Australian Government

Australian Institute of Marine Science

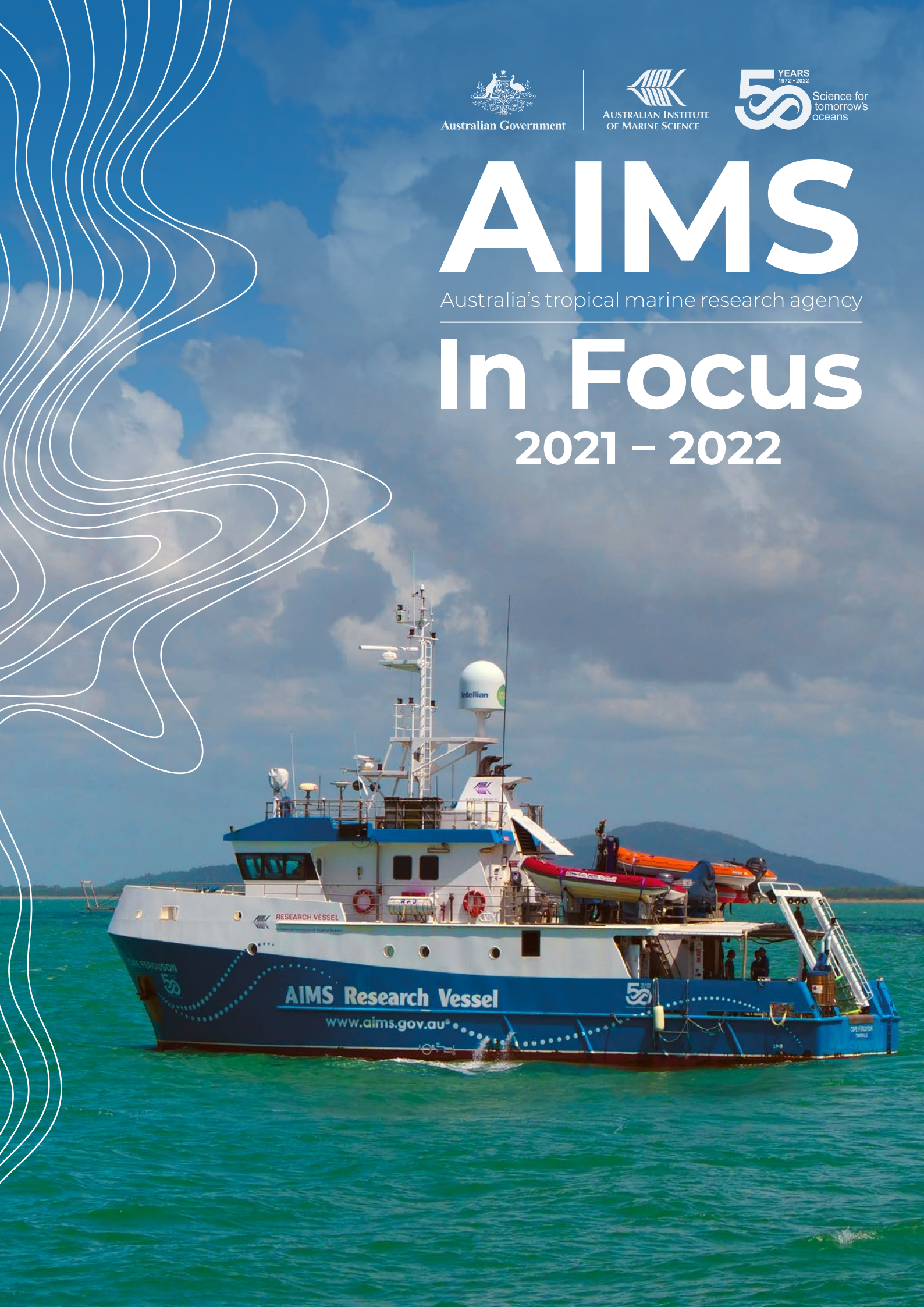
50 YEARS 1972 - 2022 Science for tomorrow's oceans

AIMS

Australia's tropical marine research agency

In Focus

2021 – 2022



Mission

To provide the research and knowledge of Australia's tropical marine estate required to support growth in its sustainable use, effective environmental management and protection of its unique ecosystems.

Values

Care for ourselves and others in all that we do

Together we create impact

Treat everyone with dignity, value diversity, support others

Energy that inspires excellence

Always transparent, ethical and objective

Vision and creativity to solve big challenges

Minimise our footprint

Cover Image
The RV Cape Ferguson in 50th Anniversary livery stands off the AIMS wharf at Cape Cleveland south of Townsville. For more than 22 years, the 'Fergie' has taken marine research to the remote tropical waters of Australia's north, steaming as much as 15,000 nautical miles, during 270 sea days a year. She is to be replaced this decade with a modern research vessel that incorporates hybrid propulsion, better sea-keeping and the latest technology platforms for integrated data collection. This will enable Australia to maintain its position as a global leader in tropical marine science and deliver science for tomorrow's oceans. Photo: Marie Roman.

Locations and assets

2021/2022 IN BRIEF

Australian Government | Australian Institute of Marine Science | 50 Years 1972 • 2022 Science for tomorrow's oceans

MARINE SCIENCE SOLUTIONS: REEF RESTORATION INITIATIVES

RRAP
Reef Restoration and Adaptation Program

RRAP brings together the best in marine STEM to develop large scale reef interventions for the Great Barrier Reef that are cost-effective, practical, safe and acceptable.

ACRRI
Australian Coral Reef Resilience Initiative

ACRRI uses an ecosystems approach to simultaneously research underwater acoustics to help rebuild fish populations, and develop coral seeding technologies for more resilient reefs.

BLUE TECHNOLOGY: INNOVATION IN MARINE SCIENCE

REEFWORKS

ReefWorks is Australia's tropical marine technology test range, enabling Australian innovators to study new marine technologies, autonomous systems and sensors in a real-world environment. Sixteen events were conducted in 2021/22 supported by about $400k external investment.

REEFSCAN

A suite of technology-based solutions for coral researchers to conduct in-field marine observations.

REEFCLOUD

ReefCloud is a cutting-edge data platform that incorporates machine learning to inform decisions by reef managers.

AN EYE ON OUR TROPICAL OCEANS: LONG-TERM BIODIVERSITY AND WATER QUALITY MONITORING

Long-term Monitoring Program

Our Long-term Monitoring Program for the Great Barrier Reef (GBR) is the world's longest record of change in coral reefs tracking coral and fish populations, crown-of-thorns starfish outbreaks, and the effects of cyclones and coral bleaching.

Great Barrier Reef Marine Monitoring Program

AIMS continues to implement the Marine Monitoring Program led by the GBR Marine Park Authority. Our team records water quality, hard and soft coral cover, macroalgae and coral recruitment on over 30 inshore reefs.

Science Output

201
PEER REVIEWED JOURNAL ARTICLES

57% IN INTERNATIONAL COLLABORATION PUBLICATIONS

40% IN NATIONAL COLLABORATION PUBLICATIONS

Science Impact

$222m
ECONOMIC RETURN ESTIMATE

4.9x
RETURN ON GOVERNMENT INVESTMENT

#1

marine science institution in the world*

Safety Performance

17% ↓
RECORDABLE INJURIES
Better than target

20% ↓
TOTAL RECORDABLE INJURY FREQUENCY RATE (TRIFR)
Better than target

National Facility

Initiation and conceptual design phases complete for the National Sea Simulator. Construction commences 2022-2023.

$36.3m

Environmental Performance

3,500t ↓
REDUCTION IN CARBON EMISSIONS*

43.2t ↓
REDUCTION IN SOLID WASTE TO LANDFILL*

*FROM BASELINE YEAR

FIELD OPERATIONS
Tropical Northern Australia

42,760
NAUTICAL MILES STEAMED

1,242
SCIENCE SEA DAYS INCLUDING CHARTERS

6,327
NUMBER OF DIVES

261
COLLABORATORS ON FIELD TRIPS

10,315
RESEARCHER FIELD DAYS

*Benchmarking by Clarivate Analytics InCites research analytical tool, as at 21 July 2022. Organisations with >200 Web of Science documents in the field of marine and freshwater biology for the period 2017-2021

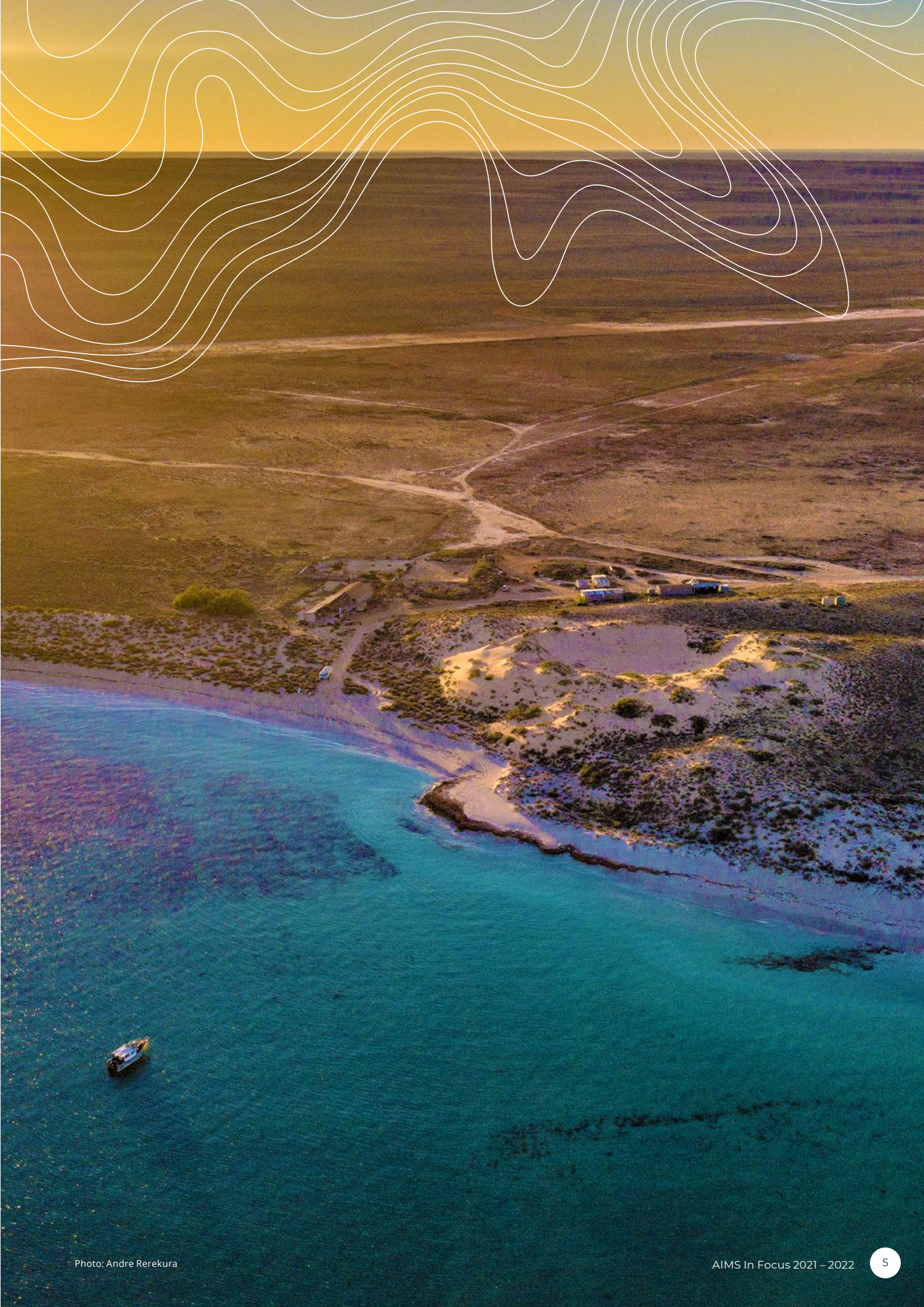


Photo: Andre Rerekura

What gets measured gets managed

Science and tech helping to save rare whales

The Australian Institute of Marine Science (AIMS) researchers are using advanced data collection and analysis to learn more about pygmy blue whales in their northward migration through Western Australian waters to tropical breeding grounds.

Despite commercial whaling ceasing in Australian waters in 1978, whales continue to face threats from human activities that degrade their environment, such as noise pollution, vessel traffic and climate change – all of which may inhibit population recovery.

Many whales, including the pygmy blue whale (*Balaenoptera musculus brevicauda*) migrate through Australian waters from the Southern Ocean to equatorial waters to breed.

Blue whales are endangered, and the pygmy blue whale is a subspecies whose IUCN conservation status is classified as "data deficient" – recognising the limited information available to assess its extinction risk. They are very difficult to study because of their small population and behaviour. They spend much of their lives far from shore and below the surface, coming up only briefly to breathe.

AIMS collaborates with the Fremantle-based Centre for Whale Research (CWR) to undertake research on these elusive creatures in their known and possible foraging grounds in Perth Canyon and Ningaloo, prior to and during their northerly migration through WA's offshore waters to Indonesia.

The AIMS/CWR pygmy blue whale research has partnered with Woodside Energy Ltd to gather more detailed knowledge about the whales' diving and feeding behaviour. The aim is to better define their important foraging areas off the coast of Western Australia with more certainty. This is consistent with Australia's Blue Whale Conservation Management Plan under the *Environment Protection and Biodiversity Conservation Act 1999*.

Photo: Grace Russell

Photo: Jo Hurford

In 2022, the project was undertaken in the Perth Canyon west of Rottnest Island.

The researchers have been gathering this information by tagging individual whales with satellite-linked tracking devices. Two types of tags are used: Fastloc GPS tags and Pop-up satellite linked archival tag (PSAT).The Fastloc GPS records data to calculate the whale's position in the very short amount of time when it surfaces to breathe. The tags transmit this data via satellite to researchers' computers for analysis at that surfacing or at a later one. The tags eventually fall out, after around 60 days on average.

The PSAT tracks movements and diving behaviour by recording accelerometry data, depth, temperature, and light level every second, which is stored in its onboard memory. On a pre-programmed date the tag releases from its host animal, floats to the surface and, over a few weeks, transmits the archived data via satellites.

The ability of these tags to transmit means each tag does not have to be physically recovered for the data to be obtained. This is crucial as it is very difficult to recover the tags from such large animals that can move over 100 kilometres in a day.

Through its research on pygmy blue whales, AIMS is building advanced technical expertise and knowledge relevant to the ecology of iconic and threatened marine species.

This new information about pygmy blue whales will identify where their movement patterns overlap with existing and future marine activities such as shipping, oil and gas and renewable energy projects.

Governments, regulators and industry can use this important information to reduce potential threats and better manage marine-based activities that intersect with important pygmy blue whale habitats. ■


Photo: Grace Russell

The sounds and seeds of coral reefs

Whole-of-ecosystem approach to restoring coral reef systems

The world's coral reefs are declining, and climate change is responsible for most of this loss. As temperatures rise, marine heatwaves become more frequent and cyclones more intense. This leaves coral reefs struggling to recover between disturbances.

Australia is responding to this challenge through the Australian Coral Reef Resilience Initiative (ACRRI), a world-first biodiversity approach to coral reef recovery. The objective is to develop new and innovative methods to improve the recovery and resilience of coral reefs and mitigate the effects of climate change.

ACRRI comprises two central research projects: the Woppaburra Coral Project on the Great Barrier Reef in Queensland, and the Reef Song Project at Ningaloo Reef in Western Australia and on the Great Barrier Reef. These projects encompass a two-pronged approach – seeding damaged or degraded reefs with juvenile corals and using underwater acoustics to mimic the sounds of healthy reef ecosystems to lure fish back to reefs that are being replenished.

Reef seeding involves raising young corals in an aquaculture facility (in laboratories like the National Sea

Photo: Cathie Page Inset: Gemma Molinaro

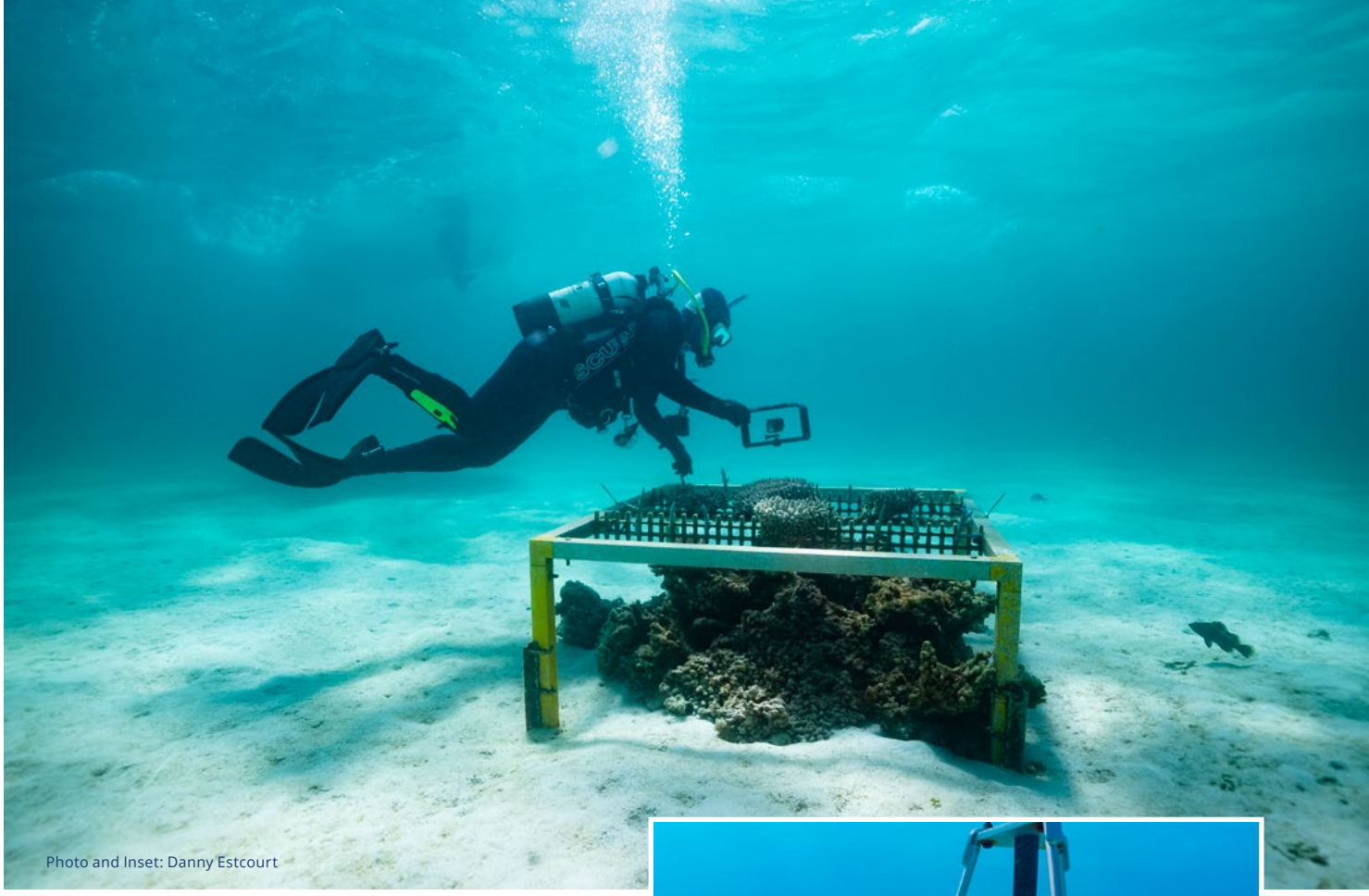
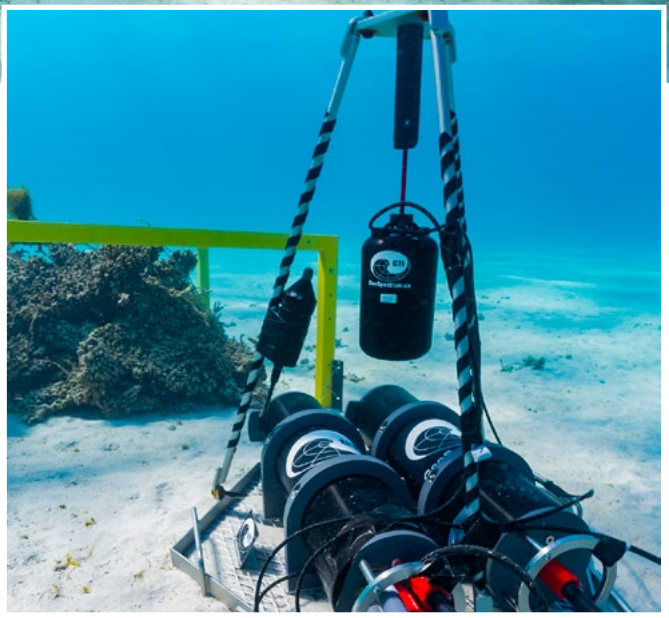


Photo and Inset: Danny Estcourt



Simulator in Townsville or our floating laboratory on our research vessel), attaching them to devices and then placing them on the reef.

AIMS scientists working in Woppaburra Sea Country (the Keppel Islands of the southern inshore Great Barrier Reef) have shown that young corals seeded onto specially engineered devices and placed on relatively healthy reefs have a more than 85 percent survival rate.

The next step is to test these devices on degraded reefs as well as to release them en masse rather than placing them individually by hand.

In November 2021, healthy adult corals were taken to the National Sea Simulator for spawning and then returned to Woppaburra Sea Country in early 2022. Their offspring, attached to 240 devices, were placed onto six reefs that ranged from very healthy to heavily degraded.

The latest devices used in this experiment have been reduced in size to test more cost-effective versions that might in the future be mass-produced. Their shape has also been modified so they better settle on uneven reef surfaces.

The growth of seeded coral juveniles is an important but slow stage in reef recovery. Accelerating that process by improving growth and survival may be possible with the addition of other members of the reef ecosystem. Cue the Reef Song project. This is a whole-of-ecosystem approach to restoring degraded and damaged reef systems.

Researchers are studying how surrounding organisms, like fish, influence the survival of corals. When fish, crabs, shrimps and other invertebrates forage, hunt, feed, groom and mate on a reef, they create a mix of sounds at high and low frequencies, all of which are an audio indicator of a healthy reef ecosystem.

Underwater loudspeakers are being used to broadcast recordings of these sounds to attract baby fish. Known as Reef Song, this project is the first known research to investigate if attracting fish to settle on reefs, using sound, can help accelerate coral recovery.

ACRRI is a $27 million research investment jointly funded by AIMS and BHP in partnership with Woppaburra Traditional Custodians. The research team incorporates traditional ecological knowledge with Western science and creates skills and employment pathways in coral aquaculture for Indigenous Australians. ■

Helping Indo-Pacific communities monitor reef health

Open-access photo platform enables real-time sharing of reef monitoring data

Coral reefs are one of the most important and complex ecosystems on the planet. Cloud-based AI is ensuring Indo-Pacific Island communities have the latest information at their fingertips to help them preserve coral reefs for future generations.

Coastal communities rely on coral reefs for food, income and shoreline protection, but climate change is putting these ecosystems at risk of collapse. Effectively managing these reefs to prevent further degradation requires timely and accurate information about reef condition – especially after damaging events such as coral bleaching and cyclones. However, there are considerable technical and logistical challenges to achieve this.

Reef monitoring across large expanses of ocean is expensive, and collating and integrating data from different formats and methodologies is labour intensive and complex. Resources for monitoring and management advancement are often limited across the world, challenging our collective capacity to take informed conservation actions.

An advancement that can contribute to addressing this issue is ReefCloud, an award-wining technology co-developed with coral reef scientists and managers from across the Indo-Pacific. Users submit photos taken during reef surveys to the online platform, along with associated data. ReefCloud deploys machine-learning algorithms to

Photo: AIMS

analyse this information into actionable data to support informing management decisions across geographies.

The open-access platform enables the world's coral reef monitoring community to share this knowledge and work together. The platform is now being adopted across more than 35 countries, after being trialled in the Indo-Pacific.

Trials show that ReefCloud analyses coral reef composition with 80–90 per cent accuracy and 700 times faster than manual assessment. It ensures reliable data is available immediately and historical comparisons to assess reef health trends can be made.

The dramatically improved functionality of the cloud-based data resource was evident during the COVID-19 pandemic lockdowns that prevented travel. The Maldives Marine Research Institute and Wildlife Conservation Society Fiji were able to enlist resort-based marine biologists to collect and enter field data into ReefCloud, allowing managers to assess information on the condition of coral reef habitats from across large geographies.

Illustrating its significant cost benefits, the Palau International Coral Reef Centre has reported that by transitioning its reef monitoring program to ReefCloud, they believe it will save up to four months of labour costs a year.

ReefCloud has been praised internationally as an example of innovative science delivering ecological and social benefit through its capacity to significantly improve protection and management of coral reefs.

The development and potential impact of this tool affirms the Australian Institute of Marine Science's (AIMS') standing as a world-leading marine research institution. ReefCloud was the Environment and Sustainability winner at the 2022 Asia-Pacific Spatial Excellence Awards.

ReefCloud was developed by AIMS in partnership with: Palau International Coral Reef Centre (PICRC), Wildlife Conservation Society (WCS) Fiji, the International Coral Reef Initiative (ICRI), University of South Pacific, Queensland University of Technology, Marine Ecology Consulting, Maldives Marine Research Institute and C2O Pacific, with in-kind support from Accenture and the Allen Coral Atlas. It was co-funded by the Department of Foreign Affairs and Trade. ■

Photo: Marie Roman

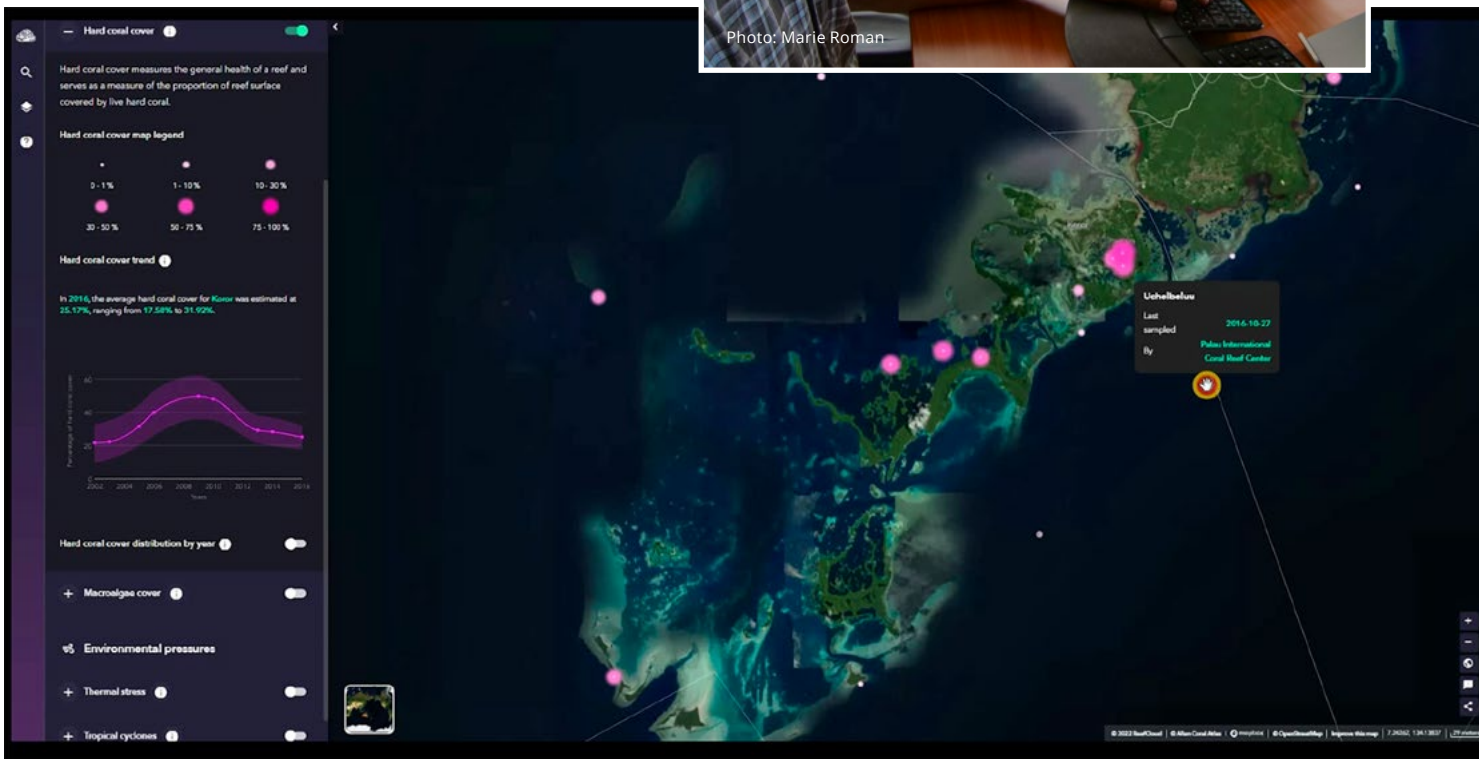
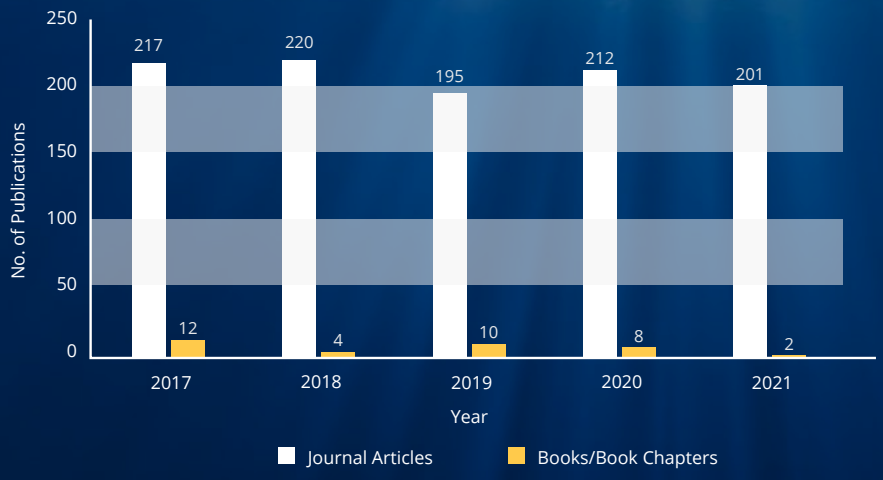


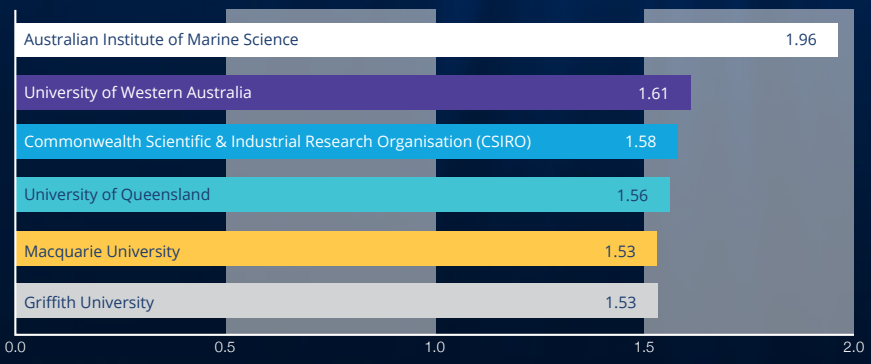
Photo: Kate Osborne

Research performance



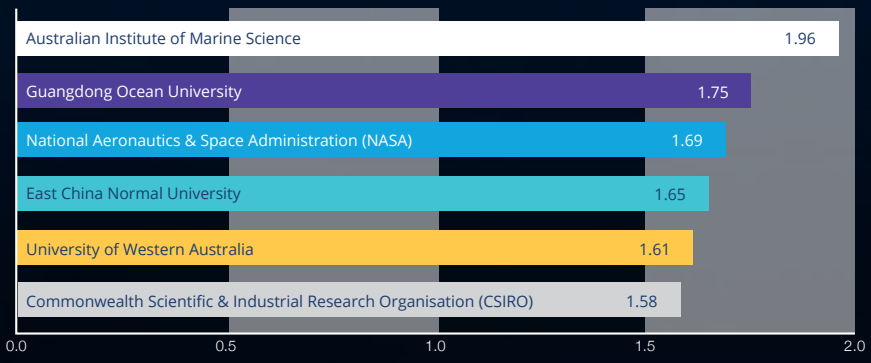
Number of AIMS publications by type, 2017 to 2021

The main types of publications produced by our research staff are peer-reviewed journal articles and reviews, books and book chapters, followed by client reports.



Top 6 organisations in the field of marine and freshwater biology in Australia ranked by category normalised citation impact

(InCites, January 2023)



Top 6 organisations globally in the field of marine and freshwater biology ranked by category normalised citation impact

(InCites, January 2023)

Out-of-season coral spawning opens new research window

Engineering multiple spawning events each year increases chances to improve coral reefs resilience

Spawning and the early life history stages of corals are key events to produce future coral generations and the replenishment of ecosystems.

But research around the effects of climate change on coral reproductive biology has been limited to the narrow window of opportunity presented by coral spawning based on daylight length, the lunar cycle and water temperature. On the Great Barrier Reef, this period occurs mostly during the nights after the full moon in November or December.

That limitation is beginning to be lifted. Staff at the National Sea Simulator (SeaSim), working with state-of-the-art technology, have recreated the seasonal cues and natural spawning conditions to prompt coral raised at the facility to spawn outside of the natural spawning period.

By engineering multiple spawning events each year, opportunities will be opened for marine scientists to fast-track knowledge-gain on coral biology. This will contribute significantly to efforts to protect coral reef ecosystems from the effects of climate change.

This technical breakthrough will enable larval and juvenile corals to be produced multiple times each year. They can then be used in experiments looking at impacts such as ocean acidification, climate change, reef restoration and adaptation, water quality, pollution and sedimentation.

Photo: Jo Hurford

Photo: Joe Gioffre

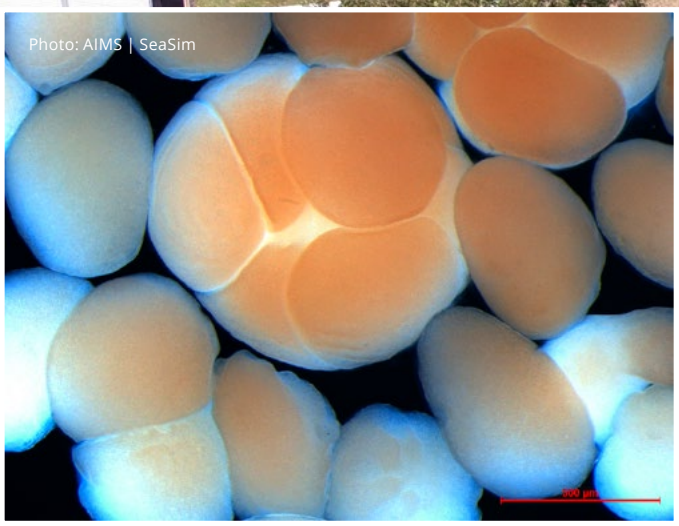


Photo: AIMS | SeaSim

Opened in 2013, SeaSim allows for multigenerational studies critical in understanding how marine organisms can adapt to a changing environment.

Bypassing the bottleneck created by seasonal larval supply increases research opportunities to rapidly accelerate the development of feasible options to protect the Great Barrier Reef.

This world-leading, large-scale spawning achievement was enabled through the sophisticated facilities at SeaSim – the world's most advanced experimental research aquaria complex and a national asset that supports the rearing and long-term propagation of different coral species.

Opened in 2013, SeaSim allows for multigenerational studies critical in understanding how marine organisms can adapt to a changing environment.

The facility received a three-year $36.3 million Australian Government funding boost in 2020 to expand the capacity, resulting in a doubling of experimental spaces available for use by national and international research groups.

Using SeaSim's experimental seawater systems, scientists can research the impact of complex environmental changes on corals and other tropical marine organisms with large, long-term experiments.

The facility allows researchers to manipulate key environmental factors, including light, temperature, acidity, carbon dioxide, salinity and contaminants.

Integrating technology used in the industrial process automation community and aquarium sectors, it enables large-scale experimental research not previously possible in Australia. ■

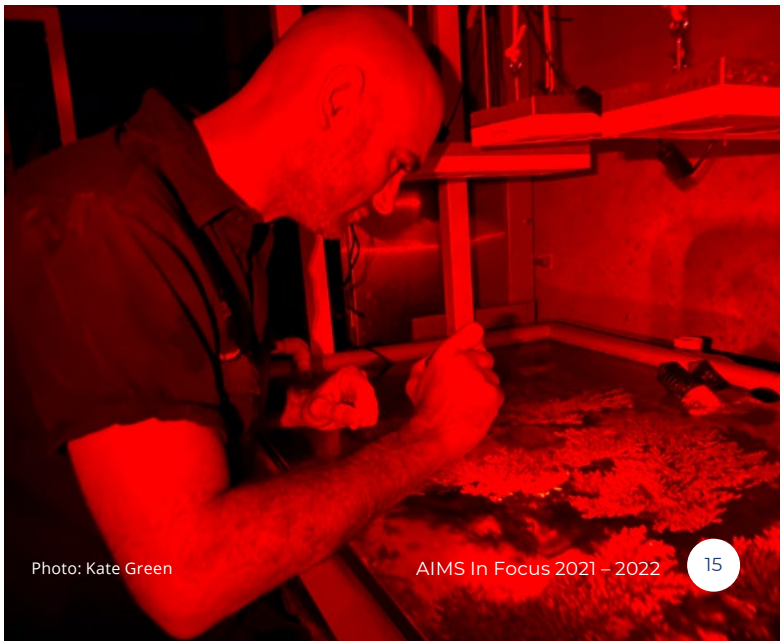


Photo: Kate Green

Arnhem Sea Country Monitoring

Knowledge partnership to keep Sea Country safe

Photo: Vinay Udwayer

Photo: Claire Streten

Photo: Simon Harries

Traditional knowledge and modern science have been brought together to safeguard climate-sensitive marine ecosystems in northern Australia. Technology developments combined with Indigenous knowledge and skills are underpinning a unique program of monitoring and managing the health of marine ecosystems across northern Australia.

With increasing sea temperatures affecting tropical reef systems, a marine survey began in 2020 to assess the biodiversity of vulnerable reef communities in the Arnhem Marine Park and the Djelk Indigenous Protected Area (IPA), which are located off the Arnhem Land Coast.

High sea surface temperatures are the main driver of coral bleaching and can reduce habitat quality and availability of food for fish. Fisheries scientists also use sea surface temperature data to understand environmental conditions and predict changes in the population health of fish species.

The monitoring program is a partnership between the Australian Institute of Marine Science (AIMS), Parks Australia, Bawinanga Sea Rangers and Traditional Owners.

The rangers are trained to deploy monitoring buoys and drop cameras. The buoys measure sea temperature, wave height and wind speed in real time, while the cameras help collect visual information about the health and biodiversity of the seafloor. The real-time temperature buoy is part of a global temperature-monitoring program that provides open-source temperature data. Data collected by real-time and static loggers supplement the satellite-based monitoring of sea surface temperatures. They collect data when the satellites cannot 'see' through clouds, which is a drawback during the wet season when coral bleaching is most likely to occur. High sediment levels in inshore waters associated with wet season rain can also disrupt satellite data collection near the coastline.

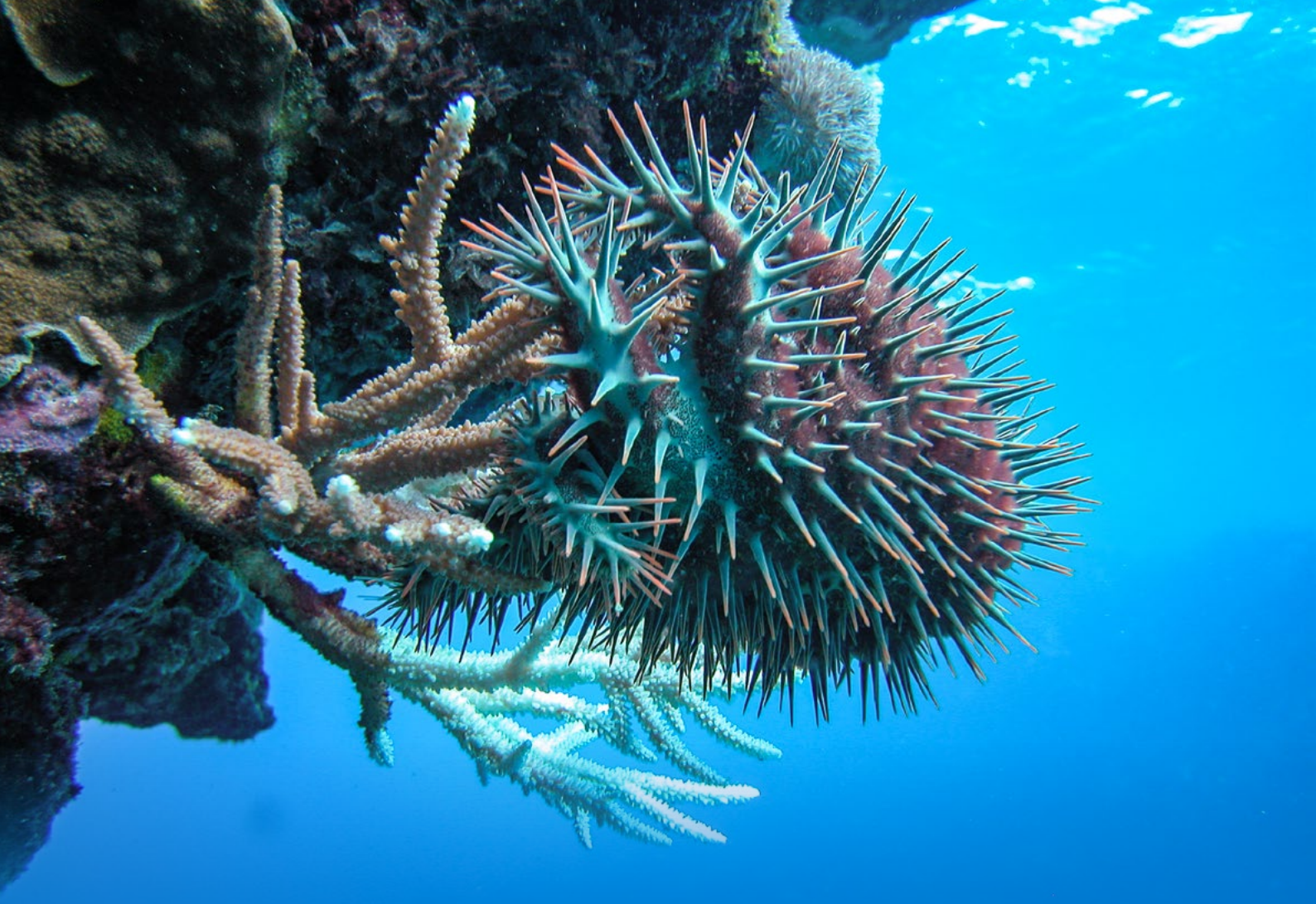
Satellite data is also being supplemented by in-water probes to record temperature over long periods. The probes, containing small temperature loggers, are positioned near benthic fauna such as corals, clams or oysters to determine if changes to these communities correlate with high sea surface temperatures.

The rangers are accessing remote areas off the Arnhem Coastline that have not previously been surveyed using the Western methods of drop camera and Baited Remote Underwater Video Systems (BRUVS), which provide visual observations of marine life and diversity.

The survey data being collected as part of this project, combined with traditional ecological knowledge, fills critical data gaps across northern Australia. This helps all interested parties to better understand and manage Sea Country, and to protect marine species that are important economically, ecologically and culturally.

The project provides an opportunity for the region's Traditional Owners to design the project by selecting survey locations based on their knowledge, exemplifying AIMS' focus on bringing together traditional ecological knowledge and Western marine science to create new insights into coastal ecosystems.

Further monitoring will take place in 2023. ■



Fish emerge as allies in the crown-of-thorns starfish fight

Fish predators of the crown-of-thorns starfish are more common on reefs closed to fishing

Photo: AIMS | LTMP

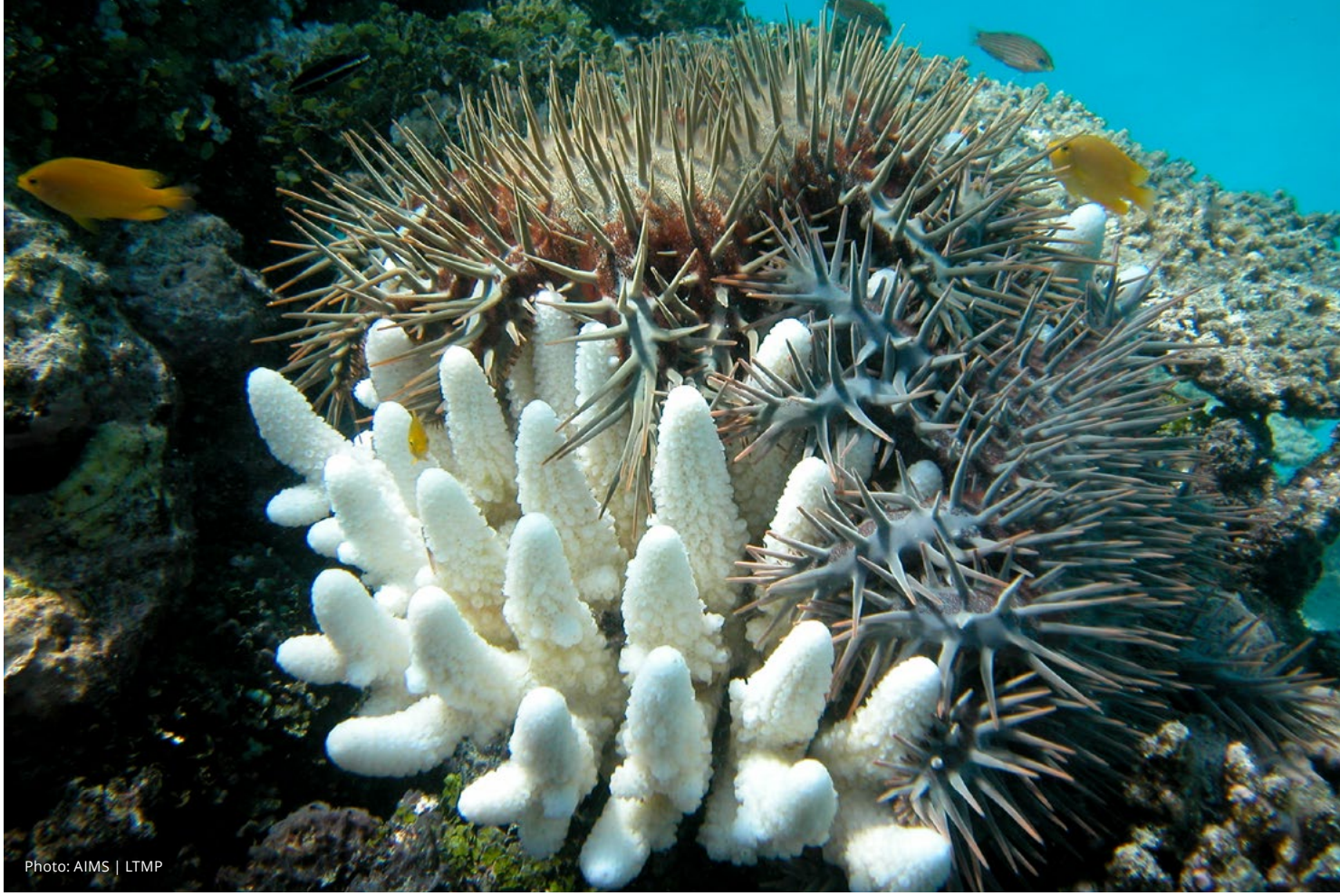


Photo: AIMS | LTMP

Outbreaks of crown-of-thorns-starfish are a major threat to coral, but insights from long-term studies are presenting new control options.

The marine invertebrate (*Acanthaster spp.*) feeds on coral and occurs naturally on reefs throughout the Indo-Pacific region. When conditions are right, their populations can reach plague proportions and devastate entire coral communities.

The Australian Institute of Marine Science (AIMS) monitors numbers of crown-of-thorns starfish as part of the Long-Term Monitoring Program for the Great Barrier Reef World-Heritage Area. This program has shown that outbreaks begin in the northern part of the Reef and migrate southward over about 15 years as ocean currents transport the starfish larvae between reefs. These surveys have shown that in the absence of other disturbances, healthy reefs can recover between outbreaks but generally take 10–20 years to do so.

One challenge for Great Barrier Reef managers and policymakers is this recovery takes even longer on reefs affected by additional stresses, such as marine heatwaves leading to mass coral bleaching, cyclones or poor water quality caused by sediment and nutrient run-off from coastal agricultural land. Where these additional stressors occur, coral has often not recovered from one starfish outbreak before the next one occurs.

Laboratory research at AIMS has revealed that crown-of-thorns starfish larvae increase in abundance when phytoplankton, their food source, is plentiful. Increased larval survivorship can then translate into increased adult numbers on reefs with enough coral to sustain these populations.

Once dense breeding populations of starfish develop on reefs, the volume of larvae they produce is huge and can establish outbreaks at reefs downstream.

A recent study revealed that overfishing appears to contribute to crown-of-thorns starfish outbreaks. Some important fishery reef fishes, such as emperors, snappers and rock cods, are predators of crown-of-thorns. On reefs closed to fishing, biomass of these fishes was 1.4–2.1 times higher and starfish densities nearly three times lower than on reefs open to fishing.

Scientists have also compared 30 years of reef fish harvest data from the Queensland Department of Agriculture and Fisheries with crown-of-thorns starfish abundance data from AIMS' long-term reef monitoring over the same period.

The relationship between fisheries harvests and the numbers of starfish is clear. The data shows crown-of-thorn starfish density is much greater in areas where reef fish biomass is reduced by harvesting.

These findings provide an opportunity to investigate new tools for controlling starfish outbreaks, such as targeted fisheries-based management.

For managers this presents some hope. Unlike pressures such as climate change, starfish outbreaks can potentially be mitigated locally through the use of marine protected areas and fisheries management, in addition to control programs. ■

Whale sharks full of big surprises

Whale sharks also eat plants, making them the world's largest omnivore

Photo: Andre Rerekura

Photo: Andre Rerekura

Marine scientists researching the giant whale shark (*Rhincodon typus*) off Western Australia's north-west coast have made some surprising scientific discoveries.

A multi-decade research program supporting conservation of the world's largest fish has overturned a fundamental assumption about the species' behaviour and its evolution.

It has long been assumed that whale sharks are carnivores – a widely held belief based on a long history of observations of these sharks consuming krill, small fish and other nekton.

Now the Australian Institute of Marine Science (AIMS) scientists have discovered that whale sharks also eat plants, making the iconic fish the world's largest omnivore.

Marine scientists behind this finding have been studying whale sharks at Western Australia's Ningaloo Reef, where they are a popular tourism attraction supporting an industry worth $12 million each year to the local economy. The aim of the research is to reduce the impact of environmental stresses and human threats that have pushed whale sharks onto the global endangered species list.

This research has included efforts to learn more about the species behaviour, feeding patterns, growth and migration. Understanding this is critical to ensuring their survival.

To find out what the animals were using for energy and growth, not just what they were ingesting, scientists analysed skin biopsies of the sharks and discovered they were digesting a lot of plant material. Tissue samples contained compounds found in *Sargassum*, a seaweed common at Ningaloo, which breaks off the reef and floats at the surface.

Whale sharks are filter feeders, ingesting food as they swim with open mouths. This means that they can incidentally consume material such as drifting algae, but in the past, it was assumed that this was regurgitated or simply passed through the gut.

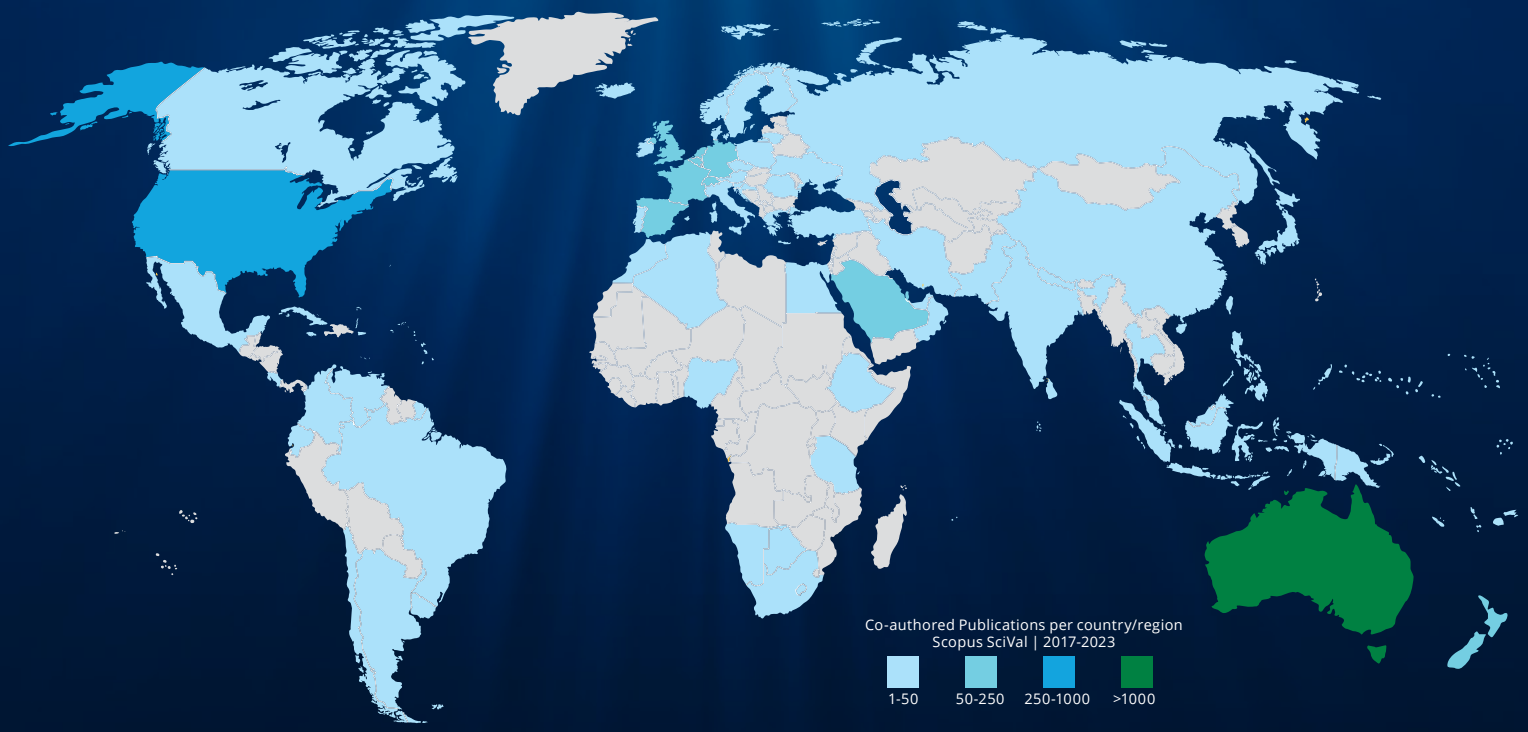
These new microchemical studies show that *Sargassum* is being digested and, as a result, the sharks are omnivorous. This discovery adds a fascinating new insight into the species' evolution and provides important new information for the protection of whale sharks.

Pollution, rising ocean temperatures and acidification are changing the physical structure and food networks in tropical oceans, creating serious challenges for these animals.

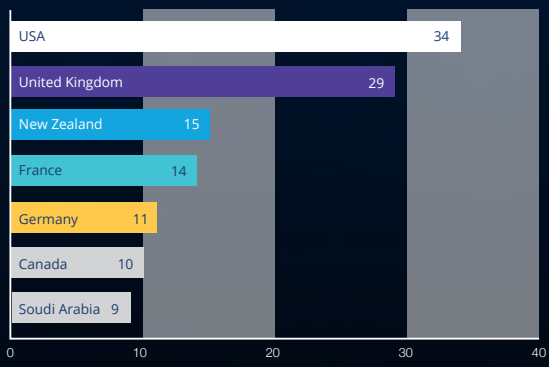
The AIMS research provides global decision-makers with information that can be used to improve the future for the species.

The whale shark research is supported by Santos and INPEX as Joint Venture participants in the Van Gogh Development. ■

Research collaboration



International collaborators



2022 collaborative project productions

86 papers including

48 countries covering

137 project areas involving

122 institutions

Collaboration is a core value of AIMS. Collaboration with domestic and international partners enables AIMS to draw on complementary skills to deliver practical research results and to share knowledge more broadly. In 2022, 55% of our publications involved international collaborators, and nearly 43% involved domestic collaborators

(InCites data for 2022, accessed 4 January 2023, subject to updating once all publications are indexed)

The subject areas of the journal articles included: Agricultural and Biological Sciences, Environmental Science, Earth and Planetary Sciences, Biochemistry, Genetics and Molecular Biology and more.

Environmental performance

Water Usage

Our operations at Cape Ferguson used 59 megalitres (ML) of water in 2021-22, an increase of 8.6 ML from the previous year due to increased running time of Thermal Energy Storage plant over the warmer and longer summer period.

Recycling

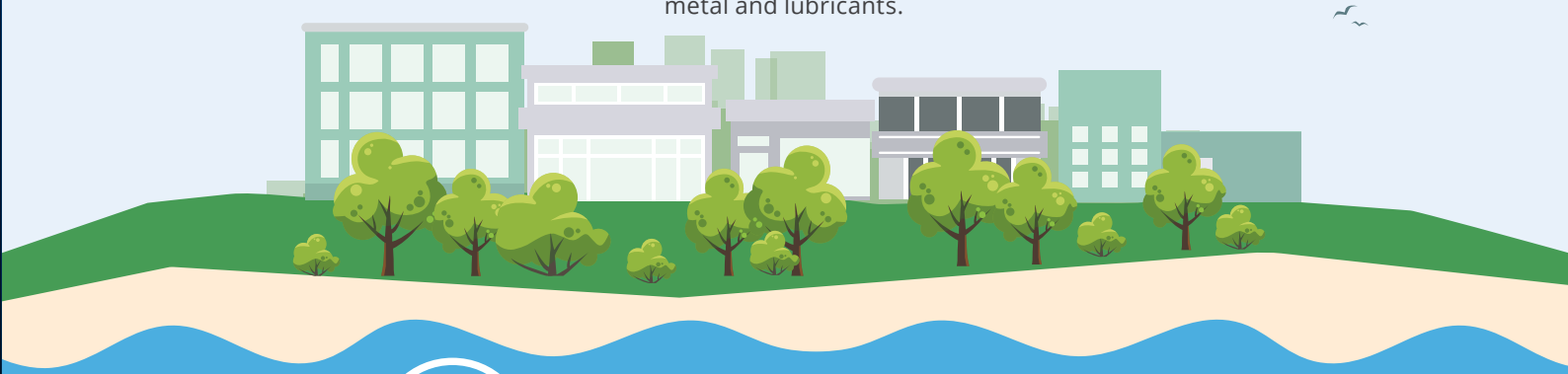
Our co-mingled recycling program continues to reduce the amount of solid waste sent to landfill. We have achieved an average reduction of 30% over the last 3 years, compared to our 2017-18 baseline.

In 2021-22 we recycled 19,300 kg of paper, cardboard and plastic products, an increase of 9% from the previous year. We continue to recycle batteries, printer cartridges, metal and lubricants.

Energy Usage

Cape Ferguson electricity usage was 6,757 MW for 2021-22. This is an increase of 7% on the previous year due to increased cooling required over the warmer and longer summer period.

Electricity production from our PV solar systems produced 1514 MW - equivalent to 1227T of carbon emission reduction.



Radiation Safety

During the year, AIMS continued to hold a source licence issued by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA).

This licence is subject to conditions including quarterly reporting, maintaining a source inventory and complying with relevant regulations, codes and standards.

Gene Technology

No new proposals for dealings involving genetically modified organisms (GMOs) were assessed by the AIMS Biosafety Committee this year.

Two projects, both involving Exempt dealings, completed during this year. AIMS now has two active dealings with GMOs. Both projects are Notifiable Low-Risk Dealings (NLRDs).

ReefWorks: the world's first marine technology testing site in tropical waters

Autonomous vessels are tested for use in rescue, surveillance and environmental monitoring

Photo: Joe Gioffre

Self-driving, or autonomous, boats are being developed to perform a wide range of marine management tasks. From monitoring and mapping to surf rescue and border patrol, the aim of this technology is to reduce human risk, environmental impact and operational costs, while increasing capability. These uncrewed systems have stringent compliance requirements for managing risks, and ReefWorks – an Australian Institute of Marine Science facility near Townsville – is providing a real-world testing site.

In 2022, ReefWorks – which is used by industry, defence, marine researchers and academic innovators – hosted several trials and demonstrations to test autonomous vehicle capabilities in a controlled environment. This included the Royal Australian Navy's Autonomous Warrior exercise that saw autonomous marine robots act on instructions from mission controllers 1800 kilometres away.

At the ReefWorks event, autonomous vessels were livestreamed to and controlled from the Navy's Jervis Bay (ACT) Autonomous Warrior command centre, using sonar to detect objects on the ocean floor and cameras to detect and identify unknown vessels that they then escorted to shore. In an Australian first, a 'swarm' permit was approved from the Australian Maritime Safety Authority for the event, allowing operators to direct a collection of vessels to work cohesively.

In other initiatives, in Australia's first significant commercial demonstration of multiple uncrewed vessels, the Trusted Autonomous Systems (TAS) Maritime showcase saw 10 uncrewed or autonomous boats participate in a static display, complete obstacle courses, avoid collisions and manage low visibility.

A next-generation smart boat, developed by James Cook University engineering students competing in the international 2022 Maritime RobotX Challenge, was also tested at ReefWorks. The RobotX Challenge required the smart boat to follow a path marked by buoys and complete various on-water and in-air activities. The teams' electric-powered Wave Adaptive Modular Vessel (WAM-V) could have several applications such as search and rescue or the observation of marine life.

ReefWorks, opened in 2021 with support from the Queensland Government, is extending Australia's capabilities in innovation in marine robotics, autonomous systems and artificial intelligence (RAS-AI). The facilities – including laboratories, workshops, wharfs and three sea test ranges with differing conditions and autonomous corridors – provide a cost-effective, safe, repeatable test environment for technology at a variety of stages, from proof of concept to operations. This will drive innovation benefitting a range of sectors including reef restoration, defence, education, filming, storm tracking, transportation, forecasting and mapping.

ReefWorks also expands Australia's capability to tackle challenges facing marine ecosystems such as coral bleaching and other effects of climate change by enhancing the capacity to monitor and respond. ■

Photo and inset: Jo Hurford

Large-scale 3D mapping brings reef complexity into focus

Photogrammetry surveys quantify the dynamics of coral growth and reef complexity in response to storms and bleaching

Photo: Marie Roman

Photo: Marie Roman

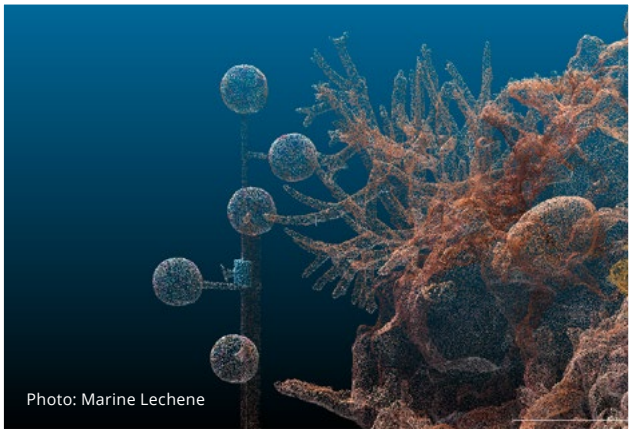


Photo: Marine Lechene

Three-dimensional (3D) photo surveys and modelling are helping scientists better understand the structurally complex physical and biological aspects that underpin healthy coral reef ecosystems.

Habitat structure provides a secure home for fish and other reef organisms. This structure is created by the healthy growth of corals and is key to resilient marine ecosystems. Consequently, any environmental change affecting the health of corals affects the structural integrity and biodiversity of a reef ecosystem.

The challenge for researchers and reef managers is having the data needed for predicting the dynamics and managing impacts on coral structures. More data is needed on the life history of corals, their growth rates in their natural environment during years without disturbances, and their growth rates during years when bleaching or storms affect them.

Other data can also determine how critical water quality and wave exposure are in changing reef complexity and recovery, or how to relate the corals' life history and 3D complexity to the vast assembly of organisms that live within it.

Ecological dynamics and functions can be measured with close-range photogrammetry, which can quantify the 3D complexity of corals and reefs across space and time. The method is labour intensive but is opening new and critical insights.

Photogrammetry techniques stitch together overlapping images collected underwater by divers, using a rig of high-resolution cameras. The merged images are processed by advanced software to create 3D reconstructions of the reef substrate. Images from different years are then compared to see changes over time.

The 3D reconstructions of reef surfaces are integrated with surveys of young corals to enable AIMS scientists to study fundamental processes in reef recovery, such as where the floating coral larvae like to settle; or how surface complexity affects the survival of new coral recruits.

The application of 3D imagery is a key part of the Ecological Intelligence for Reef Restoration (EcoRRAP). This is a research sub-program within Australia's Reef Restoration and Adaptation Program (RRAP) – a partnership of organisations working on large-scale interventions to help the reef resist, adapt to and recover from climate change and other pressures. It is also part of the AIMS Long-Term Monitoring Program (LTMP) for the Great Barrier Reef.

The 3D mapping and modelling uses innovative technologies to help reef managers meet the pressures of continued climate change and water quality, to improve the health of the Great Barrier Reef.

Funded by the Australian Government's Reef Trust Partnership with the Great Barrier Reef Foundation. ■

The crucial role of data collection over long time periods

Our long-term surveys provide detailed information on the Great Barrier Reef and how it has changed over the last 36 years

Photo: Kate Osborne

Protecting the future of the Great Barrier Reef requires detailed, ongoing monitoring to inform managers and policymakers of its condition.

The Great Barrier Reef comprises almost 3000 individual coral reefs covering an area of about 1.5 times the size of Victoria. Not surprisingly, monitoring the health of this vast ecosystem is a herculean task, and one that is vital, as the Reef is one of the most biologically rich ecosystems in the world.

Climate change impacts – such as marine heatwaves that lead to mass coral bleaching events, and ocean acidification, combined with crown-of-thorns starfish, cyclone impacts, poor water quality and coral disease – place unrelenting pressure on the overall health of the Reef.

The crucial monitoring required to inform management of these threats to the Great Barrier Reef World Heritage Area's biological integrity is the responsibility of the Australian Institute of Marine Science's (AIMS') Long-Term Monitoring Program.

Because of the Reef's vast size, it is impossible to survey every reef, so each year AIMS scientists survey a representative sample of between 80 and 130 reefs. The program has been running for 36 years and, in that time, more than 490 reefs representing a range of environmental gradients, management zones and bioregions have been surveyed.

The data collected are an essential resource for policymakers, scientists and those involved in the Reef's management and protection.

Data are gathered using manta tow surveys and fixed site surveys. Manta tow surveys involve towing researchers behind small boats to observe the condition and status around the entire perimeter of between 70 and 125 individual reefs per year. These surveys are used to identify changes in hard and soft coral cover through time, and record numbers of crown-of-thorns starfish to determine outbreak status, and numbers of coral trout and sharks. These data form the basis of the annual reef condition report.

During fixed site surveys, divers survey permanently marked sections of 70 reefs annually. These fixed site surveys provide detailed information on the reef community, including the diversity and abundance of fish and coral assemblages at low taxonomic resolution and agents of coral mortality, and how they have changed since the early 1990s.

AIMS has also introduced innovative technologies such as generating 3D models of a reef, and a machine-learning coral recognition system to gain further insights on the condition of the Reef and speed up data analysis.

The AIMS' Annual Summary Report on Coral Reef Condition for 2021/22 reported the highest level of hard coral cover in the northern and central Great Barrier Reef since monitoring began in 1986. While hard coral cover doesn't provide the full story of reef condition, it's a standard, robust measure that provides an indicator of the status and trends of reef condition.

The 2022 report emphasised that the Reef remains under pressure as disturbances are occurring more often and are more widespread, with shorter intervals between disturbances to allow recovery. However, the report also noted that recovery is possible if there is sufficient time between successive cyclones, bleaching events or crown-of-thorns starfish outbreaks.

Across the 87 representative reefs surveyed between August 2021 and May 2022, the average hard coral cover in the region north of Cooktown increased to 36% (from 27% in 2021) and to 33% in the central Great Barrier Reef (from 26% in 2021).

This increase is driven by the fast-growing Acropora corals, which are an important part of the reef community, but are susceptible to crown-of-thorns predation, coral bleaching and damage from cyclones.

Conversely, average coral cover in the southern region (from Proserpine to Gladstone) decreased from 38% in 2021 to 34% largely due to ongoing crown-of-thorns starfish outbreaks. ■

Photo: AIMS | LTMP

Photo: Jack Breedan


AIMS TENDER

Photo: Marie Roman

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