



Marine
National Facility



Marine National Facility

Year in Review 2020-21

Operated by CSIRO,
Australia's National Science Agency,
on behalf of the nation

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The Marine National Facility (MNF) is funded by the Australian Government, and is owned and operated by CSIRO, Australia's national science agency, on behalf of the nation.

CSIRO acknowledges the Traditional Owners of the land, sea and waters of the area that we live and work across Australia. We acknowledge their continuing connection to their culture and we pay our respects to their Elders past and present.



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Contents

- About the MNF1
- From the Chairperson.....2
- From the Director..... 3
- 2020–21 snapshot5
- Health, safety and environment 6
- Research delivered and supported 8
- Map of 2020–21 voyages10
- 2020–21 voyage schedule 11
 - Voyage spotlight: Quantifying Antarctic krill to inform sustainable fisheries management.....16
- Communication and engagement18
 - Communication case study: Outreach in the time of COVID: Bringing the public on board, virtually19
- Improving our capabilities..... 21
- Financial statement23
- MNF impact – seabed mapping.....24
- Looking to the future – *INVESTIGATE*.....26



INVESTIGATOR
HOBART

Image: Kate Kiefer

About the MNF

Australia has the third largest marine jurisdiction of any country and the ocean plays an integral role in our climate, culture and economy. Understanding the diverse ecosystems and managing industries in this vast area is challenging and requires navigational, sampling and data collection capabilities that meet the current and emerging needs of a diverse range of users.

The Marine National Facility (MNF) is Australia's dedicated ocean research capability. It is funded by the Australian Government and owned and operated by CSIRO on behalf of the nation. The MNF operates under the oversight of an independent Steering Committee, and enables world-class marine and atmospheric research across our vast marine estate. The MNF includes the advanced ocean-class research vessel (RV) *Investigator*, a suite of scientific equipment, technical staff and expertise, and more than 35 years of freely available marine data.

RV *Investigator* can flexibly and safely cater to the diverse and multidisciplinary research needs of Australian marine researchers and their international collaborators. It provides a broad range of oceanographic, biological,

atmospheric and geophysical research capabilities. The vessel also offers marine science, technical and maritime education and training opportunities.

RV *Investigator* is currently funded for full year operations and can accommodate a research team of up to 40 participants, stay at sea for up to 60 days, and cover 10,000 nautical miles per voyage. The vessel can operate anywhere from the Antarctic ice edge to the tropics. With the delivery in 2020 of the 10-year strategy, *MNF 2030*, the MNF is on course to fulfil its mission to facilitate safe, efficient and excellent marine and atmospheric research that is aligned with national priorities and addresses challenges facing Australia's society, economy and environment.

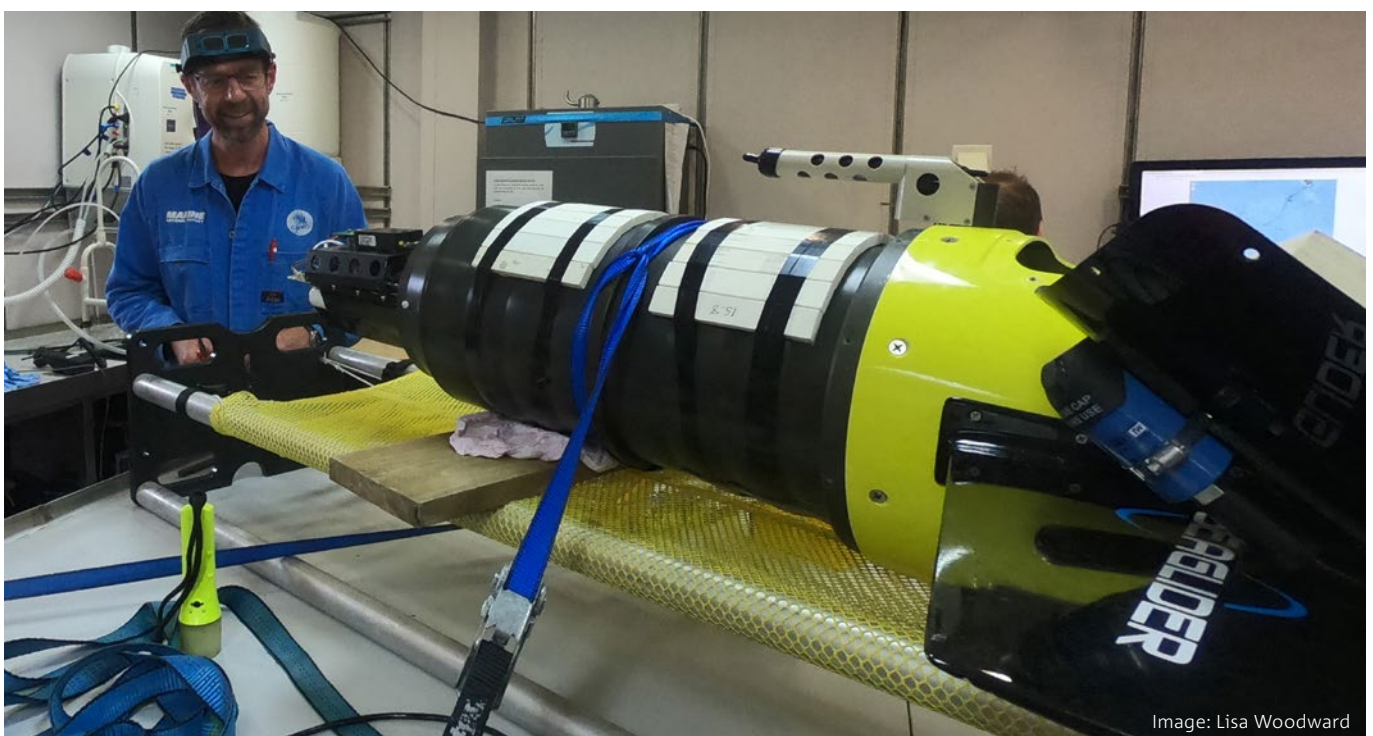


Image: Lisa Woodward

From the Chairperson

Implementation of the Marine National Facility's (MNF) milestone strategy, *MNF 2030*, is well underway. By adopting a more pro-active role in the delivery of impact by aligning the use of the facility with Australia's policy, science and innovation priorities, MNF will deliver greater return on public investment. It will serve to strengthen the MNF's reputation as the trusted custodian and operator of the nation's marine research infrastructure.

The year 2020–21 saw the first round of applications for sea time under *MNF 2030*. *MNF 2030* guides the use of Australia's dedicated marine research capability for the next 10 years with the primary objective of ensuring that value continues to be delivered from the significant government investment in the facility. *MNF 2030* is underpinned by seven strategic priorities:

- encourage policy-driven research to stimulate and support high impact projects
- diversify access to sea time to reflect the breadth of needs of our users
- introduce a flexible scheduling approach
- streamline digital tools for operational efficiency
- implement a MNF 25-year Capability Investment Framework to guide strategic development of our research capabilities
- enhance our education and training programs in collaboration with other agencies and industries
- increase our focus on raising awareness about how the research we support benefits Australians and the world.

The inaugural MNF Operations Rolling Plan (the Plan) is the primary vehicle to implement *MNF 2030*. The Plan was released in February 2021 to coincide with the 2021 call for sea time applications. The Plan was designed to help prospective users by providing information and allocation targets for the access Streams. The Plan also outlines operational, communication and engagement activities planned for upcoming schedules, including any multiyear projects as part of strategic partnerships or previous years' applications. It also sets annual operational performance targets for the MNF.

For the 2021 application round, Stream 1 (Policy-driven research) access was dedicated to research that would directly inform, influence and address the management and protection of Australian Marine Parks or improve Australia's Earth system modelling capability. Stream 1 workshops were held in April 2021 to facilitate collaboration between scientists and end-users of their research. An Australian Marine Parks focussed workshop attracted 24 research participants from 14 organisations and a Bureau of Meteorology focussed workshop attracted 12 research participants from 6 organisations. These workshops generated six Stream 1 applications. The 120-day allocation target for Stream 1 projects in the 2021 application round represents a significant investment in priority research by the MNF on behalf of the nation.

The 2020–21 MNF Year in Review showcases the continued value of the research enabled by the MNF through the RV *Investigator*, its suite of scientific equipment, technical expertise, and marine data library.

The MNF continues to deliver excellent research of benefit to the nation through the commitment and enthusiasm of the entire MNF team. I want to thank the team for the delivery of another full year of operations under challenging circumstances, and dedication to ensuring the strategic vision articulated in *MNF 2030* is well underway.



Dr Sue Barrell
Chairperson, MNF Steering Committee

From the Director

The past year has seen challenges, opportunities, and significant change for the Marine National Facility (MNF). We've introduced new pathways for applicants to access sea time and a more flexible approach to the way in which MNF schedules successful projects. In addition, the MNF has welcomed a new online application tool and implemented a COVID-19 Management Framework to ensure the safety of our staff, crew and users, all while continuing to deliver successful research voyages during a worldwide pandemic.

MNF returned to sea in July 2020 with a 10-day sea trial and calibration voyage. This was followed by the resumption of research voyages from the home port of Hobart in August 2020 and resumption of interstate operations to Brisbane and Darwin in May 2021. Under the MNF COVID-19 Management Framework, all future voyages will be managed according to a set of protocols that have been designed to provide wide-ranging measures to safeguard the health and well-being of participants. The Framework is regularly reviewed against any change in the COVID-19 situation in Australia.

Our 2021 application round opened in February and saw many firsts for the MNF: the first round of applications under our new strategy, *MNF 2030*; the first Operations Rolling Plan to guide applicants through the streams of access aligned with research priorities; and the first use of our online application and planning tool.

A particularly exciting time for MNF was the launch of our online Marine Application and Planning System (MAPS). MNF partnered with software engineering experts to develop and deliver a tool to transform the MNF user experience. MAPS is transformative and will deliver significant efficiencies to applicants, Chief Scientists and MNF operational teams tasked with voyage planning. The transition to MAPS is one of the key improvements highlighted under the *MNF 2030* strategy.

During 2020, MNF commissioned RTI International, an independent, non-profit research institute with a vision to address the world's most critical problems with science-based solutions, to provide an objective analysis of the value that MNF delivers to the nation. RTI found that RV *Investigator's* ability to collect accurate and precise bathymetric, biological, atmospheric, and geophysical data, provides valuable input to evidence-based decision making for resource and risk management strategies and offshore activities. The key areas in which MNF generates value for the nation includes seabed mapping, risk reduction for fisheries, improved reef health and ecosystem services, improved protection for marine species, shipwreck discovery, and more accurate weather and climate forecasting. Additionally, the value of the MNF as an "unparalleled" research training facility was evident. RTI estimated a conservative benefit-to-cost ratio from total investment in the vessel of 4.7. That is, for each dollar spent, \$4.70 is returned in economic and social benefits to the nation. I am honoured to be at the helm of such a valuable and valued national research infrastructure asset.

At the end of this busy and productive year, I would particularly like to thank all for their tireless work in an extremely challenging operating environment to enable the safe delivery of 293 days of operation for RV *Investigator*. The COVID-19 pandemic continues to have implications for the way we work. However, through the close adherence to our COVID-19 protocols and with the hard work, enthusiasm and dedication of the entire MNF team, CSIRO technical support and crew from ASP Ship Management, we are able to continue to deliver marine and atmospheric research to benefit the nation.



Toni Moate
Director, Marine National Facility



Image: William Seal, AAD

2020-21 snapshot

29,814

nautical miles travelled

293

research days

107,118 km²

area mapped

17.3

terabytes of data collected

20

participating organisations

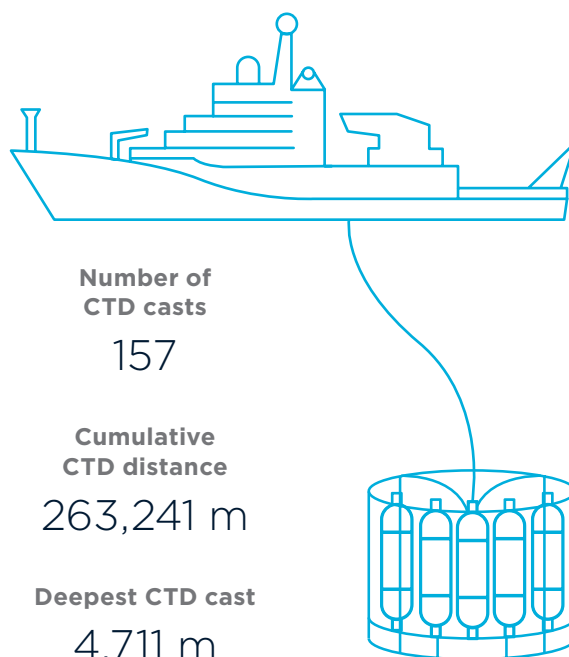
215

participating researchers

32

research publications*

*peer-reviewed journal publications recorded in MNF database as at 30 June 2021



MAPS

The Marine Application and Planning System (MAPS) successfully launched the online portal for sea time applications in February 2021. MAPS is a modular technology solution that provides a user-friendly, end-to-end application submission and management system.

The release of MAPS directly supports *MNF 2030* as applicants nominate their appropriate access stream and respond to the key criteria for research quality and research benefit within that stream. The online application process seamlessly connects to additional MAPS modules that manage inventory and planning, improving the feasibility assessment and voyage scheduling of resources.

This technology solution, together with improved business processes, has streamlined the end-to-end process for applicants, assessors and CSIRO staff providing efficiency, consistency and transparency in delivering leading marine and atmospheric research for Australia's national benefit.



MAPS was awarded the *Best Contribution to Sustainability or Protection of the Environment* in the 2021 TasICT Awards for ICT Excellence.

Health, safety and environment

An external Health, Safety and Environment (HSE) audit was initiated in 2019 to review Marine National Facility (MNF) compliance with ISO45001. This audit commended the achievements of the MNF HSE team in voyage risk assessment and management. The report highlighted several areas for review and consideration related to incident reporting and investigation, training, compliance assurance and safety management.

In response to the audit, the MNF HSE team has developed robust processes and communication pathways in the areas identified. The renewed approach has, as anticipated, resulted in a rise in the number of incidents reported due to all personnel’s increased confidence in identifying and defining a HSE incident.

The MNF HSE Team has developed a robust Safety Management System with a detailed and well-structured, centrally located Safety Management Library to provide ease of access for all key stakeholders. Procedures have been developed to support the roll out and use of the Safety Management System, with further work continuing to ensure all key stakeholders have a clear understanding of their roles and responsibilities regarding safety onboard.

The 2019 audit recommended the need to bridge the separate safety management systems in use by MNF, CSIRO HSE and the Ship Management Company ASP, by developing a ‘One Safe’ approach. One Safe is a collaborative cultural change project between MNF, CSIRO and ASP to ensure cohesion and effective management of safety on RV *Investigator*.

The One Safe Project was launched in February 2021 at the inaugural HSE Improvement Program Board Meeting, held with senior members from MNF, CSIRO and ASP and chaired by Toni Moate (Director, MNF). As a result of this meeting, independent business analysis was undertaken to understand barriers and opportunities to improvements in HSE across the key stakeholders. A survey was sent to MNF, CSIRO Engineering and Technology, and ASP staff. As a secondary measure, key personnel from each stakeholder group were invited to participate in a one-on-one conversation about HSE. The results of the survey and interviews will inform the HSE Improvement Program Board’s next steps in further developing and implementing One Safe.



Image: Matt Marrison



Image: Breeanna Muggleton

Incident Snapshot

	2018–19	2019–20	2020–21
Lost Time Injury	0	2	1
Medical Treatment Case	10	12	13
First Aid Case	4	10	19
Illness	5	15	18
Total	19	39	51
Environmental Incidents	0	0	0
Technical Incidents (Equipment damage/malfunction)	13	15	19
Near Misses	7	4	2
Total	20	19	21

The current Incident Snapshot illustrates an increase in numbers between the reporting periods. This is reflective of the operational increase onboard, with *RV Investigator* moving to full year operations. What is also of note is the increase in the First Aid and Illness incidents, which can be attributed to two key points:

1. The MNF's response to COVID-19. To recommence and maintain the schedule, robust COVID-19 protocols have seen an increase in first aid cases. This is an indicator of personnel's understanding of the need to be vigilant in reporting any cold and flu symptoms.
2. Incident reporting and investigation. Training has been a focus this year with a great deal of effort put in to provide access to all CSIRO *RV Investigator* personnel. Training in the form of an in-depth incident investigation case study workshop in addition to the development of a robust process and communication flow chart was delivered in 2020–21. This has seen a rise in the number of incidents reported, as personnel are more confident in defining an incident. Whilst the number of incidents has increased, the capacity to effectively investigate and close out these incidents has also had a marked improvement, with all incidents from 2020 now closed with sufficient remediation and lessons learned in place.

Mental health and wellbeing

MNF's goal is to create working and living conditions that also safeguard the mental health and wellbeing of our people, our partners, and the communities in which we operate. *RV Investigator* is equipped with resources to assist with work-life balance at sea. The Life at Sea: Wellbeing Hub is comprised of:

- Exercise and stretching worksheets
- Exercise videos
- Crosswords and sudokus
- Group activities
- Magazine subscription for Flourish Health and Wellbeing
- Hydration challenge
- Mental health and wellbeing resources.

MNF's HSE Team also deliver a Fatigue Risk Management Awareness Module prior to each voyage, highlighting the resources and support available, including COVID-19 protocol information and management resources.

MNF are committed to ensuring everyone experiences a safe, healthy and productive workplace.

INCIDENT CATEGORY	INCIDENT DETAILS
Lost Time Injury	A Lost Time Injury is defined as an occurrence that resulted in a fatality, permanent disability or time lost from work of one day/shift or more.
Medical Treatment Case	A Medical Treatment Case is any work-related loss of consciousness (unless due to ill health), injury or illness requiring more than first aid treatment by a physician, dentist, surgeon or registered medical personnel, e.g. nurse or paramedic under the standing orders of a physician, or under the specific order of a physician or if at sea with no physician on-board could be considered as being in the province of a physician.
First Aid Case	A First Aid Case is defined as any one-time treatment and subsequent observation provided by Ship Staff of minor injuries such as bruises, scratches, cuts, burns, splinters, and so forth. The first aid may or may not be administered by a physician or registered professional and can be administered on-board. Or the administration of drugs by the Medical Officer or Master.
Illness	An illness relates to an illness sustained on-board which is a direct result of the crew member undertaking tasks on-board. An example of a recordable illness would be a crew member sustaining a heat rash whilst working in the engine room. Non-work-related Illness (NWRI) An illness sustained on-board the vessel that does not relate to a work-related event, such as cold/flu/dental.

Research delivered and supported

July 2020 saw the successful return to at-sea operations of RV *Investigator* under a comprehensive COVID-19 Management Framework and strict set of protocols.

In a testament to the resilience and ingenuity of both the MNF staff and the user community, 2020–21 delivered a broad spectrum of research across Australia’s marine estate despite the challenges associated with at-sea operations in a pandemic.

Research achieved included: benthic habitat mapping within the Huon Marine Park; mapping the seafloor surrounding

Macquarie Island; quantifying carbon sequestration in subpolar and polar waters; investigating the distribution, density, and connectivity of populations of Antarctic krill; surveying plankton and larval fish off North Stradbroke Island; and, assessing the impact of microplastics on microbial and planktonic organisms in tropical waters. These projects were achieved in parallel to collecting a suite of atmospheric observations and deploying assorted ocean floats, seismometers and probes in Australian waters.

The MNF also continued to strongly support the Integrated Marine Observing System’s (IMOS) national research infrastructure through maintenance of both the Southern Ocean Time Series (SOTS) moorings and East Australian Current moorings.



Image: Jez Bird

The research delivered and supported has outcomes that generate tangible national benefits including:

- creating a framework for better prediction and mapping of Huon Marine Park habitats to build a framework for better prediction and mapping of deep-sea coral communities
- undertaking the first high-resolution maps of much of the seafloor surrounding Macquarie Island, including seafloor lying within the island's Nature Reserve and Marine Park to inform Macquarie Island Marine Reserve Management Plans
- enabling better monitoring of earthquakes and tsunamis that could affect Australia and New Zealand to improve tsunami risk assessments and enhance national and trans-Tasman security
- delivering a baseline for carbon export via marine snow in the Southern Ocean to validate the strength and efficiency of carbon storage by the Southern Ocean and inform global carbon cycle models
- informing Commission for the Conservation of Antarctic Marine Living Resources sustainable catch limits for the krill fishery off East Antarctica to ensure sustainability of both the fishery and the Antarctic species that depend on krill for their survival including seabirds, seals and whales
- deploying assorted floats and probes to contribute to global temperature, salinity, and current research and maintaining moorings to contribute to the global effort to understand ocean dynamics and their role in climate and responses to anthropogenic emissions to ensure that Southern Hemisphere oceanographic baselines, cycles and processes are well represented in global ocean research databases, models and decision-making forums.

Integrated with the busy research schedule, the vessel also completed sea trials, tested equipment, and commissioned a new deep towed camera system that was co-funded by the Science and Industry Endowment Fund (SIEF). Several research and outreach projects were also supported on the transit voyage from Hobart to Brisbane and the MNF hosted our third Indigenous Time at Sea Scholarship (ITSS) recipient.

Connecting globally

In addition to contributions to global marine and atmospheric datasets, including the Southern Ocean Time Series for the Global Ocean Observing System, Southern Ocean contributions to the global Argo float network and atmospheric observations for the World Meteorological Organisations Global Atmosphere Watch Programme, MNF supported international researcher engagement in voyages, albeit virtually, in real-time in 2020–21.

Professor Mike Coffin's (University of Tasmania) voyage to Macquarie Ridge (IN2020_VO6) included Professor Nicholas Rawlinson (University of Cambridge, UK) and Professor Joann Stock (California Institute of Technology, USA). Professor Rawlinson contributed his expertise in the deployment of novel seismic array experiments in regions of profound geological/tectonic interest to improve our understanding of Earth structure and processes. Professor Stock contributed her expertise in geological and geophysical field studies related to plate boundary evolution.

As the COVID-19 pandemic will continue to have implications for the way we work and engage with our international collaborators for some time, MNF will continue to find ways to engage with our global research stakeholders virtually.



Map of 2020-21 voyages



2020–21 voyage schedule

COVID-19 impact on MNF operations in 2020–21

In line with efforts to minimise the spread of COVID-19, the MNF took proactive measures to safeguard the health of our people, partners, customers and communities. These measures had implications for the way voyages were scheduled in 2020–21. Due to the on-going and often impromptu restrictions placed on interstate travel, and the necessity of staying close to our home port of Hobart while we established our COVID-19 Management Framework protocols, the researchers supported in 2020–21 are largely from CSIRO (Hobart) and Tasmanian based institutions.

July 2020

IN2020_E01 Equipment Calibration and Sea Trials [Hobart – Hobart]

Following a four-month pause in operations due to the COVID-19 pandemic, the MNF restarted at-sea operations of RV *Investigator* on 29 July 2020 with a 10-day sea trials and equipment calibration voyage. This voyage calibrated ship systems and instruments, and tested protocols for safe operation in the current pandemic. All 21 sea-going science and technical participants were from CSIRO.

As part of a the COVID-19 Management Framework, MNF took the opportunity to trial the COVID-19 protocols to be applied to all future activities onboard, providing wide-ranging measures to safeguard the health and well-being of participants.



August 2020

IN2020_V09 Southern Ocean Time Series: automated moorings for climate and carbon cycle studies in the Southern Ocean [Hobart – Hobart]

The first research voyage since the voyage schedule was suspended in March 2020 due to the COVID-19 pandemic was undertaken in August 2020. In support of the Integrated Marine Observing System's (IMOS) Southern Ocean Time Series (SOTS), CSIRO's Dr Elizabeth Shadwick led 13 science participants from CSIRO on a 16-day voyage to deploy two new SOTS moorings and recover two existing ones. These automated deep-water moorings measure the exchanges of heat, water, carbon dioxide and oxygen between the ocean and atmosphere. The moorings also measure key physical and biological processes that control these fluxes and provide a key contribution to global data sets to increase the understanding of Southern Ocean characteristics, variability and processes.

The SOTS time series is the longest time series of Southern Ocean observations operated by any nation, contributing to the global effort to understand ocean dynamics and their role in climate and responses to anthropogenic emissions. This work is part of the OceanSITES global array of time series observations (www.OceanSITES.org), an essential element of the United Nations Global Ocean Observing System (www.goosocean.org).

Additionally, IN2020_V09 recovered an oceanographic mooring deployed during voyage IN2018_V05 to investigate Antarctic Circumpolar Current (ACC). The ACC mooring collected data to improve understanding of how Southern Ocean currents respond to changes in wind speed.

During this voyage we also took the opportunity to launch three Electromagnetic Autonomous Profiling Explorer (EM-APEX) floats and three Argo floats on behalf of CSIRO physical oceanographer, Dr Stephen Rintoul. EM-APEX floats will measure the temperature, salinity, and horizontal current velocity in the upper 500 metres of the ocean and the Argo floats will contribute to the global Argo network.



October 2020

IN2020_V06 Probing the Australian-Pacific Plate Boundary: Macquarie Ridge in 3-D [Hobart – Hobart]

Chief Scientist Professor Mike Coffin (University of Tasmania) led 20 science participants from three institutions (CSIRO, University of Tasmania and the Australian National University) on a 24-day voyage to the Southern Ocean to study the geological structure and evolution of the Macquarie Ridge complex including Macquarie Island. Macquarie Island sits at ~55°S on the highly active tectonic plate boundary between the Australian and Pacific plates and is listed as a World Heritage Place because of its unique geological exposures of both crustal and mantle rocks.

The voyage's key outcomes were the first high-resolution maps of much of the seafloor surrounding Macquarie Island, including seafloor lying within the island's Nature Reserve and Marine Park, and the deployment of the full complement of 29 ocean bottom seismometers (OBS) along the central Macquarie Ridge complex. The area around Macquarie Island is among the most challenging locations in the global ocean for an OBS experiment given its extreme topography, strong currents, high winds, and high seas. This was the first time that Australian Geophysical Observing System OBS had been deployed outside relatively benign tropical latitudes, and the first time OBS had been operationally deployed from RV *Investigator*.

The OBS will be recovered following their one-year deployment and completion of seafloor mapping along the central Macquarie Ridge complex near Macquarie Island in late 2021. This research is part of an international project involving the University of Cambridge (UK) and California Institute of Technology (USA) that will enable better monitoring of future earthquakes and tsunamis that could affect Australia and New Zealand.



November 2020

IN2020_V10 Storm Bay Modelling and Bathymetric and Benthic Habitat mapping of the Huon Marine Park [Hobart – Hobart]

CSIRO led a 9-day voyage to Storm Bay and the Huon Marine Park to conduct sea trials and test various scientific equipment including the Triaxus, Profiling Lagrangian Acoustic Optical System (PLAOS), new multi-corer and Hydro-Bios multi net, as well as commission a new deep towed camera system. Research undertaken on the trials voyage involved 23 science participants from CSIRO and included a targeted sampling program to characterise the deep water of Storm Bay and its nutrient concentration (led by Karen Wild-Allen, CSIRO) and benthic habitat mapping within the Huon Marine Park (on behalf of Cath Sampson, Parks Australia).

The studies in Storm Bay aim to increase understanding of deep-water nutrient concentration. Water samples and sensor data will be used to determine whether deep water intrusions into Storm Bay have the potential to modify water quality. Benthic habitat mapping in the Huon Marine Park will be used to help build a framework for better prediction and mapping of deep-sea coral communities.

The voyage received global media coverage when the vessel's livestream camera, which broadcasts video 24/7 via the MNF website, filmed the spectacular break-up of a meteor over the Southern Ocean.



Image: Jakob Weis

December 2020

IN2020_V08 Southern Ocean Large Areal Carbon Export: quantifying carbon sequestration in subpolar and polar waters [Hobart – Hobart]

Chief Scientist Professor Philip Boyd (University of Tasmania) led 32 science participants from four institutions (CSIRO, University of Tasmania, Australian National University and Curtin University) on a 44-day voyage to the Southern Ocean to quantify carbon sequestration in subpolar and polar waters. Part of the Southern Ocean Large Area Carbon Export (SOLACE) project, this voyage captured a detailed picture of how plant life in the Southern Ocean removes carbon dioxide from the Earth's atmosphere.

The voyage combined ship-board observations, deep-diving robotic profiling floats, automated ocean gliders and satellite measurements at two primary sites (the Southern Ocean Time Series site at 47°S and a high chlorophyll polar bloom region at ~55°S) to improve understanding of the movement of carbon between the atmosphere and ocean via biological pathways. A program of trawling was also used to survey marine life in the twilight zone (ocean between 200 m to 1,000 m depths), an area of the largest and least studied fish stocks of the world's oceans.

Phytoplankton are responsible for removing as much carbon dioxide from the atmosphere as forests.

When they die, their carbon-rich particles – marine snow – fall slowly to the ocean floor. This pump plays a significant role in storing carbon in the ocean.

This voyage delivered a baseline for carbon export via marine snow, which we can track in the coming years as the ocean responds to changes in the Earth's climate.

Piggyback projects undertaken during this voyage include the collection of cosmic ray detector measurements to investigate the variation in cosmic ray flux with latitude and longitude (led by Dr Grahame Rosolen, CSIRO) and the collection of a suite of aerosol, cloud, surface radiation, surface eddy momentum, heat and moisture fluxes, and precipitation observations in areas characterised by high ocean productivity for the Cloud Aerosol Precipitation Radiation Interactions eXperiment (CAPRIX) team (led by Dr Alain Protat, BOM).



Image: Matt Marrison

January 2021

IN2021_V01 Trends in Euphausiids off Mawson, Predators and Oceanography (TEMPO) Voyage: Quantifying krill abundance for krill monitoring and management off the Australian Antarctic Territory [Hobart – Hobart]

The longest voyage of the 2020–21 schedule was the 60-day Trends in Euphausiids off Mawson, Predators, and Oceanography (TEMPO) voyage to the Southern Ocean. Chief Scientist Dr So Kawaguchi (Australian Antarctic Division) led 31 science participants from six institutions (CSIRO, Australian Antarctic Division, University of Sydney, University of Tasmania, Woods Hole Oceanographic Institution-USA and Shanghai Ocean University-China) to investigate the distribution, density and connectivity of populations of Antarctic krill.

The voyage estimated krill biomass in waters off Mawson research station, to update the precautionary catch limit set by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). The voyage surveyed more than 793,000 kilometres across six transects off Mawson station. RV *Investigator's* echosounders located and measured krill swarms and a specially designed floating camera system was deployed into krill swarms to get a 3D picture of how krill orient themselves and behave in a swarm. The team also studied the broader ecosystem using trawls, predator observations, oceanography, genetics, and deep-sea moorings. This information will be used to develop a long-term monitoring plan to inform management of the krill fishery.

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The voyage also sought to better understand the contribution of deep-sea krill to overall krill biomass in the region. The conceptual understanding of krill life history in the area has been largely based on research within the epipelagic zone (surface to 250 m). However, recent observations indicate that krill can exist down to the abyssal zone (deeper than 2,000 m). This voyage investigated the importance of the deep-sea habitat to krill for the first time.

Piggyback projects undertaken during this voyage include the collection of a suite of aerosol, cloud, surface radiation, surface eddy momentum, heat and moisture fluxes, and precipitation observations in areas characterised by high ocean productivity for the Cloud Aerosol Precipitation Radiation Interactions eXperiment (CAPRIX) team (on behalf of Dr Alain Protat, BOM) and the deployment of 12 Argo floats (on behalf of Dr Tom Trull and Dr Stephen Rintoul, CSIRO).



April 2021

IN2021_V02 Southern Ocean Time Series: automated moorings for climate and carbon cycle studies in the Southern Ocean [Hobart – Hobart]

In continued support of the Integrated Marine Observing System (IMOS) Southern Ocean Time Series (SOTS), CSIRO's Dr Elizabeth Shadwick led 21 science participants representing five institutions (CSIRO, Australian Antarctic Program Partnership, Bureau of Meteorology, University of Tasmania and University of Technology Sydney) on a 14-day voyage to maintain the SOTS long-term deep-water automated moorings.

Monitoring change to the physics, chemistry and biology of the ocean requires sustained collection of data over long time periods. The SOTS moorings, at 47°S, are located where ocean-atmosphere interactions are most extreme and where the formation of Subantarctic Mode water carries atmospheric carbon dioxide and heat into the deep ocean, a process which also supplies oxygen for deep ocean ecosystems.

IN2021_V02 also supported projects to study silica production in natural phytoplankton communities along a latitudinal gradient off Eastern Australia (led by Dr Katherina Petrou, University of Technology Sydney), quantify dust deposition to the ocean and its chemical and ecological impact using new geochemical techniques (led by Associate Professor Zanna Chase, University of Tasmania) and trial equipment for MNF.



Image: Jade Arnold

May 2021

IN2021_V03 IMOS: monitoring of East Australian Current property transports at 27 degrees South (multi-year) [Hobart – Brisbane]

The first voyage to venture north for the schedule, saw Chief Scientist in training, CSIRO's Dr Chris Chapman, lead a science team of 29 participants from 6 institutions (CSIRO, University of New South Wales, Sydney Institute of Marine Science, Griffith University, James Cook University and University of Queensland) to recover and re-deploy six deep-water moorings in waters off Brisbane (27°S) from the continental shelf to abyssal waters (500–5,000 m).

Long-term ocean monitoring by the East Australian Current deep-water mooring array, a component of the Integrated Marine Observing System (IMOS), is central to our understanding of the relationship between global ocean and climate variability.

IN2021_V03 also supported projects to survey plankton and larval fish off North Stradbroke Island to better understand biodiversity and factors influencing productivity in continental shelf waters (led by Professor Iain Suthers, UNSW), deploy Argo floats for the international Argo program (led by Dr Beatriz Pena-Molino, CSIRO), Biogeochemical-Argo floats for the Australian contribution to the global Biogeochemical-Argo program (led by Dr Peter Strutton, UTAS) and Expendable Bathythermographs (XBT) as part of the Global Temperature and Salinity Profile Programme (GTSP) (led by Rebecca Cowley, CSIRO).



Image: Hannah McCleary

June 2021

IN2021_T01 Microplastics in the food chain: impact on the microbial and planktonic organisms [Brisbane – Darwin]

Chief Scientist, Dr Viena Puigcorb  (Edith Cowan University), managed science participants remotely on the 12-day transit voyage from Brisbane to Darwin. Associate Professor Sophie Leterme (Flinders University) led a Supplementary Project to investigate microplastics in the food chain and their impact on microbial and planktonic organisms. Data collected will contribute to an oceanographic model of microplastic distribution and movement in Australian waters. Additional piggyback projects and an Indigenous Time at Sea Scholarship (ITSS) recipient were also supported during the transit:

- Research was undertaken into the link between biological carbon pump flux and microbial colonisation of sinking particles in the Coral Sea for Edith Cowan University
- Flow cytometric classification of the phytoplankton community across Australia's top end was investigated for the University of Melbourne
- Dinoflagellate and broader planktonic assemblage observation using high-throughput sequencing was supported for the Defence Science and Technology Group
- Biogeochemical-Argo (BGC-Argo) floats were deployed, cosmic ray data collected, and surface sea water dissolved inorganic carbon and total alkalinity samples were collected for CSIRO.

MNF is striving to increase access to STEM (science, technology, engineering, and mathematics) opportunities for Aboriginal and Torres Strait Islander students. This year, IN2021_T01 supported Breanna Muggleton's (Griffith University) berth on RV *Investigator* to work alongside scientists and technicians, to assist with research, and gain valuable at-sea research experience.

VOYAGE SPOTLIGHT

Quantifying Antarctic krill to inform sustainable fisheries management

In January 2021, research vessel (RV) *Investigator* departed on a two-month voyage to waters off the coast of Mawson research station in East Antarctica to study a keystone species in the Antarctic ecosystem, Antarctic krill.

The primary objective of the voyage was to generate reliable krill biomass estimates for the region. These would be used by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) to set precautionary catch limits for krill in waters off East Antarctica, where a commercial fishery is being re-established.



Image: So Kawaguchi, AAD

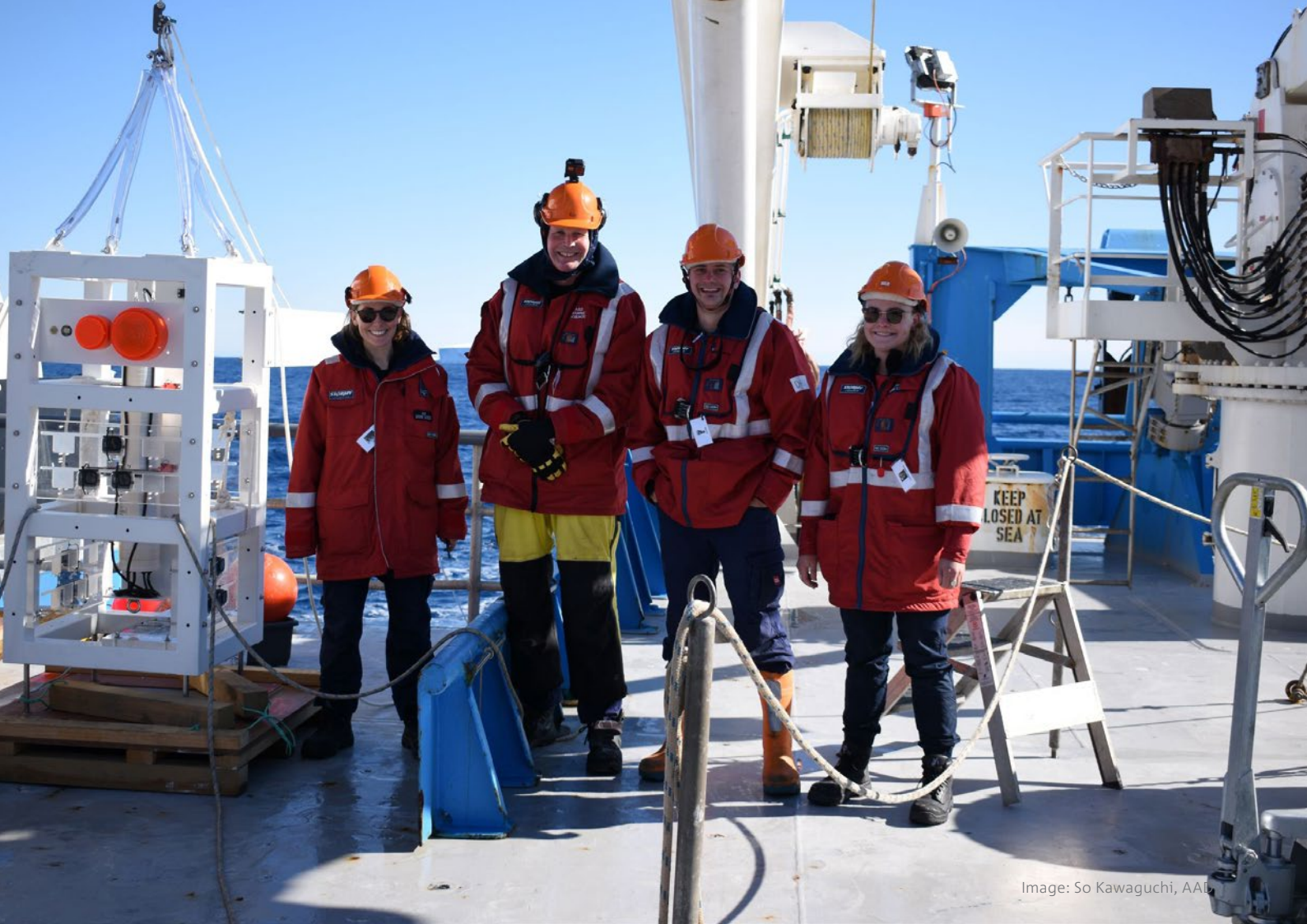


Image: So Kawaguchi, AALB

With changes in technology increasing fishing efficiency and impacts from climate change meaning vessels can now fish longer and in new areas, it is vital that high quality and quantity data is available to inform marine resource and fisheries managers and policy makers.

Led by the Australian Antarctic Division, this record-breaking voyage capitalised on both the endurance and extensive research capabilities of RV *Investigator*. It saw the ship go further south and further west than ever before. Scientists used the advanced acoustic systems (echosounders) on board the ship, as well as a range of other ship systems and novel technologies, to measure krill from all angles in Antarctic waters.

Significantly, for the first time, surveys were conducted to examine krill biomass in the deep ocean down to abyssal depths. These surveys used deep-sea moorings, a deep-sea camera and light trap, and water sampling from near the sea floor to search for the DNA signature of krill. The data collected will greatly increase our understanding of the importance of this deep-sea habitat to krill.

Observations of Antarctic predators, such as seabirds, seals and whales, were also made to examine the relationship between predators and krill distribution and density.

These studies increase understanding of the relationship between krill and predators. This will help fully inform the setting of the precautionary catch limit by CCAMLR. The research will also contribute towards the design of a practical, long-term ecosystem monitoring program, that accounts for predators and prey, and the impacts of climate change and any future krill fishery.

The multidisciplinary research program conducted on this voyage would not be possible without the expertise of Marine National Facility (MNF) staff and access to the flexible platform that RV *Investigator* provides.

The research will contribute meaningfully towards a broader understanding of the Antarctic environment in which krill live and the species they support. Importantly, the data collected will provide a more reliable and complete biomass estimate for Antarctic krill in the East Antarctic region.

This estimate will allow CCAMLR to set a precautionary catch limit for the region. This will help ensure that commercial fishing activities leave enough krill for Antarctic predators and healthy ecosystem function and support the prosperity of our growing blue economy.

Communication and engagement

The MNF is committed to deepening public understanding of marine and atmospheric science and raising awareness of the MNF's value and the contribution we make to solving our greatest challenges.

This commitment is embedded in our work and demonstrated in the *MNF 2030* strategy through Pillar 6 – Connecting with Australians and the world.

MNF communication and engagement activities inform community, government and industry of the benefit and impact of the research, education and training we deliver. We work collaboratively with research partners to deliver relevant, accessible and engaging communications to share the remarkable stories of our ship, scientists and science. In doing so, we demonstrate the significant return on investment that the MNF provides to the nation.

The past year saw the MNF strengthen collaborative relationships with key partners to amplify the benefit and reach of our respective communication activities. Accepting the challenges posed by the COVID-19 operating environment, the MNF has seized the opportunity to leverage both our technology and stakeholder networks to enhance our capability to enable and deliver virtual experiences and outreach.

4,195,194

media reach

4,216,586

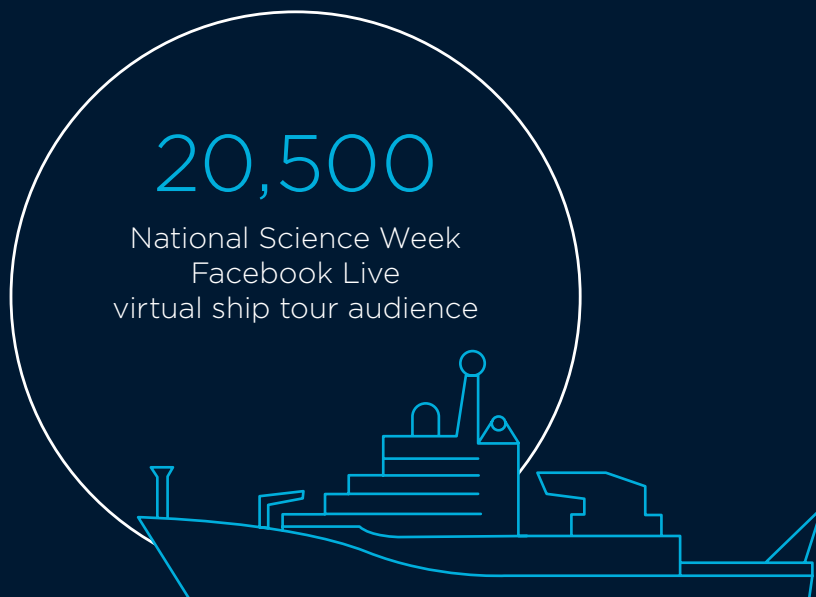
social media impressions

1,093

media items (TV, radio, print, online and other items)

13,810

livestream views (video started)



Indigenous Time at Sea
Scholarship (ITSS) students

1 on 1 voyage

250

school students
receiving broadcasts



Image: Matt Marrison

COMMUNICATION AND ENGAGEMENT CASE STUDY

Outreach in the time of COVID: Bringing the public on board, virtually

With COVID-19 putting the brakes on bringing people to the ship, the MNF communication and outreach team pivoted to take the ship to the people.

To coincide with National Science Week 2020, the MNF delivered two ship tours broadcast live via Facebook. The tours, led by Dr Ben Arthur, the MNF Stakeholder Engagement Coordinator, included staff from MNF vessel management and science operations. These events offered a chance to showcase and profile to a wide audience the ship capabilities, expertise of our people and the research that both combine to deliver.

The tours included an opportunity for viewers to ask questions of MNF staff in real time, providing the public the opportunity to connect directly with our people. The result was a successful and highly engaging outreach event that achieved more than 400 reactions (likes and other responses) and 125 comments on Facebook from viewers around the globe.

Within a month, the two videos had been viewed over 10 thousand times each on Facebook.

The pivot to quickly develop and utilise the ship's technological capabilities to deliver virtual experiences increase our capability for not only engaging with the public but also wider application for engaging with researchers on shore and in real time. This supplements existing technology, such as the ship livestreams, remote science feeds and video broadcast capabilities, bringing with it a whole world of opportunity.

These capabilities and their expanding use in the future will ensure that the MNF maintains meaningful connections with researchers, stakeholders and the public anywhere, anytime and under any conditions.

All you need is a screen and we can bring you on board.



Image: Tauri Minogue

Improving our capabilities

A key principle in the design of *RV Investigator* is modularity and research capabilities of the vessel are continually evolving as new equipment is added and technology is upgraded.

Several enhancements and upgrades are being made to the suite of capabilities available on *RV Investigator*. The heavy ocean towing system (HOTS), co-funded by the Science and Industry Endowment Fund, will see a newly installed fibre optic cable that will allow fully instrumented deployments of heavy towed equipment down to 6,500 m. Current achievable depths on the existing steel (non-instrumented) wire are up to 3,000 m. This enhancement is scheduled to be completed in the second half of 2021. This significant upgrade is the first step in readying the vessel for more advanced deep-water research capabilities.

The deep piston coring capability is also being upgraded to allow researchers to safely collect sediment cores up to 24 m deep and 6,000 m below the ocean surface. The new system includes a new Ocean Scientific International Ltd piston corer handler and Triplex corer that is more robust and, when combined with the new handling system, makes coring operations much safer with less manual handling and better recovery of usable sediment cores. The combined system is in use on the JAMSTEC *RV Kaimei*, and a similar system has been installed on *RV Nuyina* allowing for inter-operability of parts between the Australian Antarctic Division (AAD) and the MNF. The project is scheduled to be completed in the first half of 2021–22 FY. Unfortunately, work was delayed because of international border closures, which prevented specialist technical attendance to install and commission equipment in 2020.

Each year the MNF develops and implements an Annual Capital Procurement (CAPEX) Program to ensure equipment, instruments and capabilities remain relevant and meet current and emerging needs of researchers. During the 2020–21 year, the MNF completed twenty projects under the program involving repairs, replacements, upgrades and enhancements. Projects included:

- new Point of Care COVID-19 test machine installed in the hospital onboard, allowing immediate testing of symptomatic cases while at sea
- upgrades to geoscience capabilities including a new Box corer, Karsten corer, and acoustic components for the piston corer
- IT upgrades to the PABX and Iridium Certus
- updated trawl nets and balloon launcher
- development of new molecular biology sampling capability on the vessel, including a modular eDNA unit to collect samples at depth from the deep tow camera.

On the vessel, improvements to the fixed seismic infrastructure have been made to improve modularity of this capability. The seismic lines have been rerouted to the port side to support efficient transition between deployments of large-scale equipment on the back deck, in particular transitioning between piston coring and seismic operations at sea. Upgrades to the towed body winch have been completed with a new 6,000 m wire installed. The vertical sediment winch upgrade is being finalised and once complete will see an increased capability to 6,000 m for deployments from this winch.



Image: Mike Watson

Financial statement

	2019–20	2020–21
	\$'000	\$'000
External funding	7,745	6,854
Internal funding	26,567	25,956
Total revenue	34,312	32,810
Labour	9,000	9,267
Other operating	23,684	22,338
Total expenditure	32,683	31,604
Operating result*	1,629	1,206
Capital expenditure*	2,314	1,355

* 2020–21 includes \$0.961m of externally funded capital expenditure

* 2019–20 includes \$1.571m of externally funded capital expenditure



MNF impact – seabed mapping

The MNF provides advanced marine and atmospheric research capabilities and world-leading expertise to the nation through its multidisciplinary ocean research platform, *RV Investigator*.

Users from all segments of Australian society leverage information from *RV Investigator* to deepen and expand our collective understanding of ocean ecosystems, climate, and weather changes (especially in the Southern Ocean), fisheries and other important research areas.

The data generated by MNF plays a critical role in evidence-based decision making, resource and risk management strategies and offshore activities.

In 2020, CSIRO commissioned RTI International, an independent, non-profit research institute, to undertake an objective analysis of the value of the multidisciplinary research MNF delivers. RTI undertook surveys of participants and economic case studies and concluded that the median net present value generated to Australian society from *RV Investigator* was \$2.4 billion. They estimated the mean benefit-to-cost ratio to be 4.7. In effect, every \$1 invested in *RV Investigator* and its operations delivers \$4.70 in social value.

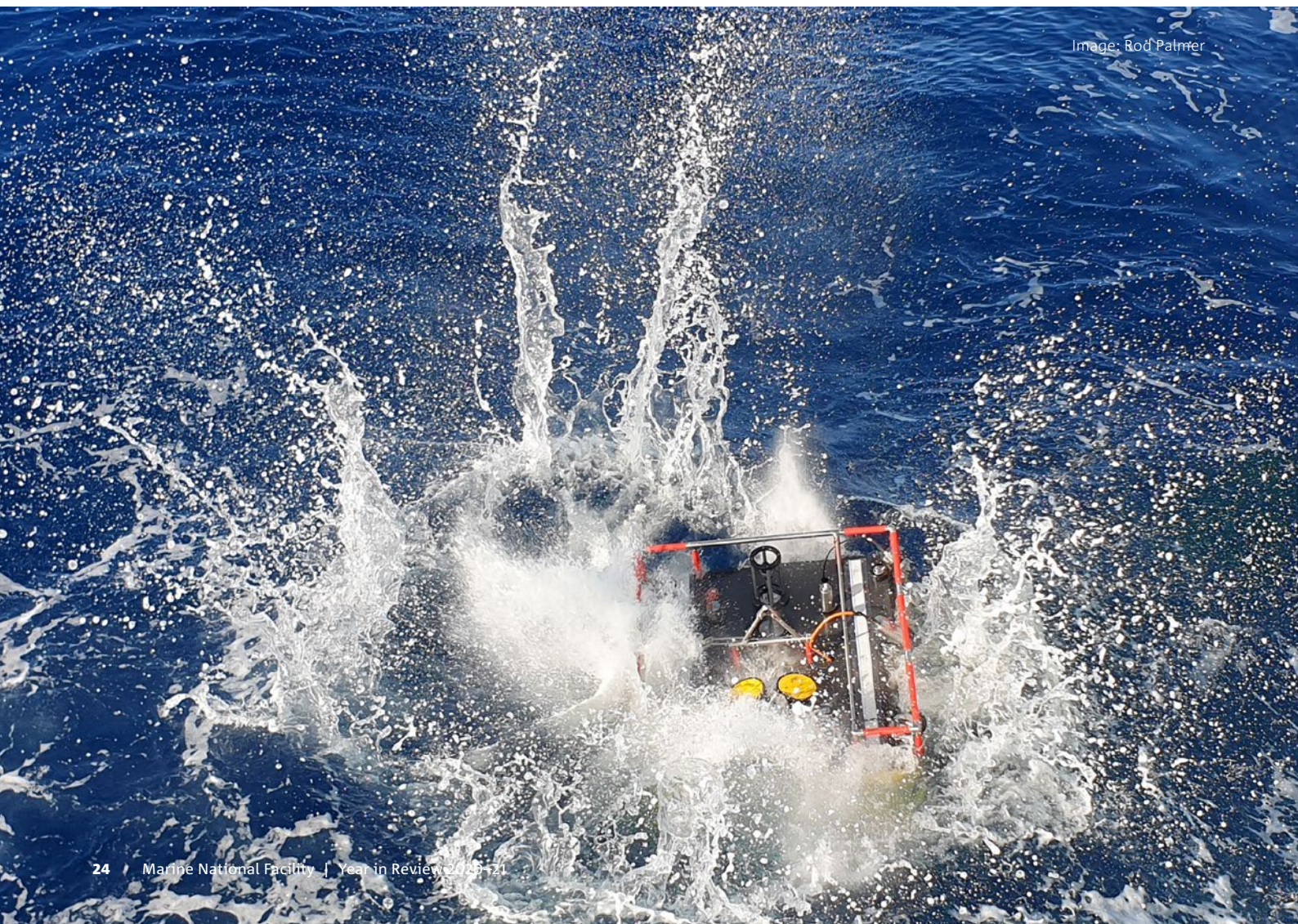


Image: Rod Palmer

One of the key areas of MNF's impact identified by RTI International is its contribution to Australian seabed mapping. *RV Investigator* possesses specialised instrumentation that allows bathymetric, biological, and geophysical data to be collected in three dimensions. All data collected are made publicly available. These data have been used to improve the management of vital ecosystems in Southern Australia, improve economic outcomes from offshore industries such as energy exploration and fishing, enable the reduction of the risk of environmental degradation by expanding our knowledge of sensitive marine ecosystems and contribute nearly 50% of the Australian

seabed mapped (1.26 million km² of 2.54 million km²) to the AusSeabed effort to improve the awareness, coverage, quality, discoverability and accessibility of mapped seabed data in the Australian region.

Estimated benefits of these contributions alone are \$2.7 billion through to 2029–30, with the greatest benefits (\$2.1 billion) coming from improved commercial outcomes in the fishing and aquaculture industries. *RV Investigator* is a demonstrably valuable and productive element of research infrastructure for Australia's people and economy.

KEY RESEARCH

Sampling the Abyss

Gunton et al. 2021. Annelids of the eastern Australian abyss collected by the 2017 RV Investigator voyage. ZooKeys 1020: 1-198 doi: 10.3897/zookeys.1020.57921

Thirty co-authors representing 19 organisations from 12 countries compiled a comprehensive taxonomic list of Australian benthic invertebrate fauna collected from the deep sea, the least explored environment on our planet. *RV Investigator* enabled the collection of deep-water (900 to 4,800 m) benthic fauna at one-degree intervals along the eastern Australian margin from Tasmania, 42°S, to southern Queensland, 24°S. A total of more than 6,000 annelid specimens consisting of 50 families and 214 species were recovered. Of these, 55 species were considered new to science. This work provides critical baseline biodiversity data on an important group of benthic invertebrates from a virtually unknown region of the world's ocean.

The new era for deep-sea biological exploration in Australia began in 2014 with the launch of *RV Investigator*, the first Australian research vessel equipped to routinely perform biological sampling to depths of 5,000 m.

In Australia, the abyssal plain and deep ocean floor covers 2.8 million km², or 30% of Australia's marine territory. *RV Investigator's* 2017 'Sampling the Abyss' voyage, the first dedicated deep-sea voyage to perform a systematic biological survey along the eastern Australian coast, generated a valuable set of annelid specimens that were part of an Australian Museum (AM), Museums Victoria (MV) and Natural History Museum (NHMUK) collaboration.

Prior to 2017, only two annelid species were described from below 2,000 m, consequently this research vastly increases our knowledge of deep-water annelids. Furthermore, because all material from this study is retained in properly curated museum collections (AM, MV, NHMUK) and a significant proportion has been preserved for molecular studies, these valuable samples are easily accessible and can be used for answering important questions on taxonomy and species' ranges along the eastern Australian margin including seven deep-water Marine Parks.

Looking to the future – *INVESTIGATE*

The MNF is committed to deepening the public’s understanding of marine and atmospheric research, especially for those unable to get onboard RV *Investigator* themselves. As we seek to make research more accessible through appealing and creative storytelling that showcases our contribution, impact, and value, we’ve commissioned *INVESTIGATE*.

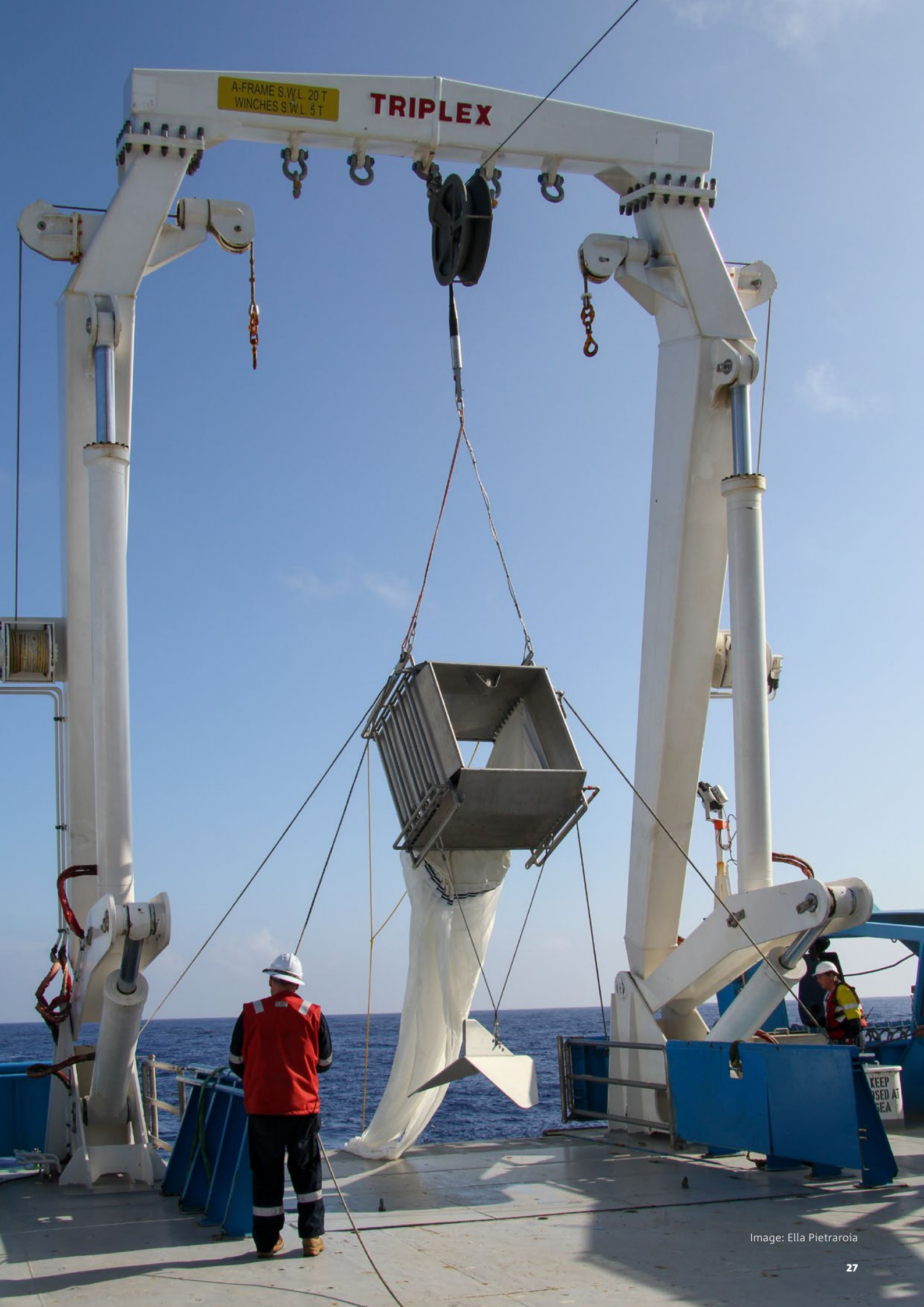
INVESTIGATE is a stand-alone shipping container that will serve as a travelling outreach tool (see below for an artist’s impression of the exterior design). Designed to inspire, engage, and educate, *INVESTIGATE* is designed to be an immersive experience encouraging users to explore Australia’s vast marine estate and the key role that the MNF plays within it. With our access to world-class technology, knowledge, and human resources, *INVESTIGATE* will use these capabilities to deliver a dynamic resource that demands attention.

With at-sea operations taking RV *Investigator* to ports around Australia, *INVESTIGATE* will be used both alongside the vessel to create a hub for community engagement by capitalising on the invaluable tool that the vessel offers to capture people’s interest. *INVESTIGATE* will extend our outreach beyond the physical location of the vessel, to educate and engage students and the public at museums and educational facilities across the country.

As a way for the Australian public and school students to engage with marine and atmospheric research in a contemporary way, *INVESTIGATE* tells the story of Australia’s blue-water marine and atmospheric research and its impact. It is an invitation to investigate a little deeper.



Exterior artwork for *INVESTIGATE* outreach container



A-FRAME S.W.L. 20 T
WINCHES S.W.L. 5 T

TRIPLEX

KEEP
CLOSED AT
SEA

Image: Ella Pietrarora

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