



Australian Government



AUSTRALIAN INSTITUTE
OF MARINE SCIENCE

SEASIM
NATIONAL SEA SIMULATOR

NATIONAL SEA SIMULATOR

YEAR IN REVIEW 2025



Enabled by

NCRIS
National Research
Infrastructure for Australia
An Australian Government Initiative



Acknowledgement of Country

AIMS acknowledges Aboriginal and Torres Strait Islander peoples as Australia's first scientists. We pay our deepest respects to Elders past and present, and to the Bindal people, the custodians of the land and sea Country on which SeaSim is located.

Cover: Chris Brunner

Inside cover: Marie Roman



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DIRECTOR'S OVERVIEW

Welcome to the inaugural edition of the National Sea Simulator: Year in Review. In this edition, we look back on some of SeaSim's achievements over the past 12 years and showcase our most significant achievements in 2025, recognising the vital contributions of our team and partners in advancing critical marine research.

As we reflect on the past year at SeaSim, it's clear that 2025 marked a period of remarkable growth, discovery and collaboration. SeaSim continues to evolve as a world-class research facility, uniquely positioned to support the urgent and complex research needed to understand, protect and restore Australia's marine ecosystems.

As Australia's marine ecosystems face unprecedented challenges, the Australian Institute of Marine Science has responded by opening the \$42.7 million expansion, which nearly doubled the amount of experimental space, effectively doubling our research capacity. Supported by the National Collaborative Research Infrastructure Strategy (NCRIS), this investment enables us to support a greater diversity of experimental designs and accelerate scientific research.

It underscores our commitment to remaining at the forefront of experimental capability for reef and ocean research.

Throughout the past year, SeaSim supported a wide range of impactful projects, from coral adaptation and spawning studies to impacts of emerging contaminants and climate resilience research. Each project contributes essential knowledge to our understanding and management of our vital marine resources.

SeaSim's achievements reflect the extraordinary dedication of our exceptional technical and scientific teams. Their expertise, innovation and commitment to transform complex research visions into reality ensures every experiment conducted within the facility meets the highest standards.

Credit: Sonia Warrell



Credit: Roslyn Budd



Looking ahead, I'm excited by what's to come. The challenges facing our oceans are significant, yet they are matched by the strength and determination of the scientific community we support. As we move into the future, SeaSim remains committed to providing the vital research infrastructure, expertise and collaborative environment necessary to address the critical issues facing our marine environments.

I want to extend my deepest gratitude to the Australian Institute of Marine Science (AIMS), the Australian Government's NCRIS and our research partners, collaborators and the broader the marine science community for their incredible support.

Finally, I want to acknowledge the incredible SeaSim staff whose enthusiasm, expertise and dedication are what make SeaSim a truly amazing and enjoyable place to work. Without your efforts, much of the research we support wouldn't be possible: thank you.

We hope you enjoy reading our 2025 story as much as we've enjoyed telling it.

Craig Humphrey

Director, National Sea Simulator
Australian Institute of Marine Science

“ **The challenges facing our oceans are significant, yet they are matched by the strength and determination of the scientific community we support** ”





ANNUAL SNAPSHOT

SeaSim—what makes it unique?

The National Sea Simulator is one of the world’s most advanced tropical marine experimental research aquaria and the largest facility dedicated to tropical marine systems.

Its unmatched scale, coupled with industrial-grade process automation and digital control architecture, enables researchers to precisely reproduce natural reef environments while simultaneously simulating future climate scenarios such as ocean warming, acidification, altered light regimes, nutrient loading and extreme events. This capacity to run long-duration, highly replicated, multi-stress experiments positions SeaSim at the forefront of global efforts to understand and accelerate adaptation and mitigation responses to climate change.

Located adjacent to the Great Barrier Reef at AIMS in Townsville and operating in close partnership with institutions such as James Cook University, SeaSim uniquely integrates controlled experimental systems with direct access to one of the world’s most iconic reef ecosystems.

What makes SeaSim different



Largest tropical marine research aquarium



Advanced process automation—precision and reliability



Ability to replicate real-world ocean conditions and future conditions



Proximity to the Great Barrier Reef and research institutes



Highly specialised workforce supporting operations



Collaborative operational model—staff build and operate systems



24/7 monitoring and support



Streamlined national access for all marine researchers

Its highly specialised workforce of engineers, aquarists, control specialists and experimental technicians design, build and operate bespoke experimental platforms around the clock, enabling ambitious, future-focused research programs in coral adaptation, assisted evolution, ecosystem resilience, restoration technologies and sustainable tropical aquaculture.



Credit: Chris Brunner



SeaSim by numbers (since 2014)



\$35M

initial investment

\$42.7M

Phase II investment

\$10M

Phase III investment

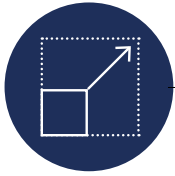


>400

experiments running from 2 to >2500 days

>300

papers, reports, theses

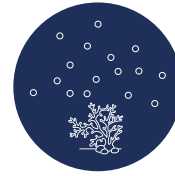


1700 to 3000m²

increased experimental spaces

28

experimental spaces 15 to 1300m²



>25

coral species spawned. >250 colonies per year, including 'out-of-season' spawning.

Studied organisms: corals, fishes, sponges, starfish, seagrass, snails, urchins, sea snakes, forams, macro/microalgae, etc.

2025 Research activity at a glance

National research infrastructure performance



29

total experiments



86

unique users



22

institutions



8

countries



14

AIMS-led experiments



15

external-led experiments

6

100% independent external experiments

International reach

Australia, Denmark, New Zealand, Netherlands, United States, Switzerland, France, China

Key partner institutions

James Cook University, University of Copenhagen, Aalborg University, University of Western Australia, University of New South Wales, Queensland University of Technology, University of Queensland, University of Melbourne, Southern Cross University



KEY ACTIVITIES

Ministerial opening

In February 2025, SeaSim reached a significant milestone with the ministerial opening of the expanded National Sea Simulator by the Hon Tanya Plibersek MP, Minister for the Environment and Water, alongside Senator Nita Green, Special Envoy for the Great Barrier Reef. The opening marked a major step forward in SeaSim's evolution as a nationally significant research infrastructure, strengthening its ability to support research that underpins the protection, management and sustainable use of Australia's marine environment.

The \$42.7 million expansion, supported by \$36.3 million through NCRIS, has nearly doubled SeaSim's experimental capacity. New infrastructure includes additional controlled indoor systems and a 1300 m² outdoor experimental area, enabling research to be undertaken at greater scale, over longer durations, and under more complex and realistic environmental conditions. These capabilities allow SeaSim to better support studies addressing climate change impacts, coral resilience, aquaculture, water quality and ecosystem responses to extreme events.

A key outcome of the expansion will be the much-anticipated launch of the National Sea Simulator Access Program. Through this merit-based scheme, a portion of the expanded facility will be made available to Australian and international researchers, fostering collaboration across academia, industry and government. By providing equitable access to world-class experimental infrastructure, SeaSim continues to enable high-impact research, support national priorities and strengthen Australia's position as a global leader in marine science.

Together, the ministerial opening and completion of the expansion represent a defining moment for SeaSim, reinforcing its role as a trusted national facility delivering long-term value for science, policy and ocean stewardship.



The \$42.7 million expansion, supported by \$36.3 million through NCRIS, has nearly doubled SeaSim's experimental capacity

Response to Townsville floods

In early 2025, widespread flooding across north Queensland displaced thousands and brought significant disruption to the region, including Townsville. While AIMS' Cape Cleveland headquarters remained physically unaffected, road access was cut off for several days due to surrounding wetland inundation. Despite these challenges, our work at SeaSim continued. Many staff transitioned to remote operations, while a small, committed team remained on site to monitor critical infrastructure and ensure the continuity of essential research.

At SeaSim, this included maintaining the highest quality seawater for our marine life and ongoing experiments, even as our nearshore intake was impacted by flood-driven fresh water and sediment.

Thanks to forward planning, robust systems and the extraordinary efforts of our team, we safeguarded both animal welfare and research integrity, exemplifying resilience in the face of natural disaster.

“ Thanks to forward planning, robust systems and the extraordinary efforts of our team, we safeguarded both animal welfare and research integrity



Credit: Kurt Pappalardo



Credit: Kurt Pappalardo





RESEARCH HIGHLIGHTS

This year's highlights included groundbreaking experiments across three areas: coral micro-volume metagenomics, naturally occurring radioactive materials, and reef restoration.

Coral micro-volume metagenomics

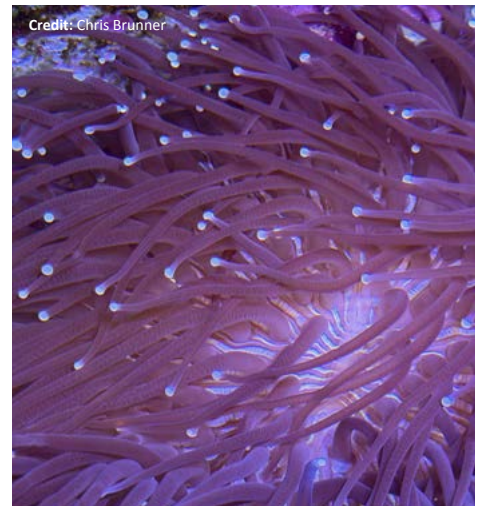
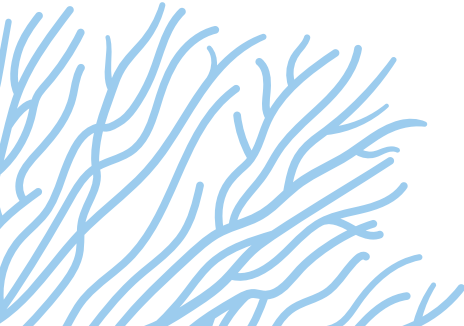
What was done: SeaSim enabled novel micro-volume sampling experiments to investigate the coral microbiome at unprecedented resolution. Researchers from the University of Copenhagen extracted DNA from extremely small samples collected directly from within coral gastric cavities.

Using microlitre-scale extractions, the team reconstructed metagenome-assembled genomes, allowing detailed genetic characterisation of bacteria living inside coral tissues rather than only on their surfaces.

Why it is new: Research on internal coral microhabitats has long been limited by technical barriers associated with low biomass sampling. SeaSim's controlled systems and ultra-low input molecular capability enabled these constraints to be overcome.

This approach provides the ability to examine microbial communities within specific coral compartments at biologically relevant scales.

Why it matters: Internal microbial communities influence nutrient cycling, stress tolerance and disease resistance. By resolving these processes more precisely, this work strengthens the foundation for targeted strategies to enhance coral health and resilience under climate change.



Naturally occurring radioactive materials

What was done: SeaSim supported a first-of-its-kind experimental assessment of ecological risks associated with naturally occurring radioactive materials (NORM) and co-occurring contaminants such as mercury linked to offshore oil and gas infrastructure.

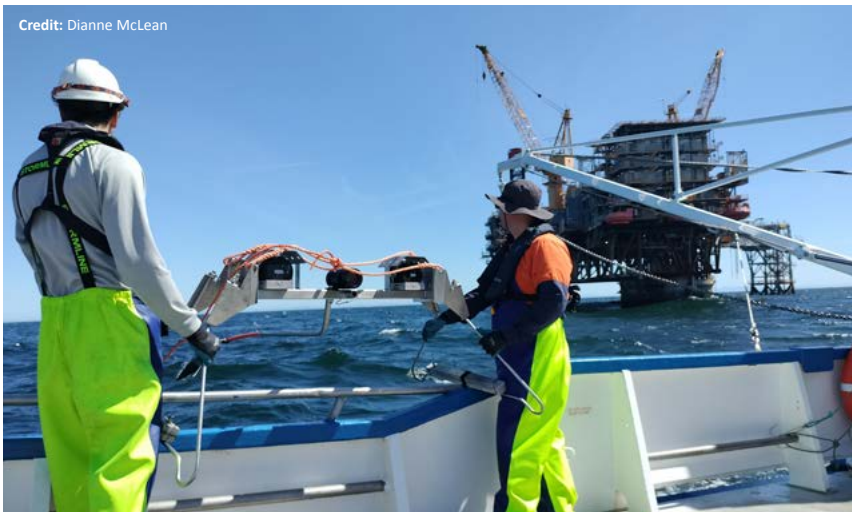
Researchers from the Australian Nuclear Science and Technology Organisation (ANSTO), working with AIMS scientists, recreated realistic decommissioning scenarios by exposing marine organisms to NORM-contaminated sediments under controlled conditions. Behavioural responses, contaminant uptake and sediment microbial changes were monitored concurrently.

Why it is new: Experimental data quantifying ecological exposure pathways for NORM have been limited. SeaSim's ability to combine controlled sediment exposure with behavioural and molecular analyses provided an integrated understanding of how radionuclides and associated contaminants interact with benthic ecosystems.

Why it matters: By generating robust experimental evidence, this research addresses a critical gap in offshore decommissioning science. The outcomes support informed, risk-based decision-making that balances environmental protection with sustainable marine management.



Credit: Marie Roman



Credit: Dianne McLean



Reef Restoration and Adaptation Program: From experimental innovation to the Pilot Deployments Program

SeaSim continued to play a central role in advancing large-scale reef restoration under the Reef Restoration and Adaptation Program (RRAP), bridging experimental research and operational deployment.

What was done: Within SeaSim's controlled systems, RRAP partners tested selective breeding of heat-tolerant corals and assisted gene flow and coral cryopreservation, shifting reef science beyond monitoring impacts toward developing practical intervention tools.

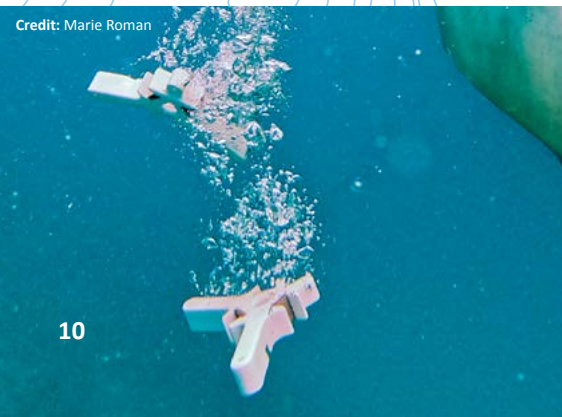
SeaSim also supported the development and validation of scalable production platforms, including automated spawning systems (AutoSpawners), Coral Spawning and Larval Incubation Containers (CSLICs), and Coral Growth and Rearing Aquaculture Systems (CGRAS). These systems were optimised under present-day and future climate scenarios.

During the 2025 spawning period, 32,580 coral settlement devices—seeded with more than 500,000 coral recruits—were produced and deployed onto the Great Barrier Reef, demonstrating restoration at unprecedented scale.

Why it is new: SeaSim uniquely combines large-scale infrastructure with fine-scale environmental control, enabling restoration technologies to be rigorously tested before reef deployment. Predictable, year-round spawning has accelerated innovation cycles and reduced technical risk. This is the first time SeaSim has used AutoSpawners, CGRAS and CSLIC at operational scale, bringing them together in an integrated, automated end-to-end production model.

Why it matters: Scaling restoration from thousands to millions of corals requires integration of biological and engineered systems. SeaSim provides the translational platform enabling this shift, strengthening the feasibility and resilience of climate-ready restoration for the Great Barrier Reef.

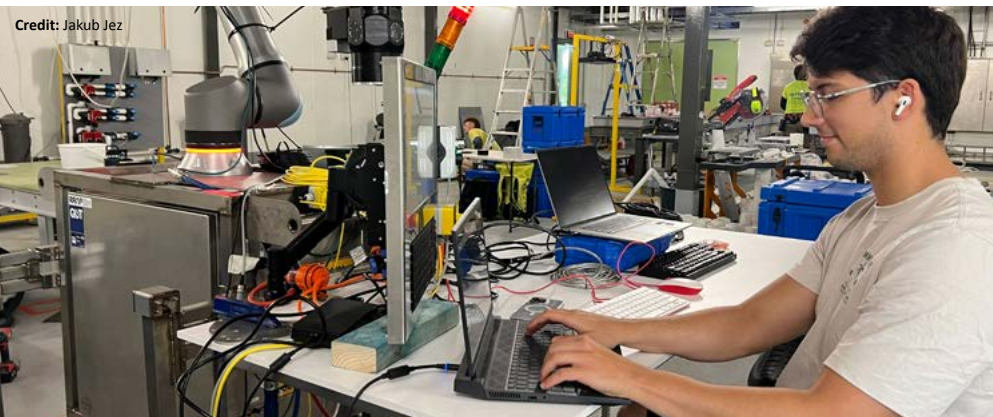
RRAP is funded by the partnership between the Australian Government's Reef Trust and the Great Barrier Reef Foundation.





Credit: Ashtyn Isaak

Credit: Jakub Jez



Credit: Marie Roman





RESEARCH IMPACT

SeaSim plays a central role in enabling high-quality research that underpins influential, peer-reviewed publications and fosters enduring scientific collaboration.

“
SeaSim provides researchers with the conditions needed to generate robust, reproducible data at scales rarely achievable elsewhere

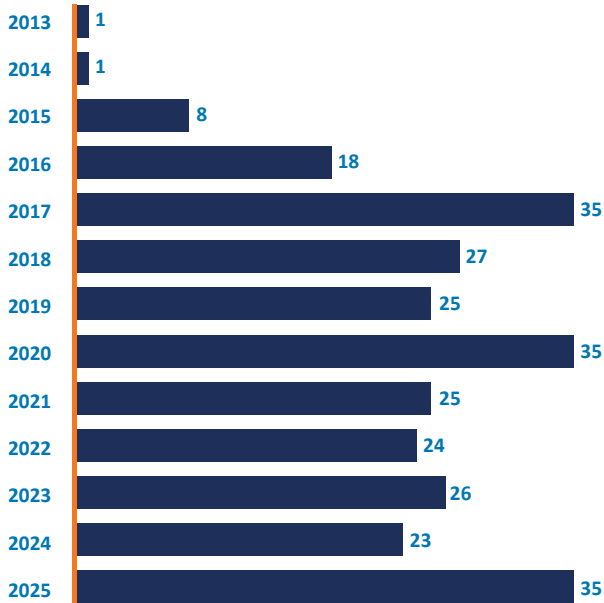
Through access to advanced experimental aquaria, highly controlled environmental systems and specialised technical expertise, SeaSim provides researchers with the conditions needed to generate robust, reproducible data at scales rarely achievable elsewhere. This integrated support model allows scientists to focus on discovery while benefiting from reliable operations, experimental consistency and long-term system stability, key ingredients for high-impact research outputs.

Between 2014 and 2025, SeaSim supported a diverse portfolio of research addressing nationally and globally significant challenges. These included probing microbial processes within coral polyps, experimentally assessing the impacts of radioactive sediments and advancing coral restoration and climate adaptation strategies. Across these projects, researchers leveraged SeaSim’s unique tropical marine infrastructure to produce new insights into ecosystem function and resilience under a changing climate.

SeaSim actively fosters collaboration across institutions and borders. Key partnerships have included Australian universities such as James Cook University, University of Melbourne, University of Queensland and University of Technology Sydney; national research agencies including CSIRO and ANTSO; and international collaborators such as the University of Copenhagen and Victoria University of Wellington. Together, these collaborations demonstrate SeaSim’s vital role as a trusted platform for world-class science, knowledge exchange and shared solutions for marine sustainability.



Annual number of publications



Between 2014 and 2025



333
publications

46
PhD and master's theses

283
peer-reviewed journal articles

Over 95%
of SeaSim publications were in the top Q1 journals.
Field weighted citation impact = 1.41.



In 2025



35
journal articles

4
PhD theses

Credit: Christian Miller



Credit: Christian Miller





Collaborations on publications



45.4%

1.41 FWCI*
international collaboration



50.4%

1.38 FWCI*
only national collaboration



3.8%

1.94 FWCI*
only institutional collaboration

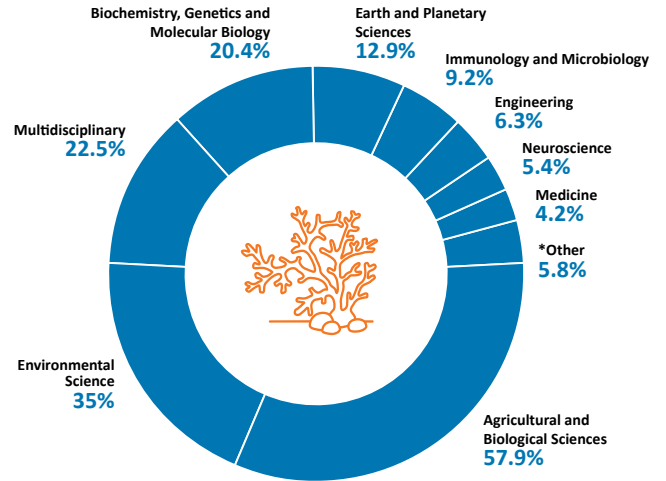


0.4%

0.21 FWCI*
single authorship (no collaboration)

*Field-weighted citation impact. Data retrieved from SciVal Jan 2026.

Subject areas of SeaSim research



Research initiatives can fall into more than one subject category

* Pharmacology, Toxicology and Pharmaceuticals (1.3%); Computer Science (0.8%); Physics and Astronomy (0.8%); Chemistry (0.8%); Chemical Engineering (0.8%); Decision Sciences (0.4%); Veterinary (0.4%); Mathematics (0.4%)

Data retrieved from SciVal Jan 2026

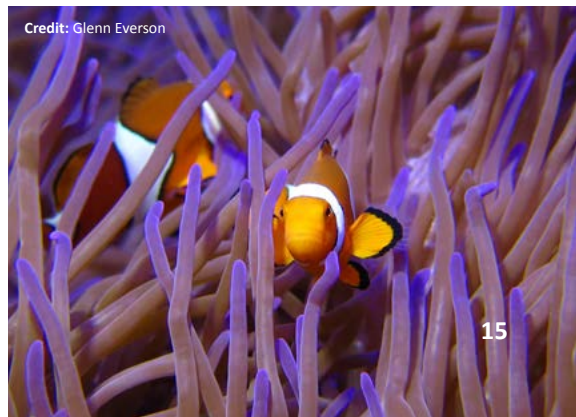




Credit: Christian Miller



Credit: Chris Brunner



Credit: Glenn Everson

WORLD AFFILIATIONS

 Author affiliations

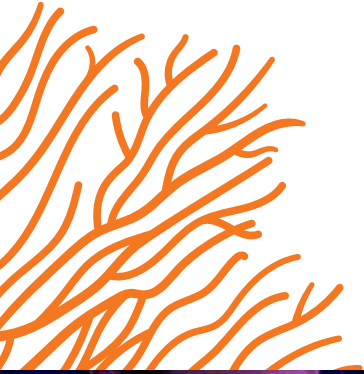
All institutions shown on this map are based on author affiliations listed in publications arising from research supported by SeaSim.





INNOVATION IN RESEARCH

Introduction of new technologies, experimental methods and their impact on advancing marine research



Marine organism phenotyping:

SeaSim is exploring integration of high-throughput bio-optical tools, including advanced imaging and active fluorescence, to establish an experimental platform for high-throughput phenotyping of corals and other reef-associated organisms. Although successfully used in plant science, this approach has not yet been applied at scale in marine research. By addressing this capability gap, SeaSim will accelerate efforts to enhance reef resilience by identifying and selecting traits linked to climate tolerance to inform coral propagation and restoration efforts.

Dissolved oxygen manipulation:

SeaSim is developing innovative experimental systems capable of replicating natural fluctuations in dissolved oxygen across a range of marine habitats, including coastal zones, mangroves, seagrass beds and coral reefs. This new capability will significantly enhance researchers' ability to investigate how marine organisms respond to interacting climate stressors such as temperature, acidification and deoxygenation. By enabling more realistic simulations of future ocean conditions, SeaSim is supporting science that informs effective management, conservation, and restoration and adaptation strategies for Australia's marine ecosystems.

Low-input molecular techniques:

SeaSim staff collaborated with researchers from Denmark and Australia to refine techniques for extracting DNA from extremely small sample volumes. This capability is key to understanding microbial processes occurring in specific parts of marine organisms, such as tissue surfaces or internal cavities, that play a vital role in organism health and resilience to environmental stress. SeaSim's laboratory spaces are now equipped for microlitre-scale DNA extraction and processing, enabling researchers to characterise previously inaccessible microbial communities and their functions.



Credit: Roslyn Budd

CORAL SPAWNING

In 2025, SeaSim supported one of its most productive coral spawning years to date, enabling large-scale larval production across multiple spawning events (Autumn and Summer).

Across key reef locations including the Palm Islands, Keppel Islands, Moore Reef, Arlington Reef and Elford Reef, hundreds of coral colonies representing multiple species were collected, resulting in the production of more than 18 million larvae and the successful settlement of millions onto tiles and deployment devices.

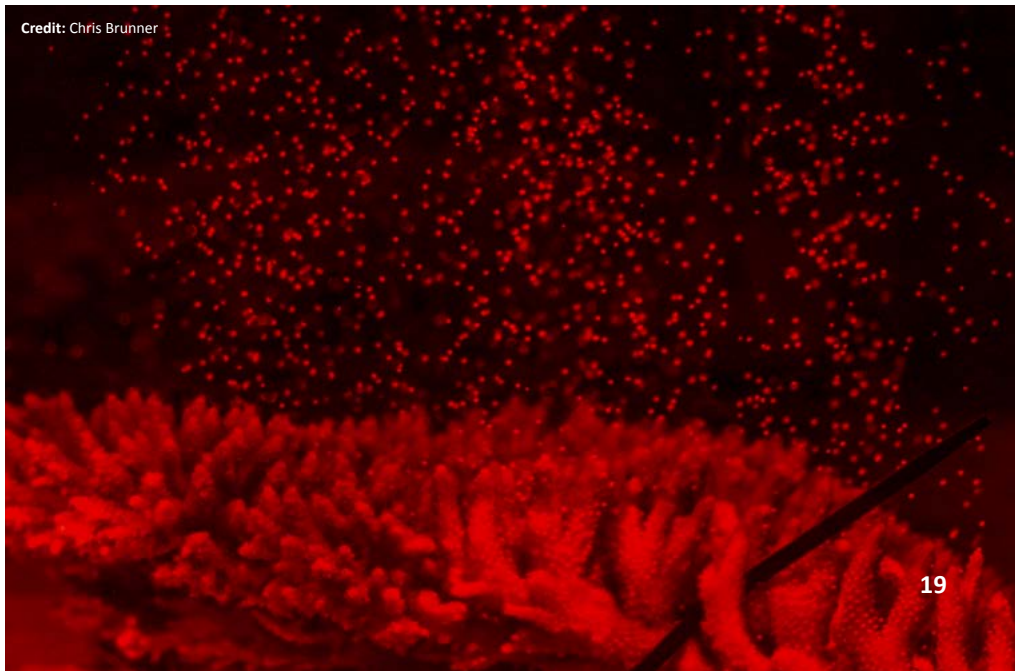
These spawning efforts supported more than 15 research and restoration projects, underpinning advances in selective breeding, larval enhancement technologies and scalable restoration systems—demonstrating SeaSim’s critical role in moving coral restoration from experimental trials toward operational deployment at reef scale.

Aquarists from SeaSim were also able to successfully induce ‘out-of-season’ coral spawning for the fourth consecutive year. The team has used advanced capabilities to manipulate seasonal patterns in temperature, day length and moonlight to induce out-of-season coral spawning six months before natural reef spawning events. In 2025, there were 30 colonies successfully spawned out of season from six different species.

Credit: Marie Roman



Credit: Chris Brunner





2025 coral spawning season

November–December performance summary

317

colonies collected

19.1M

larvae produced

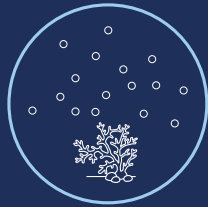
6.1M

larvae settled

32,580

ready for in-field deployment

November



Collections:
177 colonies

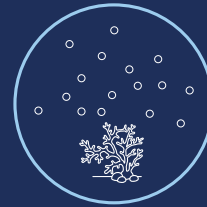
Sites:
Palm Island and Keppels

Larvae produced:
~12,000,000

Larvae settled:
~2,341,000

Devices deployed:
16,434

December



Collections:
140 colonies

Sites:
Moore, Arlington and Elford Reefs

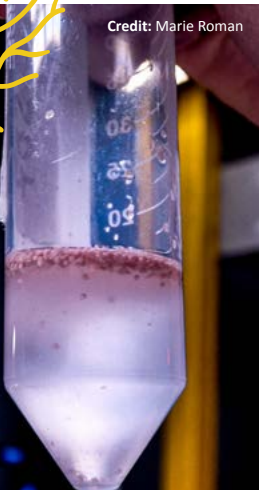
Larvae produced:
~7,124,000

Larvae settled:
~3,799,030

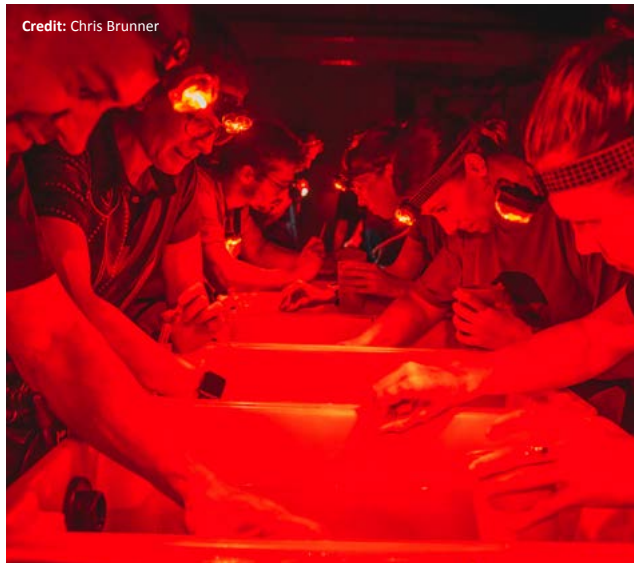
Devices deployed:
16,146

Technology integration: additional AutoSpawners, Coral Spawn and Larvae Imaging Camera System (CSLIC) and Coral Growout Assessment System (CGRAS) systems deployed for enhanced automation

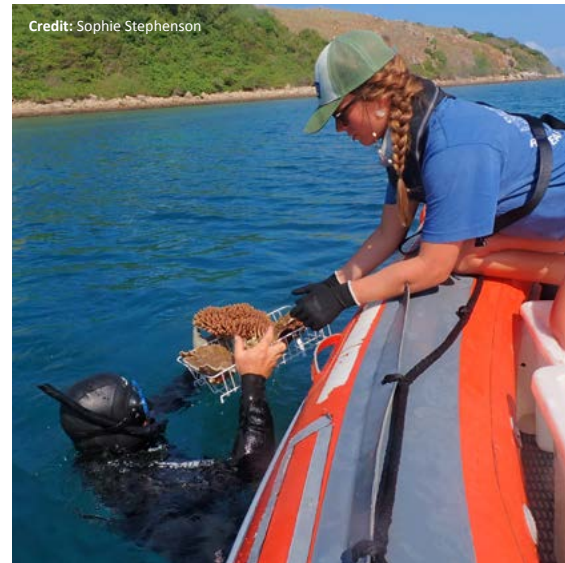
Credit: Marie Roman



Credit: Chris Brunner



Credit: Sophie Stephenson





Credit: Amanda Tuimalealifano



Credit: Anton Rocconi



Credit: Marie Roman



FUTURE OUTLOOK

SeaSim expansion: Continued facility development and expected operational upgrades

With the major expansion now complete, SeaSim's focus shifts from construction to optimisation. Over the coming year, priority will be placed on refining operational workflows, embedding new systems and ensuring the expanded infrastructure delivers maximum research efficiency and reliability.

Looking ahead, further developments are already in progress. Design work for upgraded seawater intake systems is advancing, with construction scheduled to commence in 2027. Planning is also underway for a dedicated biosecurity facility, expanded coral symbiont culture capability, and additional workspace to support a growing technical and scientific workforce.

These enhancements will strengthen SeaSim's long-term capacity to support increasingly complex, large-scale and climate-focused research programs.

Strategic priorities: National facility implementation

Over the next 12 months, SeaSim's strategic priorities will focus on establishing the foundations of its role as a nationally accessible research infrastructure aligned with AIMS Strategy 2040 and NCRIS objectives. A key emphasis will be on actively engaging with Australian marine researchers to provide clear, efficient and equitable access to the facility through transparent merit-based processes, supported by strong governance via the Advisory Committee and Science Evaluation Group. Strengthening national awareness, simplifying access pathways and building collaborative relationships will be central to positioning SeaSim as a trusted partner in experimental marine research.

Over the five-year horizon, priorities will shift towards capability maturity, deeper national and international collaboration, and demonstrable scientific and societal impact. This includes expanding partnerships, strengthening workforce capability and delivering research aligned with climate resilience, restoration, coastal futures and the blue economy. Collectively, these efforts will reinforce SeaSim's role as a cornerstone of national research infrastructure and a key contributor to AIMS' long-term strategic goals.

Credit: Christian Miller



Credit: Christian Miller



USER SUCCESS STORY

PROJECT:

What's really causing coral bleaching?

RESEARCHERS:

**Ashtyn L Isaak, Holly Koch
(PhD candidates) and
Dr. Christopher Cornwall**

INSTITUTION:

**Victoria University of Wellington,
New Zealand**

DURATION:

Eight weeks

As part of her PhD, Ashtyn Isaak travelled from Wellington, New Zealand, to SeaSim in Townsville, Queensland, to investigate the drivers of coral bleaching under climate change.

The study tested how multiple stressors—ocean warming, acidification and high light—interact to influence bleaching in two coral species (*Acropora millepora*, *Porites lobata*) and two crustose coralline algae (*Titanoderma* sp., *Porolithon onkodes*).

“SeaSim is a truly outstanding place to conduct experimental research. The facilities are world-class, and every aspect feels intentional—making the work incredibly efficient and researcher-focused. The support team is exceptional, and having round-the-clock technical expertise makes complex experimental work both efficient and seamless.” — Ashtyn Isaak

Study at a glance

- Three climate drivers: temperature, light and ocean acidification
- 36 experimental tanks, 12 treatments, 400+ samples
- They measured the photosynthetic efficiency of the symbiotic algae within the coral (pulse-amplitude modulated fluorometry), coral reflectance for pigment loss and bleaching (normalised difference vegetation index reflectance), the coral's ability to create calcium carbonate skeleton at various pH levels (Raman spectroscopy) and gene expression under stress (transcriptomics)

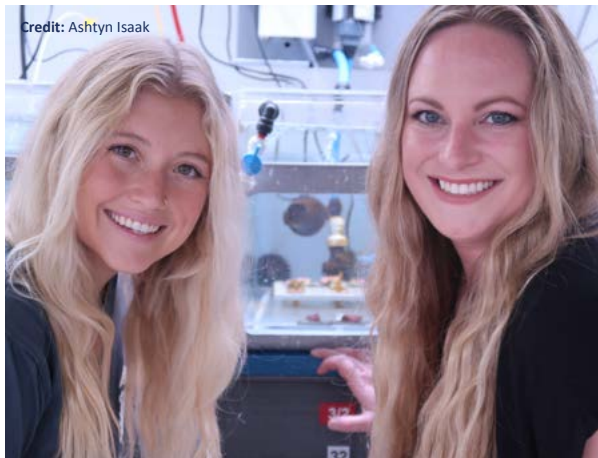
Why the researchers chose SeaSim:

SeaSim enables researchers to tackle complex environmental questions at scale, with precise control of temperature, light and seawater chemistry—replicating real-world climate change conditions.

Collaboration and support:

From experimental design to execution, Ashtyn's project was supported by SeaSim's research, coral husbandry and collections teams, backed by 24/7 technical support.

Researcher experience: Running a multi-factor experiment over eight weeks requires precision, reliability and constant monitoring. SeaSim's infrastructure and expert teams enabled the project to run smoothly from start to finish.





ACKNOWLEDGEMENTS

Our thanks to staff, researchers, partners and stakeholders

SeaSim's success in 2025 is a direct reflection of the outstanding people behind the science. Our dedicated technical and support teams have gone above and beyond to ensure the smooth operation of a complex, high-capacity facility. Their attention to detail, innovation and care provide the foundation for world-class science.

We extend our deepest appreciation to the researchers, both resident and visiting, who bring vision, perseverance and curiosity to SeaSim. Your work drives the future of marine science and reef restoration.

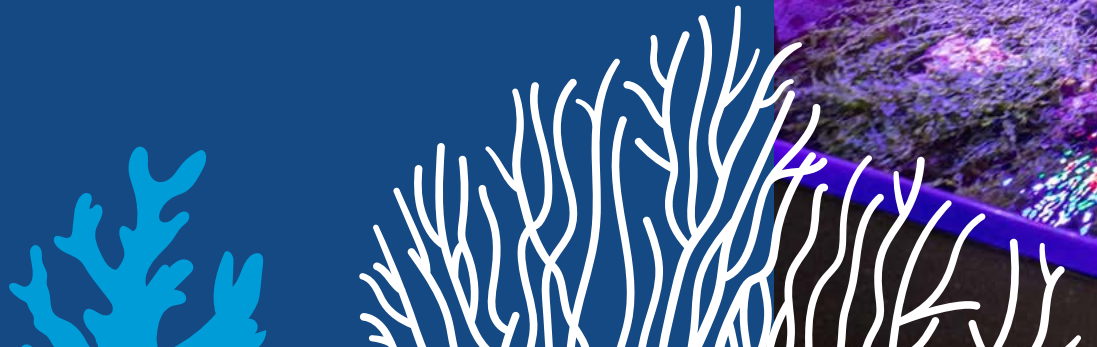
We also acknowledge the contributions of our partners and stakeholders, whose engagement, expertise and shared commitment continue to shape the direction and impact of our work. Your collaboration makes SeaSim not just a facility but also a thriving community of practice and discovery.

Acknowledgment of funding sources, governmental support and key collaborators

The achievements highlighted in this report would not be possible without the continued investment from the Australian Government through the National Collaborative Research Infrastructure Strategy (NCRIS), and the unwavering support of the Australian Institute of Marine Science (AIMS).

We are especially grateful for the significant funding that enabled the \$42.7 million Phase II expansion, of which \$36.3 million was provided through NCRIS. This investment will serve generations of marine researchers and further enhance SeaSim's global role in addressing the challenges facing our oceans.

We acknowledge the contributions of our national and international collaborators. Together, we are building knowledge, shaping policy and accelerating solutions for Australia's marine future.





Townsville

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