Assessment of Congestion and Conflicting Use Management for the Gold Coast Waterways

Volume 1: Technical Report

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Volume 1: Technical Report

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Executive Summary

This study was commissioned by the Gold Coast Waterways Authority (GCWA) to help develop a better understanding of the current and emerging users and uses of the Gold Coast waterways (GC waterways). With a growing population, the study will provide a baseline for the current status of the GC waterways and helped identify current and emerging conflicts. The GCWA will use this information to aid in the future management of the GC waterways.

On this basis, the GCWA engaged Envirosphere Consulting to undertake a comprehensive desktop assessment/literature review of the current users and uses (social, environmental and economic) of the GC waterways and current industry practices for managing congestion and conflicting waterway uses. This information was used to develop recommendations to help better manage the GC waterways for current and future users, uses and conflicts.

The following section summarises the key themes of this technical report and outlines findings from the extensive literature review, tourism and population trends, patterns of use, critical gaps in data and gaps in understanding. The summary below also presents the key strengths, weaknesses, opportunities and threats related to uses and users of the GC waterways.

Literature Review (Section 2)

Detailed examination of more than 120 international and local literature sources, selected from more than 2000 search results, revealed common themes around the issue of conflict and congestion in the use of waterways.

Conflict commonly occurs in various forms where incompatible uses cannot co-exist; where there is competition for limited natural resources; or where this same resource is exploited by different users. Of particular concern is asymmetric conflict, where the conflict is not experienced equally by both sides to that conflict, usually reflecting a spectrum based on the size, speed and noise of craft used. For example, personal watercraft (PWC) users are not annoyed by other users but are usually negatively viewed by them.

A primary source of conflict is the perception of overcrowding, which is closely linked to social carrying capacity. While users can adapt to varying extents, there are limits to this for both residents and visitors. The most likely response to persistent overcrowding is displacement, which may have economic consequences. Older and/or more affluent residents tend to have lower thresholds to perceptions of overcrowding, and are therefore amongst the first to relocate, taking that disposable income with them. Accompanying increased perceived conflict and overcrowding is rapidly diminishing support for management, loss of support for tourism operations, and increased environmental degradation.

A review of management and planning tools illustrated that various forms of Marine Spatial Planning are successful in not only resolving conflict, but in predicting and avoiding conflict in the first place. With sufficient spatially explicit information this allows mapping of areas of potential conflict, or where proposed uses may be incompatible.

Tourism and Population Trends (Section 3)

Domestic and international visitation over the last 10 years has undergone substantial growth in the GC waterways and surrounding areas – more than seven times that of visitation to the wider Gold Coast region. Concurrently, visitation for the purpose of Aquatic and Coastal[1] activities has doubled and is predicted to involve at least six million visitors by 2030. More than 50% of current visitors focus their

[1] Aquatic and Coastal activities relate to activities undertaken in and around the water including: active participation activities such as fishing and snorkelling, as well as activities based on enjoying water surrounds, such as charter boats (see `Appendix C: Visitor Usage Summary', particularly Section 9 `Detailed Activity Analysis' for details).

stay on the southern Broadwater, but that this is changing. The strongest growth in visitation over the last five years for international visitors is in the northern Broadwater, while domestic day and overnight visitation declined in all areas except the Southern Section[2] creeks.

There are also important forecast changes in population demographics. According to 2018 Queensland Treasury forecasts, the strongest growth in population in the region over the next 20 years will be in the Northern Broadwater, where the population will more than double. The increase in associated vessel traffic, and pressure on waterway access points, is of particular concern, both for the potential for user conflicts, but also because these are the most environmentally sensitive parts of the GC waterways.

Patterns of Use (Section 4)

Data searches uncovered more than 40 spatially-based datasets relevant to this study. Section 4 outlines the results of detailed analyses of these datasets and illustrates the current state of knowledge, identifies critical information gaps (Section 5), and highlights current and/or potential conflict hotspots (locations where competing potentially incompatible uses occur and the probability of user conflict is high).

Ecological values are highest in the Northern Section, where mangrove, saltmarsh and seagrass diversity and area of habitat is highest. It is also of very high value for migrating shorebirds, and as nesting habitat for coastal raptors. In contrast, available mapping shows low ecological value through the Mid-Section, with no patches of high biodiversity value. Small patches of high biodiversity value exist within those parts of the Southern Section creeks that retain natural riparian and intertidal vegetation.

Similarly, the diversity of human use of the waterways is highest in the Northern Section, where there are fewest constraints to access, either in terms of natural restrictions (water depth, tidal flow, location of 'desirable' destinations with scenic amenity value), or human infrastructure (bridges, weirs, speed limits, provision of boat ramps, marina locations). In the Mid-Section, such restrictions assist in separating potentially conflicting uses, for example larger vessels producing damaging wakes cannot access calm water reaches that are used by small unstable craft such as rowing shells.

Very little information was available about patterns of use of small (under eight metre), private recreational vessels (see Gap Analysis, Section 5). Trends in vessel registrations over time show that numbers in the three to four metre vessel class, including PWCs, is the fastest growing vessel class, growing faster than the local population. However, there is virtually no quantitative information available on areas of operation of this segment, which represents the largest group of users.

Data on actual and/or potential areas of conflict is drawn from reported boating incidents, water police infringement data, and spatial overlays of conflicting use types. Areas with the highest potential for conflicts between users, especially those that could result in accident, injury or death, are concentrated in three main locations: the Gold Coast Seaway and Wave Break Island, and around the mouths of both Tallebudgera and Currumbin Creeks. However, because of the lack of information about a) use patterns of small recreation vessels, and b) other types of conflict not likely to lead to accidents, it is suggested that the analyses presented underestimate the potential for conflicts, in terms of both location and frequency.

Gap Analysis (Section 5)

The tables in Section 5 summarise the availability of qualitative and quantitative datasets and identifies both further information required to carry out spatial analyses at the requisite scale for management planning. The highest priority is to acquire recent spatial data on smaller recreational vessels (< 8 m).

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[2] Based on the three main sections of the GC waterways used for this project as outlined below (refer Section 4 '***Users and Uses of the Gold Coast Waterways***' for details).
1. Broadwater/Northern Section - the Broadwater north of the Seaway (7,474 ha)
2. Nerang River/Mid-Section - the Nerang River and associated canal estates and lakes (1,995 ha)
3. Southern Creeks/Southern Section - Tallebudgera and Currumbin Creeks and associated canal estates (322 ha).

Several data types are required, most critically: areas used for different activities (e.g. fishing, water-skiing, sightseeing), the values users place on particular locations, and their attitudes to other users. For a comprehensive spatial hotspot analysis, information is required about potentially or actually conflicting use pairs, and the distribution of use types that are particularly vulnerable to conflict from other users.

Strengths, Weaknesses, Opportunities and Threats (Section 6)

The Northern Section is the largest section of the GC waterways, and the most diverse in terms of the mix of vessels and use types, and ecological values. This section has the greatest potential for conflict between users, both in terms of the frequency of such interactions, and the area over which they may occur.

The most distinct strength for the Mid-Section of the GC waterways is the extensive reaches of protected waters suitable for fitness-based and competitive water sports, both in the Nerang river, and in canals and adjoining lakes. To date, existing height and access restrictions, combined with speed limits, appear to (mostly) effectively separate these uses from incompatible activities. However, infringement data shows that exceeding the speed limits is the most common offence and given that the literature shows that compliance is a key to user satisfaction, vigilance is required here.

Hotspots for conflict at the mouths of the Southern Section creeks are well known, both anecdotally and quantitatively – so while these are episodic in nature, they are predictable, and therefore in theory manageable, for instance through a combination of regulation, enforcement, education and outreach. The quiet and peaceful nature of the natural vegetation-lined inner parts of the creeks, is, anecdotally, perceived to be under threat from more intrusive forms of use.

To summarise, a broad mix of uses takes place within the GC waterways. While there are known conflict hotspots, in terms of incidents, accidents and injuries, these are in absolute terms relatively rare. Set against the backdrop of increasing population, and concurrent rises in registrations of small vessels, this should be seen as a significant opportunity. There is a window in time over the next several years, given stable and invested governance, to set in place outward looking and inclusive management practises, adaptive monitoring and data gathering, to identify and ameliorate potential conflicts to avoid the mistakes of other jurisdictions.

1 Introduction

This study was commissioned by the Gold Coast Waterways Authority (GCWA) to help develop a better understanding of the current and emerging users and uses of the Gold Coast waterways (GC waterways). With a growing population, the study will provide a baseline for the current status of the GC waterways and helped identify current and emerging conflicts. The GCWA will use this information to aid in the future management of the GC waterways.

On this basis, the GCWA engaged Envirosphere Consulting to undertake a comprehensive desktop assessment/literature review of the current users and uses (social, environmental and economic) of the GC waterways and current industry practices for managing congestion and conflicting waterway uses. This information was used to develop recommendations to help better manage the GC waterways for current and future users, uses and conflicts.

1.1 Project background

The Gold Coast Waterways Authority (GCWA) is a Queensland Government statutory body with responsibility to plan for, promote and manage the sustainable use of the GC waterways as shown in Figure 1 (see Appendix A for additional information on the GCWA and the GC waterways).

The GC waterways are an extensive and iconic feature of the wider cityscape that includes the rivers, canals, lakes and dams within the City of the Gold Coast local government area as well as the areas at the mouth of the Nerang River, Currumbin Creek and Tallebudgera Creek (see Figure 1). The dominant geographic feature is the Gold Coast Broadwater, a large shallow estuarine waterbody forming part of southern Moreton Bay. It plays an important role in the region's tourism industry, recreational pursuits, and fisheries, and features a number of significant environmental values. These waterways are the subject of this project.

It should be noted that there are waterbodies within the GCWA's footprint that are effectively managed by other entities for other purposes. For example, SEQ Water manages Hinze Dam and Little Nerang Dam for the primary purpose of providing drinking water storage for the City of Gold Coast. These waterbodies are excluded from this project.

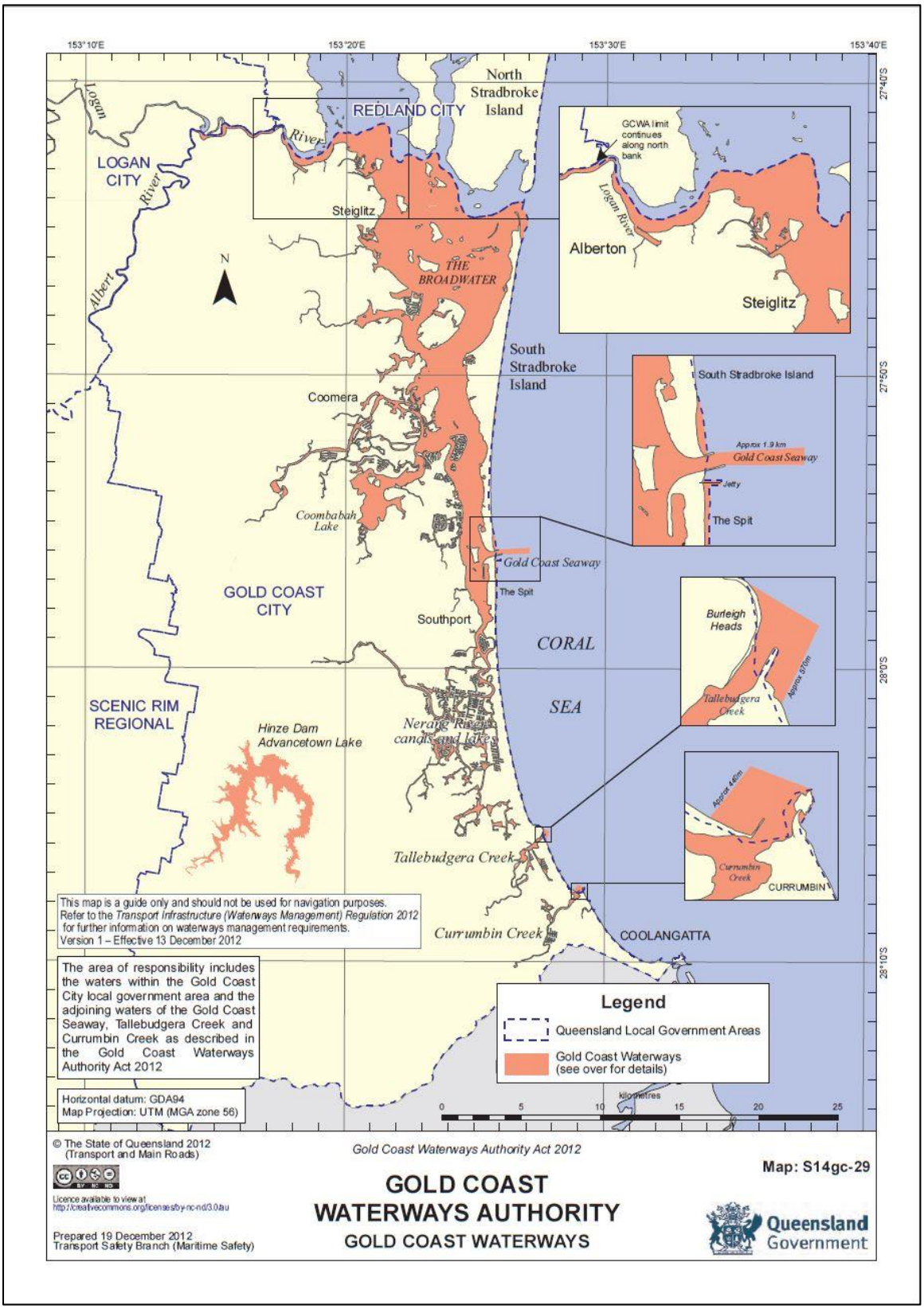

Figure 1: Map showing the relative extent of the GC waterways (source: Department of Transport and Main Roads. 2012).

1.2 Project aims and objectives

The aim of this project is to enhance the GCWA's current knowledge and understanding of the existing users, current and future uses (social, economic and environmental), current and emerging conflicts and to identify best practice management measures for congestion and conflicts on waterways.

The objective of this project is to undertake a comprehensive literature review and gap analysis and prepare a discussion paper (presented as a separate document) that will form the basis of future projects aimed at addressing the identified information gaps.

This is to be undertaken in the context of enabling the GCWA to proactively plan for and manage the GC waterways by developing a comprehensive understanding of the users and uses on the waterways (current and emerging) and the best practice management measures currently available. Then, through the adoption of the most relevant and appropriate best practice management measures for the GC waterways, build resilience, preserve environmental and social values, promote safe and equitable use and generate prosperity for a growing population.

1.3 Reporting structure

The project outcomes are reported in two key documents. The Technical Report (volume 1 – this document) includes the literature review, visitor usage summary and spatial analyses that constitute the information base for the project, as well as the Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis, and the Gap Analysis. The Discussion Paper (volume 2) contains an Executive Summary, and discussion of the implications of the key issues arising from the analyses, including recommendations for addressing the identified shortcomings of the information base. The project also delivers in digital form the datasets used for the spatial analyses, as well as the mapped outputs from those analyses.

1.4 Project scope

To assist the GCWA in actively and effectively managing users and uses of the GC waterways, Envirosphere Consulting collected, collated, reviewed and analysed currently available information and data to:

- complete a comprehensive literature review
- undertake extensive spatial mapping (including development of associated GIS data layers) of environmental, recreational and commercial users and uses including—
    - types of users and uses
    - frequency, location, timing and intensity of users and uses
    - current, emerging or potential conflicts occurring between users and uses
- perform a critical gap analysis
- prepare a well-informed discussion paper on how to best address the information requirements identified in the gap analysis

The scope of works was performed in two distinct parts as broadly outlined below.

1.4.1 Literature review

This component included undertaking a comprehensive desktop assessment/literature review of existing information (qualitative and quantitative) on the current social, economic and environmental

users and uses of the GC waterways.

The assessment was delivered as a comprehensive technical report (this report - containing maps and associated GIS data layers) that included:

- identification of users and uses—
  - environmental uses (provision of essential environmental services or hosting critical habitats and/or species)
  - past and present commercial users and uses
  - past and present recreational users and uses
  - identification of potential future users and uses
- a characterisation of the geographically and functionally diverse users of the GC waterways
- identification of conflicting uses of the waterways and potential risks arising from such conflicts (including conflicts related to adjacent land uses)
- identification of the values different users place on the waterways
- relevant best management practices from other jurisdictions (including overseas) for dealing with waterways congestion and the identified conflicts

1.4.2 Gap analysis

Using the information from 'Literature review' and in line with the overall project aims and objectives, Envirosphere Consulting worked with the GCWA, including the Science and Innovation Advisory Committee (SIAC), to clearly identify critical information gaps and develop a discussion paper with clear and concise recommendations to suitably address these gaps, including the identification and acquisition of other sources of existing data and the collection of additional data using field and online surveys. The gap analysis and discussion paper development process included the use of a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis.

Envirosphere Consulting also delivered the following two high quality presentations to the GCWA:

1. A preliminary presentation to the GCWA Science and Innovation Advisory Committee (SIAC) that succinctly summarised the major project outcomes, including an overview of users, uses and conflicts, critical information gaps and how such gaps may best be filled.
2. A final presentation to the GCWA Board at a strategy session that summarised the major findings from the project and recommendations arising.

1.4.3 Deliverables

The following items were delivered by this project:

- literature review (presented as a comprehensive technical report including extensive spatial mapping of users, uses and conflicts)
- GIS information and data layers to accompany and support current and future mapping exercises
- discussion paper
- presentations (2x)

1.5 Constraints

Although the study has met its original aims and objectives, there were several unavoidable limitations which are detailed in the report section below. These constraints were exacerbated by the Cambridge Analytica incident[3] that prompted many owners of internet sites collecting tracking data to restrict access.

The number of different potential topics, and the size of the vast literature pool, meant that one relatively short study could not be expected to review and include all of the information discovered. Many papers were culled from the original search returns because the generalised findings could not be readily applied to the Gold Coast situation and may have even been misleading, if presented.

The study design was heavily focussed on the review and interpretation of literature and existing data at the appropriate scale and did not include additional field assessments or user surveys. Where relevant, the need for such studies is identified in the Gap Analysis.

Many important sources of information that could help improve understanding of our waterway uses and users were not accessible due to business or organisational restrictions on data sharing (see Gap Analysis Section 5).

With regard to tourism usage of the waterways, core national tourism datasets (Tourism Research Australia - TRA) have limitations in terms of their usage for performance management and assessment of congestion and environmental impact. Limitations include:

- SA2 statistical regions are the smallest area units of tourism data that is available. Sample sizes limits the analysis that can be carried out at this level.
- SA2 regions, although achieving a reasonable fit with watercourses, do not align exactly and, also relative to broader regions, it is not possible to further filter this data.
- TRA surveys only include data on tourism usage, as defined by the definitions of day, international and domestic overnight visitors. Local residents and those travelling for the day from less than 50 km away/taking trips of less than four hours are excluded.
- The nature of questions asked on visitor activities relate to trips as a whole, therefore isolating visitor activities to individual waterways locations is challenging, especially for overnight and longer trips.

[3] Cambridge Analytica is a data firm based in London, UK, which acquired (possibly illegally) private Facebook data of millions of users to build voter profiles, potentially influencing the USA election and Brexit vote. This became public in March 2018, prompting a reaction against data availability.

2 Managing Congestion and Conflicting Use

This section provides information from the literature review for managing congestion and conflicting use and was designed to address the following questions:

- What nature of conflicts between users/uses are likely on GC waterways as use (and waterway traffic) increases?
- What factors contribute to these conflicts, and what options might be used to mitigate or avoid them?

2.1 Methods

2.1.1 Search strategy

Searches for primary and grey literature were initially conducted on Web of Science, Scopus, Proquest and EBSCOHost. The Boolean search string (Appendix B) was built from key concepts in the primary question. Search results contained keywords from all core concepts: 1) conflict; 2) increased user numbers; 3) aquatic location; and 4) any of the known or emerging uses or user types on the Gold Coast.

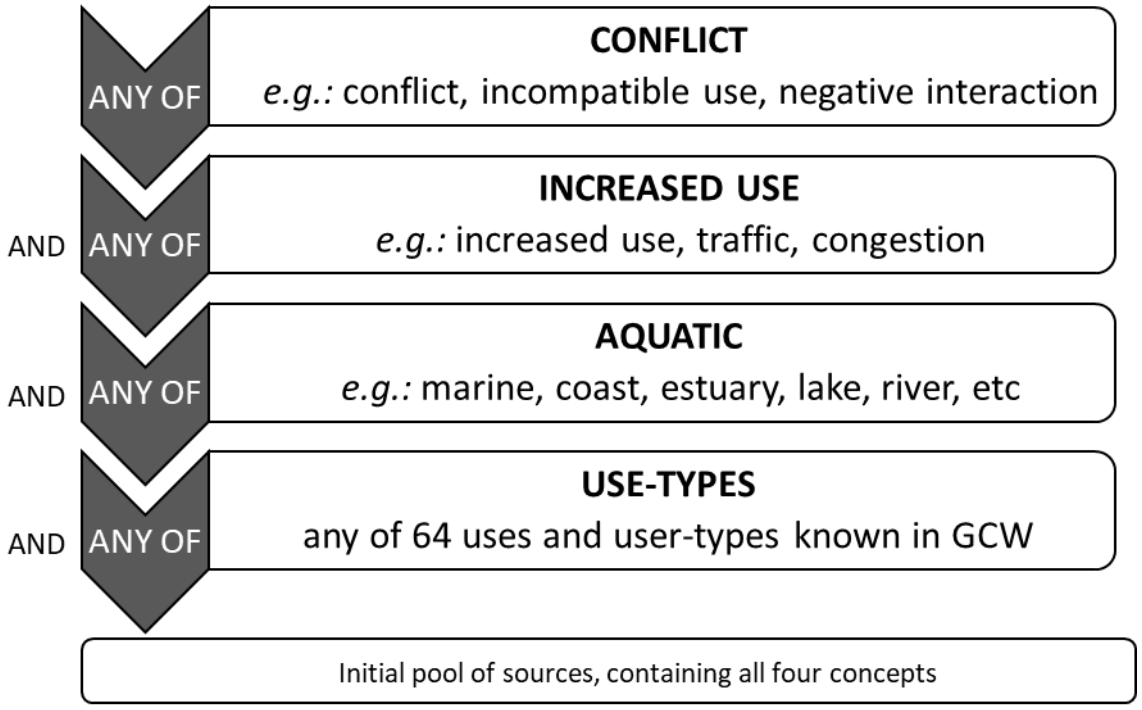

Figure 2: Strategy for this literature search

Key issues and themes appeared in the results, and to ensure these issues were fully addressed in this review, additional searches were made on Google Scholar for phrases including social carrying capacity on waterways, personal watercraft (PWC – in this context this refers to 'sit-on' craft such as jet skis) or boating injuries and multi-use waterways. Google Scholar uses a different search algorithm than primary literature databases and may produce thousands (or even hundreds of thousands) of results related to the topic, but it produces the most cited sources first. Thus, only the first five pages (100 items) were scanned and relevant items included in the source pool.

The initial pool of sources included more than 2000 results. The results were refined through a series of steps (Table 1). After initial exclusions of duplicate titles and unrelated journal types (e.g. geology, microbiology), close to 1000 results remained. The abstract for each source was then scanned – further exclusions were made when the sole focus of the source was out-of-scope, or the study was made of a condition or location not reasonably comparable to the Gold Coast (e.g. shipping conflicts in large harbours, armed conflict over freshwater drinking resources).

Finally, contents of the remaining 396 papers were read more thoroughly and sources excluded on the same criteria, and where the content was inaccessible within the time frame for undertaking this review. Sources were not excluded where they contained any description of conflict findings between users, or recommendations for managing conflict, even if the main study of the paper described another subject.

Table 1: Number of literature items returned by search terms and successive exclusions.

	Examined	Criteria	Pool of sources
Initial searches	Web of Science Scopus Proquest EBSCOHost	Boolean search string (Appendix B)	2000+
	Google Scholar	Key words and phrases	
Exclusions-1	Titles and journals	Duplicates Irrelevant source journals	938
Exclusions-2	Abstracts	Out of scope/irrelevant to Gold Coast	396
Exclusions-3	Content	Out of scope/irrelevant to Gold Coast	126

The final pool of 126 sources included both primary and grey literature drawn from a diverse set of journals/fields including law and litigation, coastal management and policy, tourism, trauma care and medicine, accident prevention, environmental conservation, park and recreation administration, urban planning, fisheries, leisure sciences, sociology and more. Methods used in the source papers were a mix of quantitative, qualitative, case study or review (Table 2).

Sources were then imported to NVivo (QSR International Pty Ltd. 2015) and categorised. The papers were read, and relevant findings were coded where they specifically addressed any aspect of the research question. These findings fell into the following six categories outlined below and further described in the following sections:

Table 2: Breakdown of final pool of 126 literature sources, showing study type and research methods.

Literature	Quant.	Quant./ Qual.	Qual.	Spatial Quant.	Discussion/ Review/Case Study	Literature Review	Total
Journal Article	50	10	8	6	29	1	104
Report	4	3	1		1	1	10
Theses	1	4	2				7
Conference Paper	1	1					2
Presentation	1						1
Book Section	1						1
Draft Plan (Government)					1		1
Total	58	18	11	6	31	2	126

Legend: Quant. = Quantitative study/research; Qual. = Qualitative study/research; Quant./Qual. = Mixture of quantitative and qualitative study/research.

1. General conflict and congestion

Findings in the first category, general conflict, addressed topics such as: general conflict models referencing waterways; the nature of conflict between users on waterways; and information on the primary source of significant conflict – that between PWC and other users. (Note: What constitutes a 'personal watercraft' is rarely defined to a level of exactitude in the literature). In some cases, an article might explicitly refer to 'jet skis' or 'Sea Doos' or note variations such as craft holding solo or multiple riders. It is clear upon reading, however, that PWC is in common use in the literature, referring to jet skis.

2. Social carrying capacity and perceived crowding

The second category deals with social carrying capacity (SCC) in aquatic locations. Social carrying capacity describes the social limit of negative experience for users, beyond which the potential for conflict is heightened. The primary method used to determine on-water SCC in these sources was to measure perceived crowding.

3. Users – social values and behaviour

The third category contains information on users, primarily related to users' assigned values (determination of perceived worth) for waterways, but more importantly, when their limits for acceptable change will be reached. Collectively, these user values will determine the social carrying capacity of the waterway. This category also includes information on key user priorities for conflict reduction which were described in this literature: enforcement of, and compliance with, regulations. Finally, this category included some findings related to predicting user behaviour and management.

4. Personal risks, adapting to change, and management tools

Personal risks to users arose from findings related to the increased use of PWCs and the resultant increase in injuries from their operation. This risk, and information on causes and prevention of boating deaths, is included a) due to a potential increase in cost to other community members, and b) the prime cause of major injuries is due to collision, both of which might reasonably expected to rise as use increases.

5. Adapting to regional cultural and industrial change

Adapting to regional cultural change touches on some known conflicts where existing populations resist change (increase in user numbers, change in use) or, as in one source, hope to preserve current and past heritage.

6. Management tools and planning

Finally, a small set of sources addressed specific management tools which may help avoid conflict between users or use of the aquatic environment.

Individual sources may have included findings that fell into multiple categories. Sources may have addressed the major question for this review either in their entirety or only in part, and themes overlapped with each other to varied degrees. Of all categories, the second, social carrying capacity and perceived crowding (waterways), is possibly the most complete review of available literature on that topic. In general, papers included under each theme should not be considered the complete literature for that theme as a whole – there is a substantial set of literature on marine spatial planning (MSP) for example, which has not been included here as most of this literature did not address its use as a tool for managing coastal waterways, or how it may be used for conflict management or prevention. Similarly, there is a much broader pool of knowledge on PWC and boating injuries in existence (e.g. hospital emergency department records) but addressing that information would require a greater time frame and a separate literature review.

2.2 Themes

As outlined above, six major themes were identified during the literature review process. These are listed below and discussed in detail in the following sections:

1. Conflict and congestion
2. Social carrying capacity and perceived crowding (waterways)
3. Users – social values and behaviour
4. Personal risks to users
5. Adapting to regional cultural and industrial change
6. Management tools and planning

2.2.1 Conflict and congestion

This theme includes findings related to intra-user conflict (e.g. between surfers), user-user conflict (e.g. between anglers and PWC users), users-managers conflict (e.g. management/aquaculture), and general conflict (understanding conflict in recreational settings).

2.2.1.1 Types of conflict

Conflict on waterways presents in different forms based on the nature of conflict, such as geographic exclusivity where uses cannot co-exist, conflict over the use of natural resources (e.g. marine conservation versus recreation), or conflict where the same resource is exploited by different users (e.g. sport versus commercial angling) (Thorhaug 2018).

Not all interactions between users lead to conflict, but there do tend to be certain pairings that will have more antagonistic outcomes (Marcouiller et al. 2010). At the core of all conflicts are human values -

desirable states of being such as self-direction or conformity (Shelby and Heberlein 1984, Jones et al. 2016). The outcome of interactions is influenced by the degree of agreement between parties' values, and by their perceptions and motivations – a jet skier's joy at high speeds and freestyling encountering a lone fisher who is visiting the same place for peace and quiet may result in conflict, for example (Arlinghaus 2005, Marcouiller et al. 2010). In addition, perceptions of other user groups can be based in deep cultural differences, such as a First Nation's spiritual connection with a species versus Western sport-fishing for the same fish (Riemer 2004), a lack of agreement about what constitutes acceptable behaviour (Bova et al. 2017), or in a user's direct or indirect threat to activities or values of another (goal interference) (Ruddell and Gramann 1994), such as the arrival of swimmers below a pier used by fishers.

Conflict appears to be most likely between user groups (Jaakson 1989) but some conflict is also expected within user groups. This appears to be most likely in the surfing (e.g. between novice and experienced surfers) and fishing (e.g. between recreational, sporting and commercial fishers) communities (Sumser-Lupson 2004, Itami 2008a, Magi et al. 2013, Usher and Gómez 2017, Buckley et al. 2017).

2.2.1.2 Asymmetric conflict

Conflict between users on the water almost always takes an asymmetric form that in many cases reflects a spectrum based on the size, speed and noise of craft used (Whittaker 1987, Jaakson 1989, Tseng et al. 2009, Anderson et al. 2012). For example, on the Mississippi River, cabin cruisers enjoy meeting all other users, while they are the least tolerated of all crafts; canoeists are the least tolerant of other users but are most tolerated by others; while all other crafts such as motorboats and 'runabouts' were in the middle of the spectrum (jet skis were not included in this study) (Becker 1979).

Similar asymmetric conflict can be found crossing shorelines, where waterside landowners find both PWC users and motorboats interfere with their enjoyment, motorboaters are affected by PWCs but not landowners, and PWC users are not affected by either of the two other groups (Wang and Dawson 2001); and in the water, where snorkelers are more acceptable to divers than divers are to snorkelers (Vsake et al. 2013).

Social conventions of nicety, such as reciprocating smiles and waves, are likely to contribute to asymmetrical relationships, as the aggravating users do not realise that the other user in fact dislikes seeing them (Adelman et al. 1982). In this way, conflicts will tend to be 'won' by the people who are having the largest negative impact, as other users will simply move away (Bates 1992). This 'displacement' effect is described further in Section 2.2.2 below.

2.2.1.3 PWC and speed boats

Jet skiers, water skiers, and speed boats are vehemently disliked by many other user groups and this places them at the extreme lower end of the asymmetrical conflict dynamic (Adelman et al. 1982, Whittaker 1987, Guyer and Pollard 1997, Splett 1999, Wang and Dawson 2001, Jones 2003). The most frequent causes of this ill-will from other users are noise disturbance, and operators' negligent and disruptive behaviour. Other users also dislike these users because they feel less safe around them, and they feel these users threaten ecological values of the waterway, such as wildlife and habitats (Antonini et al. 1994, Westphal 1998, Jones 2003, Widmer and Underwood 2004, Whitfield and Roche 2007, Valliere and Robert 2009, Beal 2011, Anderson et al. 2012).

PWC users' motivations tend to be freedom and accessibility (it's easy to get to places on the water that others can't reach), and the social nature of the activity (Beal 2011). Resentment for these users is particularly strong from other users whose motivations are tranquillity or nature-connectedness, but in at least one study (on the Northumberland Coast in the UK), PWC were not welcomed by anyone, in any site, and the activity was incompatible with almost every other use (Roe and Benson 2001).

Even when PWCs represent a very minor proportion of all vessels, they are perceived as being a significant source of conflict and environmental impact (Widmer and Underwood 2004).

2.2.1.4 General management of conflict

Some sources noted that conflict is more easily avoided than managed when it appears. In one study of a number of intense stakeholder conflicts over natural resource areas in Canada and the USA, conflicts were always preceded by policy gaps (Clermont 2018). In another analysis, of Biscayne Bay in the Caribbean, the authors described a mix of overlapping jurisdictions, uncertainty about responsibilities, lack of co-ordination, and that complex legalities left the area open to increased conflict between stakeholders (Thorhaug 2018).

In Central Queensland catchments, most waterway conflicts have some relationship with the multiple demands placed on them as economic resources. Specific concerns noted in this region include the public's loss of access to areas because they have been awarded to private concerns; the lack of responsibility accepted over resource degradation (particularly where degradation appears off-site, such as downstream); and a lack of public access to decision-making, which is perceived to be held in the hands of a narrow group (Lockie and Rockloff 2005).

When evaluating the benefits provided to communities by any user group, it would prove useful to broaden the definition of 'benefit' beyond the economic, and to ensure other users are made aware of these benefits. For example, in New South Wales, the commercial fishing sector provides many services to local communities, including directly to other users of the water (such as dock infrastructure and search-and-rescue services). Many of these are not readily attributed to this group by other users (Voyer et al. 2017).

2.2.1.5 Managing asymmetric conflict

Four main management options are available to manage asymmetrical conflict: relocation of activities (e.g. zoning or relocating shore facilities such as docks or refuelling stations); managing numbers by setting use limits (e.g. capped licenses for commercial activities); controlling categories (e.g. zoning to allow sailboats or speed boats, but not both); and regulation of activity (e.g. speed limits) (Jaakson 1989). This latter option might include certain management techniques that have been used in similar terrestrial conflicts. A number of states in the USA have regulated for 'reasonable and prudent operation' of snowmobiles, for example, and the same has been suggested as appropriate for PWC operators (Splett 1999).

Non-regulatory solutions include encouraging users to participate in new activities, as users of other types who are also PWC users are less likely to be negatively affected by PWCs around them, and shoreside residents are more likely to support boaters if they are boaters themselves (Wang and Dawson 2001, 2005, Beal 2011). Several sources note than non-regulatory approaches can and do work, and there are many possibilities for intervention opportunities, such as informative cards in gear hire shops or in hotels, in coastal tourism areas (Burger and Leonard 2000, Sidman and Fik 2005).

2.2.1.6 Enforcement

Enforcement of regulations appeared as a priority for conflict resolution in a number of studies (Moeller et al. 1974, Gobster et al. 1998, Westphal 1998, Burger 2003, Itami 2008b, Thorhaug 2018). Perceptions of other users' transgressions – particularly PWC and motorboat users' disregard for zoning/speed laws, and anglers breaking catch limits – is a key ingredient to antagonism and is often noted as the management action that is most requested. The exception to this rule appears in the surfing community – novice surfers' lack of etiquette is a primary factor in surfer conflict, but most surfers would not like to

see on-water policing, or regulations put in place (Fletcher et al. 2011, Edwards and Stephenson 2013, Usher et al. 2016).

2.2.2 Social carrying capacity and perceived crowding (waterways)

Social carrying capacity has, in recent years, primarily been measured using notions of perceived crowding, and how users' perception of crowding is influenced by their social values, norms and perceptions of waterway use and other users (e.g. Marcouiller et al. 2010).

All original studies referenced below were carried out in marine/coastal/lake/etc. areas which are used for a variety of purposes such as those seen on the Gold Coast.

2.2.2.1 Social carrying capacity

There are four kinds of carrying capacity – ecological, social, physical and facility (Shelby and Heberlein 1984). Social carrying capacity (SCC), discussed here, is the 'level of use beyond which experience parameters exceed acceptable levels specified by evaluative standards'. The notion of social carrying capacity determination has evolved (Butler 1996), alternate dimensions of the concept have emerged, and fields have created specialised frameworks (Salerno et al. 2013), but the core of the SCC concept remains useful to managers of multiple use areas (Shelby and Heberlein 1984).

Determining SCC may be as simple as finding relationships between levels of use and levels of satisfaction for different users such as boaters or shoreline residents (Ashton and Chubb 1972) or may involve more complex calculations including number and type of watercraft and patterns of activity (Adams 1993). However, the experience parameter most frequently used in determination of SCC has been how crowded users feel, as this has a direct relationship on how they feel about meeting other users on the water, and in turn how satisfied they are with their experience.

2.2.2.2 Perceived crowding

Perceived overcrowding is the most significant predictor of visitor satisfaction (Cooper et al. 2011) and as a result it can affect both tourism demand and visitor numbers (Whitfield and Roche 2007, Buckley et al. 2017).

A person's nationality, education, race and age may affect the level of crowding they perceive in an area (Ditton et al. 1983, Jin 2009, Magi et al. 2013, Rasoolimanesh et al. 2016, 2017). User characteristics can also have an effect – for example, higher levels of crowding have been reported by returning or more experienced visitors (Ditton et al. 1983, Whittaker 1987, Grossmann et al. 2006, Cooper et al. 2011); by those who visited without commercial guidance (Cooper et al. 2011) and by those that are motivated to visit for place or amenity, rather than social or activity-based reasons (Grieser and Dalton 2005, Cooper et al. 2011). Work by Jurado et al. (2013) in the coastal tourist destination of Costa del Sol in the south of Spain, found that older tourists with higher income and education felt most crowded. Another found that that visitors who had more daily spending money felt more crowded, regardless of their income (Rasoolimanesh et al. 2016).

While some factors, such as age and gender, appear to affect crowding perception differently dependent on location (Magi et al. 2013, Jurado et al. 2013, Rasoolimanesh et al. 2016, 2017), the association between crowding and normative, or expected, encounters are more universal. When locality users encounter larger numbers of people than they are 1) expecting (Ditton et al. 1983, Martinson and Shelby 1992, Sterl et al. 2004, Tseng et al. 2009), or 2) than they believe to be acceptable (norms) (Whittaker 1987, Tarrant et al. 1997, Jin 2009, Needham 2013, Needham et al. 2014), they will feel crowded, and their enjoyment of their experience will decrease (Tseng et al. 2009, Usher et al. 2016).

The number of other users that visitors will tolerate is different for different areas (Jin 2009), for different activities, or even different types of the same activity (fly-fishing or bait fishing; Martinson and Shelby 1992). In one example, anglers in California and New Zealand had different tolerance for encounters while salmon fishing, which the authors suggested was likely a reflection of the more developed setting in California than that experienced in New Zealand (Martinson and Shelby 1992). Other examples include findings that residents have higher encounter norms, and thus a lower dissatisfaction because of crowding, than do tourists/visitors to the same area (Jin 2009, Magi et al. 2013).

Following this point, it should be noted that users do not always prefer not to encounter others at all. Residents living near a lake visited by recreational tourists in Maine, for example, were more likely to find zero visitors less acceptable than tourists do (Valliere and Robert 2009), although the study does not investigate why. A non-zero number of encounters is also preferable for scuba divers and snorkelers, who most likely feel a greater sense of safety amongst others (Vsake et al. 2013).

Perceived crowding effects can be intensified by broader visitor experiences of the area. Simply seeing the impact of others on the recreational space (spotting litter or site impacts) can increase users' sense of crowding (Whittaker 1987, Needham et al. 2014) even when no direct encounter has taken place. Furthermore, a 'carry-over' effect may occur, where negative impressions of crowding during one experience will increase perceptions of crowding during another on the same day (Andereck and Becker 1993).

The relationship curve of norm/expectation with perceived crowding is likely to be different in different areas or for different activities undertaken in these areas. As an example, groups of respondents were shown images of users in a Korean recreation area. The level of crowding they perceived in each image depended on whether they believed the area was a nature preserve, a buffer zone, or was developed for visitors (Kim and Shelby 2011, Figure 3).

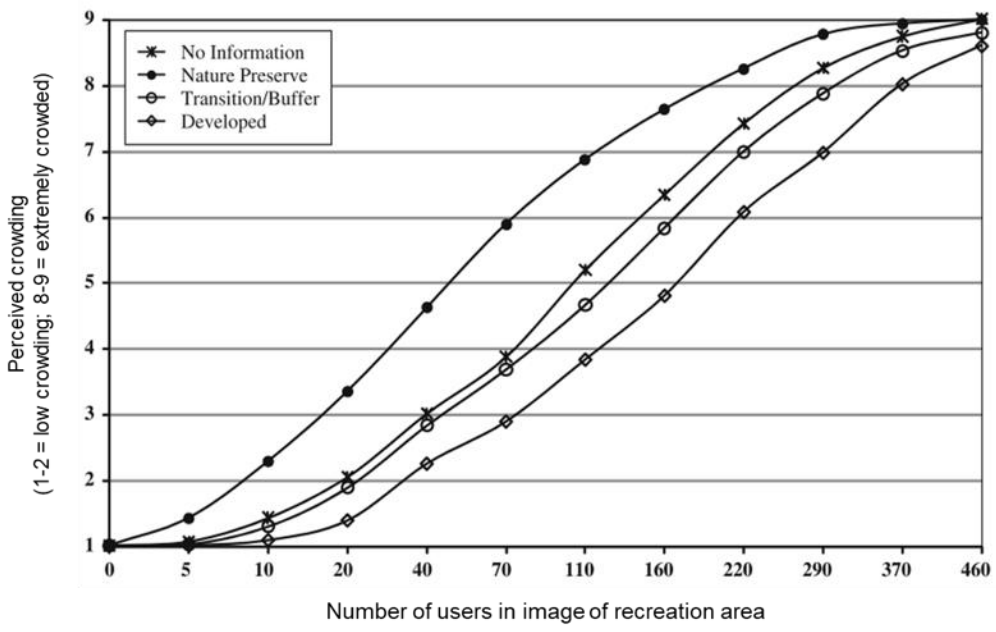

Figure 3: Norm expectation curves showing that users perceived more crowding with lower number of users if they believed the space was a nature reserve (adapted from Kim and Shelby 2011).

2.2.2.3 Effects of perceived crowding

In regard to the effects of perceived crowding most users will tolerate more encounters than they prefer (Martinson and Shelby 1992). However, as noted, perceived crowding negatively affected users'

enjoyment of their experience on the water, and this can spill over to the off-water experience of their trip (Ditton et al. 1983), so crowding is a source of concern for areas which rely on tourist visits.

The most likely response to perceived crowding is a behavioural change, or 'displacement'. In Costa del Sol (Spain), the high-income tourists who are most sensitive to crowding are inclined to leave the area completely (Jurado et al. 2013). More commonly, users will stay in the area but will move their activities to another time or space (Sterl et al. 2004). Surfers, anglers and boaters will all move to other areas or avoid peak times in order to escape perceived crowding (Whittaker 1987, Powell 1998, Usher et al. 2016, Rasoolimanesh et al. 2016, Usher and Gómez 2017).

In some places, managers have provided opportunities for recreators to self-manage displacement. For example, in Oregon (USA), waterways managers have provided pin-boards at launching sites, where boaters can signal their intended destinations. Those boaters launching later will know how many others are already on the water and how crowded particular areas may be (Bates 1992).

A final outcome of perceived crowding is that users may feel less safe. This is particularly the case with increased numbers of certain crafts such as jet skis and cabin cruisers (Powell 1998, Burger and Leonard 2000, Tseng et al. 2009).

2.2.2.4 Managing for crowds and SCC

Three conditions must be met in order to establish social carrying capacity:

1. there must be a known relationship between the level of use, and the quality of experience visitors perceive
2. there must be some agreement between users about the nature of the experience they can expect
3. there must be agreement between the groups about the appropriate numbers of users for the resource (Shelby and Heberlein 1984)

Before the social carrying capacity can be determined, therefore, it is necessary to understand what visitors expect in their experiences on the GC waterways. Surveys assessing users' satisfaction are relatively common (e.g. the National and International Visitor Survey data for SEQ presented in Section 3.3), but fewer include questions of what users expect, or expected, to see or experience. As has become clear, user expectations are central to the final perceived quality of their experience and what they feel is acceptable or unacceptable, and how they will react to others in the space.

Furthermore, such expectations change. Perceived crowding may be determined by the expected encounter levels which the visitor internally normalises, but these norms are varied through time, and with familiarity or frequency of use, so it would be fair to assume SCC is an expansive concept. Assuming people will accept more users to an infinite degree, however, would be unsupported by the data presented below (Section 3.5), where an uneven distribution of benefit from changes is indicated. In any case, clearly, ecological capacity can be exhausted long before social capacity shows signs of reaching its limit.

Another consideration for managers coping with increased visitor numbers should be the additional provision and maintenance of facilities, not only because intensified use will require additional upkeep, but because, as mentioned above, visible signs of use or misuse will increase people's sense of crowding and diminish their satisfaction (Whittaker 1987, Needham et al. 2014). Maintaining built structures are not the only way to ameliorate people's sense of crowding, however. Protecting vegetation levels and existing natural features provide similar buffers against crowds. Shoreside campsites with more vegetation are perceived to be less crowded (Hammitt 1983, Anderson et al. 2012), and on-water recreators also report a preference for spending time in locations with more trees, and restored nature areas (Westphal 1998).

Finally, as visitor numbers increase, displacement effects should be carefully monitored, as new and potentially surprising impacts will be felt on more environments and facilities. For example, boaters may damage riparian areas by seeking out off-road access points to less popular waterways; surfers may begin surfing in non-monitored breaks to escape crowds and could thus face extra risk should an accident occur. Spatial and temporal zoning (such as restricting access to an area to allow only non-motorised recreation or allowing fishing only in certain times of the year) are possible strategies to manage crowding in areas of existing use (Dimmock 2007, Usher and Gómez 2017), but thought should be given to the cost of increased monitoring and/or enforcement for such changes.

2.2.3 Users – social values and behaviour

As seen in the above sections, the values that users hold, their motivations for spending time on/by the water, and their perceptions of other users' behaviour will influence how crowded or threatened they feel in an area, and in turn whether they will respond to encounters with others positively or negatively. This section describes literature which investigated or described: 1) user-values for waterways; 2) factors which contribute to user compliance or non-compliance (a factor in relationships with other users); and 3) instances of predicting or manipulating user behaviour to avoid conflict.

2.2.3.1 User values for waterways/aquatic nature

Incompatible user values can lead to conflict. For example, a kayaker who values nature for quiet self-reflection may resent encountering a party of boaters who are playing loud music. This section describes findings about dominant values and motivations held by users for their waterway experiences.

There are no standard measures for how users value place. Values are notoriously difficult to quantify or standardise, even when attempts are made to convert what people feel or treasure to an economic worth (Willis and Garrod 1991, Garrod and Willis 1998, Bateman et al. 2013). However, there are tangible health and social benefits that healthy environments provide for humans (Hausmann et al. 2016), for example: people recover faster from surgery when they can access nature (Ulrich 1984), and nature-exposure has been found to decrease crime and aggression in urban environments (Kuo and Sullivan 2001). Despite the difficulties, it's critical to at least attempt to understand how people connect to place, in order to predict not only how they will behave after changes, but to anticipate the effect it will have on their lives, opportunities, and psyches (Bateman et al. 2013). In Utah, residents' perception of their own quality of life was related to how much they could access their waterways for recreation (Miller et al. 2015). Given such strong connection, it's understandable that potential changes to the regulatory structure of waterways, can inspire heightened tension in the community.

One broad indicator used to assess user values for natural areas is the 'sense of place'. This term, used in the Millennium Ecosystem Assessment[4], refers to an ecosystem service which provides a relationship between humans and environment that is essential for human well-being (Corvalán et al. 2005).

Sense of place is strongly associated with a sense of community and identity (Hausmann et al. 2016). In one Canadian study, the 'sense of place' felt by residents encompassed the physical sense of their marine area, but also the activities and memories they had experienced there, their family and social experiences, and indeed their entire way of life (Wozniczka 2009).

Another indicator for user values for their waterways is 'place attachment'. Definitions for this indicator seem to vary. In a study based in North Carolina, place attachment referred to the longevity and frequency of user visits to an estuarine user reserve and was positively associated with users' increased knowledge of the ecology of the estuary, and with their perceptions of site conditions (Snider et al. 2011).

[4] See https://www.millenniumassessment.org/en/index.html for details (last viewed: 12/11/18).

Place attachment for waterways was also measured in SEQ, but here, the 'overall benefit that respondents feel they receive from their local waterways' was measured. Residents of Tallebudgera catchment showed amongst the highest level of place attachment, while Logan and Albert residents were the South East Queenslanders least likely to perceive this benefit (Johnston and Beatson 2017). The reasons for this are not defined in the study. Without drawing conclusions, it is perhaps worth noting that this study also found these rankings for Tallebudgera, Logan and Albert residents were very similar for the indicators 'personal connection to nature', and 'social value' (that is, the use of these waterways for social occasions with friends or family).

Many more questions have been asked of users, to elicit the measure of value they hold for waterways. For example, users of three urban estuaries in New Jersey were asked the open-ended question 'How are coastal or estuarine habitats important to you?' and the highest responses were for outdoor sports and recreation (Burger 2003). When asked to rate the possible uses for these habitats, however, two highest rated uses were 'communing with nature' and 'open green space'. The authors suggest that these users' enjoyment of the areas for recreation is connected to and dependent on their provision of a natural space in the urban environment. Similarly, in Chicago, urban residents felt they gained benefit just by appreciating the beauty and solitude of their river, and one of the chief impediments to their enjoyment was simply a lack of access points (Gobster et al. 1998, Westphal 1998).

Residents of SEQ are more likely to feel a sense of stewardship over their waterways than any other feeling, even nature-relatedness or social utility (Johnston and Beatson 2017). In Chicago, New Jersey, and Central Queensland, residents value recreation, water quality, wildlife and aesthetics (Gobster et al. 1998, Westphal 1998, Burger 2003, Lockie and Rockloff 2005). Aesthetic or scenic amenity does not require the absence of humans. Limited residential development, historical structures and harbour scenes can add to perceived amenity (Dalton and Thompson 2013).

Residents' negative perceptions about waterways are likely to be related to water quality, with clean-ups and pollution prevention listed as the chief concern in a number of studies (Gobster et al. 1998, 1998, Burger 2003, Lockie and Rockloff 2005). Anxiety over pollution is the primary concern that residents in SEQ have regarding their waterways, based on a study of more than 3500 residents (Johnston and Beatson 2017). Residents here are less likely to visit their waterways if they perceived the water is even slightly polluted, or even when they perceive it to be 'muddy'.

Tourists visiting waterways are likely to be seeking different qualities than residents. In the Azores (off Portugal) and Fiji, non-physical attractions for tourists (easy access, social experience, infrastructure and facilities) will to an extent balance out declines in the physical/environmental conditions, although this will only hold true to a certain level of degradation (Fitzsimmons 2008, Bentz et al. 2016). High noise levels and a perceived low level of 'authenticity' (both of which are affected by visitor numbers) were likely to dissatisfy visitors to Costa del Sol in southern Spain (Jurado et al. 2013). In northwest Ireland, 'peace and quiet' are the most highly valued aspect of tourist visits to waterways, with aesthetics and the friendliness of residents also highly valued. In this study these visitors were classed as 'unfocused users' – those who simply value the experience of being on the water. The authors note that these users would be highly sensitive to noise and 'intrusive' activities such as jet skiing, water skiing and speed boating (Guyer and Pollard 1997). Users such as these are often overlooked in planning and management of waterways (Klessig 1994, Beal 2011).

User values for waterways can be mapped using Public Participation GIS (PPGIS)[5] in order to find areas of higher risk for conflict. In this way, areas where values are incompatible can be prioritised for increased enforcement or management attention (Moore et al. 2017). Conceivably, the same process could be used to map users' expectations of waterways encounters.

[5] Public Participation GIS aims to bring the technical processes of Geographic Information System (GIS) mapping and data collection into the reach of individuals and community groups, usually by providing a simply accessible web-based interface with which users can enter information, spatial information or conduct simple queries.

2.2.3.2 Norms and compliance with regulation

Users perceive other users more negatively if they feel the others are not acting in compliance with regulations (Bova et al. 2017), and a lack of enforcement increases both the chance of user-user conflict, and user dissatisfaction with management (Wang and Dawson 2001).

Social norms, which are (in general terms) the informal understandings about what individuals feel to be 'normal' or common in others' behaviours and beliefs may have a strong influence on the likelihood of individual compliance with regulations, especially in communities where conformity is rewarded (Farrow et al. 2017). For example, in Norway, fishers' compliance was not linked to any legal repercussion but to the social ramifications of non-compliance. Non-compliance in this location breaches rules of loyalty and obligation to other fishers (Gezelius 2002). As a further illustration, recreational fishers who underestimated levels of compliance amongst fellow anglers in South Africa tended to be under-compliant themselves (Bova et al. 2017). The social norm approach to understanding behaviour suggests that anglers in these studies are conforming to what they perceive is normal and acceptable in the activity 'space' (Burchell et al. 2013).

Understanding the social norms of a user-community may thus provide strategies for increasing compliance, and by extension, addressing conflict before it begins. In South Africa, for example, mentorship into the 'community' of anglers significantly improved compliance with fishing regulations, particularly when the mentor was a father (Bova et al. 2017). Conversely, in Florida where boaters were presented with notices which threatened maximum fines for breaching speed regulations (behaviour which threatened manatees), there was an overall decrease in compliance while the signs were in place. This was attributable to the 'blatant noncompliance' of jon boats (tinnies) and open fishing vessels who continued past the signs on plane (Sorice et al. 2007). Assuming a norm – in this case, that boaters would prioritise the safety of wildlife over their own money – proved false.

2.2.3.3 Predicting user behaviour and choice

Accurately predicting the likelihood of users visiting certain areas within waterways may help managers anticipate emerging conflicts and plan for conflict mitigation.

Predicting anchoring patterns

A study undertaken by Widmer and Underwood (2004) in Sydney Harbour, found that the number of boats anchored increases, as would be expected, during summer. Similarly, the number of boats anchored during inclement weather is only dependent on whether it's a weekend or not. Slightly unexpected were anchoring numbers during a city-wide event – the Olympic Games which did not result in an overwhelming increase in anchorage, compared to the baseline (Widmer and Underwood 2004).

In Florida, more than 90% of boaters stated that safety considerations (such as protection from the elements, depth, bottom holding ability, *etc.*) were important factors when choosing anchorage locations, and more than 75% of boaters stated that environmental concerns (such as the presence of seagrass or 'go-slow for manatees' areas) were important (Antonini et al. 1994). This preference for anchoring where there are high environmental values was similarly noted in Sydney Harbour, where a comparatively larger percentage of boats will anchor in an aquatic reserve. The benefits of reserves may be offset by user impacts such as littering, anchor damage, sewage and fuel pollution (Widmer and Underwood 2004). In some instances, areas of high environmental value have been designated 'no anchoring' zones, including provision of public use moorings (e.g. Flinders Reef).

The use of a non-regulatory approach to managing or influencing anchoring patterns was tested in Florida, using a guidebook including maps and information on habitats, locations, shore features and service. More than half the boaters exposed to the guidebook were influenced to try new locations. While there had been some concern the guidebook might result in overcrowding in certain areas, these effects turned out to be negligible (Antonini et al. 1994).

Predicting spatial patterns of use

The asymmetric conflict relationships described in Section 2.2.1.2 can be used to predict boating recreational patterns (Jaakson 1989). Alternatively, the Limits of Acceptable Change (LAC) model, which balances the environmental capacity of an area against social acceptance of its use by people (hence sharing similarities with social carrying capacity models), can be used to manage vessels in urban waterways, as visitor numbers increase (Itami 2008b, Diedrich et al. 2011). Boater patterns have also been measured and predicted using spatial models. Such an approach was used in Florida, where it was found boaters are 'distance-minimisers' and will choose to travel further by road to reach access points closer to their offshore destinations (Sidman and Fik 2005).

While private recreational boaters will consider cost and distance in their choice of destination, they will place more value on areas with greater species richness and abundance than those without (Viana et al. 2017). In Michigan (USA), approximately 45% of boating trips involved no spending, and the non-spenders were predominantly those with boats in marinas or at waterfront homes. When spending did occur, it was by people who travelled some distance to the water, and unless they took overnight trips (when they were likely to buy groceries) this was limited to auto and boat fuel purchases (Lee 2003).

Only one source in this review, Larson and Hammitt (1981), investigated the spatial patterns of non-boating users. Swimmers and waterside campers prefer different conditions for their use of waterways. Swimmers prefer areas close to parking for their aquatic activities, and campers don't use the water for sports as much as day visitors (Larson and Hammitt 1981).

2.2.3.4 Considering user values in GC waterways management strategies

Assigned values, or the values people hold for places, are closely related to people's perceptions, and are more easily navigated and influenced by managers than are individual or cultural 'held values' (ideologies) (Jones et al. 2016). Spatial mapping of assigned place values by participants has been used in many more studies than mentioned here, using PPGIS platforms. Outcomes are useful, quantitative, and easily incorporated into other resource area decision support tools (Moore et al. 2017).

Understanding the current difference between normative goals (the aimed-for situation assessed on the overall system or social 'good') and individual goals (the situation an individual might hope to achieve), and assessing whether these goals are based on accurate information, are critical for managing conflict (Lindenberg and Steg 2007, Cooper et al. 2011, Dalton et al. 2017). What do users perceive of others in the space, and are these perceptions accurate? If compliant behaviour, good ecological conditions, and respect for the environment and each other are perceived as social norms or are portrayed in that light, then individual users may be more likely to conform to higher standards and hold others to account. These findings reaffirm the need to establish the expectations of residents and tourists/visitors to GC waterways, as user satisfaction, and the likelihood of conflict, will be directly affected by their expectations, versus the reality, of activity, number of users, and noise of activities.

The findings which indicate users have a higher preference for areas of ecological significance (Lee 2003, Widmer and Underwood 2004, Viana et al. 2017) suggest that user behaviour and preference should be analysed in conjunction with the impacts of users' behaviours. For example, local boaters are not likely to be contributing much to the local economy through their recreation, other than through transport registrations, but the environmental impacts from these and other PWC users (boat wash, extractive fishing) may be quite high compared to other users.

Increased compliance and decreased conflict can result from the group loyalty found in communities with strong social capacity within and between groups (Gezelius 2002). Community capacity, or social capital, may be bonding (close ties within groups); or bridging (the ability of a group to productively interact with others of differing views) (Bodin and Crona 2008). Healthy ratios of bonding and bridging links indicate capacity for both intra- and inter-group conflict resolution; an unbalanced ratio can lead to

a reluctance to report breaches of compliance, or to groups becoming isolated, insulated, or even vilified. Effectively building community capacity requires comprehensive, long-term planning (for an introduction and examples, see Chaskin 2001).

2.2.4 Personal risks to users

In the initial search for sources of conflict on waterways, it became clear that 1) PWC-users draw the overwhelming majority of other users' ire and 2) an extensive body of literature has emerged related to injuries sustained by PWC-users, and that collisions (with other PWC users, other vessels, swimmers or divers, or with stationary objects) is the primary source of injury (Anderson 1998, Haan et al. 2002, Rubin et al. 2003). This topic was included here as sources consistently noted that increased numbers of PWC users are likely to result in increased injury, and that public expenditure on rescue-response and medical treatment (already substantial) is likely to increase correspondingly. It should be noted again that the findings below cannot be considered a comprehensive review of the literature related to waterways injuries. The included sources referred to some aspect of user-user or user-social conflict, and they may or may not be representative.

The sources related to this topic were published from 1998-2007. Most are related to PWC use, and include reviews of hospital admissions, although several were published medical descriptions of some unusual and serious injuries. The majority were from the USA (details in following section).

2.2.4.1 Personal Watercraft

Anderson (1998) found that rates of PWC injuries are no greater than other vessels and there is no need to single these users out for regulation, but other, more recent studies would appear to contradict this. Jones (2000) conducted a review of boating accidents in Arkansas (USA) and found 51% of boating incidents were PWC-related crashes. Pikora et al. (2011), in a separate study, noted that while open motorboats were involved in more collisions across the entire USA, the number of injuries treated in emergency departments was 8.5 times higher for PWC users than for motorboats. Such findings appear to confirm that PWC are no more inherently dangerous than other motorised vehicles on the water (Whitfield and Roche 2007), but the combination of speed, power and the exposed position of users' places operators at increased risk of injury (Shatz et al. 1998).

PWC injuries are most often due to operators' inexperience, excessive speed, and inattention (Anderson 1998, Jones 2000, Kim et al. 2003, Latch and Fiser 2004, Kapur and Frei 2007), and this results in accidents created by human error (Jones 2000, O'Connor and O'Connor 2005). Self-reported injuries in PWC operators described 'landing awkwardly' as the most common cause for injury (Pikora et al. 2011), and these were likely to result in visits to general practitioners or physiotherapists. However, reviews of hospital admissions showed most serious PWC accidents are caused by collision (Anderson 1998, Haan et al. 2002, Rubin et al. 2003) with other watercraft, or features such as rocks or docks.

The most commonly affected body parts have been found to be head or neck (Haan et al. 2002, Rubin et al. 2003), or the chest (Kim et al. 2003), and the most common injuries are fractures and lacerations (Kim et al. 2003, Latch and Fiser 2004). Several instances of serious personal injury were reported which related to passengers falling behind the craft. These injuries involved serious rectal and/or vaginal injury as passengers landed in the high-pressure current of the PWC. Sources which described these injuries recommended the use of protective clothing such as neoprene wetsuits, though the effectiveness of such a measure has not been thoroughly tested (Philpott et al. 1999, Goldberg et al. 2004, Kapur and Frei 2007).

2.2.4.2 Injuries and other watercraft

A thorough review of boating fatalities over an eight-year period (1992-1998) was conducted in Australia, using coroner's findings, search and rescue reports, photographic evidence, and other official sources (O'Connor and O'Connor 2005). The highest rate of boating fatalities (25%) involved the use of dinghies (Figure 4). Note, however, that the time period of the study pre-dates the very widespread use of PWCs. This rate was not associated with vessel length, but rather with these vessels being more likely to capsize, the greater likelihood they were being overloaded, that incidents were more likely to involve alcohol, and that operators and passengers were failing to wear a Personal Floatation Device (PFD) (Anderson 1998, O'Connor and O'Connor 2005).

Many of the sources in this review noted that PFDs should be worn by boaters to minimise the risk of fatality from accidents (Shatz et al. 1998, Jones 2000, Latch and Fiser 2004, Cortés et al. 2006). It was reported that 91% of people killed in boating accidents in Australia between 1992-1998 were not wearing PFDs (O'Connor and O'Connor 2005). Cortés et al. (2006) found that 80% of drowning fatalities in the USA in 1999 could have been prevented if the boaters had been wearing PFDs.

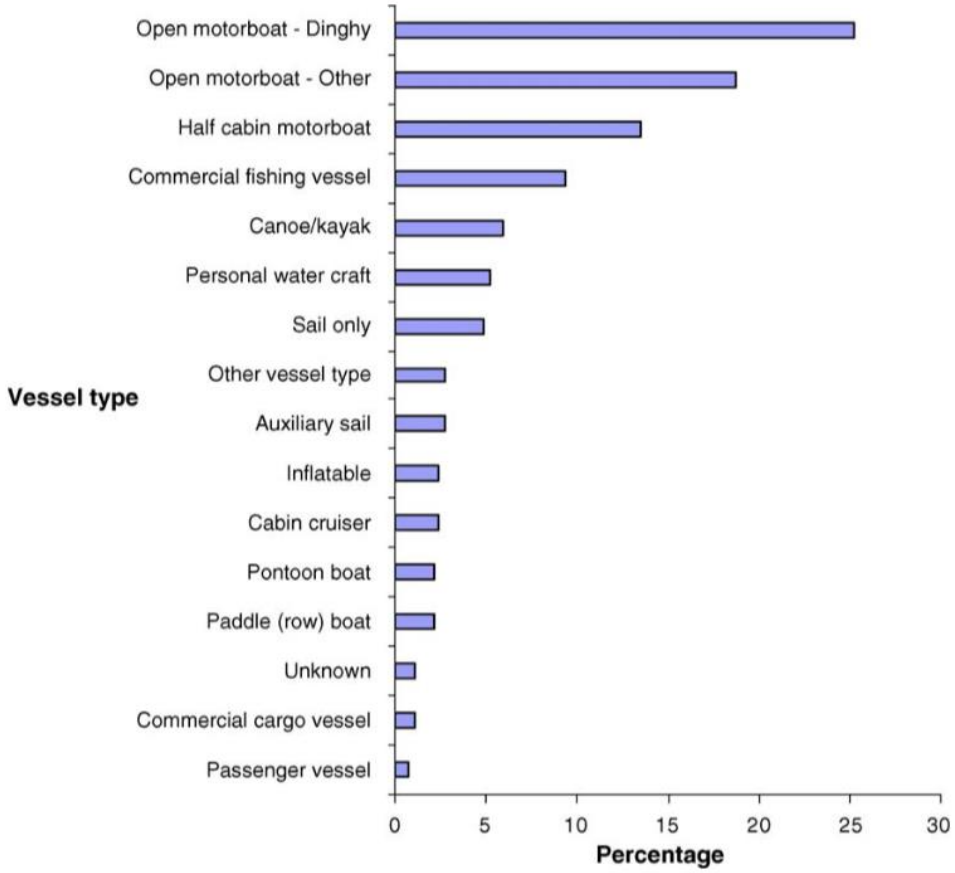

Figure 4: Boating relating fatalities in Australia for the period 1992-1998 by vessel type (from O'Connor and O'Connor 2005).

2.2.4.3 Alcohol

Alcohol contributes to boat deaths at approximately the same rate as road deaths (O'Connor and O'Connor 2005). Just as in road vehicles, boat operators with zero blood alcohol have better decision-making capabilities, faster reaction times, and better response and recovery times than intoxicated people (Cortés et al. 2006).

The power of the boat, and even whether the boat is in operation, is not an influencing factor in alcohol-related boat deaths (Smith et al. 2001). Causes are more likely to be users falling overboard, where high blood alcohol levels add additional risk of drowning. Passengers hence face the same relative risk of death as operators (Smith et al. 2001).

At least for this one issue, PWC users pose less of a problem than other boaters, as it appears alcohol is less likely to be a factor in PWC-related injuries than in other craft (Haan et al. 2002, Kim et al. 2003).

2.2.5 Adapting to regional cultural and industrial change

Conflict may arise with an influx of new visitors, cultures or industries to a regional waterway.

The review identified two studies that dealt specifically with recognition and preservation of areas of historical and cultural use (Gold Coast City Council 2004, Waterways Ireland 2015), another that described conflict between indigenous or local residents and incoming visitors (Riemer 2004), and others identified that discussed the growth or resilience of tourism in changing social and economic situations (Gormsen 1997, Biggs et al. 2015, Liu et al. 2015).

2.2.5.1 Cultural history and identity

In 2015, Waterways Ireland released a draft plan for Ireland's waterways, which was produced with an explicit aim to preserve waterways for tourism, transport and industry, while 'managing, maintaining, developing and restoring' these waterways historic, cultural and natural features. To these ends, the plan contained strategies for recording and preserving oral histories, preserving and sharing the origins of place names (which hold historical, ecological and cultural information), and maintaining and preserving cultural structures and landscape features alongside industrial and architectural 'monuments' (Waterways Ireland 2015).

Locally, a study and survey of indigenous culture on the Gold Coast found the wash from boats had destroyed, or nearly destroyed, many such shoreside cultural sites in the Coombabah and Saltwater Creek region. Also noted in this study were a number of very large middens in the lakes region that had been lost due to road and residential developments (Gold Coast City Council 2004).

In Canada, regulatory changes to preserve a marine area inspired a sense of fear in residents, partially based on the threat of changes to the mix of traditional vs recreational use. Such fear was mediated by the relationship or trust residents had for senior levels of government, and their views on tourism (Wozniczka 2009).

The tension between recreational and traditional use of resources is a common issue as regions develop. As an illustration, spearfishing in northern Wisconsin is perceived by Chippewa residents as a cultural right, supported by treaty, which is inseparable from their culture. In contrast, non-Native tourists feel this is an unfair privilege which 'locks up' resources from incoming tourists. Such conflicts, where users have different perceptions of the activity under question, are unlikely to be soothed by law, but may be calmed by creating connections and building shared understanding between groups (Riemer 2004).

2.2.5.2 Resident perceptions on tourism or aquaculture development

Work by Liu et al. (2015) in Bama, China, found that while residents may appreciate an influx of visitors initially, increased prices and living expenses for residents, and increased disturbance to the environment would diminish support for greater visitor numbers (Liu et al. 2015). This declining support is linked to a perceived loss of social and cultural identity, and resentment for foreign owners or developers who gain more benefit than residents (Liu et al. 2015, Carr and Liu 2016). Such a situation

has occurred in the Turks and Caicos Islands (in the Atlantic Ocean, southeast of the Bahamas), and in the Maldives (in the northern Indian Ocean), where inequities due to private ownership of beaches, and the distribution of tourism benefits predominantly to new and/or foreign operators, has resulted in heightened tension, and widening gaps between socio-economic groups (Carr and Liu 2016, Buckley et al. 2017).

Another source of conflict arises from differing individual's ideologies. For example, Clermont (2018) found residents who hold 'self-enhancement' ideologies (*i.e.*, they prioritize values such as power and achievement) are more likely to support development, where those who hold self-transcendence values (*i.e.,* they prioritize values such as concern for others or for nature) are more likely to speak out against development. Such ideological differences will 'greatly influence' people's support for changes in waterways (Dalton et al. 2017).

2.2.5.3 Resilience in response to crises

Where management proposes major, or even minor, changes to use of a popular public property resource, it is relevant to consider how communities respond to change. Biggs et al. (2015) aimed to determine resilience in the face of change or conflict (such as environmental collapse or disaster) that results in sudden changes to waterways which result in the decrease of visitor numbers. Studying coastal tourism operators in Australia and Thailand, the authors found that 38% of tourism operators in both countries would leave the industry with a slump of 50% for 12 months. When Australia is considered alone, that figure rises to 60%. The authors suggest the reason for the stark difference between countries is that Thai operators have had to cope with sudden disruptions before, whereas Australian operators, who have not, have less flexible organisational forms and no diverse income streams. In Australia, resilience depends also on lifestyle values. This value provides more motivation to Australian operators to tolerate risk and reduced profit than the prospect of financial reward.

2.2.6 Management tools and planning

The final theme arising from the results in this literature set includes processes and tools related to planning for conflict in multiple use areas; tools for anticipating conflict; and the use of education in mitigating conflict.

2.2.6.1 Spatial planning and spatial management tools

Tourism is the fastest growth human activity in the coastal zone (Papageorgiou 2016). As such, planning for the impacts and conflicts that come from tourist use is necessary. Marine Spatial Planning (MSP) is a promising model for management of coastal waterways use and tourism (Papageorgiou 2016). MSP is a natural progression from the Integrated Coastal Zone Management (ICZM) model. ICZM goals include sustainable management of coastal zones with awareness of the dynamic interface between land and sea, and the diverse nature of uses and users of these areas. MSP builds analysis, public participation, and adaptive measures into these considerations, and in addition uses spatial data and provides spatial outcomes appropriate for planning. MSP's rapid adoption by marine planners has seen calls for these processes to be extended to the coast, and even terrestrially. MSP has also been used specifically to anticipate, and resolve conflict, by finding and mapping incompatible use (Tuda et al. 2014).

However, care should be taken when attempting to consult with the public during the MSP process. In a case study in the Northeast USA, stakeholders who participated in MSP had high levels of dissatisfaction, due to poor communication, fragmented governance, lack of specificity about benefits and losses, and a perception of deliberate exclusion (Flannery et al. 2018). As another study, reviewing

a number of volatile stakeholder conflicts over development of aquatic resources found: 'importantly, public consultation appeared to exacerbate conflict as much as having been denied the opportunity for public consultation, because both conditions evoked issues of injustice' (Clermont 2018).

Participatory place mapping using Public Participation GIS (PPGIS) has been used to identify the type of value (ecological, cultural, historical, economic, aesthetic, etc.) that users hold for natural areas. This process has been found to be useful in planning situations as it allows managers to identify regions where stakeholders' values for areas are compatible or in potential conflict, thus allowing them to prioritise consultation and avoid conflict. On the Kimberley coast of North-West Australia, for example, two-thirds of MPAs in the region encompass incompatible values and thus hold the potential for stakeholder conflict (for example, between indigenous culture and recreational camping; Moore et al. 2017). In Washington, a similar spatial assessment for potential conflict was used and 25 cases were identified as potential conflict hotspots, based on incompatible and overlapping spatial or temporal use (e.g. commercial fishing and shipping; Freeman et al. 2016). In both cases, spatial tools using PPGIS were able to predict areas of likely conflict.

An extension of spatial approaches involves combining these with the concept of social carrying capacity in a way that may be useful for coastal managers, particularly if they are considering zoning for areas of use. For example, Jurado et al. (2012) created a model to assess carrying capacity across a number of destinations along the coastal landscape of Costa del Sol. The indicators the authors chose for use in the model were relevant to Costa del Sol, were quantifiable, and represented both social and ecological limits (e.g. perception of crowding, noise, as well as the spatial characteristics of the location). The authors found that the model was flexible, rigorous, and had the benefit of allowing for weighting of indicators as 'weak' (if they are breached, other factors may compensate) or 'strong' (if they are breached, carrying capacity would be overcome regardless of other factors).

2.2.6.2 Co-management and non-regulatory measures

Co-management represents a significant tool for repairing cross-cultural and cross-sectoral relationships (Castro and Nielsen 2001) and can result in positive changes for user-valued aquatic environments, such as the example below reported by Burger and Leonard (2000). In co-management, action is inspired locally, discussions are open and include all relevant users. Edwards and Stephenson (2013) found that support for co-management is high amongst surfers in New Zealand, who are not supportive of increased regulation of their activities but are strongly supportive of including surfers' input to local authorities in formulating policy responses to adjacent land use decisions.

Burger and Leonard (2000) documented a co-management strategy that was enacted for a specific problem, rather than as a permanent solution for managing an area. In their study, a critical decline in nesting birds on an island off New Jersey (USA) (due to PWC users consistently travelling at speed past the island) was reversed after a strategic intervention was initiated. The intervention included a series of public forums with PWC associations, rental outfits, citizens and marina owners, and resulted in the number of PWCs travelling by the island being reduced by half, and the remainder slowing down significantly. This positive outcome, Burger and Leonard stressed, was generated by co-management practices, as differentiated from an 'inform-the-public' strategy. Discussions were not dominated by biologists or managers, and no extreme regulatory measures (such as banning PWCs) were proposed.

Other non-regulatory measures, such as marketing, education and engagement, are also successful in guiding user behaviour and building positive perceptions. For example, users who were informed about improvement activities such as clean-ups were more likely to have a positive perception of the Chicago River, for example, even if they didn't participate themselves in the clean-up activities (Gobster et al. 1998).

2.2.6.3 Tools for managing multiple services

Stakeholders in some studies have been found to be quite cognisant, and supportive, of the need to manage waterways for multiple use (Lockie and Rockloff 2005, Bentz et al. 2016), but understand that compromises between values and benefits are bound to be made. Tools or models can be useful to assess the expected trade-offs and anticipate repercussions for various users. Needles et al. (2015) used a matrix tool to determine how management actions to regulate specific uses may affect other users/services. They found management actions with the fewest trade-offs with other services were those designed to: protect or enhance natural vegetation or shellfish habitat; regulate development; treat wastewater; or enhance barrier islands (Needles et al. 2015). Schmitt and Brugere (2013) built a Bayesian Belief Network[6] in order to similarly model trade-offs associated with differing intensities of aquaculture development in Thailand.

2.2.6.4 Importance of understanding relative user impacts

When discussing conflicts between users, it is important to recognise that user impacts are often assumed, leading to baseless perceptions. For example, while commercial fishers are often assumed to have the greater impact on fish stocks, a number of studies have discovered that recreational fisheries can have an equal or even larger impact on particular species and in particular locations (Cooke and Cowx 2004, Brown 2016). Cooke and Cowx (2006) broadly compared global commercial fishing and recreational fishing impacts and determined that the default assumption – recreational fishing cannot possibly have the same impact as commercial fishing – simply does not hold true. As the authors noted, there are far more recreational fishers, they have access to habitats that commercial fishers do not, and by numbers they are capable of placing great pressure on policy makers to continue activities without check (Cooke and Cowx 2006). It should be noted that Queensland has no licensing or reporting requirements for recreational fishers (Department of Agriculture and Fisheries 2017).

2.3 Conclusions

It is apparent that conflict and congestion on waterways internationally presents a range of common issues, principally: conflict commonly occurs in various forms where incompatible uses cannot co-exist; where there is competition for limited natural resources; or where this same resource is exploited by different users.

Of particular concern is asymmetric conflict, where the conflict is not experienced equally by both sides to that conflict, usually reflecting a spectrum based on the size, speed and noise of craft used. PWC users are not annoyed by other users but are almost universally negatively viewed by them.

A primary source of conflict is the perception of overcrowding, which is closely linked to social carrying capacity. The experience of crowding has different thresholds amongst different users and can change over time. However, there are limits to both residents and visitors' capacity to adapt, and the most likely response to persistent overcrowding is displacement, with obvious economic consequences for instance to local tourist operators. With persistent and/or increasing overcrowding or other forms of conflict comes a loss of support for management, loss of support for tourism operations, increased environmental degradation, and therefore greater likelihood of more, and widening conflict.

Continued over-use of waterways can lead to real costs in terms of human safety, although there is no suggestion that the Gold Coast is at that point. Nonetheless, the rise in PWC use internationally has seen elevated rates of (particularly) head and neck injuries, especially from collisions as a result of poor operating skills. More broadly, boat-based injuries in Australia are predominantly from small craft, that

[6] A Bayesian Belief Network is a statistical model that represents the probability of particular outcomes for a range of variables, and how the outcome of each affects the others. They are usually represented graphically with variable 'nodes' connected by vectors.

are less stable and more susceptible to overloading, and accidents that occur as a result of alcohol, or poor survivorship from not wearing a PDF.

Various forms of Marine Spatial Planning are successful in not only resolving conflict, but in predicting and avoiding conflict in the first place. Primary requirements for this type of approach are high quality spatially explicit information about natural assets and patterns of use (much of which currently exists in various formats), but also of the values that different types of users place on particular areas, species or features. This allows mapping of areas of potential conflict, or where proposed uses may be incompatible. To date such spatial information about values that users place on areas, species or features does not exist within the GC waterways at the requisite scale; this is identified in the Gap Analysis (Section 5).

3 Tourism and Resident Demographics Summary

3.1 Introduction

This appraisal of the GC waterways users and types of uses focuses on tourism and resident demographics. The following review is based on a distillate of long-established tourism data complimented by expert opinion of the strategic positioning of the waterways as part of the destination 'Gold Coast' and its unique selling points. Analyses of tourism data included preparation of a visitor profile (including trip numbers, nights, and visitation patterns), visitor activities (focusing on coastal and aquatic activities) and quantification of the value of tourism in the region, focusing on marine/coastal and aquatic activities. Future scenarios were developed using Tourism Forecasting Panel forecasts, estimating tourism demand and its associated likely growth scenarios for the GC waterways over the next decade.

3.2 Methods

Tourism Research Australia (TRA) National Visitor Survey (NVS) and International Visitor Survey (IVS) data were used as a proxy for overall use and visitation, as there is scant detailed local-level information available that can be directly related to GC waterways. These surveys collect information including the main destination for day trips, stopover locations for domestic and international overnight trips, purpose of travel, accommodation, travel party and activities undertaken whilst travelling. In-depth analysis of the visitor profiles for the Gold Coast region was undertaken using generally recognised methods for extrapolating total visitor numbers from raw TRA data.

The Gold Coast tourism region, as defined by TRA using adjoining clusters of smaller spatial units (SA2) outlined by the Australian Bureau of Statistics (ABS), was selected as the spatial entity for a general characterisation of the Gold Coast, as one of Australia's leading tourist destinations. Elemental ethics and legal conditions prohibit the release of detailed individual results from TRA surveys (e.g. address of accommodation). This prevented geocoding and subsequent analyses of raw data at a fine scale and therefore eliminated any prospects of isolating spatially explicit waterway usage patterns. These restrictions, and the kerbed number of completed surveys (raw data), limited estimations of visitation and usage to the four ABS SA2 clusters (hereafter referred to as GC 'tourism regions' for the remainder of this section of the report) surrounding the GC waterways.

The four tourism regions were:

1: Broadwater North Waterways

2a: Southern Broadwater Waterways

2b: Nerang River and Central Waterways

3: Southern (Tallebudgera and Currumbin) Creeks (see Figure 5 below)

Note: It should be noted that in other parts of this report (most notably Sections 4 and 6), the study area was divided into three sections (i.e. 1 'Northern Section/Broadwater', 2 'Mid-Section/Nerang River and 3 'Southern Section/Southern Creeks – see Section 4.1.1 for details). For consistency and ease of understanding, tourism regions 1 and 3 of this section align directly with Sections 1 and 3 of other sections, while tourism regions 2a and 2b of this section combine to align with Section 2 of other sections.

Projections of visitors, visitor nights and expenditure were undertaken to assess the future size, scale and demographics of the Gold Coast visitor market. Visitor projections are based on the long-term forecasts generated by TRA's Tourism Forecasting Reference Panel. The number of visitors interested in taking part in particular activities were also projected using the TRA reference panel forecast, as these estimates are more stable and encompass broader market conditions than current growth rates.

Figure 5: Geographic areas used for analysis (from Earthcheck 2018).

3.3 Gold Coast visitation and trends

The information presented below is largely taken from the Gold Coast Waterways: Visitor Usage Summary (August 2018) presented in Appendix C, as well as Queensland Treasury data released in October 2018.

In 2017, visitation to the wider Gold Coast region peaked at 13.1 million visitors. This included approximately 10 million domestic and 1.04 million international visitors, representing respective increases of 16.3% and 24.9% over the past decade. Forecasts issued by the Tourism Forecasting Panel estimate that this figure will grow to approximately 16.2 million visitors by 2030.

Over the same year, these visitors generated a total of 22.7 million visitor nights with a split of 13.5 million and 9.2 million for domestic and international visitors, respectively. The average length of stay for domestic visitors was 3.8 nights compared to an average of 8.9 nights for international visitors. The average length of stay (ALOS) for all visitors to the Gold Coast region averaged 5.0 nights per visitor with a downward trend over the past 10 years.

NVS data indicated a strong weekend pattern for domestic day visitors averaging two million day-visits on a Saturday or Sunday compared to 770,000 during the week. Domestic overnight visitation showed a similar pattern, with approximately 48% of domestic visitors returning home from their trip on Sunday or Monday. Marginal seasonality was consistent with school holidays (March/April, June, September, December), with higher numbers of visitors returning home in the months following the holiday periods.

The primary purpose of domestic overnight visitation to the wider Gold Coast region was to 'holiday' (53.2%), followed by 'visiting friends and family' (32.4%), and 'business travel' (11.0%). The 5-year trend showed a steady increase for 'business travel' and 'visiting friends and family', while the number of 'holiday' visits remained constant. International travel had a clear 'holiday' focus (79.8%), while 'visiting friends and relatives' (15.0%) and 'business travel' (3.3%) contributed smaller visitor numbers.

Most domestic day trips (86.2%) originated from within Queensland with an additional 8.6% of visitors travelling across the State's border from Northern NSW. The fastest growing day visitor market emerged from within the Gold Coast itself. The data was, however, limited by TRA's definition of a visitor trip requiring a minimum to-and-from distance of 50 km to be covered, which prohibited capturing many day trips by visitors living west of the Pacific Motorway.

Approximately half of domestic overnight visitors were from intrastate (48.5%), principally from the greater South East Queensland (SEQ) region. The main interstate visitor markets were Sydney (16.2%) and Melbourne (11.0%), with both these markets showing steady growth of around 3% per annum over the past five years.

By 2017, the Chinese market had developed into the Gold Coast's largest international source market (308,986), followed by New Zealand (201,872) and the United Kingdom (70,385). For the same year, total visitor expenditure for the Gold Coast region reached an estimated AUD 5.0 billion, comprising AUD 3.1 billion by domestic overnight visitors, AUD 1.2 billion by international visitors and AUD 666 million by day trip visitors. In this context it is worth a mention that recent profiling by Tourism Australia highlighted 'Aquatic and Coastal'[7] as being considered a 'Top 5 important factor' to 35% of visitors from China, 22% of travellers from Hong Kong, and 26% of New Zealand visitors.

3.4 Visitation and trends of Gold Coast tourism regions surrounding the GC Waterways

The regions around the GC waterways received approximately 2.8 million domestic overnight and 4.9 million domestic day trip visitors in 2017 and 640,000 international visitors. This constitutes a total of 8.3 million visitors to the regions surrounding and inclusive of the waterways, representing an increase of 114% since 2007, and accounting for approximately 63% of total visitation to the Gold Coast region.

[7] Aquatic and Coastal activities relate to activities undertaken in and around the water including: active participation activities such as fishing and snorkelling, as well as activities based on enjoying water surrounds, such as charter boats (see 'Appendix C: Visitor Usage Summary', particularly Section 9 'Detailed Activity Analysis' for details).

Placing the focus on the four ‘tourism regions’ surrounding the GC waterways (Figure 6) revealed that almost 50% of all visitors were drawn to the Broadwater South area, followed by the Nerang River and Central Waterways. The remaining areas at the most southern and northern sections of the GC waterways hosted a roughly equal number of 1.3 and 1.2 million visitors, respectively.

Visitation to the Broadwater North region was clearly dominated by domestic day visitors (73.8%), followed by 22.8% for overnight visitors and an almost negligible proportion of international visitors (3.4%). As previously identified, the Southern Broadwater area hosted almost as many visitors (4.1 million) as all other areas combined (4.3 million). Visitors to this area were split into 53.7% day visitors, 34.0% domestic overnight visitors, and 12.3% international visitors. About 1.8 million tourists visited the Nerang River and Central Waterways region with fairly evenly distributed proportions of day visitors (53.7%) and domestic overnight visitors (44.9%) and only a small proportion of international visitors (5.5%). The Tallebudgera and Currumbin Creeks region received 1.3 million visitors, the majority of whom were day visitors (69.5%), followed by domestic overnight visitors (28.4%) and a very small number of international visitors (2.2%).

Of more concern from an ecological point of view (see Section 4.2), are differences in cumulative growth of visitation to these regions over the past five years. Over this period, international visitor numbers increased in all regions, with the highest cumulative growth in the Broadwater North region (41.2%, Figure 6) and a little over half of this (25.6%) in the region immediately south, the South Broadwater.

A different scenario was evident for overnight and day trip domestic visitors. Day trip numbers decreased in all regions apart from areas at the most southern end of the GC, the Tallebudgera and Currumbin Creeks. Here, the cumulative growth was the highest across all categories: a remarkable 44.8%. Although this translated to an increase of 435 000 visits and perhaps a shift of location and possibly activity preferences for the Southern Creek region, the overall loss of day trips to the GC waterways regions exceeded 360 000 when comparing 2012 and 2017 data. Providing this trend continues, it will reduce the overall usage pressure on the northern parts of the Broadwater but further increase the risks of accidents and injuries in the already heavily crowded estuary of Tallebudgera Creek and, possibly more pressingly, the more heavily visited mouth of Currumbin Creek around its northern groyne and Currumbin Rock (refer to the Flickr data in Figure 41 and Figure 42 in Section 4.4).

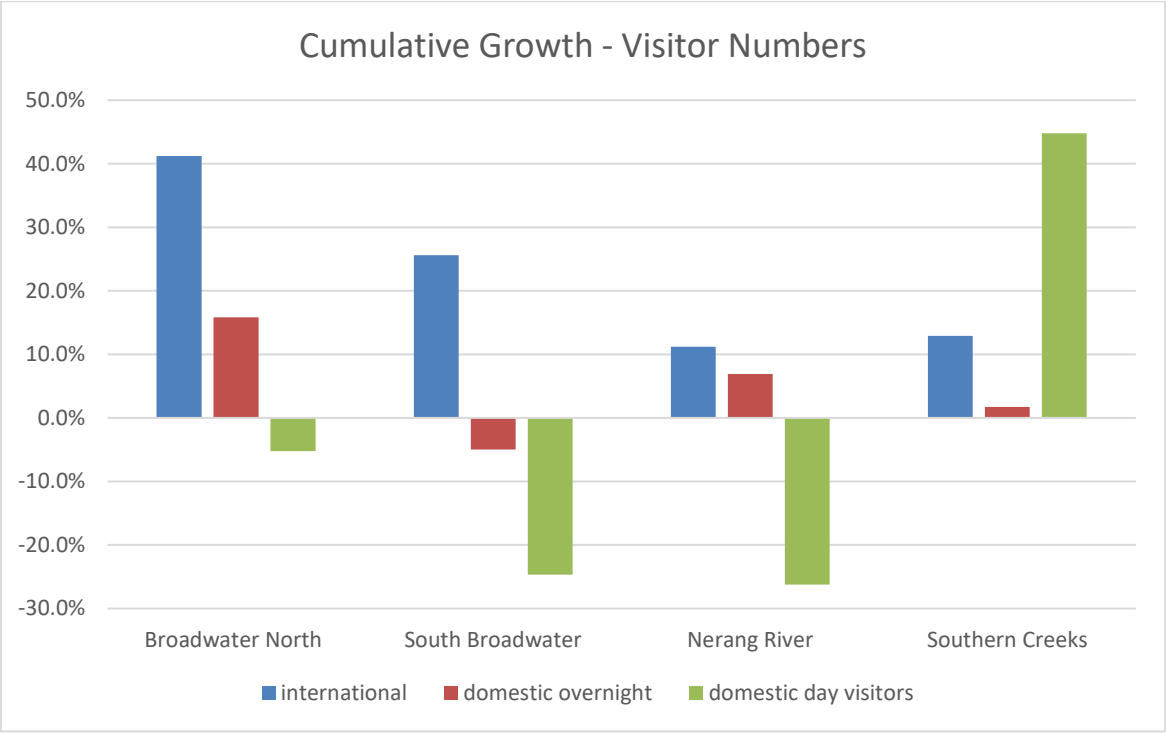

Figure 6. Cumulative growth of international and domestic overnight/day visitors.

An almost opposite trend emerged from calculating cumulative growth in domestic overnight visitors. The highest growth occurred in the Broadwater North region, which also hosts most of the high value natural assets of the GC waterways (refer to Figures 14-20 in Section 4.2). This increase in domestic overnight visitors has to be considered in the context of urban growth in this area and the fact that the purpose of almost half of all domestic overnight trips related to 'visiting friends and family' (see above). If these friends or family members have a recreational vessel, it will likely be one of the key attractions to take visitors out for 'a spin through their aquatic backyard', in this case the northern part of the GC Broadwater.

The Broadwater North is facing the strongest growth in urban development with a development mix dominated by separate housing structures. The vast majority of this new housing product has been or is still being built with double lock-up garages that provide the space for storing a small trailerable vessel, especially PWCs. Data released by the Queensland Treasury on 12 October 2018 point to a concerning growth scenario for the northern GC waterway regions (Figure 7), and the potential for future conflict, given that these are the most ecologically sensitive parts of the GC waterways (Section 4.2).

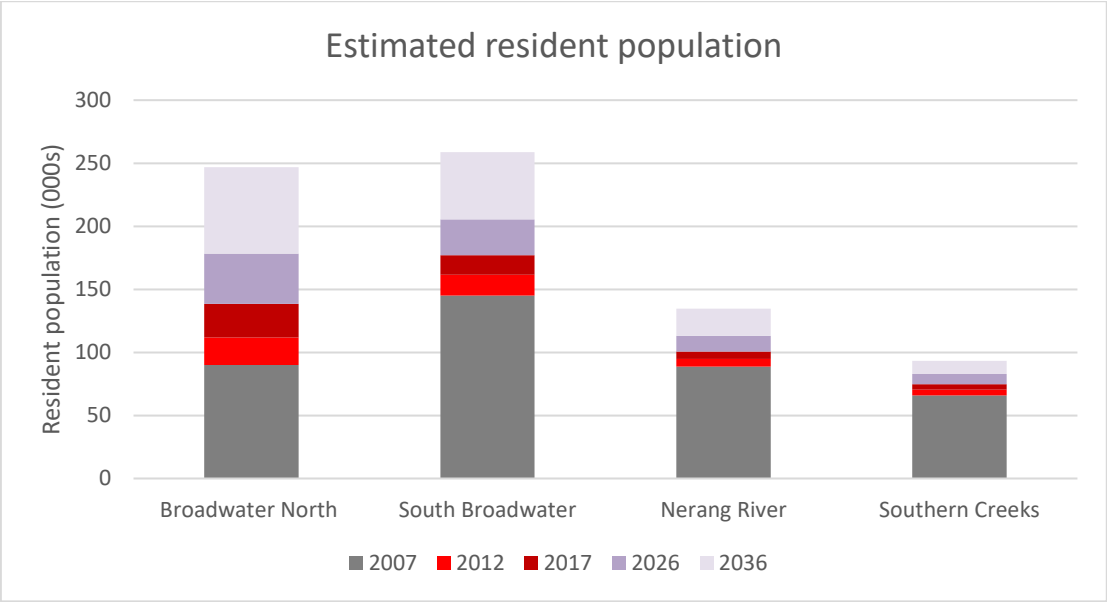

Figure 7. Estimated resident population (taken from 'Queensland Regional Profiles, Resident Profile - people who live in the region', Queensland Treasury Statistical Office 12 October 2018).

By 2017 housing growth in the northern Gold Coast resulted in the second highest number of residents (per area) for the city, with the population in the Broadwater North region rapidly catching up to the number of residents in the South Broadwater area. Further, the housing mix in the former region has a much higher proportion of separated houses that facilitates storing trailerable vessels (Figure 8).

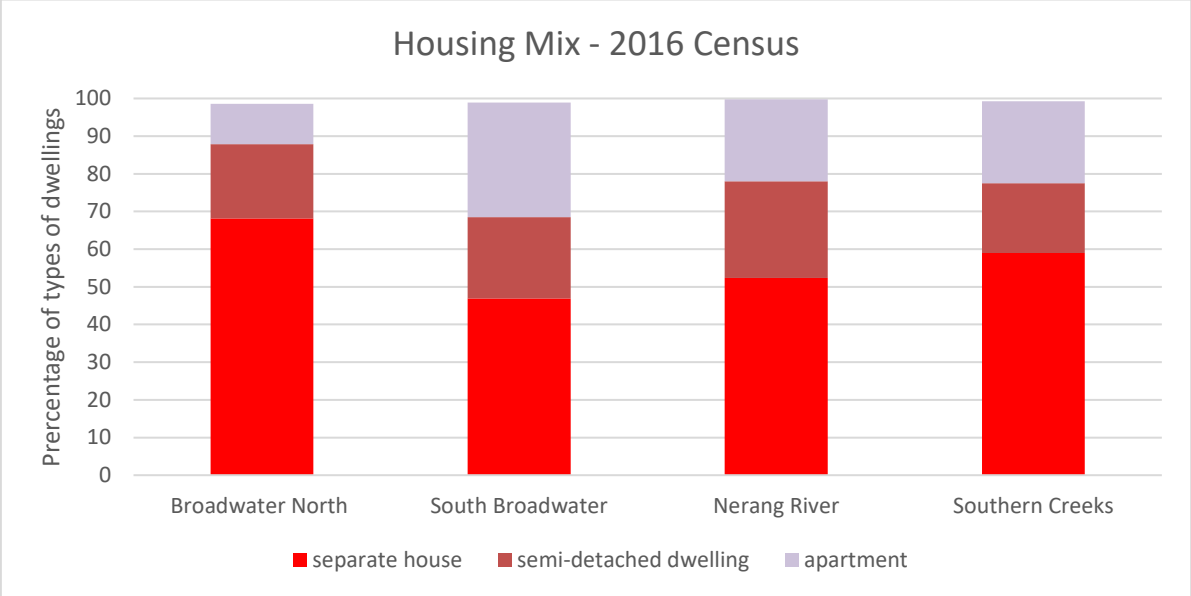

Figure 8. Major types of dwellings, ABS Census data 2016 ('others' not included).

The confounding effect of the two figures above are illustrated below in Figure 9. It uses some tentative assumptions about the ratio between the number of trailerable vessels per resident in different housing types. When using factors of 0.1, 0.05 and 0.01 for separate houses, semi-detached dwellings and apartments reflecting car parking spaces, income and age profiles, the distribution of trailerable vessel numbers and potential uses signals an even greater pressure on the North Broadwater region (Figure 9). Certainly, a more detailed data mining exercise using recreational vessel registrations by suburb and relevant socio-economic data from the 2016 ABS Census would refine these predictions. Nevertheless, this trend is mirrored by the growth in domestic overnight visitors between 2012 and 2017 (Figure 6).

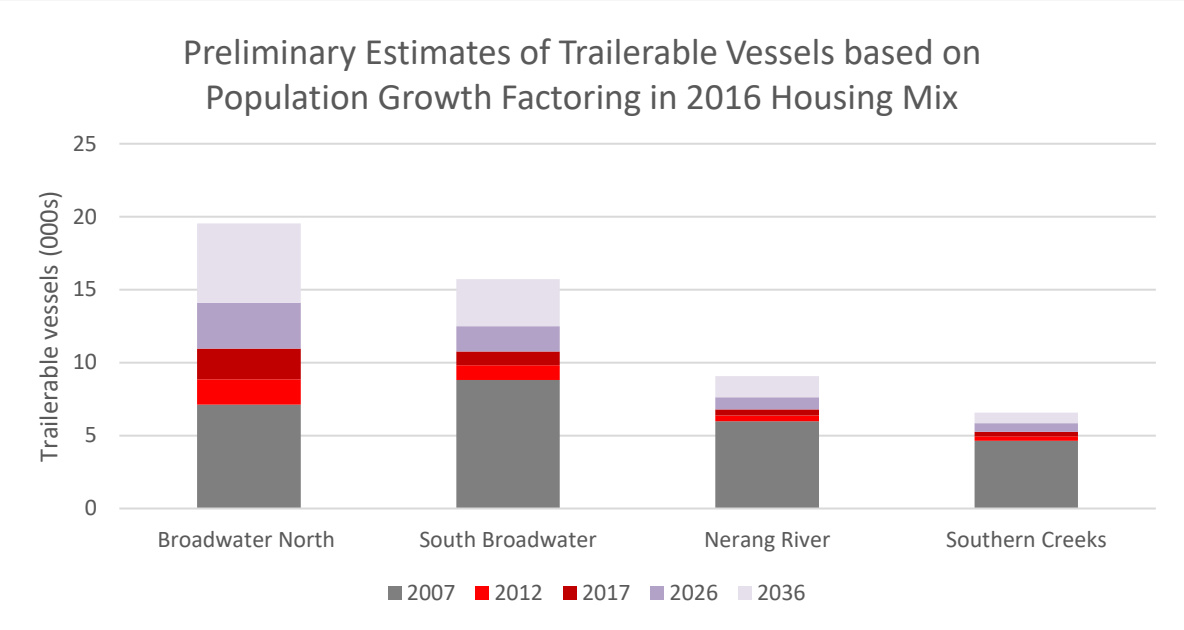

Figure 9. Preliminary estimates of the distribution of trailerable vessel numbers.

From a Tourism Research Australia (TRA) perspective, predictions estimate that by 2030, visitation is expected to increase to 1.7 million in the Broadwater North region, 5.8 million in the Broadwater South region, 2.5 million in the Nerang River and Central Waterways, and 2.0 million at Tallebudgera and Currumbin Creeks. International visitation is set to double in the Broadwater North and Broadwater South Waterways, and more than triple in the Nerang River and Central Waterways region. The additional visitation is expected to increase pressure predominantly on commercial tour operators, who mostly restrict their tours to areas south of the Seaway or use the near shore ocean areas. In relation to vessel usage on the GC waterways, especially the Broadwater North region, the main tourism growth of concern relates to domestic overnight visitors and in the opinion of the research team, TRA figures might be an underestimate given the recent urban expansion in this region.

Visitor numbers to the Gold Coast and its waterways is likely to grow unabatedly with approximately 75% of the total visitor nights spent in the four regions along the GC waterways. Some lessening of the associated pressure on GC waterways could arise from a downwards trend in the 'average length of stay' (ALOS) for all GC visitors over the past 10 years, with those visiting the regions inclusive of and surrounding the waterways revealing a greater decline (ALOS ↓1.0% p.a. vs ↓2.0% p.a.).

In light of 20 years' experience with projects involving GC tourism and especially its accommodation mix[8] the research team is predicting an increase in the geographic shift of visitation by domestic overnight and day trips contracting to the north and south of the GC waterways and international visitors, especially those from SE Asia, India and the Middle East[9], concentrating on the middle and environmentally less sensitive sections of the GC waterways.

Total expenditure for the regions including and surrounding the GC waterways totalled $3.8 billion for 2017. Overall expenditure by domestic overnight visitors was $2.5 billion in 2017, while international visitors contributed $830.8 million and domestic day visitors $501.7 million. This is expected to grow proportionately with the predicted domestic population growth and distribution and predicted overall increases in international tourism outlined in preceding sections.

[8] See 7.3 'Gold Coast tourism and accommodation References'.

[9] The largest source market for areas surrounding the GC waterways is New Zealand (163,815), followed by China (103,928) and the United Kingdom (49,714). The fastest growing international source market for the Gold Coast Waterway surrounds is India (36.7% p.a.), followed by Hong Kong (35.2% p.a.) and China (26.9% p.a.).

3.5 Activity analysis

The Gold Coast is attractive to tourists because of its mix of waterways, urban precincts, bayside villages, hinterland environs and expansive inland waterways, which provide a range of quality activities that enhance visitor experience. City-based activities have dominated visitor experiences over the past five years (44.2%), followed by Aquatic and Coastal activities (22.1%), and Natural Beauty (9.4%). During 2017 almost four million visitors took part in Aquatic and Coastal activities in the areas including and surrounding the GC waterways. However, a limitation in the data is that much of this activity occurred outside of the GCWA area of jurisdiction, and it is almost impossible to infer the proportion of the data that is represented by the GC waterways.

The number of visitors taking part in Aquatic and Coastal activities has grown almost four times faster within the four GC waterway areas than the broader Gold Coast over the past 10 years. Visitors to these areas have a slightly lower level of participation in Aquatic and Coastal activities (47.9%) than visitors to the wider Gold Coast, probably because the area defined as 'inclusive of and directly surrounding the waterways' do not include many of the open ocean beach areas.

Aquatic and Coastal activities accounted for a larger proportion of visitor activities (25.2%) within the waterway areas than the broader Gold Coast region (22.1%). This category includes: visiting the beach; visiting the reef; fishing; scuba diving; surfing; charter boats, cruises and ferries; and visiting or staying on an island. Water activities and sports from within the Sports and Adventure[10] activity group were also included in the analysis.

The most popular activity within the Gold Coast statistical area (as encompassed by survey data) in 2017 was going to the beach, which had 3.9 million visitor participants, representing 46.8% of total visitors. Approximately 88.7% of international visitors went to the beach during their trip to the region, 260,727 visitors (3.2%) took part in surfing, 247, 536 (3.0%) took a chartered boat, cruise or ferry, and 190,299 (2.3%) went fishing. Approximately 243,212 visitors (2.9% of total visitors) participated in water activities and sports such as kayaking, windsurfing and sailing, representing an annual growth of 8.8% in participation in these activities since 2012. Also, a total of 75,541 visitors (1.4%) took part in snorkelling, while scuba diving accounted for the smallest visitor market (75,541 visitors) but it was the fastest growing of all activities at 17.3% p.a. over the past five years.

By 2030 it is expected that around 5.8 million visitors will go to the beach within the areas surrounding the GC waterways. The number of visitors engaging in cruises, ferries and charter boats (approx. 496,561) is expected to surpass those participating in surfing (415,325). Visitors participating in water-based activities are expected to double to 390,477, due to the growing popularity of soft adventure activities.

Due to insufficient sample sizes, individual activities for National and International visitors were collapsed to two areas by combining the two northern and two southern regions. Visiting the beach accounted for a higher proportion of activities in areas surrounding the southern GC waterways (81.7%) than the northern region (68.6%), a pattern which also held true for surfing. All other water activities were more prevalent in areas surrounding the Broadwater North waterways.

3.6 Conclusions

The GC waterways are extensive and form an integral part of local and visitor engagement within the Gold Coast region. As participation in outdoor recreation and 'soft adventure' activities (e.g. parasailing, jet boat tours) continues to grow, the sustainable development and use of these waterways will be vital

[10] Includes water-based sports such as swimming, kayaking, wind surfing, parasailing etc.

to supporting the future use of the local network of rivers, canals, lakes and dams. Utilising Tourism Research Australia visitor and activity data is the best proxy for analysing visitor behaviour and trends in and around the GC waterways.

Domestic and international visitation has undergone substantial growth in the GC waterways and surrounding areas – more than seven times that of visitation to the wider Gold Coast region. Visitation for the purpose of Aquatic and Coastal activities has doubled in the past 10 years and is predicted to involve at least six million visitors by 2030 (Qld Treasury, 2018).

The distinct seasonality of visitation creates major challenges for further developing and managing peak-period capacities on the Gold Coast and its direct impacts on waterway usage and development. With an estimated contribution of $3.8 billion to the local economy it is critical for the GCWA to proactively plan for and manage the GC waterways not only to benefit local residents and users, but also to provide opportunities for a range of different visitors and their coveted recreational activities.

However, the most striking demographic trend for future management of the GC waterways is the projected growth in population, and accompanying vessel use, in the northern Broadwater. This is of particular concern, both for the potential for user/user conflicts, but also because these are the most environmentally sensitive parts of the GC waterways.

The figures presented in this part of the report are based on the most recent available data (Qld Treasury, October 2018) but include a range of assumptions about levels of vessel ownership and use per household type. These will need to be validated with more detailed analyses (refer to the Gap Analysis in Section 5 of this report). Nevertheless, it is concerning that there is likely to be a very marked increase in vessel use in the area with the highest ecological values (see Section 4.2). The value of the detailed analyses on population trends will be enhanced if considered together with the recommended surveys of current patterns of use, and user expectations and values (see Gap Analysis, Section 5).

4 Users and Uses of the GC Waterways

4.1 Background and methods

The main aim of this section was to identify any source of data that contained spatial references relating to users and uses of the GC waterways, including those that could affect directly or indirectly the distribution of these uses and their future management. Where possible, spatial datasets of sufficient accuracy were error checked and reprocessed so that they could be presented in a consistent format, usually as densities at the spatial resolution of one hectare, that is, 100m x 100m grid cells.

Data searches undertaken accessed and utilised:

- publicly accessible repositories of GIS layers (Geoscience Australia, Australian Bureau of Statistics, QSpatial, Gold Coast City Data Portal),
- data layers from GCWA reports and projects
- online developer portals for social media data collections (geotagged Flickr photos, geotagged tweets on Twitter, MapMyFitness, STRAVA)
- online data of annual AIS vessel position data at hourly intervals
- online high-resolution satellite imagery and navigation charts provided by ESRI, Google and Navionics

All spatial analyses were undertaken in ArcGIS version 10.4 (ESRI). Densities were calculated using the kernel interpolation with barriers tool for a 100 m cell grid with a 110 m search radius. Details of the sources and types of data, the time periods to which they relate, any caveats on accuracy, and the parameters for individual analyses are given in the relevant sections relating to each use type.

4.1.1 Geomorphological setting for the GC waterways

The GC waterways sit within the catchments of the Logan, Albert, Pimpama, Coomera and Nerang Rivers, and Currumbin and Tallebudgera Creeks (Figure 10). The water quality and upstream activities in each of these catchments directly affect the physico-chemical properties of the water bodies, as well as sediment availability and distribution. All catchments have been modified by a number of human-made features ranging from dams and weirs, shore bank stabilisation (rock armour), excavation of canal estates and modifications or stabilisation of their entrances or mouths (discharge points into open ocean waters). To derive a classification of the different parts of the GC waterways, the following data sources were used.

- Digital Elevation Model (DEM) 25 m based on Geoscience Australia 2009 data available through QSpatial and extracted using City of Gold Coast (CoGC) [11] Local Government Area (LGA) boundary sourced from GC open data portal
- Catchment boundaries extracted from Water plan catchment layer available through QSpatial (published 4 April 2018) and verified against SEQ Atlas catchment boundaries (2013)
- Drainage lines for major rivers and creeks extracted from 8th to 4th order from Qld Watercourse lines (by area of interest) available through QSpatial

[11] The Local Government Area/Authority (LGA) of Gold Coast City/Gold Coast City Council (GCCC) is now referred to as City of Gold Coast and Council of City of Gold Coast (CoGC).
See http://www.goldcoast.qld.gov.au/default.html for details (last viewed: 14/11/18).
However, reference to the LGA in relevant Queensland legislation is still to the GCCC. For example, the *Planning Act 2016*, the *Planning Regulation 2017* and the *Local Government Regulation 2012*.
See https://www.legislation.qld.gov.au/ for details (last viewed: 14/11/18).

Based on these analyses, for the purposes of this section the GC waterways were subdivided into three sections based on catchment geomorphology. Areas were derived from the waterway boundary layer intersected with catchment boundaries:

1: Northern Section (Broadwater), covering 7,474 ha, characterised by rivers (Albert, Coomera and Pimpama) and several creeks (Pimpama and Broadwater creeks) draining via extended lowlands mostly modified by human-made drainage channels into a shallow sandy estuary system.

2: Mid-Section (Nerang River), covering 1,995 ha, with a heavily regulated flow regime (Hinze Dam, Little Nerang Dam) draining through a heavily urbanised area with an extensive network of human-made canals and lakes into a narrow estuarine section also modified by a number of human-made structures, including a heavily modified and stabilised entrance system (this includes tourism regions 2a and 2b defined in Section 3.2).

3: Southern Section (Southern Creeks), covering 322 ha, comprising a combined catchment of two major creeks carrying runoff from the hinterland plateau and slopes along a comparatively steep altitude gradient (in relation to the Broadwater North and Nerang River sections) via short and partly modified estuaries with narrow openings stabilised by rock formations and human-made breakwaters.

A key geomorphological feature of the system is its natural variability or instability. Historically, both the Jumpinpin and Nerang River openings shifted or even closed from time to time until the late 1800s and then the mid-1880s when the Jumpinpin Bar was opened up in the aftermath of the grounding of the *Cambus Wallace* and the 1980s when the Nerang River mouth was stabilised by constructing the Gold Coast Seaway, respectively. Despite these major events and all the other human-made changes mentioned above, the Broadwater remains a dynamic system that requires continuous dredging to maintain certain water depths within its network of identified navigation channels (for further details see bathymetry maps D1 to D3 in Appendix D).

These dynamics and the many areas of shallow structure of lower parts of the Gold Coast estuaries pose major challenges for defining the exact area that should be considered as the GC waterways. Overlaying the contour for the Australian Height Datum (AHD) extracted from detailed bathymetry models (maps D1 to D3 in Appendix D) indicate notable changes over a period of five years (Figure 11). These are even more extreme when comparing the AHD contours from bathymetry models based on different input data. In this case, models largely developed from LiDAR data input (2009, 2014 data) and models based on actual depth soundings compiled over a wide range of years by Maritime Safety Queensland for its Beacon to Beacon online publications[12]. Such deviations in physical boundaries pose a major challenge for defining the area of the GC waterways in more detail, especially when different authorities use different physical boundaries that define the extent of waterways.

[12] See https://www.msq.qld.gov.au/Boating-maps for details (last viewed: 13/11/18).

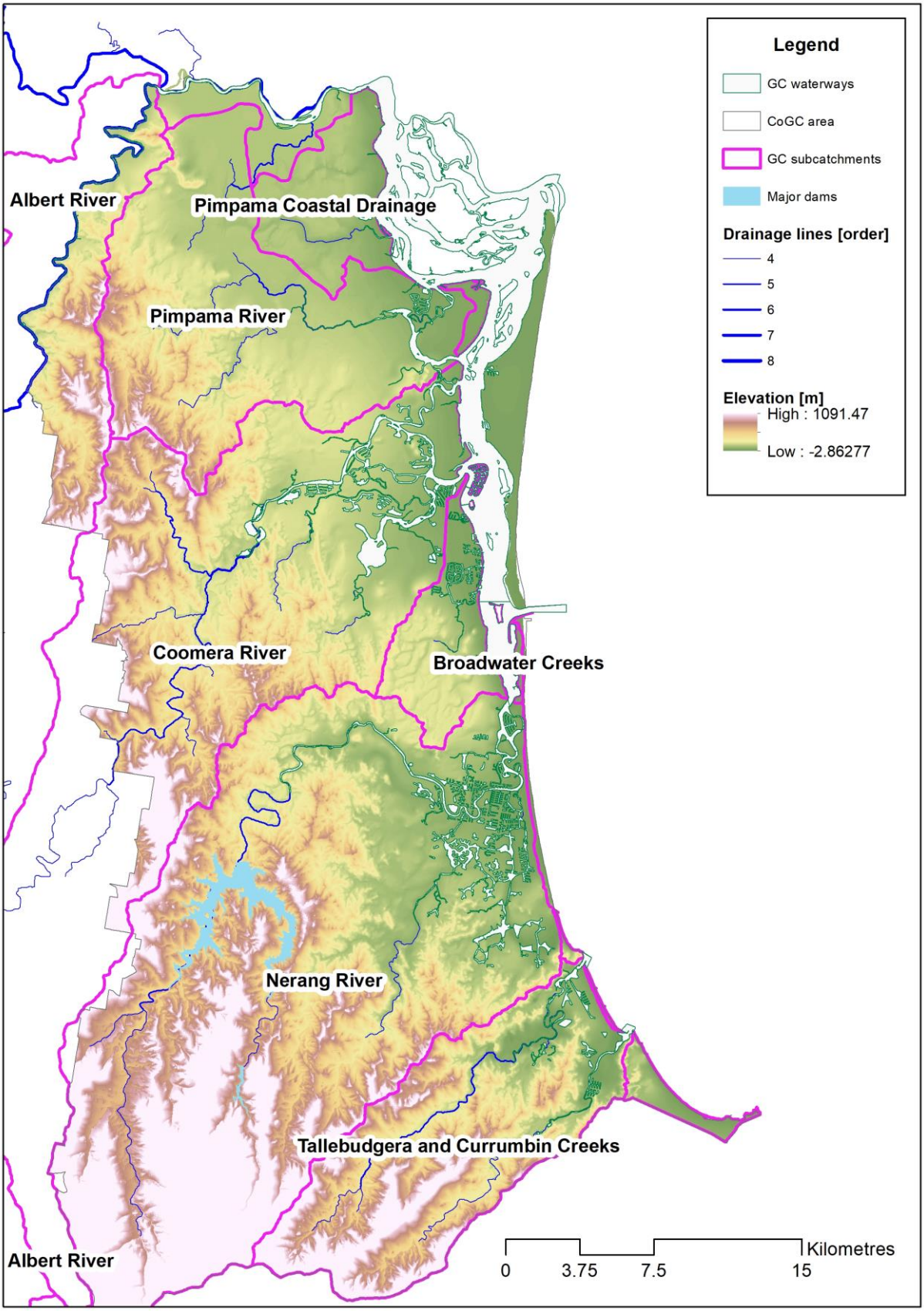

Figure 10: Catchments, drainage and elevation surrounding the GC waterways.

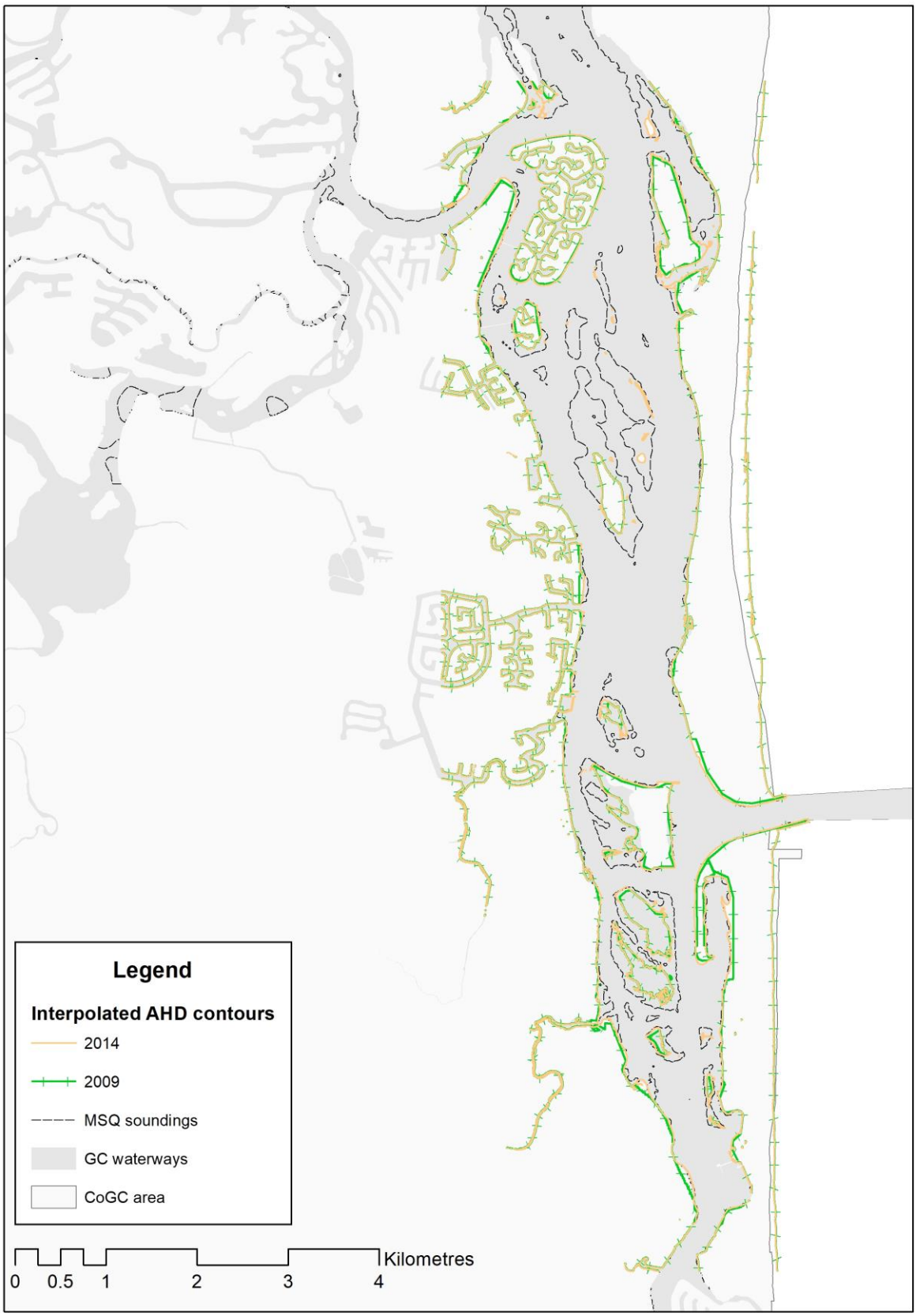

Figure 11: Derived change in Australian Height Datum (AHD) contours of the southern section of the Gold Coast Broadwater between 2009-2014.

4.1.2 Defining detailed boundaries of the GC waterways for spatial analyses

The dynamic nature and shallow profile of the lowers sections of the GC waterways created a major problem for defining spatial boundaries, accurate at sufficiently fine scales to be used for spatial analyses for the purposes of this study.

Under the *Gold Coast Waterways Authority Act 2012*, the GC waterways are defined in relation to waters and waterways within a defined boundary as follows:

(1) The Gold Coast waters are all of the waters within the following areas—

(a) the Gold Coast City local government area;

(b) the area near the mouth of Currumbin Creek described in schedule 1, section 1;

(c) the area near the Gold Coast Seaway described in schedule 1, section 2;

(d) the area near the mouth of Tallebudgera Creek described in schedule 1, section 3.

(2) The GC waterways are all of the waterways in Gold Coast waters.

The map of waterways developed by GCWA for dissemination via their website (see Figure 1) utilises spatial information provided by Qld Department of Agriculture and Fisheries for defining 'waterways' to assist in the determination of whether a site of proposed waterway barrier works requires assessment and approval under the *Fisheries Act* 1994 (Qld). In the first instance, the upper boundaries appear to be defined from flood maps representing inundation during the Highest Astronomical Tides (HAT) and did not include human-made canals. The latter are shown in Figure 1 and appear to share the spatial extent of watercourses shown in the digital cadastral database (DCDB) downloaded in May 2017. Overlaying the possible original source layers revealed considerable differences in what could be considered as 'waterways' within the Gold Coast area (Figure 12).

Therefore, to overcome these spatial uncertainties, a new GC waterways layer was developed that reflected areas of open water navigable by powered and unpowered watercraft during most times of the year. This information was extracted from two key datasets, the Qld Regional Ecosystems layer (V 10.1, 2015) and the Qld Land Use Mapping Program layer (QLUMP, 2011 updated). These were overlayed using the Union tool of ArcGIS 10.4 (ESRI) and the resulting inconsistencies checked manually against online satellite imagery supplied by ESRI as part of their global base map data set. The resulting 'GC waterways' layer shown in Figure 12 represents the lower boundaries of the QLUMP and RE layers and therefore a mid- to low tide water level in these water courses. The layer excludes Hinze and Little Nerang Dam since these are not within the scope of this study.

It should be noted that there was no precise GC waterways spatial data layer available (as 'GC waterways' is not a specifically recognised water body per se). Also, this situation is not uncommon in regard to obtaining existing spatial data for bodies of water where current, clearly defined boundaries can be problematic to identify and difficult to keep up to date.

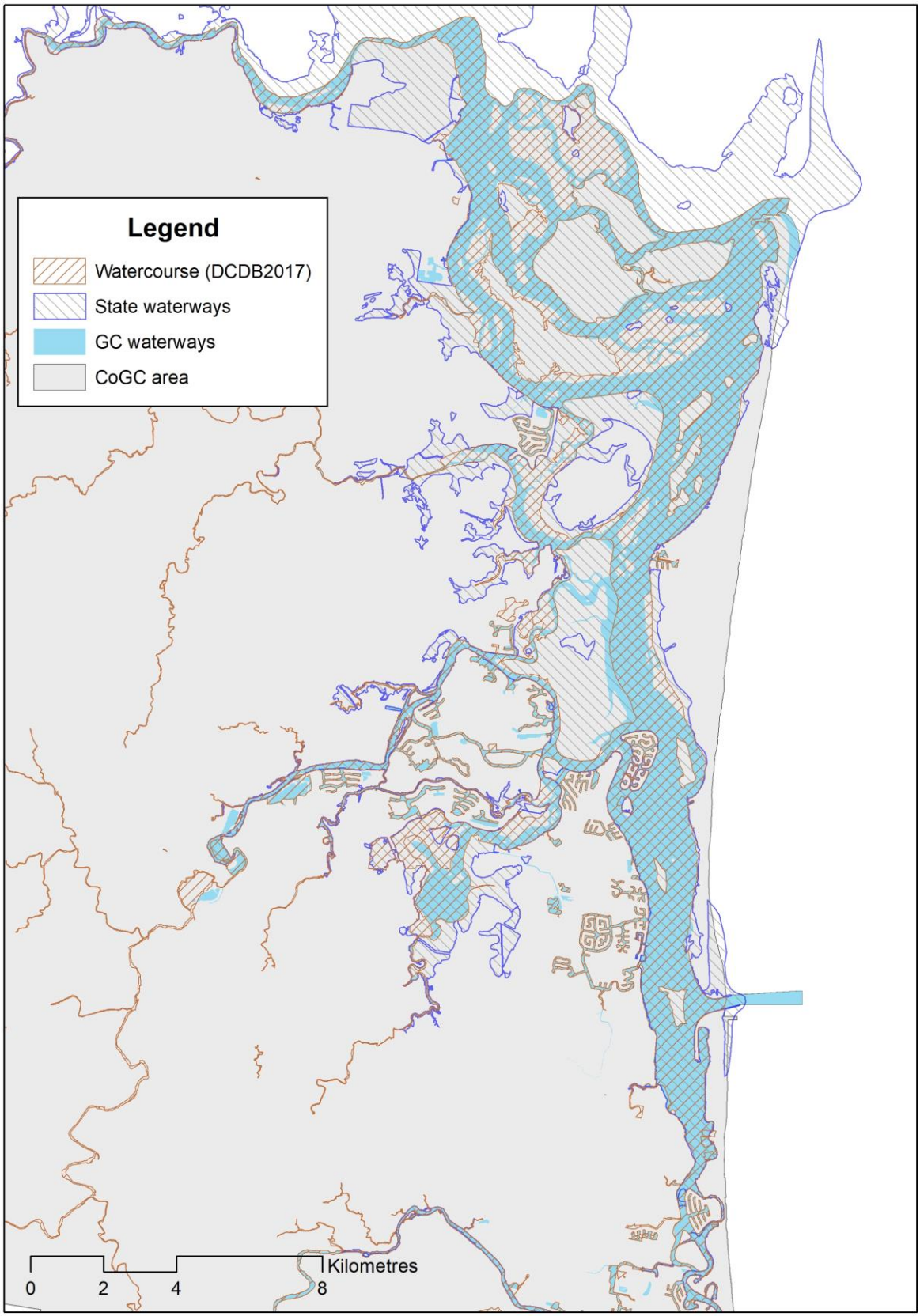

Figure 12: Derived map of northern portion of GC waterways based on Qld Regional Ecosystems layer (V 10.1, 2015) and the Qld Land Use Mapping Program layer (QLUMP, 2011 updated).

4.1.3 Tenure of land surrounding the GC waterways

A key challenge for managing the uses and users of the GC waterways originates from the development of an extensive network of canal and golf estates along the GC waterways. Ownership of most of these human-made watercourses are vested with the local government authority, City of Gold Coast (CoGC), or private entities. The resulting types of tenure as captured by the digital cadastral database (DCDB, extracted in May 2017) are depicted in Figure 13. The cadastral data did not capture ownership by CoGC over the earlier canal estates along the Nerang River, Paradise Point, Biggera Waters and the Southern Creeks.

Day to day maintenance of most human-made waterways is the responsibility of CoGC through its City Maintenance Division under the Transport and Infrastructure Directorate. The only exception are small lakes and water features as part of drainage systems within large golf estates, which are managed by their owners.

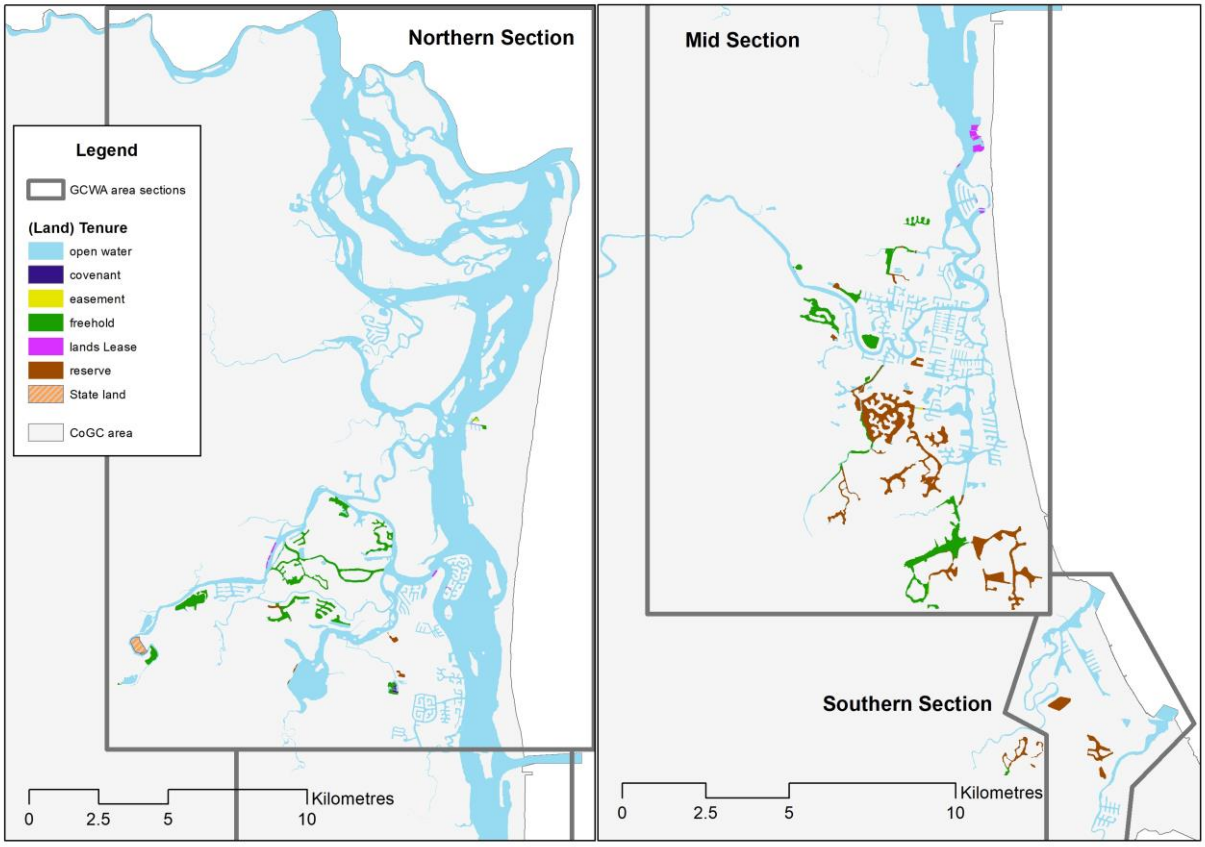

Figure 13: Sections of the GC waterways (Section 4.1.1 and subsequently) and the tenure registered in the Qld lands title register (extracted from land parcels captured in the Qld cadastre, May 2017).

As outlined in Section 4.1.1, the GC waterways was subdivided into three sections; these are shown in Figure 13 and used for discussing further results presented in subsequent maps and figures.

4.2 Environmental 'uses' of the GC waterways

4.2.1 Data sources

The Northern Section of the GC waterways hosts large areas of natural intertidal habitat that provide the ecological basis for a wide range of invertebrate, fish, crustacean and bird species as well as some marine mammals such as dolphins and dugongs. The following provides a summary of information available in digital spatial format. Key data sources included the Regional Ecosystem (RE) layer compiled bi-annually by the Qld Herbarium for managing vegetation under the *Vegetation Management Act* 1999 (Qld), seagrass mapping exercises for different projects in the Broadwater and Moreton Bay system and a GCWA report combining shorebird data from a range of sources.

4.2.2 Intertidal and associated habitats

Combining spatial data relating to vegetation communities and seagrass (Figure 14) clearly illustrates that the largest extent of coastal habitats can be found in the Northern Section of the GC waterways. The types of habitat include, in landward to seaward order, *Casuarina glauca* woodlands and saltpan or saltmarsh communities, mangroves mostly dominated by *Avicennia marina* (grey mangrove) and, in a few pockets, *Rhizophora stylosa*. Seagrass species can be mostly found at the lowest end of intertidal areas along deeper channels in the eastern part of the Broadwater.

The urban build-up along the Mid-Section of the GC waterways displaced all remnant *C. glauca* stands and saltpans. A few isolated stands of mangrove trees still exist around Loders Creek and Biggera Creek mouths and along the Nerang River. These, however, were too small (< 1 ha) to be included in the RE layer. Several seagrass patches, on the other hand, still exist across areas large enough to be captured as part of relevant mapping exercises (Figure 15).

The Southern Creek Section retained the same types of coastal habitat found in the Northern Section, however, all considerably smaller in areal extent. Most of these patches were located upstream of the creek mouths, which have been subject to anthropogenic modifications starting with sand mining and then urban development plus construction of rock walls to stabilise their entrance locations.

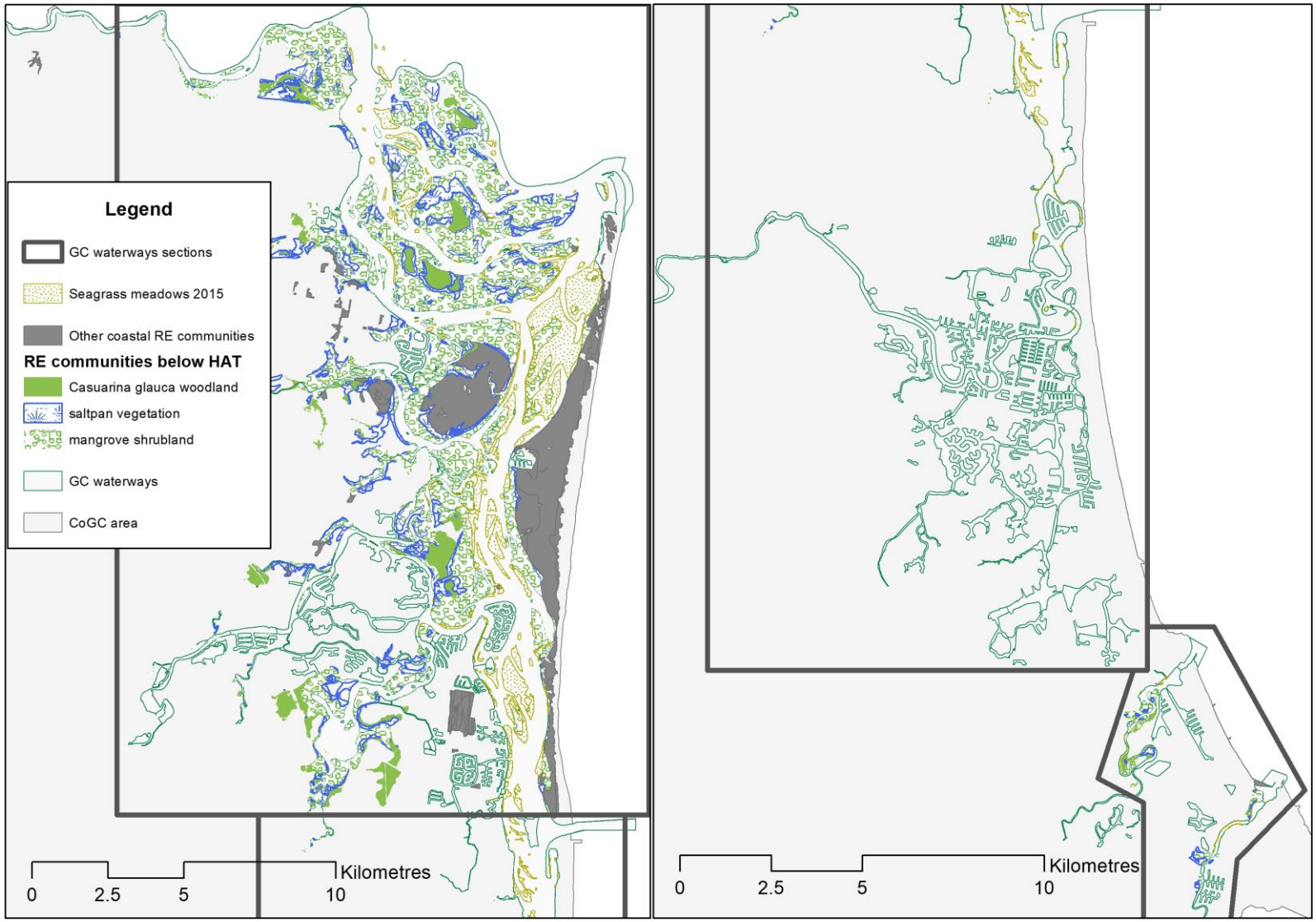

Figure 14: Marine vegetation types and seagrass meadows within and adjacent to the GC waterways.

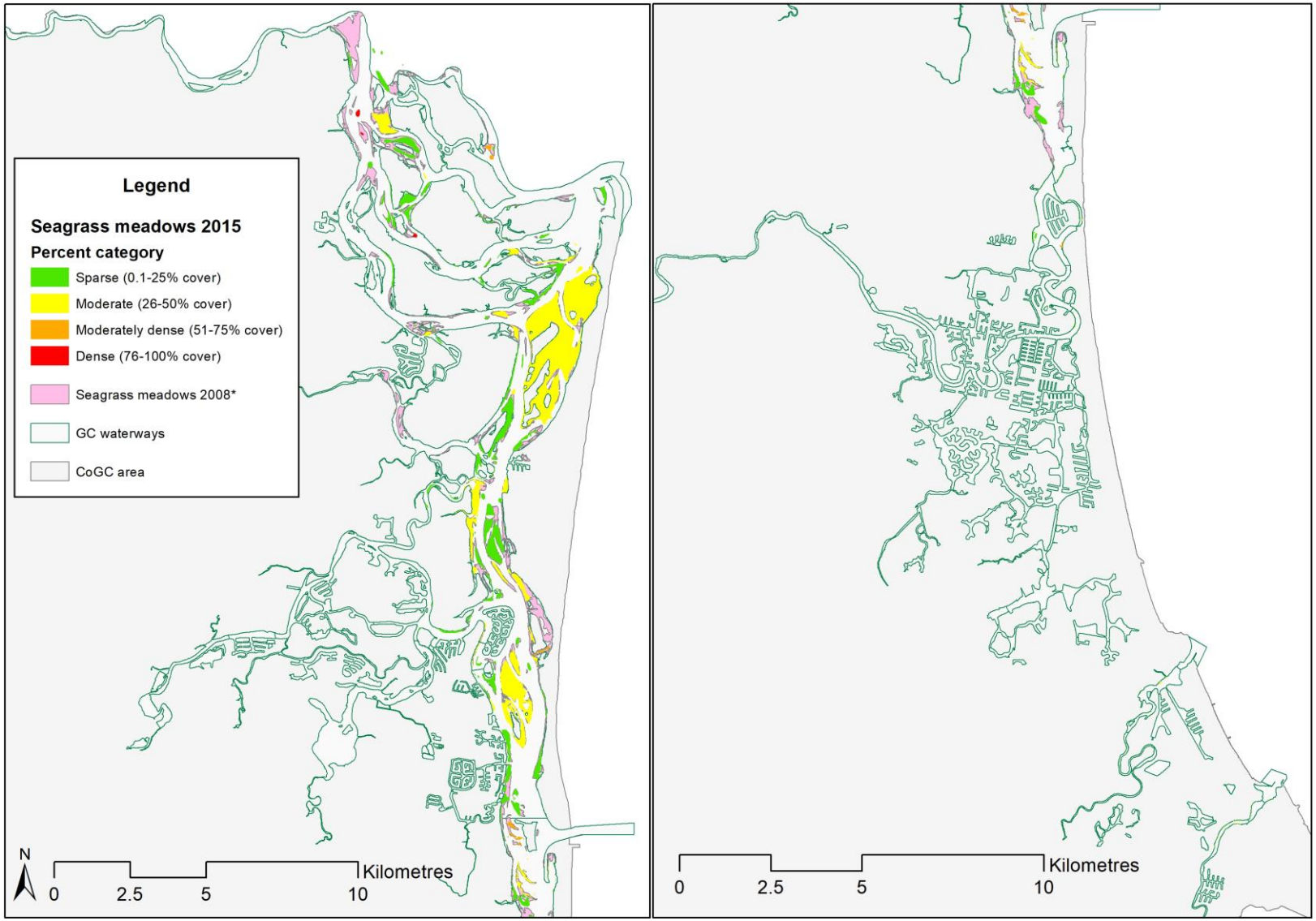

Figure 15: Distribution and density of seagrass meadows within the GC waterways (source: Gold Coast Seagrass Habitat Mapping, TropWATER, 2015).

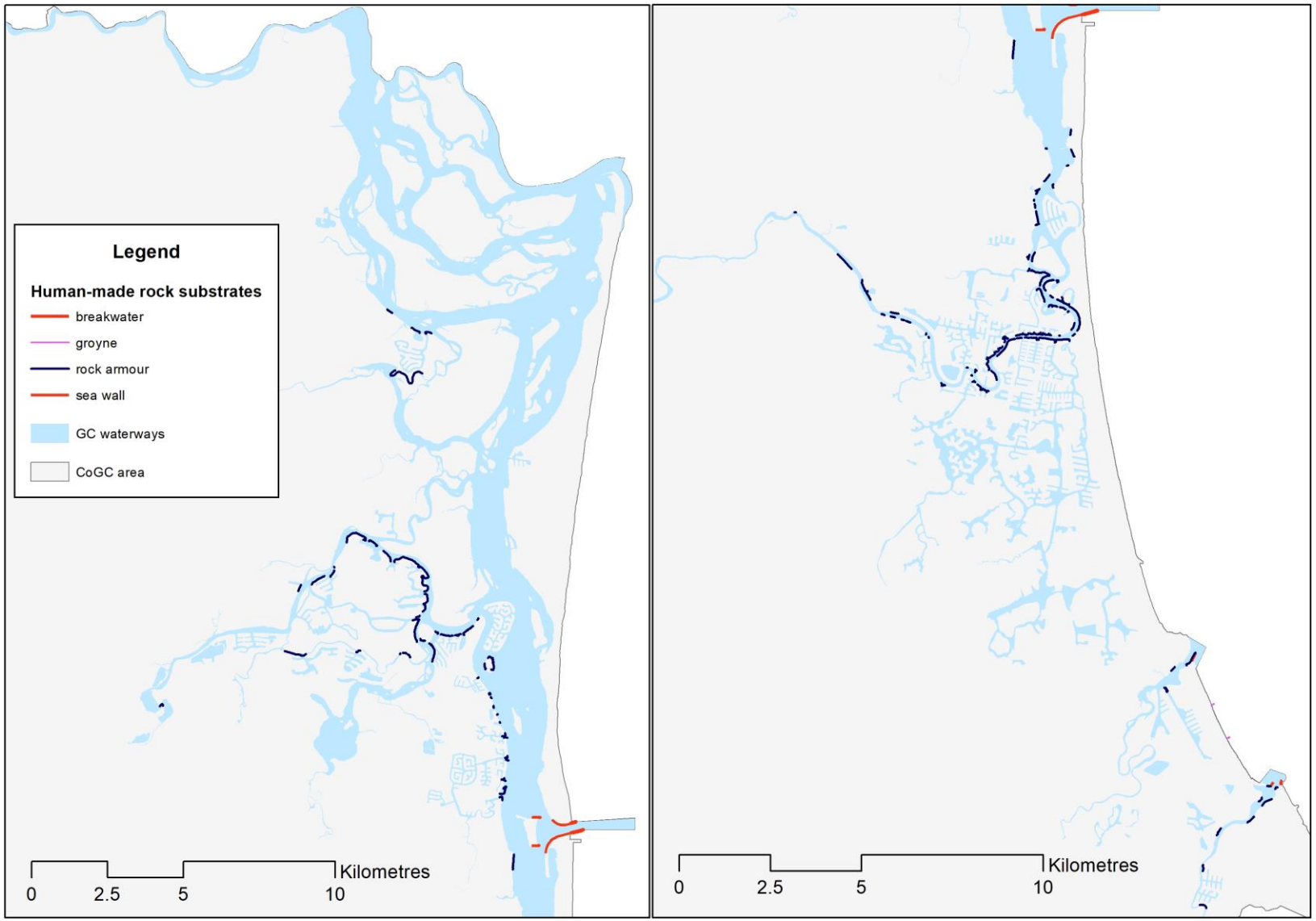

Figure 16: Rock and gravel reinforcement along GC waterways shorelines (canals not included).

More persistent changes to the intertidal structure of GC waterways habitats resulted from shoreline stabilisation using rock and gravel armour. Recent high-resolution satellite imagery available through ESRI's online global map data and Google Maps were used to trace sections of shoreline along the area's major rivers and creeks that were reinforced with rock, gravel or concrete structures (Figure 16). The extensive artificial waterways and canals were not included in this process.

Overall, these protective measures introduced approximately 37.7 km of new habitat, i.e. rocky or hard surfaces that would have been quite rare prior to urban development. This figure does not include bund walls, pylons, pontoons, boat ramps and similar structures. The lower part of the Nerang River was the most heavily modified natural waterway with shores on both sides lined with rock or concrete walls. By far the largest areas of remaining natural intertidal and coastal habitats were mapped for the Northern Section of the GC waterways. Their spatial complexity and location in relation to the Australian Height Datum (AHD) are shown in Figure 17. The AHD boundary lines were extracted from a grid layer with a 10 m cell size that was interpolated (using a spline with barriers) from depth soundings collected and compiled over several years by Maritime Safety Queensland (MSQ) and made available on QSpatial. Apart from some seagrass meadows with moderate cover (Figure 17) north of Dux anchorage[13], no major habitat was identified within any of the deep channels mostly used for navigation.

Figure 17 also illustrates that most deep channels run in close proximity (10s of metres) to seagrass, mangrove or saltpan habitats and in some instances even close to *Casuarina glauca* communities that are considered 'endangered' under the *Vegetation Management Act 1999* (Qld). The only parts of the GC waterways with more extended navigable open water and, therefore, not immediately adjacent to intertidal coastal habitat are the Deep Hole north of the Seaway and Millionaires' Row south of the Jumpinpin Bar.

[13] Note on place names. Most places referred to (e.g. The Spit, or Broadbeach) will be familiar to the readership of this report. Others, however, are informal terms used by locals to refer to particular stretches of seascape, fishing spots or anchorages. Illustrating all of these on every map would be too complex; therefore, a master place names map is provided at Appendix E.

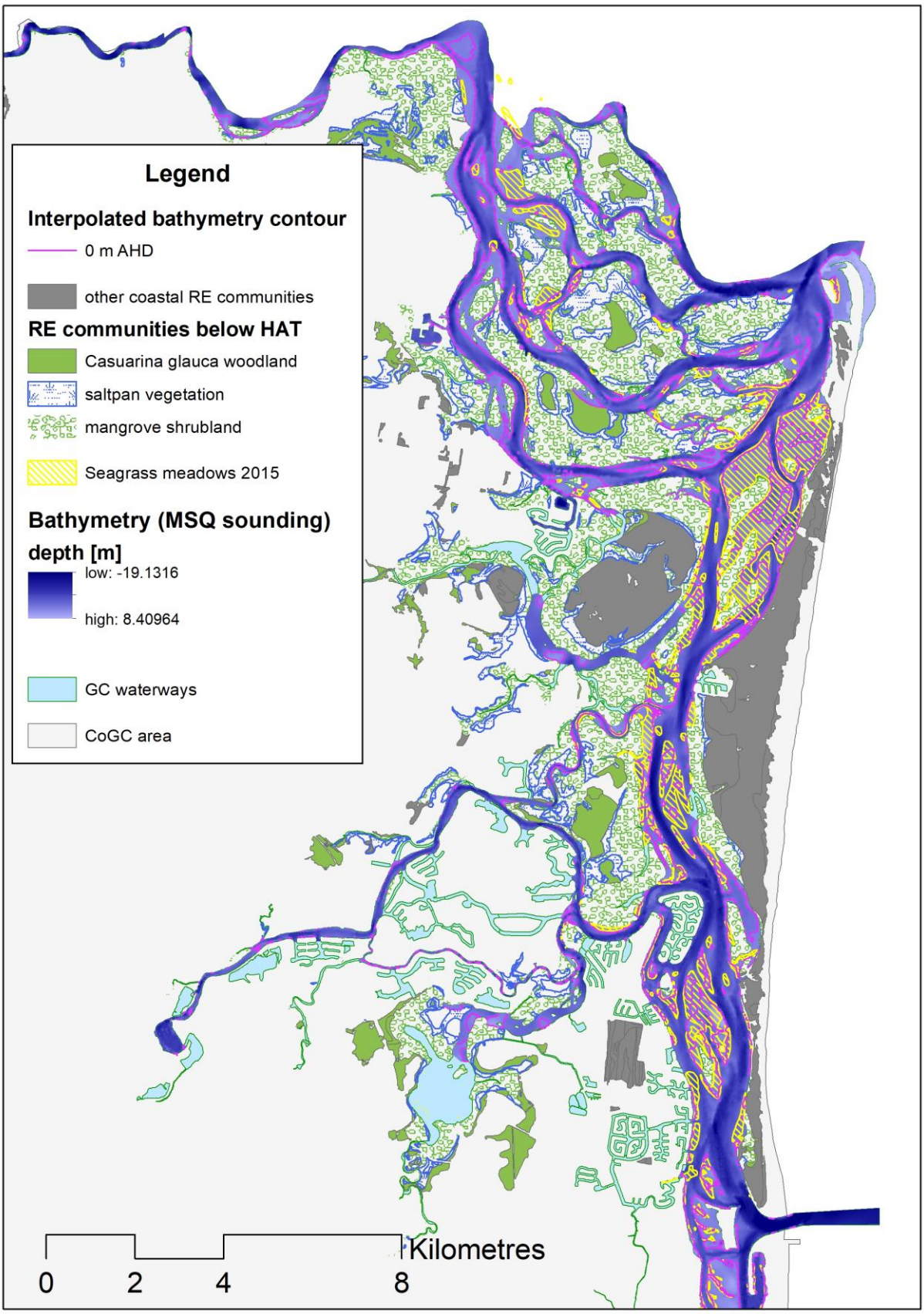

Figure 17: Marine vegetation types within and adjacent to the Gold Coast Broadwater.

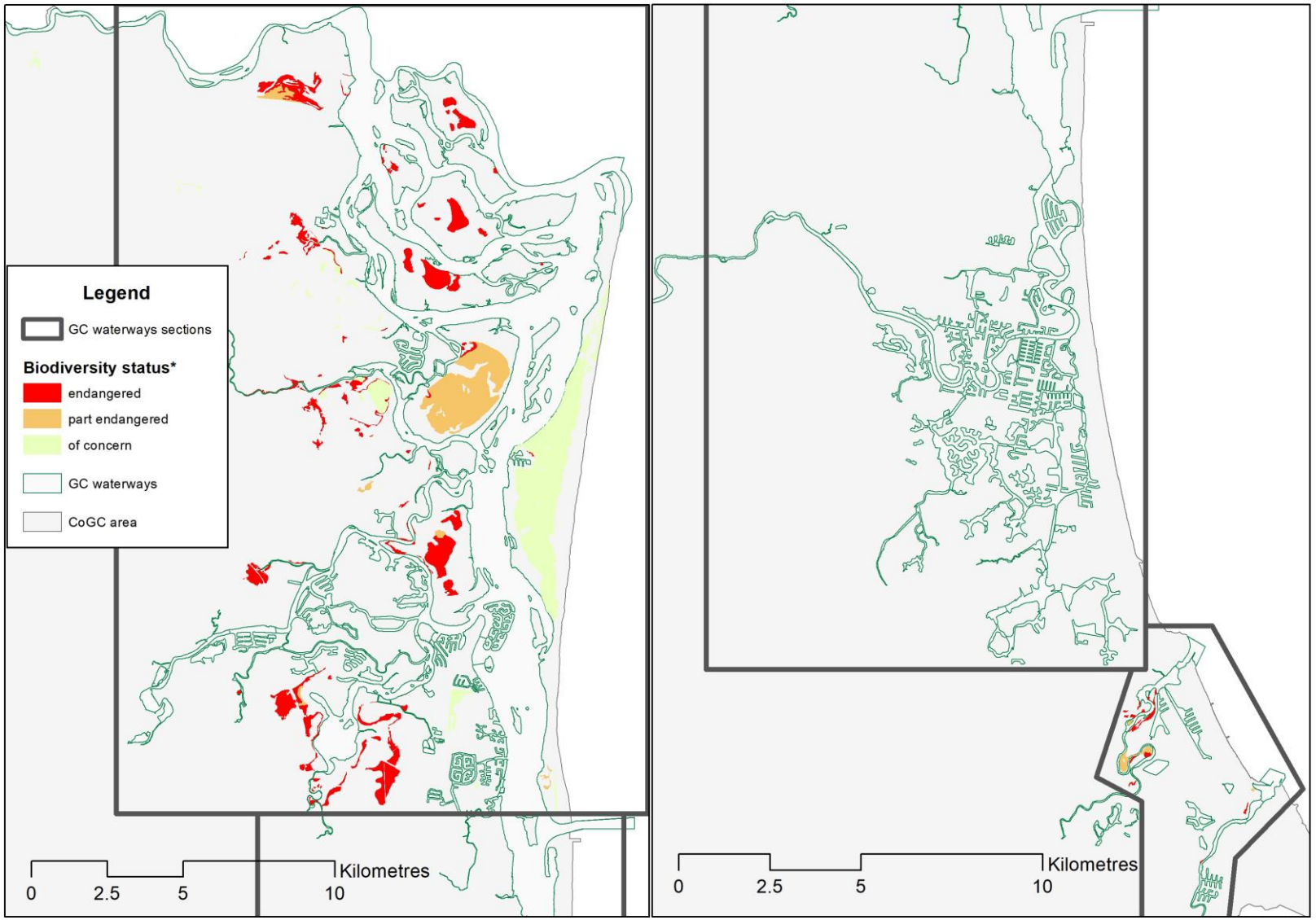

Figure 18: Biodiversity protection status of coastal vegetation communities under the Vegetation Management Act 1999 (Qld).

The absence of any patches with high biodiversity value in the Mid-Section was best highlighted when mapping the biodiversity status of vegetation communities classified in the Regional Ecosystem layer (Figure 17 and Figure 55). With seagrass meadows not included and mangrove patches not of concern, this left the entire Nerang River section without any patches of coastal vegetation of high biodiversity value (Figure 18).

Both the Northern Section and Southern Creek Section of the GC waterways included a number of coastal vegetation communities listed as either 'endangered' or 'of concern' under Queensland's *Vegetation Management Act 1999*. Their current health status was mostly unknown, however, analyses of aerial Light Detection and Ranging (LiDAR) data could be used to compare changes between scans, i.e. in this case about every five years (Arthy and Accad, 2017). This should also reveal shoreline erosion changes resulting from vessel traffic and natural processes (such as flooding, extreme weather events etc).

Spatial data layers from a review by GCWA of shore bird distribution and threats however indicated that at minimum, the area south of Jumpinpin Bar hosts assemblages of shorebirds with the highest species richness and abundance in the entire GC waterways area (Stevens et al. 2017, Figure 19).Though not mapped in this document due to concerns about egg and hatchling poaching, recent surveys of coastal raptor nest sites revealed a major concentration of nests in the mangrove islands between Jumpinpin and Jacob's Well (Thomson pers comm.[14]).

A range of spatial management layers apply to the northern part of the GC waterways and adjacent areas, most importantly the Moreton Bay Marine Park zoning plan, which regulates particularly extractive (trawling, fishing, crabbing, bait collection) uses of the waterways within the Marine Park boundary. It does not, at the present time, regulate vessel use in general, although there are designated go-slow or no-entry areas for the purposes of environmental or cultural heritage protection (Figure 20).

Much of the northern Broadwater, including the sand islands, are designated as Wetlands of International Significance to migratory wading birds, under the internationally recognised RAMSAR agreement. GCWA regulates the use of moorings within established zones on the South Stradbroke Island and mainland shorelines (Figure 20).

[14] Victoria Thomson, Griffith University, nest surveys conducted July 2018.

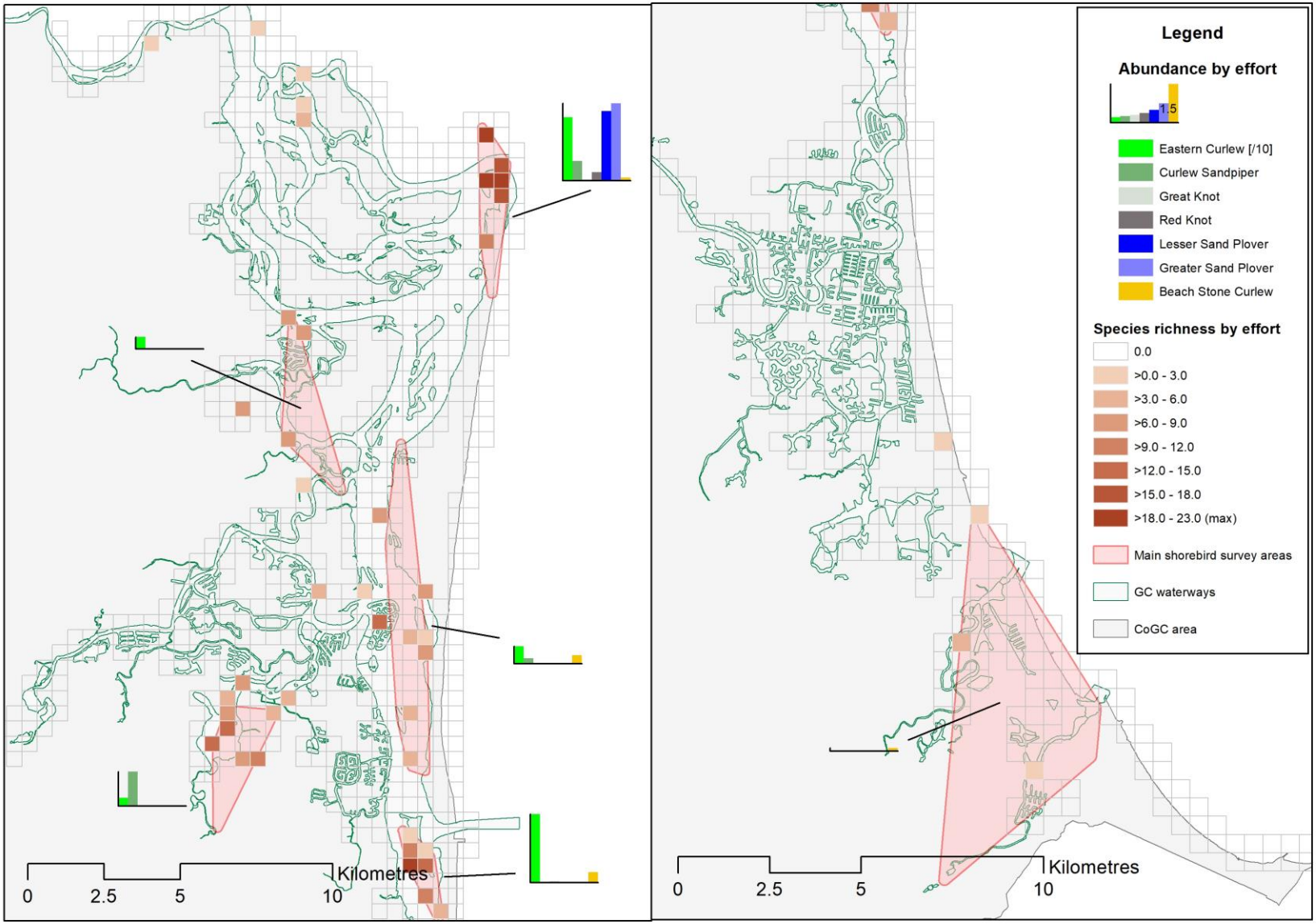

Figure 19: Wading bird species richness from northern (left) and southern (right) parts of the study area (data layers compiled from Stevens et al. 2017).

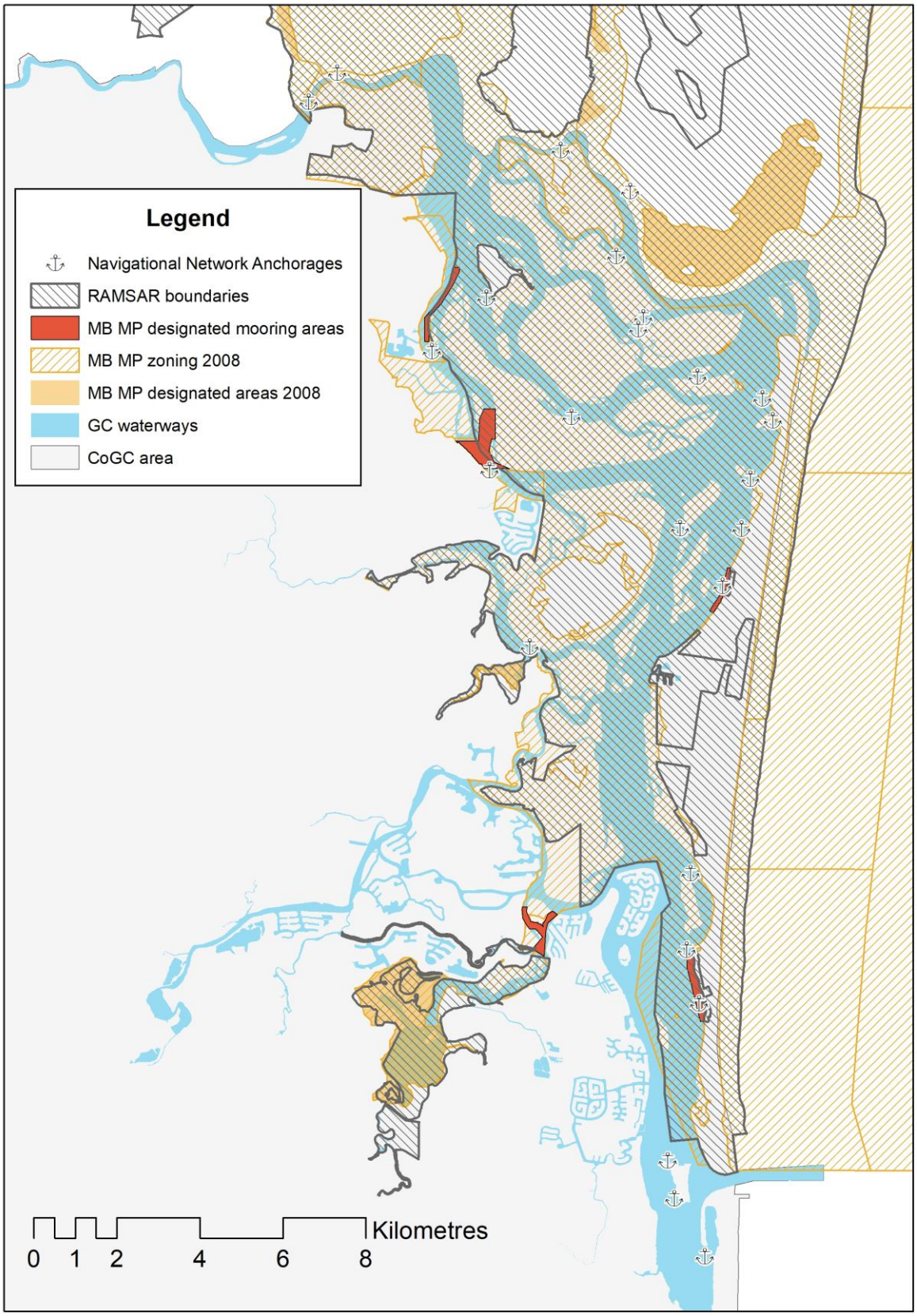

Figure 20: Jurisdictions and Moreton Bay Marine Park and Ramsar wetland area boundaries of the Gold Coast Broadwater.

4.3 Anthropogenic uses of the GC waterways

4.3.1 Restrictions to navigation within the GC waterways

The diverse nature of the GC waterways and surrounding urban development impose varying local limitations as to what type of water craft can be used. Access to most parts of the Nerang River, the Southern Creeks and their canal estates is restricted by the height of road bridges (Figure 21). Most of these limit access to vessels with a height of structures above their waterline of less than four metres. Other sections are completely blocked by barrages or sections of dry land with subsurface culverts. Access to a few canal estates is controlled by locks that can be operated by resident boat owners only with a swipe card or similar device.

These height restrictions exclude vessels with vertically extended fixtures and superstructure, such as sailing yachts and flybridge cruisers, and other large vessels from using upper sections of the area's rivers and creeks and most canal estates.

Vessel movements are further restricted by water depths in areas within road bridges, i.e. the Broadwater and lower sections of the Coomera and Logan Rivers. All watercraft with a draught of more than one metre are confined to using the deeper channels. The dynamic nature of the GC waterways necessitates regular dredging to guarantee minimum safe design depths and safe passage through these channels (GCWA 2017).

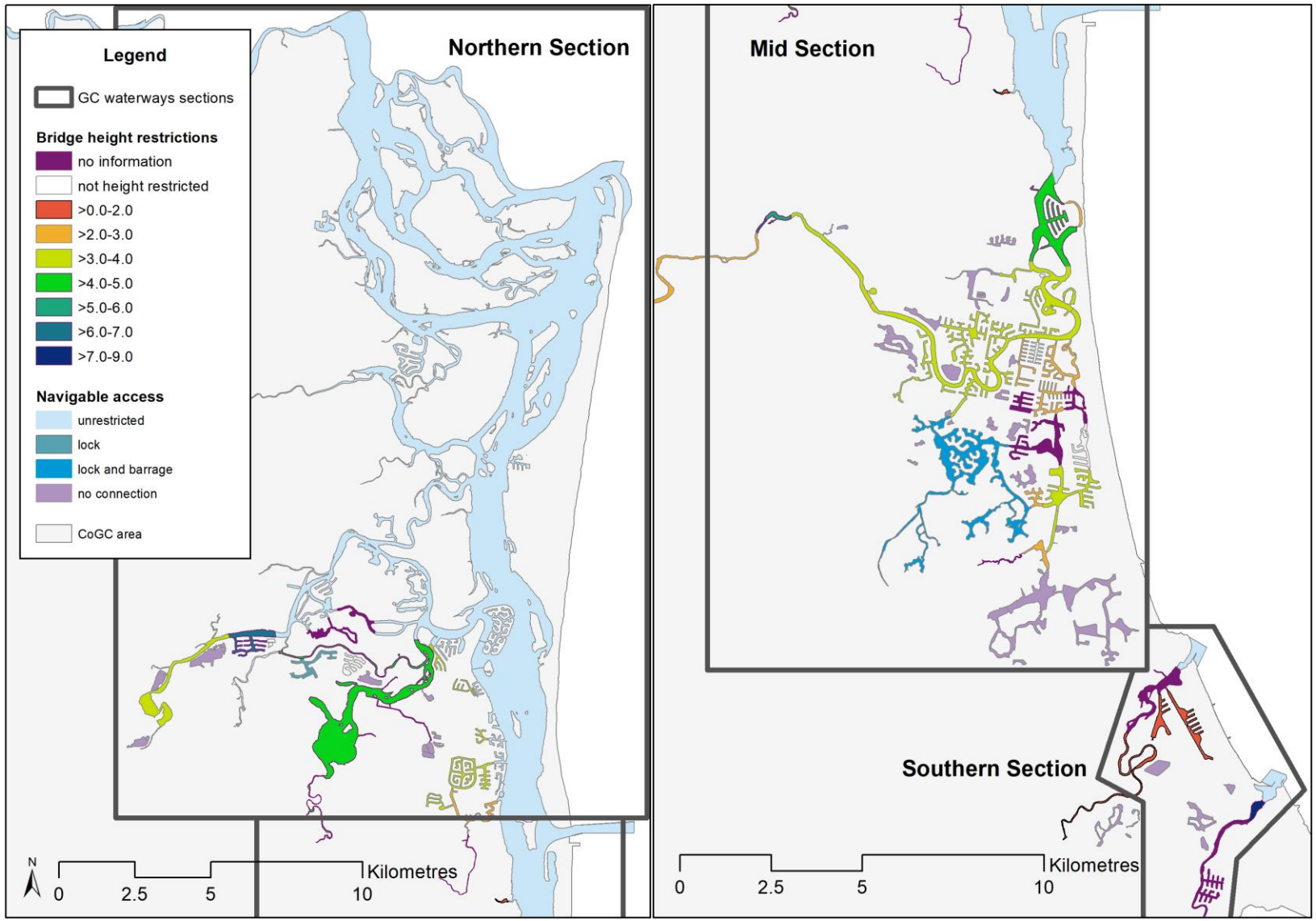

Figure 21: Boating access restrictions within the GC waterways (bridge heights taken from Navionics ChartViewer).

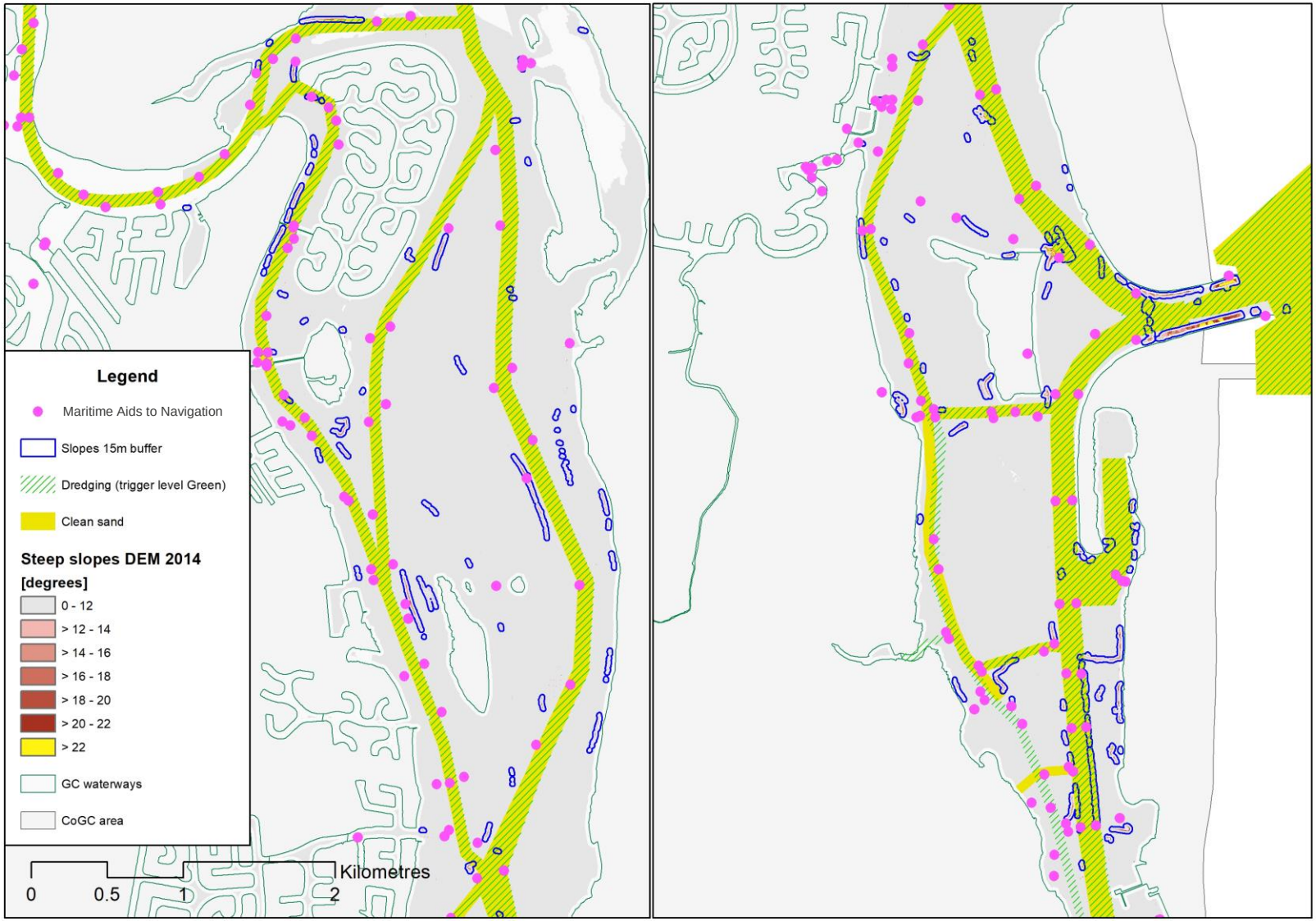

Figure 22: Steep and potentially unstable slopes (> 20 degrees) in the southern section of the Gold Coast Broadwater.

4.3.2 Boating infrastructure provided for users of the GC waterways

Public access to the GC waterways for powered watercraft is provided by a number of public boat ramps with associated facilities such as car and trailer parking spaces and, in some cases, pontoons or even jetties. Further access is provided via non-public boat ramps used by City of Gold Coast (CoGC) staff for maintenance works of canals and artificial lakes (Figure 23). Although much of this data is readily available from CoGC data portal and relevant State Government layers, the number of trailer parking spaces associated with public access was not available and had to be captured from satellite imagery via Google and ESRI global base maps. Taking these and the number of ramps into account clearly indicated that the main access points for trailerable vessels (Figure 23), were located at (from north to south):

- Jacobs Well
- Watersports Lane (Coomera River)
- Muriel Henchman Park
- Broadwater Parklands
- Thrower Drive (Currumbin Creek).

Other ramp access points for trailerable vessels were provided in most marinas, however, using these requires either membership or association with relevant clubs or mooring owners.

Marinas, especially those with slip and vessel maintenance and repair facilities, provided the major access points to the GC waterways for non-trailerable vessels. Those with launching facilities for non-trailerable vessels are highlighted by their name in Figure 24. Other locations with a large number of fixed or floating berthing facilities were developed as part of large residential mixed-use developments. These only represent a fraction of protected berthing facilities for non-trailerable vessels. The vast majority of apartment complexes and waterfront homes along artificial and natural waterways had pontoons or jetties suitable for mooring vessels and non-trailerable vessels, but no single data source was available to capture the number and distribution of these non-commercial vessels.

Non-trailerable vessels could also be moored in one of the area's 13 swing mooring locations managed by the GCWA as outlined in Figure 24 (see also page 20 of the GCWA 'Buoy Mooring Management Strategy: Final August 2017')[15]. Some of these were earmarked for increasing the number of moorings provided, which would further raise the number of larger vessels used in the Northern Section of the GC waterways.

[15] Gold Coast Waterways Authority. Buoy Mooring Management Strategy: Final (August 2017). Available online at: https://gcwa.qld.gov.au/wp-content/uploads/2017/03/BuoyMooringMStrategyFinalAug17.pdf. Last viewed: 04/01/19.

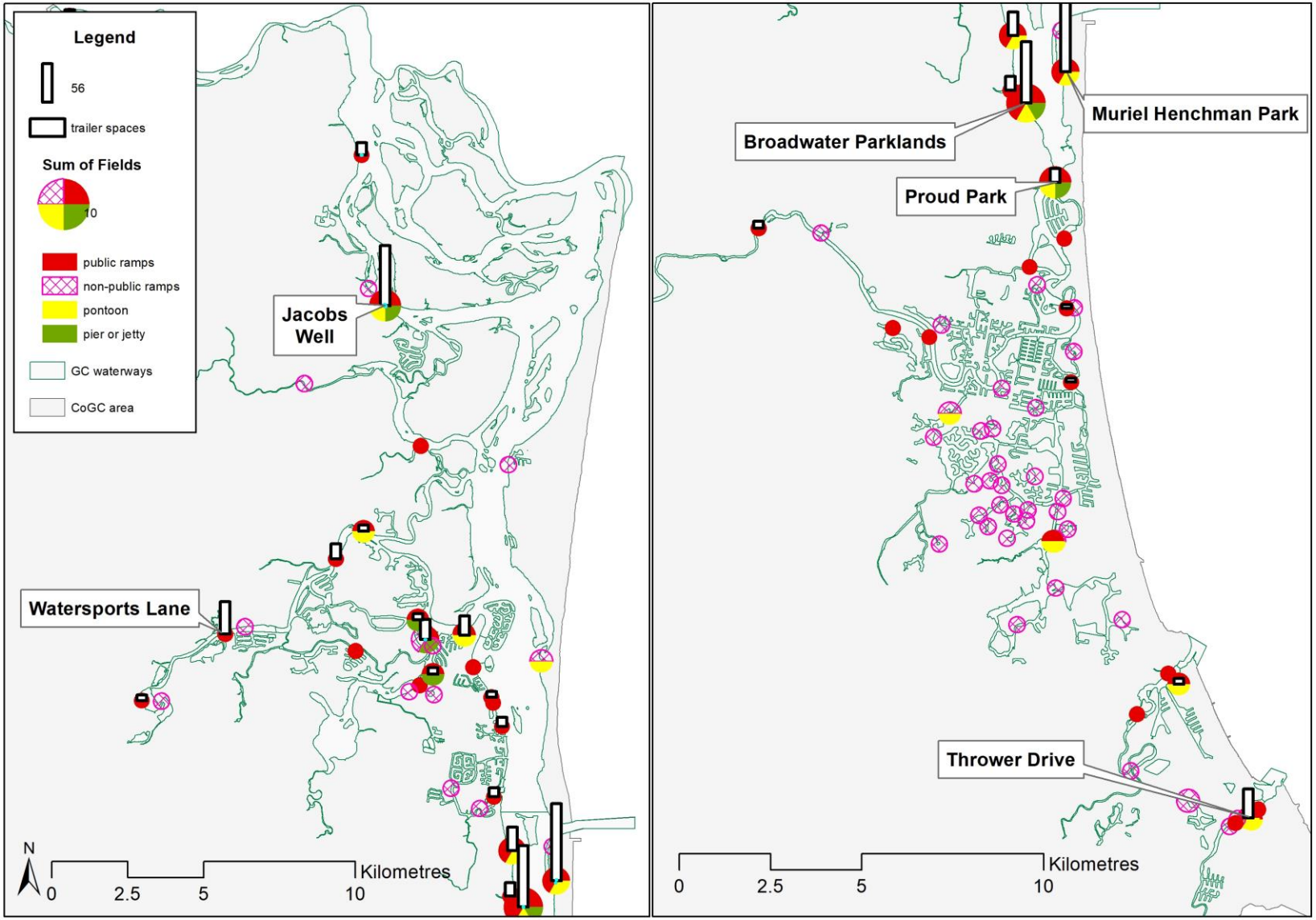

Figure 23: Boating access points to the GC waterways and associated boating infrastructure (boat ramps, pontoons, jetties and trailer parking spaces).

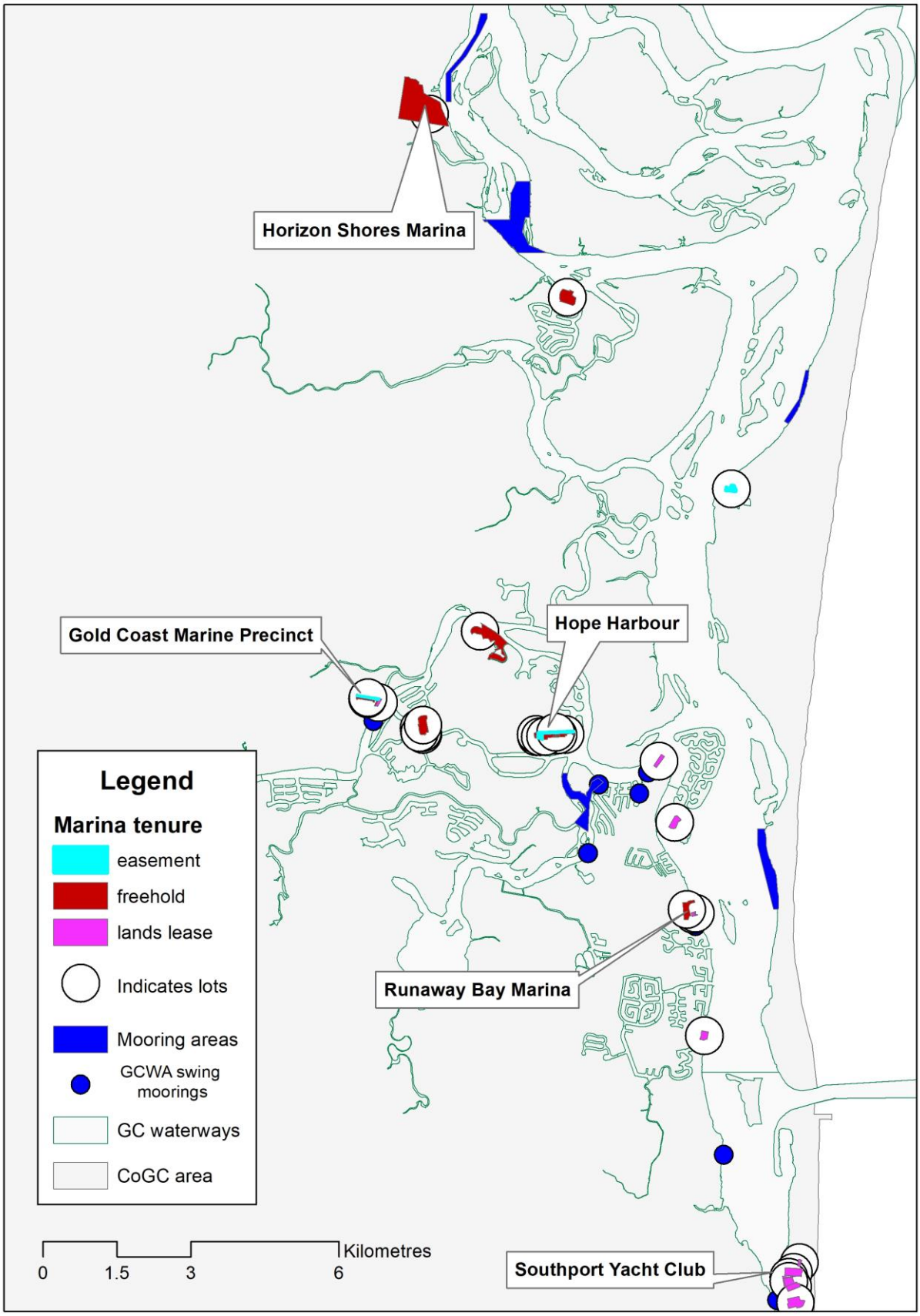

Figure 24: Marinas and swing moorings in GC waterways.

4.3.3 Motorised watercraft - commercial operators

Personal observations of all the members of the research team over more than 20 years (each) suggested that commercial operators would use GC waterways more consistently (at both weekly and seasonal timescales) than recreational users. Almost all commercial operators utilising this area could be classified as either tour operators (including charter boat operators) or commercial fishers. The only other remaining types of commercial activities related to dredging, and sea trials or presentation of vessels offered for sale, notably those produced at the Gold Coast Marine Precinct (see Figure 24 for details). The data relating to commercial tour operators and fishing vessels were collected by a) mapping all advertised tours (and their schedules) from published information, and b) using hourly position records of the Automated Identification System (AIS) available from the Australian Maritime Safety Authority (AMSA). To allow some comparisons between the data sets, either point (AIS) or line (tours) data were converted to grid data with a 100 m cell size (one hectare) using the kernel interpolation with barriers tool in ArcGIS 10.4 (ESRI) with a 110 m search radius. The resulting grid data were then overlaid with the boundaries of the GC waterways layer compiled for this report as described in Section 4.1.2. Zero values were given the same colour as the background CoGC area, which indicated the limits of the kernel density grid where this extended beyond the GC shoreline.

4.3.3.1 Commercial fishers

AIS data contained attribute information that allowed identification of commercial fishing vessels. Positions of these were extracted and mapped as the density of recorded hourly position per hectare over one year (Figure 25). This clearly indicated that practically all commercial fishing vessels use the GC waterways only for transit between their mooring areas and access points to open ocean waters. This primarily applies to trawler and offshore charter operations. Commercial fishing activities with trailerable smaller vessels, primarily inshore capture fisheries, are not yet required to carry AIS devices, and hence are unlikely to be captured by this approach (See Gap Analysis, Section 5).

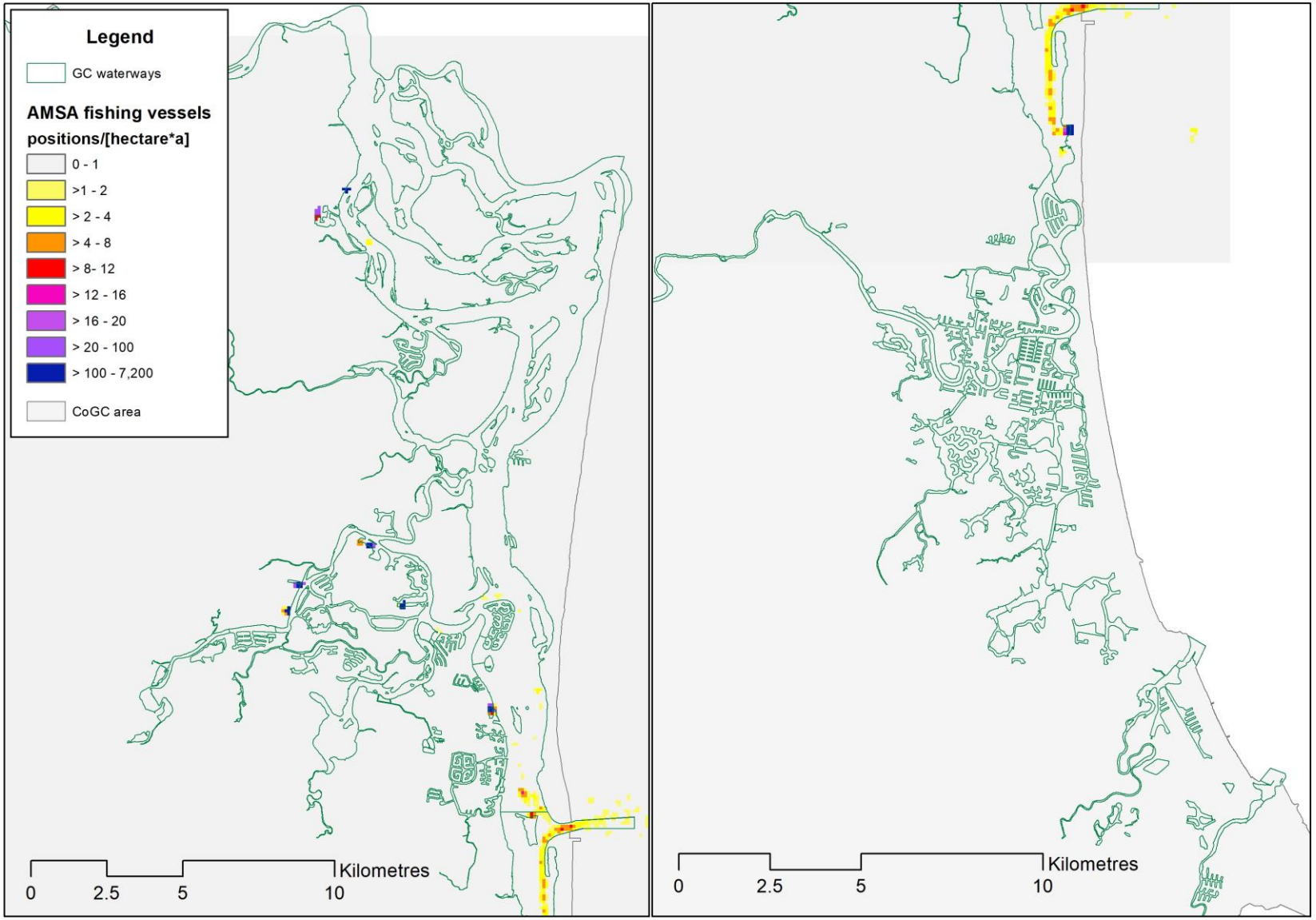

Figure 25: Average position density.yr^{-1}.ha^{-1} for commercial fishing vessels (trawlers and fishing tour operators) within the GC waterways for 2017 based on the AIS data provided by AMSA.

4.3.3.2 Marine tour operators

General use patterns of marine tour operators were developed from mapping the tracks of tours as advertised on operators' websites or hand-outs. Schedules for each type of regular (daily) tour were then used as (attribute) weights for each digitised tour track. The overall number of trips per track was multiplied by a factor of 0.8 to incorporate cancellation due to bad weather or lack of participants. For some operators, these weightings could be compared to video surveillance data collected at boat ramps by CoGC.

The resulting overall usage pattern for fair weather conditions is shown in Figure 26. It indicates highest trip densities in the Seaway and its southern main channel connecting it to the Southport marina precinct and the mooring facilities around Appel Park in Surfers Paradise. Commercial operators seldom use sections of the Nerang River upstream from Appel Park.

Separating tour operators by the frequency of trips per week revealed slight differences in the spatial extent of their use patterns. Regular cruise and day tour operators (≥ three trips/week) launched mostly from moorings around Appel Park or berths at Marina Mirage to either sail through the Gold Coast Seaway into open waters or ran a loop around Wave Break Island. Some continued on, crossing the Deep Hole further into the GC Broadwater, however, no use was shown of any parts of the Northern Section of the GC waterways past Sovereign or Rat Islands.

Another special but also frequent type of commercial tour operations used the GC waterways for short sight-seeing trips in amphibious vehicles. These operators relied on public boat ramps at Muriel Henchman Park and Proud Park (see Figure 23).

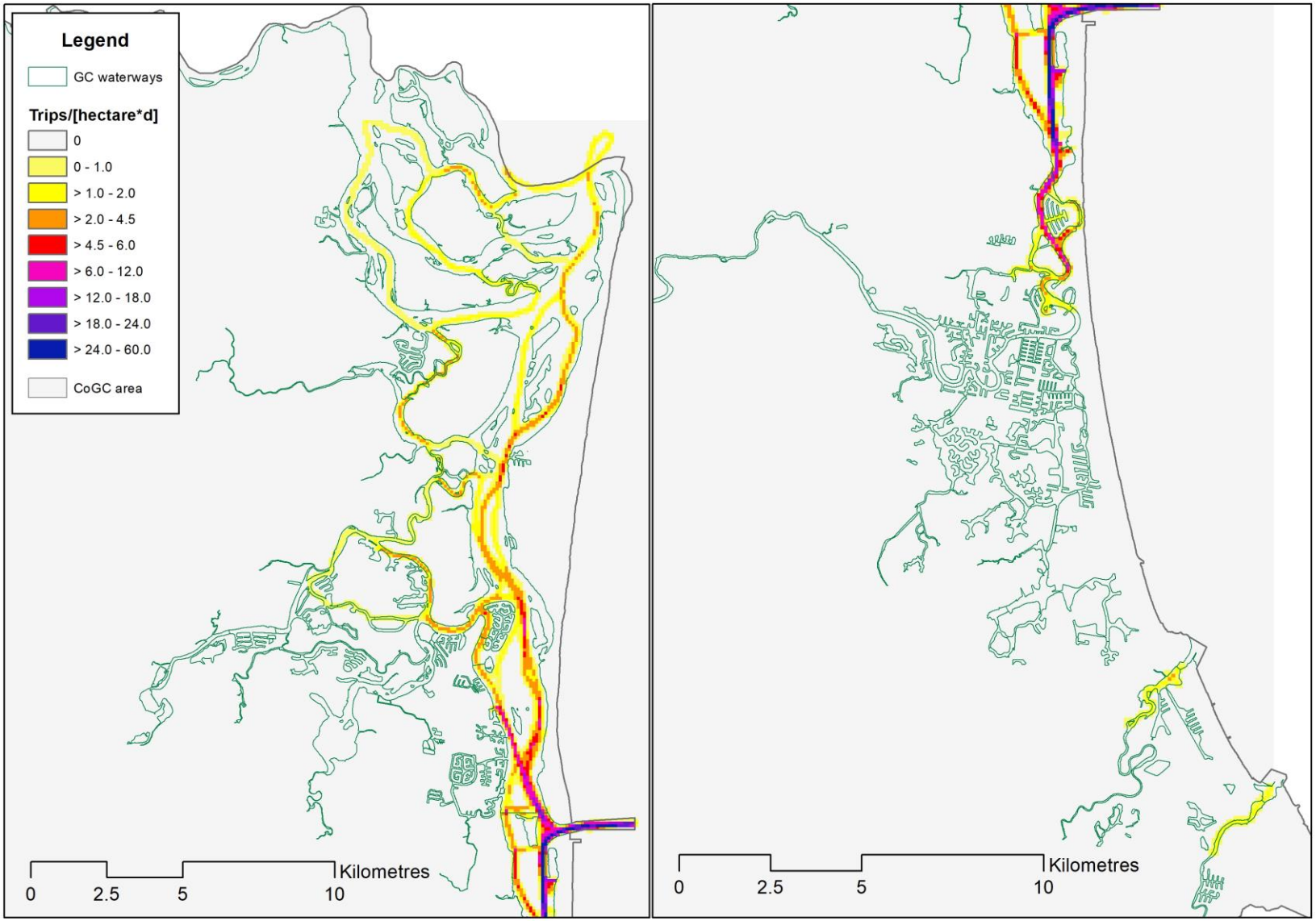

Figure 26: Estimated density of trips.day^{-1}.ha^{-1} for all tour operators during peak season (derived from 80% of all vessels, on all publicised routes in operation) within the GC waterways.

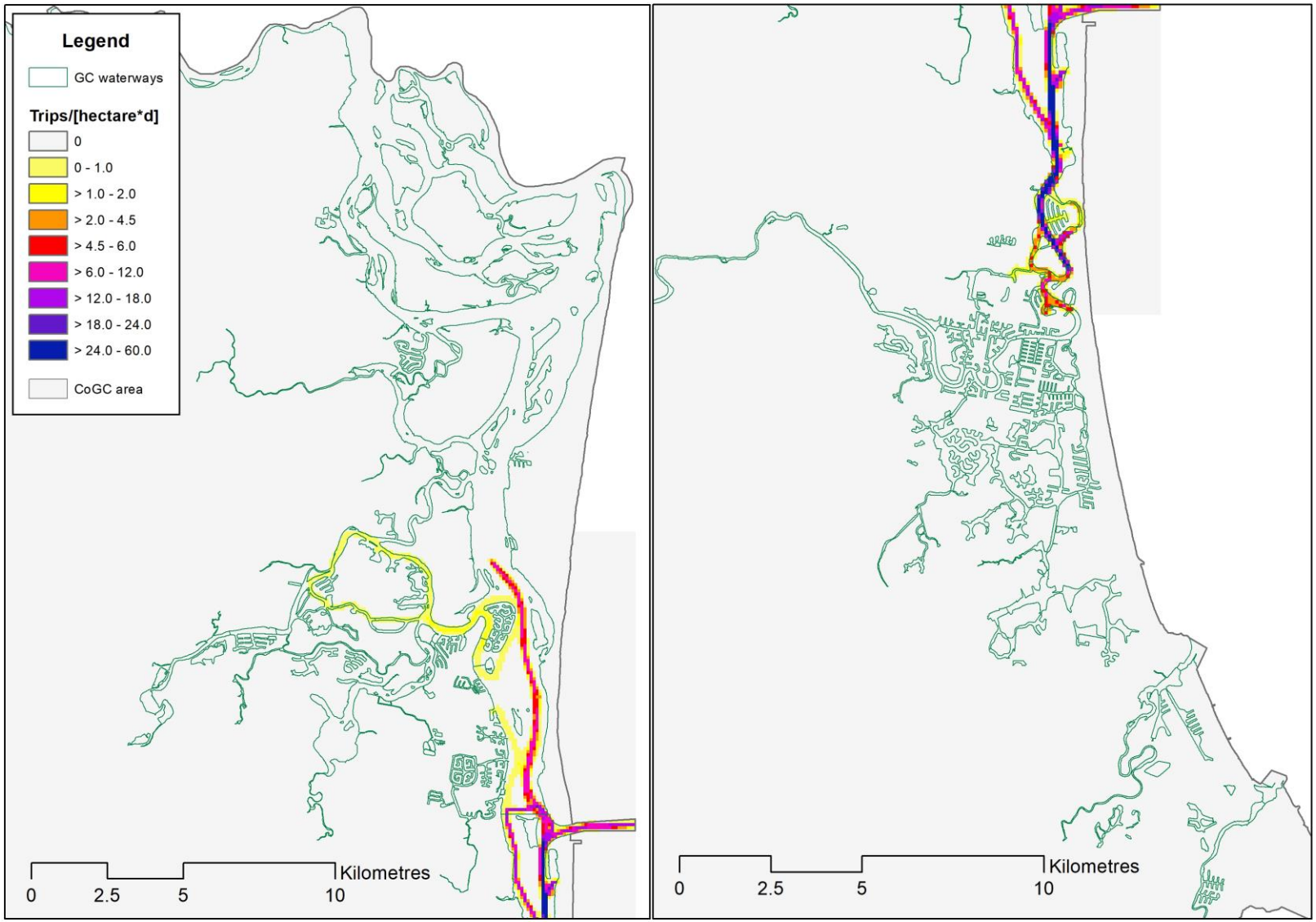

Figure 27: Estimated density of trips.day^{-1}.ha^{-1} by regular cruise and day tour operators within the GC waterways.

The majority of charter boat operators with trips averaging four to five times per week during peak season offered special fishing trips. Their most popular launch sites were the same as for amphibious vehicles, however instead of touring the GC canals and southern Broadwater, many used the Seaway to access open waters (Figure 28).

Some smaller operators included trips in Tallebudgera Creek and Hinze Dam, the latter being excluded from this study.

Practically all regular cruises and days tours as well as most fishing charters used vessels skippered by qualified staff of relevant tour companies. A few operators offered guided self-drive tours on PWCs. Depending on the hire period, these guided tours explored most parts of the GC waterways north of the Seaway (Figure 29). The launching points for these tours were all located along the western side of The Spit, from Marina Mirage to Muriel Henchman park. Accordingly, all operators used the main channel to navigate past Wave Break Island, which generated the highest trip density of up to 4.5 trips.day^{-1}.ha^{-1} for this area.

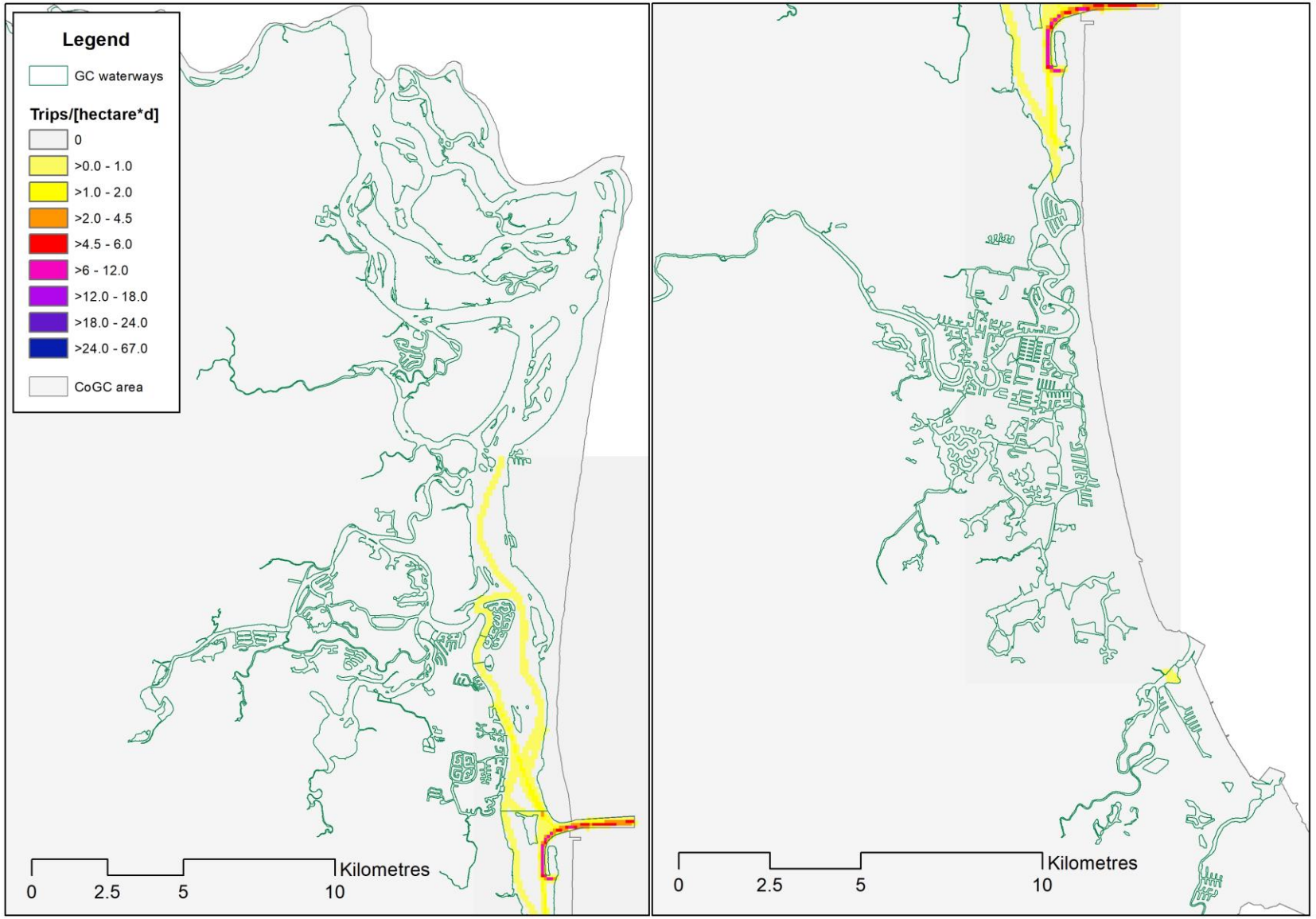

Figure 28: Estimated density of trips.day^{-1}.ha^{-1} by charter operators (4 to 5 days per week) within the GC *waterways.*

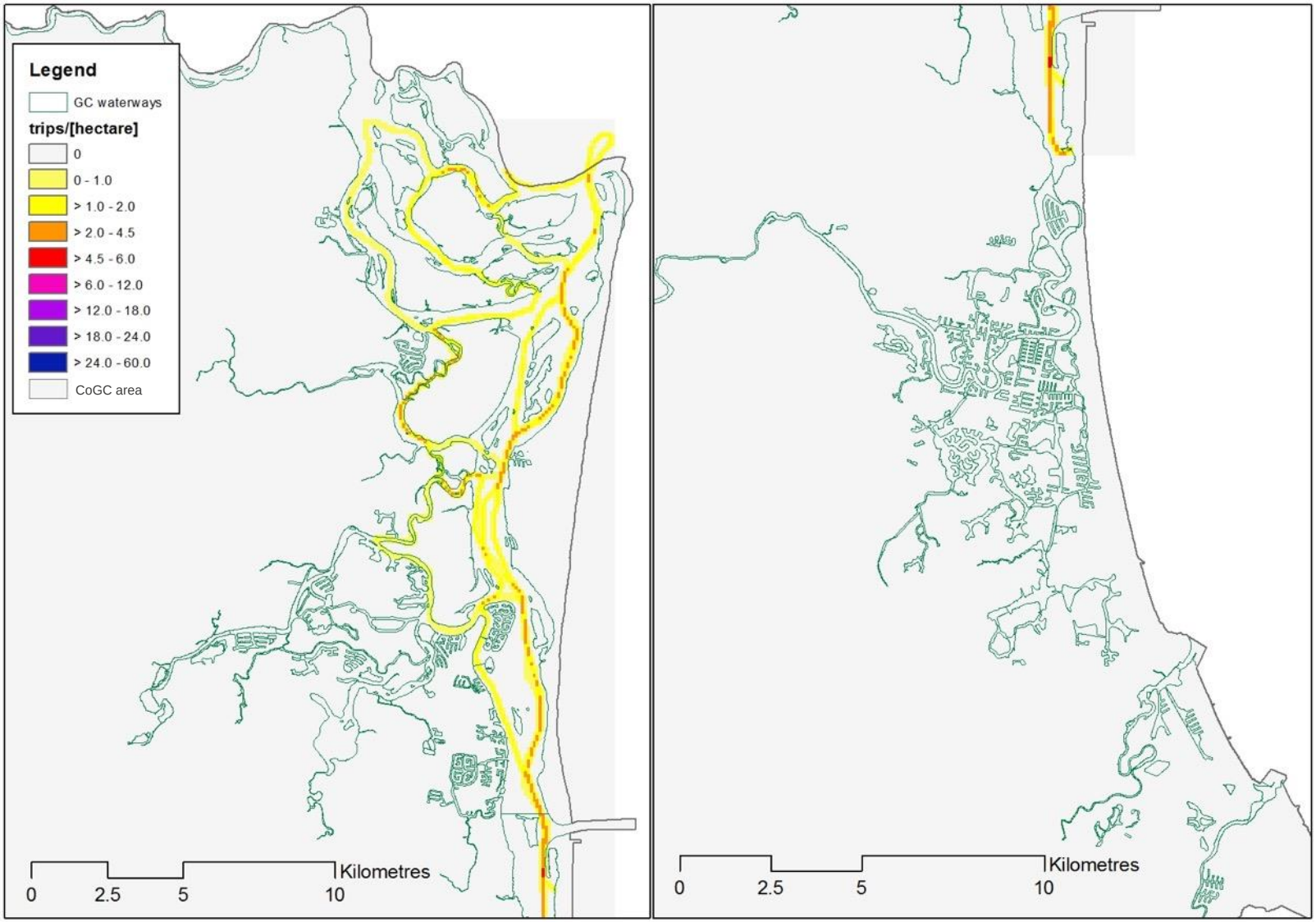

Figure 29: Estimated density of trips.day^{-1}.ha^{-1} by commercial operators with small motorised craft (predominantly PWCs) within the GC waterways.

4.3.4 Motorised watercraft - recreational vessels

All owners of motorised watercraft with an engine producing 3kW (4hp) or more used for recreational purposes are required to register their vessels individually or, in some cases, as a tender of a larger vessel. Extracting these registration data by owner address location allowed calculation of growth rates in relevant vessel classes for a particular area of interest. Figure 30 provides a snapshot at the end of each financial year for vessel registrations by overall length, where owners had their principal residence in the CoGC area for the period of June 2008 to February 2018 (the most recent date of data extraction).

Data for the first two years may have been affected by changes to local government boundaries under the *Local Government (Reform Implementation) Act* 2007 (Qld). As a result, the City of Gold Coast lost some of its northern area and population to Logan City Council. The period of stagnant growth between 2009 and 2013 coincided with the fallout and recovery from the Global Financial Crisis in 2007 and 2008. Despite these two major events, the number of registered recreational craft grew by 6,151 vessels from 25,868 in 2008 to 32,019 in 2018, an increase of 23.7% over ten years. Over the same period, recreational vessel registrations grew only by 17.4% in the remainder of Queensland.

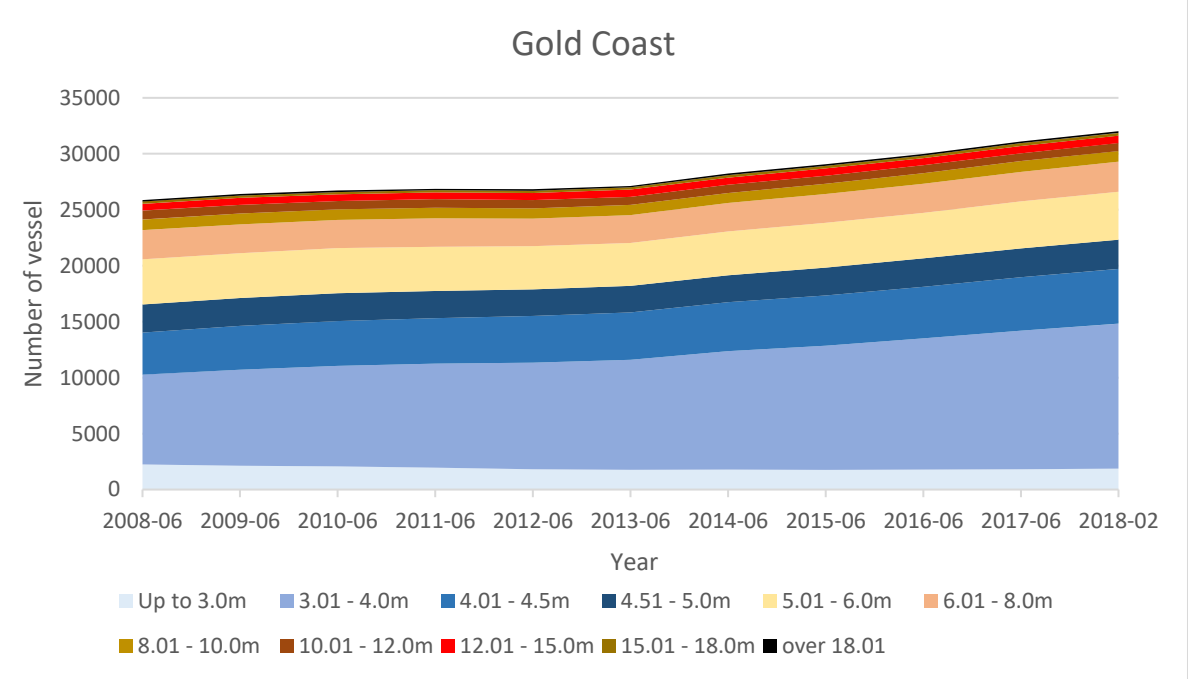

Figure 30: Recreational vessel registrations by length, overall for the Gold Coast City LGA area in June for years 2008-2018 (NOTE: figures for 2018 were captured for the period up until February only).

The overall and average growth rates varied considerably between different vessel classes. Consistently positive growth rates were observed for vessels in the 3.01 m to 4.00 m and 4.01 m to 4.50 m trailerable watercraft classes (Figure 31a, below). Negative growth was recorded for vessels less than 3.00 m in length and those between 10.01 m and 12.00 m in length while increases in the numbers of vessels between 4.51 m and 10.00 m were negligible.

This was in clear contrast to growth rates recorded for the rest of Queensland where the number of vessel registrations grew across all categories from 3.01 m to 8.00 m in length (Figure 31(b)). By February 2018, registrations in the 3.01 m to 4.00 m class, which includes most personal watercraft (PWC) or jet skis, comprised 13.4% of all vessels owned by residents on the Gold Coast. For the rest of Queensland registrations in this class only represented 12.3% of all recreational vessels. Overall this suggests that preferences for PWCs might have been a major factor for the accelerated growth in recreational vessels in the CoGC area.

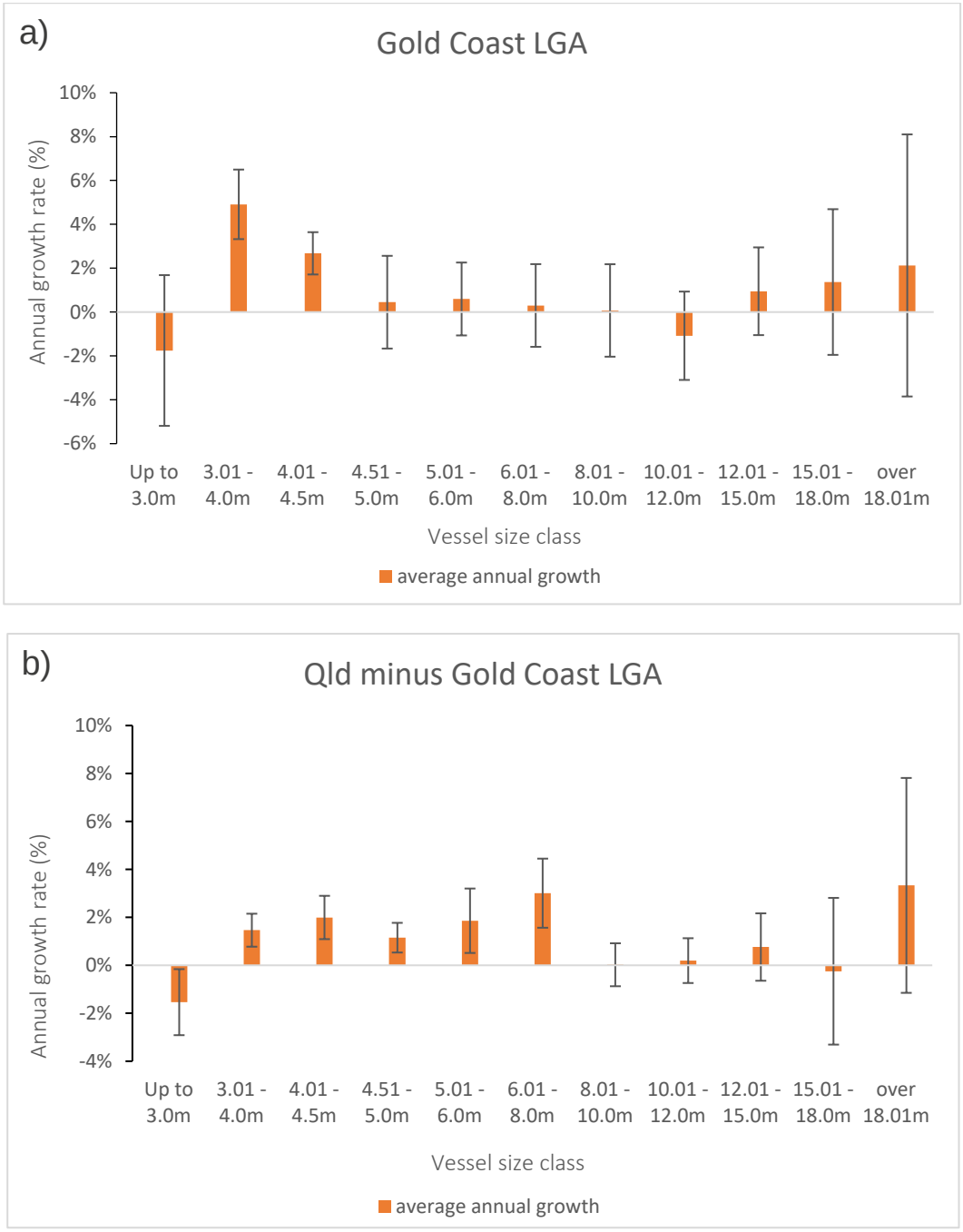

Figure 31: Average annual growth rates for recreational vessel registrations for the period 2008-2018 by length overall for (a) the Gold Coast Local Government Area (LGA) and (b) the remainder of Queensland less the Gold Coast LGA figures shown in (a).

Much of the growth in recreational vessel registrations would have been the result of a continuously growing resident population. Over a similar period, i.e. between 2007 and 2017, the estimated population within the CoGC boundaries increased from 466,940 to 592,330, or by 26.8%. Comparing annual growth rates (Figure 32) showed a lower figure for much of the 2010 to 2014 period, which coincided with a slower increase in recreational vessel registrations.

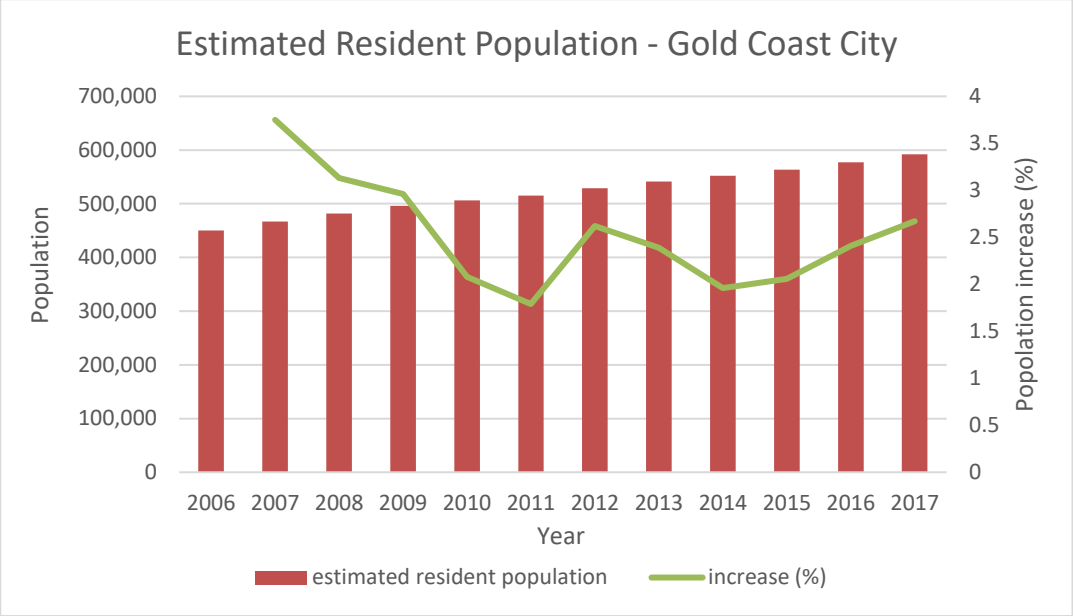

Figure 32: Estimated resident population and annual population growth rates within the City of Gold Coast area (2006-2017). Source: https://profile.id.com.au/gold-coast/population-estimate, last viewed 28/11/18.

A direct comparison of annual growth rates for GC residents (per calendar year) and recreational vessel registrations (per financial year) revealed a noticeably close but non-significant relationship for the 4.01 m to 4.50 m length of vessels, but not for the 3.01 m to 4.00 m length containing most PWCs (Figure 33). More importantly though, the regression line for population growth and both vessel classes revealed a positive incline. That is, vessel registrations grew faster than the local resident population.

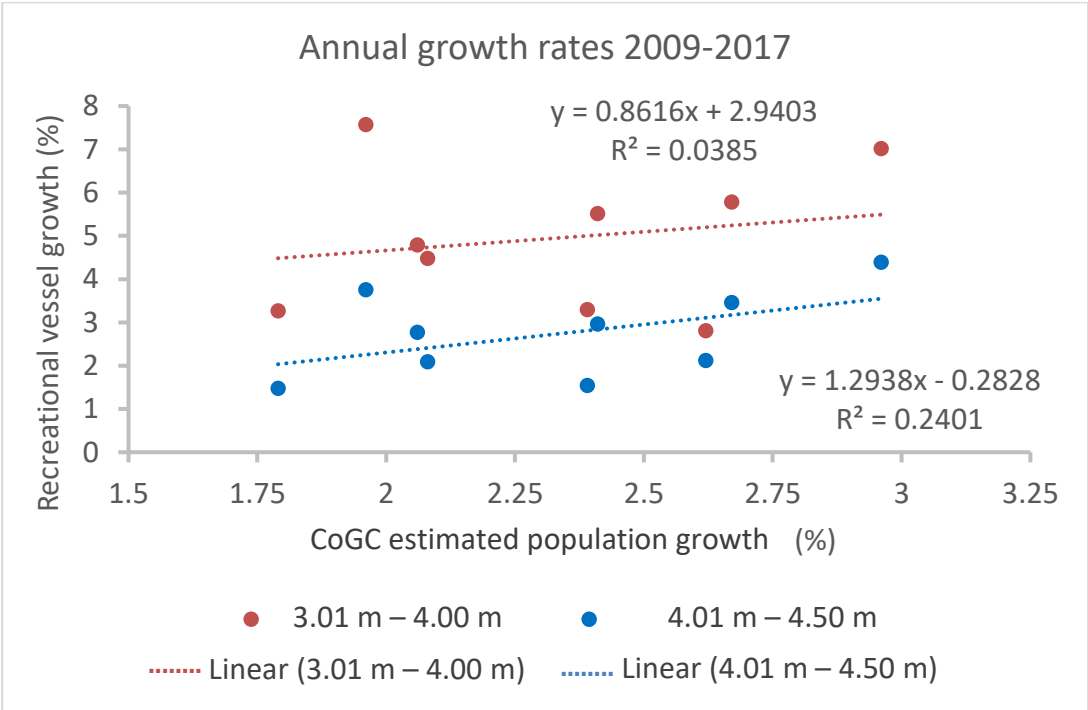

Figure 33: Comparison of annual growth rates between the two smallest classes of recreational vessel registrations (3.01 m-4.00 m and 4.01 m-4.50 m in length overall categories), compared to underlying population growth for the City of Gold Coast.

A possible explanation of such high growth rates might be found with a change in building densities and design of new residential estates within the CoGC area. Much of the urban renewal in existing residential areas involves multi-ownership complexes with only limited space for storing motorised watercraft. This may not always be due to the lack of an extra car parking space. It may also be the result of restricted ceiling heights or general space constraints for manoeuvring wide boat trailers in underground parking areas, which in turn may encourage the purchase of a much smaller PWC rather than a tinnie or small cabin cruiser. To some extent this advantage applies to towing a vessel in general: trailers for PWCs are about as wide as their towing vehicle and can be easily parked in a double lock-up garage. Many modern housing estates leave little space for building an extra shed for a boat or leaving the vessel and trailer on the front lawn. Such changes in urban design and its ramifications for choosing a motorised vessel certainly warrant further investigation, including possible consequences for resident perceptions about the use of local waterways.

For trailerable watercraft there were no readily available data sources that would permit mapping of the patterns of use of the GC waterways. This is a significant omission, since these are by far the numerically dominant form of recreational use of the waterways and warrants a targeted mapping study to fill this important gap (this has been clearly identified and addressed in the gap analysis in Section 5). Analyses are therefore limited to temporal trends in numbers.

4.3.5 Non-motorised watercraft – commercial operators

Visitors to the Gold Coast were also offered a variety of tours using non-powered watercraft such as canoes, kayaks and stand-up paddle boards (SUPs). Mapping the tracks advertised by relevant operators revealed two areas of high intensity uses for short tours: a short stretch of the Nerang River along the eastern side of Chevron Island and the area around the southern and eastern edges of Wave Break Island (Figure 34). Far less frequent longer tours, some with an overnight stay, used waterway areas as far north as Tipplers. Similar low trip densities were identified for the southern creeks.

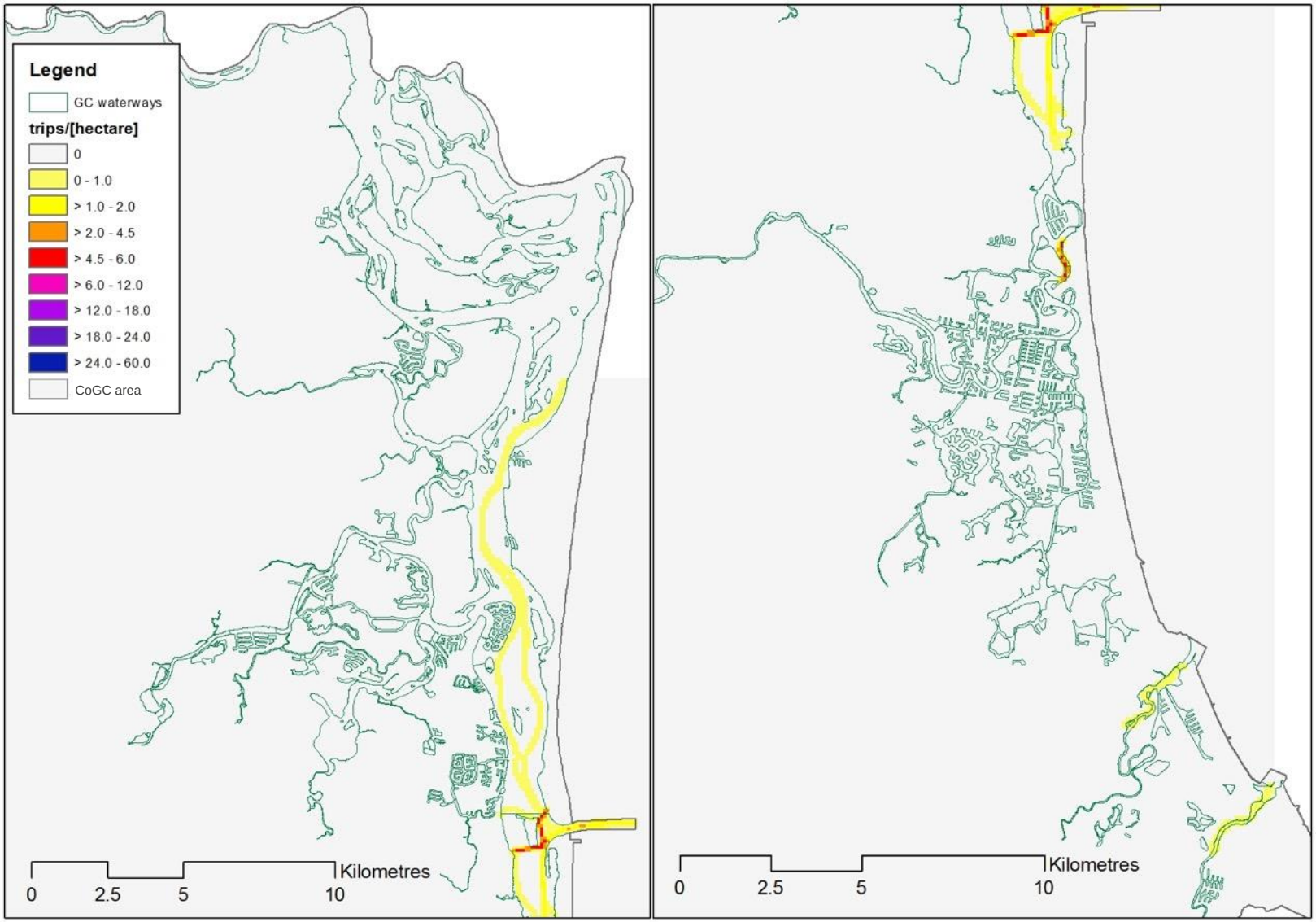

Figure 34: Estimated density of trips.day^{-1}.ha^{-1} by commercial operators with non-powered craft (kayaks, SUPs, sailing catamarans) within the GC waterways.

4.3.6 Non-motorised watercraft - recreational operators

Spatial patterns of waterways used by persons pursuing recreational activities with non-motorised craft or by simply swimming (Figure 35) were extracted from sources including:

- tracks uploaded to MapMyFitness and online heatmaps (STRAVA) compiled from tracks of mobile fitness recording devices such as the Apple Watch, Fitbit Versa, etc.
- water sport club websites and information provided by club representatives
- school sport coordinators

The MapMyFitness dataset takes the form of georeferenced tracks (individual points in space linked by vectors) tagged with date, time, and limited information about the activity undertaken. In practise, this dataset was of limited utility, since it is limited to mostly Apple devices only and had limited uptake. The dataset available was up to 2015 and was used to produce density plots (trips.ha^{-1}.day^{-1}, Figure 35) in the same manner as the preceding plots of vessel use. After 2015, the STRAVA multi-device platform became more popular. At the time of writing, source data for the STRAVA platform is not available, but a rasterised 'heatmap' image, (i.e. density of use per unit area) was provided and used for subsequent analyses (e.g. Figure 38).

The extent of overlapping areas of recreational activities was analysed by using information from representatives and websites of relevant clubs and coordinators of high school sports activities. All spatial details were incorporated into identifying the stretches, sections or spots of GC waterways used for each type of water sport. This was then digitised using the GC waterways layer compiled for this study together with relevant landmarks identified on Google satellite imagery (Figure 36, Figure 37).

The area with the highest number of overlapping club and school activities was identified as the section of waterways around and to the south of Wave Break Island. This was mostly caused by outrigger and sailing clubs navigating through this area to get to their actual regatta or training sites, which were either in open ocean waters ('sailing' and to a lesser extent 'outrigger canoes') or further north up to Couran Cove ('sailing').

Rowing was a non-motorised water sport activity that allowed some further quantification of waterway usage. Most rowers train for competitions and require calm water conditions, and most use is related to training activities managed by high schools and clubs. Part of this tight link to school and club activities was thought to be the result of rowing boats being owned by these entities rather than private owners, especially for boats carrying two or more rowers. Another argument is the difficulty of transporting modern rowing vessels. Even a single-person racing rowing boat (a 'shell') may be over 8 m long, enough to generate unsafe overhang when carried on the roof rack of a private car. Most vessels are therefore stored in sheds and transported on large trailers that can carry up to ten boats.

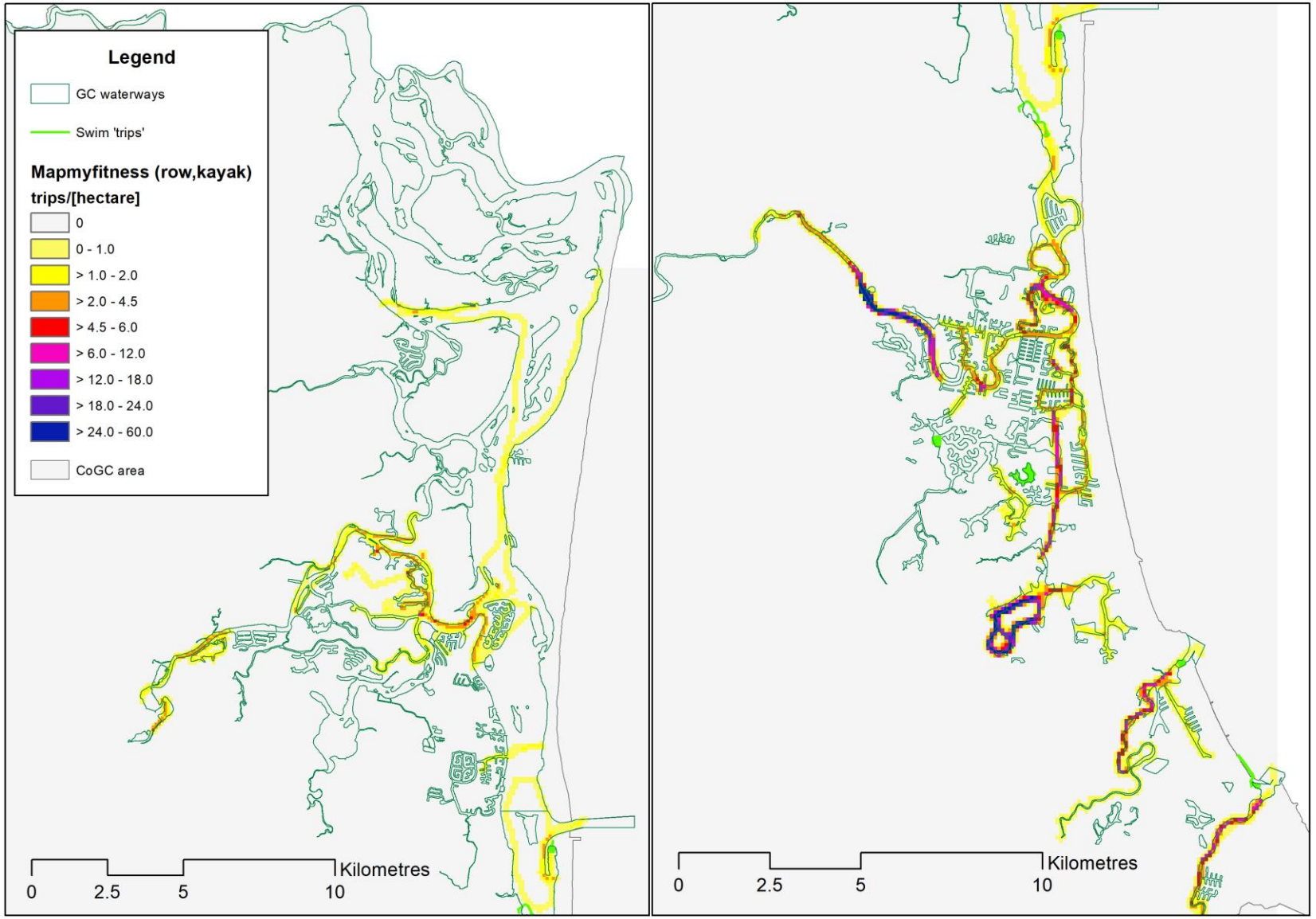

Figure 35: MapMyFitness data (kayak, rowing boats, swimmers) within the Northern (left) and Mid and Southern (right) sections of the GC waterways.

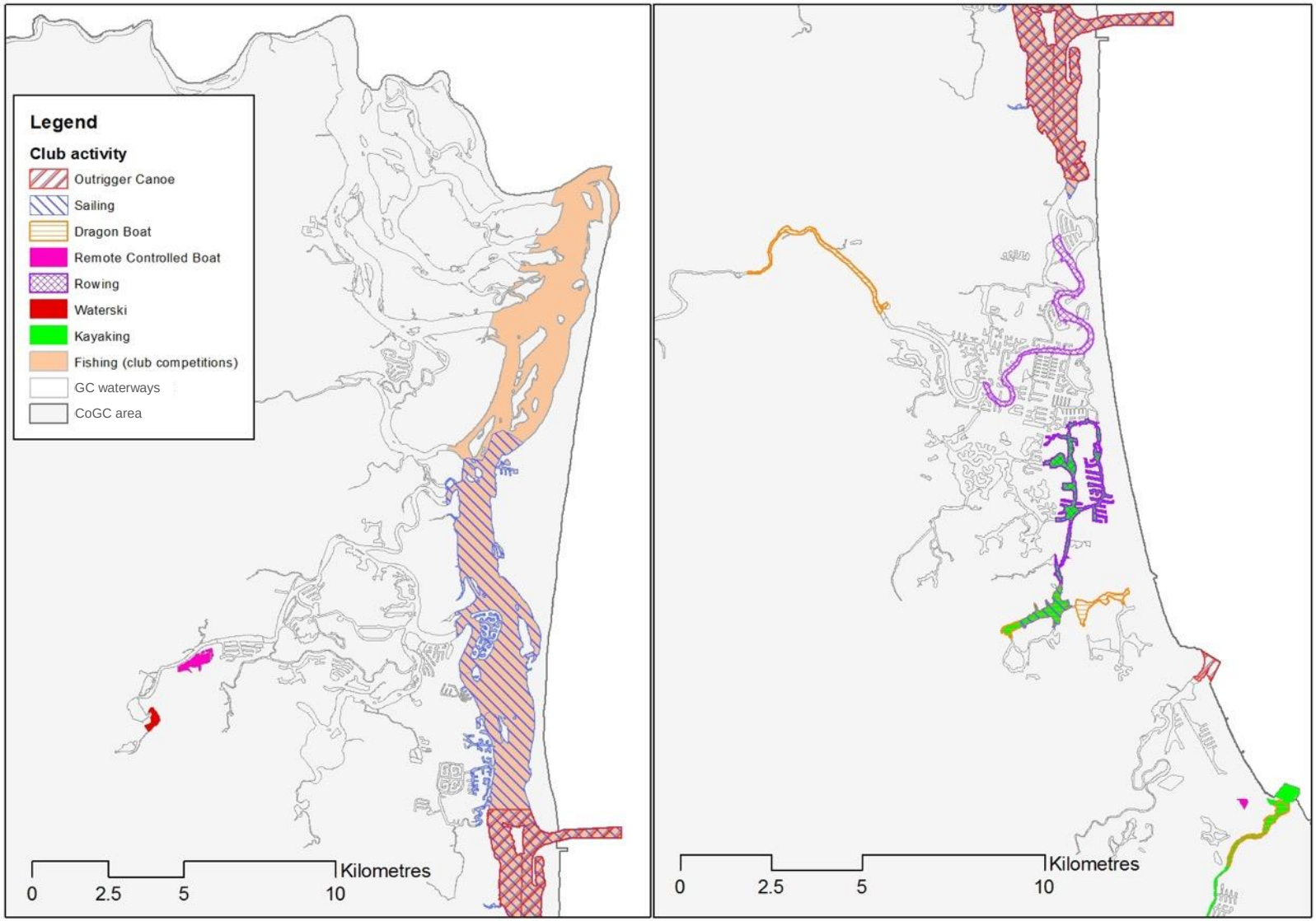

Figure 36: Use of GC waterways by water sports clubs shown by their various areas of interest within the Northern (left) and Mid and Southern (right) sections.

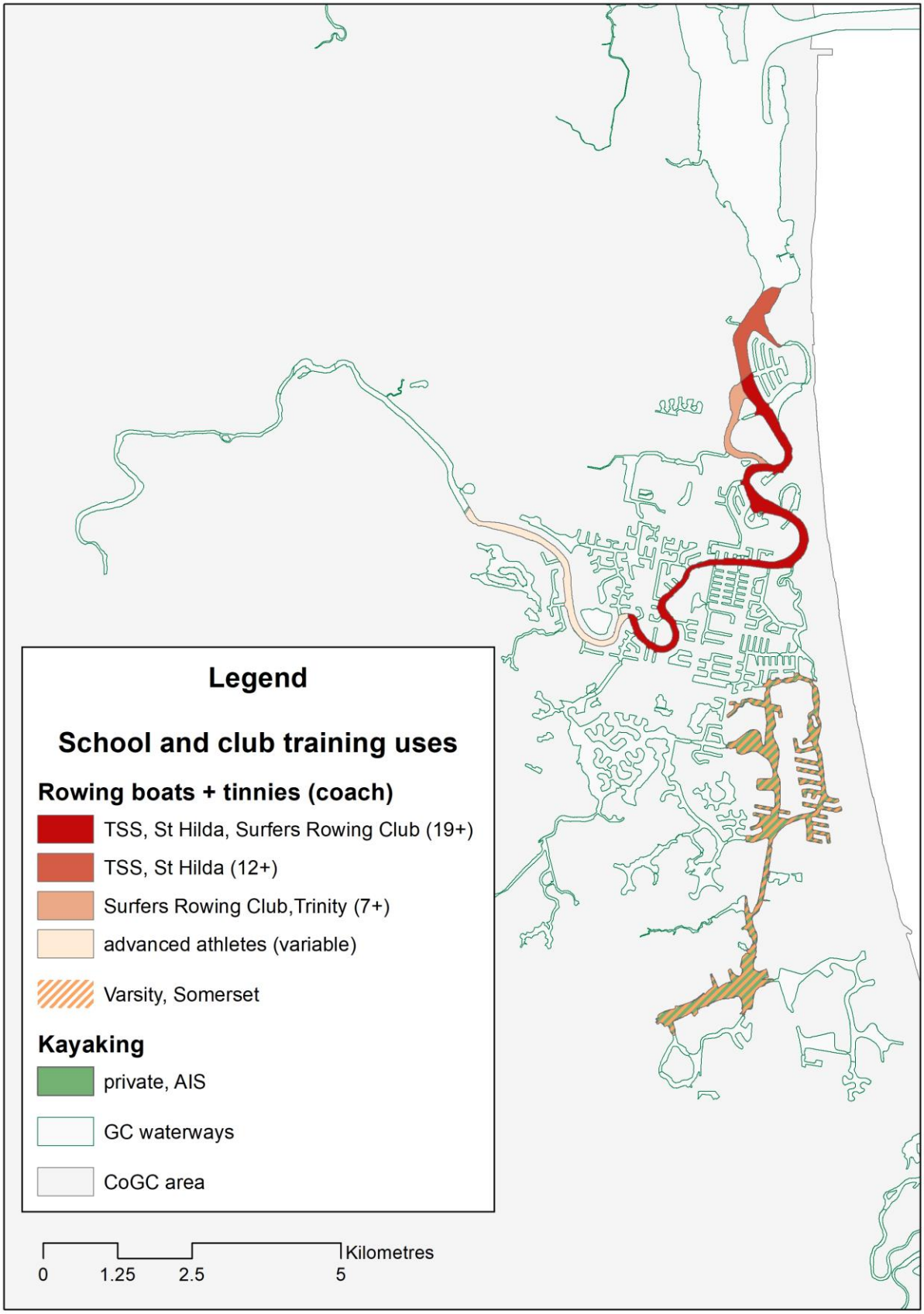

Figure 37: Use of GC waterways by rowers from local high schools and clubs (Mid-Section only shown).

Rowing boats are also the type of craft most sensitive to rough water conditions. To avoid these, most rowing training sessions occur in the early mornings, from about 5:30 am to 8:00 am at the latest. The number of boats on the water is also largely restricted to the number of tinnies used by coaches. By incorporating this information, the use of the Nerang River and Varsity Lakes by rowers during morning hours is summarised in Figure 37.

Quite a similar pattern was highlighted by a heat map of water sport activities published by STRAVA (Figure 38 and Figure 39), a more recent multi-device internet platform for uploading training tracks captured by mobile fitness devices to compare results with those achieved by other athletes. The Nerang River between The Southport School (TSS) main campus and the kink east of Clear Island Lake was labelled with the highest use intensity. Other hotspots on the heat map included the mouth of Currumbin Creek, the sections of Tallebudgera Creek east and west of the GC Highway bridge, the waterways just south of Crab Island and a number of lakes without any open water connection to the rest of the GC waterways (e.g. Evandale Lake).

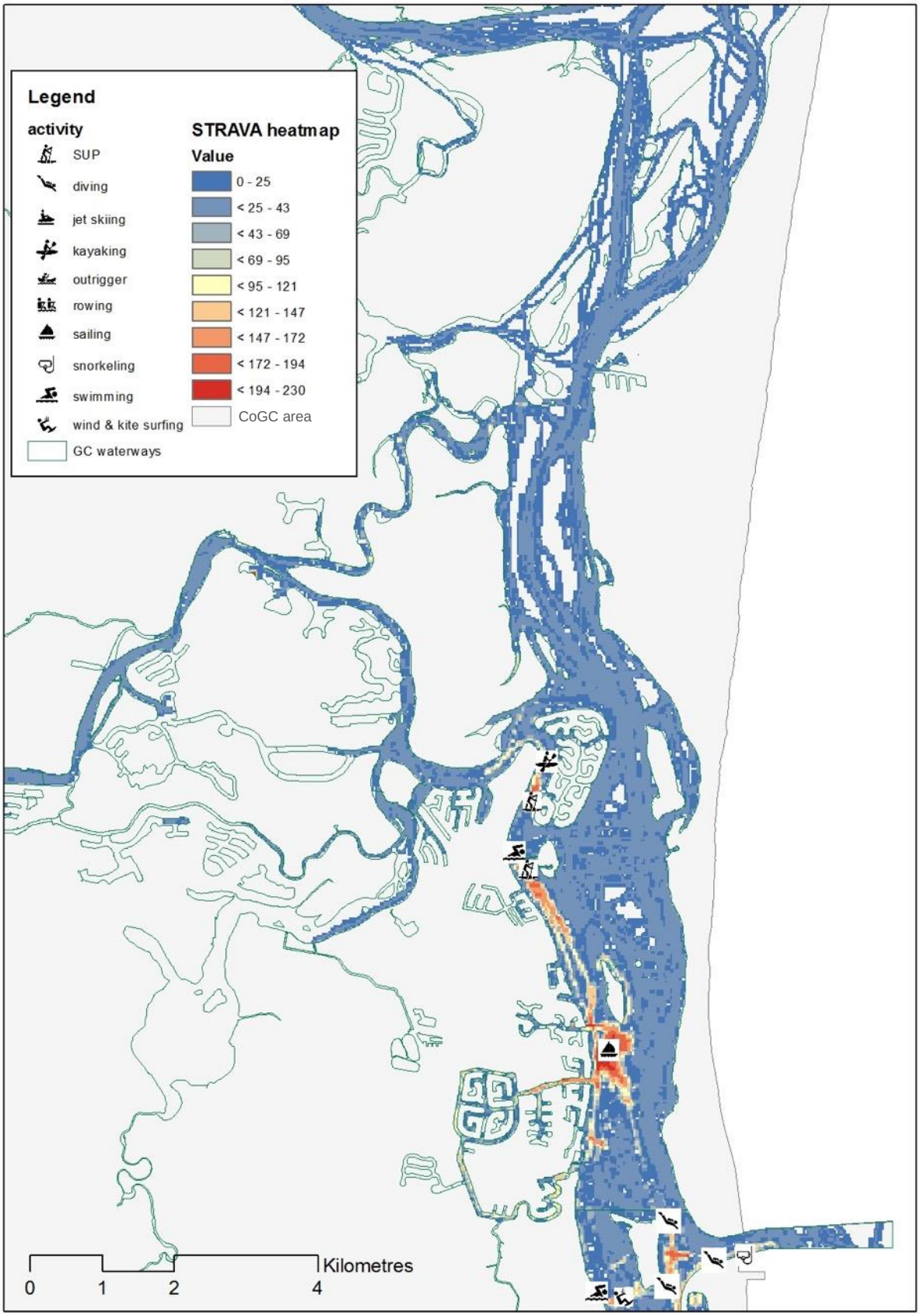

Figure 38: STRAVA heatmap of all available types of water-based sport activities occurring in the Northern Section of the GC waterways.

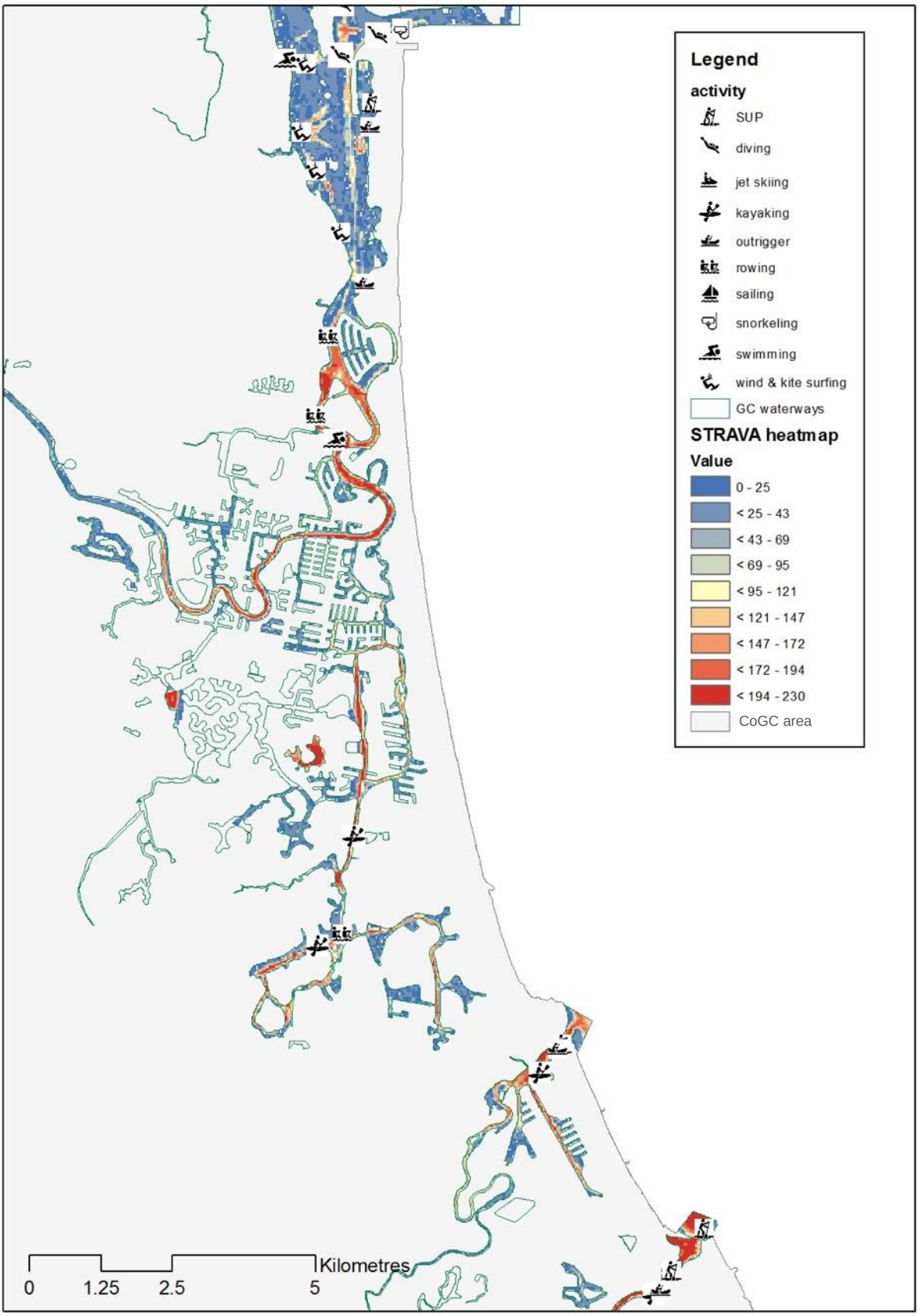

Figure 39: STRAVA heatmap of all available types of water-based sport activities in the Mid and Southern Sections of the GC waterways.

General sports symbols were used to pinpoint either hotspots of activities known to the authors or major launching points such as the Australian Institute of Sports (AIS) kayak training facilities at Pizzey Park, the TSS and Surfers Paradise Rowing Club boat sheds and the Muriel Henchman boat ramp as a general location for parking trailers of outrigger canoes along Seaworld Drive.

4.4 Tourism data

Data relating to tourism uses were extracted from traditional visitor surveys and more than 5000 geotagged photos uploaded by visitors and residents to flickr.com, a Canadian internet-based image hosting service created in 2004. Visitor survey data for the GC area were provided as raw data from the National Visitor Survey (NVS) and International Visitor Survey (IVS) collected by Tourism Research Australia (TRA) and extrapolations based on standardised TRA methods (Figure 40). The NVS uses telephone interviews, which can include overnight and day visitors to the GC that arrive by boat. The IVS is based on interviews conducted at departure lounges of major international airports and therefore does not include visitors departing by boat or vessel. Further details about these two sources are available in the report provided at Appendix C.

The geotagging data from flickr.com was plotted and converted to densities to highlight clusters of higher photographic activity. The locations of these photos, taken presumably mostly by visitors but also possibly by some local residents, was considered as indicating those parts of the GC waterways that were used most frequently and therefore valued for providing memorable experiences, desired motives or backdrops worth taking a photo. The final sample was comprised of 5,616 records of photos taken between 2006 and 2018 with 2,242 of them taken while travelling on water and 3,374 photos within 15 m distance from the GC waterways shoreline (derived by overlaying the GC waterways boundary layer described earlier). The resulting cloud of point data was converted using a kernel interpolation with boundaries to a 100 m cell raster layer showing the density of photos taken per hectare for all years combined (Figure 41).

The most popular spots for photos taken while travelling on water were found to be in the Seaway and the area south as far back as the Sundale Bridge (Figure 42). A second major spot was the mouth of Currumbin Creek, locally known as ‘Currumbin Alley’ and a location frequented by surf schools and novice board riders of all types, including SUPs. Photographs taken along the GC waterways shoreline highlighted similar hotspots, but also emphasised interest in the waterways around the Gold Coast Convention Centre in Broadbeach, areas around Bond University, and the north facing shoreline of Burleigh Heads headland.

Some of these areas of high-density photo locations revealed much higher than average uploads by a single person, mostly identified as a sequence of locations with photos taken over a few hours using the same device. Such sample bias is quite common for data from an open source (Sessions et al. 2016), however, in this case it had little effect on the overall distribution when eliminated from the sample.

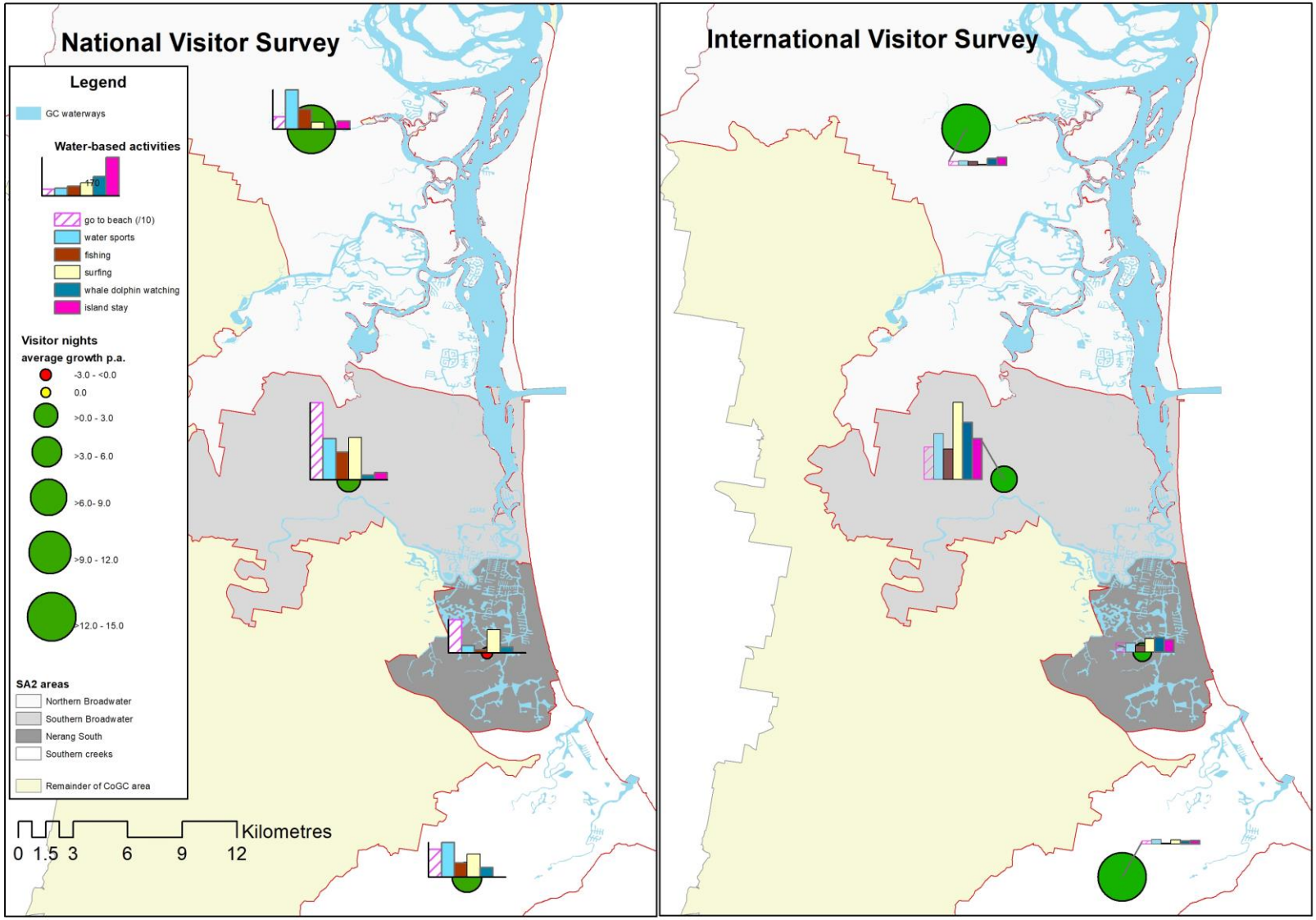

Figure 40: Tourism use (number of domestic visitor nights per activity) for Statistical Area level 2 from five years of National Visitor Survey (left), and International Visitor Survey (right), Tourism Research Australia 2012-2017 (Appendix C).

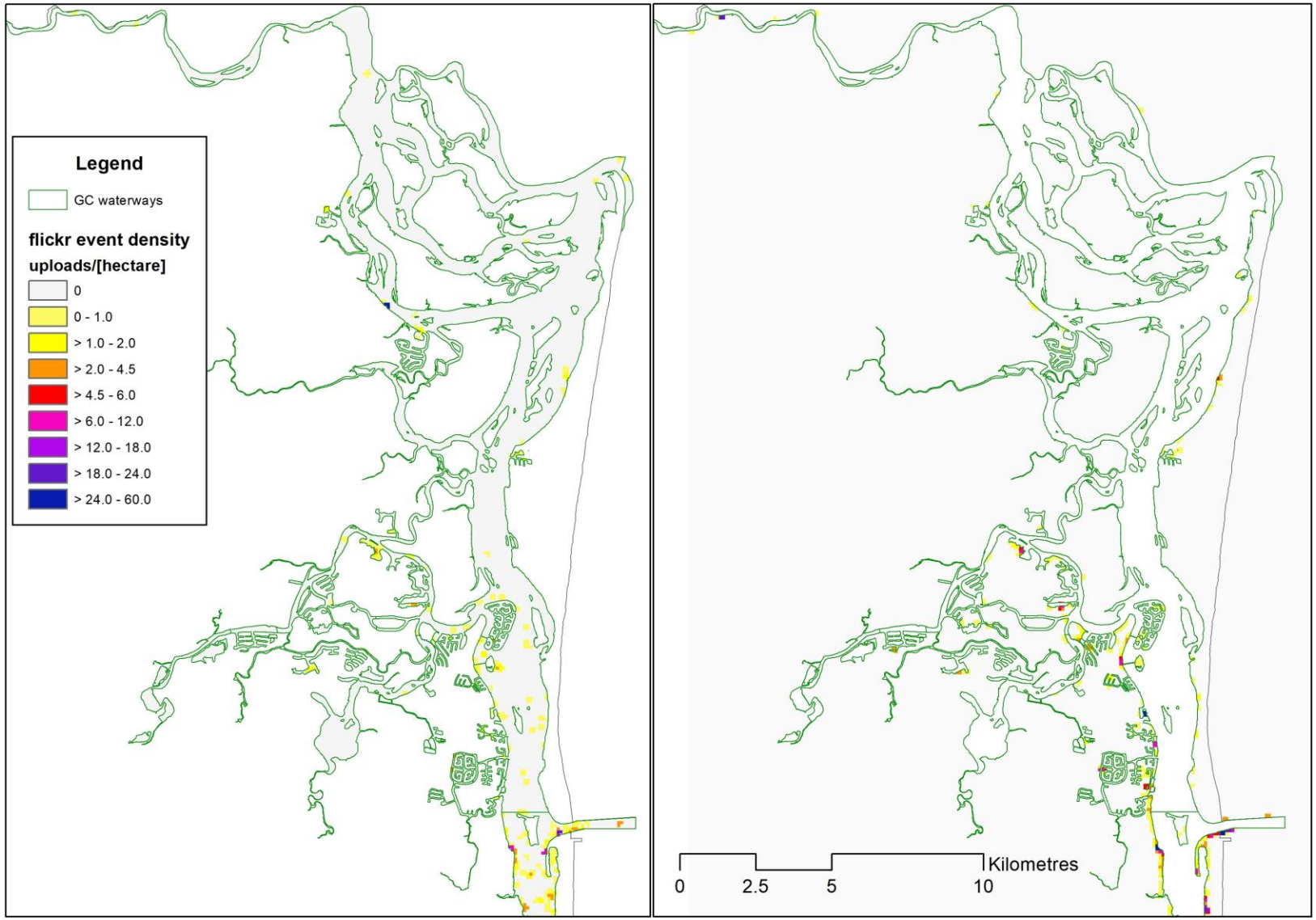

Figure 41: Flickr sourced event data from the Northern Section of the GC waterways from on-water events (left) and on-land events (right).

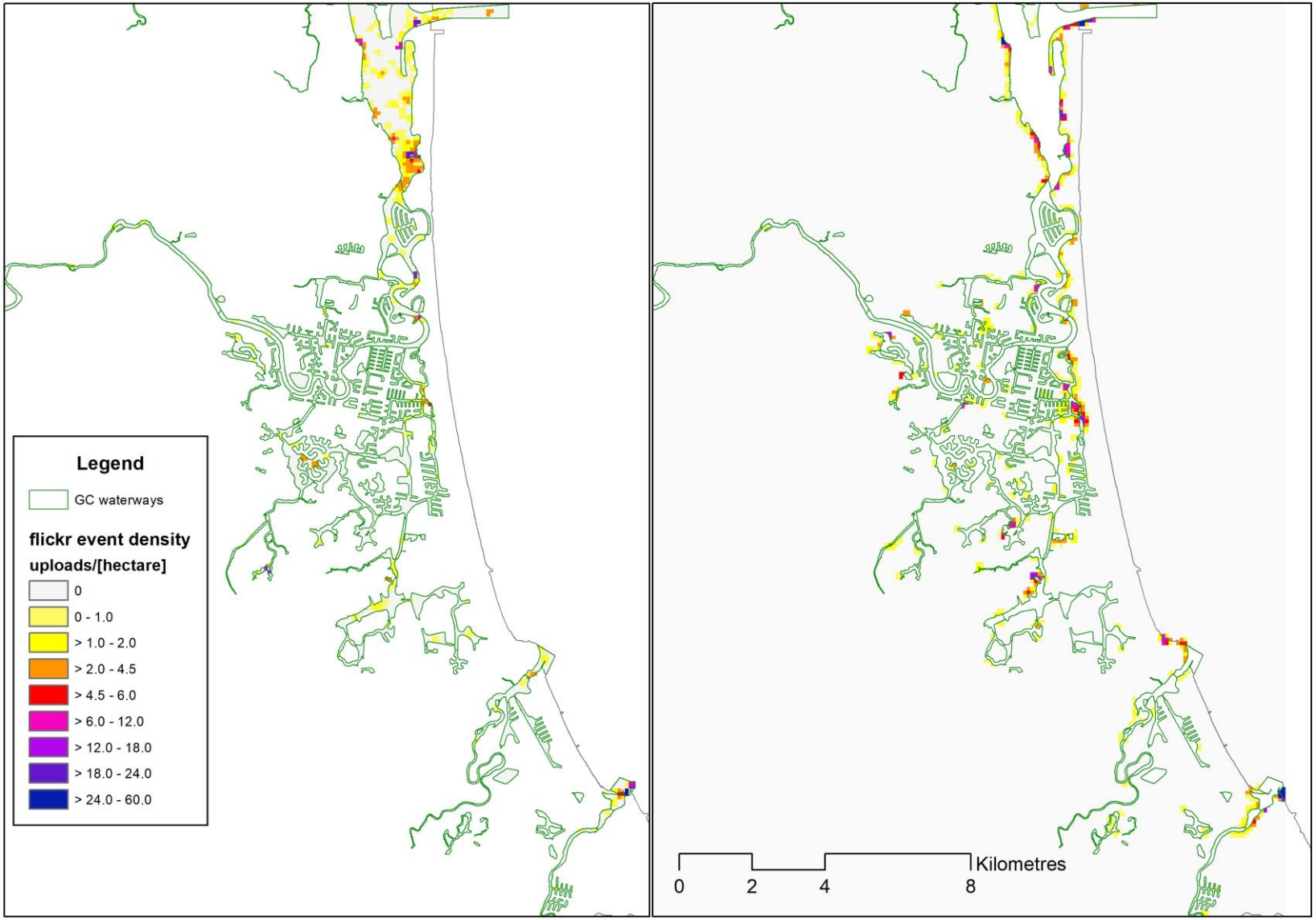

Figure 42: Flickr sourced event data from Mid and Southern Sections of the GC waterways from on-water events (left) and on-land events (right).

4.5 Temporal trends in use of the GC waterways

Variations in the use of GC waterways between different days of the week and different recreational seasons (non-holidays, long weekends and major holidays) were investigated using data from:

- video surveys of boat ramps commissioned by CoGC (Figure 43)
- AIS hourly vessel position data available from AMSA (Figure 44)
- data collected for work by Leon and Warnken (2008) (Figure 45)

GC 'waterways'

<u>CoGC ramp and pontoon video surveys:</u>

Maximum 7 events 2011-2018 (mostly a single day, mainly during peak Christmas holidays (January))

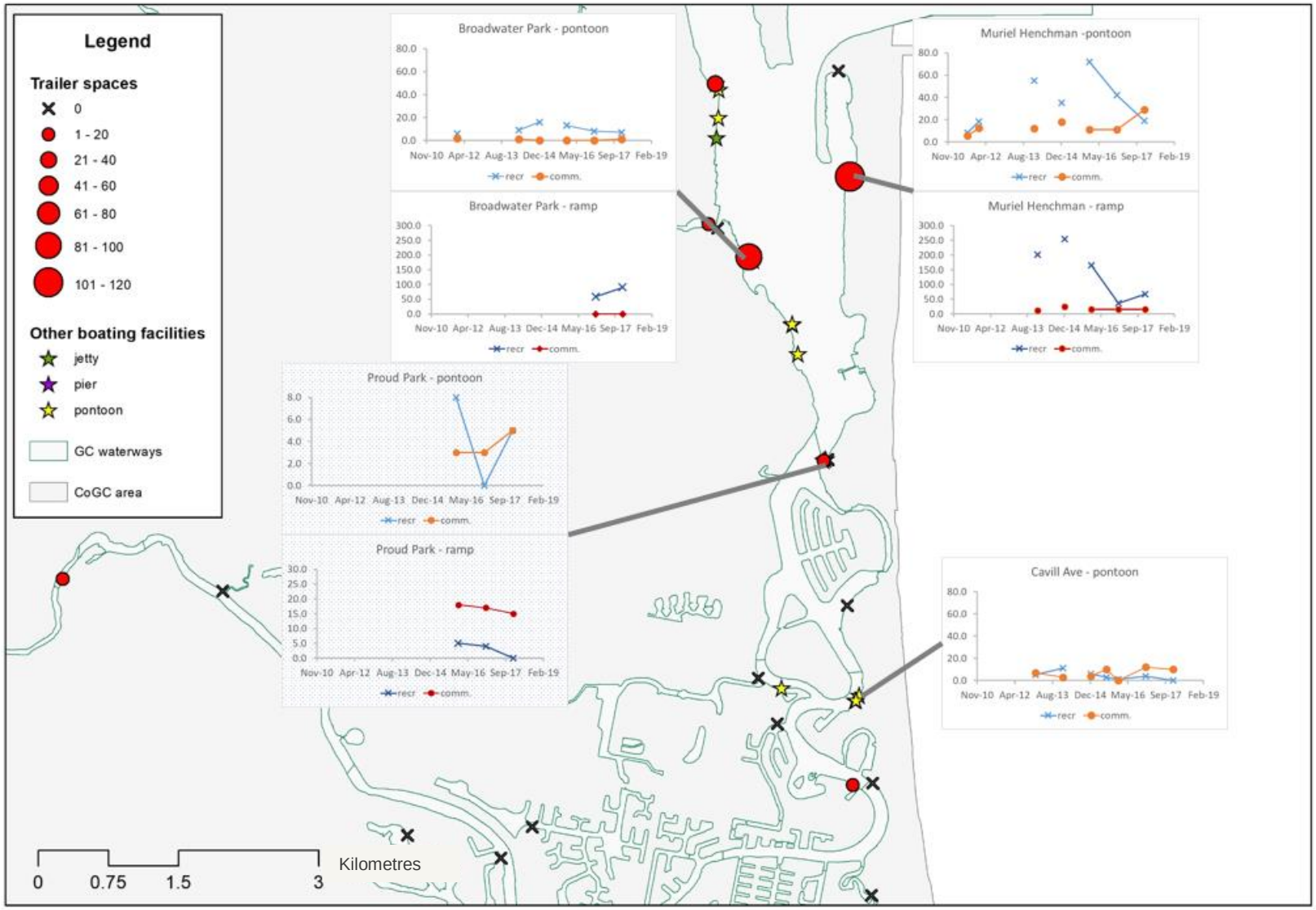

Figure 43: Use of major pontoons and jetties in the GC waterways monitored by City of Gold Coast over daylight hours during a single day per year.

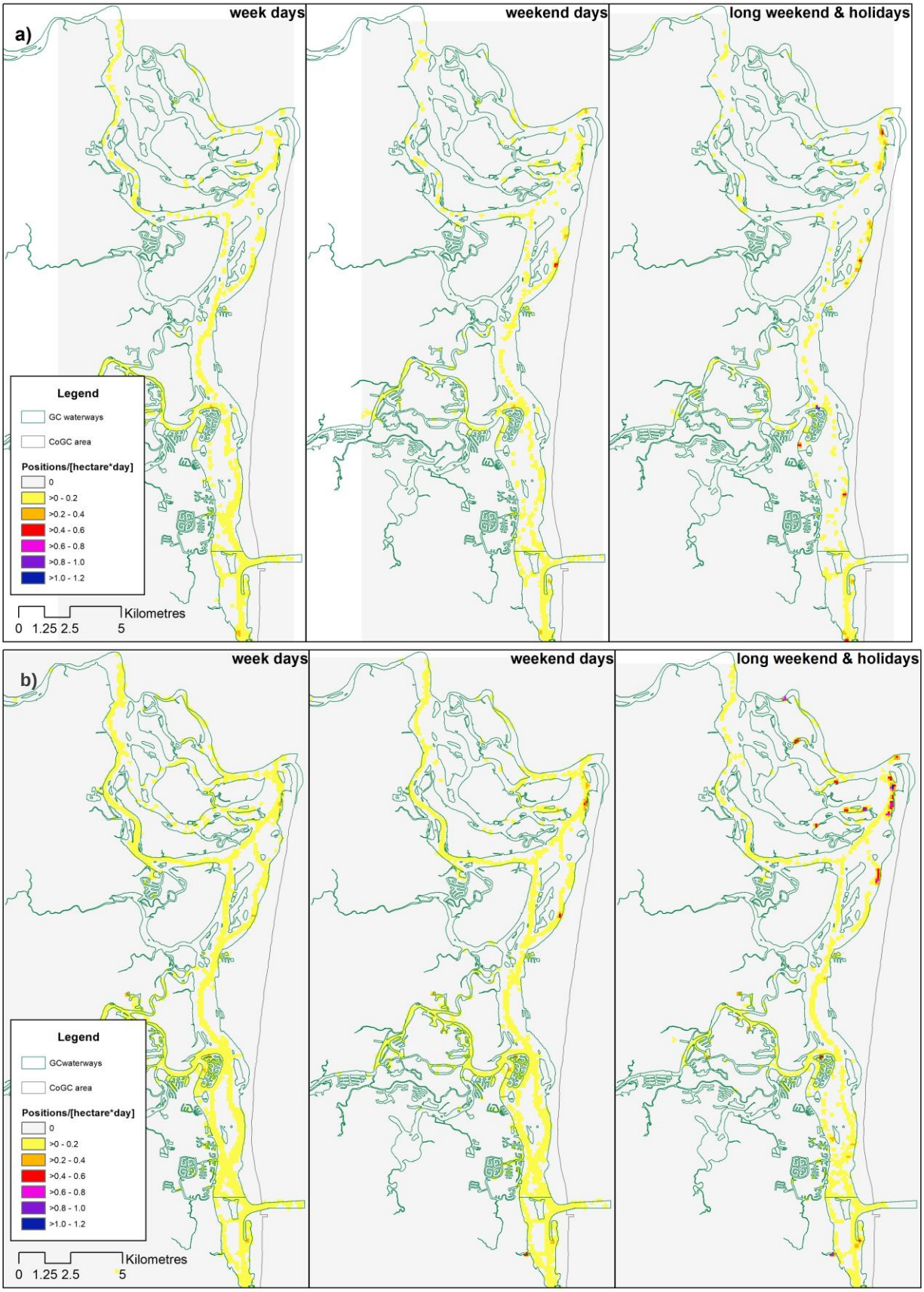

*Figure 44: 2017 average AIS position density.day^{-1}.ha^{-1} for vessels with **a) > 52** and **b) ≤ 52** position recordings in main marina and boat harbour locations within the GC waterways (provided by AMSA).*

Data was captured over a period of 1.5 years between 2004 and 2006 by taking photos from low flying aircraft on 58 days as described by Leon and Warnken (2008). The raw data was re-analysed for anchorages within the GC waterways, including Tipplers, Dux Anchorage, The Bedrooms, Millionaires Row and Perry's Hole (see Map E1 in Appendix E for relative locations).

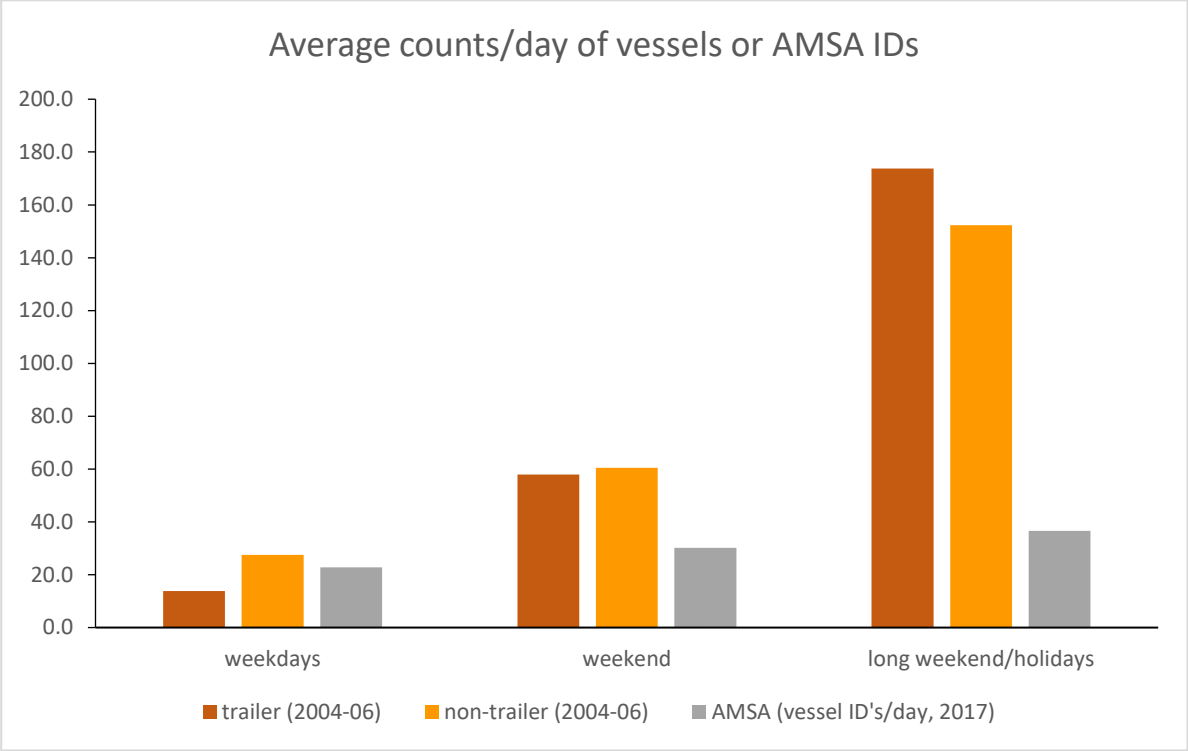

Figure 45: Average number of vessels counted at major anchorages in the Gold Coast Broadwater in 2004 – 2006 and average number of AMSA AIS vessel position IDs using the same area during 2017.

4.6 Actual/potential conflict areas within the GC waterways

One of the most reliable sources for certain types of on-water conflicts are records maintained by Maritime Safety Queensland (MSQ) for marine incidents. Under the *Transport Operations (Marine Safety) Act 1994* (Qld), a marine incident is an event causing or involving—

a. the loss of a person from a ship; or
b. the death of, or grievous bodily harm to, a person caused by a ship's operations; or
c. the loss or presumed loss or abandonment of a ship; or
d. a collision with a ship; or
e. the stranding of a ship; or
f. significant damage, or danger of significant damage, to a ship; or
g. significant damage caused by a ship's operations; or
h. danger of significant damage to a structure caused by a ship's operations; or
i. danger to a person caused by a ship's operations.

There is a legal requirement to report marine incidents within 48 hours of the incident occurring[16]. Compliance with this obligation may not be equally well adhered to across all classes of recreational vessels. However, by using several years of data, spatial analyses can generate sufficient information to identify areas with recurring incidents and thereby hotspots where users may be at increased risk; provided that the same level of compliance monitoring effort has been applied to the whole of the GC waterways.

Nevertheless, some incidents do go unreported, and so some hotspots are not identified. However, these may be identified by using other sources of data such as marine traffic infringements (see below), trauma and injury data related to water sport accidents, and possibly meeting points of marine rescue vessels and any watercraft that requested their assistance. These are identified in the Gap Analysis (Section 5); and a separately funded project examining hospital admission data is underway.

4.6.1 Distribution of marine incidents reported within the GC waterways

A total of 995 incidents were recorded for the Maritime Safety Queensland (MSQ) Gold Coast Region over 10 years, i.e. between 1 January 2007 and 14 December 2017. Over three quarters (750) occurred within the boundaries of the GC waterways and the area immediately north of the Seaway's northern breakwater, locally known as 'The Other Side' or 'TOS'. Just over half of all incidents (499) involved recreational craft only. Their locations already indicate a concentration of incidents for recreational craft around the Seaway entrance and the mouths of the Southern Creeks (Figure 46).

Commercial vessels were involved in 114 incidents with recreational craft, and 137 without. The majority of mixed incidents occurred south of the Seaway along the mooring areas for large vessels around Sea World, Marina Mirage and down to the Southport Yacht Club (Figure 46).

As for previous analyses, marine incident densities were mapped at 100 m cell resolution. These settings place emphasis on local distributions and therefore highlight grid cells with more than one incident. The highest densities of incidents were found in the Marine Stadium, in the southern Broadwater and the mouths of the Southern Creeks (Figure 47). The latter is probably the result of damage to motorboats after running aground while crossing the bars that are known to be difficult to negotiate (e.g. see relevant comments on MSQ's 'Beacon to Beacon' maps[17]).

[16] See https://www.msq.qld.gov.au/Safety/Marine-incidents for further details (last viewed: 08/11/18).
[17] See https://www.msq.qld.gov.au/Boating-maps for details (last viewed: 19/11/18).

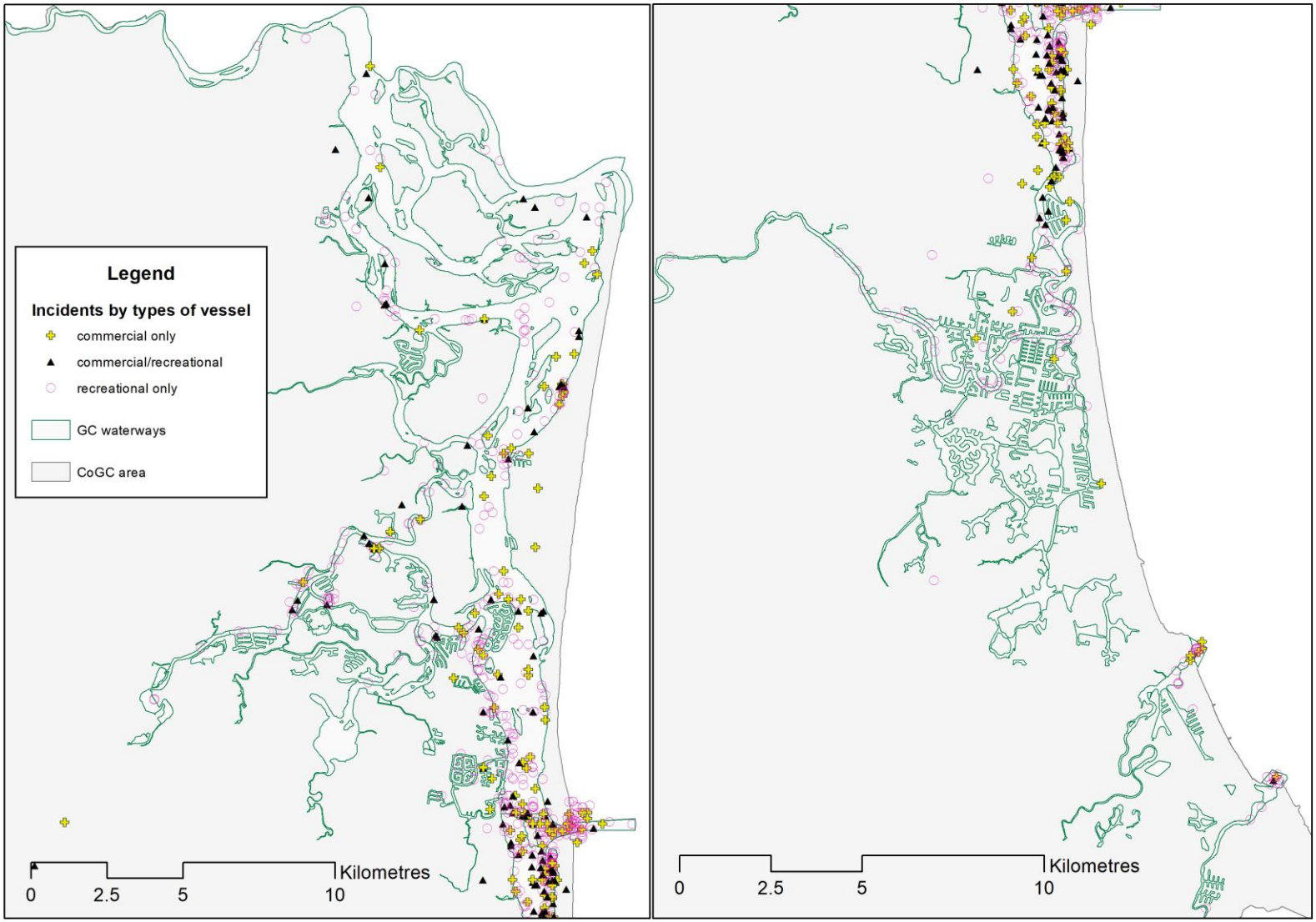

Figure 46: Marine incidents reported between 01/01/2007 and 14/12/2017, grouped by principal type of vessel use (commercial, recreational) within the Northern (left) and Mid and Southern (right) Sections of the GC waterways.

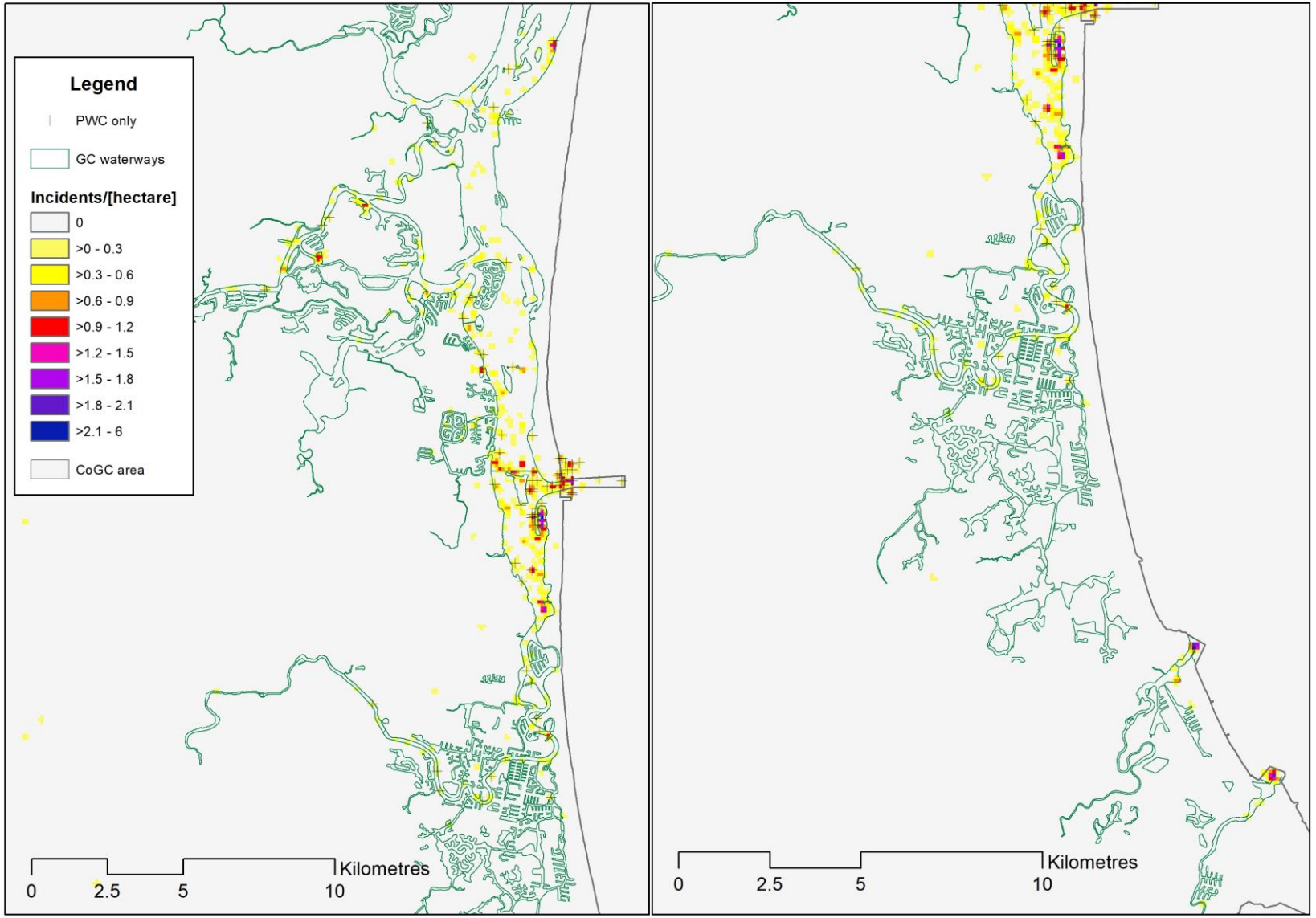

Figure 47: Density of all types of marine incidents/ha^{-1} reported within the Northern (left) and Mid and Southern (right) sections of the GC waterways between 01/01/2007 and 14/12/2017.

4.6.2 Temporal trends in incidents and injuries

With recreational craft having caused the highest number of incidents and PWCs being noted for a high rate of accidents internationally (Section 2.2.4) it was considered necessary to investigate which type of recreational craft was involved in incidents recorded for the GC waterways area. Attributes for the records provided by MSQ allowed to discriminate between incidents involving PWCs only, PWCs and recreational motorboats, motorboats only and combinations with other recreational craft. Based on these categories, recreational motorboats caused more than half of the incidents recorded each year between 2007 and 2017 (Figure 48). Until 2014, the number of incidents declined, which was followed by a sharp rise in recreational motorboat incidents in 2016 (however, it was not possible to determine the cause of this anomaly within the scope of the current project). Much of this trend was reversed the following year to levels last recorded in 2010.

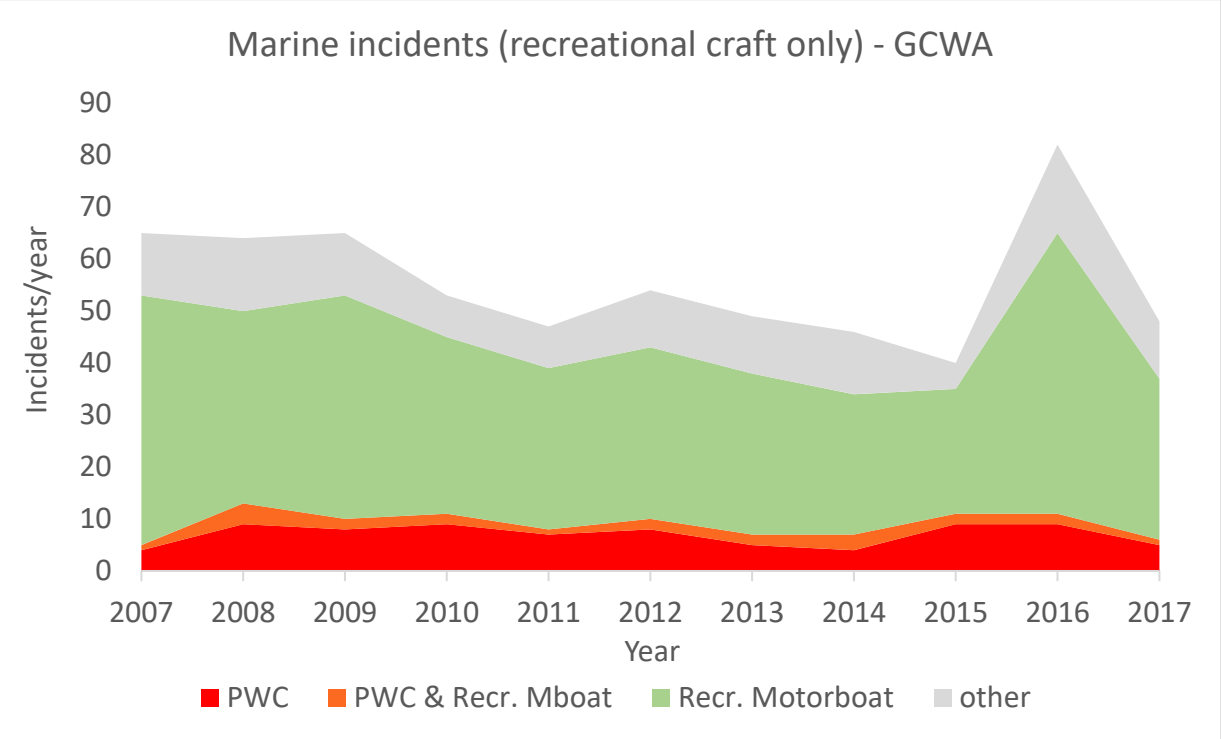

Figure 48: Marine incidents in GC waterways by type of craft for incidents involving recreational vessels only between 01/01/2007 and 14/12/2017

The same data set also recorded the date of each incident. This allowed a closer look at the rate of incidents for different boating-relevant times throughout the year (Leon and Warnken 2008). Such times can be split into three groups: weekdays, weekends (Saturday and Sunday) and long weekends (when a public holiday or general holiday precedes or follows a weekend immediately or with a Friday or Monday in between).

The resulting graph (Figure 49) clearly shows higher rates of incidents for weekends and long weekends all trending down until 2014. Weekends were the first type of day with an upward trend in 2015 and then a spike in 2016. The latter was mirrored by incident rates for weekdays, but not for long weekends.

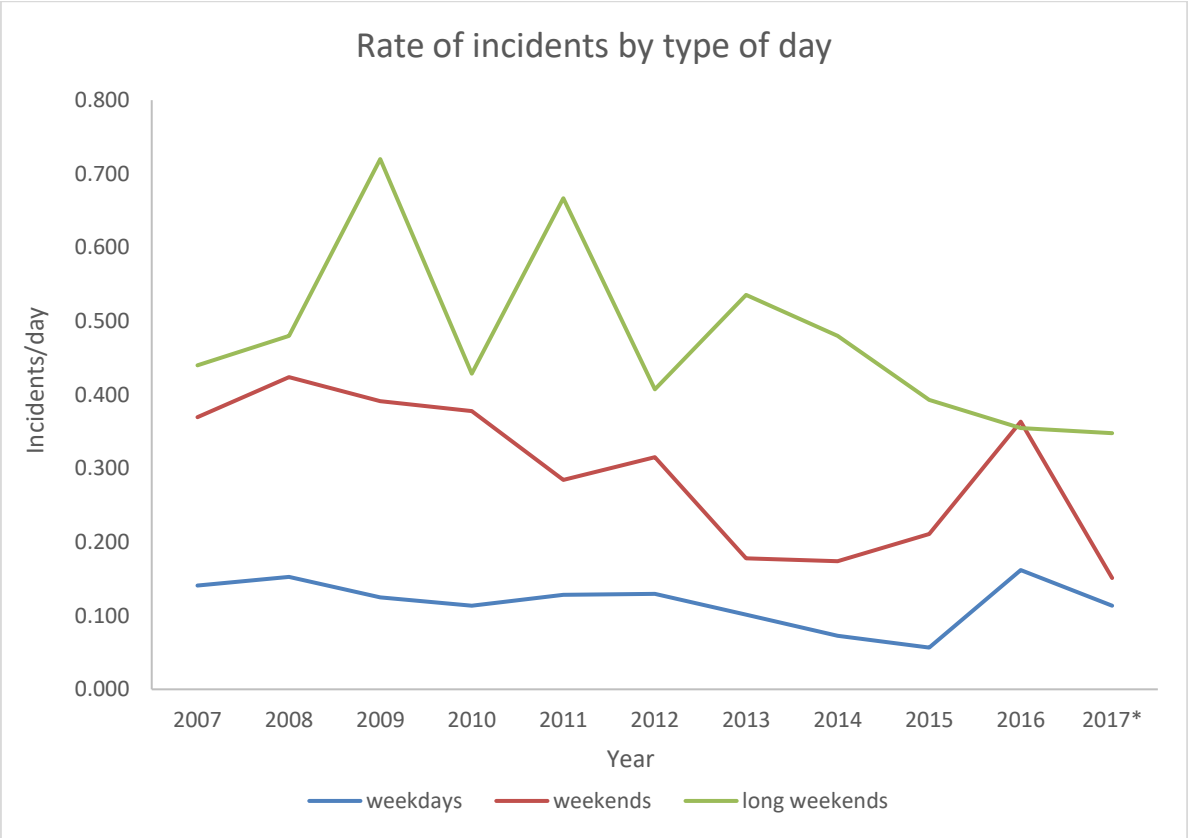

Figure 49: Rate of marine incidents reported within the GC waterways involving recreational craft only, by type of day (i.e. weekday, weekend, etc.) for the period 01/01/2007 to 14/12/2017.

Marine traffic infringements, especially those relating to excessive speed, were considered as another data set that could highlight areas of potential conflict between GC waterway user types, between users and waterfront residents, and between use types and environmental values. A limited dataset of marine infringement notices issued between 3 April 2017 and 27 June 2018 was provided by the Queensland Police Service (Gold Coast Water Police). The dataset contained 1,127 records over the period (see Figure 50). Information about the location of the infringement was only provided by 'suburb' or waterway land mark (e.g. 'Tipplers') without any further geographic coordinate locations. Accordingly, all records were summarised for their respective suburbs and initially linked to the centroid of each relevant suburb polygon available from the ABS online data packs for the 2016 Population Census or a point feature representing a waterway landmark on the online 'Beacon to Beacon' maps published on the MSQ website[18]. Suburb centroids were then moved to their nearest section of GC waterways shoreline.

[18] See https://www.msq.qld.gov.au/Boating-maps for details (last viewed: 19/11/18).

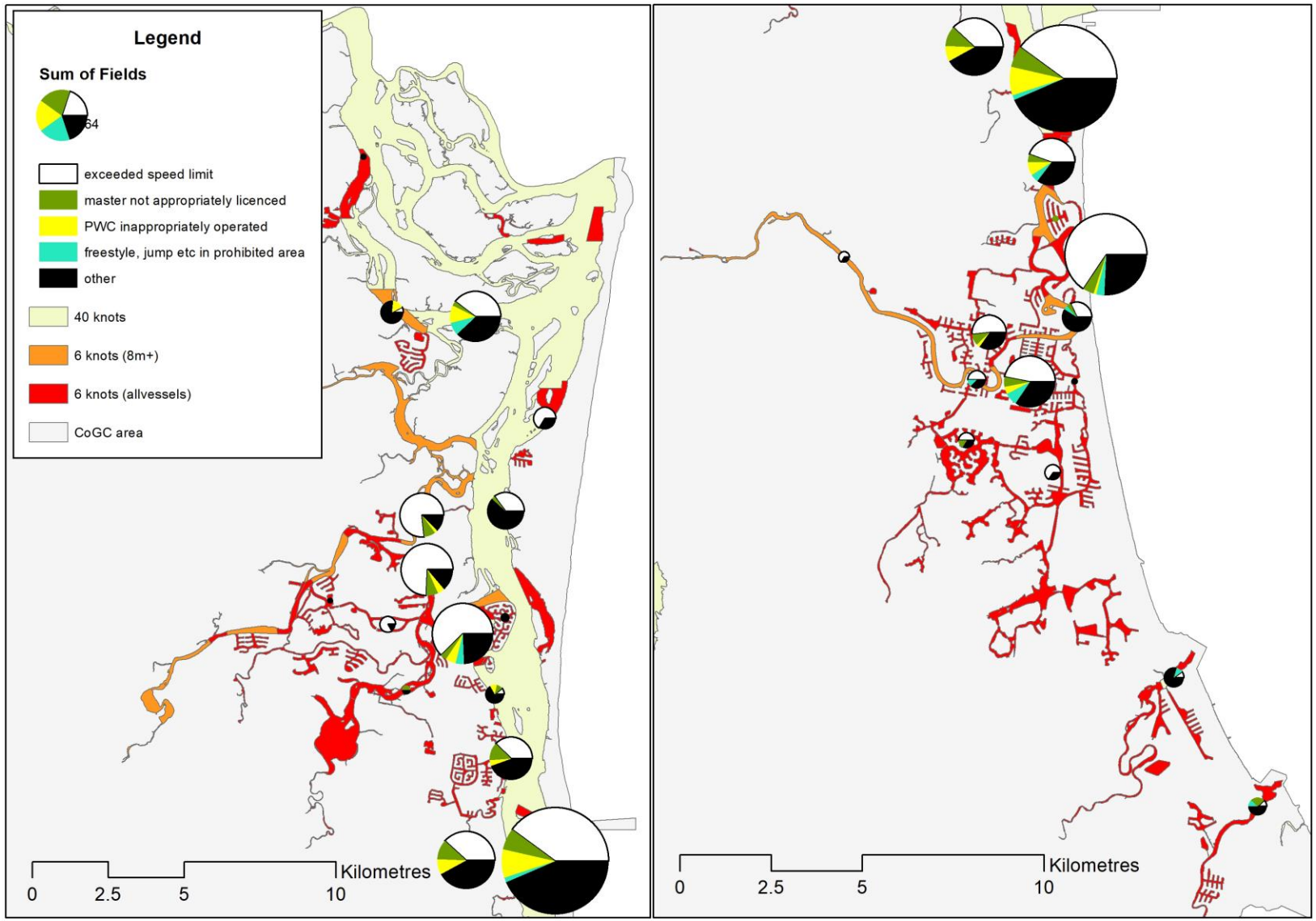

Figure 50: Speed restriction zones and marine infringement notices issued between 03/04/2017 and 27/06/2018 within the Northern (left) and Mid and Southern (right) Sections of the GC waterways.

The location where the highest number of marine infringement notices were issued, by far, was identified as the area around the main channel south of the Seaway. The areas where the proportionally highest numbers of speed-related marine infringement notices were issued were the north and south arms of the Coomera River closely followed by the waterways west of Surfers Paradise (Figure 50, white sections of pie charts). Offences relating to inappropriately operating a PWC were, in relation to other infringements, most common in the main channel between Woogoompah and Kangaroo Islands (refer Map E1 in Appendix E for relative locations).

Offences recorded for the Southern Creeks mostly related to matters other than speeding, inappropriate use of PWCs and operating a vessel without a licence. Violations of freestyling, wave jumping, and tow-in surfing restrictions was the other recurring, and therefore noticeable, type of offence.

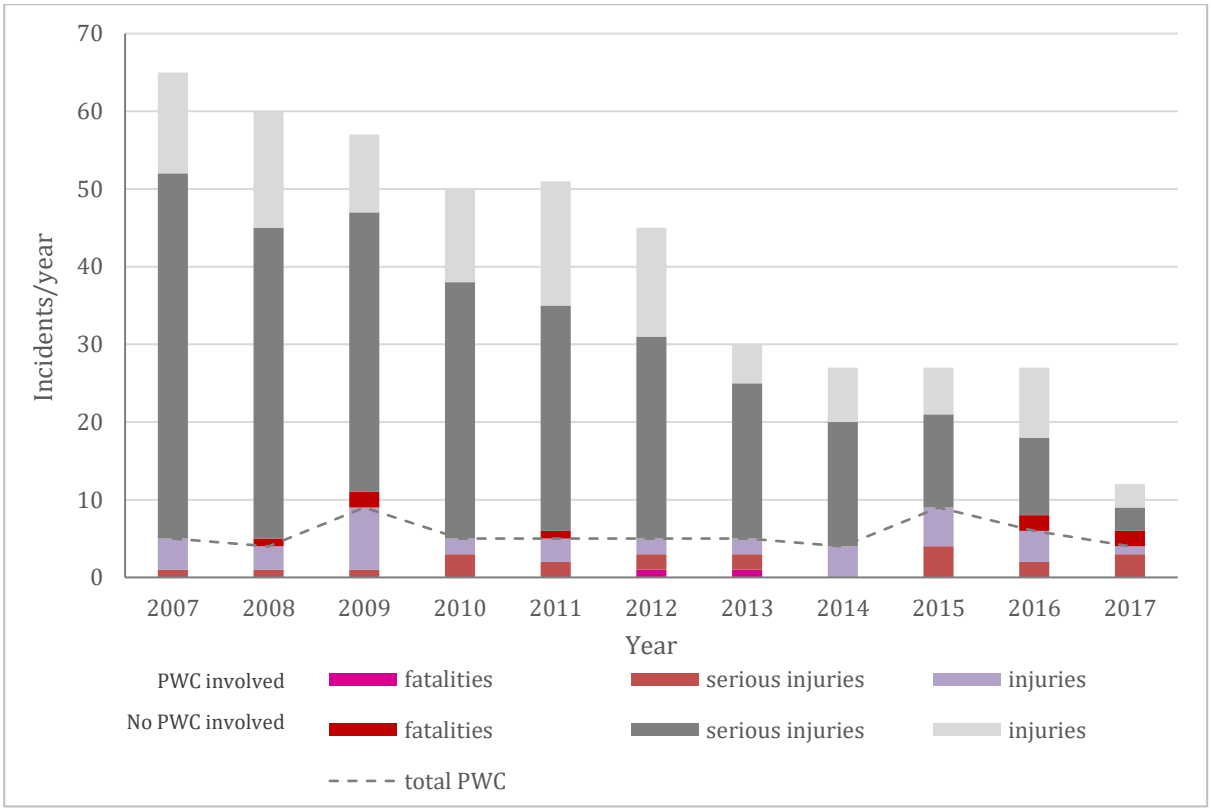

Figure 51: Number of marine incidents recorded between 2007 and 2017 within the GC waterways. Within this dataset, one actual incident could have been counted in two or even three categories (e.g. a collision involving more than one vessel in which one person was killed and two others injured, one seriously). Commercial vessels have been included in this data.

Figure 51 above shows a trend of declining incidents and it seems that there is a more marked decline in the number of incidents (serious ones in particular) for those that did not involve PWCs, compared to those that did. Incidents with PWCs are also downward trending (from 2015) but the reason for this is not clear, particularly given that registrations in this class have increased more than in all other classes (see Figure 30 above). Further analysis will be required to determine the factors that have led to these declining trends (Gap Analysis, Section 5).

4.6.3 Hotspot analysis

The data compiled for this section did not allow a hotspot analysis in a strict (statistical) sense, because the information captured in most layers lacked the required spatial resolution and detail (see Gap Analysis, Section 5). To shed some light on areas that are currently, or are likely in the future to be locations of conflict, even if only at peak times, data were extracted from previous maps using layer-specific filters or cut-offs to either retain visually prominent hotspots (e.g. STRAVA heat map), overlaying use areas (e.g. rowing) or densities captured in the two highest out of nine categories (top 22 % of values), and shown in Figure 52.

Some of these overlaps are, as already indicated, only spatial, not temporal. Rowing training and commercial tour operators are using the same section of the Nerang River between Appel Park and Sundale Bridge, however, rarely at the same time. Very few tourism vessels start before 8:00 am and most training sessions using rowing boats or other craft would have finished by then.

The area of most overlapping activities, incidents and position recordings is the Marine Stadium with the Muriel Henchman boat ramps. Here, most motorised watercraft activities converge including large non-trailerable vessels, motorboats, PWCs, regular and charter operators and amphibious craft. The same area is also known as a launching site for outrigger canoes and a popular spot for near-shore activities such as having a barbecue and a swim during hot summer days for those members of the local community who are hesitant to use the open beaches.

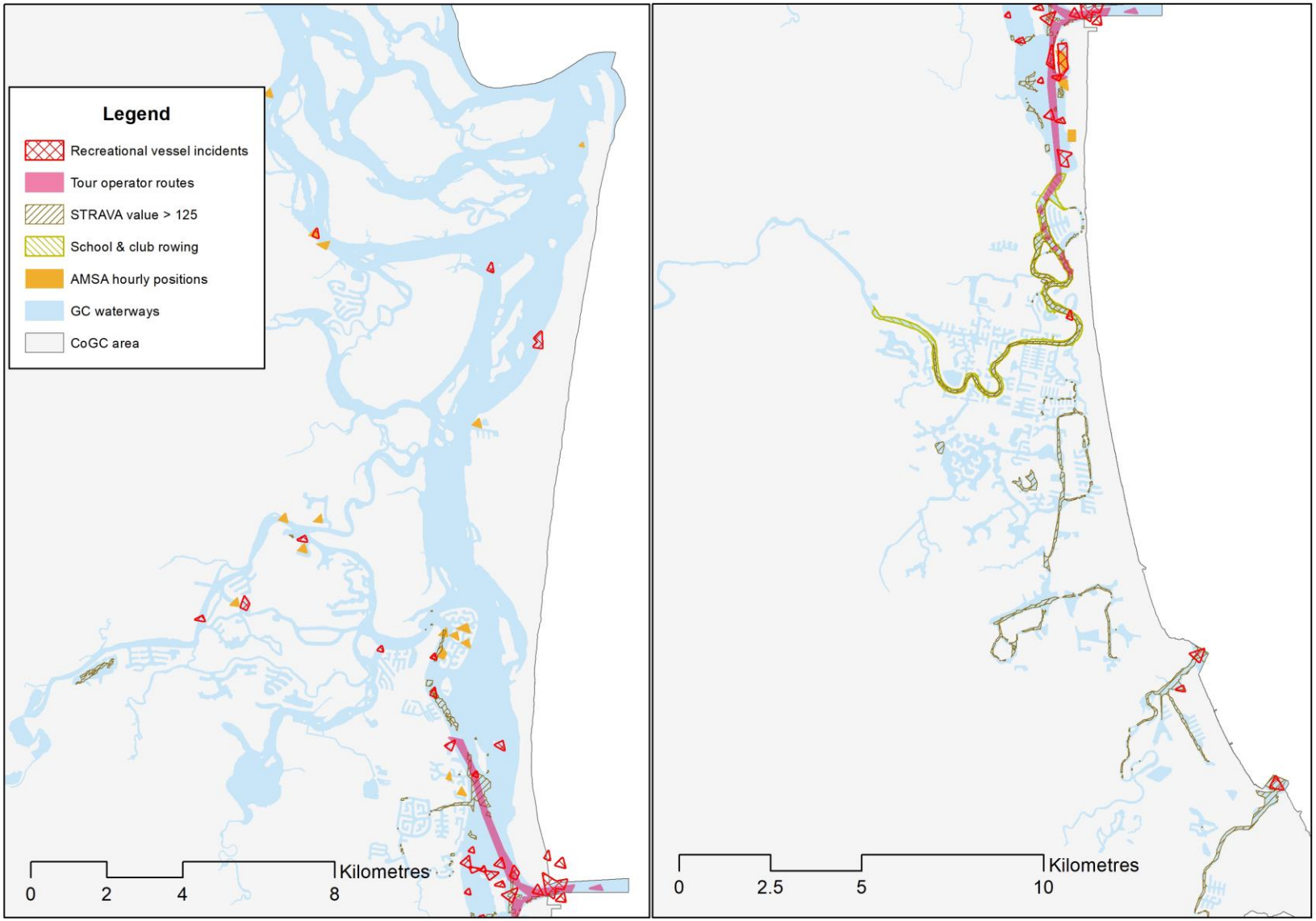

Figure 52: Preliminary hotspot analysis of possible conflict areas within the Northern (left) and Mid and Southern (right) Sections of the GC waterways.

4.7 Conclusions

Data searches uncovered more than 40 spatially-based datasets relevant to this study, from all levels of government, internal GCWA sources, consultants' reports, research papers, personal communications and social media. They were accessed in many different formats, from pre-existing GIS layers that required little reprocessing, to raw co-ordinate pairs requiring interpolation and raster classification. Most have been converted into density-based plots to allow comparisons and spatial overlays to highlight activity patterns and current or potential conflict areas, within the three sections defined. All these layers will also be provided to GCWA in digital form as part of the project deliverables.

The key outcomes of all these analyses can be considered as follows:

Environmental 'Uses': Examination of available mapping for intertidal and subtidal habitats, marine/coastal vegetation, avifauna distributions, biodiversity status, existing ecological management and international obligations shows that the Northern Section holds most of the areas of high ecological value. Mangrove, saltmarsh and seagrass diversity and area is highest here, and it is of very high value for migrating shorebirds, and as nesting habitat for coastal raptors. In contrast, available mapping shows low ecological value through the Mid-Section, with no patches of high biodiversity value. Small patches of high biodiversity value exist within those parts of the Southern Section creeks that retain natural riparian and intertidal vegetation.

Patterns of Human Use: The areas in which people use the GC waterways for different activities are largely driven by access restrictions. These are in part natural restrictions (water depth, tidal flow, location of 'desirable' destinations with scenic amenity value), and partly anthropogenic (bridges, weirs, speed limits, provision of boat ramps, marina locations). In some ways these assist in separating potentially conflicting uses, for example larger vessels producing potentially damaging wakes cannot access calm water reaches of rivers or lakes that are used by small unstable craft such as rowing shells and kayaks. Nevertheless, there are areas accessible to all, at some times of the year – weekends, and especially summer public holidays – which are subject to high volumes of traffic and consequent conflicts between uses and users.

The highest density of uses for commercial operations (fishing vessels, tour operators, PWC/boat hire operators) occurs in the southern Broadwater, from Sundale bridge up to the Seaway, and around Wave Break Island. This also applies to non-powered commercial tours / hires, such as kayak tours and SUP hire; these were also well represented in the Southern Section creeks. There were also high densities of operators using high speed craft, such as Jet-boat tours, and guided PWC tours, further north through the Broadwater, as far as Jumpinpin and around Woogoompah Island (see Map E1 in Appendix E for relative locations).

Very little information was available about patterns of use of small (under eight metre), private recreational vessels (see Gap Analysis, Section 5). Patterns in use of recreational vessel of eight metres or over are to an extent encapsulated in the analyses of AIS data but cannot be explicitly separated from other vessel types in that size range. Trends in vessel registrations over time show that numbers in the three to four metre vessel class, which includes PWCs, is by far the fastest growing vessel class, and is in fact growing faster than the local population. However, there is virtually no quantitative information available on areas or densities of operation of this segment, which represents the largest group of users.

As noted above, school and club training areas for competitive water-based sports (rowing, canoeing, kayaking, dragon boating) are principally in the Mid-Section protected reaches of the Nerang River, or artificial lakes. Non-competitive fitness-based activities, in contrast, are distributed throughout the GC waterways, but with higher densities in the lower reaches and entrances of the Southern Section creeks, Mid-Section lakes and the Nerang River, and within the Northern Section, concentrated around Wave Break Island and Crab Island (refer to Map E1 in Appendix E for relative locations).

Actual/potential conflict areas: Separate but concurrent analyses of data from reported marine incidents, marine infringement data from the Gold Coast Water Police, and spatial overlays of conflicting use types showed good agreement in the areas where there was potential for conflicts between users, especially those that could result in accident, injury or death. These are concentrated in three main locations: The Gold Coast Seaway and Wave Break Island, and around the mouths of both Tallebudgera and Currumbin Creeks. However, there are caveats on these results on two counts. First, the lack of data on patterns of use of small private recreational vessels, who constitute by far the largest number of users; and second, the total lack of data on the other types of conflict, especially between users and environmental values, and between users at the level of perceptions of crowding, impacts on amenity, etc., as detailed in the Literature Review (Section 2). Taken together, these data limitations suggest that the analyses presented here completely underestimate the potential for conflicts, in terms of both location and frequency.

5 Gap Analysis

5.1 Structure and rationale

A very large number (> 40) of datasets were accessed and analysed for this project. Considering the data available and comparing this to data types used in case studies both locally and overseas (see literature review, Section 2), use and user types could be identified that had limited data available to allow a spatially explicit analysis of potential conflicts across the range of conflict types identified from the literature. In addition, it was identified that data representing user attitudes (as distinct from activities) for particular places was required as well. To represent this, data gaps have been complied in tabular form. Table 3 shows gaps in *quantitative* data about temporal or spatial patterns of different uses or users or attitudes to other uses/users), and Table 4 shows gaps in *qualitative or anecdotal* data in the same categories.

Each table has been assigned a priority for acquiring that data, based on the following hierarchy:

Highest: No data at all on this use/user type, or no spatial information

Next: Limited data on this use/user type, or of limited scope or spatial resolution

Next: Sufficient spatial / temporal scope, but requires significant reanalysis

Lowest: Qualitative data available, requires validation

In some cases, data sources that may fill gaps are known, but it is not in a form that allows spatial analysis. Therefore, where there is significant further work required to enable these to be represented as densities, or in units permitting spatial analyses of hotspots of possible future conflicts, they have been included in a separate table. The identified data sets from which density or otherwise standardised information may be derived are summarised in Table 5, together with the current custodians of the data, and the required research and development work to extract this in a useable form.

Other identified data types that would enhance the spatial analyses, but not included in the tables because they are of limited scope, or lower priority, include:

- Counts (or densities) of waterway uses by types of transport (three major classes):
  - Non-trailerable recreational, tourism and fishing vessels: spatially and temporally detailed data for all vessels with AIS, supplemented by Leon and Warnken (2008) to extrapolate figures for weekends and long weekends/holidays, longitudinal data (spatio-temporal trends) from marine incident records.
  - Trailerable recreational vessel: some information from marine infringement notices, Australian Volunteer Coast Guard (AVCG) and Volunteer Marine Rescue (VMR).
  - Non-powered watercraft: indication of local (spatial) hotspots, no data related to temporal variation.
- Counts (or densities) of GC waterway uses by types of activity.
- Demographics of water users in categories compared to spatially explicit (SA1 level) longitudinal ABS census information.

5.2 Gap analysis tables

Priority (on a scale of 1 to 3, with 1 being the highest priority and 3 being the lowest), assigned to each data type is indicated in the right-most (top) column. Colour in Tables 3 and 4 indicates data status: Green = sufficient; Yellow = some; Orange = few; Red = none.

Table 3: Availability of quantitative data about use and user types within the GC waterways.

	Spatial distribution			Temporal distribution				Priority
	General use areas	Hot spots	Densities	Day	Week	Season	Trends	
Recreational fishing (from vessel)	YES (DAF*)	SOME (club competitions)	NO	NO	NO	NO	SOME (DAF)	1
Sailing (trailerable and non-trailerable)	YES (Regatta courses, anchorages)	SOME (Leon & Warnken 2008)	SOME (Leon & Warnken 2008)	NO	SOME (Leon & Warnken 2008)	SOME(Leon & Warnken 2008)	SOME (Qld recr. vessel register)	3
Power boating	SOME (large vessels only)	NO	SOME (Leon & Warnken 2008)	SOME (GCCC boat ramp surveys)	SOME (Leon & Warnken 2008)	SOME (Leon & Warnken 2008)	SOME (Qld recr. vessel register)	1
PWC use	SOME (tour operators only)	NO	NO	NO	NO	NO	NO	1
Water skiing, wake boarding	YES (club activities, GCWA restricitions)	SOME (STRAVA)	NO	NO	NO	NO	NO	2
Rowing	YES (school & club activities)	YES (STRAVA)	NO	SOME (school & club activity logs)	SOME (school & club activity logs)	SOME (school & club activity logs)	SOME (school & club activity logs)	3
Kayaking, outrigger canoeing	SOME (STRAVA, tour operators)	SOME (STRAVA)	NO	FEW (AIS activity logs)	FEW (AIS activity logs)	FEW (AIS activity logs)	FEW (AIS activity logs)	2
SUP boarding	SOME (STRAVA, tour operators)	SOME (STRAVA)	NO	NO	NO	NO	NO	2
Wind surfing, kite surfing	SOME (STRAVA, tour operators)	SOME (STRAVA)	NO	NO	NO	NO	NO	2
Diving	YES (clubs & tour operators logs)	YES (clubs & tour operators logs)	SOME (clubs & tour operators logs)	SOME (clubs & tour operators logs)	SOME (clubs & tour operators logs)	SOME (clubs & tour operators logs)	SOME (clubs & tour operators logs)	2
Snorkeling, swimming	NO	NO	NO	NO	NO	NO	NO	1
User values for (e.g.): Visual amenity Cultural significance Peace and quiet, etc	NO	NO	NO	NO	NO	NO	SOME (Healthy Land and Water)	1

* DAF = Queensland Department of Agriculture and Fisheries.

Table 4: Availability of qualitative or anecdotal data about use and user types within the GC waterways.

	Spatial distribution			Temporal distribution				Priority
	General use areas	Hot spots	Densities	Time of day	Part of week	Season	Trends	
Recreational fishing (from watercraft)	YES (most of Northern Broadwater)	Some (north wall of Seaway)	NO	Some (mostly morning and afternoon)	NO	YES	NO	1
Sailing (trailerable and non-trailerable)	YES (most deeper parts of Northern Broadwater)	YES (Hollywell, main channel Southport Yacht Club to Seaway)	Some (regatta registrations)	YES (Wednesday afternoons, weekends late morning to afternoon)	YES (Wednesdays & weekends)	Some (regattas)	NO	3
Power boating	Some (Coomera & Nerang Rivers, Broadwater)	NO	NO	Some	Some	NO	NO	1
PWC use	Some (everywhere unless banned)	NO	NO	NO	Some	NO	NO	1
Water skiing, wake boarding	YES	YES	NO	Some	YES	Some	NO	3
Rowing	YES (see spatial analyses)	YES	YES	YES	YES	YES	Some	3
Kayaking, outrigger canoeing	Some (see spatial analyses)	Some	Some	Some	Some	Some	Some	2
SUP boarding	Some (Southern Creeks, protected canals & areas around Broadwater islands)	Some	NO	Yes	Some	NO	NO	2
Wind surfing, kite surfing	YES (Southern Broadwater)	YES	NO	Some	Some	YES	Some	2
Snorkelling, diving, swimming	YES (Seaway & Wavebreak Island rock walls)	YES	NO	YES	Some	Some	Some	2
User values for (e.g.):	NO	NO	NO	NO	NO	NO	Some	1
Visual amenity								
Cultural significance								
Peace and quiet								

Table 5: Candidate data sets and associated projects for filling identified information gaps within the GC waterways from existing datasets (5a) and data from new studies (5b).

5a

Existing data set type	Extractable information	Custodian of data set	R&D requirements
Location of mobile phones (IDs) on waterways	Movement, hotspots, launch places, spatio-temporal trends for any watercraft (based on speed and area of use)	TELSTRA	Algorithms to discriminate between types of users (watercraft)
Tracks of sports activity monitoring mobile devices	Movement, hotspots, launch places, spatio-temporal trends for non-powered watercraft (based on user-defined type of activity)	STRAVA	Automated GIS module to extract and analyse incoming vector data
Location and type of injuries from water sport activities from GC hospital admissions to emergency departments	Conflict hotspots and identification of actual high risk activities and areas, spatio-temporal trends	Qld Health	Method for extracting relevant information from relevant Qld Health databases
Forecast GC population demographics based on housing development trends	Forecast increases/trends in housing type at best available resolution	Qld Treasury	Validate assumptions relating to vessel ownership and household type
Multi-year AIS position data and IDs	Mooring, transition and anchoring hotspots of larger (mostly > 8 m) commercial operators, spatio-temporal trends in relation to marine incident reports	AMSA, Vesselfinder.com	Automated (GIS) module to extract and analyse incoming point data
Multi-year location information on issue of infringement notices	Non-compliance types and hotspots, spatio-temporal trends (effectiveness of risk aversion measures)	Queensland Police Service	Method for extracting location information and mapping of incident records
Imagery from waterways surveillance cameras	'Ground truthing' for AIS and mobile phone data, characterisation of behavioural patterns (=usage of watercraft)	CoGC, Dept of Transport and Main Roads	Method for automated screening of video footage
Navionics waypoints database	Recreational fishers waypoints uploaded to Navionics website	Garmin Ltd	GIS spatial analysis process to condense several years of vector and point data (can build on STRAVA analyses)

5b

New data set type	Information Type	Eventual Custodian	R&D requirements
Spatial distribution of Small Powered Recreational Vessels (SPRVs)	Densities, i.e. vessels.ha^{-1}.day^{-1} over identified temporal units (weekdays, weekends, holidays)	GCWA/Researchers	Targeted surveys using multiple methods (e.g. aerial snapshot surveys, boat ramp surveys, on-water census)
Spatial distribution of activities from (SPRVs)	Densities (as above) by activity types (e.g. fishing, water sports, sightseeing, transit)	GCWA/Researchers	Targeted surveys using multiple methods (e.g. aerial snapshot surveys, boat ramp surveys, on-water census)
Place-based user values	Polygons with value scores for value types (e.g. visual amenity, cultural heritage, peace and quiet)	GCWA/Researchers	Public Participation GIS (PPGIS), questionnaires, boat ramp surveys
User attitudes to other use types	Conflict scores for use type pairs (e.g. water skiers' attitudes to large > 8 m vessels; fishers' attitudes to PWC users)	GCWA/Researchers	PPGIS, questionnaires, boat ramp surveys

5.3 Data notes

Taken together, the tables show that the highest priority is to acquire spatially explicit information about the numerically dominant users of the CG waterways: small (< 8 m) private recreational vessels (SPRVs). Several data types are required, most critically areas used for different activities (e.g. fishing, water skiing, sightseeing), the values these users place on particular locations, and their attitudes to other users.

Of lesser priority, but still required for a comprehensive spatial hotspot analysis, are:

- Quantitative information about potentially or actually conflicting use pairs, apart from those included above.
- Quantitative information about the distribution of use types that are particularly vulnerable to conflict from other users, either from the point of view of human safety (e.g. swimmers, snorkelers, small unstable craft), user amenity (e.g. peace and quiet, cultural heritage); or ecological sensitivity (e.g. erosion potential of unstable banks; disturbance of endangered species or critical habitats).

6 SWOT Analysis

6.1 Background and aim

This analysis aims to provide a structured snapshot of the Strengths, Weaknesses, Opportunities and Threats posed by the current and possible future levels of water-based uses of the GC waterways. It draws upon all the datasets derived from the spatial and temporal analyses in preceding sections, and includes actual (from the preliminary hotspot analysis, plus anecdotal information) and potential (based on projections of population demographic, vessel registrations, etc.) conflicts. It is necessarily incomplete given the identified information gaps (previous section) but provides a useful overview and starting point for considering management options.

6.1.1 Structure

For the purposes of this project, the study area was divided into three sections (as described in Section 4.1), as shown in Figure 53, based on geomorphic and waterway characteristics as follows:

- Northern Section – Broadwater north of the Seaway (7,474 ha)
- Mid-Section – Nerang River, associated canal estates and lakes (1,995 ha)
- Southern Section – Tallebudgera and Currumbin Creeks and associated canal estates (322 ha)

Within each section the Strengths, Weaknesses, Opportunities and Threats (*i.e.* SWOT) were considered based on existing spatial and temporal patterns of use, economic and ecological values, and where relevant, administrative/management arrangements. Subheadings differ between sections depending on availability of data and relevance. Note that in some cases figures may be duplicates of those provided in preceding sections; they are provided here for convenience of reference.

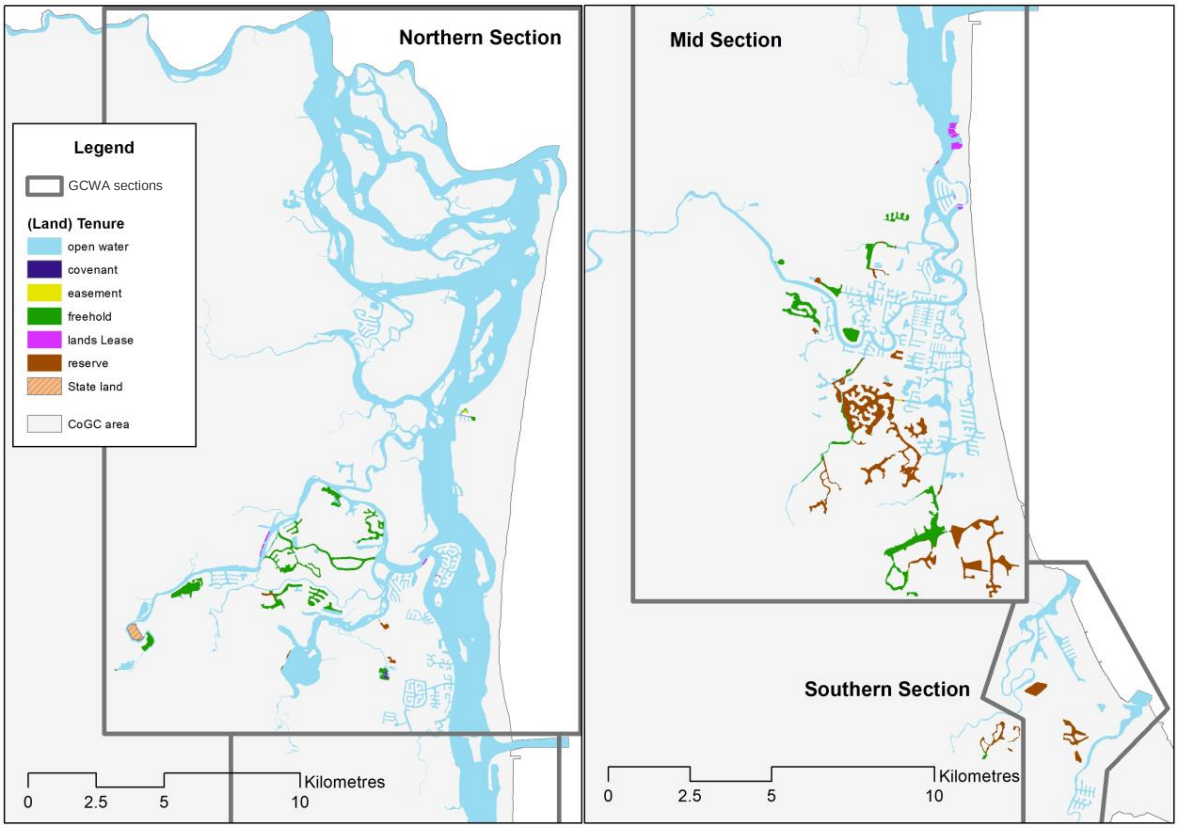

Figure 53: The three sections of the GC waterways with tenure registered in the Queensland lands title register (extracted from land parcels captured in the Queensland cadastre, May 2017).

6.2 Northern Section: Broadwater

6.2.1 Strengths

Together with the ocean beaches, the Northern Section of the GC waterways constitutes what most would consider to be the Gold Coast's most valuable natural asset.

6.2.1.1 Spatial

This section provides smooth and protected natural waters and artificial waterways either very close to or within high density urban development, as well as safe access to open coastal waters (during most weather conditions). This promotes a broad spectrum of water-based recreational activities that are readily accessible, either directly (canal estates) or within less than a half an hour drive (boat ramps, jetties, etc.). Compared to the Mid-Section and Southern Section, access to the Northern Section of the GC waterways is largely unrestricted for small craft, or by height or other potential waterway obstructions for larger craft (Figure 54).

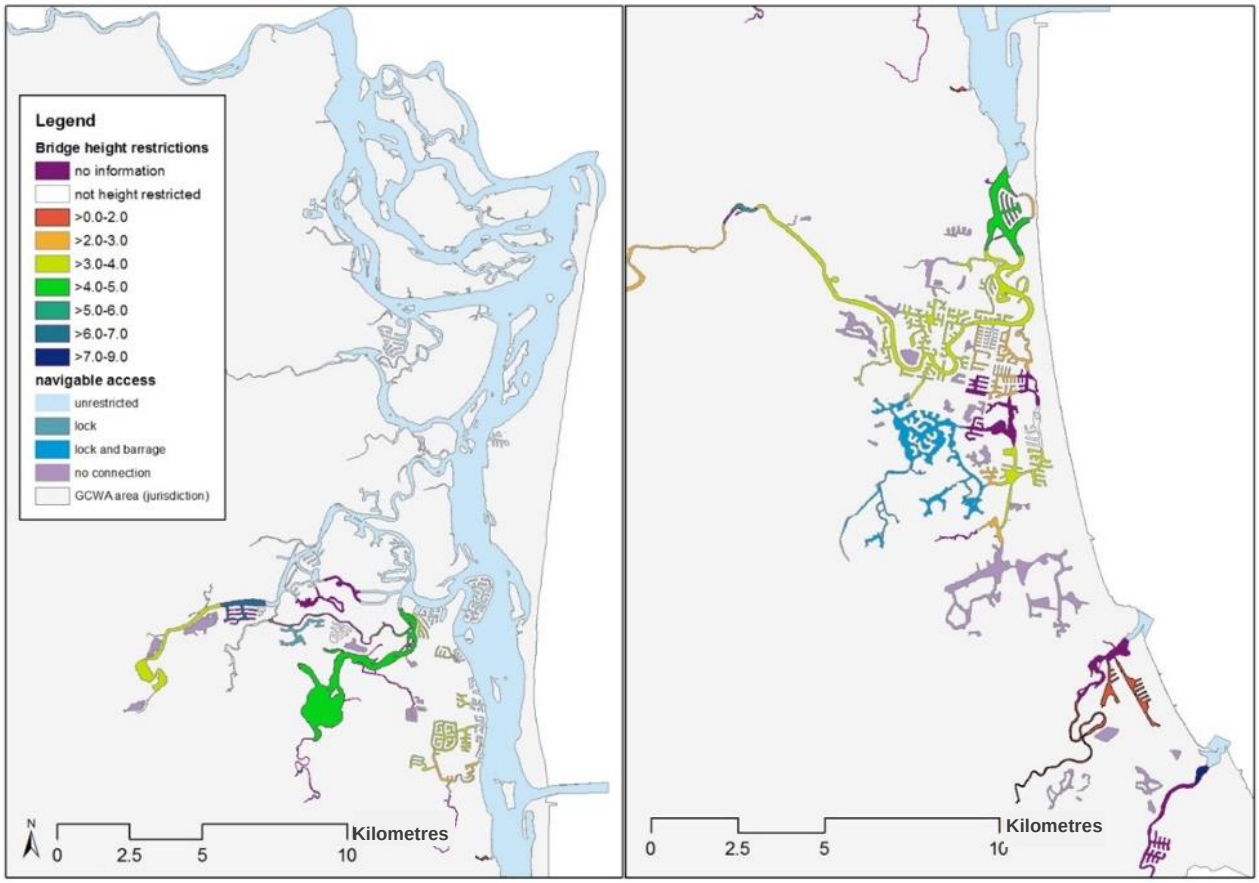

Figure 54: Boating access restrictions within the GC waterways.

The Broadwater is by far the largest section of the GC waterways and allows for overnight trips, either staying on board or using one of several onshore camping, resort or boating club facilities (depending on the type of vessel).

Apart from a small fleet of fishing vessels and regular dredging activities, waterway uses are generally recreational and tourism-focused (i.e. no known conflicts with large commercial vessels, military or resource extraction activities).

6.2.1.2 Economic

Ease of navigational access, well-developed road connections and the scenic backdrop of estuarine waters and habitat have promoted high-value real estate development and the establishment of a (recreational) marine industry precinct (*i.e.* the Gold Coast Marine Precinct (GCMP)). The high (but unquantified, refer Section 5, Gap Analysis, for details) number of recreational fishers, bait collectors, sailors and other on-water and island-based activities are assumed to make a substantial economic contribution – principally fuel, bait, food and drink supplies.

6.2.1.3 Scenic contrast and amenity

The location of the Broadwater places high value, high density urban development in close proximity to high value natural assets (e.g. RAMSAR wetlands, State Marine Protected Area (MPA), island Environmental Parks and Reserves) that provide largely unmodified, tranquil natural settings, especially north of Sovereign Islands.

6.2.1.4 Ecological

Despite being an enclosed estuary, the Jumpinpin Channel/Bar and Gold Coast Seaway openings and their resulting north to south flow regimes ensure high flushing rates of the system and therefore good water quality. While subject to some disturbance, the north section has the most substantial areas of intact marine habitats (saltmarsh and mangroves, seagrass, intertidal sand and mud flats, subtidal sediment substrates; Figure 55), which in turn support all the nature-based activities (above), but particularly fishing, crabbing, bait collecting and non-extractive appreciation (such as bird watching). These are also important, and internationally recognised, habitats for migratory and resident waders, shorebirds and coastal raptors (see Section 4.2).

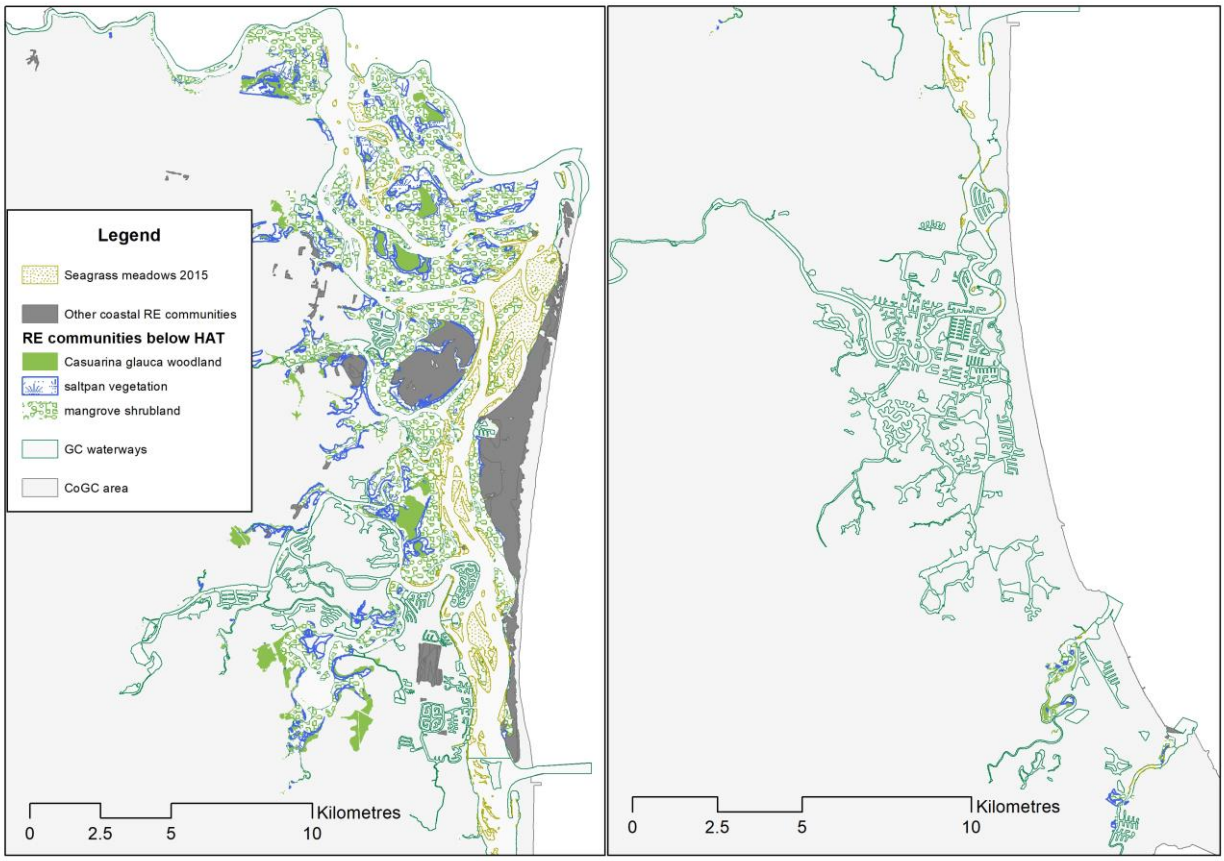

Figure 55: Regional Ecosystem mapping within and adjacent to the GC waterways.

Human-made hard substrates in the Northern Section of the GC waterways, including extended rock walls around the Seaway entrance, and canal estates, provide habitat for reef fish assemblages, which in turn support targeted fishing, from both small vessels and from the rock walls themselves.

6.2.2 Weaknesses

6.2.2.1 Spatial

Most parts of the estuary are shallow with relatively few narrow channels for navigating vessels with draughts in excess of half a metre or even less (especially at low tide), which restricts movement of vessels and concentrates densities of large vessel traffic (Figure 56).

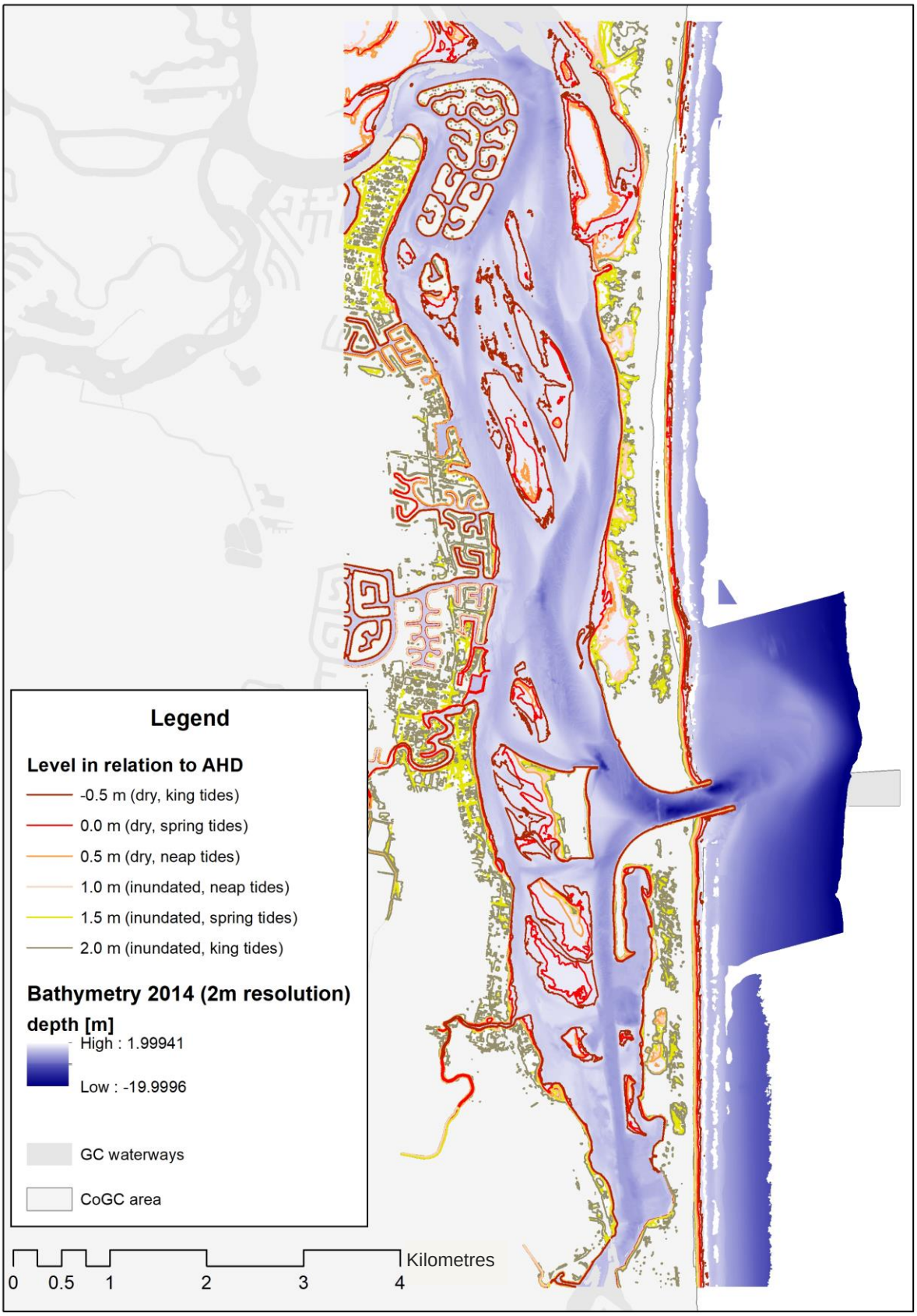

Figure 56: LIDAR-derived bathymetry for the Northern Section of the GC waterways.

While the density of urban development in areas south and west of the Broadwater can continue to increase by going 'up' (allowing greater building heights), the area of the waterway is fixed by its essentially planar (2D) dimensions, so the capacity to absorb higher densities of use is limited and finite.

The Northern Broadwater can be affected by inputs from the Logan/Albert Rivers and their catchments (especially after major rain events). These have been repeatedly rated for their poor ecological health in comparison to other river systems in SEQ (Healthy Land and Water Report Card, 2018).

6.2.2.2 Temporal

The highest vessel densities occur during special holidays (Easter, Christmas) and on some long weekends (e.g. Australia Day). Outside of these particular times, for the majority of the year, recreational vessel numbers are almost an order of magnitude lower compared to those on peak holidays (Figure 57).

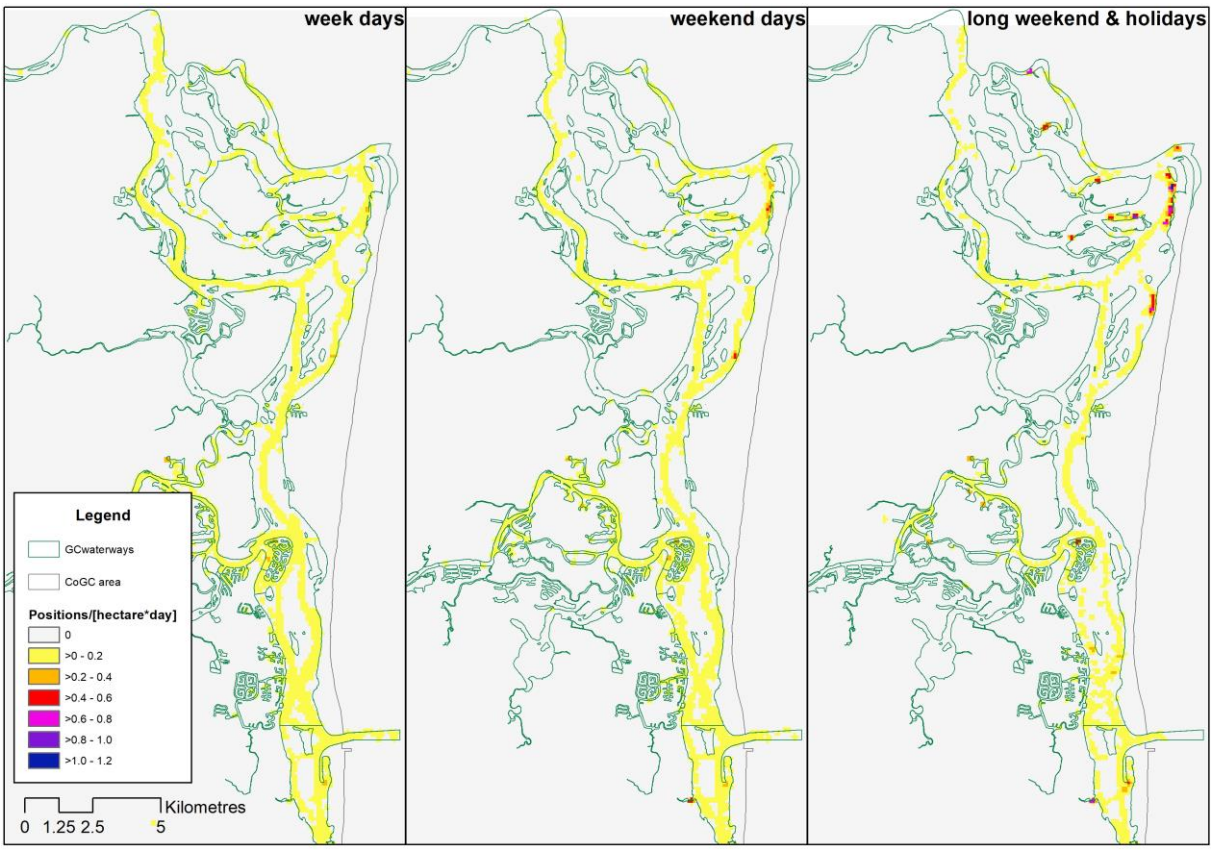

Figure 57: Differing densities of use of the GC waterways for weekdays, weekends, and public holidays.

6.2.2.3 Administrative and operational

At this stage, different aspects of the management of marine uses on the Broadwater are undertaken by a range of authorities and administering legislation across all three levels of government (local, state, federal). Integration and co-ordination of information and planning across these levels within a discrete spatial area such as the GC waterways may be challenging.

As a partial consequence, there is no identified centralised source of data to support management decisions – this has become clear during the course of this study. There is a need for a central repository of spatial, economic and ecological datasets relevant to the GC waterways, to allow coordinated planning for and review and assessment of, management initiatives.

Compliance with vessel traffic rules are often difficult to monitor and certainly more expensive to enforce (compared to road rules where automated systems can be used). However, as reported in the literature review, a major determinant of users' compliance to rules is if they observe the rules being enforced on others.

6.2.3 Opportunities

6.2.3.1 Spatio-temporal separation

A number of recreational activities occurring on the waterways of the Gold Coast Broadwater are already quasi-separated spatially and temporally. For example, larger vessels are generally confined to deeper channels, although smaller shallow draught vessels (such as PWCs, especially with their jet propulsion system) can still utilise almost all areas. Similarly, weather conditions mostly separate windsurfers and kite surfers from jet skis or powerboats. However, more could be done to segregate incompatible uses by designating certain areas for certain uses at certain times (e.g. by deploying small marker buoys similar to those used in the Whitsunday section of the GBRMP for cordoning off no-anchor zones), similar to the requirements for road users. Additionally, representatives of local clubs could be encouraged to take on a stewardship role for particular sections of waterway and during relevant events (e.g. rowing regattas). Current data suggests that PWC-related accidents and incidents are not increasing concurrent with increases in registration for vessels in similar size classes – therefore there is a window of opportunity to put effective controls in place (e.g. regulatory or education based) before vessel density becomes unmanageable.

6.2.3.2 Automated surveillance

Much of the high intensity and overlapping areas of uses are located close to the shoreline. Installation of some form of automated surveillance equipment would assist in improving co-ordination and efficiencies of policing the behaviour of waterway users.

6.2.4 Threats

In light of the Gold Coast's projected population growth, ultimately the biggest threat to the current status of the Northern Section of the GC waterways, and particularly the Broadwater, would be failure to contain incompatible and irresponsible uses, as has occurred elsewhere (e.g. Florida, Thailand; see Literature Review, Section 2). Resulting impacts could include:

- damage to the physical structure of the waterways themselves (bank erosion and sedimentation from boat wakes).
- loss of, or damage to, associated ecological and environmental values such as raptor nest sites, low-tide roosts for migratory waders, seagrass beds through increased sedimentation, mangrove and saltmarsh communities from bank undercutting and shoreline erosion, fish and invertebrate habitat through declining water quality.
- negative impacts on the amenity of other users, such as disturbance of anchorage sites from boat wakes, excessive noise and 'nuisance' from powered recreational and commercial vessels.
- economic impacts resulting from declining users, particularly visitor experience and loss of international reputation, as well as declining satisfaction of local residents and recreational users.
- more seriously, increased probability of incidents and injury because of increased vessel densities and/or failure to adequately separate conflicting uses. A key, and difficult to predict component of this, is the emergence of new and more affordable on-water technologies, e.g.:
    - introduction of hydrofoils to stand-up paddle boards (SUPs) and windsurfers, plus

electric hydrofoil boards – which are more difficult to manoeuvre, travel at high speed and are likely to use similar areas to jet skis and small powerboats.

- automated production of surfboards, especially SUPs etc., or inexpensive self-drive propulsion systems for any recreational watercraft (widespread use of autopilot systems).

Figure 58: SWOT summary for the Northern Section of the GC waterways.

The caveat to both Sections 6.2.3 and 6.2.4 is that the movements and density of the numerically dominant users of the waterway, that is, recreational users of small (< 8 m) trailerable vessels, are largely not captured by the existing datasets. Proxies are available from estimates derived from information contained in club and user group websites, but these may not be representative, and while patterns may be apparent, absolute densities are not available. This can only be resolved by a targeted survey program, and/or the use of anonymised mobile phone location data sources from telecommunications companies (See Gap Analysis, Section 5).

6.3 Mid-Section: Nerang River and central canal estates

6.3.1 Strengths

6.3.1.1 Economic

The extensive artificial waterways constructed along both sides of the Nerang River are a key component of the Gold Coast's local and international identity, and real estate remains an important economic driver. Some sections of these waterways and their residential dwellings are used by commercial operators as the backdrop for parts of their waterway tours.

6.3.1.2 Recreational

This section of the GC waterways includes long stretches of sheltered, mostly artificial waterways that are limited to smaller craft because of height restrictions imposed by road and pedestrian bridges. These settings provide the most reliable calm water conditions for competitive, long distance inland water sport activities such as kayaking and rowing, as well as recreational and fitness-based activities, as reflected in the maps derived from shared fitness activities (such as Strava, MapMyFitness; Figure 59).

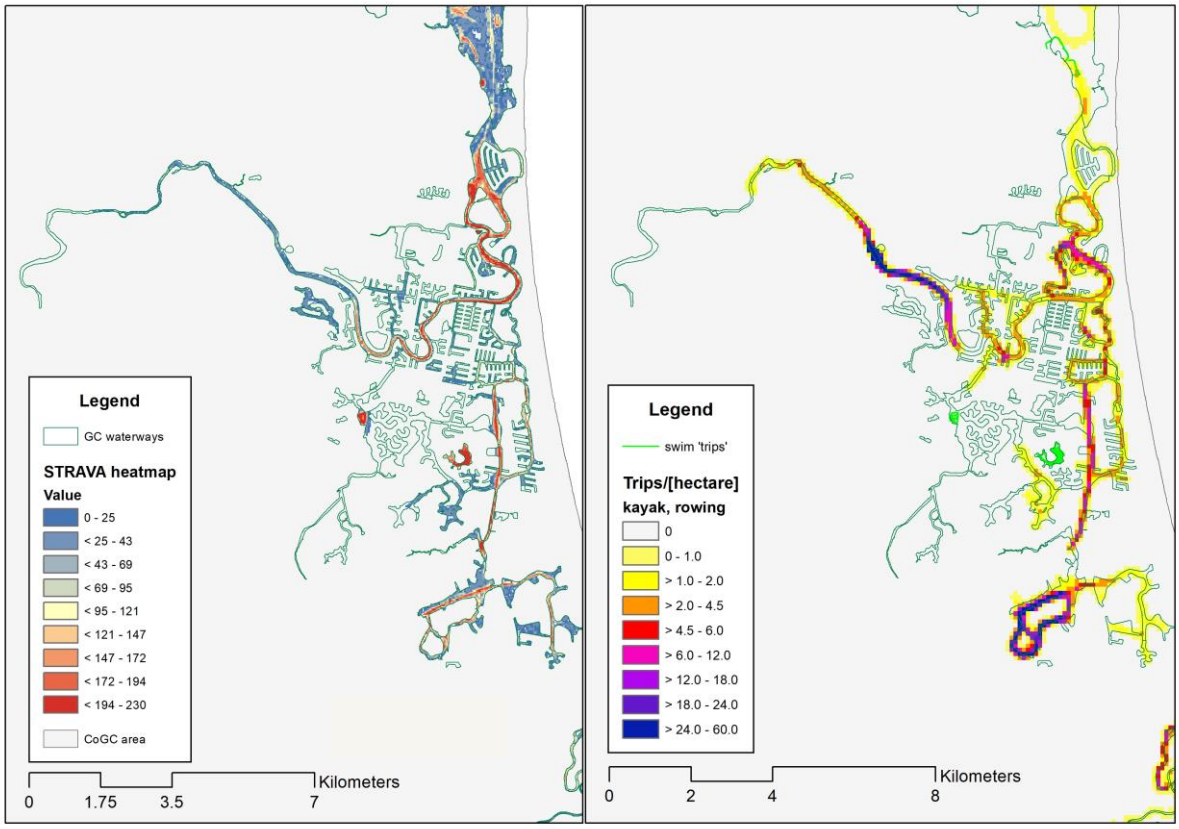

Figure 59: Fitness mapping data heatmaps for the Mid-Section of the GC waterways using STRAVA (left) and MapMyFitness (right) data.

Similarly, a number of lakes not connected or tentatively connected to the Nerang River system (e.g. Lake Orr, Silvabank Lake, refer Map E1 in Appendix E for details) are important for unpowered craft recreational activities.

6.3.1.3 Ecological

A large proportion of the Nerang River shoreline, plus all the artificial waterways, are lined with hard substrates to stabilise the shoreline (Figure 60). This, in addition to other in-water hard structures such as private pontoons, jetties, piles and bridge pylons provide hard surfaces that supplement natural reef substrates by providing surfaces for settlement and growth of algae and marine invertebrates, which in turn support fish and mobile invertebrate assemblages.

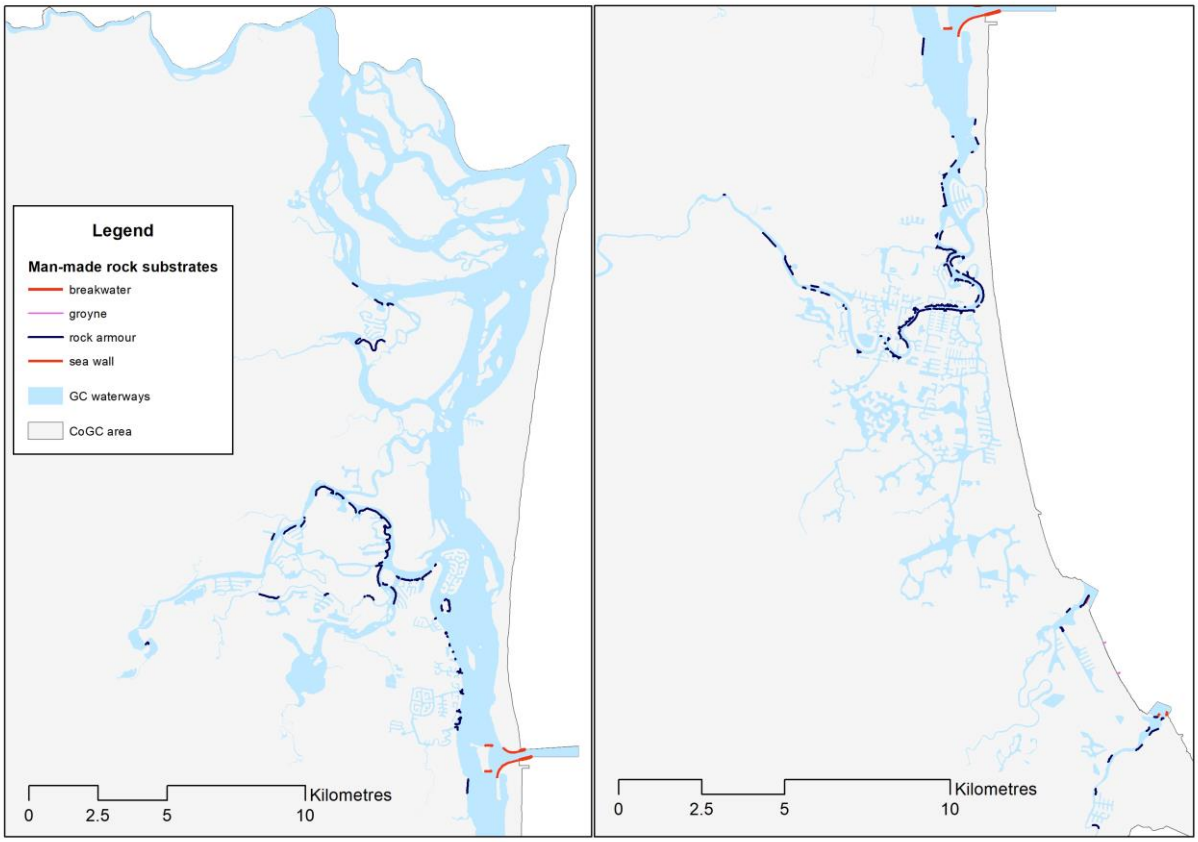

Figure 60: Human-made hard structures lining major waterways within the GC waterways (canals not included).

6.3.2 Weaknesses

6.3.2.1 Ecological

Artificial waterways including canals have limited tidal flushing, especially with increasing distance from the river connection, and water quality can be poor (low DO, increased nutrient concentrations and possible contaminants) which limits their value as fish habitat. During rainfall events, these canals receive much of the urban run-off and associated contaminants and refuse. This can result in pulses of poor-quality water which is eventually transported down the river and ultimately out to sea through the Gold Coast Seaway. Large quantities of refuse from urban run-off is often deposited on the ocean beaches of South Stradbroke Island and further north.

Older canal systems have sandy intertidal areas that provide breeding habitat for sand flies and midges, that requires ongoing management.

6.3.2.2 Recreational

The mostly calm water conditions and, in some areas, narrow width of the waterways, bring together two mostly incompatible uses: non-powered craft (rowing boats, kayaks and SUPs) and powered craft such as PWCs, runabouts and trailerable motorboats. The latter group can create significant wakes that interfere with the operation of non-powered craft. Speed limits are in place in many parts of these waterways, but infringements are common (Figure 61).

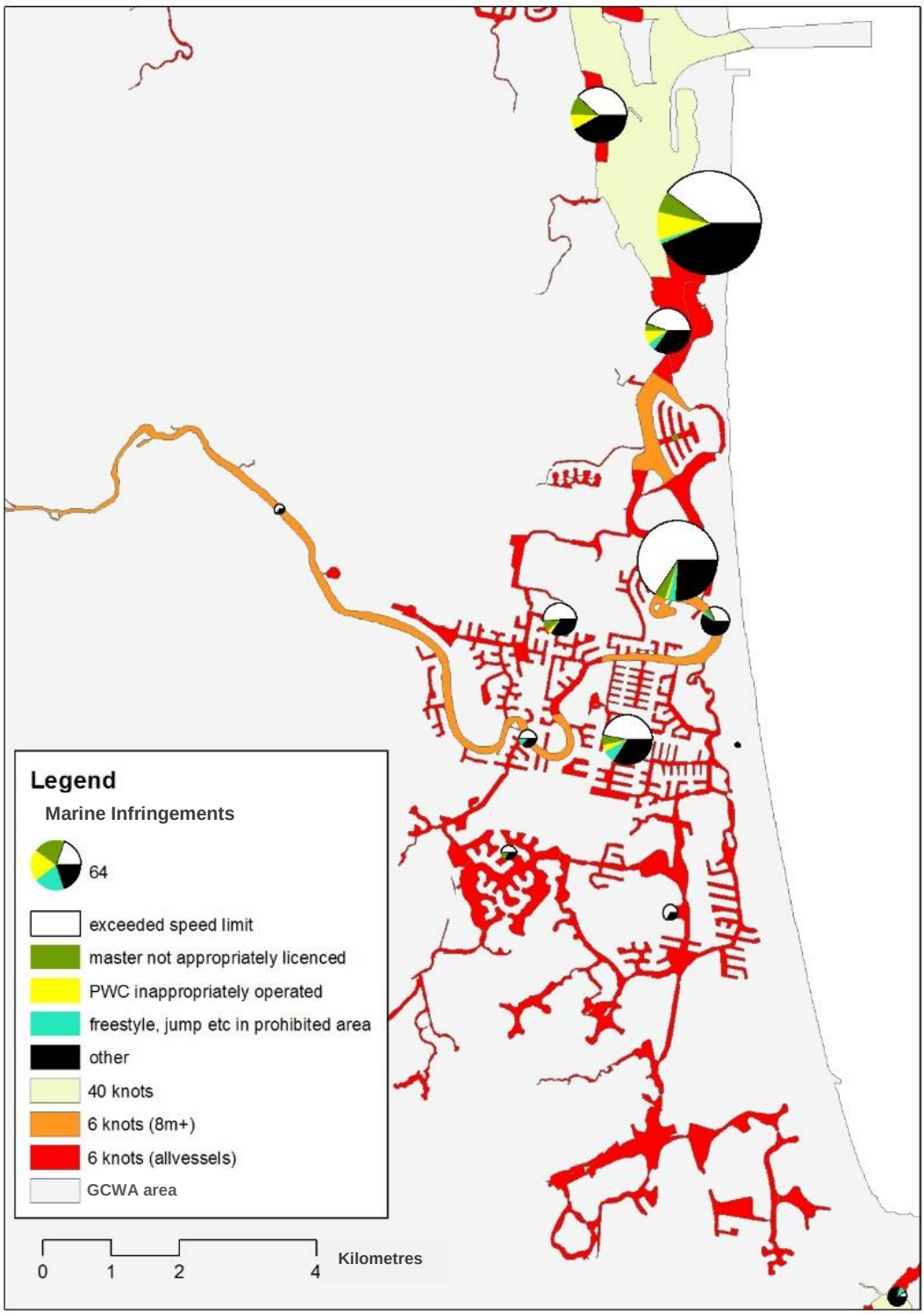

Figure 61: Frequency and type of marine infringement notices issued in the Mid-Section of the GC waterways, overlaid on the speed limit restriction zones for the area.

6.3.2.3 Amenity

On narrow canals, powered craft generate noise in close proximity to residential dwellings, which can become a nuisance to home owners and their guests.

6.3.3 Opportunities

These extensive calm waterways, and the associated backdrop of the City skyline, can be further utilised for unpowered recreational and competitive activities, which themselves may prove a drawcard, provided that the conflicting uses (above) can be adequately managed.

6.3.4 Threats

The key threat, as in the Northern Section of the GC waterways, is the increased risk of incidents, accidents or injury if incompatible activities cannot be appropriately managed, such as through the use of spatial or temporal separation. The range of activities occurring is less complex, but the non-powered activities to which these waterways lend themselves are more vulnerable to disturbance, incident or accident (these craft are small, slow, low to the water, and the occupants are unprotected). The calm water surfaces of these artificial waterways provide ideal conditions for learning how to operate watercraft, so there may be the added issue of occupants being relatively inexperienced.

An additional factor is the emergence of new and/or low-cost technologies, including do-it-yourself (DIY) electrically driven surf boards and wake boards. There is no data currently available on the growth or distribution of such activities, but it is reasonable to assume that they may be trialled on calmer waterways, introducing another use category within these waters.

Figure 62: SWOT summary for the Mid-Section of the GC waterways.

6.4 Southern Section: Tallebudgera and Currumbin Creeks

6.4.1 Strengths

Currumbin Creek is the southern-most access point of the GC waterways to the near-shore reefs and fishing spots, as well as being a popular location for novice board riders. It is frequently used by surf school and board hire operators of all types (long boards, SUP, short boards, etc.).

Both Currumbin and Tallebudgera Creeks have shallow protected stretches of ocean-quality water on sandy substrates with associated sandy beaches, and so are ideal, and heavily patronised by families with young children, especially on weekends and holidays.

Similarly, the protected nature of the waterways, and the relatively unmodified shore, lined with mangrove and riverine vegetation, of the inland stretches, provides scenic amenity for exploration trips using small, shallow draught vessels. These are mostly unpowered (kayaks, canoes, SUPs, etc.). Surf kayaks are also popular in the waters around the creek mouths. The popularity of use of these areas is evident in fitness tracking data (such as MapMyFitness, Strava; Figure 63).

Tallebudgera Creek is used by schools for safe kayaking tours as part of school camps (grades 5-8) and has its own Surf Life Saving Club (SLSC) to protect swimmers.

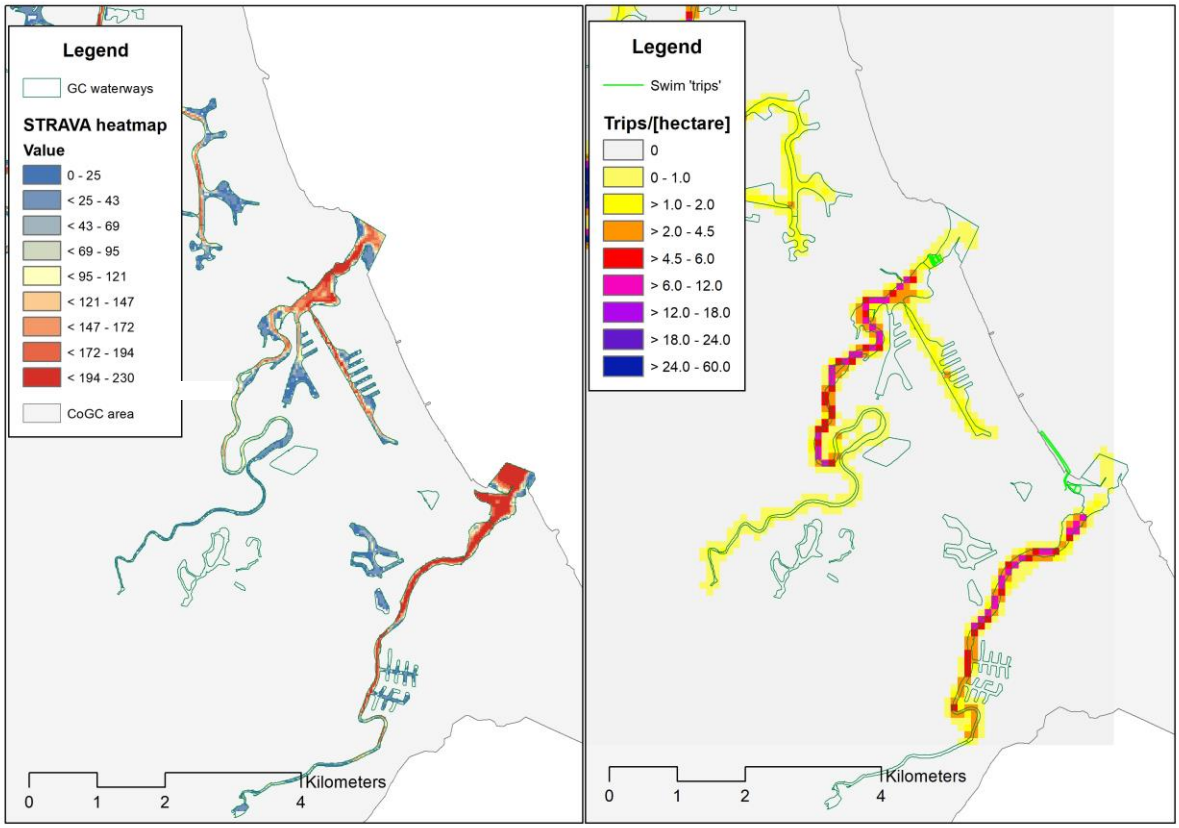

Figure 63: Fitness mapping heatmaps for the Southern Section of the GC waterways.

6.4.2 Weaknesses

The range of uses described above, combined with the small area of water (<322 ha, including areas periodically inundated) in which these uses are concentrated, raises issues about the compatibility of

powered versus non-powered uses of the creeks. This issue is no doubt faced by the many waterways adjacent to populated areas throughout Queensland, and the rest of the world, with similar characteristics and appeal with a similar offering of recreational opportunities.

Mapping of reported marine incidents shows a concentration at the mouths of both creeks (Figure 64). Both creeks have shallow and shifting sand bar entrances that can be difficult to navigate and may be affected by debris washed down during heavy rainfall events.

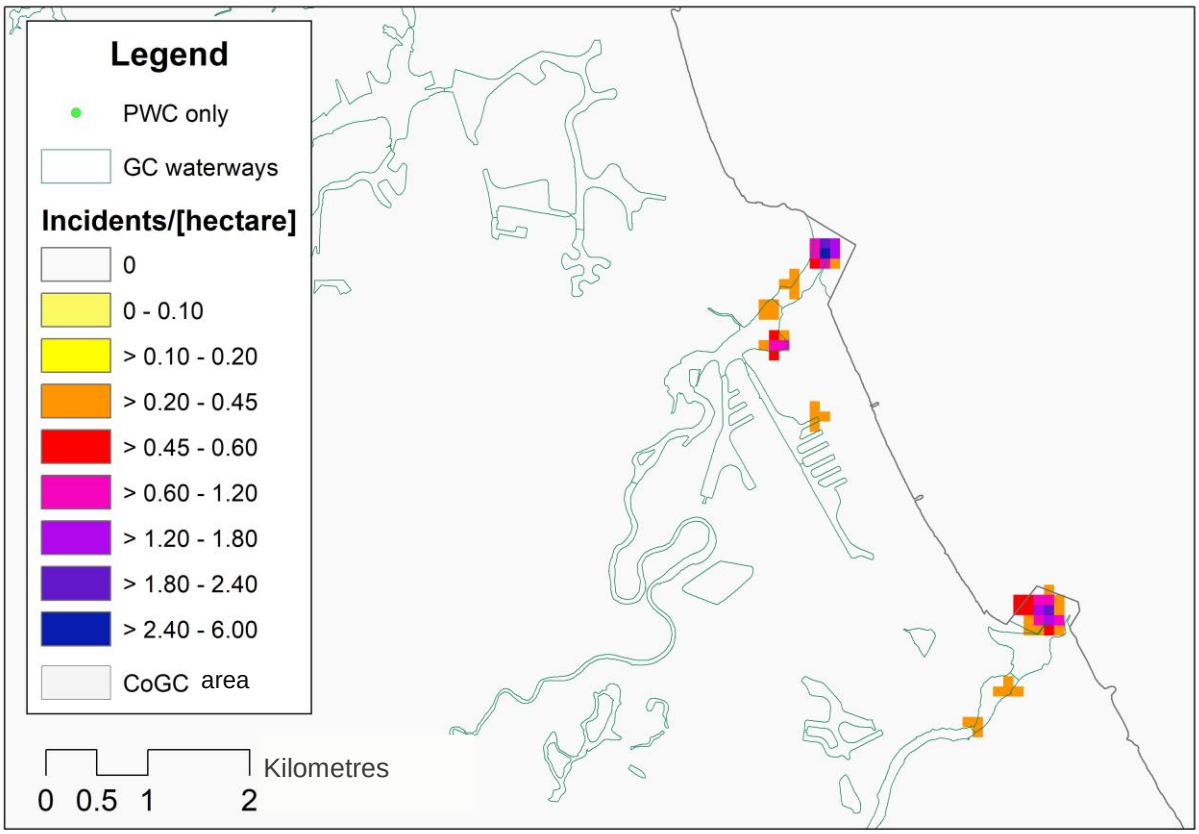

Figure 64: Reported marine incidents per hectare between 2007 and 2017 in the Southern Section of the GC waterways.

6.4.3 Opportunities

There are advantages to retaining the quiet 'family friendly' nature of recreational opportunities within the Southern Section of the GC waterways. The high scenic value of the setting is a strong contrast to the artificial waterways of the Mid-Section. Promotion of the area for non-competitive, low intensity uses retains the perceived character of the creeks, as well as underpinning real-estate values.

6.4.4 Threats

The creeks and associated riparian areas of the Southern Section are likely to be most susceptible to the immediate impacts associated with climate change, including sea level rise and increased severe weather events. The creeks receive largely unabated run-off from nearby sections of the hinterland with steep slopes (Figure 65), so that there may be increases in storm flows and associated risks (increase in debris, higher chances of injury to board riders, damage to small powered watercraft).

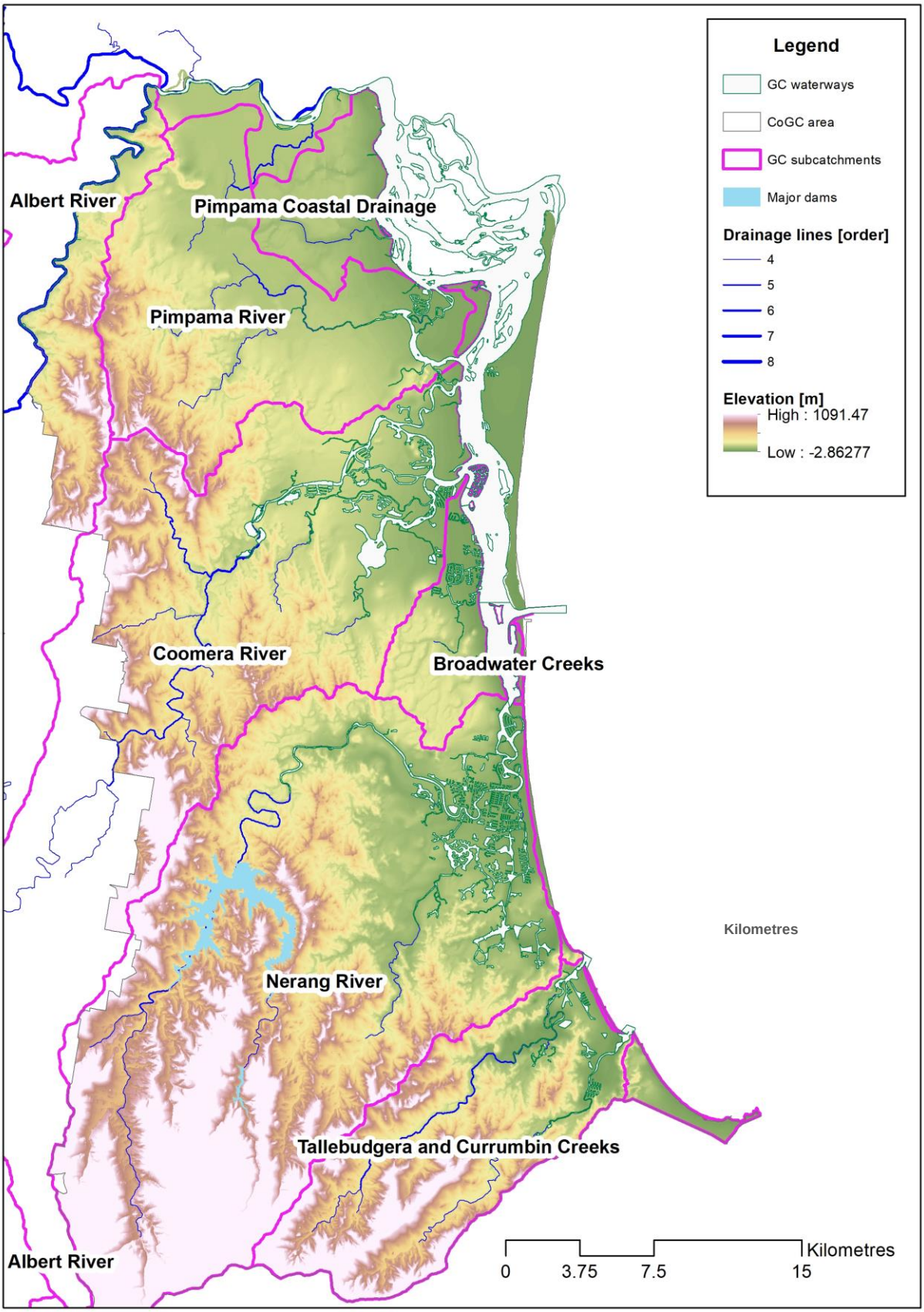

Figure 65: Gold Coast area catchments and drainage.

Risks of conflicting uses at creek mouths are already apparent in reported marine incident data (see Figure 64) and this is likely to increase over time and also with climate change because of more variable weather patterns, flow regimes and therefore more rapid changes to bar conditions. The risks associated with new forms of very small high-speed powered craft, as described in Section 6.3.4 above, in these quiet protected locations, are similar.

Figure 66: SWOT summary for the Southern Section of the GC waterways.

6.5 Conclusions

The preceding analyses show that each section of the GC waterways has a distinct mix of strengths, weaknesses, opportunities and threats. As the largest section, and the most diverse in terms of the mix of vessels and use types, and ecological values, the Northern Section has perhaps the greatest potential for conflict between users, both in terms of the frequency of such interactions, and the area over which they may occur. Bear in mind that the analyses to date are almost certainly an underestimate, given the data gaps shown in the previous section. The overarching threat in the Northern Section would be the

failure to identify and manage emerging conflicts, especially given the predicted population growth in the northern part of this section.

The most distinct strength for the Mid-Section of the GC waterways is the extensive reaches of protected waters suitable for fitness-based and competitive water sports, both in the Nerang River, and in canals and adjoining lakes. To date, existing height and access restrictions, combined with speed limits, appear to (mostly) effectively separate these uses from incompatible activities. However, infringement data shows that exceeding the speed limits is the most common offence and given that the literature shows that compliance is a key to user satisfaction, vigilance is required here. Proposed activities that could present a conflict (including emerging technologies, and perhaps the proposed high-speed ferry service) will need to be carefully assessed.

Hotspots for conflict at the mouths of the Southern Section creeks are well known, both anecdotally and quantitatively – so while these are episodic in nature, depending on surf, tides and sea conditions, as well as day type (weekday, weekend, holiday), they are theoretically predictable, and therefore in theory manageable, for instance through a combination of regulation, enforcement, education and outreach. The quiet and peaceful nature of the natural vegetation-lined inner parts of the creeks, is, anecdotally, perceived to be under threat from more intrusive forms of use such as backyard encroachments, illegal removal of vegetation (for views), illegal track and trail construction, informal boat launching points, etc.

In spite of these differences, there are common themes that run through the preceding analyses. A broad mix of uses takes place within the GC waterways. While there are known conflict hotspots, in terms of incidents, accidents and injuries, these are in absolute terms relatively rare. Set against the backdrop of increasing population, and concurrent rises in registrations of small vessels, this should be seen as a significant opportunity. There is a window in time over the next several years, given stable and invested governance, to set in place outward looking and inclusive management practises, adaptive monitoring and data gathering, to identify and ameliorate potential conflicts, in order to avoid the mistakes of other jurisdictions.

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8 Appendices

Appendix A: Extract from Gold Coast Waterways Authority Act 2012

The Gold Coast Waterways Authority (GCWA) was established under Queensland law in 2012 by the passage of the ***Gold Coast Waterways Authority Act 2012***. The following extracts from the Act outline its purposes and the areas to which it applies:

"An Act to provide for the establishment of the Gold Coast Waterways Authority"

"Section 3 Purposes of Act and their achievement

(1) The main purpose of this Act is to deliver the best possible management of the **Gold Coast waterways** at reasonable cost to the community and government, while keeping government regulation to a minimum.

(2) Other purposes of this Act are to do the following—

(a) plan for and facilitate the development of the **Gold Coast waterways** over the long term in a way that is sustainable and considers the impact of development on the environment;

(b) improve and maintain navigational access to the **Gold Coast waterways**;

(c) develop and improve public marine facilities relating to the **Gold Coast waterways**;

(d) promote and manage the sustainable use of the **Gold Coast waterways** for marine industries, tourism and recreation.

(3) To achieve the purposes, this Act establishes the Gold Coast Waterways Authority to strategically plan for, facilitate and manage the development and use of the **Gold Coast waterways**."

"Section 7 Meaning of Gold Coast waters and Gold Coast waterways

(1) The Gold Coast waters are all of the waters within the following areas—

(a) the Gold Coast City local government area;

(b) the area near the mouth of Currumbin Creek described in schedule 1, section 1;

(c) the area near the Gold Coast Seaway described in schedule 1, section 2;

(d) the area near the mouth of Tallebudgera Creek described in schedule 1, section 3.

(2) The **Gold Coast waterways** are all of the waterways in Gold Coast waters."

“Schedule 1 Gold Coast waters

1 Area near the mouth of Currumbin Creek

For section 7(1)(b), the area near the mouth of Currumbin Creek is the area within the following boundary—

(a) starting at the point on the boundary of the Gold Coast City local government area that is latitude 28°07.598' south, longitude 153°28.791' east (the **starting point**);

(b) to latitude 28°07.393' south, longitude 153°28.972' east;

(c) to the point on the boundary of the Gold Coast City local government area that is latitude 28°07.476' south, longitude 153°29.219' east;

(d) along the boundary of the Gold Coast City local government area to the starting point.

2 Area near the Gold Coast Seaway

For section 7(1)(c), the area near the Gold Coast Seaway is the area within the following boundary—

(a) starting at the point where the boundary of the Gold Coast City local government area intersects the high water mark on the south side of the northern breakwater of the Gold Coast Seaway (the **starting point**);

(b) along the high water mark to the easterly tip of the northern wall of the Gold Coast Seaway;

(c) to latitude 27°55.90' south, longitude 153°27.06' east;

(d) to latitude 27°56.10' south, longitude 153°27.06' east;

(e) to the eastern tip of the southern wall of the Gold Coast Seaway;

(f) along the high water mark of the northern side of the southern breakwater to the point where the high water mark intersects the boundary of the Gold Coast City local government area;

(g) along the boundary of the Gold Coast City local government area to the starting point.

3 Area near the mouth of Tallebudgera Creek

For section 7(1)(d), the area near the mouth of Tallebudgera Creek is the area within the following boundary—

(a) starting at the point on the boundary of the Gold Coast City local government area that is latitude 28°05.425' south, longitude 153°27.580' east (the **starting point**);

(b) to latitude 28°05.584' south, longitude 153°27.879' east;

(c) to the point on the boundary of the Gold Coast City local government area that is latitude 28°05.898' south, longitude 153°27.713' east;

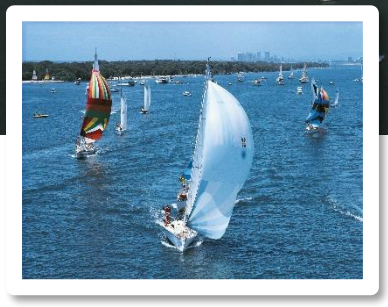
(d) along the boundary of the Gold Coast City local government area to the starting point.”

Appendix B: Literature review search terms

The following Boolean search string was used to find sources which might answer the question of interest. Note 'TS' is a 'topic' search was used for the Web of Science database, the string was modified for other databases.

TS=(marine OR coast* OR canal* OR estuar* OR watercourse OR waterway OR harbor OR harbour OR embayment OR bay) AND TS=(conflict OR 'negative interaction*' OR incompatible OR 'incompatible use' OR 'competing use') AND TS=(jetski* OR jet-ski* OR jetpack* OR jet-pack* OR jet-boat* OR jetboat* OR 'stand up paddleboard*' OR sup OR 'personal watercraft' OR sailboard OR dingh* OR tinn* OR scooter* OR kayak* OR canoe* OR rowing OR outrigger OR flyboard OR surfing OR 'surf ski*' OR 'water ski*' OR 'recreational activity' OR freestyl* OR 'kite ski*' OR 'whale watch*' OR whalewatch* OR aquaduck OR aqua-duck OR cruis* OR 'hire boat' OR hireboat OR 'house boat' OR houseboat OR charter OR watersport OR water-sport OR tour* OR 'eco cruis*' OR 'outdoor recreation' OR 'nautical tourism' OR 'water tourism' OR 'water recreation' OR ecotour OR 'tourism impact' OR adventure OR safari OR speedboat* OR 'motorised vessel' OR watercraft OR boat* OR yacht* OR sail* OR catamaran OR launch* OR mooring OR berthing OR anchor* OR fishing OR angling OR diving OR snorkel* OR collect* OR crabbing OR bait OR net* OR trawl* OR 'life sav*' OR 'life guard' OR swim* OR bath* OR photography OR nature-watching OR regatta OR triathlon OR 'sporting event*' OR 'boat rac*' OR 'aquatic event*' OR 'boat ramp*' OR 'boat-ramp*' OR marina* OR police OR enforcement OR compliance OR pilotage OR slipway* OR slip* OR shipyard* OR 'adjacent land use' OR gentrification OR maintenance OR storage OR 'marine park*' OR 'marine protected area' OR refuel* OR 'go slow' OR 'marine services' OR aquaculture OR waterfront OR 'fish farm*' OR mariculture OR ecotourism OR 'search and rescue' OR 'environment* protection' OR ferry OR barge OR 'water taxi' OR access OR safety OR 'loss of income' OR 'income loss' OR 'land use' OR 'waterside development' OR construction OR dredg* OR sewage OR sewerage OR 'artificial structures' OR 'boat wash' OR 'riparian vegetation' OR 'vessel traffic' OR 'citizen science' OR 'marine educat*' OR conservation* OR environmentalis* OR visitor OR touris* OR seaplane OR sea-plane OR 'sea plane') AND TS=('increased traffic' OR crowd* OR overcrowd* OR congestion OR 'more vessels' OR 'more users')

Appendix C: Visitor usage summary



Gold Coast Waterways

Visitor Usage Summary

August 2018

Prepared by EarthCheck for: Gold Coast Waterways Authority
In conjunction with: Envirosphere Consulting

Table of Contents

Background

The Gold Coast boasts a spectacular network of waterways made up of five main rivers, numerous creeks, lakes, canals and the magnificent Broadwater. Some 480 kilometres of rivers and streams, as well as 774 hectares of lakes, dams and canals, wind their way through the city's landscape to our famous ocean beaches[1].

EarthCheck, as part of a team led by Envirosphere Consulting, was contracted to conduct an environmental scan of usage of the Gold Coast waterways on behalf of the Gold Coast Waterways Authority (GCWA). The GCWA is a Queensland Government statutory body tasked with managing and enhancing Gold Coast waterways for the enjoyment of locals and visitors. GCWA's vision embraces sustainable management of Gold Coast waterways which improves their total quality, both now and in the future, in a way that maintains the multiple aesthetic, economic, environmental and social values on which they depend[2].

GCWA has responsibility for inland waterways including rivers, canals, lakes and dams within the City of Gold Coast local government area as well as the areas at the mouth of the Nerang River, Currumbin Creek and Tallebudgera Creek[3]. GCWA's area of responsibility (Figure 1) extends from south of the Logan River to the New South Wales border.

The GCWA's mission is to retain and build on its successful infrastructure program, while adopting a broader focus on supporting sustainable commercial and recreational uses of the waterways as the Gold Coast population grows. They are tasked with managing these multiple uses and ensuring acceptable behaviours, as well as preserving environmental values including water quality and waterways resilience[4].

GCWA is supported by its Science and Innovation Advisory Committee (SIAC) which provides strategic advice related to scientific, technical and innovation directions, and provides oversight to the implementation of programs under the Environmental Management Framework for managing sand resources in Gold Coast waterways, and other matters related to the management of Gold Coast waterways[5].

The Gold Coast Waterways Management Strategy (2014-2023) was developed to guide the responsible management of the Gold Coast's waterways and the Authority's land-based reserves. Since the first Strategy, two significant imperatives – increased congestion and resilience in response to increasing use and climate change impacts – have emerged which will significantly shape the GCWA's long-term plans and planning approach[6].

This evaluation of the waterways usage included a comprehensive review of tourism and leisure use of the waterways including a review of strategic positioning of the waterways as part of Gold Coast's tourism proposition and unique selling points, preparation of a visitor profile (including trip numbers, nights, and visitation patterns), analysis of visitor activities (focusing on coastal and aquatic activities) and quantification of the value of tourism in the region, focusing on marine/ coastal and aquatic activities.

Utilising Tourism Forecasting Panel forecasts, the estimated future tourism demand for the Gold Coast Waterways was analysed, to model the potential growth scenario - highlighting anticipated visitation trends over the next decade.

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[1] City of Gold Coast. *Protecting waterways*. Available online at: http://www.goldcoast.qld.gov.au/environment/gold-coast-waterways-573.html. Last viewed: 17/08/18.
[2] Gold Coast Waterways Authority. *Our Vision*. Available online at: https://gcwa.qld.gov.au/about/. Last viewed: 17/08/18.
[3] Gold Coast Waterways Authority. *Our Organisation*. Available online at: https://gcwa.qld.gov.au/our-organisation/. Last viewed: 17/08/18.
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[5] Gold Coast Waterways Authority. *Our Committees*. Available online at: https://gcwa.qld.gov.au/committees/. Last viewed: 17/08/18.
[6] Gold Coast Waterways Authority. *Our Strategy*. Available online at: https://gcwa.qld.gov.au/about/. Last viewed: 17/08/18.

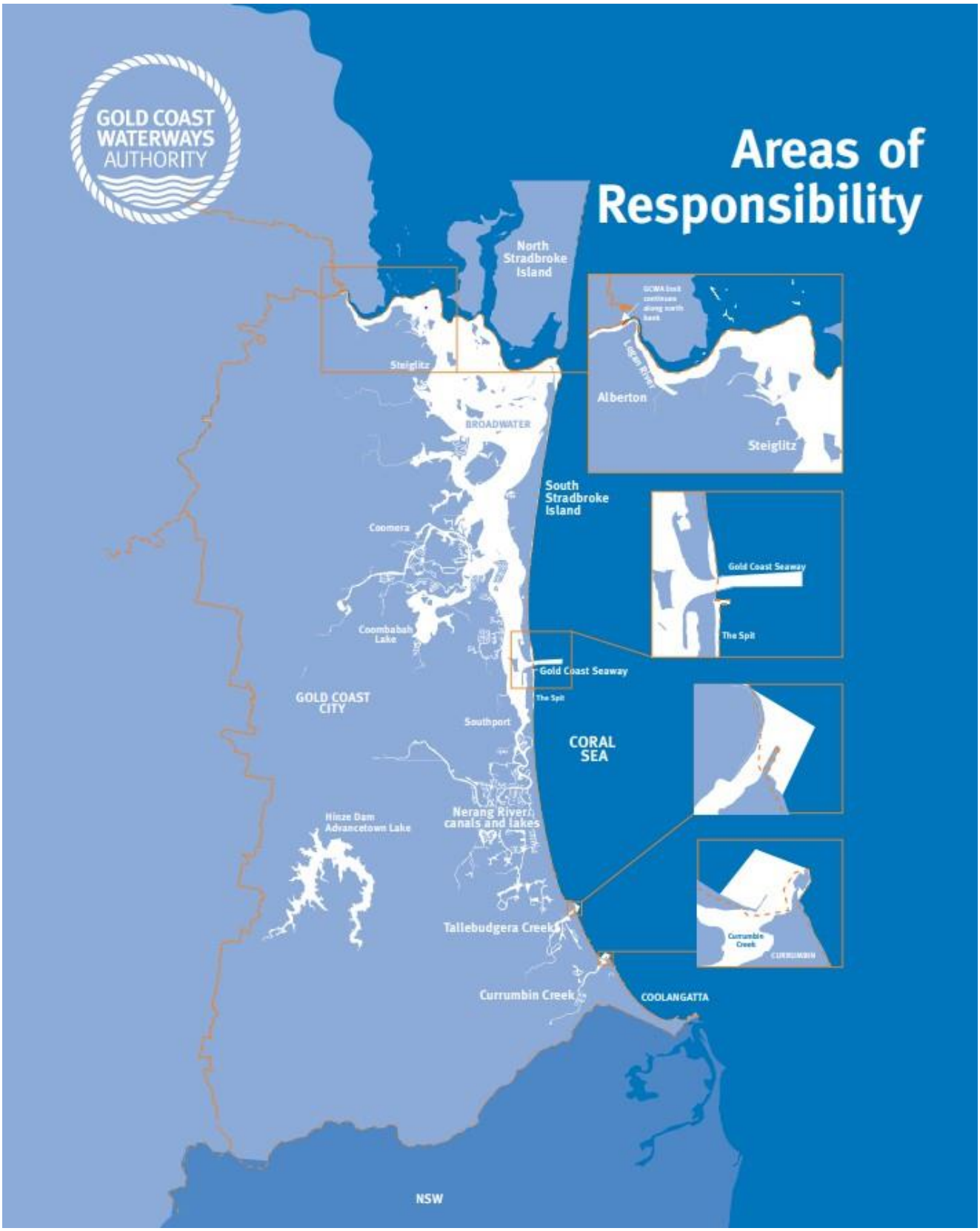

Figure 1: Map of the Gold Coast waterways[7].

[7] Gold Coast Waterways Authority. *Explore*. Available online at: https://gcwa.qld.gov.au/maps/. Last viewed: 17/08/18.

Methodology

In order to estimate the user market of the Gold Coast Waterways, the Tourism Research Australia visitor survey data was used as a proxy for overall use and visitation.

Tourism Research Australia (TRA), a branch within the Tourism Division of Austrade, is Australia's leading provider of quality tourism intelligence across both international and domestic markets. TRA data equips industry with information to strengthen their marketing and business decisions. TRA data also underpins government tourism policy and help improve the performance of the tourism industry for the benefit of the Australian community.

EarthCheck has paid access to the raw Tourism Research Australia's **National and International Visitor Survey** data, allowing the Project Team to undertake a more in-depth analysis of the visitor profiles for the Gold Coast region and its surrounding peer group. This level of analysis gets to the heart of informed decision making.

Information is collected for each reported trip; their main destination for day trips, stopover locations for domestic and international overnight trips, their purpose of travel, accommodation used, travel party and other behavioural elements such as the type of activities they took part in whilst travelling.

Throughout this project, the TRA National Visitor Survey (NVS) and International Visitor Survey (IVS) data for both domestic and international visitors was extracted and analysed to gain insight into visitation to the Gold Coast, as a broader destination for relative context, and more specifically the regions surrounding the waterways.

The Gold Coast tourism region, as defined by TRA, was used for the broader overview of Gold Coast visitation to align with national and state reporting. Because visitation is attributed to visitors' descriptions of where they travelled, accurately pinpointing visitation on a granular level, such as Statistical Areas Level 2 (SA2's)[8] or suburbs, is not possible – thus limiting any chance to isolate waterway usage from surrounding areas.

To estimate visitation and usage of the Gold Coast Waterways, the visited geographic areas inclusive of, and directly bordering the waterways[9] (where a waterway fell between two statistical areas), were isolated and custom data drawn from Tourism Research Australia for these regions. While the SA2 regions do not overlap exactly with the waterways, they are the best proxy of visitation to the waterways in the absence of commissioned, primary research.

Visitor and Usage Forecast

Projections of visitors, visitor nights and expenditure have been undertaken in order to understand the future size and scale of the Gold Coast visitor market, as well as the visitor mix.

Visitor marketing projections are based on the long-term forecasts generated by TRA's Tourism Forecasting Reference Panel (the Panel). The forecasts are based on global and domestic economic conditions, aviation capacity and airfares (to, from and within Australia), domestic accommodation capacity and room rates, seasonality, as well as significant events affecting source markets. The Panel forecasts represent 'business as normal' in the sense of the best available forecast based on trends impacting on the visitor economy. These forecasts are updated annually.

The number of visitors interested in taking part in particular activities were also projected using the TRA reference panel forecast, rather than current growth rates for individual activities / group – as TRA estimates (although more conservative) are more stable and take into account the broader market conditions.

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[8] The SA2 is the smallest area for the release of Australian Bureau of Statistics (ABS) non-Census and Intercensal statistics. Within cities, the SA2s represent gazetted suburbs rather than functional areas, but can vary based on geography, population, historical recognisable areas and the need to avoid arbitrary subdivisions.

[9] Summarised in Appendix A.

Definitions

Day visitor:
Day visitors (or same day visitors) are those domestic residents who travel at least 50 kilometres away from home (round trip), are away from home for at least 4 hours, but do not spend a night away from home as part of their travel. Overnight visitors who undertake day trips are excluded, as is routine travel for such purposes as commuting for work.

Domestic overnight visitor:
A traveller is a visitor to a destination if they stay one or more nights in a particular region that is not their home area while travelling within Australia. It is possible for a respondent to be a visitor to several locations depending on the number of tourism regions they have visited while on their trip.

International visitors:
Overseas visitors coming to Australia for a period of less than twelve months are interviewed upon departure. As for overnight travel, only international travellers who have been away from home for less than 12 months are within the scope of this study. International visitors departing by sea are not interviewed; but account for less than 1% of the total visitors to Australia.

Activities Analysis:
The analysis of 'visitor activities' in the areas surrounding and inclusive of the waterways is principally drawn from data in the National and International Visitor Surveys where respondents are asked to list the 'activities' they participated in when visiting a destination. For higher level analysis, these activities are grouped in broad categories by theme (as per Appendix A), which have been developed in line with Tourism Australia's strategic marketing directions e.g. *Aquatic and Coastal* or *Food and Wine*.

Waterway Boundaries
The North Broadwater Waterways region: Stretches down the length of South Stradbroke Island from south of the Logan River to the Gold Coast Seaway.
The Broadwater South Waterways region: Stretches from the Gold Coast Seaway to the Nerang river.
The Nerang River and Central Waterways region: Stretches from south of the Nerang river to Burleigh Waters.
The Tallebudgera and Currumbin Creeks region: Stretches from Burleigh Heads to south of Currumbin Waters / Bilinga.

Data Sources

The **National Visitor Survey (NVS)** commenced in January 1998. The aim of the survey is to gather data relating to the demographics, travel behaviour and attitudes of Australian residents towards tourism and to monitor changes and trends in these characteristics. The NVS is collected via a Computer Assisted Telephone Interview (CATI) and has an annual quota of 120,000 interviews (60,000 landline and 60,000 mobile). An overnight trip refers to trips where visitors stayed at least one night, a minimum of 40km from home (round trip).

The **International Visitor Survey (IVS)** represents the most comprehensive source of information on international visitors to Australia. It has been operating since the early 1970s and is jointly funded by the Commonwealth, State and Territory Governments under the guidance of the Australian Standing Committee on Tourism (ASCOT). Every year, the International Visitor Survey samples 40,000 departing, short-term international travellers aged 15 years and over who have been visiting Australia. The survey is conducted by Computer Assisted Personal Interviewing (CAPI) in the departure lounges of the eight major international airports; Sydney, Melbourne, Brisbane, Cairns, Perth, Adelaide, Darwin and the Gold Coast. Prior to 2005 the sample size was 20,000 per year. There are currently 8,000 interviews conducted in Mandarin, Japanese and Korean each year. The IVS is weighted to the number of short term overseas visitor arrivals aged 15 years and over. Figures from the Overseas Arrivals and Departures (OAD) database are provided by the Department of Immigration.

1. Gold Coast Visitation and Trends

1.1. The Wider Region

In the year ending (YE) December 2017[10], the Gold Coast **visitation peaked at 13.1 million visitors**.

This included approximately **3.5 million domestic overnight** and **6.5 million domestic day trip visitors**, representing a **0.2% increase p.a.** in domestic overnights and a **2.5% increase p.a. in day trips** from 2007. This is a **total growth of 16.3%** over the past 10 years.

In terms of international visitors, the Gold Coast region saw approximately **1.04 million international visitors**, the result of a 2.5% p.a., or 24.9% total, increase in visitation over the past 10 years.

For Queensland as a whole, domestic overnight visitors grew by 4.9% p.a. and international visitors by 4.3% p.a.

Using the forecast figures issued by the Tourism Forecasting Panel, it is estimated that visitation to the Gold Coast will grow to approximately **16.2 million visitors by 2030,** with international visitors set to account for 13.3% of all visitors – compared to its current 9.4%.

1.2 The Waterways

During the year ending December 2017, Gold Coast waterways received approximately **2.8 million domestic overnight** and **4.9 million domestic day trip visitors**. This represents an **8.3% increase p.a.** in domestic overnights and a **16.3% decrease p.a. in day trips** from 2007.

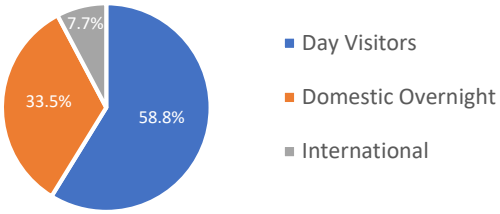


Figure 2 – Gold Coast Waterways Visitor Mix

In terms of international visitors, the Gold Coast region saw approximately **640,000 international visitors**, the result of a 2.6% p.a. increase in visitation since 2007.

Overall, the regions around the Gold Coast waterways received a **total of 8.3 million visitors** in 2017, an **increase of 114.0%** over the past 10 years.

Visitation to the areas surrounding and inclusive of the waterways accounts for approximately 63% of total visitation in the Gold Coast region.

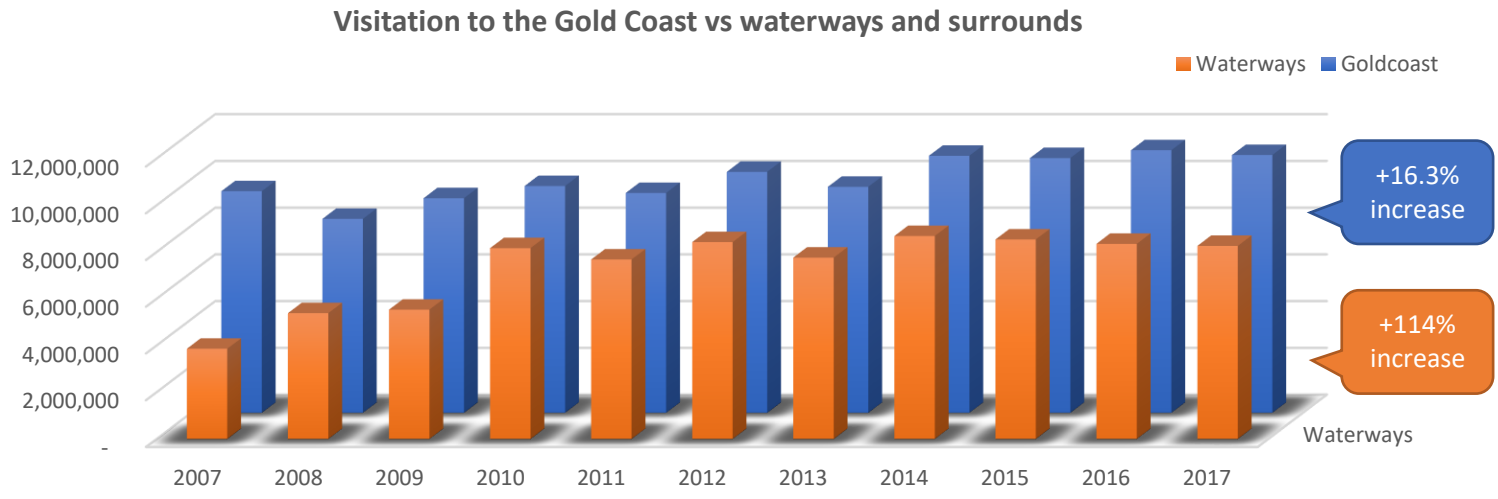


Figure 3 - Visitation Trends (2007-2017)

[10] All visitation figures refer to data from Tourism Research Australia, for the year ending December 2017

As demonstrated in Figure 3 above, the 10-year trend for visitation growth to the regions surrounding the Gold Coast waterways is more pronounced than visitation to the wider Gold Coast.

2 Visitor Nights

2.1 The Wider Region

The Gold Coast attracted a total of **22.7 million visitor nights** for year ending (YE) December 2017. There were **13.5 million domestic visitor nights** in Gold Coast during YE December 2017, and **9.2 million international** visitor nights. This represents a decrease of **1.6% in domestic nights and 2.3% increase in international visitor nights over the past 10 years.**

The average length of stay (ALOS) for domestic overnight visitors is 3.8 nights, whilst international visitors stay approximately 8.9 days in the region. The overall region average for YE December 2017 was 5.0 nights per overnight visitor.

2.2 The Waterways[11]

There were **10.4 million domestic visitor nights** in the areas around the Gold Coast waterways during YE December 2017, and **6.4 million international** visitor nights. This represents an increase of **4.1% for domestic visitor nights** and a **2.5% increase in international visitor nights** from 2007.

Overall there were a total of 16.8 million visitor nights spent in the areas surrounding the Gold Coast waterways, averaging a **3.5% growth trend p.a**. or a **total growth of 34.7%** since 2007.

The ALOS for domestic overnight visitors is 3.8 nights, whilst internationals stay approximately 10.0 days in the region.

The ALOS for all Gold Coast visitors has decreased over the past 10 years with those visiting the regions inclusive of and directly surrounding the waterways seemingly more affected (ALOS ↓1.0% p.a. vs ↓2.0% p.a.).

The opposite seems to be true for the past 5 years specifically, however, in that although still decreasing; both domestic (ALOS ↓1.8% p.a. vs ↓1.1% p.a.) and international visitor ALOS was less affected than the overall region (ALOS ↓2.5% p.a. vs ↑2.1% p.a.).

3. Seasonality [12]

Visitation data from the National Visitation Survey indicates a very strong weekend pattern to domestic day visitation. Whilst the Gold Coast region averages **770,000 day visitors during the week** (Monday to Friday), the **average number of day visitors to the coast on a Saturday or Sunday is 2,000,000.**

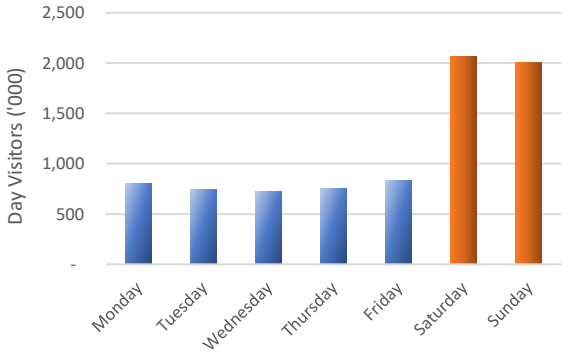


Figure 2 - Day Visitor Seasonality highlighting days of highest visitation

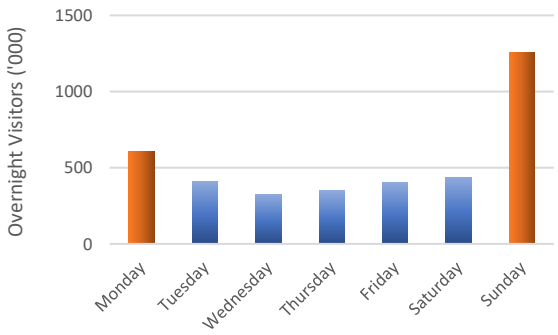


Figure 3 - Day of Return (Domestic Overnight Visitors) highlighting days of highest visitation

Domestic overnight visitation showed a similar weekend-heavy pattern with most domestic visitors (33.2%) returning home from their domestic trip on a Sunday, and a further 16.0% stating they returned on a Monday.

Using 3-year averages[13] for the *month of return* data documented in the National Visitor Survey, Figure 6 shows a fairly consistent level of domestic overnight

[11] Noting the limitations on providing specific 'waterways' data (refer 'Methodology', page 5, for details).

[12] Seasonality is based on 3-year averages over the period 2015-2017.

[13] 2015-2017

visitation for the Gold Coast, with the exception of December/January.

Marginal seasonality is **consistent with school holidays** (March/April, June, September, December), with the month following a holiday period (highlighted) registering a higher number of returns.

The highest number of returns are recorded in January (11.3%), with the lowest returns in June (7.1%).

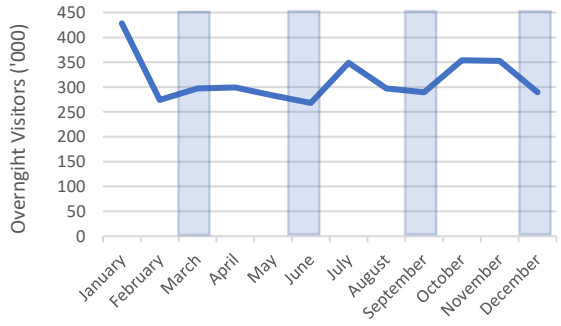


Figure 6 – Month of Return (Domestic Overnight Visitors)

Unfortunately, sample size limitations prevented analysis of seasonality for the waterways regions.

4. Purpose of Visit

4.1 The Wider Region

The primary purpose of domestic overnight visitation to the Gold Coast is to ***holiday*** **(53.2%), followed by *visiting friends and family* (32.4%) and *business* travel (11.0%)**. The 5-year trend data shows a fairly **steady increase** of approximately 5.8% p.a. for visiting *friends and family* and 10.6% p.a. for *business* travel since 2012. Holiday travel for domestic overnight visitors has **remained largely consistent**.

International travel to the Gold Coast has **a very clear *holiday* focus**, with 79.8% of visitors stating this as their purpose of travel. Approximately 15.0% of international visitors indicated that they visited the Gold Coast to *visit friends and relatives,* **whilst 3.3% travelled for *business*.**

4.2 The Waterways

Travel to the Gold Coast waterways **remains largely for *holiday* purposes**, with 77.8% of international visitors stating this as their purpose of travel. A slightly higher percentage of international visitors to the waterways indicated that they visited the Gold Coast to ***visit friends and relatives* (15.9%)** – compared to those in the region as a whole, however, and similarly, **4.1% travelled for business** (compared to 3.3% of general visitors).

The primary purpose of domestic overnight visitors to the areas around the Gold Coast waterways regions is to *holiday* (55.4%, ↑3.2% higher than general visitors), followed by *visiting friends and family* (31.0%, ↓1.4% lower than general visitors) and *business* travel (10.6% – similar to general visitors).

The **5-year trend data shows a fairly steady increase of approximately 3.5% p.a.** for visiting *friends and family* (↓2.3% slower than general visitors) and **7.5% p.a. for *business* travel** (↓3.1% slower than general visitors) since 2012. Holiday travel for domestic overnight visitors **has remained largely consistent**.

5. Origin of Visitors

5.1 The Wider Region

Day Visitors

More than 8 out of 10 domestic **day trips** originate from within **Queensland (86.2%),** whilst an additional 8.6% of day visitors travel from North Coast NSW. The Gold Coast's proximity to the border means it is well placed to capture visitors from both states.

The fastest growing day visitor market is from within the Gold Coast itself, with more respondents stating that they went on a 'day trip' within their wider region of residence. Given the size and reach of the Gold Coast, it could very well be that more residents are exploring their 'own back yard'. A limitation of this data however, is the classification minimum of a 50 km round trip – which does not capture many of the immediate / local daytrips.

Domestic Overnight

Domestic overnight visitors are **primarily intrastate** (48.5%), with the majority of these visitors from the **South East Queensland (SEQ) region** (41.5%).

The **main domestic visitor markets from interstate are Sydney** (16.2% of visitors) and **Melbourne** (11.0%), with both of these **markets showing a steady growth** of 3.3% p.a. and 2.7% p.a. over the past 5 years respectively.

Table 1 - Origin of domestic overnight visitor

Home Region	Overnight Visitors	Trend (% p.a.)	% of all Overnight visitors
Brisbane	843,688	+2.3%	30.5%
Sydney	447,449	+3.3%	16.2%
Melbourne	305,230	+2.7%	11.0%
Sunshine Coast	153,282	+2.6%	5.5%
Darling Downs	150,978	-1.2%	5.5%
North Coast NSW	150,149	-4.7%	5.4%
Gold Coast	81,264	+7.3%	2.9%
Adelaide	70,755	0.0%	2.6%

International Visitors

As illustrated in Table 2, the **Chinese market** is currently the Gold Coast's largest international source market (308,986), followed by **New Zealand** (201,872) and the **United Kingdom** (70,385).

Table 2- Top 10 International Markets to Wider Gold Coast

Country of Residence	Visitors 2017	Trend (% p.a.)	% of Int. Visitors
China	308,986	+19.4%	28.9%
New Zealand	201,872	+3.5%	18.9%
United Kingdom	70,385	+6.3%	6.6%
Japan	64,698	+0.9%	6.1%
USA	39,218	+8.6%	3.7%
Taiwan	37,604	+27.8%	3.5%
Hong Kong	37,406	+26.0%	3.5%
Korea	33,859	+5.5%	3.2%
India	32,813	+28.5%	3.1%
Other Countries[14]	47,908	+9.4%	4.5%

In addition to being Gold Coast's largest international source market, the Chinese market is also the fourth fastest growing international market with an average growth of 19.4% p.a. – doubling visitor numbers between 2012 and 2017.

Other visitor markets who have doubled their visitation over the past 5 years include India (↑28.5% p.a.), Taiwan (↑27.8% p.a.), and Hong Kong (↑26.0 p.a.).

5.2 The Waterways

Table 3 outlines the number of international visitors to the Gold Coast waterways surrounds, from each of the listed countries during 2017. It also highlights the rate at which that market has grown over the past 5 years (2012-2017) and what percentage of the international visitor market they account for.

Unlike the wider Gold Coast area, the largest international source market for the Gold Coast waterway surrounds is **New Zealand** (163,815),

[14] TRA category as benchmarked to the Australian Bureau of Statistics, not all remaining countries not listed in this table.

followed by **China** (103,928) and the **United Kingdom** (49,714).

The fastest growing international source market for the geographic areas surrounding the Gold Coast waterways is India, with an average growth of 36.7% p.a. between 2012 and 2017. Other fast-growing markets include Hong Kong (↑35.2% p.a.) and China (26.9% p.a.).

Table 3- Top 10 International Markets to the areas surrounding the Gold Coast Waterways

Country of Residence	Visitors 2017	Trend (% p.a.)	% of Int. Visitors
New Zealand	163,815	+3.7%	25.6%
China	103,928	+26.9%	16.2%
United Kingdom	49,714	+4.8%	7.8%
Japan	48,543	-2.2%	7.6%
USA	27,046	+10.4%	4.2%
Singapore	23,647	-3.4%	3.7%
Hong Kong	23,398	+35.2%	3.7%
Germany	20,128	+9.2%	3.1%
India	19,620	+36.7%	3.1%
Other Countries	33,736	+8.7%	5.3%

Large, national tourism campaigns by Tourism Australia, like the recent *Outdoor Experiences Expo* held in conjunction with Tourism and Events Queensland (TEEQ) and Destination NSW in Hong Kong[15], and The India Travel Mission (2018)[16] in Jaipur, India supports and drives strong growth from these markets to the coast.

There are however a range of visitors experiences available within this geographic area, so care should be taken when making direct inferences about what activities motivate different nationalities.

More reliable inferences can be made through the international consumer profiling recently done by Tourism Australia[17] which shows that Aquatic and Coastal is considered a 'Top 5 important factor' to 35% of travellers from China, 22% of travellers from Hong Kong and 26% of New Zealand travellers.

6. Expenditure

6.1 The Wider Region

In 2017 (YE December), **domestic overnight visitor expenditure[18] reached $3.1 billion**, an increase of 9.0% from 2016. Domestic overnight visitors spend on average $238 per night - 4.6% more than in 2016.

International visitor expenditure **increased by 4.1%** from 2016 to 2017, coming in at **$1.2 Billion**. Overall spend per international visitor night is estimated as being $130 per night.

Day trip visitors decreased by 0.5% between 2016 and 2017, resulting in a 5.1% decrease in day visitor expenditure (down to $666.4 million in 2017). Similar results were also seen for Queensland day trip visitors (expenditure down 2.0%, to $4.3 billion). The average spend per visitor is $103 (per day trip).

Total expenditure for the Gold Coast region for 2017 therefore totalled $5.0 billion.

6.2 The Waterways

The average spend per visitor was assumed to remain consistent with general spend for the Gold Coast.

Based on the number of day visitors that visited the areas inclusive of and immediately surrounding the Gold Coast waterways, domestic overnight visitor expenditure is estimated at $501.7 million, a decrease of 3.2% from 2016 – attributed to a decrease in the number of daytrips taken to the waterways.

Despite a 0.8% decrease in domestic visitor nights, a 0.3% increase in total domestic overnight visitors and the increase in spend per visitor night contributed to overall expenditure by domestic overnight visitors increasing to $2.5 billion (up 8.1% since 2016).

The international visitor expenditure in areas surrounding the Gold Coast waterways for 2017 is estimated as being $830.8 million. International visitor nights to waterway areas increased by 3.8% from 2016, albeit slower than the 5.2% p.a. increase seen across the wider Gold Coast region. **Total expenditure for the regions including and surrounding the Gold Coast waterways therefore totalled $3.8 billion for 2017.**

[15] YMT Travel Expo, Tourism Australia
[16] The India Travel Mission (2018), Tourism Australia
[17] International Markets, Tourism Australia
[18] Based on visitor spend per day / night

7. Activity Market Analysis

High-quality, memorable experiences are the essence of tourism (Ritchie, Tung and Ritchie 2011). Great leisure tourism destinations draw people to actively want to travel there, truly experience the destination and stay for extended periods – thus creating more memorable experiences.

The more quality activities a visitor can engage with, the higher their overall experience will be classified, and the more likely they will be to not only return but recommend the destination to others.

The Gold Coast has the benefit of having an interesting mix of waterways, urban precincts, bayside villages, hinterland environs and expansive inland waterways and fertile countryside.

7.1 An Overview

Using the Tourism Australia national and international visitor survey *activity* data, an overview of the activities visitors engage in can be built – providing valuable insight into the visitor experience the average Gold Coast visitor has.

Activities relate to all activities visitors say they participated in whilst on their trip, measured through the National and International Visitors Survey.

This means that the number of activities can outnumber the number of visitors, as they can participate in multiple activities. **Trip Activities are the best way to increase visitors' expenditure during their trip, and possible length of stay as a follow on.**

7.2 The Wider Region

Over the past 5 years, *City based activities* have dominated visitor experiences on the Gold Coast, **accounting for almost half of all annual visitor activities (44.2%, Table 5 below).** These include shopping for leisure, eating / dining out, sightseeing and guided tours etc. (a full breakdown of the subcategories can be viewed in Appendix A). *Aquatic and Coastal activities* (fishing, snorkelling, beach and surf) is a clear second (22.1%), followed by *Natural Beauty* (visiting national parks, rainforests and botanical gardens) and *Food and Wine*.

Sports and Adventure activities includes all outdoor activities, but of particular interest is *water activities and sports.*

The average growth rate of visitors within each activity category in the Gold Coast, and more specifically the areas including and directly surrounding the waterways, have been highlighted in Table 4.

Table 4 – Activity Growth (2007-2017)

Activity Group	Gold Coast Growth (p.a.)	Waterways Growth (p.a.)
City Based	1.9%	11.9%
Aquatic and Coastal	2.0%	9.4%
Sports and Adventure	4.9%	8.9%
Wildlife	0.8%	8.0%
Food and Wine	2.2%	6.9%
History and Culture	0.5%	4.8%
Natural Beauty	0.8%	4.0%

Table 5 – Activity Analysis for Gold Coast and Waterways

2017	Gold Coast			Gold Coast Waterways		
	Number of People taking part in Activities	Current Activity Market share	% of Visitors who partake in activities	Number of People taking part in Activities	Current Activity Market share	% of Visitors who partake in activities
City Based	10,738,965	**44.2%**	97.3%	7,156,405	45.6%	86.6%
Aquatic and Coastal	5,383,549	**22.1%**	48.8%	**3,956,553**	**25.2%**	**47.9%**
Sport and Adventure	1,840,689	7.6%	16.7%	**1,222,942**	**7.8%**	**14.8%**
Food and Wine	2,041,840	8.4%	18.5%	1,184,101	7.5%	14.3%
Natural Beauty	2,276,893	9.4%	20.6%	1,034,989	6.6%	12.5%
History and Culture	1,288,735	5.3%	11.7%	682,360	4.3%	8.3%
Wildlife	743,244	3.1%	6.7%	463,013	2.9%	5.6%
Total activity numbers	24,313,915	100.0%	-	15,700,363	100.0%	-

7.3 The Waterways

During 2017 almost 4 million visitors took part in *Aquatic and Coastal* activities in the areas inclusive of and directly surrounding the Gold Coast waterways (Table 5). However, it should be noted that a major limitation in the data is that many of these activities occurred outside of the Gold Coast Waterways Authority area of jurisdiction. Furthermore, it is near impossible to extract what proportion of overall data may be represented by the Gold Coast waterways.

Analysis of visitor trends show the pure number of visitors taking part in *Aquatic and Coastal* activities have grown almost 4 times faster within the waterway areas (9.4% p.a.) over the past 10 years than the broader Gold Coast region (2.0% p.a.). This is a total growth of 94% in visitors taking part in *Aquatic and Coastal* activities, compared to the 20% overall growth in the broader region, as illustrated in Figure 7. This growth rate has eased somewhat over the past 4 years, in line with Aquatic and Coastal visitation to the wider region.

Visitors to these areas have a slightly lower level of participation in *Aquatic and Coastal Activities (*47.9%), (those taking part, as a proportion of all visitors to the areas surrounding the waterways), than visitors to the wider Gold Coast (48.8%).

This is probably due to the area defined as 'the areas inclusive of and directly surrounding the waterways' largely do not include a lot of the open beach areas.

Although a small selection of areas bordering the open beaches are captured as part of the subset of areas selected for isolation around the waterways, it can be expected that the broader coastal region would have a marginally higher participation rate in coastal activities than the isolated waterway areas.

Aquatic and Coastal Activities accounted for a larger proportion of all visitor activities (25.2%) within the areas inclusive of, and directly bordering the waterways than the broader Gold Coast area (22.1%) – in keeping with their primary geographic attributes.

Sports and Adventure activity market share amongst those who visit the areas inclusive of, and directly surrounding the waterways (7.8%), is largely consistent with the wider Gold Coast region (7.6%). Whilst the participation of those in the broader Gold Coast is higher, this could be attributed to any of the sports activities on the coast.

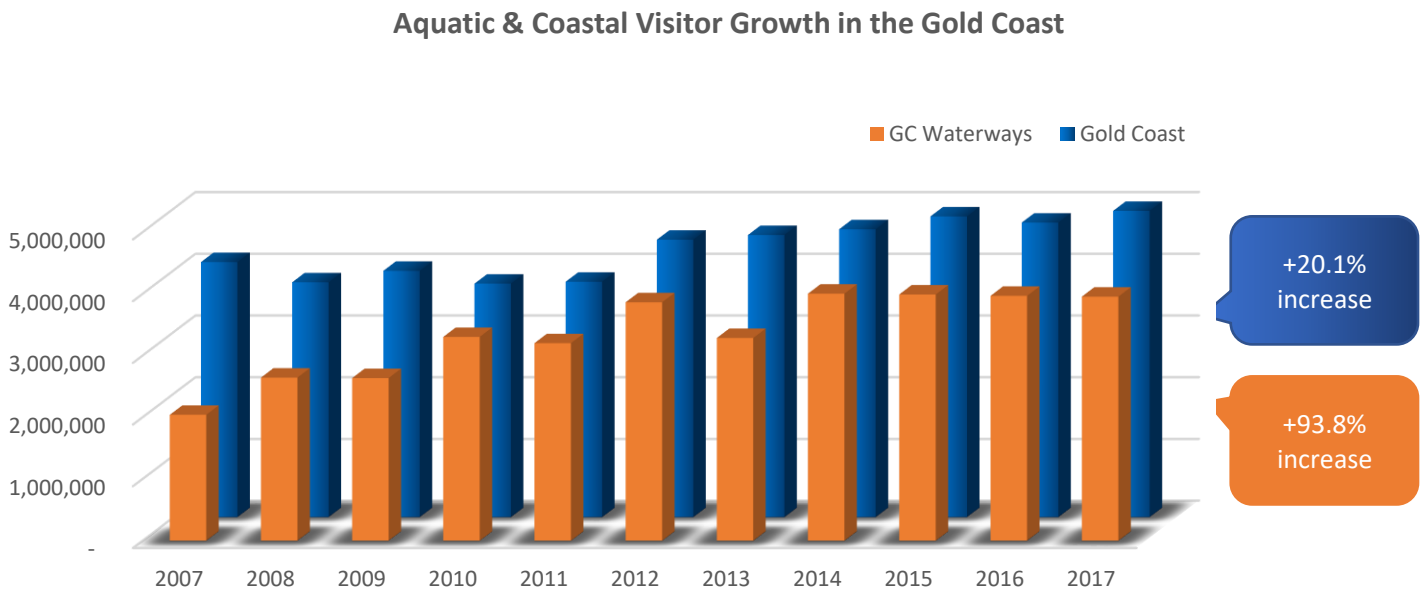


Figure 7 - Aquatic and Coastal visitation (2007-2017)

8. Regional and Trend Analysis

For the purpose of further analysis, the geographical areas surrounding the Gold Coast waterways was divided in 4 main regions[19].

- Broadwater North Waterways
- Broadwater South Waterways
- Nerang River and Central Waterways
- Tallebudgera and Currumbin Creeks

Table 5 (p.13) highlights the size of the visitor market for each of the regions.

A map outlining the borders of the chosen statistical areas can be seen on p.16. Further detail about the specific areas included within each region can be found in Appendix B.

8.1 Broadwater North Waterways

The Broadwater North region of the Gold Coast region hosted 1.2 million visitors during 2017. Approximately 73.8% of these visitors were day visitors, with a further 22.8% domestic overnight visitors. International visitors accounted for 3.4% of Broadwater North visitors during 2017.

Domestic overnight visitation has grown by 3.8% p.a. and international visitation has grown by 14.0% p.a. whilst domestic visitation over the past five years has declined by 1.0% p.a.

By 2030, visitation to this region is expected to reach 1.7 million, with international visitors set to double to 88,000 international visitors.[20] Please see Figure 9 for an illustration of regional growth forecasts.

8.2 Broadwater South Waterways

The Broadwater South waterways of the Gold Coast region hosted 4.1 million visitors during 2017. Unlike Broadwater North Waterways, a much smaller portion of the visitor market (53.7%) are day visitors, with 34.0% domestic overnight visitors. International visitors (12.3%) accounted for almost four times that of Broadwater North Waterways (3.4%) during 2017. This underpins the significantly stronger forecasts for Broadwater South Waterways in comparison to the other regions (Figure 8).

Domestic day and overnight visitation have declined in this region, by 4.0% p.a. and 0.9% p.a. respectively, during 2012-2017, whilst international visitation has grown 6.9% p.a.

By 2030, visitation to this region is expected to reach 5.8 million, with international figures set to double – growing from 485,892 to 1,036,934 international visitors.

8.3 Nerang River and Central Waterways

The Nerang River and Central Waterways region of the Gold Coast hosted 1.8 million visitors during 2017.

Visitation to the Nerang River and Central waterways was split somewhat more evenly between day visitors (53.7%) and domestic overnight visitors (44.9%), whilst international visitors accounted for 5.5% of overall visitation during 2017.

Despite a decline in day visitors (-4.2% p.a.), domestic overnight visitation and international visitation has grown by 1.5% p.a. and 2.5% p.a. on average over the past five years.

By 2030, visitation to this region is expected to reach 2.5 million, with international market share to grow from 2.5% to 8.3%.

8.4 Tallebudgera and Currumbin Creeks

The Tallebudgera and Currumbin Creeks region hosted 1.3 million visitors during 2017. Approximately 69.5% of these visitors where day visitors, with a further 28.4% domestic overnight visitors. International visitors accounted for only 2.2% of Tallebudgera and Currumbin Creeks visitors during 2017 – the lowest proportion of international visitors across all 4 regions.

Domestic day visitation has grown remarkably (16.2% p.a.) over the past 5 years, along with strong growth in international visitors (3.0% p.a.). Domestic overnight visitation has remained largely the same (0.4% p.a.). By 2030, visitation is expected to peak at 2 million.

[19] These are summarised in the *Definitions* (p. 3)

[20] Using TRA Reference Panel Forecast

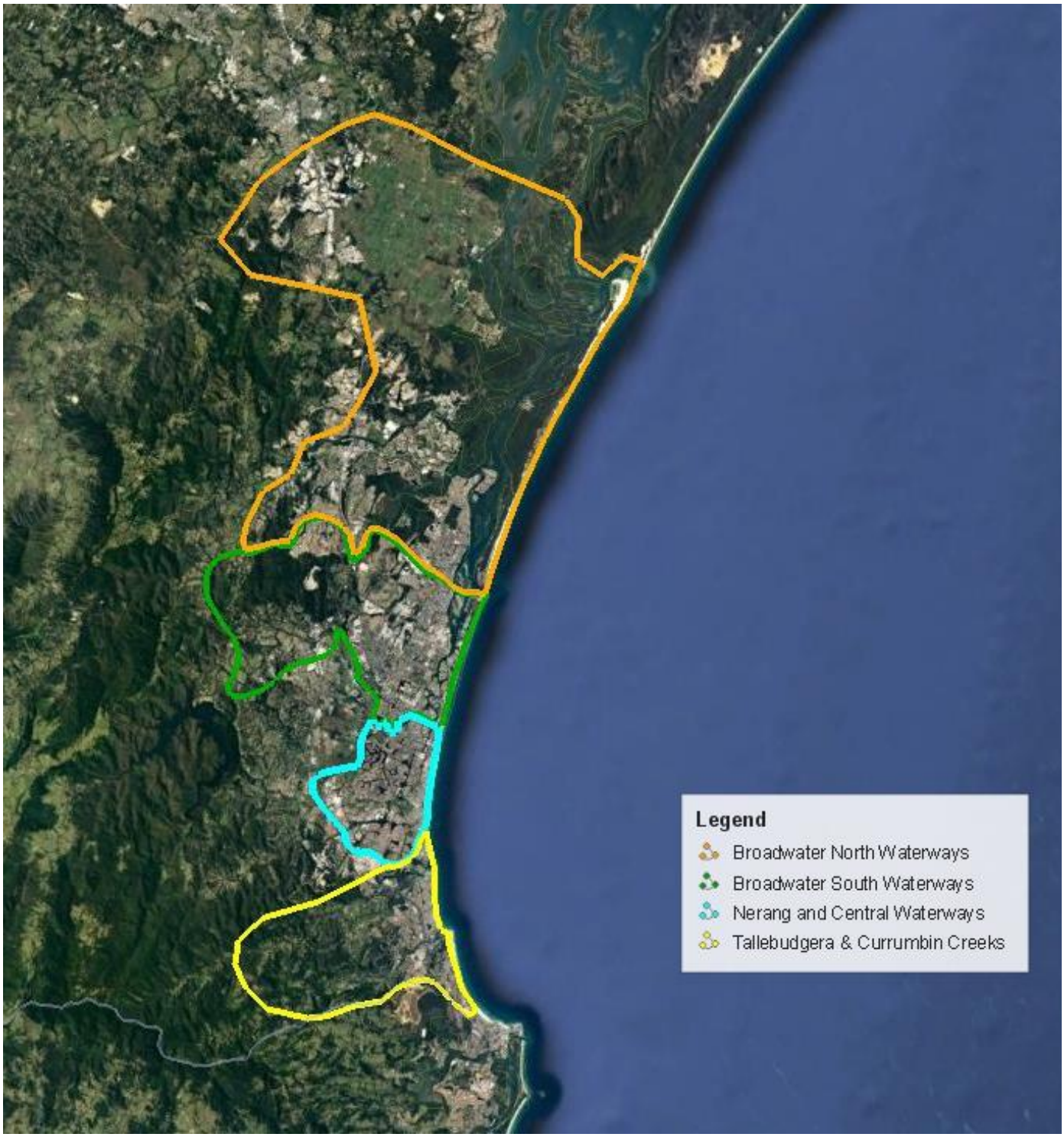


Figure 8 – Geographic Areas used for analysis

Table 6 – Visitor Activity Group Analysis by Waterway Region

		Broadwater North Waterways	Broadwater South Waterways	Nerang River and Central Waterways	Tallebudgera and Currumbin Creeks
Aquatic and Coastal Activities	Number of visitors doing this activity:	243,900	2,093,520	779,703	858,648
	Activity Market Share	13.4%	25.5%	25.5%	31.8%
Food and Wine Activities	Number of visitors doing this activity:	107,759	687,321	224,568	173,480
	Activity Market Share	5.9%	8.4%	7.3%	6.4%
City Based Activities	Number of visitors doing this activity:	1,065,789	3,503,020	1,453,892	1,176,510
	Activity Market Share	58.4%	42.6%	47.5%	43.6%
Sport and Adventure Activities	Number of visitors doing this activity:	172,486	594,802	255,034	206,238
	Activity Market Share	9.4%	7.2%	8.3%	7.6%
History and Culture Activities	Number of visitors doing this activity:	80,383	448,006	102,629	57,390
	Activity Market Share	4.4%	5.5%	3.4%	2.1%
Natural Beauty Activities	Number of visitors doing this activity:	123,155	566,980	186,580	166,159
	Activity Market Share	6.7%	6.9%	6.1%	6.2%
Wildlife Activities	Number of visitors doing this activity:	32,364	320,269	56,251	59,742
	Activity Market Share	1.8%	3.9%	1.8%	2.2%
Total Number of Visitors to the Region (2015-2017 Ave.)		1,224,541	4,060,824	1,809,168	1,327,754
Activity Market (taking into account overlap between groups)		**1,825,835**	**8,213,920**	**3,058,656**	**2,698,168**

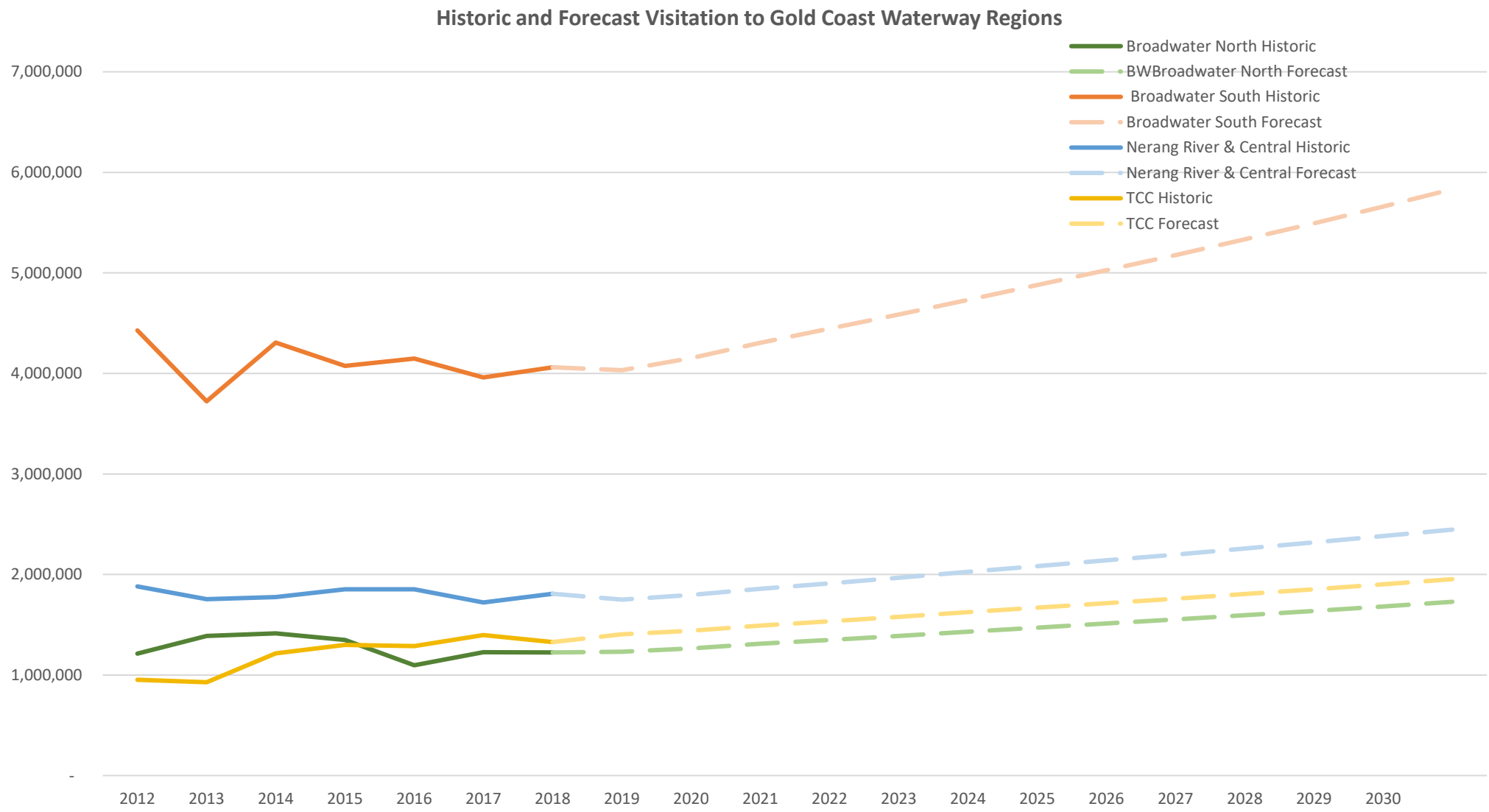


Figure 9 - Historic and Forecasted visitation of the areas inclusive of, and directly surrounding the Gold Coast waterways - by region. Note: TCC stands for Tallebudgera and Currumbin Creeks and the dotted line represents forward projections.

9. Detailed Activity Analysis

Aquatic and Coastal Activities [21]

Aquatic and Coastal activities relate to activities undertaken in and around the water. They include active participation activities such as fishing and snorkelling, as well as activities based on enjoying water surrounds, such as charter boats.
It includes:

- visiting the beach
- visiting the reef
- fishing
- scuba diving
- surfing
- charter boats / cruises / ferries, and
- visiting or staying on an Island.

Also included for this purpose was *water activities and sports* from within the Sports and Adventure activity group.

9.1 Current Participation

As outlined in Table 7, the most popular activity within the Gold Coast waterways' geographic area was *going to the beach*. During 2017, **3.9 million visitors took part in this** activity, which equates to 46.8% of all visitors to this region. Approximately **88.7% of international visitors went to the beach** during their trip to the region, whilst only 36.0% of domestic day visitors did this during their trip.

In line with this, approximately **3.2% of visitors (260,727) took part in surfing**.

When looking at activities on the water, **247,536 visitors** (3.0%) **took chartered boats, cruises and/or ferries** during their trip to the region, whilst **190,299 (2.3%) participated in fishing**.

Approximately **243,212 visitors participated in water activities and sports (e.g. kayaking, windsurfing and sailing**), which equates to 2.9% of waterway visitors. Participation in these activities has grown 8.8% p.a., on average, since 2012.

Approximately 75,541 visitors (1.4%) took part in snorkelling during 2017, with an activity growth of ~10.2% p.a. over the past 5 years. Likewise, scuba diving accounts for the smallest visitor market within the Aquatic and Coastal activity group with 75,541 visitors during 2017 but is growing faster than any of the other activities at 17.3% p.a. over the past 5 years.

9.2 The future of activities

By 2030 approximately 5.8 million visitors are expected to go to the beach within the areas surrounding the Gold Coast Waterways.

Looking at visitor forecasts, the number of those surfing in 2030 (approx. 415,325) is expected to be surpassed by the 495,561 visitors engaging in cruises, ferries and charter boats around the Gold Coast waterways. This can mainly be attributed to its larger, faster growing proportion of international visitors.

Visitors taking part in water-based activities are expected to double, to 390,477 by 2030. Soft adventure activities such as these are a growing trend, with kayaking said to be the fifth fastest international growing experience category for global travellers (+67%), and the eight fastest international growing experience category for US travellers (+49%).[22]

According to Smarter Traveller, "active travel isn't among the travel trends that are going away any time soon: Fitness trips are rapidly expanding their options... It's never been easier to find an active vacation that suits you while also crossing a destination off your bucket list." [23]

A summary of the current and forecast number of visitors for each activity can be seen in Table 7. Please note visitors can take part in multiple activities, so each activity should be considered in isolation. For more information regarding the size of the visitor market by 2030, please consult section 8 (p. 16).

[21] Due to limitations in sample size, this level of detail cannot be analysed by region, but will be examined for the waterways as a whole.

[22] TripAdvisor
[23] 2018 Trends, Smarter Travel

Table 7 – Individual activity analysis in the regions surrounding the Gold Coast waterways

	2017 Activity Visitation	% of all Waterways visitors	Historic Trend (2012-2017)	2030 Forecast Activity Visitation
Go to the beach	3,865,995	46.8%	0.8%	5,781,840
Surfing	260,727	3.2%	-4.5%	415,325
Charter boat / cruise / ferry	247,536	3.0%	1.6%	495,561
Water activities / sports	243,212	2.9%	8.8%	390,477
Fishing	190,299	2.3%	-3.0%	290,140
Visit or stay on an island (2016-2017)	128,972	1.6%	-16.0%	255,591
Go whale or dolphin watching	119,341	1.4%	4.3%	248,153
Snorkelling	119,183	1.4%	10.2%	240,477
Scuba diving	75,541	0.9%	17.3%	138,971

9.3 Regional Participation

Unfortunately, National and International visitor survey sample sizes are not sufficient for breakdown of individual activities by the four geographical areas surrounding the waterways explored in Section 8 (p.15).

When collapsed to 2 regions however, the grouping of the top two and bottom two regions, the sample is stronger and more reliable.

Table 8, below, outlines the number of visitors who took part in each of the individual activities (during 2017), within the two summary regions.

Visiting the beach accounted for a much higher proportion of all activities in the areas surrounding the southern Gold Coast waterways (81.7%) than the northern counterpart (68.6%). Similarly, this also held true for surfing (6.9% vs 3.8% respectively).

Almost all of the other water activities however, were much more prevalent in areas surrounding the Northern Waterways. This includes the use of *charter boats /cruises/ ferries, fishing, island stays* and *whale watching.*

Table 8 – Individual activity analysis in the regions surrounding the Gold Coast waterways

	North (Broadwater region)	Relative Percentage of North Region	South (Nerang to border)	Relative Percentage of South Region
Go to the beach	2,261,055	68.6%	1,623,852	**81.7%**
Surfing	124,014	3.8%	138,082	**6.9%**
Charter boat / cruise / ferry	220,655	**6.7%**	29,818	1.5%
Water activities / sports	150,932	4.6%	94,002	4.7%
Fishing	70,396	**2.1%**	17,905	0.9%
Visit or stay on an island (2016+)	119,408	**3.6%**	11,018	0.6%
Go whale or dolphin watching	94,880	**2.9%**	26,917	1.4%
Snorkelling	108,899	3.3%	32,090	1.6%
Scuba diving	144,975	4.4%	13,814	0.7%

10. Conclusion

The Gold Coast waterways are extensive and play an integral part in local and visitor engagement within the Gold Coast. As soft adventure activities and outdoor recreation continues to grow, the sustainable development and use of these waterways become vital to supporting the future use of the network of rivers, canals, lakes and dams that comprise the Gold Coast waterways.

Using Tourism Research Australia visitor and activity data as the best means for estimating existing user numbers, and current usage of the Gold Coast waterways, a custom region was created for analysis – using statistical regions (SA2) that encompass or directly border the Gold Coast waterways (where the waterways fall between two statistical areas). Visitation and activities undertaken in this custom region is the best proxy for isolating travel behaviour in and around the Gold Coast waterways. [24]

Visitation from domestic and international visitors to the areas inclusive of, and directly bordering the Gold Coast waterways have seen substantial growth over the past 10 ten years – seven times that of visitation to the broader Gold Coast region. This could be attributable to not only population growth, but also development and investment in the upkeep of the Gold Coast waterways, as well as tourism experience development on the Gold Coast waterways.

Aquatic and Coastal activities have been identified as one of the key strategic marketing initiatives for Tourism Australia, and through their targeted marketing campaigns internationally and growing trends locally is only set to increase in popularity and uptake. This includes fishing, scuba diving, snorkelling, and other water activities such as canoeing and paddle boarding. Visitation for this purpose to the regions inclusive of, and immediately surrounding the waterways has already doubled in the past 10 years and is set to continue along this trend – with an estimated market of 12 million visitors to the waterway regions by 2030, at least half of which have a particular interest in doing water related activities.

Confirmed seasonality, with weekend visitation 2.6 times higher than mid-week visitation, creates significant challenges in management and development of peak-period capacity within the Gold Coast. With visitation to the areas inclusive of, and surrounding the waterways currently accounting for 63% of overall visitation to the region, this seasonality has a direct impact on waterway usage and development; as well as potential conflicts in the future.

With an estimated economic contribution of $3.8 billion to the local economy in terms of tourism, it is vital for the GCWA to proactively plan for and manage the Gold Coast waterways in a way that not only benefits the local residents and users but also provides opportunities for a range of different users and uses as discussed in the detailed activity analysis.

The findings within this report highlight current, emerging and future uses and lays the foundation for further discussion regarding the planning requirements for the Gold Coast waterways and their development.

[24] For more detailed data of the waterways usage, primary commissioned research might be worth exploring, either as a once off or ideally on an ongoing basis.

Appendix A – Activity Groups

City Based Activities

Visit amusements / theme parks
Go on guided tours or excursions
Visit a health spa / sanctuary / well-being centre
Visit friends and relatives
Pubs, clubs, discos etc
Visit casinos
Go shopping for pleasure
Eat out / dine at a restaurant and/or cafe
Sightseeing/looking around
Movies/videos
Attend movies/cinema

History and Culture Activities

Attend theatre, concerts or other performing arts
Visit museums or art galleries
Visit art / craft workshops / studios
Attend festivals / fairs or cultural events
Visit history / heritage buildings, sites or monuments
Experience aboriginal art / craft and cultural displays
Visit an aboriginal site / community
Tourist trains
Visit industrial tourist attractions / mines / breweries (breweries excl. 2016 onwards) *Domestic Only

Aquatic and Coastal Activities

Go to the beach
Go whale or dolphin watching
Visit the reef
Fishing
Scuba diving
Snorkelling
Surfing
Charter boat / cruise / ferry
Visit or stay on an island

Food and Wine Activities

Visit farms
Go to markets
Visit wineries
Visit breweries or distilleries (2016 onwards)
Visit farmgates (2016 onwards)
Visit food markets (2016 onwards) *Domestic Only
Picnics or BBQs

Natural Beauty Activities

Visit national parks / state parks
Bushwalking / rainforest walks
Other outdoor activities

Sports and Adventure Activities

Golf
Water activities / sports
Snow skiing
Cycling
Exercise, gym or swimming
Play other sports
Attend an organised sporting event

Wildlife Activities

Visit wildlife parks / zoos / aquariums

Appendix B – Regional Summary

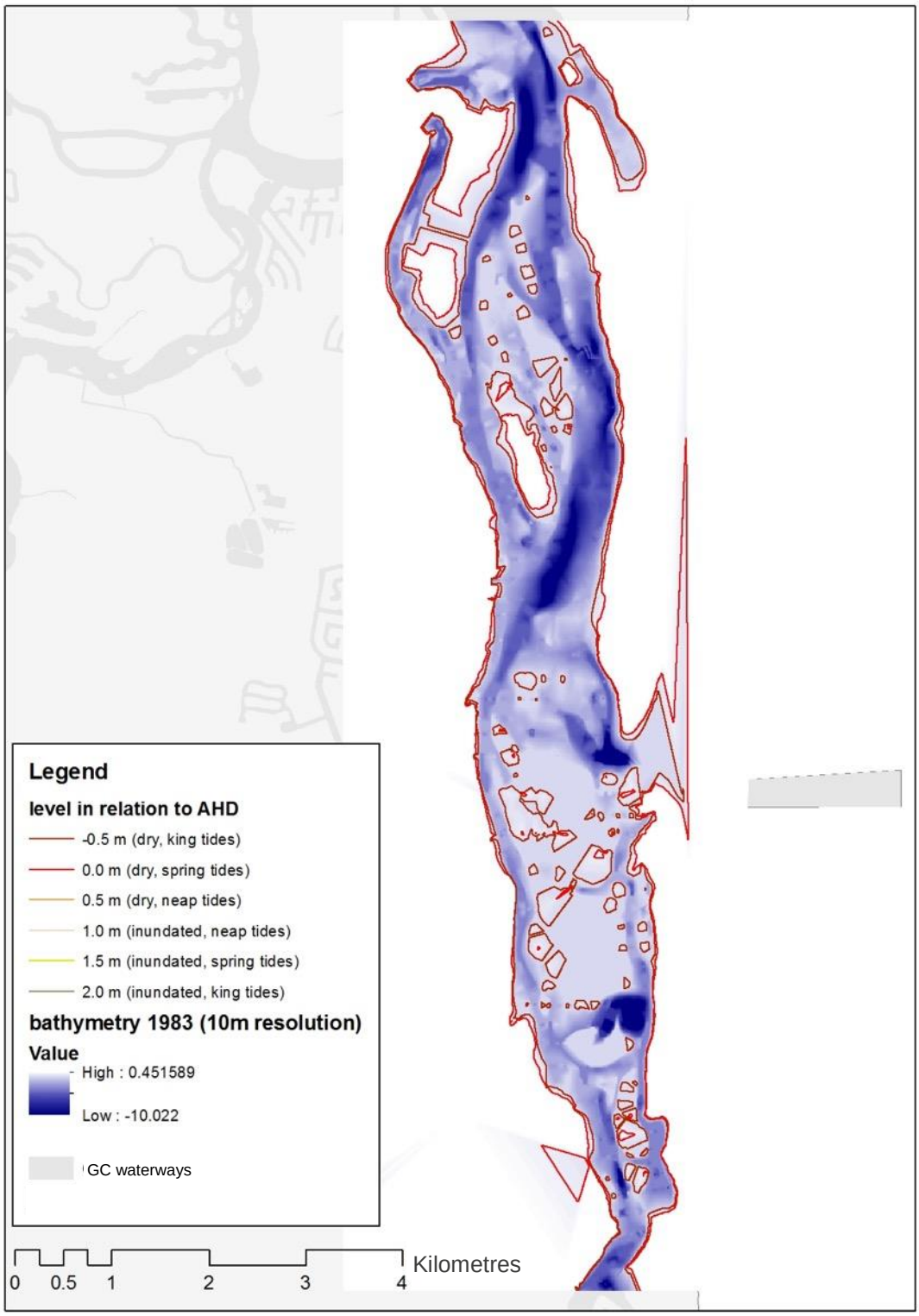
Broadwater South Waterways
Labrador
Nerang - Mount Nathan
Pacific Pines - Gaven
Ashmore
Parkwood
Benowa
Bundall
Main Beach
Surfers Paradise
Southport - North
Southport - South

Broadwater North Waterways
Biggera Waters
Coombabah
Paradise Point - Hollywell
Runaway Bay
Coomera
Helensvale
Hope Island
Jacobs Well - Alberton
Oxenford - Maudsland
Pimpama

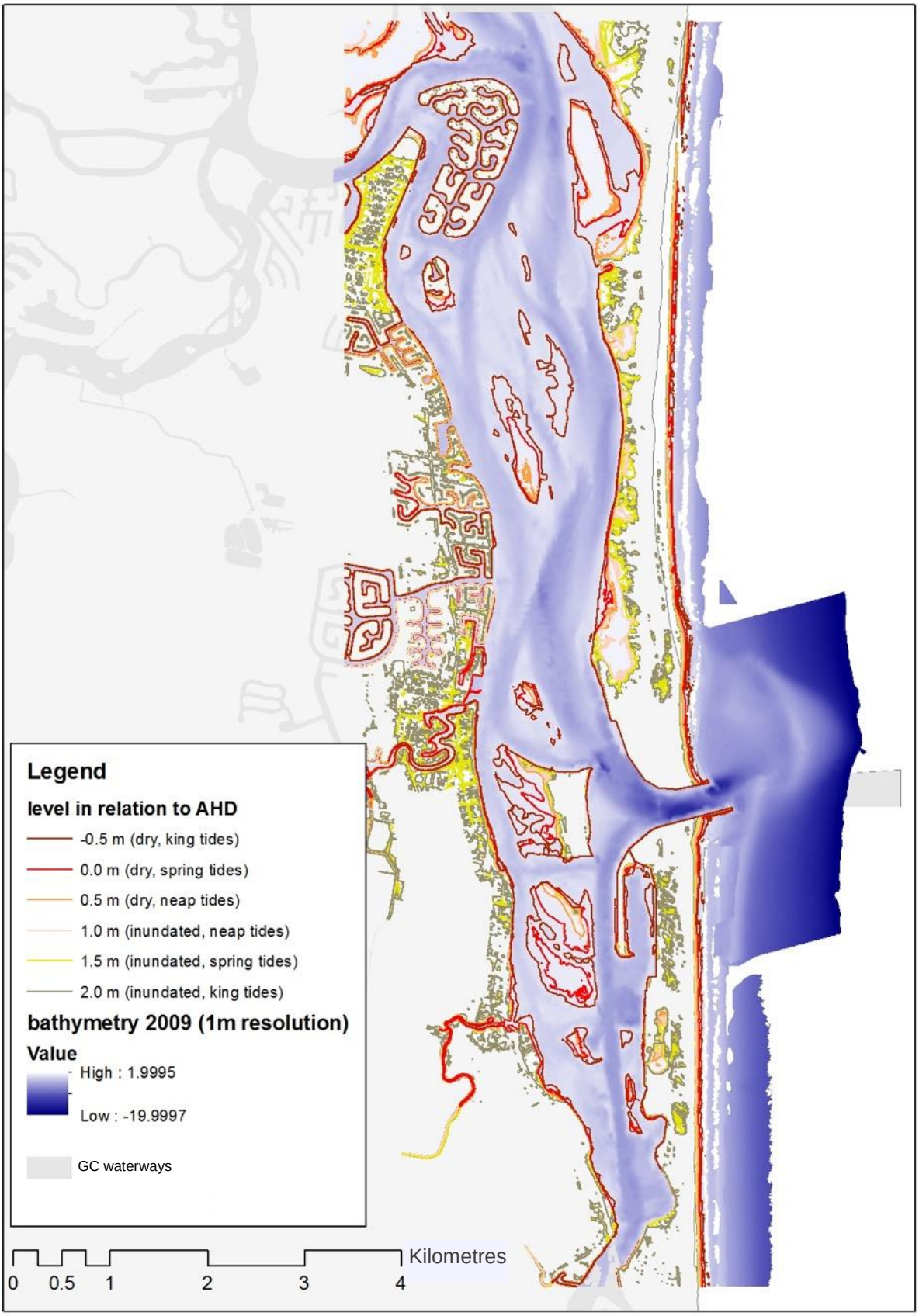
Nerang River and Central Waterways
Burleigh Waters
Mermaid Beach - Broadbeach
Mermaid Waters
Miami
Clear Island Waters
Robina
Varsity Lakes

Tallebudgera and Currumbin Creeks Waterways
Burleigh Heads
Currumbin - Tugun
Currumbin Waters
Elanora
Palm Beach
Currumbin Valley - Tallebudgera

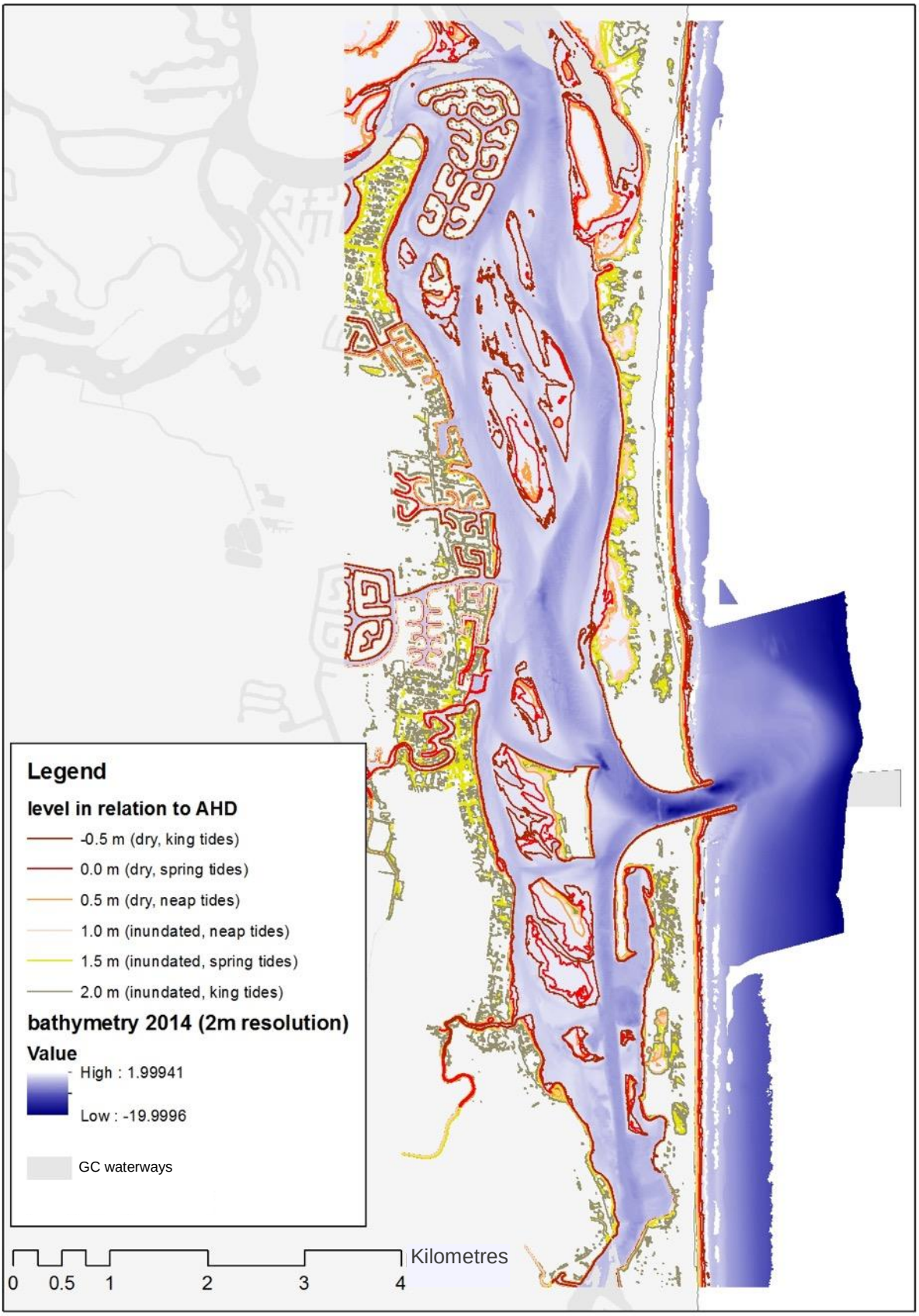
Appendix D: Bathymetry map snapshots of the Gold Coast Broadwater for the years 1983, 2009 and 2014



Map D1: Bathymetry of the Gold Coast Broadwater in 1983 (source: BMT WBM).

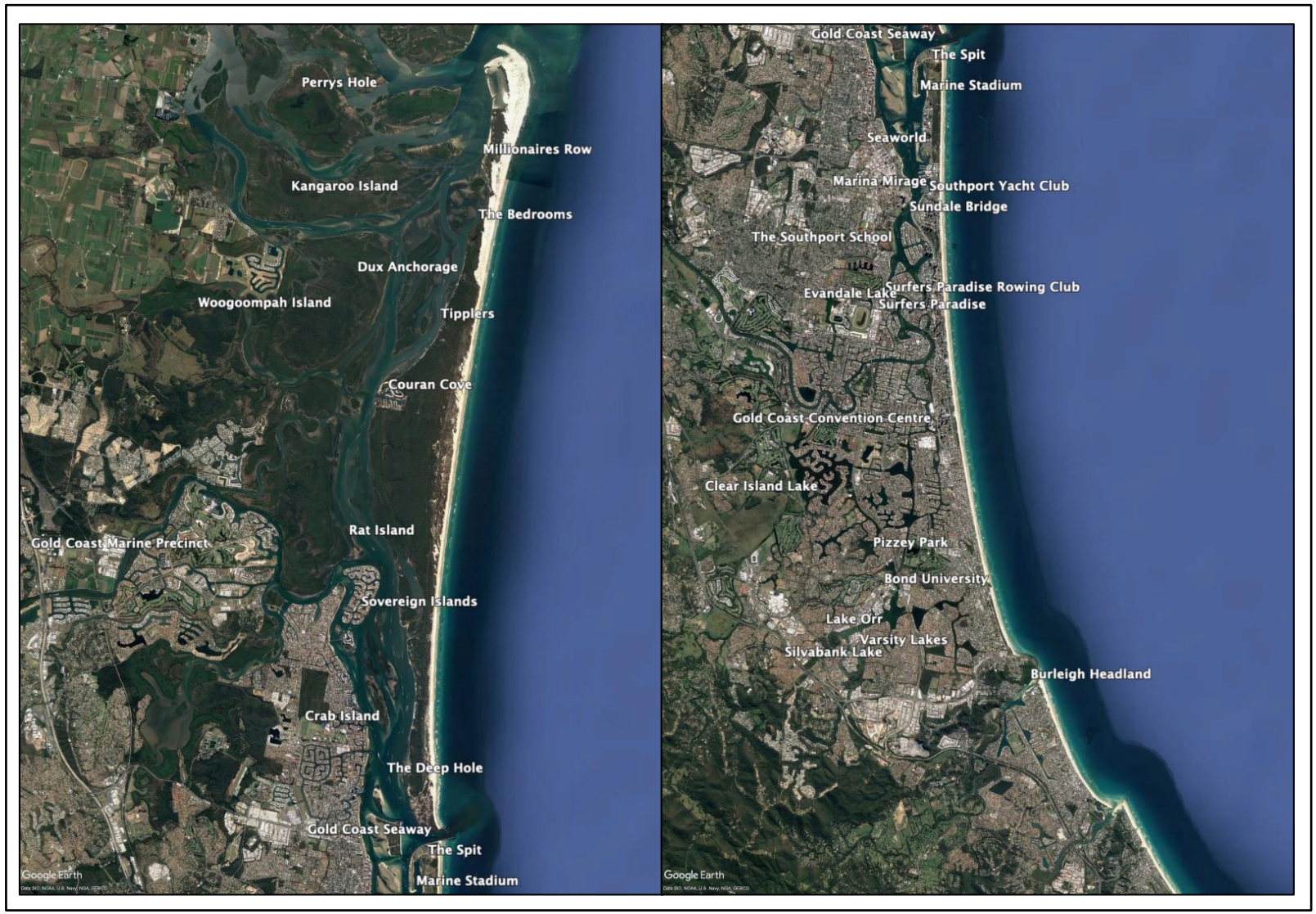


Map D2: Bathymetry of the Gold Coast Broadwater in 2009 (source: BMT WBM).



Map D3: Bathymetry of the Gold Coast Broadwater in 2014 (source: BMT WBM).

Appendix E: Place Names Map



Map E1: Place names used in this report, Northern Section (left), Mid- and Southern Sections (right).