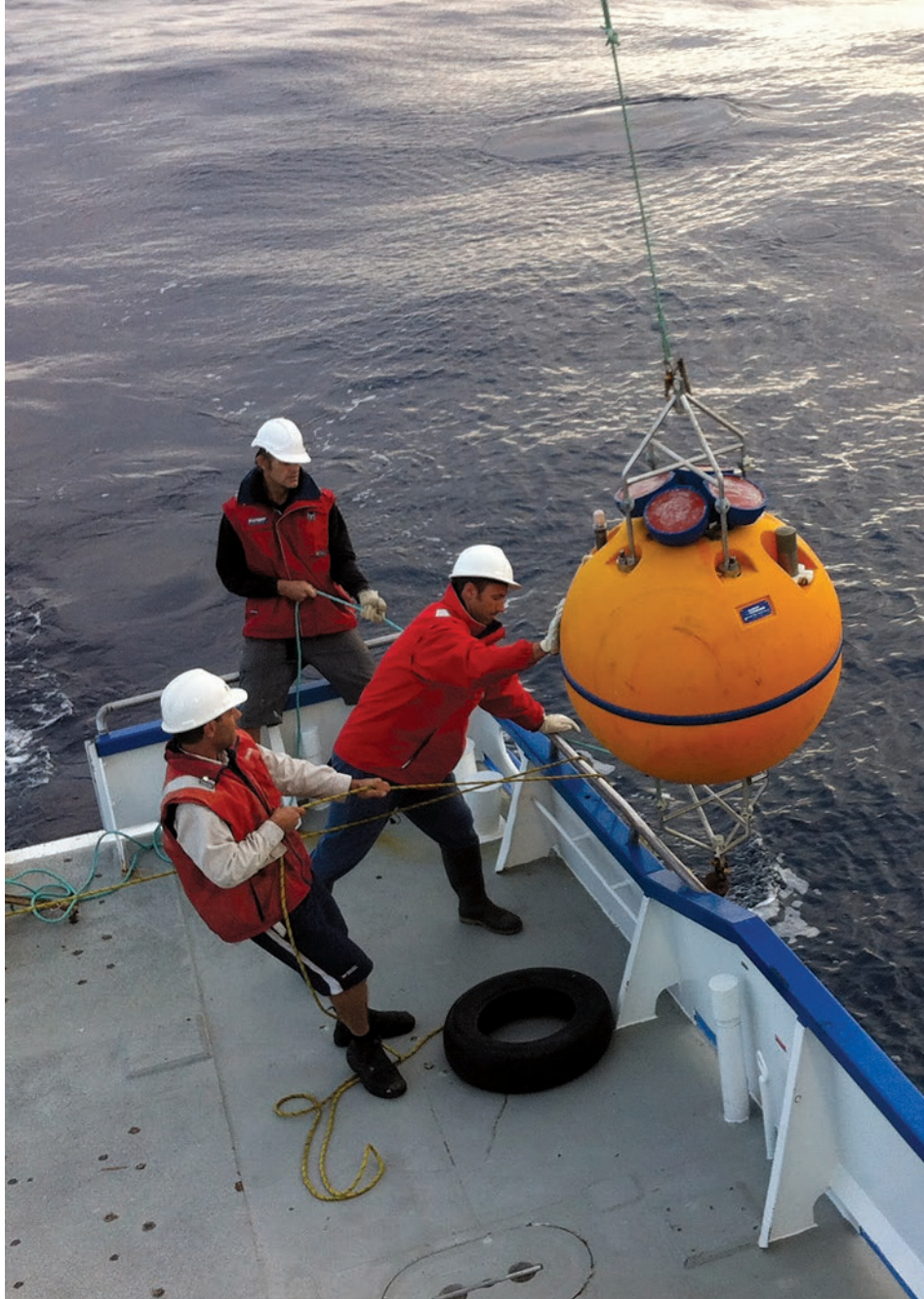


Photo: Paul Malthouse, SARDI

2017–18 Impact

Marine hotspot off Tasmania most intense yet

The frequency of extreme warming events in the ocean is increasing globally. In both 2015 and 2016, approximately one quarter of the ocean surface area experienced a marine heatwave that was either the longest or most intense ever recorded since global satellite records began in 1982. These events devastated marine ecosystems globally but there is limited understanding of their physical drivers and the role of anthropogenic climate change.

A recent study reported on the most intense and longest marine heatwave on record that occurred in the Tasman Sea in 2015/16, using data from the IMOS Maria Island National Reference Station and ocean surface circulation data from IMOS *OceanCurrent*.

The marine heatwave lasted for 251 days reaching a maximum intensity of 2.9°C above climatology. The January averaged temperature (anomaly) at the IMOS National Reference Station at Maria Island was 18.4 °C (+2.02 °C), which was more than 1 °C warmer than the previous record summer of 2011/12. The anomalous warming is dominated by a convergence of heat linked to the southward flowing East Australian Current.

This event impacted regional biodiversity, with the appearance of marine species normally found further north, and was a detrimental stressor on coastal fishery and aquaculture industries, including the abalone, Pacific oyster and Atlantic salmon industries. Even human interactions with the ocean were modified, where swimmers and surfers noted the unusual warmth of the waters around Tasmania.

The approach taken by this study could become part of a real-time system that would provide alerts to the emergence and evolution of a marine heatwave, thus supporting the adaptive management of marine resources in these systems.

Oceanographic drivers of bleaching in the Great Barrier Reef

Mass coral bleaching occurred on the central and northern sectors of the Great Barrier Reef (GBR) in 2016 and 2017 and Torres Strait in 2016. A reported 29% of the 3,863 reefs of the GBR and Torres Strait has been severely affected as a result of these two coral bleaching events.

A new project funder under the National Environmental Science Programme (NESP) Tropical Water Quality Hub is looking to understand how local, regional and global oceanographic and meteorological processes influence the severity and spatial variability of coral bleaching.

The project will summarize the oceanographic conditions during the 2015-17 bleaching years using all available observations, and draws on IMOS data from multiple facilities including Satellite Remote Sensing, National Mooring Network and Ocean Gliders. This will be the most comprehensive summary of how individual coral reefs faired and the quality-controlled data set will be made publicly available.

The data will then be used to improve the current understanding of the relationship between heat stress and bleaching response from repeated in situ observations of coral health, and also assess the eReefs models performance.

Finally, a new product will be made for the seasonal prediction of marine heatwaves, allowing for targeted management of the GBR. For example, with the knowledge of why different regions warm differently, resources can be put into areas that may be on the fringe of susceptibility. These reefs are more able to respond to remediation and thereby increase the footprint of healthier coral reefs.

A better understanding of the Great Australian Bight region

The Great Australian Bight (GAB) contains significant natural resources, including some of Australia's largest and most valuable fisheries, as well as under-explored oil and gas provinces. The GAB also provides critical habitats and migration pathways for iconic species and apex predators, and is of global conservation significance.

The socio-economic value of the Bight is important with strong cultural connections for Indigenous communities to the region, and many coastal towns relying on the marine environment to support aquaculture, fisheries, recreational fishing and tourism.

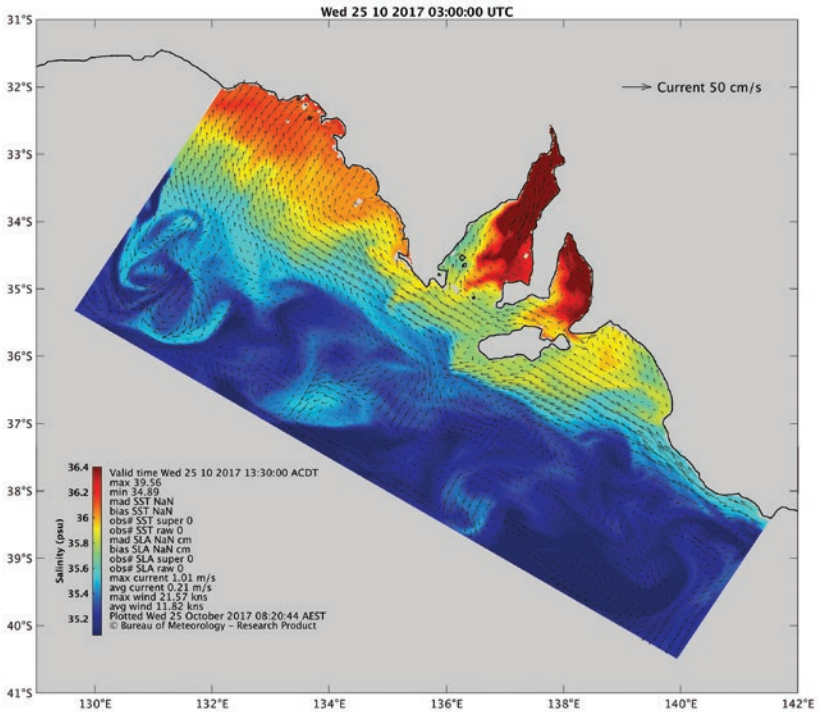
The Great Australian Bight Research Program was a four-year, $20 million research collaboration between BP, CSIRO, the South Australian Research and Development Institute, the University of Adelaide and Flinders University.

The program developed and analyzed deep-sea and shelf-focused models to provide an in-depth understanding of the oceanography of the region. IMOS data from moorings, ocean gliders, ocean radar and satellite remote sensing was used to validate these hydrodynamic models, allowing researchers to understand the seasonal, inter-annual and spatial circulation patterns in the Bight, and underpin other studies in the program.

Researchers used physical, chemical and biological data collected from the RV *Ngerin* at the regular surveys at the Kangaroo Island IMOS National Reference Station mooring, with remote-sensed daily primary productivity data from the AODN Portal, with wind data from the Bureau of Meteorology to investigate seasonal changes in food web structure in the eastern Great Australian Bight.

The results have significantly advanced the understanding of pelagic ecology, providing the necessary link between oceanography and the distribution and abundance of apex predators.

The comprehensive program findings have transformed the deep ecosystems of the GAB from one of Australia's least studied environments to one of the better understood deep water ecosystems in the world.



eSA-Marine system

Photo: Neal Cantin, AIMS

National

IMOS has a clear focus on national-level governance, management and delivery mechanisms. Key components include the Australian Ocean Data Network (AODN) and IMOS *OceanCurrent*.

Australian Ocean Data Network (AODN)

Enabling open access to marine data, regardless of how its acquisition is funded, is considered to be core business for IMOS. This is key to how we will grow the use of marine observations and data by the Australian research community to do science with social, economic and environmental impact.

Access to IMOS and 'non-IMOS' data via the AODN Portal continues to grow. The AODN Portal contains 209 collections, with 54% representing IMOS data (including a portion of AODN collections with significant IMOS collaboration), and 46% representing AODN data (either harvested or hosted by IMOS).

The AODN is currently harvesting data collections from the Institute for Marine and Antarctic Studies (IMAS), Reef Life Survey (RLS), Australian Antarctic Division (AAD), Deakin University and Tasmanian Partnership for Advanced Computing (TPAC); and internationally from National Institute of Water and Atmospheric Research (NIWA), as well as hosting data collections from 32 of Australia's leading marine research organizations.

This growth of exciting new data collections is made possible by AODN working with Australian research partnerships and programs, and in collaboration with our international counterparts, to ensure that marine observations are readily accessible via the AODN Portal.

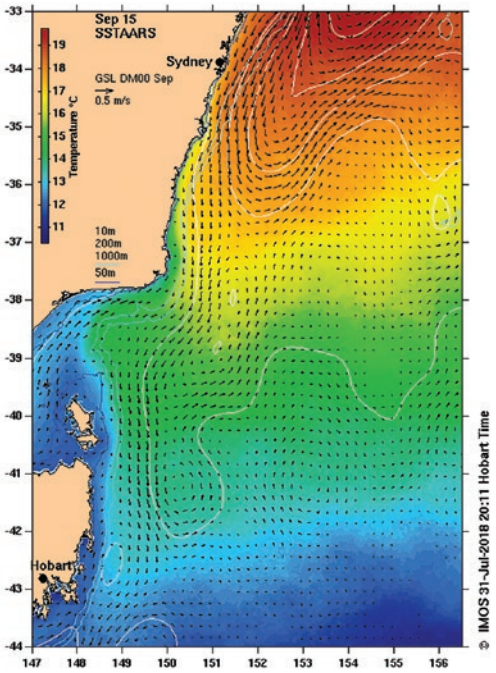
For example, over the past year a collection of wave buoy observations in near real-time have been made available. The collection assembles observations from Waverider buoys of wave height, wave period, and for some sites wave direction. The buoys are operated by the Bureau of Meteorology and the Western Australian Government Department of Transport.

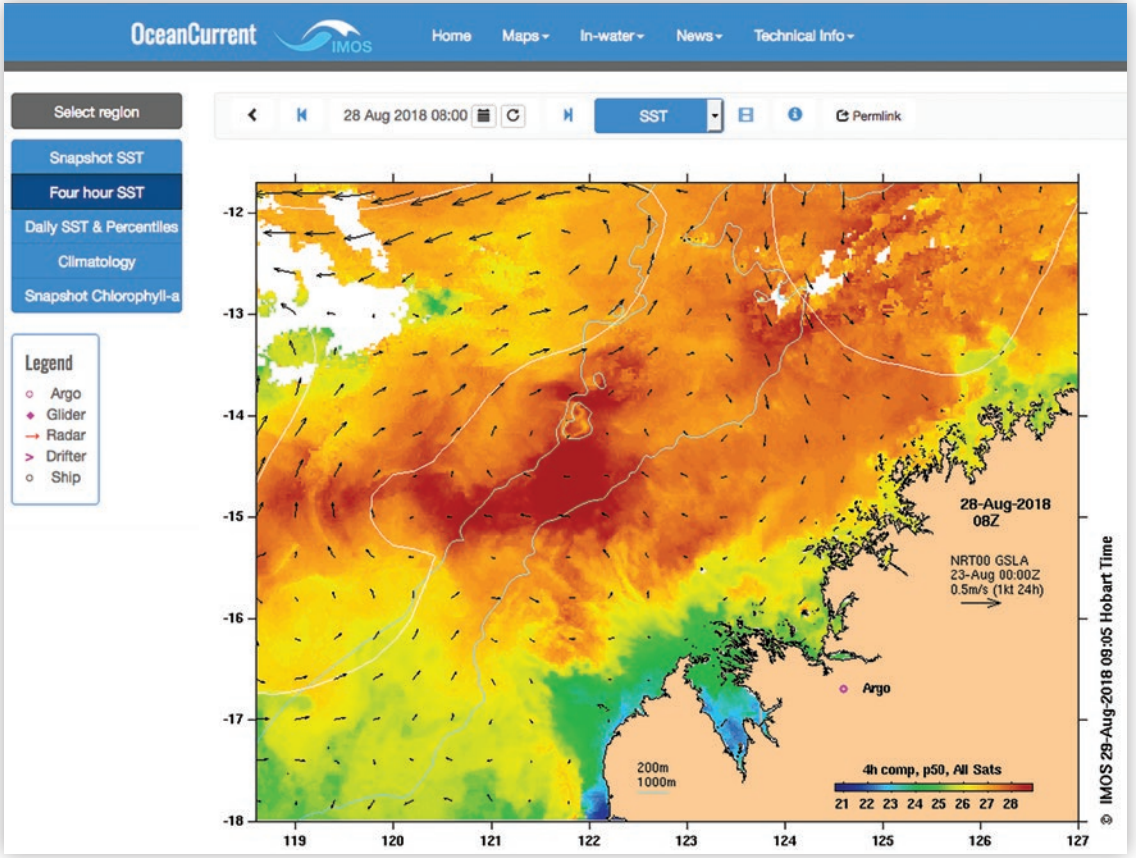
The long-term collaboration between IMOS and the National Institute of Water and Atmospheric Research (NIWA) of New Zealand resulted in the launch of the NZODN Portal. The NZODN portal infrastructure is built upon the AODN open source code, which allows for seamless integration of new data collections between the two portals. The first two data collections to be harvested into the AODN Portal are the NIWA-SOOP Underway CO_2 Measurements, and fish and squid occurrence data.

Finally, a new data product, the SST Atlas of Australian Regional Seas (SSTAARS) is now available via the AODN Portal. SSTAARS uses 25 years of de-biased and tightly navigated sea surface temperature data to underpin a unique seasonal Atlas of the Australasian Seas. The Atlas has a spatial resolution of ~2 km and thus reveals unprecedented detail of regional oceanographic processes, including wind-driven upwelling, tidal mixing, boundary jets, the footprint of the boundary current flows and other features in the major offshore currents. The Atlas will be a resource for ecosystem studies where temperatures (and their extremes) impact on ocean chemistry, species ranges and distribution.

Photo: Julian Uribe-Palomino, CSIRO

Photo: Asher Flatt





Maps sourced from oceancurrent.imos.org.au

IMOS *OceanCurrent*

The IMOS *OceanCurrent* website provides ready access to quick-look graphics of Australian ocean conditions, including sea surface temperature and ocean colour, overlaid with sea level contours and surface current velocities.

It sources data from a number of the IMOS facilities including Satellite Remote Sensing, Deep Water Moorings, National Mooring Network, Ocean Radars, Ocean Gliders and Argo. The daily IMOS *OceanCurrent* maps are highly valued by the IMOS science community and a broader stakeholder base.

Developments over the past year aim to improve the user experience and provide new data products for research. The website has recently been re-designed to allow for easier navigation of the growing list of SST and Chlorophyll *a* products. With the new navigator it is easy to flip between different types of SST to compare and select the best one for the job.

A new four-hour SST product is also now available on IMOS *OceanCurrent*. It uses SST images from Japan's advanced geostationary weather satellite, Himawari-8, as well as all other available SST to provide six images per day. Four-hour SST provides an image every four hours using all 10-minute data within a 4-hr time-window. There is also a parallel product called Filled-SST where the cloud gaps are filled with the latest previous SST. Additionally, the average wind speed is included (courtesy of the Bureau of Meteorology), in order to help identify low-wind regions where the SST only represents a thin, extra-warm layer at the surface. Monthly climatology images from the new SSTAARS Atlas (mentioned in the AODN section) are also included for each region.

The imagery on IMOS *OceanCurrent* is updated several times a day, attracting users from outside the research community as well as allowing members of the research community to locate and study specific ocean phenomena.

Satellite imagery from the Australian north-west shelf helped to identify and describe two types of frontal systems in the region, extending over 1000 km from North West Cape to Cape Leveque. Ocean fronts are regions of large horizontal gradients in water properties (such as temperature or salinity) and are areas of high productivity.

Ocean colour maps tracked the impact of Tropical Cyclone Marcus, with the wind causing vertical mixing of the water column, bringing nutrients and a deep layer of phytoplankton up to the surface.

Ocean glider data revealed the presence of a dense cold pool, low in oxygen, in the deepest part of Bass Strait. It is likely that this bottom layer was the portion of Bass Strait water that could not exit the previous winter because of the deep ridge across the eastern edge of Bass Strait.

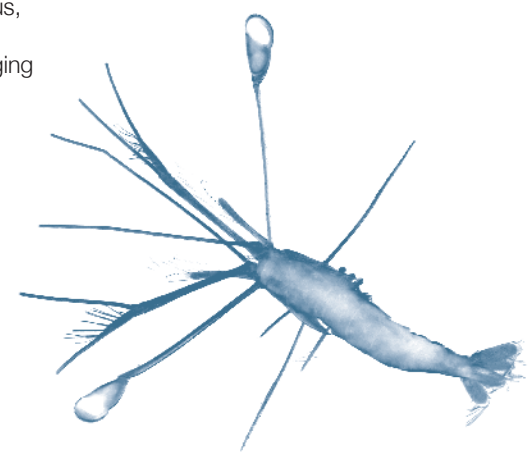


Photo: Julian Uribe-Palomino, CSIRO

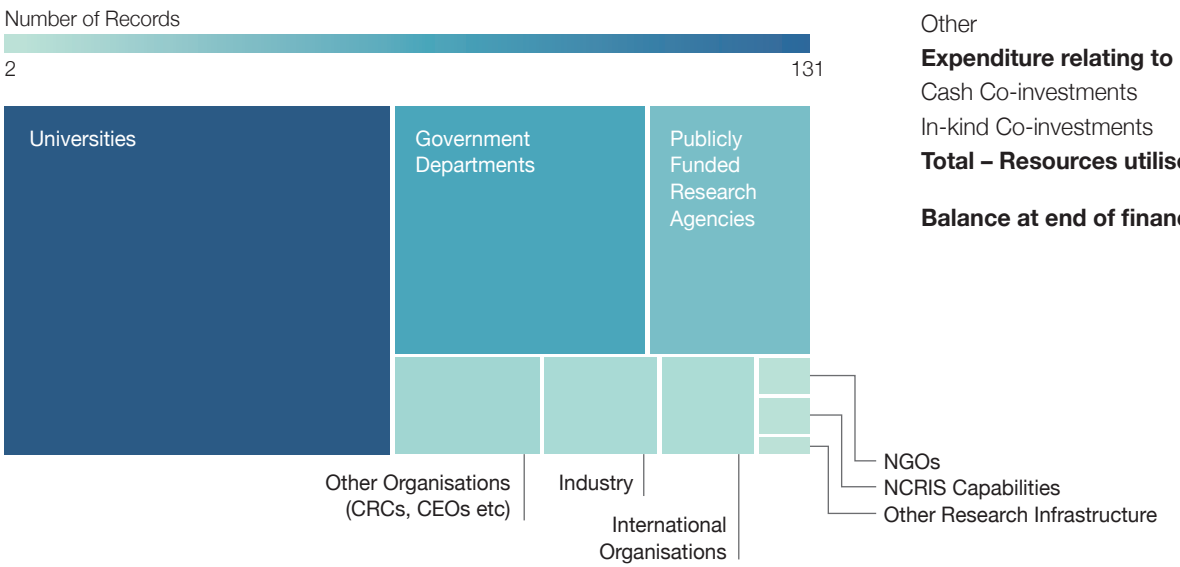
Performance Indicators & Financials

Performance Indicators

The uptake and use of IMOS data is measured in terms of research projects, postgraduate students, publications and products. These are fully listed on the IMOS website at http://imos.org.au/news/news-publications/imospublications/.

Counting science outputs is useful, but it does not necessarily tell the full story of the impact IMOS is having. For example, the annual achievements highlighted in this document are drawn from eight publications and three projects as shown in the references. These 11 outputs had a total of 119 different authors from 50 institutions, both national and international, providing an insight into the breadth of use that IMOS is enabling.

The figure below further demonstrates the breadth of organizations that have used IMOS data in the past year:



Financial Summary

A summary of the IMOS finance for 2017–18 is provided below:

FINANCIAL OVERVIEW	2017–18	2016–17
Balance at beginning of financial year	**2,976,729**	**2,587,452**
National Collaborative Research Infrastructure Strategy	16,099,075	15,573,697
Cash Co-investments	1,118,213	3,444,249
In-kind Co-investments	24,144,326	21,708,441
Total – Resources received	**41,361,614**	**40,726,387**
Capital / equipment purchases	2,945,359	1,919,532
Personnel	10,252,716	9,456,552
Other	3,209,473	4,161,228
Expenditure relating to NCRIS funds	**16,407,549**	**15,537,312**
Cash Co-investments	696,272	3,091,357
In-kind Co-investments	24,144,326	21,708,441
Total – Resources utilised	**41,248,147**	**40,337,110**
Balance at end of financial year	**3,090,196**	**2,976,729**

Partners

PRINCIPAL PARTICIPANTS

> Australian Institute of Marine Science
> Bureau of Meteorology
> Commonwealth Scientific and Industrial Research Organisation
> South Australian Research & Development Institute
> Sydney Institute of Marine Science (University of New South Wales, University of Sydney, Macquarie University, University of Technology Sydney)
> University of Tasmania
> University of Western Australia

ASSOCIATE PARTICIPANTS

> Australian Antarctic Division
> Curtin University

CO-INVESTORS

> Austral Fisheries
> Corporate Alliance Enterprises
> Darwin Ports Corporation
> Deakin University
> Department of Defence
> Department of Environment and Science, Qld
> Department of Environment and Water, SA
> Department of Primary Industries, NSW
> Department of State Growth, Tas
> Environmental Protection Authority, Victoria
> Fisheries, WA
> Flinders University
> Great Barrier Reef Marine Park Authority
> Marine National Facility
> Monash University
> Oceanographic Field Services Pty Ltd
> Office of Environment and Heritage, NSW
> Parks, Victoria
> Research Attraction and Acceleration Program, NSW
> Rio Tinto
> Royal Australian Navy
> Sydney Water Corporation
> University of Melbourne

INTERNATIONAL COLLABORATORS

> European Space Agency
> First Institute of Oceanography
> French Polar Institute
> Hokkaido University
> National Aeronautics and Space Administration
> National Center for Scientific Research, France
> National Institute of Water and Atmospheric Research,
> National Oceanic and Atmospheric Administration
> National Science Foundation
> Ocean Tracking Network
> Scripps Institution of Oceanography
> Sealord
> Shanghai Ocean University
> Southern Ocean Observing System
> University of Stockholm

RESEARCH PARTNERSHIPS

> Antarctic Climate & Ecosystems Cooperative Research Centre
> Australian Research Council
> BlueLINK Ocean Forecasting
> eReefs
> Fisheries Research and Development Corporation
> Great Australian Bight Research Program
> National Environmental Science Programme Earth Systems and Climate Change Hub
> National Environmental Science Programme Marine Biodiversity Hub
> National Research Providers' Network (Fishing & Aquaculture)
> Reef 2050 Integrated Monitoring and Reporting Program
> Western Australian Marine Science Institution

Photo: Rob Harcourt, Macquarie University

NCRIS
National Research Infrastructure for Australia
An Australian Government Initiative

IMOS is a national collaborative research infrastructure, supported by Australian Government. It is operated by a consortium of institutions as an unincorporated joint venture, with the University of Tasmania as Lead Agent. **www.imos.org.au**

PRINCIPAL PARTICIPANTS

University of Tasmania (Lead Agent)

Australian Government

Australian Institute of Marine Science

Australian Government Bureau of Meteorology

CSIRO

Government of South Australia

SARDI Research and Development Institute

The University of Western Australia

sims sydney institute of marine science

UTS

The University of Sydney

Macquarie University

UNSW Sydney

SIMS is a partnership involving four universities.

ASSOCIATE PARTICIPANTS

Curtin University

Australian Government
Department of the Environment and Energy
Australian Antarctic Division

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Design: Lea Walpole, Tasmania.
Cover photo: Carlie Devine, CSIRO

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