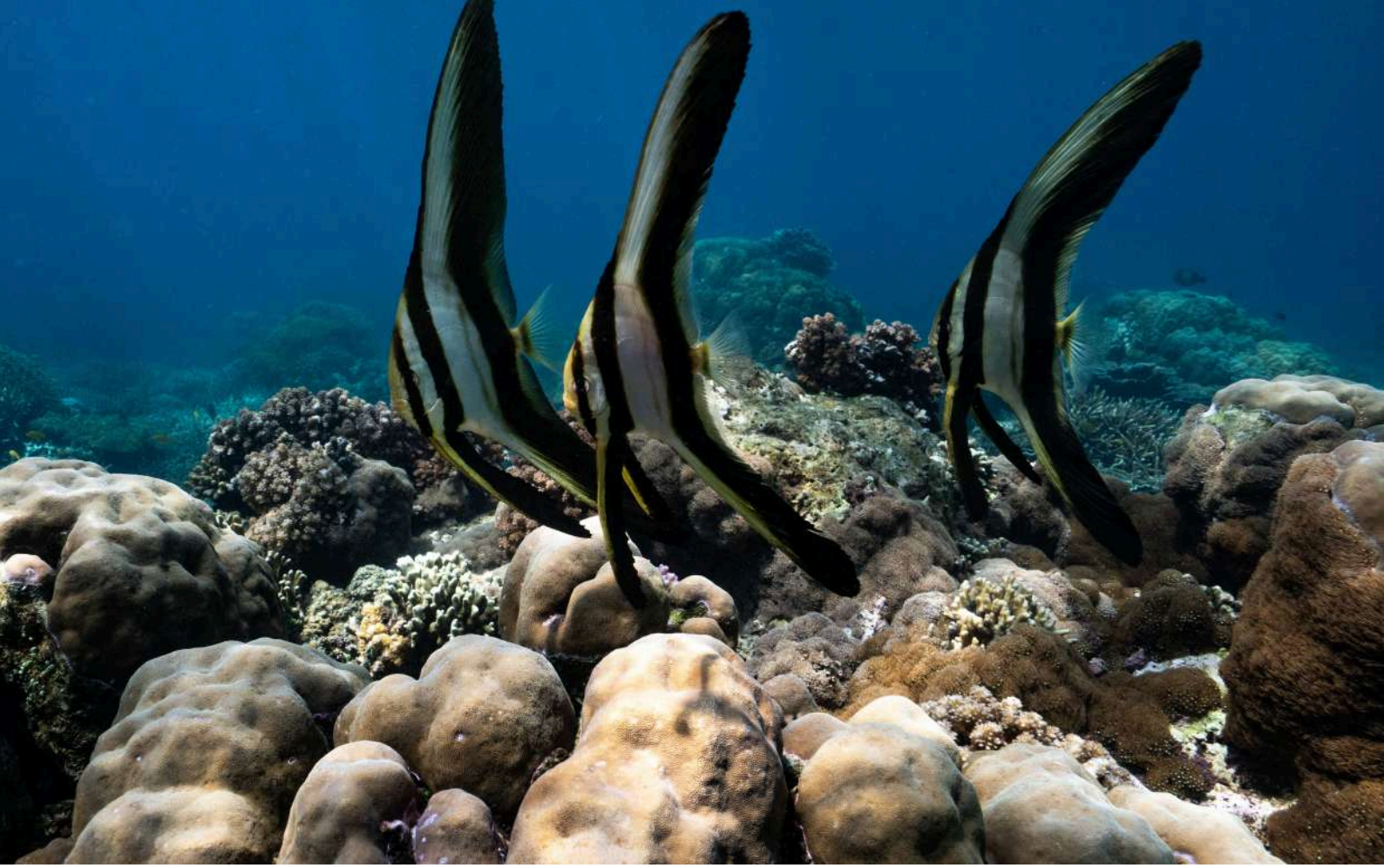
2025 OUTLOOK REPORT

INSTITUTE FOR MARINE RESEARCH

DAUIN · PHILIPPINES



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This report, along with a range of information about IMR, is available online at www.institutemarineresearch.org

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Prepared for the
Dauin Local Government Unit

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A MESSAGE FROM THE DIRECTORS

As we reflect on another remarkable year at the Institute for Marine Research (IMR), we are incredibly proud of how far our organization has come and the impact we continue to make within marine conservation, education, and community engagement.

This year marked a major milestone for IMR as our Co-Director, Dr Chelsea Waters, successfully completed her PhD — an achievement that reflects the dedication to scientific excellence and research-driven conservation that defines our organization. Her accomplishment strengthens IMR's growing capacity to contribute meaningful marine science both locally and internationally.

Over the past year, IMR has continued to grow in both scope and reach. We have expanded our educational initiatives, strengthened our research programs, and welcomed an increasing number of students, volunteers, and collaborators into the IMR community. One of the highlights of the year has been the continued development of the Reef Rangers Initiative — a program that empowers young women through marine conservation, leadership, and dive training opportunities. Seeing the confidence and passion of the Reef Rangers grow has been one of the most rewarding aspects of our work.

We were also proud to launch the ONE International Afterschool Program, creating new opportunities for young learners to engage with marine science and conservation through hands-on education and environmental stewardship. Inspiring the next generation remains central to IMR's mission.

Academically, 2025 was another strong year for research mentorship at IMR, with eight Master's students conducting research projects through the institute. Supporting emerging scientists and facilitating impactful field research continues to be a core pillar of our work. IMR also embarked on an independent study assessing the effectiveness of macroalgal removal as an intervention technique towards encouraging higher coral settlement rates following spawning events. We hope to have this manuscript accepted into a journal towards the end of 2026.

Our partnerships have also continued to strengthen. This year, we were excited to collaborate with Liquid dive resort and Atmosphere resorts & spa to support the Divemaster Program, helping bridge professional dive training with marine conservation and research experience.

None of this would be possible without the support of our staff, students, partners, volunteers, and local community. Together, we are building a future where marine conservation is driven not only by science, but by education, collaboration, and opportunity.

Thank you for being part of IMR's journey.

Rafael Manrique & Dr Chelsea Waters

IMR in Numbers (2025)

62

***Acanthaster* spp. Culling Dives in 2025**

8

***Drupella* spp. culling dives in December 2025 following LGU approval to begin controlling the population**

40

FRAGS maintenance dives to support coral growth

38

Surveys conducted for the Dauin long-term reef monitoring project

18

Dive Against Debris dives to remove ocean trash

156

days required to analyse footage for the 2025 Dauin LTRMP dataset

6

Reef Rangers from the Bata ng Calabnugan orphanage certified to PADI Advanced Open Water

26

Students from ONE International trained in marine science topics

59

resort guests from Atmopshere Resorts & Spa supporting coral outplanting efforts

28

PADI professional divers created

8

Master's students conducted independent research projects

43

Research Assistant's trained in IMR's monitoring methods

INSTITUTE FOR MARINE RESEARCH

DAUIN · PHILIPPINES

DAUIN LONG-TERM REEF MONITORING PROJECT

Research Methodology

Dauin Long-Term Reef Monitoring Project (LTRMP)

The Dauin LTRMP was established in **February 2019** with the purpose of tracking fine-scale changes in the overall reef community over time. To do this, IMR has collected high quality data for conservation management using the following research techniques:

1. Diver-Operated Stereo Video System (DO-SVS)

2. Structure from Motion (SfM) Photogrammetry

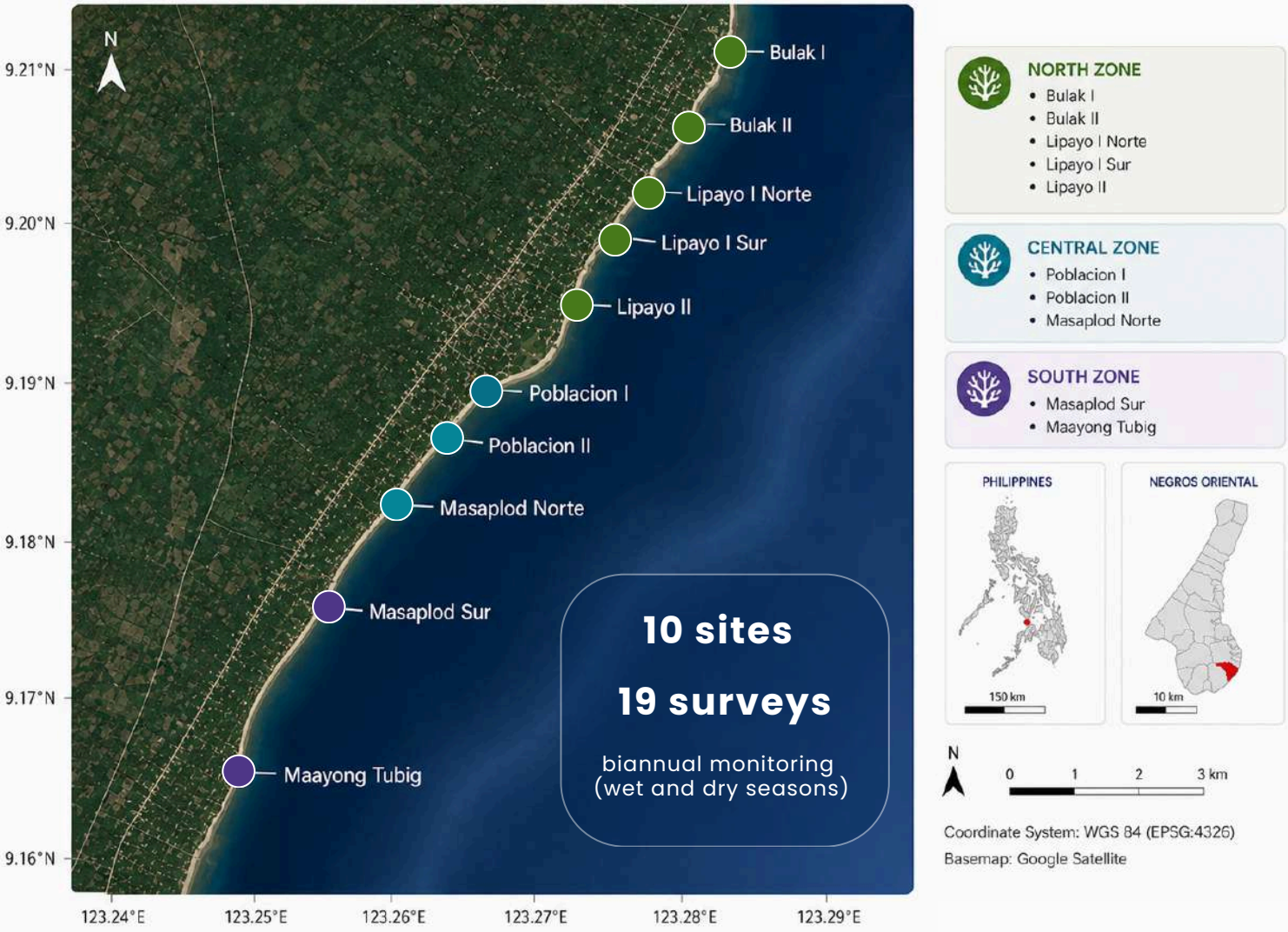
3. Benthic Community Composition

4. Coral Larval Supply & Natural Recruitment Events

5. Drivers of Coral Mortality

Survey Sites

The Dauin LTRMP covers **10 sites** of protected and non-protected area status. **19 surveys** are conducted within these sites, across permanently tagged areas of the reef. Surveys are conducted biannually (wet and dry seasons).



Benthic Assays

Surveys of sessile benthic organisms were conducted via capturing images along a transect line using a GoPro camera held approximately 0.5 m above the substrate: one image per 1 m interval, totalling 50 images per 50m transect.

METHOD

- GoPro camera ~0.5 m above substrate
- 1 image per 1 m interval
- 50 images per 50 m transect

ANALYSIS TOOL

- **ReefCloud** software (reefcloud.ai)
- 30 randomly distributed points analysed per image
- Machine learning classification + expert verification
- Significantly reduces manual processing time whilst maintaining high accuracy

OUTPUT

- Percent (%) cover of categories:
  1. Indo-Pacific coral genera
  2. Octocorals
  3. Macroalgal genera
  4. Rubble & binding organisms
- Data used to determine spatio-temporal changes in Dauin's reef

Reef Impacts & Coral Mortality

The SCUBA search was designed to provide a more detailed picture of the causes and relative scale of coral mortality.

SURVEY DESIGN

50 m transect
2 m belt (1 m either side of the transect)

Transect width
100 m²

Observers record presence of key stressors:
Acanthaster spp, *Drupella* spp., coral bleaching, coral disease, physical damage, trash (fishing, general).
100 m²

Photographs of impacted colonies
Taken using an Olympus TG-6 camera with a ruler for scale. Frame used to measure affected areas (cm²) with ImageJ software.

Diver-Operated Stereo Video System (DO-SVS)

Fish surveys were conducted using a DO-SVS compromised of two GoPro 10 Black cameras. EventMeasure V5.25 (SeaGIS, Melbourne, Australia) was used to synchronize SVS footage, calibrate camera measurements, and measure fish encountered along the transect. EventMeasure resolves centre points of each individual fish encountered into distances on a three-dimensional coordinate system).

SYSTEM
DO–SVS with two GoPro 10 Black cameras

TRANSECT
50 m transect parallel to reef crest

CAMERA ANGLE
Angled ~20° downward

CAMERA HEIGHT
50 cm above the substrate

DURATION
4 minutes (+/- 30 seconds)

From Field to Analysis

Diver Operated Stereo Video System

EventMeasure (SeaGIS, V5.25)

EXCLUSION ZONES
Fish outside 2.5m of the transect were excluded from analysis to maintain a consistent survey belt along the transect.

SIZE MEASUREMENTS
For fish visible in both cameras, measurements were obtained. For those only seen in the left camera, a point identifying the fish to species level was recorded.

SPECIES IDENTIFICATION
Fish encountered were identified to species level. The genus name was used when species-specific identification was not feasible.

For points where length measurements were not possible, the mean length for the species recorded at the same depth and survey site was used. Length at first maturity of all recorded fish species (where available) was obtained from FishBase.

3-Dimensional Reef Modelling

Structure from Motion (SfM) Photogrammetry

On tropical coral reefs, structural complexity has been shown to be a major driver of productivity, biodiversity, and overall functionality of reef ecosystems. To understand more precisely the nature between structural complexity and reef health, we use 3-Dimensional (3D) Modelling as a tool to quantify topography, rugosity and other structural characteristics that play an important role in the ecology of coral reef communities. This 3D reconstruction of reef structure and complexity becomes integrated with other physiological and ecological parameters to improve monitoring of the health and function of coral reef ecosystems in the Philippines, whilst providing a visual view of complexity change to IMRs partnering coastal managers.

EXAMPLE ORTHOMOSAIC (TOP VIEW)

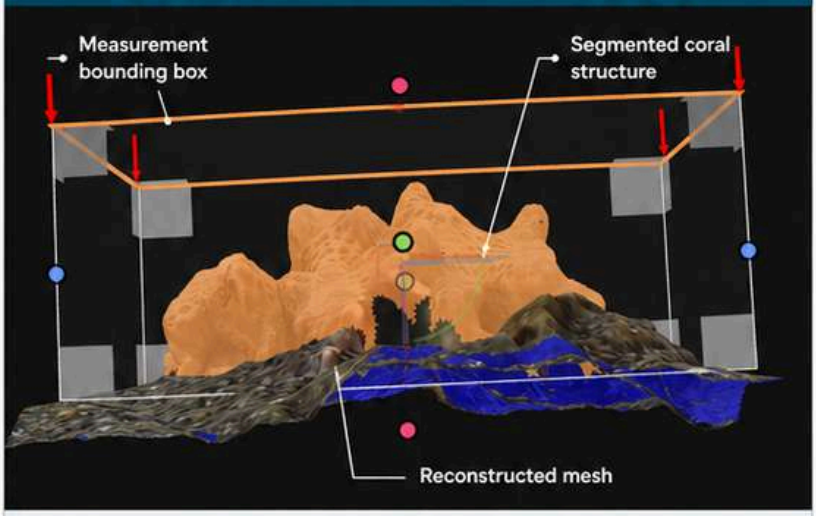
Top-down orthomosaic of the transect used for recruit detection and subsequent 3D model generation.

Coral Larval Supply & Natural Recruitment Events

The ability for coral populations to recover post-disturbance is highly dependent on patterns of reef connectivity, with the interchange of larvae among reefs supporting the recovery of disturbed reefs at varying distances from larval source reefs.

IMR monitors the recruitment, mortality and net turnover of juvenile corals (<5cm) arriving into Dauin's reefs using 3D-modelling techniques. These techniques allow us to monitor volumetric growth, alongside determining the bottlenecks towards succesful recruitment.

3D MODEL SEGMENTATION (VOLUME EXTRACTION)



Example of a reconstructed coral recruit model used to derive volumetric measurements from photogrammetry outputs.

METADATA

Before every survey dive, the following environmental and human activity data was recorded:

ENVIRONMENTAL DATA

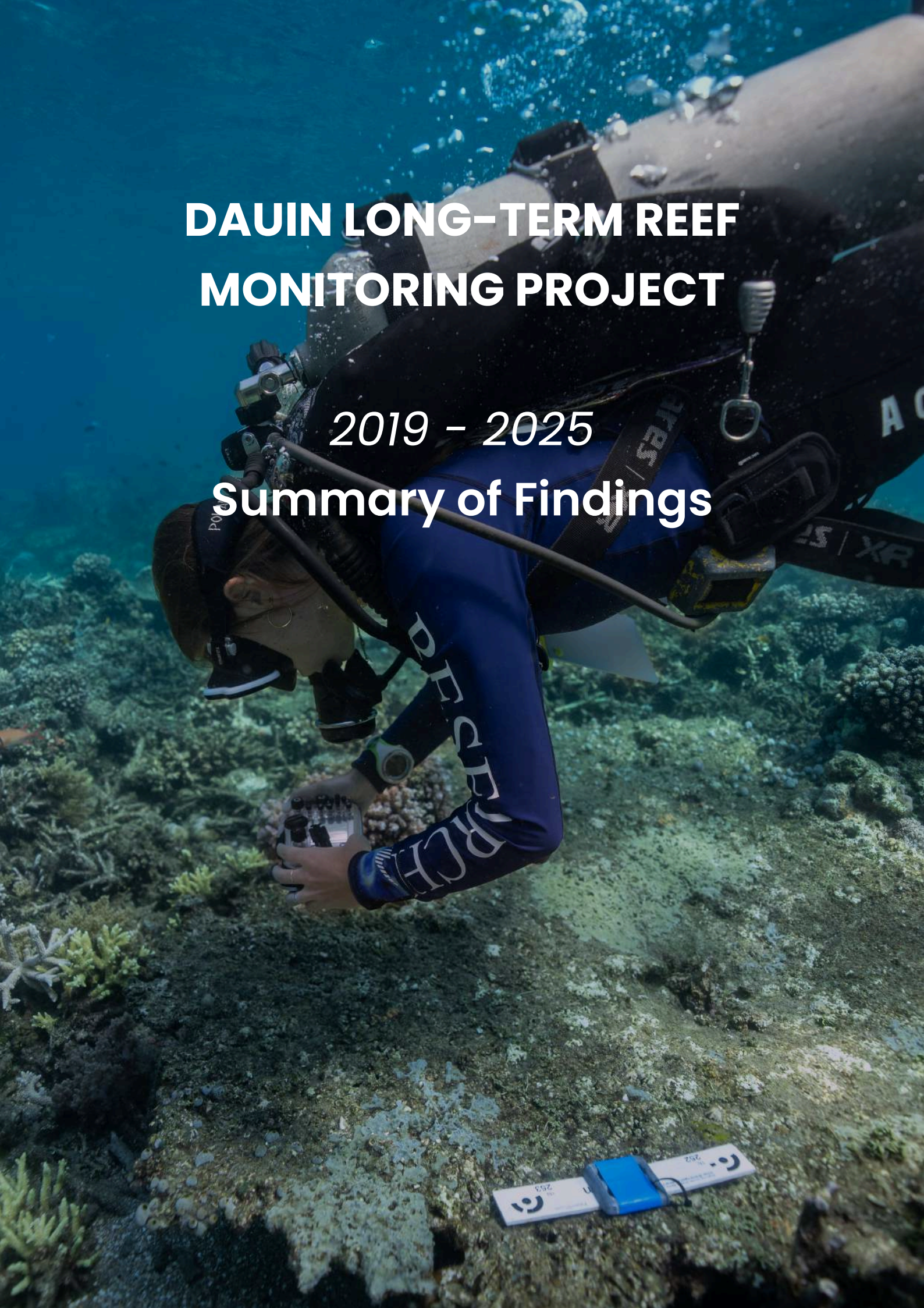
- Air temperature
- Wind speed
- Tidal state
- Sea state

HUMAN ACTIVITY DATA

- Boat activity (number of fishing and diving boats present

USE

This data can be used in conjunction with any other data collected when needed.



DAUIN LONG-TERM REEF MONITORING PROJECT

2019 - 2025

Summary of Findings

2019 - 2025

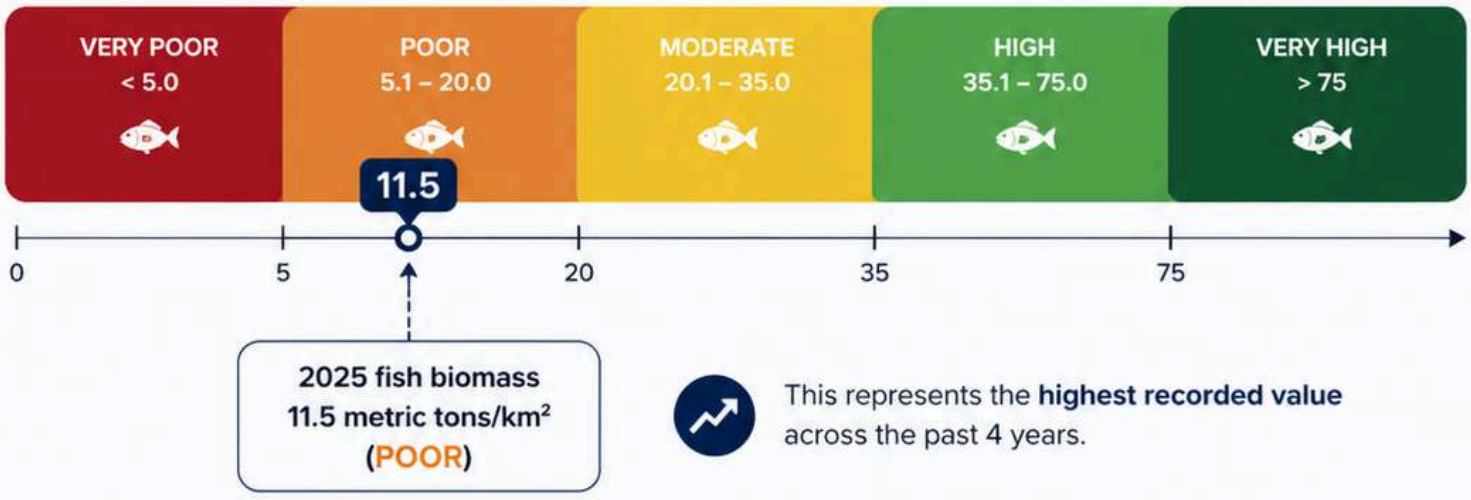
FISH POPULATION DYNAMICs

Fish Biomass (metric tons/km²)

- Fish biomass herein refers to the combined weight of the fish community within IMRs long-term reef monitoring sites, and is expressed as metric tons per km²
- Fish biomass data is collected by calculating the length of each fish species recorded and estimated using the equation:

$$W = aL^b$$

Where:
W = weight (metric tons)
L = length (cm)
a, b = species-specific constants



Fish Biomass (Trophic Guilds)

- **Fish & cephalopod predators (FisCep)** continue to be the dominant source of fish biomass (g/ha) within the reef associated system of Dauin (Fig 2). Whilst this has been achievable despite a low population abundance (ind./ha, Fig 4), this group remains critically sensitive to fishing pressure.
- **COVID-19** saw a significant decline in the biomass of FisCep species between 2020-21, with a two-fold recovery in FisCep biomass occurring between 2021-25.
- Based on current recovery trajectories, **it will take another 4-yrs for the FisCep population to return to 2020 levels.**

HIGHEST BIOMASS IN 4-YEARS
11.5 metric tons/km²

CURRENT CLASSIFICATION
POOR
5.1 - 20 metric tons/km²

RECOVERY TREND
POSITIVE
Continuing 2021-25 recovery trajectory.

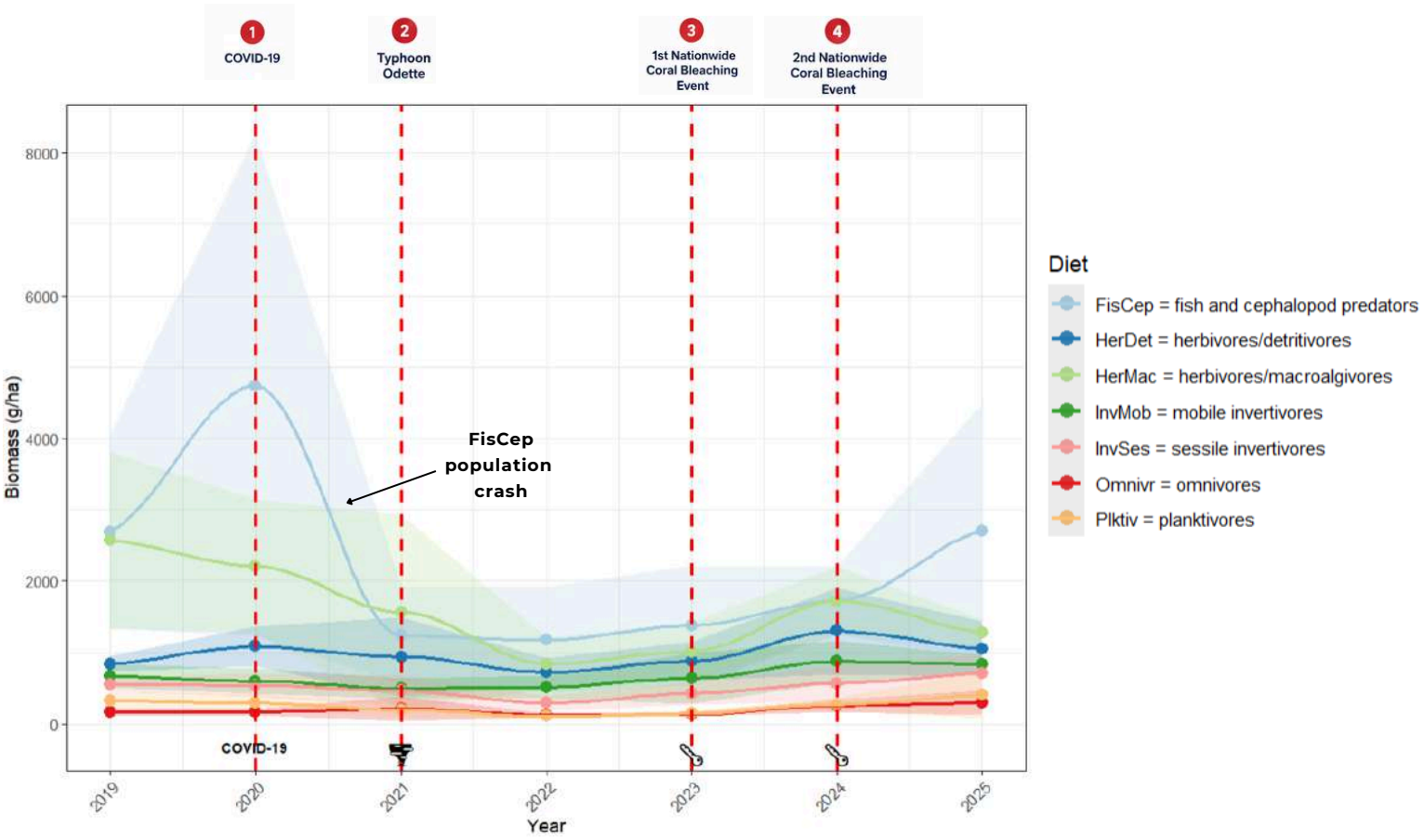


Figure 2. Fluctuations in fish biomass (grams per hectare) among trophic guilds across a 7-year timeframe. Four major disturbance events have been included; COVID-19, Typhoon Odette, and two nationwide coral bleaching events.

DISTURBANCE EVENTS TIMELINE

1 COVID-19

2020

COVID-19 pandemic impacted Marine Protected Area surveillance.

2 Typhoon Odette

2021

Severe tropical cyclone caused physical damage to reef habitats.

3 1st Nationwide Coral Bleaching Event

2023

Elevated sea temperatures recorded nationwide. Dauin remained unaffected.

4 2nd Nationwide Coral Bleaching Event

2024

Elevated sea temperatures recorded nationwide. Dauin remained unaffected.

KEY TAKEAWAYS

The **COVID-19** pandemic resulted in a sharp delcine in fish biomass in 2020.

Typhoon Odette in 2021 continued to suppress biomass recovery in most dietary groups.

Biomass is beginning to recover despite **two nationwide coral bleaching events** in 2023-2024.

Fish Density (Abundance/km²)

- Fish density refers to the number of fish recorded within IMRs long-term reef monitoring sites, and is expressed as count per km².

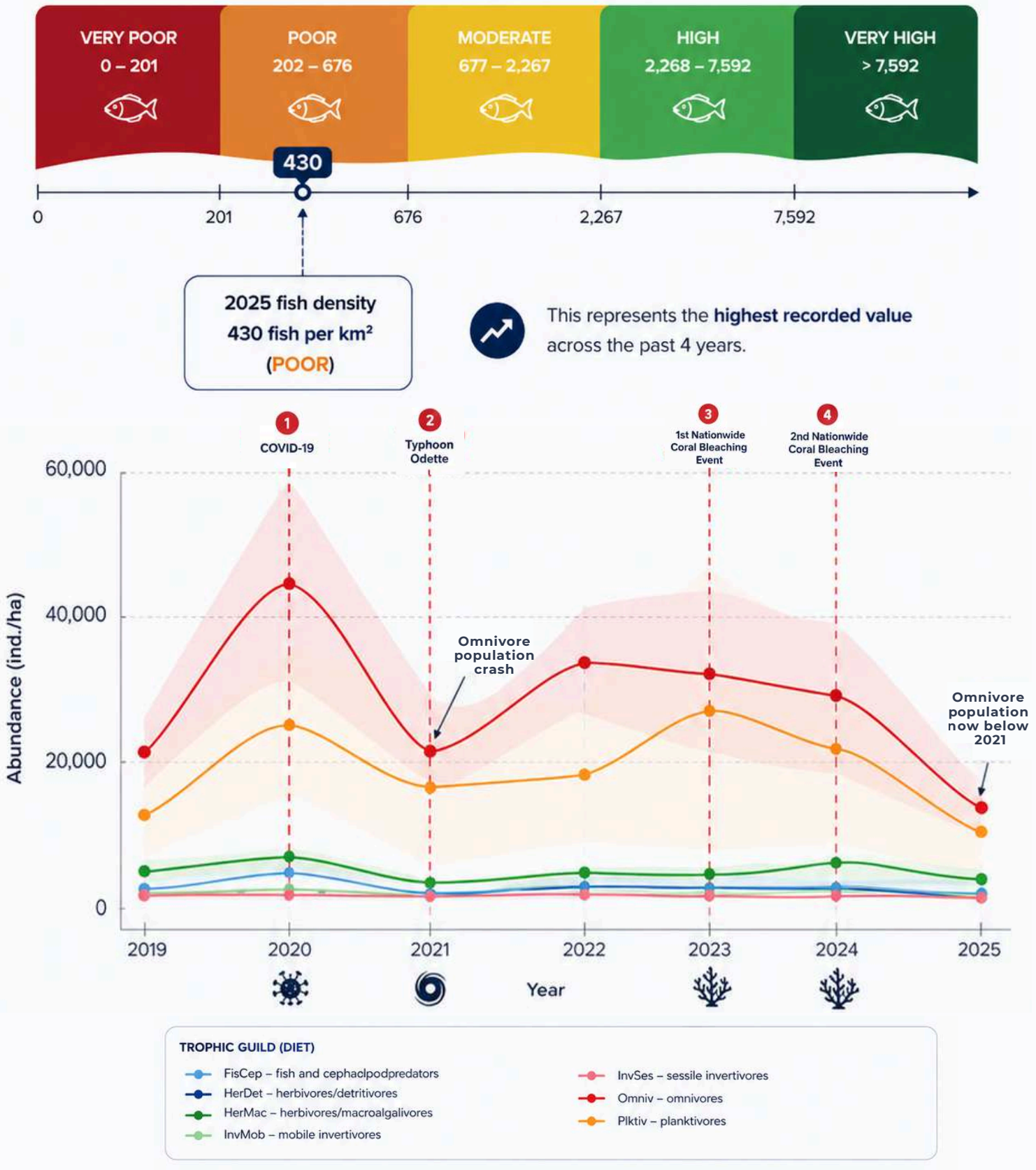


Figure 3. Fluctuations in fish density (individuals per hectare) among trophic guilds across a 7-year timeframe. Four major disturbance events have been included; COVID-19, Typhoon Odette, and two nationwide coral bleaching events.

Fish Density (Trophic Guilds)

- Omnivorous fish continue to provide the highest fish density to Dauin's reef, followed by planktivorous fish
- As a result, these fish population are also vulnerable to fishing pressures, being the most available on the reef.
- COVID-19 saw the first major decline in the ominovorous fish population, with 2025 levels now below those in 2021.

KEY INSIGHT

Omnivorous fish continue to provide the highest fish density to Dauin's reef, but their population has declined since 2020 (with a small recovery window observed in 2022). As of 2025, levels are now **below** those observerd in 2021.

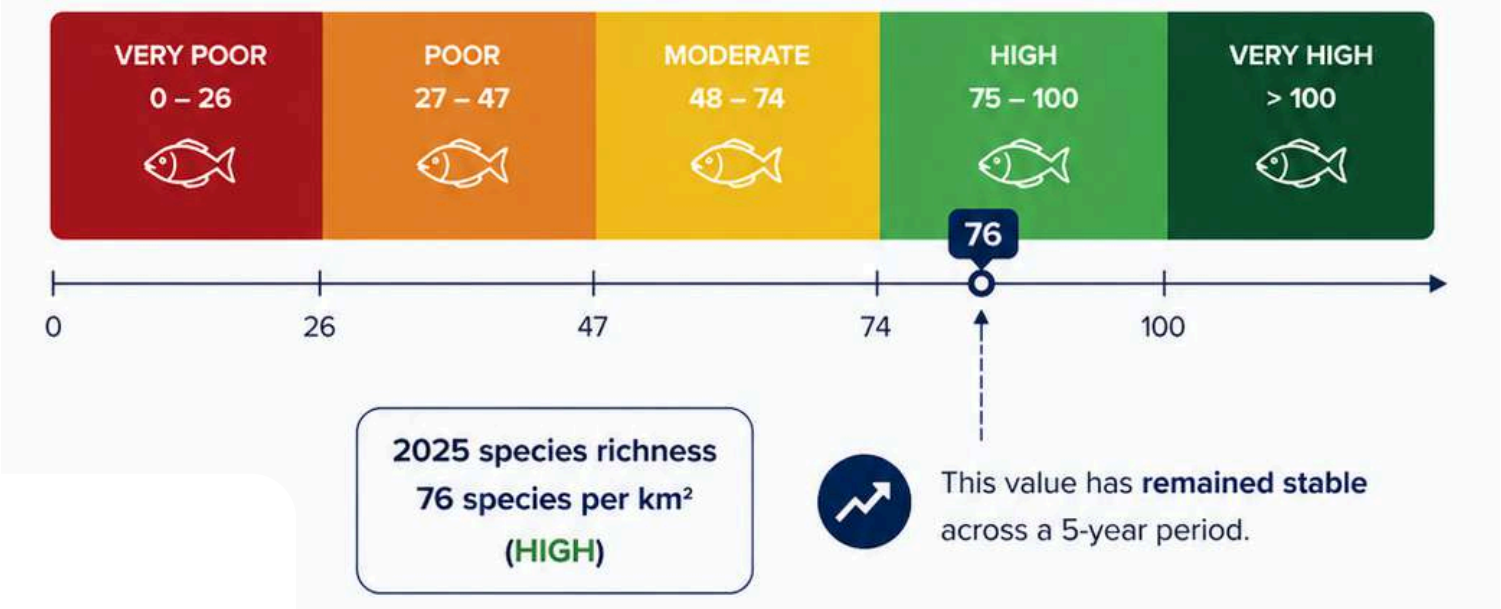
HIGHEST DENSITY IN 4-YEARS
430 fish per km²

CURRENT CLASSIFICATION
POOR
202 - 676 fish per km²

RECOVERY TREND
POSITIVE
Continuing 2021-25 recovery trajectory

Species Richness (species/km²)

- Fish species richness refers to the number of fish species recorded within IMRs long-term reef monitoring sites, and is expressed as count per km²
- The number of fish species identified via IMRs long-term monitoring surveys is considered **HIGH**, with this value remaining stable between 2020 - 2025.



Fishing Pressure

- All fish species recorded in the Dauin LTRMP have been assigned into four categories of fishing vulnerability as guided by FishBase (**Table 1**).
- Fish species of '**Very High**' fishing vulnerability have been on the decline since 2019, and are now **absent** since 2024 (**Figure 6**).
- Fish species of '**High**' fishing vulnerability have also been on the decline since 2019. Whilst they are still present in IMR surveys, their population is low suggesting heavy fishing pressure on these species.

Table 1. Fishing vulnerability classifications as assigned by FishBase.

Fishing Vulnerability	Risk Level
< 25%	Low
26 – 49%	Moderate
50 – 64%	High
> 65%	Very High

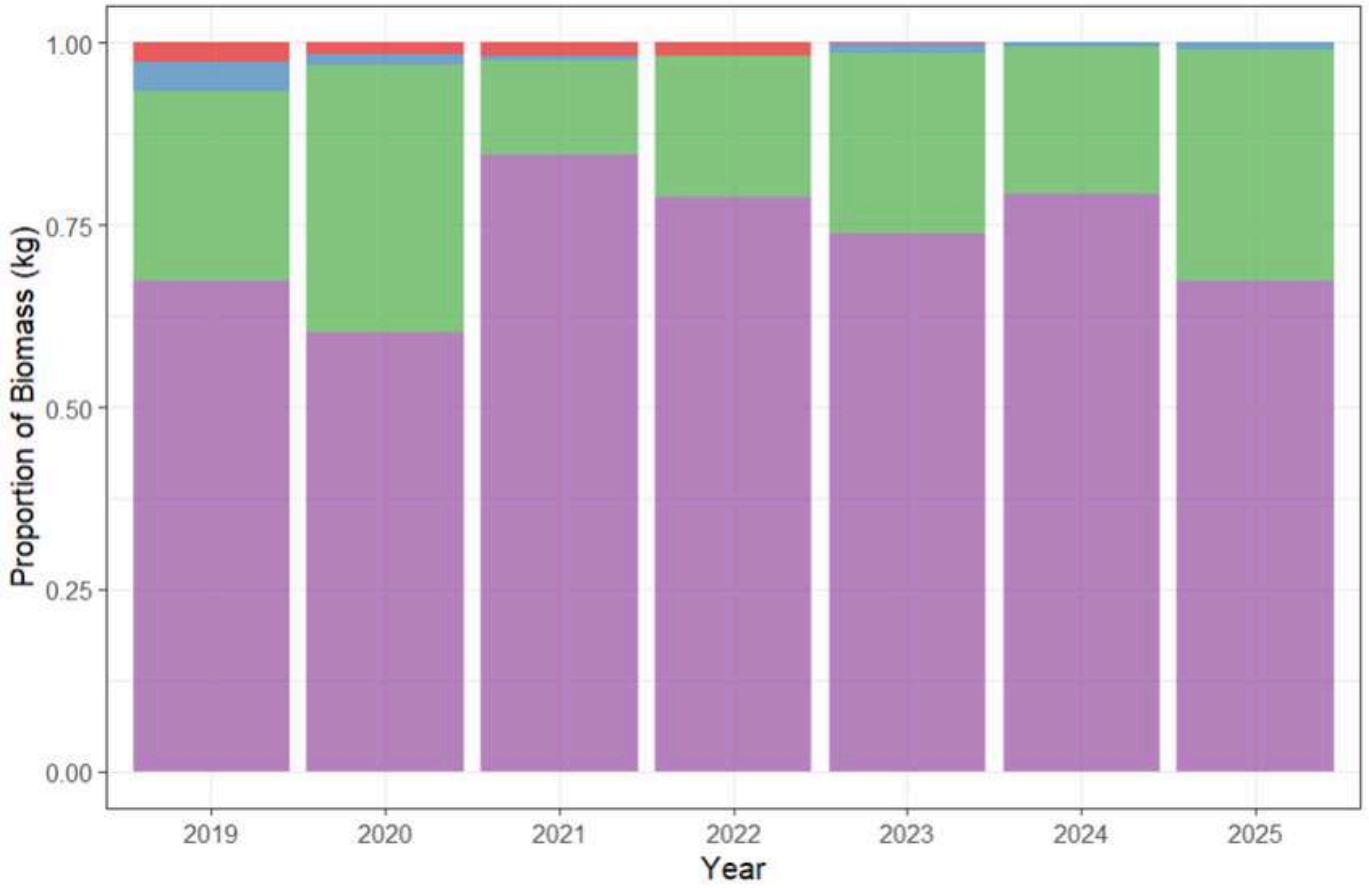
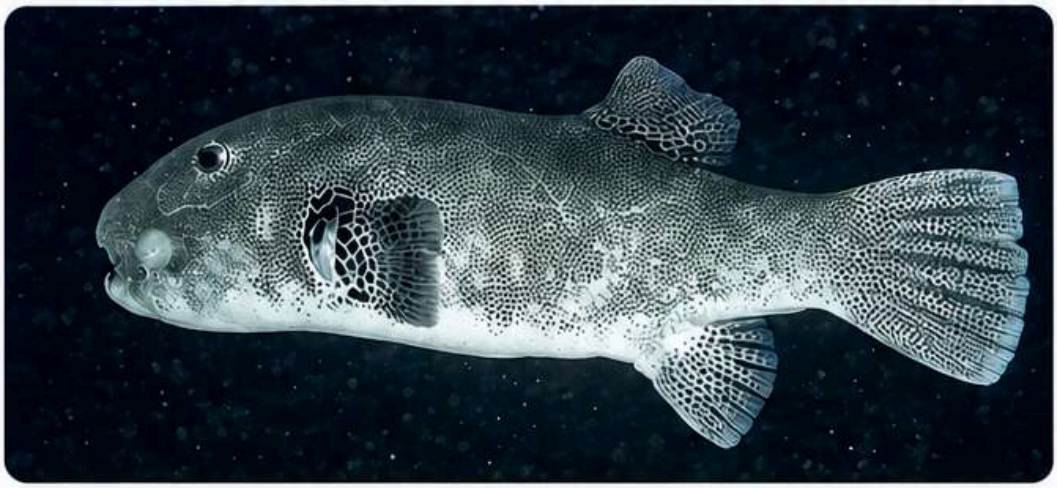


Figure 6. Proportional change in fish biomass (kg per hectare) among four fishing vulnerability categories (low, moderate, high, very high) across 7-years.

2 YEARS
without recording fish of '**Very High**' fishing vulnerability.

Where did they go?

Monacanthidae
Aluterus scriptus



Tetraodontidae
Arothron stellatus

For 2 years these fish of **'very high'** fishing vulnerability have **not been recorded** in IMR surveys.

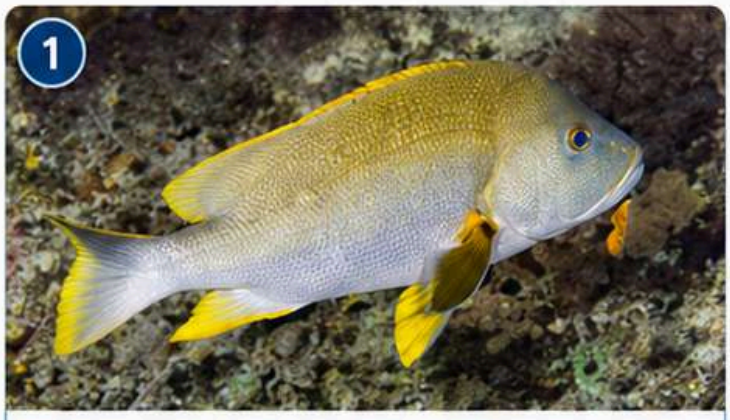
What does this mean?
Their population size is now of low ecological significance, and the fishing of these species should be avoided to allow their popualtion size to grow.

Serranidae
Epinephelus fuscoguttatus

Acanthuridae
Naso unicornis

Fishing Pressure

The following fish are of **'High'** fishing vulnerability. Whilst these fish are still present (although in low numbers) as of 2025, the collapse in ecologically significant fish in the **'Very High'** fishing vulnerability category may result in the following fish to be targeted:



Lutjanidae *Lutjanus rivulatus*

Carangidae *Caranx melampygus*

Balistidae *Balistoides viridescens*

Serranidae *Cephalopholis miniata*

Tetraodontidae *Arothron caeruleopunctatus*

6 SPECIES
most likely to be targeted by commercial fishing pressures in 2026

Continued monitoring is essential to track population trends and inform effective fisheries management and conservation actions.

2019 - 2025

BENTHIC COMMUNITY COMPOSITION

Changes in Reef Associated Organisms

Over a 4-year period (2021-2025):

- Hard coral (**-2.7% /yr**)
- Sponge (+0.3% /yr)
- Soft Coral (+0.8% /yr)
- Ascidian (-0.2% /yr)
- Macroalgae (+1.6% /yr)
- Cyanobacteria (+0.2% /yr)

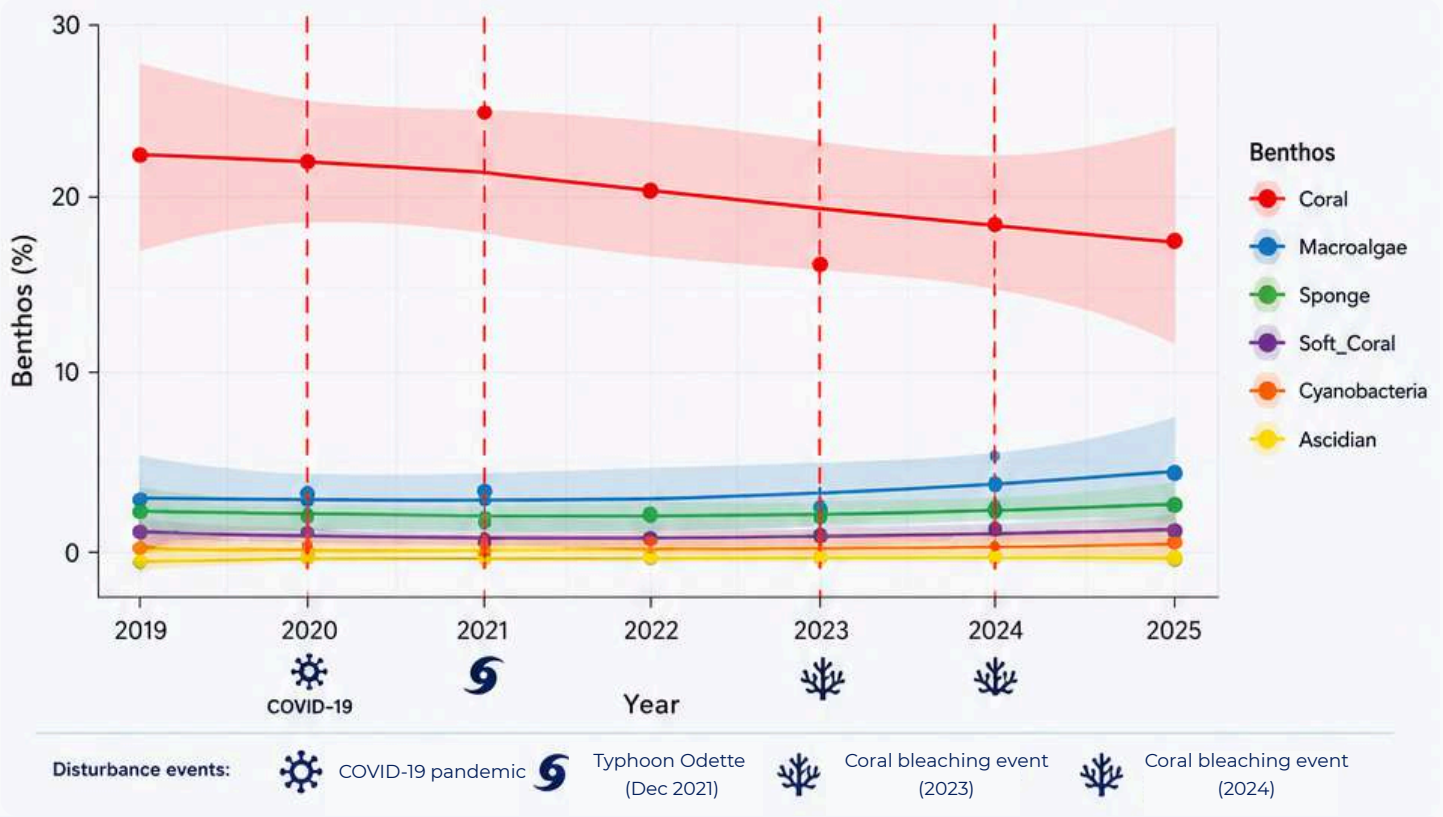


Figure 6. Change in the percentage (%) cover of six major benthic categories recorded in Dauin across 7-years. Four major disturbance events have been included: COVID-19, Typhoon Odette, and two nationwide coral bleaching events.

Coral Community Composition

- The overall coral community composition has remained stable across 7-years, with only 1 coral genus (***Acropora* spp.**) experiencing significant fluctuations across years.
- ***Acropora* spp. has declined by 52% since 2021**, with the average cover at 4.36% per 100m² following 2025 surveys.

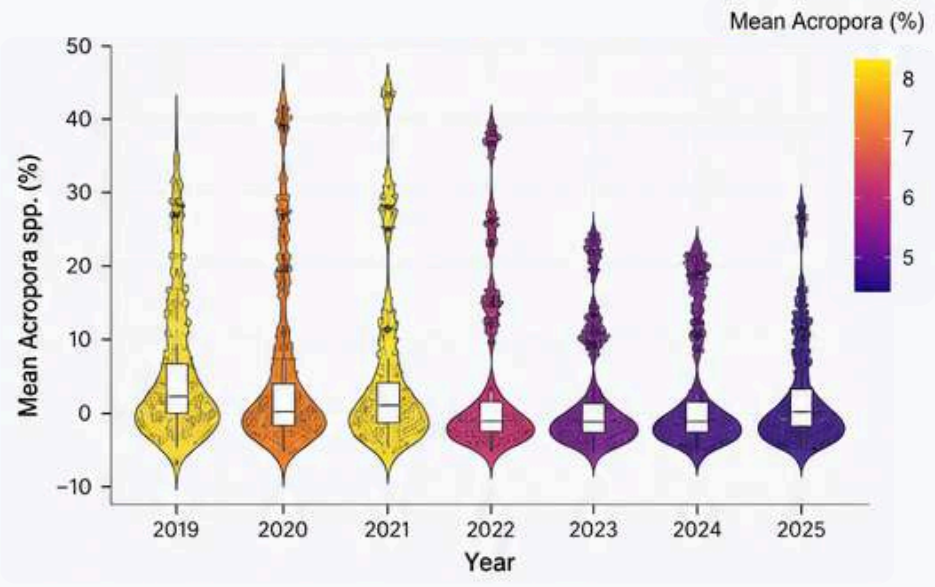


Figure 8. Violin plots representing the average *Acropora* spp. cover recorded across 7-years. Colour indicates the mean recorded in each year.

Major threats to *Acropora* spp. cover in Dauin include:

i) Rubble generation following typhoons

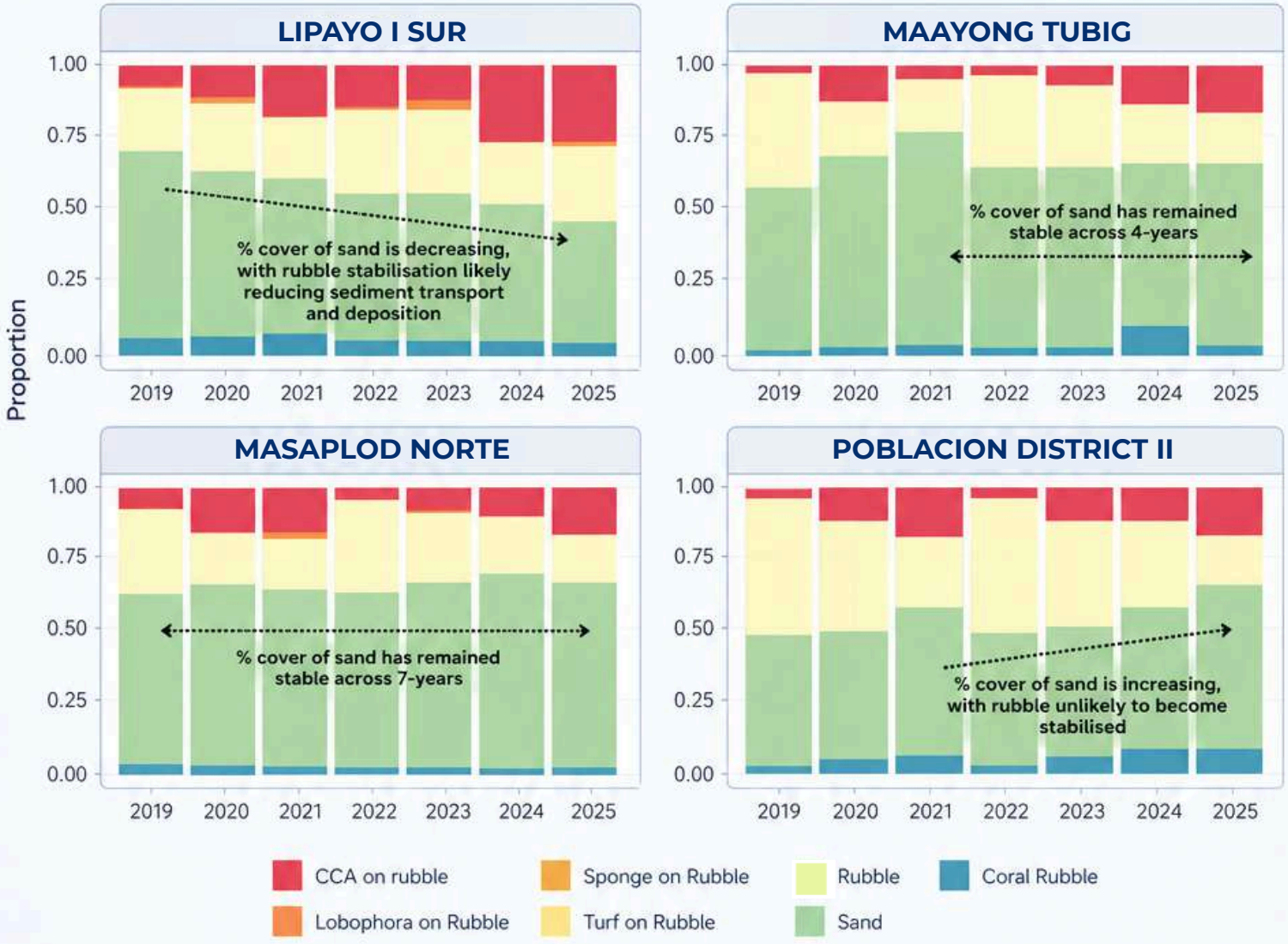
ii) *Acanthaster* spp. outbreaks

iii) *Drupella* spp. outbreaks

Protecting *Acropora* means addressing multiple pressures to sustain healthy reef ecosystems.

Rubble Stabilisation

- Four sites have been identified with a high percent (%) cover of unconsolidated substrate: **Lipayo I Sur, Poblacion District II, Masaplod Norte,** and **Maayong Tubig.**
- The profile of these rubble beds have been monitored over 7-years to determine their capacity to reconsolidate., with the likelihood of rubble consolidated outlined below:



Likelihood of Rubble Reconsolidation:

LIPAYO I SUR

Recovery is progressing unaided.

Rubble pieces are naturally binding together with little to no additional sediment support.

POBLACION DISTRICT II

Rate of erosion is outpacing rubble accretion and binding.

Rubble pieces are not binding effectively due to high disturbance and sediment loss.

MASAPLOD NORTE

Recovery is progressing unaided, although there is risk of sediment smothering following a high wave exposure event.

Rubble is binding but may be inhibited if sediment accumulates.

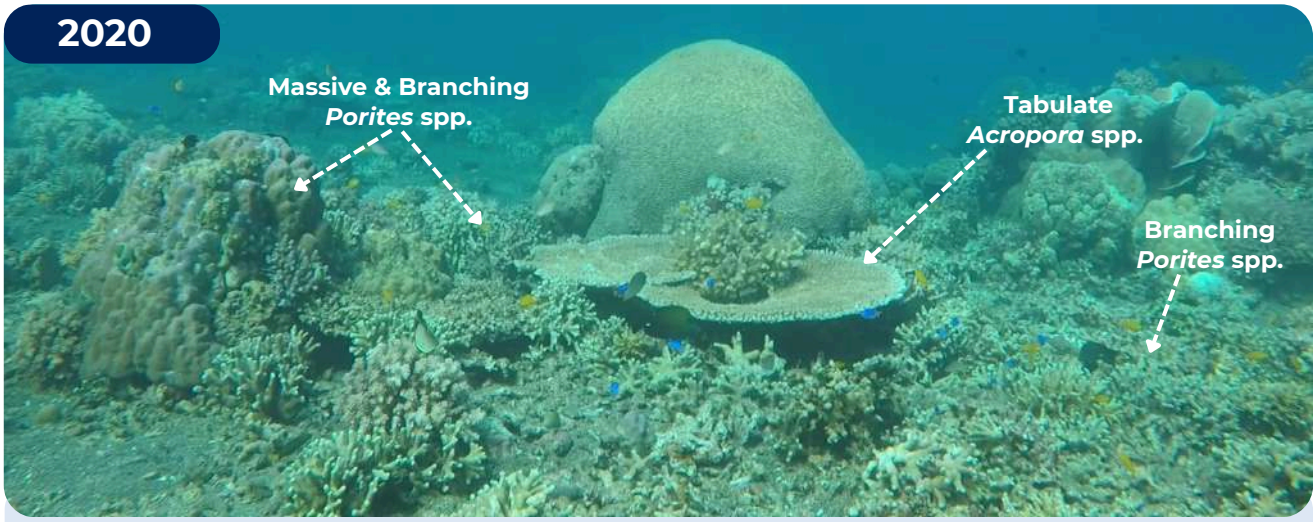
MAAYONG TUBIG

Newly generatedrubble (coral rubble) is being covered by sand deposition.

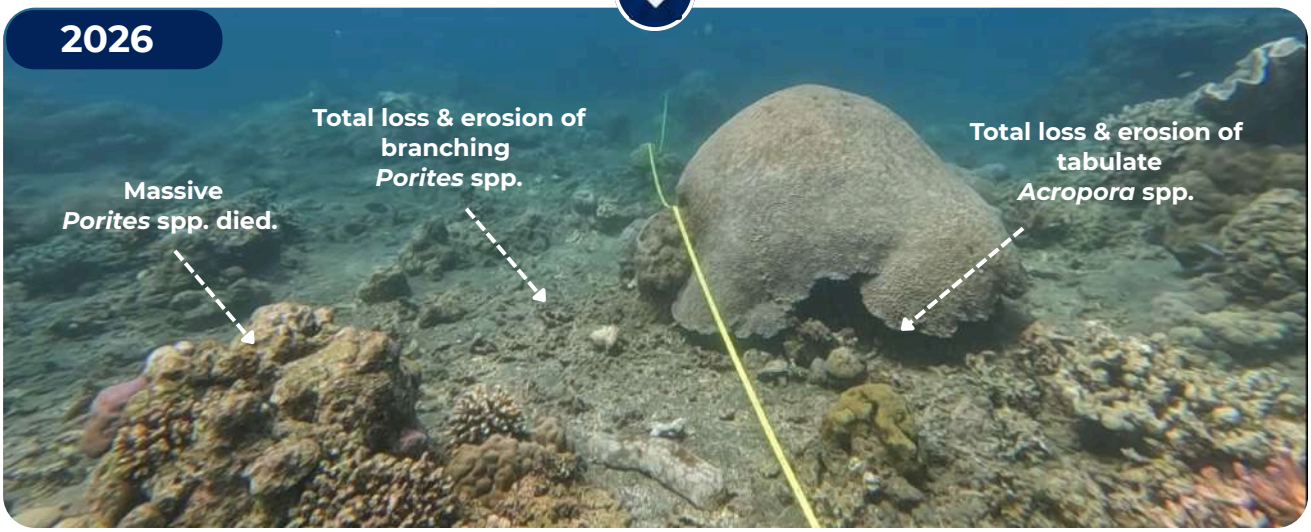
Rubble pieces are smothered by sediment, slowing binding.

2020 vs. 2026
(Protected Area of Poblacion District II)

Significant reef flattening has occurred over 6-years within the Marine Protected Area of Poblacion District II.



In March of 2021, *Acanthaster* spp. predation has weakened the skeletal framework on the *Acropora* spp. table. By December 2021, Typhoon Odette has destabilised coral substrate, with persistent moderate wave exposure resulting in high erosion and sand deposition.



KEY EVENTS

March 2021
Acanthaster spp. predation weakens *Acropora* spp. skeletal framework.

December 2021
Typhoon Odette destabilises coral substrata.

2021–2026
Ongoing erosion and sand deposition drive reef flattening and loss of complexity.

Natural Recruitment

In 2024, IMR integrated the monitoring of naturally recruiting coral individuals (corals <5cm) along IMRs 19 survey sites. The results recorded herein describe the changes in recruitment, mortality and net turnover of juvenile coral genera between 2024-2025.

Key Definitions:

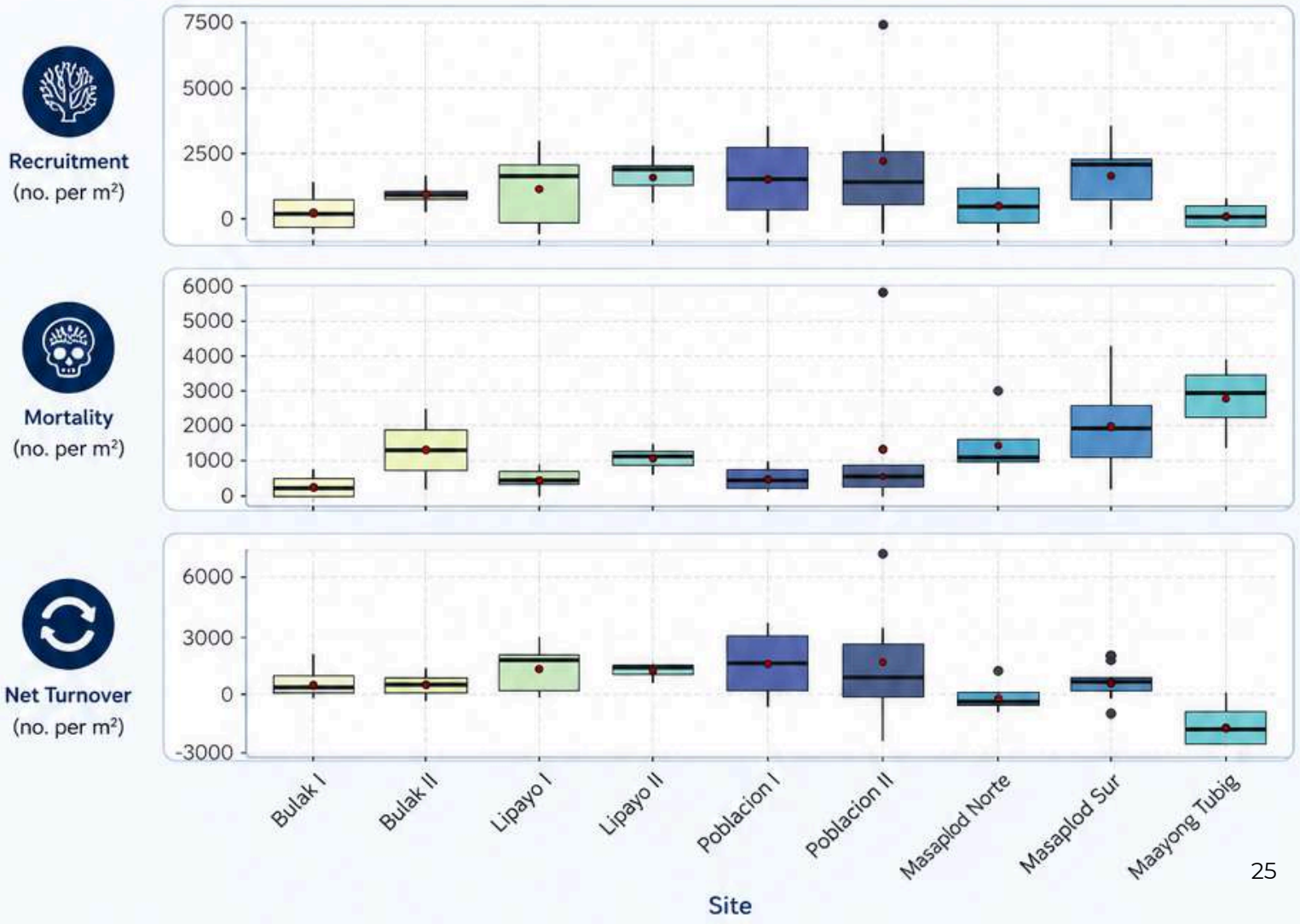
Recruitment
no. of new individuals (per m²) since 2024

Mortality
no. of individuals died (per m²) since 2024

Net Turnover
Recruitment - Mortality

Site-Specific Outcomes:

- Lipayo II, Poblacion I, Poblacion II and Masaplof Sur experienced the **highest annual recruitment** rates, each recording >2,000 new recruits per m².
- High coral recruitment, coupled with low mortality resulted in Poblacion I and II to experience the highest **positive net turnover.**
- Bulak II, Masaplod Norte, Masaplod Sur and Maayong Tubig experienced the highest mortality rates (>1,000 recruits per m²). Despite this, Bulak II and Masaplod Sur still experienced a **positive net turnover.**
- Maayong Tubig and Masaplod Norte were the only sites to experience a **negative net turnover.**



Taxon-Specific Outcomes:

- Agariciidae (specifically *Pavona* spp.) is the **highest recruiting taxa**, with recruitment recorded across all survey sites. A positive net recruitment of 1119 recruits per m^{-2} was recorded for this taxa.
- As the cover (%) of *Acropora* spp. declines across the coastline, the arrival of new *Acropora* spp. propagules is imperative. Currently Acropora spp. has a low, yet positive, net turnover of 381 recruits per m^{-2}.
- Continued monitoring of naturally occurring coral recruits will be required to determine if propagule supply is on the rise/decline.

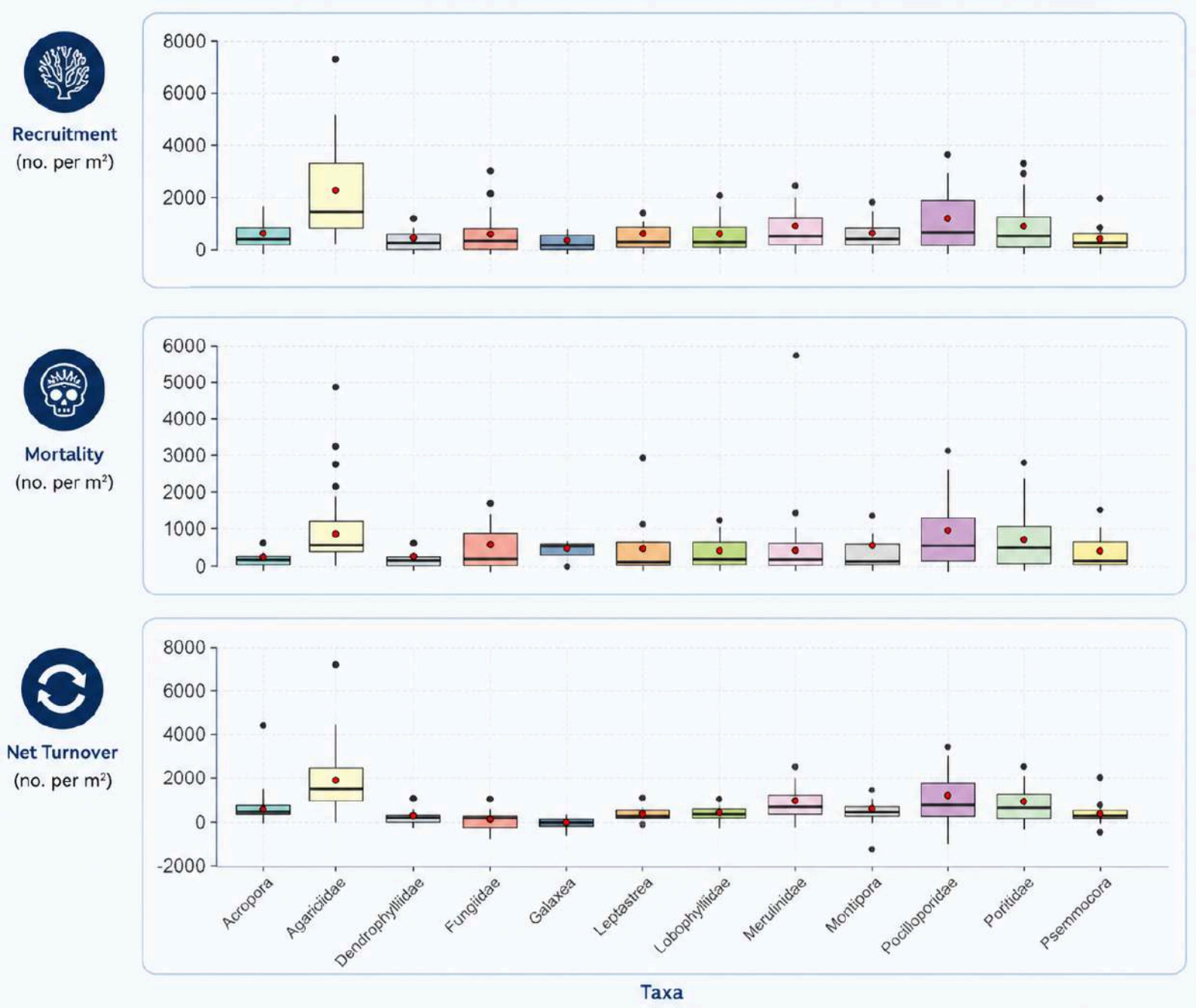


Figure 9. a) Recruitment, b) Mortality, and c) Net Turnover of coral genera <5cm in size, standardised per m^2.

2019 - 2025

REEF IMPACTS

Coral Disease (White Band Disease)

- White Band Disease (WDB) is becoming a significant threat to corals in Dauin.
- Whilst prevalence is low, mortality of corals in rapid, with 100% mortality occurring in monitored corals.

29 DAY PROGRESSION TIMELINE

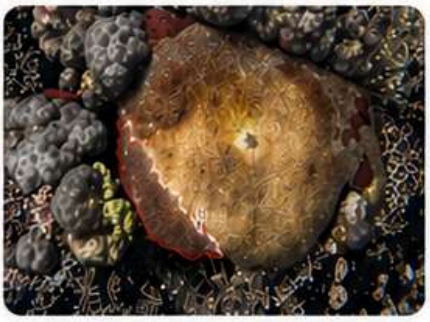
1 — 5th January 2025

40% live coral

2 — 18th January 2025

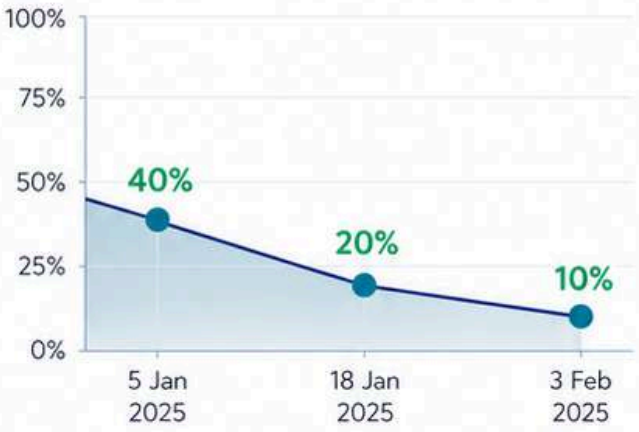
20% live coral

3 — 3rd February 2025



10% live coral

LIVE CORAL COVER (%)



100% mortality
observed in monitored corals

DISEASE PROGRESSION SUMMARY

Day 0
Healthy coral with live tissue

↓

Early infection
White band appears, tissue loss begins

↓

Progression
Cyanobacterial mats form, live tissue decreases

↓

Outcome
Live tissue lost, 100% mortality

WBD spreads quickly and can result in total colony mortality within weeks.

Continued monitoring is critical to detect early signs and reduce impact.

Coral Predators

***Acanthaster* spp.** continues to be a significant threat to coral within Dauin, with monthly culling efforts occurring at Poblacion District I and II, Masaplod Sur and Maayong Tubig to modulate populations.

***Drupella* spp.** outbreaks are occurring at Poblacion District I and II, Masaplod Sur and Maayong Tubig.

IMR has been **granted permission** to cull *Drupella* spp. across outbreak sites.

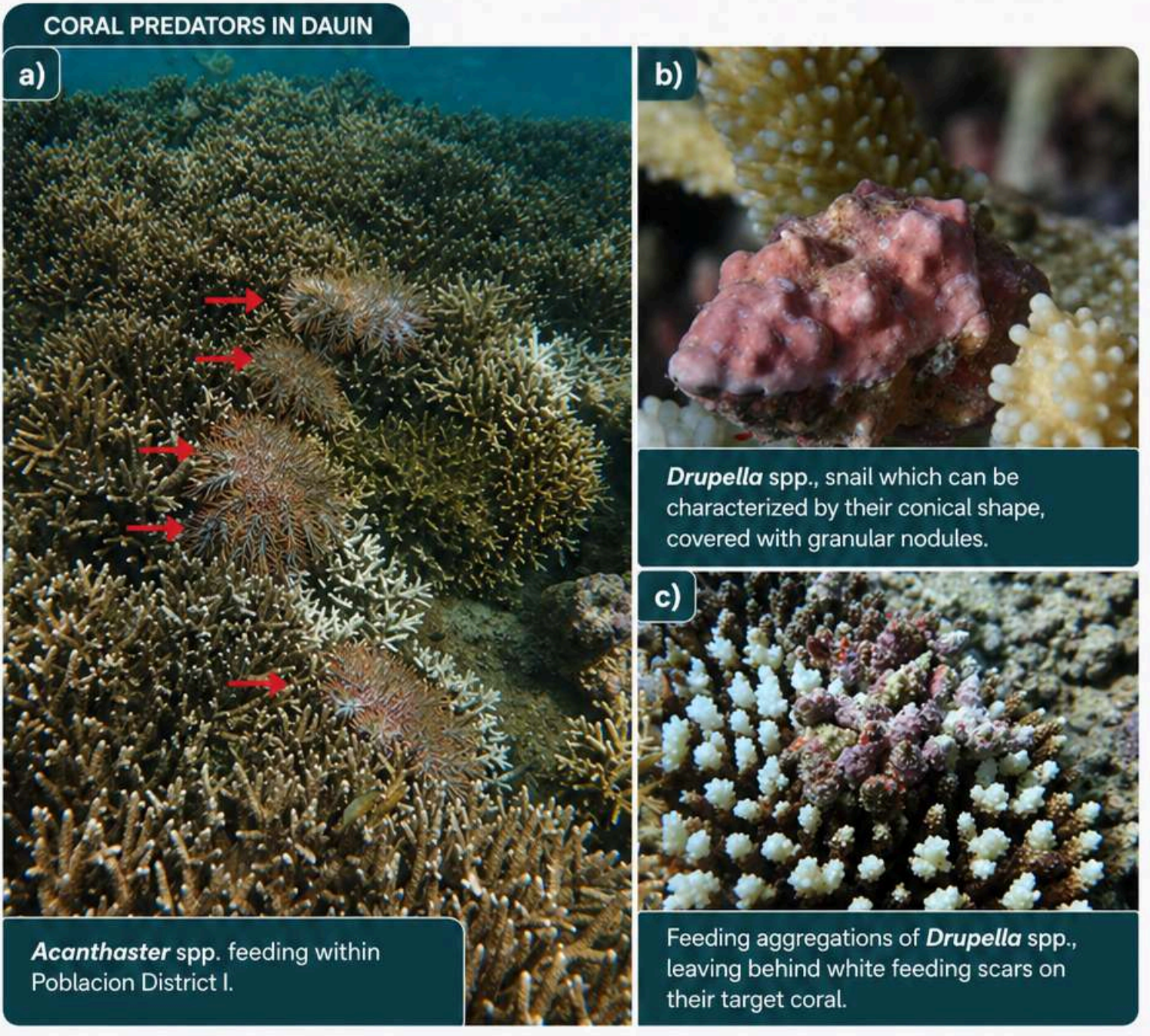


Figure 10. Corallivorous invertberates currently found in outbreak population across Dauin's reefs. Culling of their populations is ongoing to reduce major loss of healthy coral tissue.

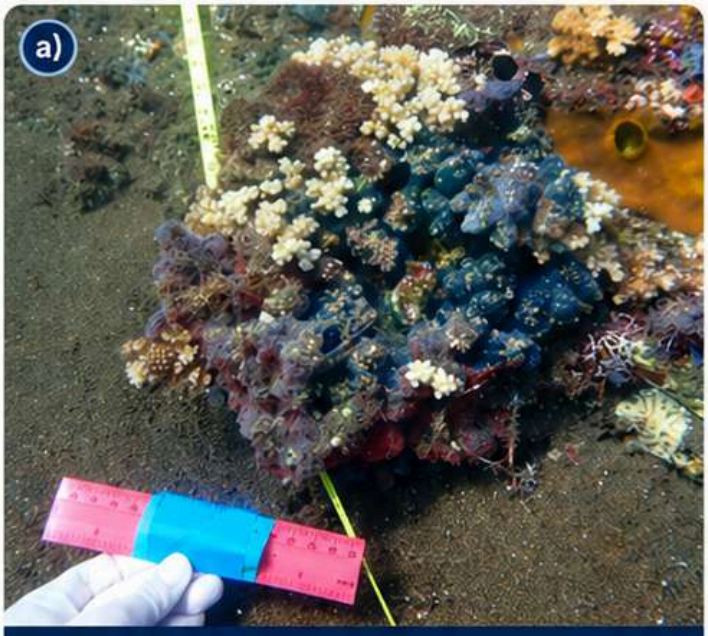
Direct Competition

Sponge, colonial ascidian and **cyanobacteria** have been identified to target and overgrow **healthy** coral tissue.

Increasingly prominent on Dauin's reefs as **water quality is compromised**, promoting the rapid growth of these competitive organisms.

Targeted corals are primarily of the genus ***Pocillopora* spp.** and ***Acropora* spp.**

Mortality of corals is **100%** once targeted.



Combination of colonial ascidian, sponge, and cyanobacteria smothering *Pocillopora* spp.

Colonial ascidian overgrowing and outcompeting healthy tissue of *Pocillopora* spp.

Figure 11. Smothering of *Pocillopora* spp. following direct competition from a) combination of colonial ascidians, sponge, and cyanobacteria, and b) colonial ascidian.

KEY TAKEAWAY

Direct competitors are rapidly colonizing coral surfaces, leading to **100% mortality** once targeted. Improving water quality is essential to reducing their growth and supporting coral survival.

Management Actions

01

REVIEW THE PROTECTION OF FISH
Specifically those classified as "Very High" fishing vulnerability.

02

CONTINUE *DRUPELLA* & *ACANTHASTER* SPP. CULLING
This is required to protect declining Acropora spp. (%) cover.

03

PROTECT SEAGRASS BEDS & LIMIT FISHING ACTIVITY
To reduce sedimentation deposition onto adjacent coral reef.

04

IMPROVE WATER QUALITY
To reduce the growht of coral competitors (ascidian, cyanobacteria, sponge, macroalgae) , and spread of coral diseases.

05

PRIORITISE SUCCESSFUL FERTILISATION OF *ACROPORA* SPP.
Ensure restoration attempts target the fertilisation success of *Acropora* spp. to boost cover and future larval supply across the coastline.

Future Research

01

IDENTIFY "HOTSPOTS"
For the emerging white band disease.

02

UNDERSTAND OUR SEAGRASS BEDS
Including i) species composition, ii) their connectivity to adjacent coral reefs, and iii) if their loss is translating into increased sediment loads onto adjacent reefs.

03

IDENTIFY SIZE-ESCAPE THRESHOLDS
In recruiting coral genera in Dauin. Additionally, is there is spatio-temporal consistency in recorded negative net turnover rates.

04

IDENTIFY JUVENILE FISH HABITATS
Specifically the location of juvenile fish species of 'Very High' fishing vulnerability.

05

DETERMINE FEASIBILITY OF SPAWNING HUBS
within Dauin to improve fertilisation success.

INSTITUTE FOR MARINE RESEARCH

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