CLEVELAND BAY – A NATURALLY DYNAMIC ECOSYSTEM

EXECUTIVE SUMMARY

Cleveland Bay supports a diverse range of interconnected ecosystems including coral reefs, seagrass meadows, mangroves, beaches, estuaries and intertidal habitats. These ecosystems exist within a naturally dynamic environment influenced by tides, weather, river flows and regional climate patterns. Long-term monitoring shows that Cleveland Bay ecosystems have demonstrated resilience to natural disturbances. However, recent decades have seen increasing pressure from climate-driven events including floods, marine heatwaves, cyclones and prolonged periods of reduced water clarity. Understanding these natural and climate-related influences is important when assessing ecosystem condition and interpreting environmental monitoring results.

INTRODUCTION

Cleveland Bay is located between Cape Cleveland and Cape Pallarenda adjacent the city of Townsville. It is a shallow embayment where land, sea and freshwater meet creating complex, dynamic, and diverse ecosystems. Cleveland Bay supports a diverse range of habitats including coral reefs, seagrass meadows, intertidal mud flats, mangrove estuaries, sandy beaches and rocky intertidal habitats.

Figure 1: Water movement in Cleveland Bay, (NASA Ocean Colour Data, Landsat 8)

Cleveland Bay's ecosystem condition is shaped by the interaction of chemical processes, physical drivers, and ecological components, including nutrient cycling, water quality, hydrodynamics, climate, seagrass, fisheries, coral reefs, and connected coastal ecosystems.

RECENT CLIMATIC PRESSURES

In recent years, the Townsville region has experienced multiple climate-driven pressures with limited recovery time between successive disturbance events. These cumulative impacts have affected marine and coastal ecosystems throughout Cleveland Bay, including:

- **Elevated rainfall and river discharge**: Above-average rainfall during the 2018/19, 2021/22, 2022/23 and 2024/25 wet seasons, including record flooding in January–February 2019 and exceptionally high river discharge during February–March 2025, which resulted in sustained freshwater inflows, increased sediment delivery and reduced water clarity across the region. These conditions can adversely affect many marine ecosystems in Cleveland Bay.
- **Prolonged low-light conditions**: Repeated periods of climate-related low-light conditions over multiple years have reduced the amount of light reaching benthic habitats. Reduced light availability limits photosynthetic productivity in seagrass meadows and coral communities, affecting growth, condition and ecosystem resilience.
- **Extreme temperature events and marine heatwaves:** A series of extreme temperature events, including Australia's hottest year on record in 2019, record-high sea surface temperatures in February 2020, and above-average summer sea surface temperatures in 2021/22 and 2023/24 increased thermal stress on the shallow water marine ecosystems of Cleveland Bay.
- **Tropical cyclones and intense weather systems**: Tropical Cyclone Jasper (December 2023), Tropical Cyclone Kirrily (January 2024), and a strong low-pressure system in January–February 2025 generated elevated turbidity, sediment resuspension and physical disturbance, affecting the condition of coastal and marine habitats across the region.

Together, these cumulative pressures influence the resilience and health of the ecosystems in Cleveland Bay.

WHAT THIS MEANS:

Recent changes in ecosystem condition across Cleveland Bay have occurred during a period of repeated floods, cyclones, heatwaves and prolonged low-light conditions, highlighting the importance of considering regional climate drivers when assessing environmental change.

A DYNAMIC AND RESILIENT ECOSYSTEM

Like all natural ecosystems Cleveland Bay is constantly changing. Beaches naturally erode and rebuild; estuaries are reshaped by tides, river flows and sediment movement, seagrass meadows expand and contract, and coral reefs experience periods of growth and decline in response to changing environmental conditions.

Long-term scientific studies demonstrate that this variability is a natural feature of Cleaveland Bay. Like tree rings, corals form annual growth bands that provide a record of past environmental conditions. Analysis of a core from a Porites coral from Magnetic Island showed 175 years of growth (from 1813 to 1986). This core revealed that inshore coral growth has varied considerably over time, (Lewis et al. 2007). This study, through chemical analysis of trace elements in the coral core, provided evidence that sediments originating from erosion within the Burdekin River catchment can reach Cleveland Bay during flood events, despite the Burdekin River mouth being located approximately 90km to the south of Cleveland Bay. This highlights the strong influence that regional catchment and climate processes can have on Cleveland Bay's marine environment.

A correlation between seasons of elevated river discharge (high sediment/nutrient loads) and reduced water clarity/light in approximately the following 6 months has been established for many parts of the GBR lagoon (Fabricius et al. 2016). The health of coral reefs and seagrass meadows in the inshore central Great Barrier Reef is influenced by how often they are exposed to flood plumes from the Burdekin River, (GBRMPA 2024). Scientists have also found a strong link between high freshwater river flow periods, low salinity, low light and the shrinking of seagrass meadows, (Collier et al. 2012; Petus et al. 2014).

WHAT THIS MEANS:

Changes observed in seagrass, coral and water quality are often influenced by multiple interrelated environmental factors operating across the region rather than a single activity or event.

Inshore coral reefs, like those in Cleveland Bay, are more resilient than many offshore reefs because they have evolved in naturally variable conditions, including fluctuating water quality, temperatures and turbidity. However, the Bay's ecosystems are increasingly being challenged by a combination of climate-related pressures. Repeated flood events, above-average rainfall and river discharge, marine heatwaves, prolonged periods of low light caused by cloud cover and/or suspended sediments, and the physical impacts of cyclones are placing increasing stress on coral reefs, seagrass meadows and other coastal habitats.

While these ecosystems retain a strong capacity to recover from individual disturbances, the increasing frequency and intensity of climate-driven events are reducing recovery opportunities and placing greater pressure on the long-term health and resilience of Cleveland Bay.

Figure 2: D. Yates 2002

STORMS, CYCLONES AND COASTAL CHANGE

Cyclones and monsoonal storms can rapidly alter the condition of Cleveland Bay's coastal and marine ecosystems. Seagrass meadows are vulnerable to damage from strong waves, sediment movement and reduced water quality associated with these events, however, they also have a strong capacity for fast recovery. For example, Tropical Cyclone Yasi and ongoing significant cloud cover in 2011 caused the largest decline in seagrass recorded during 19 years of monitoring in Cleveland Bay (2007-2025). Despite this substantial impact, recovery was rapid in the following year, when good growing conditions returned. In contrast, recovery following Tropical Cyclone Jasper in December 2023 has been limited due to subsequent disturbances, including Tropical Cyclone Kirrily in January 2024 and a strong low-pressure weather system experienced during January and February 2025.

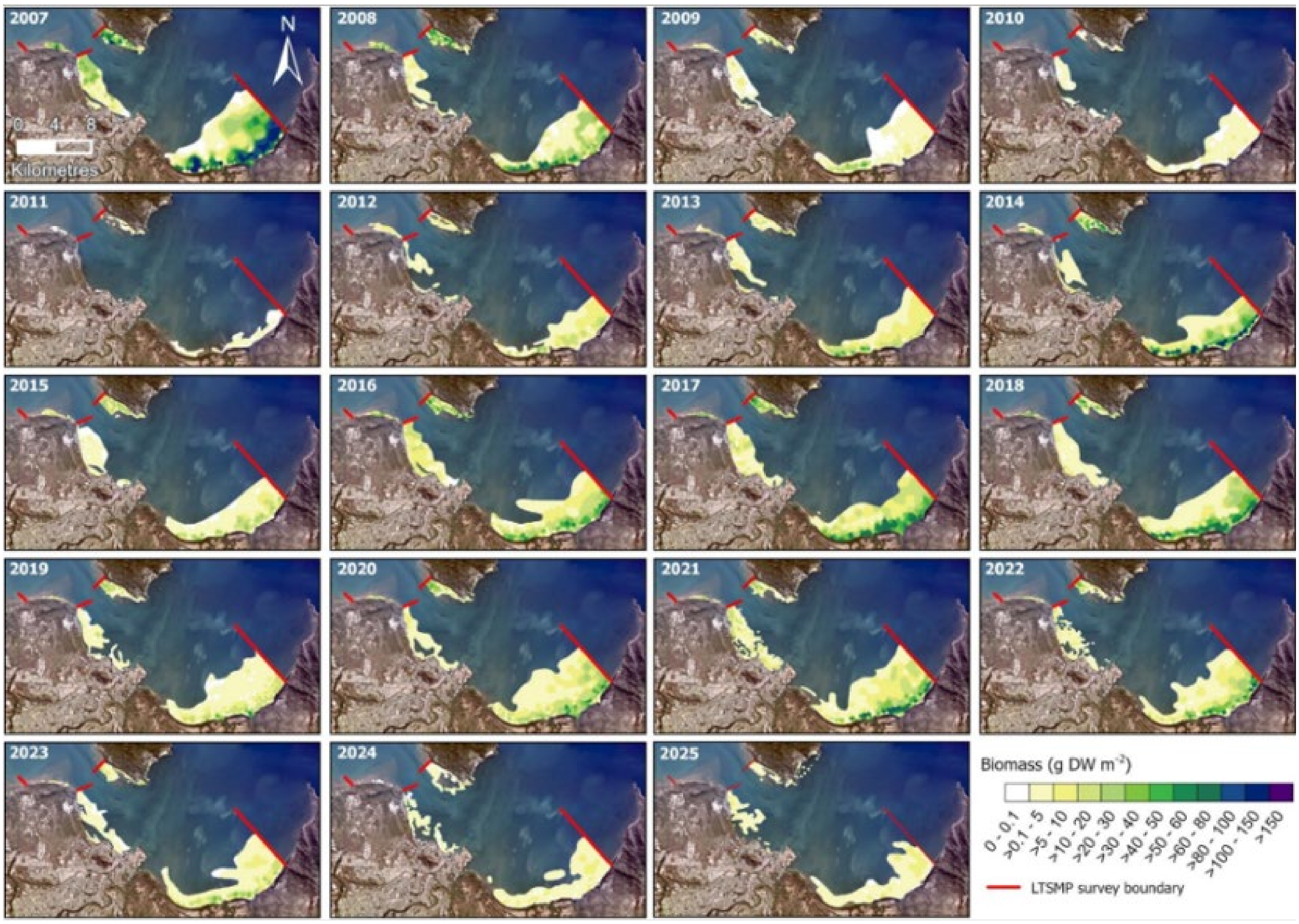

Figure 3: Seagrass above-ground biomass, location and spatial extent of meadows from 19 years of Monitoring in Cleveland Bay, (Tol, S.J. et al., 2025, Port of Townsville Seagrass Monitoring Program)

Severe storms and cyclones drive short, sharp episodes of coastal erosion, particularly along low lying beaches and intertidal areas contributing to ongoing shoreline change. In addition, gradual sea level rise, increases the baseline vulnerability of these coastal environments, meaning that storm events can have greater impacts than they have in the past.

Together, these factors highlight both the natural resilience of Cleveland Bay's ecosystems and the increasing challenges they face as extreme weather events become more frequent and recovery periods become shorter.

CLIMATE CHANGE, CORAL REEFS AND COASTAL ECOSYSTEMS

The Great Barrier Reef Outlook Report, 2024 identified climate change, particularly ocean warming, as the primary driver of ongoing declines in the condition of reef ecosystems. Rising ocean temperatures are increasing the frequency and severity of marine heatwaves, placing corals and other marine species under growing stress. A notable example occurred in 2022, when a mass coral bleaching event took place during a La Niña year, a climate pattern that has historically been associated with cooler conditions in the region. This highlights the increasing influence of long-term climate warming on reef ecosystems.

Another significant challenge is ocean acidification, caused by the absorption of increasing amounts of atmospheric carbon dioxide by the world's oceans. As seawater becomes more acidic, the availability of carbonate minerals declines. These minerals are essential building blocks that corals use to form their calcium carbonate skeletons, making it more difficult for reefs to grow and recover from disturbance.

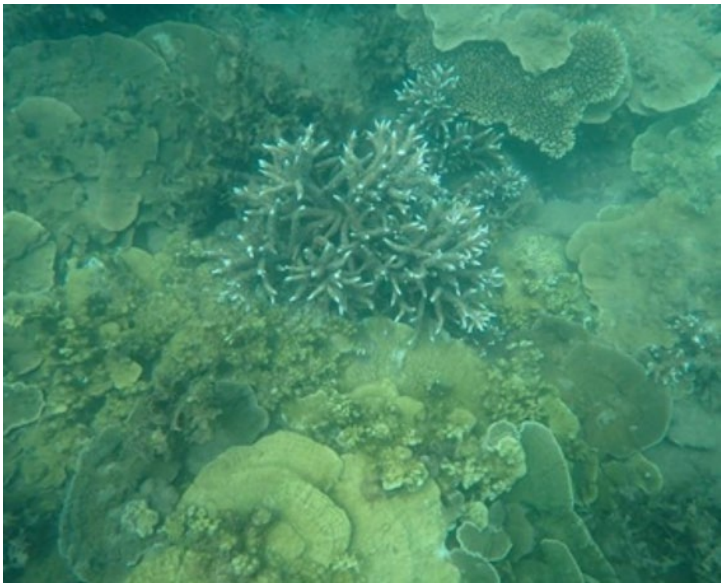

Figure 4: Corals of Geoffrey Bay, Magnetic Island, (Photos: Smith, A., Songcuan, A. (2024) Port of Townsville Coral Monitoring Program. Reef Ecologic, Townsville.

Magnetic Island's fringing reefs — including Geoffrey Bay, Nelly Bay, Florence Bay and Arthur Bay are among the most extensively studied inshore reefs within the Great Barrier Reef region. Over recent decades, these reefs have been exposed to more frequent storm events, increased wave energy and changing environmental conditions. The increased frequency of days with sustained winds results in fine sediments being suspended more often and for longer periods, reducing light penetration and therefore reducing the light available to seagrasses and corals for photosynthesis. Increased flood activity can also expose reefs to freshwater and sediment runoff, adding further environmental stress.

While some habitats are under increasing pressure, others continue to adapt and change. Mangrove communities throughout Cleveland Bay have shown signs of expansion in recent years, consistent with broader trends observed across North Queensland. A particularly strong recruitment year in 2016 contributed to extensive expansion of mangroves at the mouth of Ross River and in the southeast corner of Rowes Bay. Mangroves also continue to thrive along the sheltered western side of Magnetic Island.

Understanding these changes relies on long-term monitoring and collaboration. The Healthy Water Partnership for the Dry Tropics brings together more than 20 partners including government, industry, science, research, education, business and community to assess and report on the health of the waterways of this region. Each year, the Partnership publishes the Waterways Report Card which evaluates environmental condition from the catchment to the reef, recognising strong connections between land, rivers, estuaries and marine ecosystems.

The Waterways Report Card can be found here: https://www.healthywaterspartnership.org/.

The partnership also produces a series of StoryMaps as an interactive educational tool. These can be found here: https://www.drytropicshealthywaters.org/our-catchments

The StoryMaps include:

- Seagrass of Cleveland Bay
- Hydrology and Hydrodynamics of Cleveland Bay
- Corals of the Townsville Region

Together, these changes highlight the strong connections between Cleveland Bay's catchments, coastlines and marine ecosystems, and the growing influence of climate change across the region. While coral reefs, seagrass meadows, mangroves and other coastal habitats have evolved to cope with natural environmental variability, increasing pressures from ocean warming, marine heatwaves, extreme weather events, changing water quality and sea-level rise are placing pressure on these ecosystems. Ongoing monitoring, scientific research and collaborative management are essential for understanding these changes, supporting ecosystem resilience, and helping to protect the long-term health of Cleveland Bay and the Great Barrier Reef.

RESEARCH INSIGHT

Analysis of coral cores from Magnetic Island provides evidence that sediments from the Burdekin River catchment have influenced Cleveland Bay reefs for more than 150 years.

CASE STUDY – SEAGRASS ROCOVERY

Following Cyclone Yasi in 2011, Cleveland Bay experienced the largest seagrass decline recorded during the monitoring program. However, when favourable growing conditions returned, substantial recovery occurred within the following year.

SUMMARY

Cleveland Bay is a highly diverse and dynamic coastal environment where coral reefs, seagrass meadows, mangroves, mudflats, beaches and estuaries are connected through complex natural processes. These ecosystems have evolved in a naturally variable environment and have demonstrated a strong capacity to adapt and recover from disturbance over time.

The health of Cleveland Bay is influenced not only by local conditions, but also by broader regional processes that operate across catchments, coastlines and the Great Barrier Reef. Long-term scientific studies have shown that sediments from the Burdekin River catchment can reach Cleveland Bay during flood events. This highlights the important role that regional rainfall patterns, river discharge, oceanographic processes and catchment condition play in shaping Cleveland Bay's ecosystems.

In recent years, Cleveland Bay has experienced increasing pressures from climate-related disturbances, including flood events, elevated river discharge, prolonged low-light conditions, marine heatwaves, cyclones and severe storms. While ecosystems can recover from these events, the increasing frequency and intensity of disturbances are reducing recovery opportunities and placing greater pressure on ecosystem condition and resilience.

Protecting the long-term health of Cleveland Bay requires an understanding of the strong connections between the catchment, coast and reef. Ongoing scientific monitoring, collaborative management and community stewardship are essential for tracking environmental change, supporting ecosystem resilience and informing decisions that will help safeguard Cleveland Bay's natural values for future generations.

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