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From Reef to region: a multi-scalar analysis of tourism resilience

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ABSTRACT

The Great Barrier Reef (GBR) is one of the world's most iconic tourism destinations, supporting local economies along Australia's northeast coast. The COVID-19 pandemic severely disrupted global tourism, with particularly acute effects on regions like the GBR that depend heavily on inbound visitors. Using a multi-scalar resilience framework grounded in ecological theory and regional studies scholarship, we analyse economic indicators of impact and recovery across spatial and functional scales in the GBR region. Drawing on monthly and annual data from 2013 to 2023, we examine how tourism and employment patterns in the GBR marine park and surrounding coastal areas responded to pandemic-related shocks and recovery phases. Our findings reveal marked variation in resilience across time, space, and scale. Marine-based tourism recovered more slowly than broader regional visitation, while remote and tourism-dependent subregions were more vulnerable to disruption. In contrast, employment impacts were less pronounced, likely cushioned by national policy interventions such as the JobKeeper wage subsidy. This study offers methodological and empirical insights into how tourism systems respond to severe disturbances, with implications for monitoring and enhancing resilience in tourism-dependent regions exposed to global shocks and market volatility.

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1. Introduction

The COVID-19 pandemic has amplified longstanding concerns in regional science about how local economies experience, absorb, and recover from systemic shocks. As global disruptions increase in frequency and complexity, ranging from climate

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change and geopolitical instability to pandemics and digital transformation, understanding how regions adapt has become a pressing priority (Cadaval-Sampedro et al., 2025; Eichengreen et al., 2024; Harrison et al., 2021). In this context, regional economic resilience has gained renewed relevance, providing a framework to assess the capacity of local systems to endure and rebound from disturbances (Christopherson et al., 2010; Martin & Sunley, 2015; Pendall et al., 2010). Much of the empirical literature on regional resilience has focused on economic downturns, particularly financial crises (Di Caro, 2015; Martin et al., 2016; Mikheeva, 2021; Wang & Wei, 2021). These studies have examined the differential impacts of macroeconomic shocks across regions, providing insights into the structural, spatial, and institutional factors that influence recovery. Yet, comparatively little work has examined how sector-dependent regions, especially those reliant on volatile service economies, such as tourism, respond to non-financial global disruptions. Moreover, limited attention has been given to how resilience unfolds across multiple geographic and functional levels, despite calls for more nuanced, multilevel analyses (Boschma, 2015; Song et al., 2023).

While regional resilience research has traditionally focused on macroeconomic shocks, a growing body of literature has begun to explore how tourism-dependent regions respond to crises, including natural disasters, political instability, and pandemics. Recent studies have modelled tourism resilience in small and structurally vulnerable economies, highlighting the importance of adaptive capacity, institutional responses, and destination-specific characteristics in shaping recovery (Bangwayo-Skeete & Skeete, 2022; Barbhuiya & Chatterjee, 2020; Wang et al., 2022). Other contributions have drawn on frameworks such as socio-ecological systems, community-based adaptation, and destination governance to understand resilience in tourism contexts (Biggs et al., 2012; Hall et al., 2017; Vermeulen-Miltz et al., 2023). Despite these valuable contributions, significant gaps remain in the empirical assessment of tourism resilience. Many existing studies rely on conceptual or model-based approaches, with limited use of high-resolution, real-world tourism data to evaluate actual disturbance and recovery patterns over time (Jiao et al., 2025). Moreover, most empirical analyses tend to focus on a single spatial or functional scale, such as national-level tourism flows or regional economic indicators, without examining how resilience may differ across nested levels of analysis. Comparative studies that explore differences between tourism-specific and broader economic recovery, or between site-level and regional visitation patterns, remain scarce. Addressing these gaps is essential for developing a more nuanced and operational understanding of resilience in tourism-dependent regions.

In this article, we examine economic resilience in a quintessentially vulnerable regional context: Australia's Great Barrier Reef (GBR) region. This globally significant and tourism-dependent coastal zone was acutely affected by the COVID-19 pandemic. As an inbound tourism destination geographically remote from major population centres, the GBR region provides a critical test case for analysing how remoteness, market exposure, and sectoral reliance interact to shape the dynamics of economic shock and recovery. The GBR, however, is not a case study in isolation. Comparable vulnerabilities are evident in other marine tourism regions embedded within larger national economies, such as Florida's coral reef tract in the United States (Alvarez et al., 2024) or the Coral Triangle areas of Southeast Asia (Adams et al., 2021), where reef-based tourism is a significant economic driver. Similar dynamics are also present in nature-based destinations, such as

Kenya's safari parks, which rely heavily on international visitation and are sensitive to global disruptions (Muragu et al., 2023). Even culturally significant sites such as Machu Picchu in Peru or Petra in Jordan face analogous challenges due to their dependence on long-haul travel and concentrated visitor flows (Khater et al., 2025; Schlauderaff et al., 2022). These parallels suggest that the insights from the GBR case may apply to a broader range of tourism-dependent regions.

Drawing on monthly and annual data spanning over a decade, our study contributes to the scholarship on regional resilience and tourism geographies in several ways. First, it operationalises both engineering and evolutionary definitions of resilience (Folke, 2006; Martin & Sunley, 2015; Simmie & Martin, 2010) by analysing not only return times to pre-shock conditions, but also the depth of initial impact and the shape of recovery trajectories over time (Bartelet & Mulder, 2020). While engineering resilience focuses on the speed of return to equilibrium, evolutionary resilience highlights that return times alone may obscure important dynamics, such as how severe the initial disruption was, whether recovery was rapid or gradual, and whether the system ultimately returned to its previous state or transformed into a new configuration (Simmie & Martin, 2010). Second, our study extends this framework across multiple hierarchical levels, from individual tourist attractions to subregional visitation patterns, tourism-sector employment, and broader regional labour markets, thereby offering a novel application of multi-scalar resilience analysis. This kind of nested, cross-scale comparison is well established in ecological resilience theory, where researchers examine resilience at the level of individual species or sites in relation to broader ecosystem dynamics (Allen et al., 2005; Levin, 1992). However, such approaches remain underutilised in socio-economic and tourism resilience research (Duan et al., 2022; Song et al., 2023). Third, we provide a rare empirical account of tourism-led regional recovery, a dimension often overlooked in broader regional studies, which tend to focus on manufacturing or financial services. By integrating ecological concepts of scale and system dynamics with regional economic analysis, this study offers a more nuanced understanding of how resilience manifests across interconnected levels of the tourism economy.

Rather than treating the GBR as a single destination, our analysis disaggregates the region into three subregions: northern, central, and southern, each with varying levels of remoteness, infrastructure, and pre-pandemic exposure to international tourism. By comparing tourism and employment dynamics across these subregions and functional scales, we reveal how resilience varies depending on market proximity, dependence on external demand, and interventions such as Australia's JobKeeper program. In doing so, this study contributes to broader debates in regional science and tourism geographies on how recovery processes are shaped by spatial configuration, sectoral interdependence, and the level of analysis (Biggs et al., 2012; Espiner et al., 2017; Jiao et al., 2025). The findings also offer methodological insights and practical implications for monitoring and strengthening resilience in regions highly exposed to global volatility and covariate shocks.

1.1. Background and study sites

Despite Australia's relatively low COVID-19 case numbers and resilient macroeconomic performance during the pandemic (Guven et al., 2023), its tourism sector experienced

one of the steepest historical declines. The economic value of tourism in Australia halved from $62 billion in 2018–19 to $27.8 billion in 2020–21, as stringent travel restrictions effectively closed international and interstate movement for extended periods (Australian Bureau of Statistics, 2022).

The GBR region, a globally iconic natural attraction and one of the most tourism-dependent areas in the country, bore the brunt of this disruption. Comprising a network of towns and coastal communities in Queensland, the region supports a wide array of small and medium-sized tourism enterprises offering reef-related activities, from scuba diving and sailing to island stays and helicopter tours (Cumming et al., 2022). Before the pandemic, Queensland's marine tourism sector generated over $12 billion annually, with the GBR at its centre (Australian Institute of Marine Science, 2020). The region's economic structure made it particularly vulnerable to pandemic restrictions, especially in its northern and central zones, where a higher share of visitors were international and travel distances from major domestic markets (e.g. Brisbane) were substantial.

Government support measures, such as the national JobKeeper wage subsidy scheme (Australian Government, 2020; Borland & Hunt, 2023), helped temporarily buffer labour market impacts in 2020. However, regional tourism dynamics fluctuated through repeated lockdowns, phased border openings, and shifting domestic demand. This created a complex landscape for recovery, shaped as much by spatial accessibility and visitor composition as by broader macroeconomic trends.

To capture this complexity, we adopt a multi-spatial and multi-scalar approach, as shown in Figure 1, that evaluates resilience at four hierarchical levels (tourist attraction, regional visitation, tourism employment, and total employment) and three geographical groupings (northern, central, and southern GBR). This design allows us to explore how functional and spatial heterogeneity shape resilience trajectories and to probe the interactions between sector-specific shocks and broader regional economic systems.

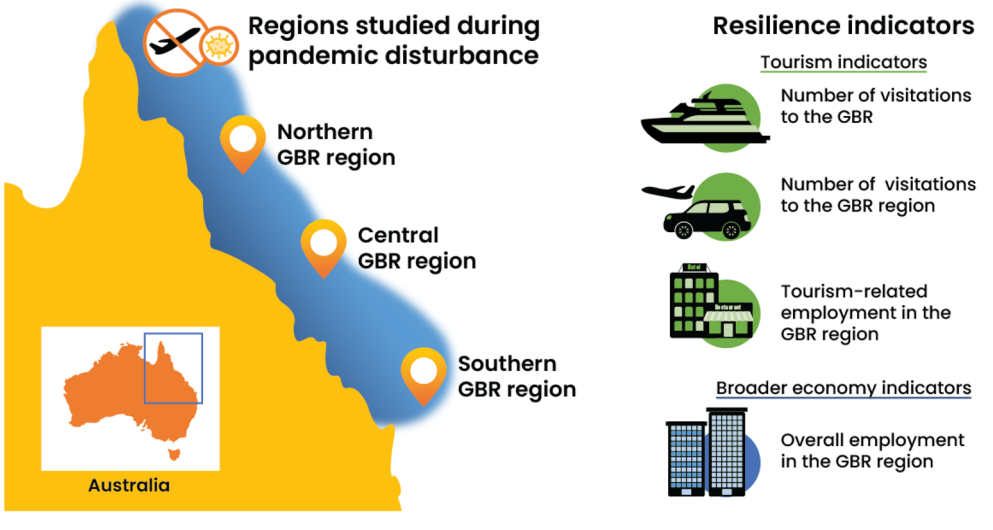


Figure 1. Conceptual and methodological framework used to study the resilience of the Great Barrier Reef Region's tourism sector and overall economy.

2. Methods

Our analysis draws on secondary datasets covering tourism activity and employment in the Great Barrier Reef (GBR) region, sourced from the Great Barrier Reef Marine Park Authority (2024b), Tourism Research Australia (2024a), and the Australian Bureau of Statistics (2024a). These datasets were aggregated to consistent regional units to enable spatially comparative analysis. Figure 2 outlines the regional delineations used in the study, including the GBR Marine Park management areas, tourism regions, and labour force statistical areas. To examine the recovery dynamics following the COVID-19 shock, we developed a set of resilience indices that capture changes in visitation to the Great Barrier Reef (GBR) Marine Park, overall regional tourism, and employment within the broader GBR region. Each index uses either the pre-disturbance calendar year (2019) or the reference month (February 2020) as a baseline, allowing for a comparative assessment of relative recovery trajectories across spatial and functional

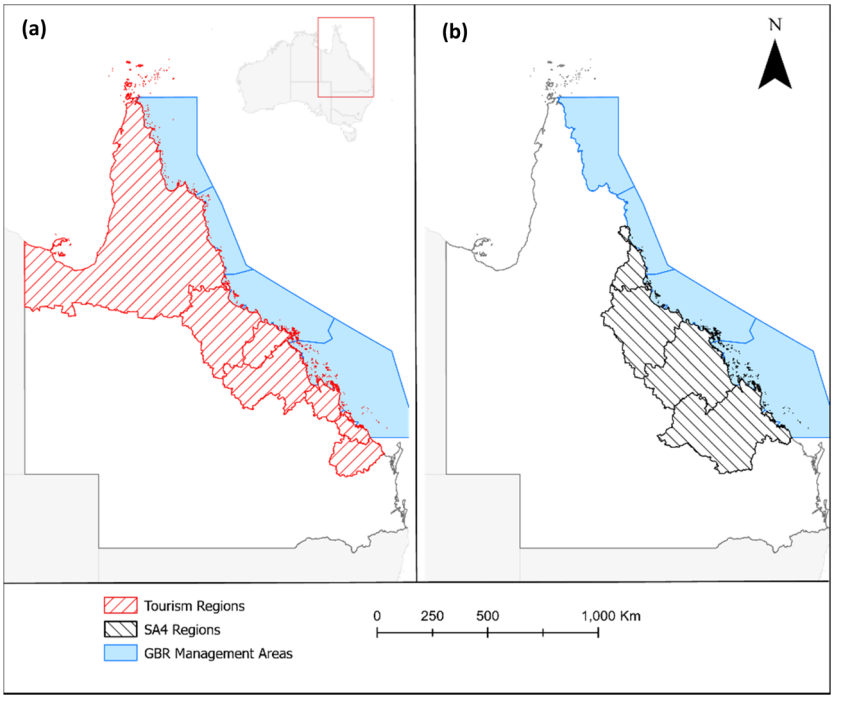


Figure 2. Overview of Queensland's regions within the Great Barrier Reef catchment area. *Notes*: Extending over 2,000 kilometres, the Great Barrier Reef (GBR) runs along Australia's northeast coast, from the northern tip of Cape York to approximately two-thirds down the Queensland coastline. Shown in blue regions over the ocean, the GBR Management Areas (MA) are defined by the GBR Marine Park Authority of the Australian Government. In the map, from north to south, they are: Far Northern MA, Cairns/Cooktown MA, Townsville/Whitsundays MA, and Mackay/Capricorn MA. Tourism Regions, panel (a), are defined by Tourism Research Australia. From north to south: Tropical North Queensland, Townsville, Whitsundays, Mackay, Capricorn, Gladstone, and Bundaberg. SA4 regions, panel (b), are Statistical Areas level 4 (SA4) regions defined by the Australian Bureau of Statistics. From north to south: Cairns, Townsville, Mackay-Isaac-Whitsunday, and Central Queensland. *Source*: Authors based on shapefiles from the Australian Bureau of Statistics (2024c) and Tourism Research Australia (2024a).

scales of the tourism economy. We complement the assessment of recovery trajectories with the estimation of a specific resilience indicator, following engineering resilience definitions, as return times to equilibrium measured in months after the onset of the disturbance (Bangwayo-Skeete & Skeete, 2022; Bartelet & Mulder, 2020; Folke, 2006). Our quantitative assessment of resilience is less complex and more straightforward compared to other recent studies that have focused on larger geographical areas, multiple sectoral, and less well-defined disturbances for which resilience would have to be estimated (Song et al., 2022; Wang & Wei, 2021).

2.1. Tourism visitors' data

Tourist visitation data to the GBR Marine Park were obtained from the Environmental Management Charge (EMC) dataset managed by the Great Barrier Reef Marine Park Authority (2024a). The EMC is a user fee applied to each tourist visiting the Marine Park *via* a licensed commercial operator. Operators submit monthly reports detailing visitor numbers, which are aggregated into 'visitor days.' This means that short visits (e.g. a half-day tour) are counted proportionally, while multi-day stays are recorded as multiple full days. For example, one person staying for two days and one night would contribute two full visitor days to the data. Notably, the EMC applies only to the first three days of an extended charter, and certain exemptions apply (e.g. children under four, school groups, charities).

For this study, we focus exclusively on "full-day visits," defined as trips exceeding three hours within the Marine Park, as this category most accurately reflects core reef-based tourism. We excluded "part-day visits" (e.g. short commercial trips, such as jet-ski tours or sunset cruises), as well as exempt categories and stand-alone scenic flights or coral viewing tours that are not part of broader reef excursions. We also excluded the Far Northern Management Area due to its consistently low visitation, fewer than 400 visitors in December 2019, representing under 1% of total GBR visitation, and its extreme remoteness from major urban centres and transport hubs (Figure 2).

We obtained monthly EMC data for the Cairns/Cooktown, Townsville/Whitsundays, and Mackay/Capricorn Management Areas from January 2013 to December 2023, resulting in 132 data points per region. These three zones account for the overwhelming majority of GBR tourism activity. We visualised marine tourism recovery trends and calculated return times using resilience indices anchored to March 2020 (the last pre-pandemic month with normal visitor levels).

In addition to EMC-based data, we collected annual visitor statistics for the broader GBR tourism regions from Tourism Research Australia (2024a), which encompass both marine and non-marine tourists. These estimates are derived from the International Visitor Survey (IVS) (Tourism Research Australia, 2024b) and National Visitor Survey (NVS) (Tourism Research Australia, 2024c). The IVS is based on arrival card data and face-to-face interviews with overseas visitors. At the same time, the NVS uses a stratified sample of approximately 60,000 domestic travellers per year *via* telephone surveys. We analysed data from seven GBR-related tourism regions: Tropical North Queensland, Townsville, Whitsundays, Mackay, Capricorn, Gladstone, and Bundaberg. Because of the limited availability of monthly data for all GBR regions included in our study, we could not compare the time to return to equilibrium (in months) for this tourism scale in the analysis.

To compare marine and broader tourism dynamics, we constructed a "GBR visitation ratio" by calculating the proportion of total visitors to the GBR region who participated in activities related to the Marine Park. This allows us to assess whether the recovery of marine tourism kept pace with overall visitation trends. For all indicators, we analysed changes over the 2013–2023 period to contextualise pandemic impacts within a long-term trend.

2.2. Sectoral employment data

To analyse employment trends across the GBR regions, we used monthly data from the Australian Bureau of Statistics' Labour Force Survey (LFS) (2024a). The LFS is based on a rotating sample of approximately 50,000 individuals and provides high-frequency employment data disaggregated by industry and region (Australian Bureau of Statistics, 2024b). Although full population counts from the national Census are also available, these are collected only every five years (most recently in 2021), making the LFS more suitable for tracking short- and medium-term economic changes over the pandemic period.

Regional LFS data are available at the Statistical Area Level 4 (SA4), the largest sub-state units used in ABS labour market reporting. We selected four SA4 regions that closely align with our study area: Cairns, Townsville, Mackay–Isaac–Whitsunday, and Central Queensland (see Figure 2). The SA4 north of Cairns was excluded due to its low population and limited tourism activity, similar to the Far Northern Marine Area. For each of the selected SA4 regions, we analysed monthly data from February 2017 to February 2023, focusing on full-time employment.

The LFS reports employment across 19 sectors based on the Australian and New Zealand Standard Industrial Classification (ANZSIC). For analytical clarity, we consolidated these into seven broader categories. Our primary focus is on the "Tourism-related Services" category, which most directly reflects employment in sectors sensitive to tourism activity:

- Tourism-related services: Accommodation and Food Services; Arts and Recreation Services
- Primary sector: Agriculture, Forestry and Fishing; Mining
- Secondary sector: Manufacturing; Construction
- Public sector: Electricity, Gas, Water and Waste Services; Public Administration and Safety; Health Care and Social Assistance
- Trade sector: Wholesale Trade; Retail Trade; Transport, Postal and Warehousing
- Commercial services: Information Media and Telecommunications; Financial and Insurance Services; Rental, Hiring and Real Estate Services; Administrative and Support Services; Other Services
- Knowledge/Scientific Services: Professional, Scientific and Technical Services; Education and Training

Grouping these sectors allowed us to isolate the relative impacts of the pandemic on tourism-linked jobs compared to other parts of the regional economy. Full-time job counts in each category were aggregated quarterly to smooth short-term fluctuations and facilitate the calculation of relative resilience indices, using 2019 as the baseline.

2.3. Regional consolidation

The datasets used in this study are reported using three different regional classification systems: the Great Barrier Reef Marine Park Authority's Management Areas (MAs), Tourism Research Australia's tourism regions, and the Australian Bureau of Statistics' Statistical Area Level 4 (SA4) labour force regions. Figure 2 illustrates the spatial boundaries of these classifications and their geographic overlap. While the delineations differ slightly, there is sufficient alignment to enable consistent regional comparison for this analysis.

To ensure analytical coherence and reduce complexity, we consolidated the data into three overarching regions: Northern GBR, Central GBR, and Southern GBR. These aggregated regions reflect both geographic and functional characteristics of the GBR tourism system and correspond to areas of consistent data coverage across all sources.

- **Northern GBR** includes the Cairns/Cooktown Marine Area (MA), the Tropical North Queensland tourism region, and the Cairns SA4 region.
- **Central GBR** encompasses the Townsville/Whitsundays MA, the Townsville and Whitsundays tourism regions, and the SA4 regions of Townsville and Mackay–Isaac–Whitsunday[1].
- **Southern GBR** covers the Mackay/Capricorn MA, the tourism regions of Mackay, Capricorn, Gladstone, and Bundaberg, and the Central Queensland SA4 region[2].

These groupings enabled consistent cross-regional comparisons across the different indicators used in our resilience analysis.

Pre-pandemic vulnerability varied significantly across the three GBR regions (Table 1). The Northern GBR was the most exposed, with the highest dependence on international visitors, the greatest distance from domestic population centres, and the largest share of employment in tourism-related services. In contrast, the Southern GBR region was more proximate to Brisbane and had a lower share of international visitors and tourism-related employment. Notably, however, the Northern GBR also hosts the Cairns International Airport, which provides the most direct international access to the GBR and may influence regional patterns of resilience and recovery.

Theoretically, the loss of international visitors to Australia could have been partially offset by domestic travellers who were unable to travel overseas due to the international border closure implemented in March 2020. Before the pandemic, the number

Table 1. Indicators of pre-pandemic vulnerability across GBR regions.

	Northern GBR	Central GBR	Southern GBR
Distance from closest capital city (Brisbane)	1,700 km	1,113 km	360 km
Dependence on international visitors before the pandemic (2019)	27%	15%	6%
Share of employment in tourism-related services (February 2020).	9.3%	5.4%	5.0%

Notes: Distance to the nearest capital city was calculated using Google Maps, measuring from Brisbane to Cairns (Northern GBR), Airlie Beach (Central GBR), and Bundaberg (Southern GBR). The dependence on international visitors reflects the share of total regional tourism made up by international arrivals in 2019, as calculated by the authors using data from Tourism Research Australia (2024a). GBR-specific visitor data are not disaggregated by visitor origin, so regional tourism statistics were used as a proxy. The share of employment in tourism-related services is based on the authors' calculations using Labour Force Survey data from the Australian Bureau of Statistics (2024a).

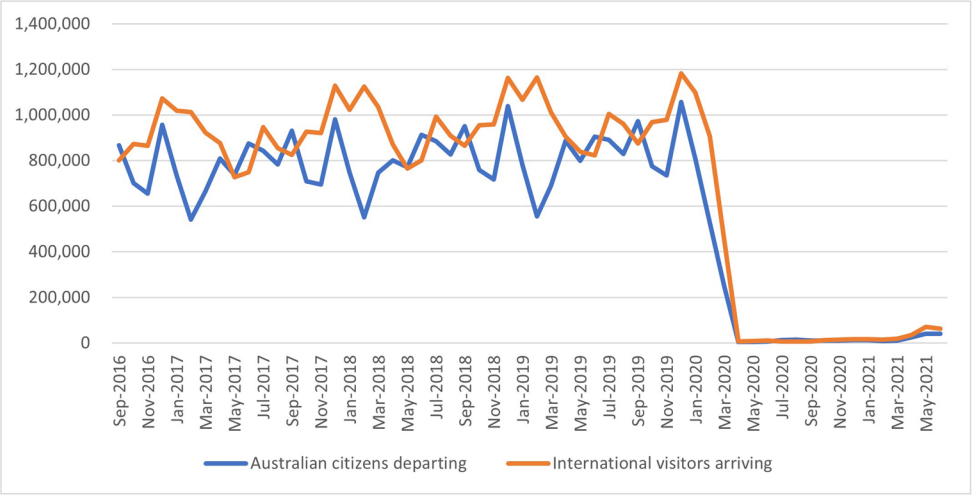


Figure 3. Inbound and outbound travel to and from Australia. *Notes:* Australian citizens travelling overseas and international visitors arriving in Australia (Australian Bureau of Statistics, 2021).

of Australian citizens travelling abroad was comparable, albeit slightly lower, than the number of inbound international visitors (Figure 3). This shift in available domestic demand created a potential buffer for tourism-dependent regions, such as the GBR, particularly those capable of attracting domestic tourists who might otherwise have travelled internationally. However, as we examine in later sections, the ability of different GBR subregions and tourism products, such as marine-based experiences, to capture this redirected domestic demand varied considerably.

3. Results

The COVID-19 pandemic triggered an unprecedented collapse in tourism activity across the Great Barrier Reef (GBR) region. Our analysis reveals substantial variation in recovery patterns across spatial and functional levels of the tourism economy. By integrating visitation and employment data, we assess the relative resilience of GBR marine tourism, regional visitation more broadly, and tourism-related employment across three consolidated regions: Northern, Central, and Southern GBR.

3.1. Marine and regional tourism recovery

Figure 4 illustrates monthly full-day visitation to the GBR Marine Park, showing a sharp decline from approximately 160,000 visitors in January 2020 to just 45 in April 2020, the lowest level on record. Recovery was gradual and uneven over the next three years, with monthly visitor numbers only approaching pre-pandemic levels by late 2023.

Disaggregating these trends spatially, Figure 5 shows that prior to the pandemic, the Northern GBR region was the primary destination for marine tourism, followed closely by the Central GBR, with the Southern GBR receiving a much smaller share. All regions experienced a simultaneous collapse in visitation, but recovery trajectories diverged.

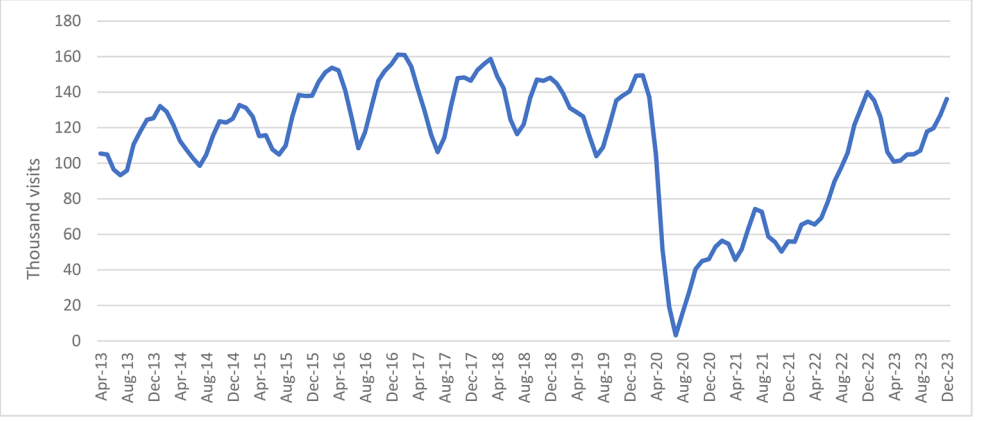


Figure 4. Full-day visitors to the Great Barrier Reef (moving average, 3 months). *Notes*: Authors' visualization based on Environmental Management Charge data (Great Barrier Reef Marine Park Authority, 2024b).

During the initial rebound phase (mid-2020 to early 2021), the Central GBR outperformed the North, likely due to greater accessibility from domestic markets. However, from early 2022, as international borders reopened, the Northern GBR began to catch up.

By December 2023, the Central GBR region had returned to its pre-pandemic visitation levels, while the Northern and Southern GBR regions remained 8% and 14% below their respective benchmarks for December 2019. Despite its proximity to Brisbane, the Southern GBR displayed only a brief period of faster recovery in mid-2021, suggesting that accessibility alone does not fully account for resilience (Figure 5(b)).

Return times to pre-disturbance equilibrium were broadly similar across regions, ranging from 2.6 to 3.0 years (Table 2). This highlights the protracted nature of recovery in marine-based tourism, regardless of market proximity.

To contextualise marine tourism within the broader visitor economy, we constructed a relative resilience index comparing GBR-specific visitation to overall regional visitation (Figure 6). While both indicators declined sharply in 2020, regional visits proved more resilient. In 2020, GBR Marine Park visits dropped by 61%, compared to a 35% decline in overall regional visits. By 2021, regional visits had recovered to 80% of their 2019 levels, while GBR-specific visits remained below 50%. The gap narrowed in 2022 and 2023, coinciding with the return of international tourism.

These patterns varied by subregion. Figure A1 (Online Appendix A) shows that the Northern GBR experienced the largest absolute declines, reflecting its pre-pandemic reliance on international markets (Table 1). However, it also demonstrated relatively strong recovery in converting regional visitors into Marine Park participants, suggesting a partial adaptation to domestic market preferences.

3.2. Employment resilience

While tourism visitation collapsed in 2020, the employment response was more muted. Figure 7 shows that total full-time jobs in the GBR region continued to grow until

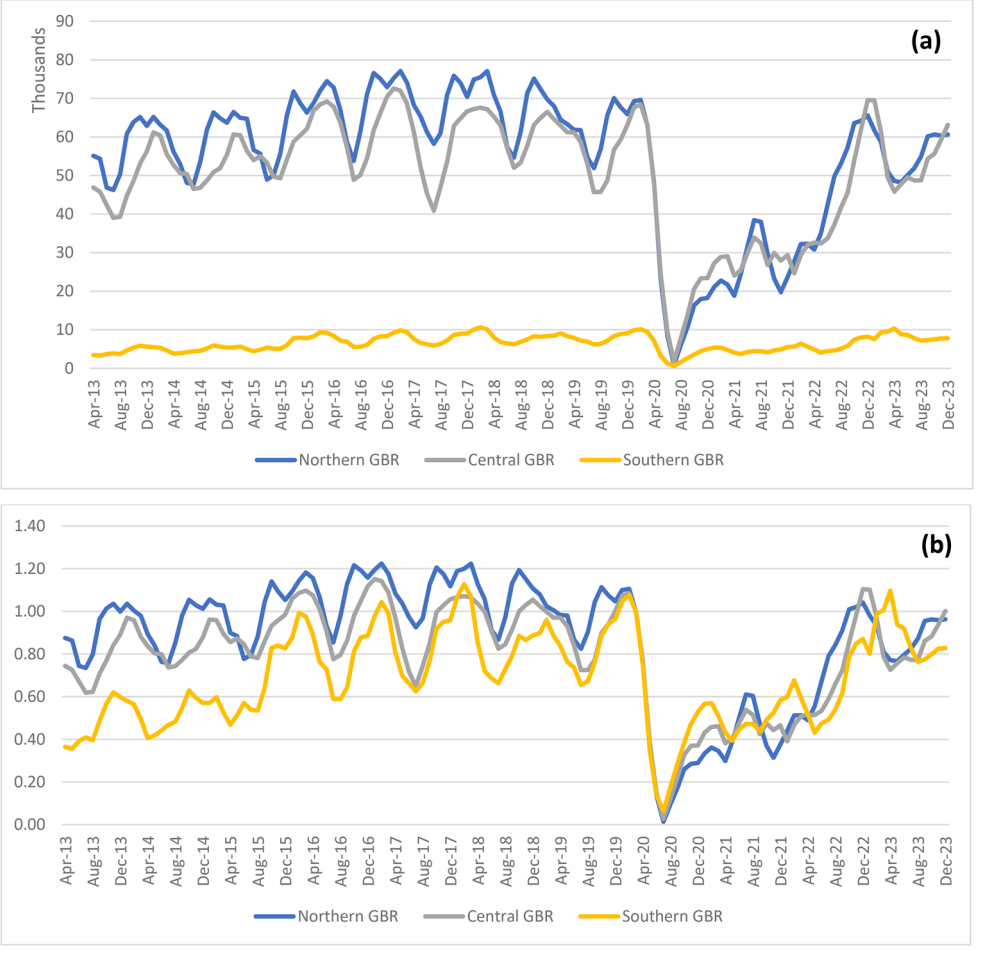


Figure 5. Full-day visitors to the Great Barrier Reef by region (moving average, 3 months). Chart b) shows changes using an Index equal to 1 in March 2020 levels. *Notes*: Authors' visualization based on EMC data (Great Barrier Reef Marine Park Authority, 2024b). Northern GBR includes Cairns Cooktown MA, Central GBR includes Townsville Whitsunday MA, and Southern GBR includes Mackay Capricorn MA.

Table 2. Return time to equilibrium for GBR visits across consolidated and three specific GBR regions.

	GBR – total	Northern GBR	Central GBR	Southern GBR
Month when reached pre-disturbance equilibrium[1]	December 2022	October 2022	December 2022	March 2023
Time to pre-disturbance equilibrium	33 months/2.8 years	31 months/2.6 years	33 months/2.8 years	36 months/3.0 years

Notes: We used the three-month weighted average visitor numbers for March 2020 as the pre-disturbance equilibrium. Table developed by authors based on EMC data (Great Barrier Reef Marine Park Authority, 2024b).

May 2020 and declined only modestly thereafter. From a peak of 329,000 jobs in May 2020, the region lost around 11,000 jobs over the next nine months until February 2021, with the most pronounced losses in the trade sector (–6,700), scientific services

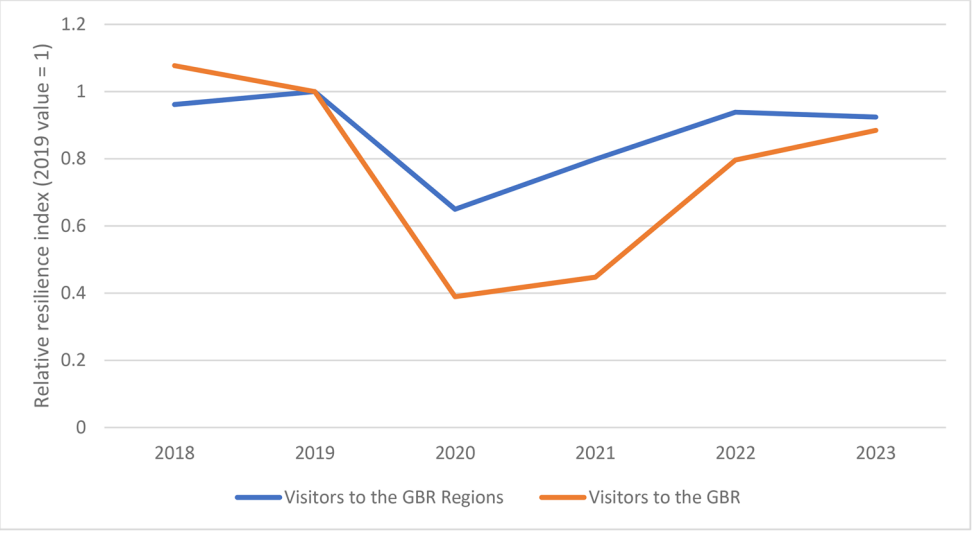


Figure 6. Relative resilience index comparing visitor dynamics to the Great Barrier Reef Marine Park and visitors to the Great Barrier Reef Regions. *Notes*: The resilience index is measured as the annual visitor numbers divided by the visitor numbers in the index year 2019, which was one year before the pandemic started. Authors visualization based on EMC (Great Barrier Reef Marine Park Authority, 2024b) and Tourism Research Australia (2024a) data.

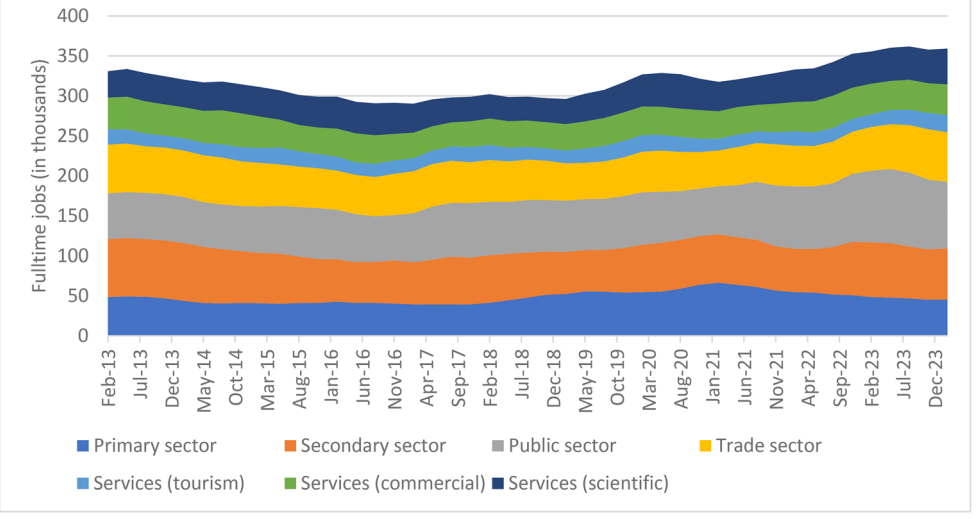


Figure 7. Changes in full-time jobs (in thousands) across the Great Barrier Reef Region between 2013 and 2023. *Notes*: Authors visualization based on Labour Force Survey (Australian Bureau of Statistics, 2024a).

(–5,600), and tourism-related services (–4,900). These losses were offset in part by a significant rise in primary sector employment (+11,000), particularly mining.

Tourism-related employment saw its sharpest decline in 2021, following the conclusion of the national JobKeeper wage subsidy scheme in March. Figure 8 illustrates

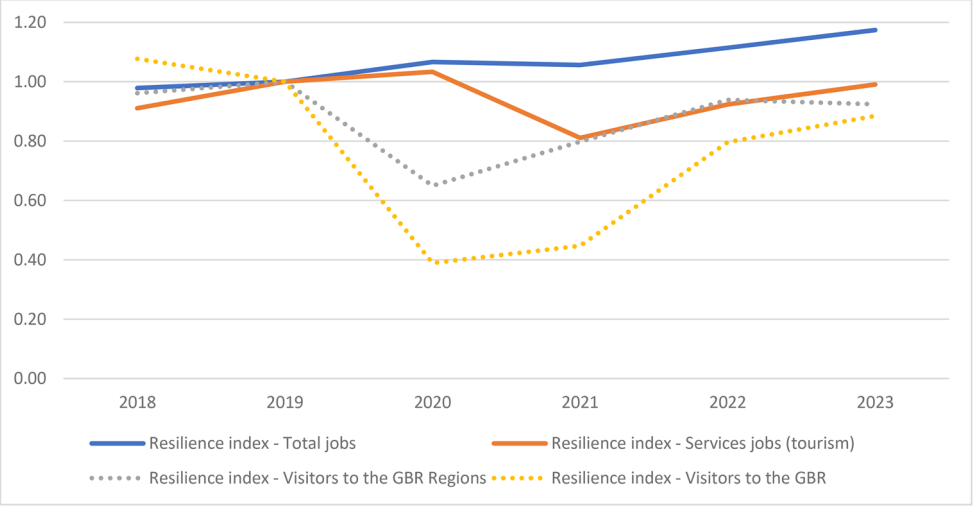


Figure 8. Employment Relative Resilience Index comparing total full-time jobs and full-time jobs in the tourism-related sector in the GBR region. *Notes*: For comparative purposes, we also included the Relative Resilience indices for visitors to the GBR and to the GBR Regions that were presented in Figure 6. The resilience index is measured as the average number of annual jobs in a certain year divided by the average number of annual jobs in the index year 2019, which was one year before the pandemic started. The average number of annual jobs was calculated based on quarterly jobs data provided by the Labour Force Survey. Source: Authors' using data from the Labour Force Survey (Australian Bureau of Statistics, 2024a).

that tourism jobs declined by 20% in 2021 relative to 2019 levels but returned to pre-pandemic levels by early 2024. By contrast, total employment grew steadily, reaching levels 20% above 2019 by 2023.

At the regional level, employment impacts were uneven. As shown in Figure B1 (Online Appendix B), the Central GBR region (Townsville and Mackay–Isaac–Whitsunday) experienced no net job loss during the pandemic, as primary sector growth outweighed tourism-related declines. The Northern GBR (Cairns) lost 7,600 jobs between February 2020 and February 2021, mostly in construction, scientific services, and commercial sectors. The Southern GBR (Central Queensland) recorded the largest absolute losses (–9,400), concentrated in tourism-related and trade sectors, but also saw compensatory growth in mining (+11,800).

Figure C1 (Online Appendix C) further illustrates that the Cairns region initially experienced a surge in tourism-related jobs in 2020 (+26% compared to 2019), likely driven by JobKeeper, followed by a delayed contraction in 2021. In contrast, the Southern GBR experienced a sharp drop in leisure sector employment in both 2020 (–35%) and 2021 (–55%) but rebounded quickly thereafter.

Return times for employment varied by region and indicator (Table 3). Tourism-related employment in the Northern GBR returned to its February 2020 level by early 2024, while the Central and Southern GBR recovered earlier, in 2022. Total employment, however, rebounded much faster, returning to pre-pandemic levels by May 2020 in all regions except the Northern GBR, which required 2.5 years to recover.

Table 3. Return time to equilibrium for tourism-related and overall employment across consolidated and three specific GBR regions.

	GBR – total	Northern GBR (Cairns)	Central GBR	Southern GBR
Services jobs (tourism)				
Month when the pre-disturbance equilibrium was reached	February 2024	May 2020[2]	February 2022	November 2022
Time to pre-disturbance equilibrium	48 months/4 years	3 months/0.3 years	24 months/2 years	32 months/2.7 years
Total jobs				
Month when the pre-disturbance equilibrium was reached	May 2020	August 2022	May 2020	May 2020
Time to pre-disturbance equilibrium	3 months/0.3 years	30 months/2.5 years	3 months/0.3 years	3 months/0.3 years

Notes: We used the employment count in February 2020 as the pre-disturbance equilibrium. Labour Force Surveys measure employment data across four yearly intervals, February, May, August, and November. We note here the likely impact of the JobKeeper scheme that prevented the tourism-related jobs from decreasing in the Northern GBR Region in the first year after the pandemic. LFS data showed that the first decline in tourism-related jobs in the Northern GBR region was reported in February 2021, which was a year after the onset of the pandemic and a month before the JobKeeper scheme ended. However, in this same region (Northern GBR), after the delayed decline in tourism jobs, based on our latest data point in February 2024, tourism-related jobs have not yet recovered to their February 2020 baseline level. Table developed by the authors based on data from the Labour Force Survey (Australian Bureau of Statistics, 2024a).

4. Discussion

This study makes both empirical and methodological contributions to the understanding and measurement of regional economic resilience, defined as the capacity of local systems to absorb and recover from disturbances (Christopherson et al., 2010; Martin & Sunley, 2015; Pendall et al., 2010). By focusing on the COVID-19 pandemic, we expand the empirical literature that has largely centred on economic downturns and financial crises (Di Caro, 2015; Martin et al., 2016; Mikheeva, 2021; Z. Wang & Wei, 2021). Moreover, we analyse a tourism-dependent regional economy that is highly vulnerable to global travel restrictions. Our findings highlight the unprecedented decline in tourism activity in the GBR region, where visitations to the Marine Park dropped from approximately 150,000 per month to near zero in early 2020, followed by a protracted and uneven recovery (Figure 4). It took nearly three years for visitor numbers to return to pre-pandemic levels, with reef-specific tourism showing a slower recovery than broader regional tourism (Table 2). In 2021, regional tourism had rebounded to around 80% of 2019 levels, while GBR-specific visits remained below 50% (Figure 6). This divergence highlights the limits of domestic tourism as a substitute for international demand in niche marine experiences, a point also supported by qualitative research on consumer preferences during the pandemic (Curnock et al., 2023).

The concept of a domestic 'cushion effect' is useful but insufficient to explain the weak rebound in reef-specific activities. Our results suggest that tourists increasingly prioritised cost-saving and risk-averse behaviours, opting for general visitation over more expensive reef tours (Boto-García & Baños Pino, 2024). This aligns with broader studies on price sensitivity and changing tourist preferences during crises (Allan et al., 2022; Arbulú et al., 2021). Interestingly, despite having the highest international visitor

dependency before the pandemic, the Northern GBR region displayed relatively higher resilience in converting regional visitors into GBR tourists (see Online Appendix A), suggesting spatially differentiated capacities for adaptation (Bartelet et al., 2025; Hartman, 2016). This pattern may be explained by the centrality of the GBR itself as a primary drawcard for domestic visitors to that region. In contrast to other parts of the GBR where tourism offerings are more diversified or embedded within broader regional travel circuits, visitation to the Northern GBR is more directly tied to reef-based experiences. As such, domestic tourists who chose to travel to this remote region during the pandemic were likely motivated specifically by the opportunity to engage with GBR-related attractions, resulting in a higher conversion rate from general regional visitation to site-specific tourism activity.

In contrast, employment in the region proved more resilient than visitation. Total employment not only recovered but grew above pre-pandemic levels by 2023 (Figure 8), while tourism-related employment returned to baseline by early 2024 (Table 3). Losses in tourism and scientific sectors were partially offset by growth in the primary and public sectors. The muted employment impact in 2020 can be largely attributed to the JobKeeper program (Borland & Hunt, 2023), which helped retain workers even amid visitation collapses. However, the end of JobKeeper in March 2021 coincided with a 20% drop in tourism jobs, highlighting the fragility of recovery in the absence of policy buffers.

Methodologically, this paper contributes to tourism and resilience research by applying a multi-scalar framework rooted in ecological systems thinking (Allen et al., 2005; Levin, 1992; Peterson et al., 1998). Our relative resilience indices allow comparison across spatial and functional levels, revealing that tourism recovery was slower at the level of attractions (Marine Park) than at the broader regional scale, a pattern that would be obscured in single-scale analyses. These findings reinforce recent calls to incorporate scale explicitly into regional resilience studies (Duan et al., 2022; Song et al., 2023). A limitation of our current approach is that we were not able to include causal or correlational analysis of the determinants of resilience between different scales or regions (Song et al., 2022; Wang & Wei, 2021). While we did set out some contextual pre-disturbance differences between the regions included in our analysis (Table 1) we were not able to test their direct effect on return times to equilibrium (Tables 2 and 3) because of the small sample size (three GBR regions). Similarly, our analysis included three functional scales (GBR tourism, regional tourism, and the broader economy) that limited opportunities for quantitative analysis. Testing for the determinants of resilience would be more suitable using regions across all of Queensland or all of Australia, using both regional tourism and employment data, but this approach would likely obscure the functional scale of specific tourism attractions such as the GBR. Future research could explore avenues to increase sample size without losing the multi-scalar resilience dimension.

Our findings contribute to and extend existing tourism resilience research in several important ways. Consistent with prior studies, we find that tourism-dependent and geographically remote regions were more vulnerable to disruption during the COVID-19 pandemic (Gera & Kumar, 2023; Wang et al., 2022). While some studies have noted shifts in visitor profiles and the importance of local markets during the pandemic (Duro et al., 2024; Vermeulen-Miltz et al., 2023), few have systematically compared

recovery dynamics across spatial and functional scales as we do here. Our study thus adds new insight by demonstrating that these patterns are not uniform across scales. While site-level and subregional visitation remained suppressed for extended periods, broader regional tourism and employment indicators showed more rapid and stable recovery. This divergence is rarely captured in existing studies, which typically focus on a single level of analysis (e.g. national tourism flows or regional GDP). By applying a multi-scalar framework, our study reveals how resilience can manifest differently across nested systems, an approach more common in ecological research (Allen et al., 2005) but still underutilised in tourism and regional economic studies (Amore et al., 2018; Song et al., 2023). This methodological contribution enables a more granular understanding of vulnerability and recovery and highlights the importance of scale-sensitive policy responses in tourism resilience planning.

At the same time, our results reveal limitations in existing data systems for monitoring tourism resilience. For example, GBRMPA's visitor dataset does not distinguish between international and domestic visitors, while Tourism Research Australia's regional data lacks detail on purpose of visit (e.g. leisure vs business) as well as monthly granularity for some of the regions. This absence of disaggregated data (e.g. on international versus domestic visitors or according to purpose of visit) should be considered when interpreting our resilience indices. More granular data on visitor origin, type, and travel behaviour, along with improved occupational classifications for tourism jobs (e.g. under ANZSCO), would greatly enhance real-time resilience assessments, monitoring and planning (Australian Bureau of Statistics, 2024a; Curnock et al., 2023).

Finally, these findings have broader implications for resilience planning in tourism-dependent regions (Biggs et al., 2012; Espiner et al., 2017). First, strategies should account for the asynchronous and scale-dependent nature of recovery because tourist attractions may remain vulnerable even as broader economies rebound. Second, domestic markets can offer some buffer against international shocks, but they are not perfect substitutes. Third, spatial accessibility and distance to major markets (as seen in the relatively faster recovery of the Southern GBR region; Figure 5b) remain key determinants of resilience. Developing flexible policy responses and adaptive management practices that reflect these dynamics will be essential for building tourism system resilience in the face of future global shocks.

5. Conclusion

This study offers a novel, multi-scalar analysis of tourism resilience in one of the world's most iconic and vulnerable destinations: Australia's Great Barrier Reef (GBR). By drawing on high-frequency, longitudinal data spanning tourism activity and employment across marine, regional, and sectoral scales, we provide rare empirical insights into how economic systems respond to global shocks, such as the COVID-19 pandemic. Our analysis shows that resilience is uneven across space, time, and functional levels: while total regional employment rebounded relatively quickly, partly due to policy interventions, marine tourism remained highly exposed, with a slower and more fragile recovery.

Methodologically, we contribute to the literature by adapting a multi-scalar resilience framework rooted in ecological theory to the context of regional tourism economies. This approach captures dynamics often overlooked in single-scale assessments,

such as the divergence between attraction-level visitation and broader regional indicators. It also highlights the importance of cross-scalar interactions, for example, how macro-level border closures cascade through local tourism sectors.

Practically, our findings underscore that tourism resilience is not simply a matter of aggregate recovery but must be understood as a complex, layered process shaped by remoteness, market dependency, and policy responsiveness. The buffering role of domestic tourism and government stimulus was critical but uneven across subregions. Importantly, marine-based tourism products, those requiring specialised infrastructure, staff, and visitor commitment, proved more challenging to substitute or adapt during the crisis.

Looking forward, building tourism resilience will require more than reactive policy. It demands anticipatory planning that recognises spatial and sectoral asymmetries, invests in data systems that support real-time monitoring, and strengthens the adaptive capacities of regions highly exposed to external shocks. As climate, health, and economic uncertainties grow, the framework and evidence we present here offer a foundation for more targeted, responsive, and equitable strategies to support sustainable tourism futures, not only in the GBR, but in similarly vulnerable destinations worldwide.

Notes

1. We included the SA4 of Mackay–Isaac–Whitsunday within the Central GBR region. Although Figure 2 shows that this SA4 spans both the Townsville/Whitsundays MA and the Mackay/Capricorn MA divisions, its functional role in GBR visitation justifies this classification. Airlie Beach, located in the northern part of this SA4, is one of the most important gateways to the Great Barrier Reef and a major departure point for reef-related tourism. In contrast, the other major population centre in the SA4, the city of Mackay, sits at the intersection of the Townsville/Whitsundays and Mackay/Capricorn MA regions. While Mackay is a significant urban hub in Queensland, it is not strongly connected to GBR tourism. All data to replicate and test findings under different assumptions are available as supplementary information.
2. Although the Bundaberg tourism region does not spatially intersect with the GBR Mackay/Capricorn MA (see Figure 2), we included it in our analysis, given Bundaberg's role as a key access point for boat-based visits to the southern parts of the GBR. All data to replicate and test findings under different assumptions are available as supplementary information.

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Research ethics

This research did not contain primary data collection. De-identified datasets with no personal information were provided by the Great Barrier Reef Marine Park Authority and Tourism Research Australia.

Author contributions

CRediT: **Henry A. Bartelet**: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing; **David Fleming-Muñoz**:

Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing; **Gareth L. Phillips**: Writing – review & editing; **Matthew I. Curnock**: Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Writing – review & editing.

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No potential conflict of interest was reported by the author(s).

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Data availability statement

Our research used publicly available data from the Australian Bureau of Statistics, the Great Barrier Reef Marine Park Authority, and Tourism Research Australia. Data are available as supplementary information.

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