Spatial mapping of non-fishing recreational activities and associated values in Cockburn Sound, Western Australia

Theme: Social and Community Values

WAMSI Westport Marine Science Program

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ABOUT THE MARINE SCIENCE PROGRAM

The WAMSI Westport Marine Science Program (WWMSP) is a $13.5 million body of marine research funded by the WA Government. The aims of the WWMSP are to increase knowledge of Cockburn Sound in areas that will inform the environmental impact assessment of the proposed Westport development and help to manage this important and heavily used marine area into the future. Westport is the State Government's program to move container trade from Fremantle to Kwinana, and includes a new container port and associated freight, road and rail, and logistics. The WWMSP comprises more than 30 research projects in the biological, physical and social sciences that are focused on the Cockburn Sound area. They are being delivered by more than 100 scientists from the WAMSI partnership and other organisations.

FUNDING SOURCES
The $13.5 million WAMSI Westport Marine Science Program was funded by the Western Australian Government, Department of Transport. WAMSI partners provided significant in-kind funding to the program to increase the value to >$22 million.

DATA
Finalised datasets will be released as open data, and data and/or metadata will be discoverable through Data WA and the Shared Land Information Platform (SLIP).

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Disclaimer: *The identification of activities occurring at specific locations shown on the mapped outputs presented within this report do not imply official endorsement or acceptance by WAMSI or the project's Research Partners. There may be cases where activities have been reported by study participants in restricted areas (e.g. public safety exclusion zones). It was not the objective of this project to investigate compliance of activities with current land tenure; the scope was limited to identifying what activities are undertaken and where, through self-reported data by participants. There can be a variety of reasons for why activity markers may be self-reported in restricted areas when using an online PPGIS methodology including that there may be a degree of error in how precisely markers are placed due to lack of familiarity of the respondent with the exact geography of the location or with using the online platform, or that the markers have been correctly placed and the activities have been undertaken at the location either with permission of the property manager, through accidental encroachment of activities into restricted areas due to poorly delineated boundaries or signage, or through intentional access of the site.*

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The WAMSI Westport Marine Science Program is a $13.5 million body of research that is designed to fill knowledge gaps relating to the Cockburn Sound region. It was developed with the objectives of improving the capacity to avoid, mitigate and offset environmental impacts of the proposed Westport container port development and increase the Western Government's ability to manage other pressures acting on Cockburn Sound into the future. Funding for the program has been provided by Westport (through the Department of Transport) and the science projects are being delivered by the Western Australian Marine Science Institution.

PROJECT 6.3 REPORT - Spatial mapping of non-fishing recreational activities and associated values in Cockburn Sound, Western Australia

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Executive Summary

Context

Cockburn Sound is the most intensively used embayment in Western Australia (WA), including industrial use as well as a wide range of recreational activities and associated values. The Western Australia Environmental Protection Authority identified general recreational use as a significant component of the social and aesthetic values of Cockburn Sound that pre-dates its industrial development. Consequently, Cockburn Sound is a highly contested and increasingly congested space. While Cockburn Sound hosts a range of recreational activities, much of the management attention is on recreational fishing while non-fishing recreational activities have received relatively less attention. Therefore, this project focused on understanding non-fishing recreational activities and values in the Sound. Mapping non fishing recreational use activities and associated values provides spatially explicit information on how Cockburn Sound is used and valued through a broad range of activities that represent the complex public recreational use context for Cockburn Sound management and the Westport development.

Project Aims:

- Identify the range and spatial extent of non-fishing recreational activities and associated values
- Provide an economic valuation for key recreational sites identified by the PPGIS process
- Provide a detailed understanding of non-fishing recreational activities and values

Method

A public participation GIS (PPGIS) approach was used to map the variety and types of non-fishing recreational activities and associated values in Cockburn Sound, Western Australia. An online questionnaire was developed using the Maptionnaire online PPGIS survey tool as a platform (Maptionnaire 2022). The questionnaire gathered respondent data including demographics, frequency of visit and mode of travel to Cockburn Sound. Respondents used an interactive map to place specific points and/or lines relating to a recreational activity they undertake in Cockburn Sound. Water-based and land-based activities were mapped separately by respondents during the survey. Respondents could place as many activities as lines or points as they wished. Respondents also indicated one or more values they associated with each of the recreational activities they mapped. The activities and values were selected by respondents from drop-down lists. The lists were developed by the project team based on a review of relevant literature. A travel cost model approach was used to evaluate the monetary value attributable to recreational use of key sites in Cockburn Sound. The PPGIS questionnaire was distributed online between August 2022 and February 2023 using a range of methods including recreational clubs distributing online via their social media platforms and member contact lists, notices with a QR code placed in local community centres and businesses, and the WAMSI social media platforms.

Key Findings

The questionnaire received 597 responses and a total of 31 non-fishing recreational activities were identified and mapped in Cockburn Sound including 16 land-based activities and 15 water-based activities.

A considerable proportion of survey respondents were members of a club or organization associated with the recreational activity mapped by the respondent (approximately 75%).

The northern end of the study area (Woodman Point Reserve) was most frequently visited by survey respondents for both land and water-based recreational activities. This likely to be related to accessibility and facilities in this area of the Sound.

Mapped land-based activities were concentrated at the northern (Woodman Point Reserve), and southern (Rockingham foreshore and Cape Peron) areas of the Sound with an additional concentration adjacent to and just south of the Beeliar Regional Park shoreline area.

Mapped water-based activities covered the entire Cockburn Sound area as well as areas to the west of Garden Island.

The entire study area was associated with one or more recreational activity values. The most commonly allocated values included 'have fun', 'improve physical health' and 'socialise with friends and family'.

The travel cost analysis was restricted by the small number of respondents providing the required data for each activity in each zone defined for the analysis. In person intercept surveys would provide more comprehensive data but project budget limitations meant this method was not possible.

Some activities had adequate data, including horse riding/exercising, beach activities and walking/running activities. The estimated value of a trip to the Naval Base horse beach was $14.75 per trip, which was relatively high compared to other beach activity value studies. The estimated value of a trip for beach activities was between $6.74 and $7.35 per trip. Walking and running activities were valued between $3.19 and $4.09 per trip.

Online PPGIS tools enable collection of data from a large and/or dispersed population within a limited time frame and budget. However, there is a trade-off between acquiring a large enough sample within a short time frame and the depth and quality of the data.

Conclusions

Both land and water-based recreational users value the entire Cockburn Sound area to fulfil a diverse set of activities. This means the recreational carrying capacity of the region may be relatively high in this respect. However, there are several specialised and spatially focused recreational activities which should be considered in planning decisions.

1 Introduction

1.1 Context

The Western Australian economy is reliant on freight transportation to deliver vital goods and to export products from the state. Fremantle's current Inner Harbour facilitates access to the products that allow Western Australians to enjoy some of the highest living standards in the world (Westport Taskforce 2020). As the primary container import and export facility for Perth and the State, Fremantle is said to be one of the most important pieces of economic infrastructure in Western Australia (Westport Taskforce 2020).

The Westport Taskforce has recently concluded that Fremantle's inner harbour will continue to play a key role in trade for our State, however a new container port for Western Australia will need to be developed soon to ensure trade can continue to move effectively into the future. It will also provide an opportunity to establish a modern freight network that can adapt to future growth and technologies over time (Westport Taskforce 2022). The logistical and interconnected nature of a trade supply chain means a major port at this scale must be thoroughly researched and planned. This allows any future developments to be considered and gives the major construction projects that follow enough time to be carefully designed and delivered before trade or social bottlenecks occur in the future (Westport Taskforce 2022). Based on the combined results of the second multi-criteria analysis the Westport Taskforce concluded that the development of a second port in the City of Kwinana in the Cockburn Sound would be the best course of action, as seen in Figure 1 (Westport Taskforce 2020).

Cockburn Sound, located in Perth's coastal waters south of Fremantle, is one of the most intensively used marine embayment in Western Australia. The Sound is highly valued by the community for its ecological and recreational values and hosts a vital part of the State's economy (EPA 2015). The Government of Western Australia is conscious of the need to protect the diverse values of the Sound, including its ecological, social, economic, scientific, educational, cultural, recreational and aesthetic values (EPA 2015). Cockburn Sound is known to be particularly important for activities such as fishing, aquaculture, tourism, and recreation, which are associated with high levels of environmental quality. The Sound is also important to the Australian Defence Force, associated with the HMAS Stirling naval base on Garden Island (EPA 2015).

The Western Australia Environmental Protection Authority identified general recreational use as a significant component of the social and aesthetic values of Cockburn Sound that pre-dates its industrial development (EPA 2015). Consequently, Cockburn Sound is a highly contested and increasingly congested space. While Cockburn Sound hosts a range of recreational activities, much of the management attention is on recreational fishing while non-fishing recreational activities have received relatively less attention. Therefore, this project focused on understanding non-fishing recreational activities and values in the Sound. Mapping non-fishing recreational use activities and associated values provides spatially explicit information on how Cockburn Sound is used and valued through a broad range of activities that represent the complex public recreational use context for Cockburn Sound management and the Westport development.

1.2 Project Scope

This investigation focuses on non-fishing outdoor recreational activities. For this review, outdoor recreation can be defined as "activities that are undertaken by people in their free time; have a physical component; require access to natural, rural, and urban open spaces; are not primarily focused on competitive outcomes; and meet a range of purposes that are determined by the needs of the individual participant. Outdoor recreation does not include: sporting activities; indoor activities; or activities that do not have a physical component" (NZ Sport 2009). A key consideration was the geographical area defining the Cockburn Sound study area. This was defined in discussion with the project team and WAMSI representatives. The project study area includes the shore and waters between Woodman Point, Cape Peron and includes Garden Island and Carnac Island (Figure 1).

Figure 1: Cockburn Sound non-fishing recreational activity mapping project study area as indicated by the brown boundary line. **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

1.3 Project aims:

- Identify the range and spatial extent of non-fishing recreational activities and associated values
- Provide an economic valuation for key recreational sites identified by the PPGIS process
- Provide a detailed understanding of non-fishing recreational activities and values

1.4 Recreational uses of coastal marine areas

Recreational activities are just one of a range of marine and coastal uses that need to be factored into planning and management, especially in areas with heavy demand for multiple and potentially contested uses (Aanesen et al. 2018, Elliott et al. 2018), such as Cockburn Sound (EPA 2015). In addition to fishing, recreational activities in marine and coastal areas may include water based sub-marine activities (e.g. scuba diving, Freediving), water-based surface activities (e.g. Motor boating, kayaking), wind powered activities (e.g. Kite surfing, windsurfing), and land-based activities (e.g walking, beach activities). Each of these recreational activities are characterized by significant spatial variability that can range across large areas, especially for water-based activities (Kenchington 1993, Queffelec & Maes 2013, Le Tixerant et al. 2018). The activities may also be associated with different types of values that in turn influence the way in which participants interact with the marine and coastal environment and how management of that environment is perceived (Cosquer et al. 2019). Understanding how people use marine coastal areas for recreational activities and the values associated with such uses, is an important consideration for the development and management of these areas (Elliott et al. 2018, Cosquer et al. 2019).

1.5 Values associated with recreational activities

Nature's ecological and economic values are increasingly being used to identify high-priority locations for coastal development and management (Van Riper et al. 2012). However, social values based on human perceptions of ecological products and services are rarely taken into account (Van Riper et al. 2012). Investigating people's values is critical for efficient planning and management, especially when it comes to 'public' assets like Cockburn Sound (Strickland-Munro et al. 2016). For the purposes of this current project on Cockburn Sound, the definition of social values was, "*the importance of places, landscapes, and the resources or services they provide as defined by individual and/or group perceptions and attitudes towards a given place or landscape*" (Strickland-Munro et al. 2015). In the context of this project, values can be associated with the benefits recreational users of Cockburn Sound derive from recreational activities, similar to Moyle and Weiler's (2017) list of benefits associated with national parks in Australia, curated for relevance to recreational activities in Cockburn Sound.

Table 1.

The social benefits derived from the use or conservation of natural areas can contribute to the fulfilment of preferred 'end states' of human existence (Table 2), which are in turn conducive to human wellbeing (Wallace et al. 2020). According to a comprehensive classification of human wellbeing values linked with natural areas, 'end state values' are: "*enduring beliefs concerning the preferred end states of human existence, including those required for survival and reproductive success, which taken together determine human wellbeing*" (Wallace et al., 2020: 2). The nine end state values proposed by Wallace et al. (2020) include having: adequate resources; access to an aesthetically pleasing environment; access to a benign physical environment; meaningful occupation; and protection from other organisms, among other values. The links to human wellbeing derived from these end states are context-dependent, rather than being specifically causally linked with mental and physical health. In the case of Cockburn Sound, end states that contribute to wellbeing derived from performing or participating in recreational activities are thus associated with 'recreational satisfaction'.

Table 1: Benefits associated with visiting Australian national parks (Source: Moyle and Weiler, 2017)

Benefits
Access natural experiences
Achieve mental health benefits
Achieve physical health benefits
Appreciate scenic beauty
Be in a comfortable and safe place
Connect with culture
Connect with heritage
Connect with nature
Connect with spiritual side
Experience something new and different
Find peace and solitude
Have fun
Learn about nature, culture and heritage
Reflect on personal values
Relax and unwind
Socialise with friends and family
Strengthen family ties
Strengthen social networks

Table 2: End State values linked with experiencing natural areas (source: Wallace et al., 2020)

End State Values
Adequate resources
Aesthetically pleasing environment
Benign physical environment
Knowledge-heritage fulfilment
Meaningful occupation
Protection from other organisms
Recreational satisfaction
Social fulfilment
Spiritual-philosophical fulfilment

If required, the quantification of values associated with recreation can be achieved in a number of ways: through eliciting the importance of the value to wellbeing or welfare through ranking or ratings questions, or through identifying a monetary value associated with the recreational activity. The latter typically denoted the “willingness to pay”, represents the inferred maximum that a respondent would pay for the recreational experience, if there was an associated market. Its estimation does not imply that the activity should be charged for, but that by quantifying the values in a monetary metric it allows for aggregation across assets in a commensurate way, and potentially the values can be used as an input into benefit-cost analysis.

2 Materials and Methods

The method included three general components, a desktop review to initially identify types of non-fishing recreational activities in Cockburn Sound; an online survey incorporating public participatory mapping to identify the spatial extent and frequency of the recreational activities and associated values; and estimation of the monetary value of key recreation sites using a travel cost model drawing on data from the online survey. The method enabled identification of the variety of non-fishing recreational activities and where they occur in the Cockburn Sound study area. This method does not identify the relative significance or importance of each of the activities.

This research was approved by the Murdoch University Human Research Ethics Committee (project approval 2022/038).

2.1 Desktop review of Cockburn Sound recreational uses

The desktop review was conducted between February and April 2022. A systematic search of online databases was used to access reports, scholarly literature and a range of websites and social media. The focus was on identifying non-fishing recreational activities and relevant organizations (if applicable) associated with the use of Cockburn Sound. This was achieved by curating a list of recreational activities generally conducted on or near the ocean. Following this, a systematic search for each activity with the key words “Cockburn Sound”, “Rockingham”, “Kwinana” or “Cockburn” was undertaken. All groups and organisations associated with the study region and activities were recorded. The above data set was validated through reviewing local government (Rockingham, Kwinana, and Cockburn) websites and though a Google Maps area search, with any missing activities or group added to the list.

2.2 Questionnaire design

A PPGIS survey method was used to obtain spatially explicit data on non-fishing recreational activities and values in Cockburn Sound. PPGIS is a well-established method that has been applied in various contexts to identify spatial human use patterns and values. These data can provide important insights to inform resource management and decision making (Strickland-Munro et al. 2016, Moore et al. 2017). An online survey tool was adopted owing to the mostly unknown and geographically and temporally dispersed target population, budget, and time restrictions and COVID risks prevalent at the time of project design that meant in person participatory mapping was not feasible.

The online PPGIS questionnaire was designed using the Maptionnaire PPGIS online tool (Maptionnaire 2022). The Maptionnaire tool was selected based on a review of various online PPGIS mapping tools by a team member expert on this topic. Maptionnaire offered the best flexibility in design and the most user-friendly interface for public participation mapping within the project budget. Consideration was given to the data security and functionality of the online questionnaire when attempted on different devices (e.g. laptop, desktop, mobile phone).

A series of multiple-choice questions were developed based on the project scope, aims and past literature together with discussion between project team researchers. Questions included demographics, visitation frequency, mode of transport to Cockburn Sound and other relevant participant information (Appendix 2). These questions were used to characterise the sample, provide context for the recreational activities mapped and provide data for the travel cost evaluation component of the project.

The mapping component of the questionnaire included interactive maps that enabled participants to indicate where they undertook specific activities by adding a point or drawing a line on the map. Additional information was requested in relation to the frequency of access and the values associated with each activity point or line added (Appendix 2). Detailed instructions in plain language were

embedded in the questionnaire to assist participants with the mapping of activities and values. Participants selected activities and values from a list populated with a range of options based on the desktop and literature reviews. They also had the option of adding an activity using an 'other' option. Water based and land-based activities were mapped separately as consecutive tasks in the survey. Activities were mapped by participants placing lines or points on a map of Cockburn Sound to indicate a route taken for an activity or a specific location. Participants were able to zoom in to any area or location on the map when placing a line or point. Once lines or points were placed, a series of options were provided to indicate the type of activity, one or more associated values and frequency of visit for that activity within the past 12 months. Participants could map as many activities, lines, and points as they wished. None of the questions were compulsory except for the question requiring a response for the suburb where the respondent lived.

Development of a list of values to be mapped was derived jointly from Wallace et al.'s (2020) framework and the benefits identified by Moyle and Weiler (2017) (Table 3). First, the end-state values relevant for recreational activities in Cockburn Sound were identified from Wallace et al. (2020). Then, we reviewed Moyle and Weiler's (2017) list of benefits associated with national parks in Australia, selecting the benefits most applicable to recreation (Appendix 1), and aggregating benefits to (a) avoid redundancy and (b) achieve a manageable number of value categories for the PPGIS survey (Table 3). Finally, the selected benefits from Moyle and Weiler (2017) were related to the end-state values that they help to deliver in Wallace et al.'s (2020) framework, ensuring that the value statements shown to respondents were both familiar and specific to the recreational opportunities provided in Cockburn Sound and linked to an overarching and replicable classification of values. In some cases, multiple benefits were linked to the same end-state value.

Once the questions were developed, the survey was distributed to several volunteer individuals for testing. Their feedback regarding improvements in the clarity of instruction was implemented for the final version of the survey.

Table 3: Value options included in the PPGIS survey for allocation to recreational activities. The values were derived from Wallace et al. (2020) and Moyle and Weiler (2017). A combination of wording from the respective sources was used in the questionnaire to enhance clarity of meaning for respondents.

Values for mapping allocation
Appreciate natural beauty
Experience something new
Gain personal or spiritual fulfilment
Have fun
Improve physical health
Learn about cultural heritage
Learn about natural environment
Perform the activity in a comfortable physical environment
Perform the activity in a safe place
Relax
Socialise with friends/family

2.3 Survey implementation

2.3.1 Target population

The target population was people who had visited Cockburn Sound and participated in non-fishing recreational activities within the past 12 months. This population included independent users and users who were part of organized recreation clubs or groups associated with recreational activities in Cockburn Sound. The size of the population was unknown because little or no monitoring of recreational uses apart from recreational fishing had been conducted in the Cockburn Sound area. The unknown size of the target population meant that a maximal approach to sampling was adopted, using a range of recruitment avenues and audiences. For social survey samples, a sample of about 200- 400 unique respondents is deemed adequately representative for populations of over 500 people (Neuman 2011).

2.3.2 Recruitment

Recruitment included a number of strategies to maximize the exposure of the survey to a wide range of people who may have accessed Cockburn Sound for recreational activities within the past 12 months. Recruitment activities included:

- distribution of invitations to participate and URL links via a range of Perth area recreation club member mailing lists;
- posting invitations on various recreation club and recreation group social media pages;
- posts on WAMSI social media, including Facebook;
- displaying hard copy posters advertising the survey, with a QR code, in local businesses and public venues in the Cockburn Sound area;

The online questionnaire was open between September 2022 and February 2023 and received a total of 597 unique responses.

2.3.3 Validation

Validation of the PPGIS data was conducted using two independent techniques. Firstly, we interviewed a recreational club representative to discuss and draw locations typically organised by the club with the participation of its members and members from other clubs in the Perth metro area. We contacted several clubs; however, only Fremantle Sailing Club was available for the interview. During the interview, a set of A3 printouts of the Cockburn Sound marine navigation chart was used to mark the geographic footprints of the following activities/features:

- Dinghy inshore sailing
- Other yachts inshore sailing
- Important cruise/course marker
- Diving locations organised through the club
- Powerboat time trials
- Typical destinations of the cruising boat division

The second approach to validation was through cross-checking that the locations identified as high-use areas (hotspots) were spatially correlated with specific infrastructure, including access points, or being at a particular type of location to make it possible to undertake such an activity. For example, if the activity was mapped as picnicking, any of the following features identified on Google Earth Pro images or Google Street View was considered valid: access roads or paths, picnic tables, BBQs, public parks, or beaches. A summary table with comments was constructed to validate approximately 120 hotspots of land or water-based activities. Using hotspot locations identified through analysis of kernel density layers for each activity was considered appropriate as these layers were a sum of point and line inputs by the respondents (Appendix 3).

Finally, we compared data collected through WWMSP Project 6.1 "Community values for changes in environmental conditions", where a representative sample of the Perth metropolitan community was collected through an online survey. In the survey, a question was included asking respondents about what sorts of activities they have undertaken in Cockburn Sound during any visits to the location in the last 5 years. The activity categories in the question included the same activities as those listed in the survey instrument for this project. The count data from this question are reported in Appendix 3. Given that the Project 6.1 survey question focussed on a 5-year period, it does not allow us to directly compare the representativeness of the Project 6.3 sample in terms of whether the frequency of nominated activities is consistent, as Project 6.3 collected visitation frequencies over a 12-month period – the implication being that we cannot use the data in Appendix 3 to extrapolate the visitation rates (or intensity) for the activities reported here. However, it enables us to observe whether the *rankings* of most frequently reported activities (as shown in Table 9 and Appendix 3) are observationally similar across the two project samples, such that we can draw a loose inference as to how representative the Project 6.3 sample is of the wider Perth community with respect to the frequency of engaging in recreational activities in Cockburn Sound.

2.4 Data treatment and analysis

Survey results were downloaded from the Maptionnaire website as an Excel file (respondent data) and GIS-formatted files (ESRI shape file format) with the respondent ID and geo-information as points or lines capturing activities, values, and frequency of visitation/activity.

2.4.1 Data cleaning and formatting

Several steps were followed to clean the dataset before undertaking any analysis:

- Data entries outside the survey period (8th September 2022 through to 6th February 2023) representing testing of the survey instrument, and entries outside the study area (original study area polygon + 1000 m buffer) were removed.
- Land-based activities (points and lines) were removed if mapped further than 100 m from the coastline (mean high water polyline from Landgate). Water-based activities were consistently placed in the water, or on the coastline and did not require removal.
- Shapefiles were exported to the ESRI geodatabase and reprojected to GDA2020 MGA50.
- Entries allowing respondents to enter text were standardised (i.e., suburb and club names).
- Postcode data were added to respondent information (based on the suburb name).
- Additional or new activities were identified from entries submitted as 'other' activities, and names were standardised.
- Additional activities were saved in the new fields 'Other_act2, Other_Act3 etc. Some activities entered under 'other' were deleted as inappropriate, vague, or irrelevant (e.g., working, standing, drinking).
- Activities listed under 'other' that were land-based but entered by respondents in the water-based component of the mapping exercise were moved to the land-based activities file.
- Any activities that were water-based but entered in the land-based component under 'other' were also moved to the water-based activities file.
- Text entries for values were parsed into separate fields in the database (i.e., Val1, Val2 etc.).

2.4.2 Activity and values mapping

A series of database queries were created to filter the database for each activity value and visitation frequency. These filtered layers were used to create feature maps and to calculate kernel densities (heat maps).

Kernel density rasters (with the study area added as a barrier) were calculated for each activity and value. Kernel density (KD) rasters were created in ArcMap 10.7 using a 100 m cell size and a 1000 m search radius. Separate KD rasters were calculated separately for point and line features and then added using a raster calculator. Final kernel density maps (heat maps) displays were created with data histograms stretched to display min-max values and zero values displayed as transparent (no colour).

Feature maps and kernel density for community volunteering, photography and all activities (riding or swimming) related to horses were created from combined land and water-based map entries.

Additional activities identified through respondent 'other' entries provided in the online survey were added to the geodatabase (Table 3). In the interest of streamlining map outputs, the following activities were mapped as land and water-based:

- Community volunteering (several comments indicated seagrass restoration, dune rehabilitation or seagrass seed collecting)
- Horseback riding /swimming with horses
- Photography

Activities entered by respondents in the 'other' activity field that were outside the scope of the project were not included in the analysis, for example crabbing or fishing.

The final list of land and water-based activities and the frequency of mapped features illustrate the breadth of recreational activities in the area (Table 4).

Table 4: Summary of land and water-based activities.

Land-based activities	**Water based activities**
Beach activities	Community volunteering#
Birdwatching	Freediving
Café/bar*	Hoverboarding
Camping/caravan	Hydrofoiling
Community volunteering#	Jet-skiing
Cycling	Kayaking
Dog beach activities	Kite boarding
E-scootering	Kite surfing
Horse exercising#	Motor boating
Photography*	Photography*#
Picnicking	Sailing
School/community camps	Scuba diving
Sightseeing*	Snorkelling
Skateboarding*	SUP boarding
Walking/running	Swimming
Yoga	Swimming with horses*#
	Wake Boarding
	Water Skiing
	Windsurfing

* Activity added by survey respondents

Cases where land- and water-based activities have been reported and mapped together

2.4.3 Travel cost evaluation

Travel cost theory

The individual, single site travel cost method is one of a suite of revealed preference approaches to valuing access to a recreational site. It requires information on individuals' frequency of visitation to the site, and an estimate of the cost that the individuals incur in accessing the site. Because there is typically no process associated with access, the travel cost becomes a proxy for access price, and hence one infers a 'demand function' for the site by estimating the relationship between the frequency of visitation and travel cost.

The simplest form of single site models posits that trip frequency (v) for individual (i) is a function only of travel cost (tc):

$$v_i = f(tc_i \quad (1)$$

The model requires the site to be valued to be defined, and the reason for visiting the site, and then a representative sample of respondents to the site needs to be interviewed. The primary data needed from the respondent is visitation rate, consistently defined (i.e. visits per year) and then an estimate of the costs incurred in making the trip. The full definition of those costs may include the direct travel costs, any access fees, if they exist, equipment costs and an estimate of the cost of time taken to get to the site. It is important that these costs be defined as marginal costs, that is only costs that are incurred because of the decision to visit the site, not other standing costs. Thus, in the case of a day trip to a beach, by car, the appropriate costs are the incurred fuel costs and any attribution of service costs associated with additional distance travelled. 'Fixed' costs of vehicle purchase and insurance, for example, are not included. Costs should be adjusted to reflect the number of people traveling in the same car. Equipment costs should also constitute the marginal cost: it is suggested that for capital costs this should be the imputed rental cost, but often equipment costs are sufficiently small that they are not included in the model. If this 'fixed' costs per trip (e.g. associated with a boat or diving equipment) is common across all respondents, then this does not affect the estimated value per trip, although it may affect predicted number of trips taken.

The issue of how to value the cost of time taken to get to the site is challenging. A convention is that there should be an estimate of the opportunity cost of time, which is typically taken as 1/3 of the wage rate. But for some the trip itself may be pleasurable, and the justification for the 1/3 value is not clear (Czajkowski et al, 2019).

Estimation of the trip function requires one to specify a functional form for the relationship. It needs to respect the nature of the visitation data, that is it must be non-negative, and integer. The most common functional form used is the Poisson model. The probability that an individual takes v trips is assumed to be

$$\Pr(v) = \frac{\exp(-\lambda)\lambda^v}{v!} \quad (2)$$

Where λ is the expected number of trips and is defined in the simplest model by i.e. equation (1) above.

Estimation of the model will identify the parameters of equation (1) which, if linear, is simply a constant and a coefficient on the travel cost term, which one would expect to be negative.

The value per trip for an individual, defined as the consumer surplus they gain from the trip, is given by

$$WTP = -1/\beta_{cost} \quad (3)$$

Where β_{cost} is the estimated cost coefficient.

There are two extensions to the model that are often made. The first relates to a bias that arises from 'intercept' surveys on site where everyone interviewed, by definition, must have made at least one visit. This selection bias can be accounted for by subtracting 1 from all the trip visitation rates. The second extension is to relax the assumption that is adopted by the commonly used Poisson model where the variance in visitation rate is modelled assuming that the variance is equal to the mean. A less restricted model, the negative binomial model, relaxes this assumption.

For more information on the travel cost method, refer to Parsons (2017), and applications to coastal recreation can be found in (Rogers & Burton 2019).

Travel cost implementation

Taking the above understanding, the implementation of the travel cost method for recreation in the Cockburn Sound area is set out below.

At the heart of the travel costs method is the definition of the visitation area. The PPGIS approach allows respondents complete freedom in selecting where they place their markers, but there must be some aggregation of locations across individual for the travel cost approach to be applied.

We start the process by dividing the map into a number of zones (see Figure 2). A set of 29 polygon-based regions were created in ArcMap and linked to the database of the activities and values. The boundaries have been determined through reviewing the raw data for the distribution of markers, and an understanding of where significant features are in the area (e.g. beach locations, hard structures, geological features, local government boundaries). Separate areas are identified on land and water. To allow incorporation of the line-based entries in the travel cost analysis, a new point-feature layer was created by calculating a centre point for each of the lines and then linked to the travel cost region. Latitude/longitude fields were added to the database. Data were exported from the geodatabase to Excel for further analysis.

In the discussion that follows, we consider each of the activities separately, and by individual.

Because respondents could place multiple markers within a zone, and potentially include a visitation rate for multiple markers, it is necessary to apply a rule as to how these markers within a zone are to be treated. That is, should they be taken to represent:

a) *the same* visit within the zone (e.g. they visit the zone once a week, and recreate at more than one location on each visit); or

b) *different* visits to the zone, where they go to different locations.

There is no way to discern from the mapping outputs what the true representation of the markers are, and hence we apply a rule:

i. If there are multiple point markers for an activity with a zone, which each have visitation rates recorded, then these are assumed to be independent visits to the zone, and the visitation rates are aggregated, where given.

ii. If there are both line and point markers given, the assumption is that these are complementary records of visitation to the zone, and the maximal visitation rate from that calculated from (i) and the visitation rate for the line is used to define the visitation rate to the zone.

In support of the above approach, inspection of the data identified regular cases where point markers within a zone had visitation rates included, and which were different to each other, while there were relatively few cases where visitation rates were reported for both point and line data, and where they were, they were typically the same rate.

Where respondents left points and/or lines, but gave no record of visitation rate, then the observation could not be included in the analysis.

Because of the possible spatial error in respondents dropping the markers precisely at the visited location, while we refer to the land/water zone identifier for relevant land/water activities, in identifying visits to a zone we include visits in the neighbouring zone as well. That is, in the case of swimming for example, visits to zone 10 will also include any markers dropped into zone 30 with an activity identified as swimming, while land-based activities tagged, for example, in zone 25 will include markers for the same activity type(s) from zone 16.

When respondents dropped markers they were asked to identify the activity they undertook at that area, which allows us to estimate travel cost models by activity. Obviously, if they did not report an activity they are excluded from the analysis.

A key element of the travel cost approach is estimating the costs of each trip to the location by the respondent. In the survey they reported the suburb they live in. Information for the suburb long/lat data was obtained from the open-source data base at (Proctor 2023). Taking the central point of the coast of each zone with vehicle access as the destination location, travel distances were estimated using the *gmapsdistance* command in R (R Core Team 2021, Melo & D. Zarruk 2022), which uses the Google maps distance matrix API (Google Maps Platform 2023) to calculate the distance between a respondent's suburb and each zone. All distances were calculated assuming travel by car, allowing a complete matrix of starting /destination location travel distances to be calculated.

Cost was defined as twice the estimated distance x $0.14 per km for most activities. $0.14 was estimated from the 2022 RAC Car Running Costs guide (RAC 2022) for medium sized cars as the marginal cost per km (i.e. fuel and servicing). Where the activity could reasonably require a larger vehicle (pulling a boat or horse trailer) a cost of $0.16 was used. An adjustment was made if there were multiple people in the car; that is, costs were shared if the respondent identified that they travelled by car, and they had people accompanying them.

There are additional costs that could be included, specifically parking costs at the destination, but this information was not collected, and it is not possible to estimate what these may be given differences in availability of paid/unpaid parking, and the time of the visit (across days in the week and times of day). No estimate of the value of time was used, as this would require an estimate of income, and hence further reduce sample where that was not given. As such the estimate of trip cost is likely to be an underestimate, and hence the estimates of value per trip also a lower bound.

With each marker placed the respondent could identify the frequency of visitation from a list:

- 5-7 days a week
- 2-4 days a week
- About once a week
- About once a month
- A few times a year
- Once a year

These were translated into a numerical measure of visitation rates per year: 312, 156, 52, 12, 6 and 1 respectively, with -1 subtracted from each to account for the sampling bias implicit in only considering people who indicated they visited the zone for the activity.

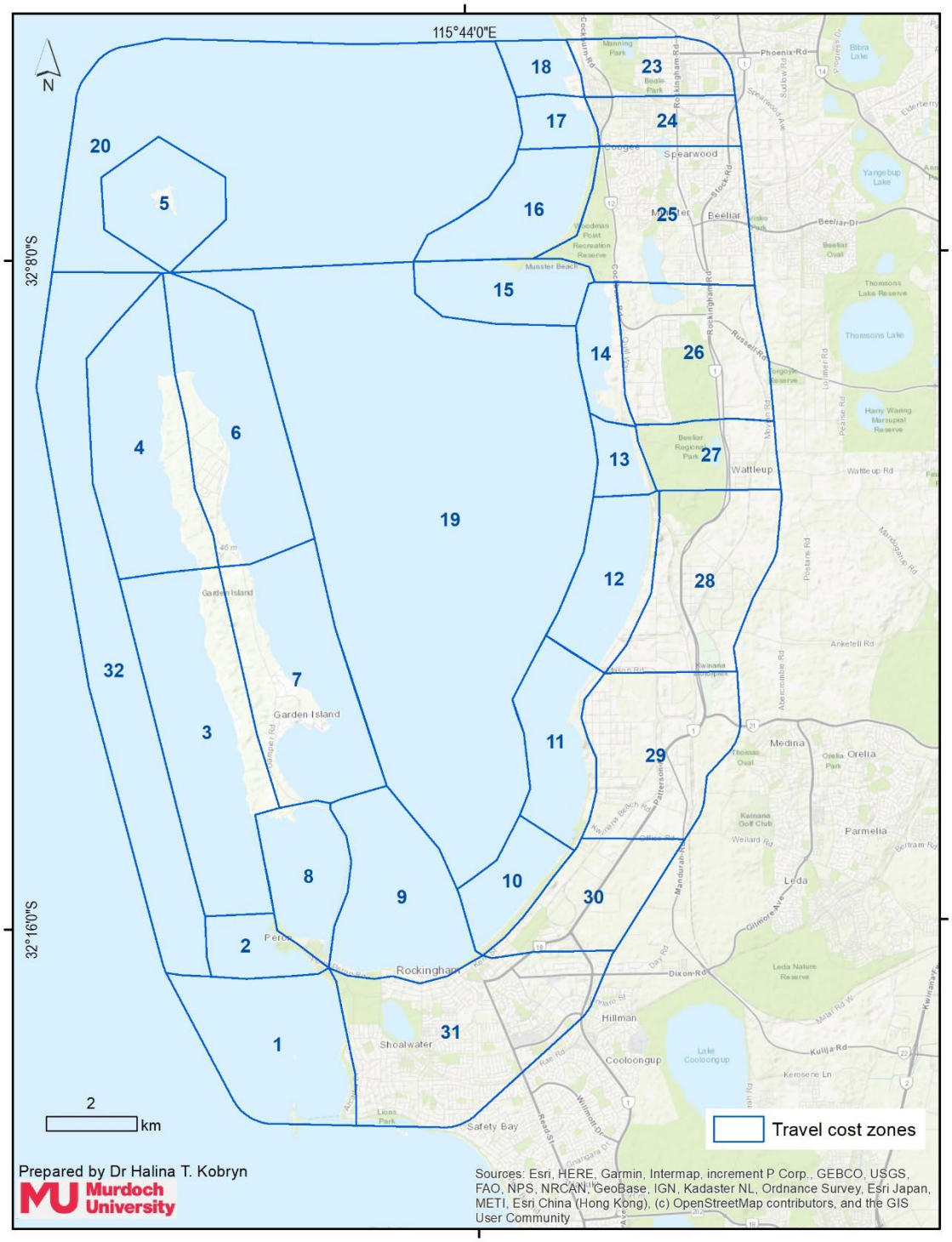

Figure 2: Boundaries of travel-cost evaluation zones. **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

3 Results: desktop review

The desktop review indicated that Cockburn Sound hosts a range of shore based and water based non-fishing recreational activities. This section outlines the recreational activities identified categorized by shore based and water-based activities and listed in alphabetical order. A range of recreational organizations that promote or facilitate non-fishing recreational uses of Cockburn Sound were also identified.

3.1 Shore based recreational activities

Birdwatching: This is a growing area of interest across Australia for both individuals and hobbyist groups (Janeczko et al. 2021). There are over 70 known species of marine and terrestrial birds in Cockburn Sound (Sutton & Shaw 2019). Birdlife Australia is a prominent group in the Cockburn Sound region and organises a wide range of recreational activities (Birdlife Australia 2022). Key birdwatching locations identified by Birdlife Australia in the Cockburn Sound area include: Lake Richmond, Garden Island, Cape Peron, Woodman Point, Mt Brown Reserve and Henderson Reserve (Birds Australia 2019, Birdlife Australia 2021).

Camping and Caravanning: Cockburn Sound hosts four camping/caravan parks located near the foreshore. While the peak season is during Western Australian school holidays, the camping and caravan parks are used all year round (City of Cockburn 2022).The four main parks in the region are the: Cee & See Caravan Park, Rockingham Holiday Village, Naval Base Holiday Park and Woodman Point Holiday and Caravan Park.

Dog beach activities: There are several beaches that are accessible to dogs either on or off leash**.** The Cockburn, Kwinana, and Rockingham local governments all have at least one dog beach in the Sound. These include Jervoise Bay, Naval Base Horse Beach, Rockingham Dog Beach, and Cape Peron (City of Cockburn 2021, City of Kwinana 2022, City of Rockingham 2022b).

Horse exercising: Horse exercising occurs at Naval Base Horse beach and is highly valued by the horse-riding community (City of Kwinana 2016). A designated area near CY O'Connor Reserve is open to horses between 4am and 8am daily (City of Cockburn 2016). Many users of this horse beach are active through the Horse Beach Facebook Club that promotes riding in this area and also organises group outings and events (Facebook 2022).

Picnicking: The beaches and nearby public reserves around Cockburn Sound are popular for picnicking, predominantly in the summer months (Rediscover Rockingham 2022c). The Cities of Cockburn and Rockingham have developed facilities including designated picnic areas, BBQ facilities, public toilets, playgrounds and lookouts to promote this activity (City of Kwinana 2016). Some of the most popular picnic areas are documented as being: Cape Peron Reserve, Memorial Palm beach, Benjamin Way Reserve, Rockingham Foreshore, Naval Memorial Park, Governor Road Reserve, Woodman Point Reserve.

School/Community Camps: There are three school/community camps located in the Cockburn Sound area. Point Peron Camp and the Seaside Camp for Children are located at the southern end of the Sound and cater specifically for school groups (Fairbridge 2022, Seaside Camp 2022). Woodman Point Recreation Camp is located at the northern end of the Sound and facilitates team building for both school, community and corporate groups (DLGSC 2022).

Social Sports: For the purpose of this review social sports are defined as "sporting activities where the primary purpose of the activity is participation, with the related goals of improved physical fitness, fun, and social involvement" (Sports 2022). Most of the social sports occur in a sporting complex and nearby urban parks/reserves toward the southern end of the Sound. This review identified 15 social sports that undertaken in the study region across the year.

Walking, Running and Cycling: There are a number of walking, cycling and running groups that use the Cockburn Sound area. There are also several well-established walking, running and cycling trails (Destination Perth 2022)**.** Some of the most popular trails include:

- **Coastal trails**; Kwinana Beach to Rockingham Beach Trail, Perth-Peel Coastal Walk Trail and Rockingham Beach to Cape Peron Trail (Middle 2022).
- **Nature reserve trails;** Henderson Reserve trail, Woodman Point Regional Park Loop, Lake Richmond Loop and the Cape Peron Loop trail (City of Cockburn 2017, All Trails 2022, DPAW 2022).
- **Urban trails;** the Henderson to Naval Base Shacks Trail (Middle 2022), public art walk trail through streets, parks and foreshore areas of Rockingham.

Yoga and Pilates: There are several paid and free Yoga and Pilates groups clustered towards the southern (Rockingham) end of Cockburn Sound**. T**he City of Rockingham organises free weekly Yoga classes on the Rockingham foreshore at "The Lookout" (City of Rockingham 2022d).

3.2 Water-based recreational activities

Jet-Skiing: Jet-Skiing in the Sound is concentrated towards the southern end in Mangles Bay which is claimed to be one of the most popular social Jet-Skiing areas in the state (Jet Sports West 2022). There are several jet ski businesses that use the area including: Jet ski Tours Perth, Little Diggers, Adventure Hire Perth and Break Loose. Independent jet ski users also frequent the Mangles Bay area.

Jetpack Flyboarding/Hoverboarding: This is a niche recreational activity. Currently there is one business operator in Perth, "Jet Pack Perth", which operates towards the southern end of the Sound off Rockingham Beach (Rediscover Rockingham 2022b). This review did not find any evidence of participation by individuals independent of the Jet Pack Perth business operation.

Kayaking and Stand-up Paddle (SUP) Boarding: The protected waters of the Sound provide good conditions for Kayaking and SUP boarding (Rediscover Rockingham 2021). While there is evidence of independent users, there are several commercial entities that promote this activity including: Rockingham Kayak and SUP Hire, Capricorn Sea Kayaking, WASUP and River Gods Kayaking. There are also two clubs, the Rockingham Outrigger Canoe Club and the Sea Kayak Club of Western Australia, that facilitate and promote the activity in the area (Sea Kayak Club 2021, Waka Ama Rockingham Club 2021). TrailsWestern Australia has developed and promotes the Garden Island Kayak Trail which loops between Cape Peron and the southern end of Garden Island (Trails WA 2022).

Kite Surfing/Boarding: There are designated Kite boarding zones towards the northern end of the Sound. There are many independent kite boarders as well as businesses that use the area, such as the Perth Kite Boarding School (City of Cockburn 2016). Depending on wind conditions, most kite boarding occurs in Safety Bay to the south of Cockburn Sound and at Coogee Beach to the north of the Sound.

Kite boarders will access Cockburn Sound when the wind conditions are appropriate (Cockburn Sound Coastal Alliance 2021).

Motor boating: Cockburn Sound is popular for recreational Motor boating. There are four boat ramps and numerous public jetties located across the Sound. While fishing is a common accompaniment to Motor boating, Motor boating may also include picnicking, pleasure cruising, swimming, SCUBA diving, snorkelling, Freediving, Wake Boarding and Water Skiing among other recreational activities on the water. There are generally few motor boat access restrictions in the Sound other than those around the Naval Base on Garden Island (Department of Transport 2021).The Cockburn Power Boats Association is the largest club in the Sound (Cockburn Power Boats Association 2022). There are several businesses associated with motor boat training that use the Sound including; Easy Learn Boat School, Perth Boat School, Rockingham Boating, Skippers Tickets Rockingham, Skippers Tickets Woodman Point (City of Rockingham 2022a).

Sailing: There are several recreational sailing clubs that operate in and around the Sound that run competitive events as well as facilitating non-competitive sailing activity in the area (Rediscover Rockingham 2022a). Clubs whose members access the Sound include the; Cruising Yacht Club of WA, South of Perth Yacht Club, Royal Freshwater Bay Yacht Club, Jervoise Bay Sailing Club, and the Fremantle Sailing Club. There may also be a significant number of non-club members who go sailing in the Sound.

Scuba/Freediving/Snorkelling and Training: Cockburn Sound is popular for recreational scuba and Freediving for both Perth locals and tourists (Cockburn Sound Management Council 2005). The main attractions to the area are the; Kwinana Grain Terminal Diving, BHP Bulk Jetty Dive site, numerous Cape Peron dive sites and the D9 shipwreck (City of Rockingham 2022c, Howies Scuba 2022). There are also several snorkelling and dive trails in the area these include: Little Penguin Trail, Cape Peron Trail, and Churchill Park Dive Trail. The main local dive companies are Scubatek Australia and Scubanautics Diving Academy and are located near the Rockingham foreshore and Perth Scuba often launches in the area.

Swimming: The Sound is frequented by swimmers for leisure and exercise year round but predominantly in the summer months (Cockburn Sound Management Council 2005). This desktop review could only locate one recreational stakeholder club in the area, Rockingham Master Swim Club as most other swimmers are independent individuals or groups and numbers are not monitored.

Water Skiing and Wake Boarding : This activity is directly associated with Motor boating in the Sound. There is a Water Skiing zone in the southern end of the Sound in Mangles Bay designated by the Department of Transport (Department of Transport 2021). This desktop review has found no notable commercial or recreational clubs in the area, this activity seems to be conducted primarily by independent groups.

Windsurfing and Hydrofoiling: These recreational activities are conducted throughout the Sound (City of Cockburn 2016).Western Australia Surf is the only local kite shop/school and teaches and promotes Windsurfing and hydrofoiling in the area (Rediscover Rockingham 2022d). The University of Western Australia's Outdoor Club also undertakes and promotes Windsurfing in the area.

3.3 Recreational activity organizations accessing Cockburn Sound

The desktop review identified 60 organisations of various types associated with non-fishing recreational activities in Cockburn Sound. These included not for profit organisations, commercial businesses and social or recreation clubs (Table 5).

Table 5: Organisation names and types associated with the various recreational activities conducted in Cockburn Sound.

Activity	Organisation	Type
Birdwatching	Birdlife Australia	Not for Profit
Camping/ caravan parks	Cee & See Caravan Park	Commercial business
	Rockingham Holiday Village	Commercial business
	Naval Base Holiday Park	Commercial business
	Woodman point Holiday and Caravan Park	Commercial business
Cycling	Rockingham Social Cycling Group	Social club – paid membership
Dog beach activities	Westie Walkers Southside (Dogs)	Social club
Horse riding	Horse Beach Facebook Club	Social club
Jet-Skiing	Jetski Tours Perth	Commercial business
	Little Diggers	Commercial business
	Adventure Hire Perth	Commercial business
	Jet Sports WestWestern Australia Jetski Club	Commercial business
	Break Loose	Commercial business
Jetpack/ Flyboarding/Hoverboarding	Jet Pack Perth	Commercial business
Kayaking and SUP boarding	Rockingham Kayak and SUP Hire	Commercial business
	Capricorn Sea Kayaking	Commercial business
	WASUP	Commercial business
	River Gods Kayaking	Commercial business
	Rockingham Outrigger Canoe Club	Social club
	Sea Kayak Club of Western Australia	Not for profit - paid membership
Kite surfing/boarding	Perth Kite Boarding School	Commercial business
	Kite Boarding Australia	Commercial business
	West Oz Kite and SUP	Commercial business
Motor boating	Cockburn Power Boats Club	Not for profit - paid membership
	Garden Island Fishing and Aquatic Association	Not for profit - paid membership
Photography	WA Underwater Photography Society	Not for profit - paid membership
Sailing	Jervoise Bay Sailing Club	Not for profit - paid membership
	South of Perth Yacht Club	Not for profit - paid membership
	Jazzia Experience Sailing	Commercial business

Activity	Organisation	Type
	The Cruising Yacht Club ofWestern Australia	Not for profit - paid membership
School/ community camps	Seaside Camp for Children	Commercial business
	Woodman Point Recreation Camp	Commercial business
	Cape Peron Camp	Commercial business
Social sports	Mike Barnett Sports Complex	Not for profit
	WA Disabled Sports Association	Not for profit
	Rockingham Basketball and Recreation association	Not for profit
	Rockingham Bowling Club	Not for profit - paid membership
	Rockingham District Cricket Club	Not for profit - paid membership
	Rockingham BMX Club	Not for profit - paid membership
Snorkelling, scuba/Freediving	Perth Scuba/ Manta Dive Club	Not for profit
	Scubanautics Diving Academy	Commercial business
	Scubatek	Commercial business
	Perth Freedivers Facebook Club	Not for profit
	Murdoch University Divers	Social club
	Underwater Explores Club of WA	Not for profit - paid membership
	UWA Underwater Club	Non-commercial
	Rockingham Masters Swimming Club	Non-commercial
Walking/running	Park Run Rockingham and Baldivis	Community event (weekly)
	Secret Rocky Runners	Social club – paid membership
	Heart Foundation Walking groups	Social club
	Rockingham Walking For Fitness and Pleasure Group	Social club
	Pole Walking Group Rockingham	Social club
	Rockingham Senior Recreation Council Pole Walking	Social club
	Walkie Talkies	Social club
Windsurfing and Hydrofoiling	WA Surf	Commercial business
	UWA Outdoor Club	Not for profit - paid membership
Yoga and Pilates	Lokya Yoga	Commercial business
	Beachside Pilates	Commercial business
	Safety Bay Yoga Centre	Commercial business
	Soul Costal Yoga and Body Prep	Commercial business

4 Results: PPGIS survey of recreational activities and values

A total of 1,235 unique respondents accessed the online survey of which 597 answered at least one of the survey questions. While the absolute response rate is unknown given the unknown population size, the proportion of participants who proceeded with answering questions after accessing the online survey was about 48%. The number of respondents varied between the various questions in the survey including the mapping of activities and values. Respondents mapped a total of 2,097 features (points and lines). The number of unique respondents mapping activity points and lines for water and/or land-based activities varied (Table 6). Respondents did not always provide information about the type of activity, values and/or visit frequency associated with mapped features.

The data indicate that non-fishing recreational activities occur over the entire Cockburn Sound study area. There are key areas with notable concentrations of recreational activities at the northern (Woodman Point Reserve) and southern (Rockingham foreshore, Cape Peron) areas of the Sound. Similarly, the whole study area is associated with a range of values.

Table 6: Summary of total points and lines mapped and number of unique respondents per type of feature. Unique respondents may have mapped both lines and points, or water-based and land-based activities. Not all respondents indicated activity type, value or visit frequency for the features they placed on the map. The number of features with no activity, value and/or visit frequency is indicated.

	Feature			
	Land based activities		**Water based activities**	
	points	**lines**	**points**	**lines**
Unique respondents count	354	213	254	145
Total feature count	790	341	668	298
Max # of features per respondent	25	14	18	15
Median # of features per respondent	1	1	2	1
Average # of features per respondent	2.2	1.6	2.6	2.05
Features with no-response for:				
Activities	*75*	*61*	*28*	*16*
Values	*76*	*32*	*25*	*15*
Visit frequency	*225*	*102*	*181*	*120*

4.1 Respondent characteristics

Male respondents were slightly more numerous than females. Most respondents had a university level education (graduate/postgraduate) (54%). The age of respondents was generally evenly spread across the age ranges between 18 and 59 although the 35-39, 50-54 and 55-59 age ranges had a relatively higher proportion compared to other age groups (Table 7). More than half of respondents had an annual personal income of $78,000 - $90,999 or higher.

The most frequently reported category for years of experience participating in recreational activities in Cockburn Sound was 11-20 years (Figure 3) although 40% of respondents reported categories with 10 years or less experience. A considerable number of respondents indicated membership of at least one recreational activity club or group **(Table 8)**. The most frequently identified clubs included horse riding (29.5% of respondents) and scuba/snorkelling/Freediving (25.3% of respondents).

Table 7: Online survey respondent demographics. N for each variable is indicated in the total respondents row.

Gender	Count	%	Age range	Count	%
Female	275	46.4	18-24	37	8.6
Male	307	51.8	25-29	32	7.4
Non-binary	2	0.3	30-34	31	7.2
Prefer not to say	9	1.5	35-39	54	12.6
Total respondents	**593**	**100.0**	40-44	38	8.8
Highest Education			45-49	42	9.8
Primary/some secondary school	8	1.4	50-54	58	13.5
Secondary school	65	11.1	55-59	57	13.3
Vocational/technical training	99	16.9	60-64	36	8.4
Some undergraduate tertiary study	98	16.7	65-69	21	4.9
Bachelor degree or equivalent	186	31.7	70-74	19	4.4
Postgraduate degree	131	22.3	75-79	5	1.2
Total respondents	**587**	**100.0**	Total respondents	**430**	**100.0**

Life Stage		
Couple with children – at least some of the children are still dependent	68	19.9
Couple without children	66	19.3
Couple with children – with all children independent or having left home	62	18.1
Single without children	60	17.5
Mature family (children older than 15 years at home)	45	13.2
Single with children – at least some of the children are still dependent	16	4.7
Single with children – with all children independent or having left home	11	3.2
Other	14	4.1
Total respondents	**342**	**100.0**

Annual Personal Income before tax (AU$)		
Nil income	12	3.6
$1 - $7,799 per year	6	1.8
$7,800 - $15,599 per year	7	2.1
$15,600 - $20,799 per year	5	1.5
$20,800 - $25,599 per year	7	2.1
$26,000 - $33,799 per year	13	3.9
$33,800 - $14,599 per year	9	2.7
$41,600 - $51,999 per year	15	4.5
$52,000 - $64,999 per year	22	6.5
$65,000 - $77,999 per year	26	7.7
$78,000 - $90,999 per year	39	11.6
$91,000 - $103,999 per year	25	7.4
$104,000 - $155,999 per year	51	15.1
$156,000 - $181,999 per year	12	3.6
$182,000 or more per year	45	13.4
Prefer not to respond	43	12.8
Total respondents	**337**	100.0

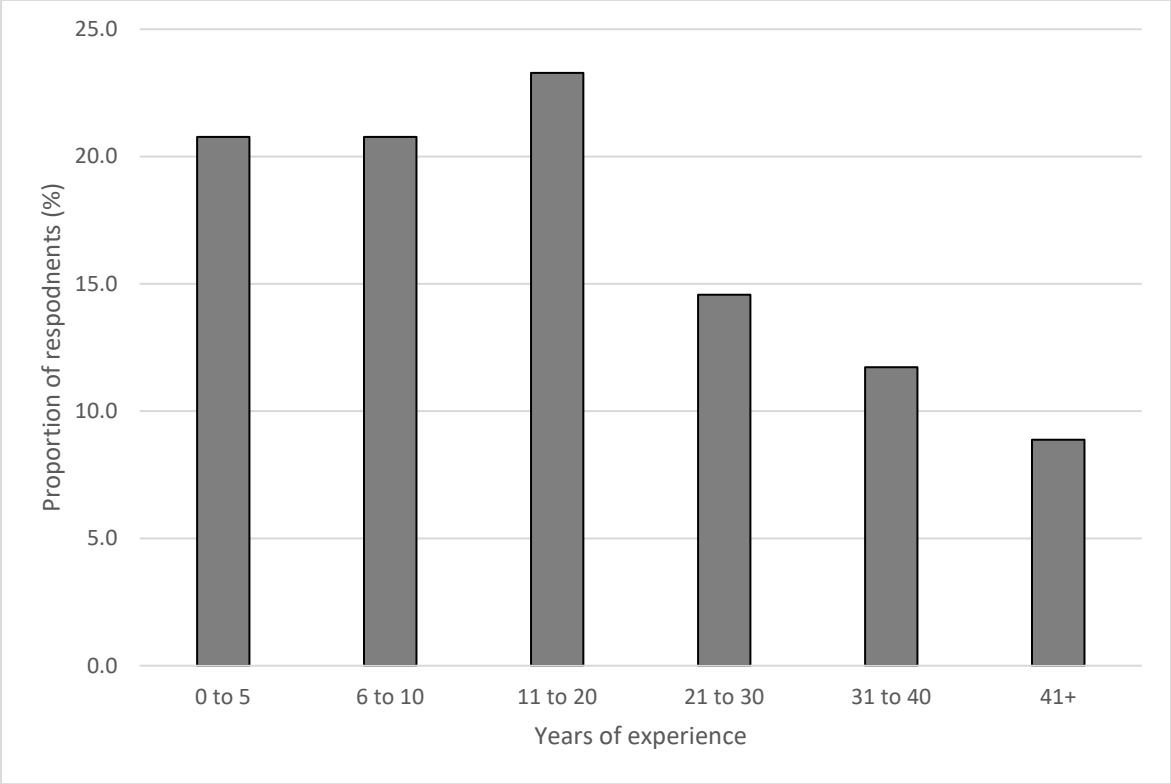

Figure 3: The number of years of experience over which respondents have visited Cockburn Sound for recreational activities (n=597).

Table 8: Number and proportion of respondent indicating membership of one or more recreational activity clubs or other non-commercial organisations. Respondents could select more than one option (n=241)

Club Activity Type	count	% Respondents
Horse riding	71	29.5
Snorkelling, scuba, or freediving	61	25.3
Sailing	46	19.1
Swimming	41	17.0
Motor boating	25	10.4
Environmental volunteering	24	10.0
Walking/running	22	9.1
Windsurfing	21	8.7
Cycling	12	5.0
Kayaking and SUP boarding	11	4.6
Birdwatching	7	2.9
Garden Island (Defence community)	6	2.5
Jet-Skiing	5	2.1

Most survey respondents travelled to Cockburn Sound by private car (Figure 4). About 70% of car-using respondents travelled with someone else, usually with 1 or 2 passengers (70% of shared cars) or occasionally with 3 -4 passengers (26% of shared cars).

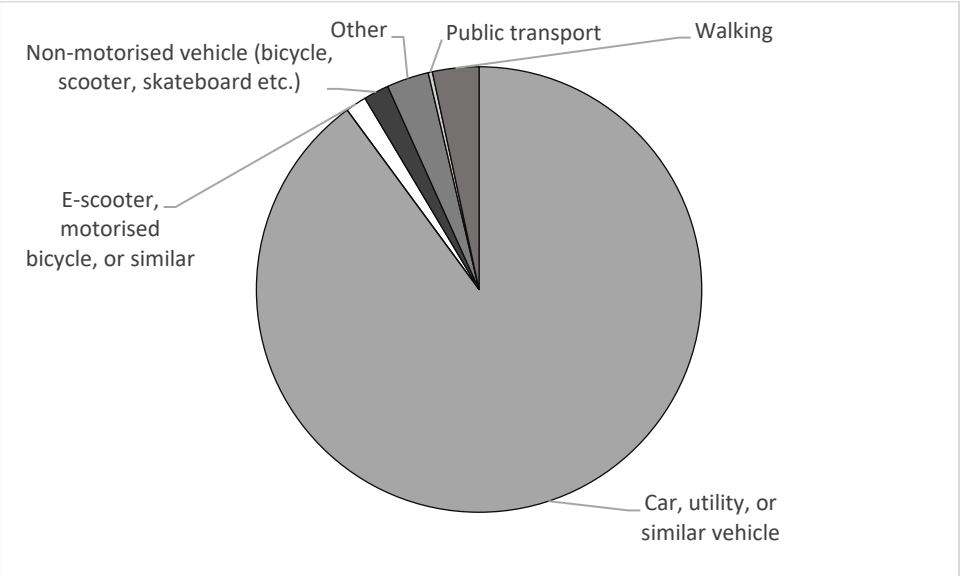

Figure 4: Transport modes used by respondents to travel to Cockburn Sound for recreational activities (n=327).

4.2 Recreational activity and values summary characteristics

When asked was they mostly participate in water-based recreational activities, 78% of respondents indicated Cockburn Sound with the remainder indicating another location (n = 305). The same question was asked regarding land-based activities and 70% indicated they mostly do land based recreational activities in the Cockburn Sound area (n=311).

4.2.1 Summary of recreational activities selection and values allocations

Beach activities was the most commonly mapped type of recreational activity, followed by walking/running, swimming and horse riding/exercising (Table 9). Hoverboarding and school/community camps were associated with the least number of unique respondents. 'Have fun', 'Improve physical health' and 'Socialise with friends/family' were associated with the highest number of unique respondents. 'Learn about cultural heritage' was notably less frequently allocated by respondents (Table 10).

Table 9: Number of unique respondents who mapped each type of recreational activity as a line or a point. Respondents may have mapped more than one type of activity.

Mapped Recreational Activity	Unique respondents count
Beach activities	166
Walking/running	101
Swimming	95
Horseback riding and swimming with horses	87
Snorkelling	65
Dog beach activities	52
Scuba diving	51
Motor boating	43
Picnicking	42
Sailing	42
Cycling	35
Freediving	29
Kayaking	22
Windsurfing	20
Birdwatching	18
Kite surfing/boarding	17
Sightseeing	12
SUP boarding	12
Community volunteering	7
Café/bar	5
Camping/caravan	4
Hydrofoiling	4
e-scootering	2
Jet-skiing	2
Photography	2
Wake Boarding	2
Water Skiing	2
Yoga	2
Hoverboarding	1
School/community camps	1

Table 10: Number of unique respondents allocating respective values for all activities mapped as a line or a point. Respondents could allocate more than one value to a single activity line or point or allocate a single value to multiple activity lines and points that were mapped.

Values	Unique respondents count
Have fun	357
Improve physical health	328
Socialise with friends/family	313
Relax	307
Appreciate natural beauty	291
Perform the activity in a safe place	249
Perform the activity in a comfortable physical environment	247
Gain personal or spiritual fulfilment	172
Learn about natural environment	148
Experience something new	132
Learn about cultural heritage	53

While a unique respondent may not have allocated all values to a specific activity they had mapped, the aggregation of all respondents resulted in a collective allocation of all values to many of the activities. For example, beach activities were collectively allocated all values by the 166 unique respondents, although the greatest proportion of respondents (81%) allocated 'have fun' while a much lower proportion of respondents (8%) allocated 'learn about cultural heritage' to beach activities. While most values were collectively nominated by respondents for each of the activities, the relative proportion of values nominated varied between each of the recreational activities (Figure 5). For example, 'Beach activities' and 'Freediving' both had all values associated with them, but with a primary emphasis on 'Have fun', 'Improve physical health', 'Socialise with friends/family', 'Relax', and 'Appreciate natural beauty' with approximately even allocation distribution between these five values. All values were allocated to sailing with an emphasis on these same five values but with the addition of 'Perform the activity in a safe place' with equal emphasis. Cycling was also allocated all values with respondents focussed on the same five values as beach activities but with a greater proportion of respondents indicating 'Improve physical health' and less of an emphasis on 'Relax'. Two activities, Jet-Skiing and Hoverboarding, had a singular or notably strong emphasis on 'Have fun' with few other values allocated to these activities. It is worth noting that Jet-Skiing had two unique respondents while hoverboarding had one unique respondent.

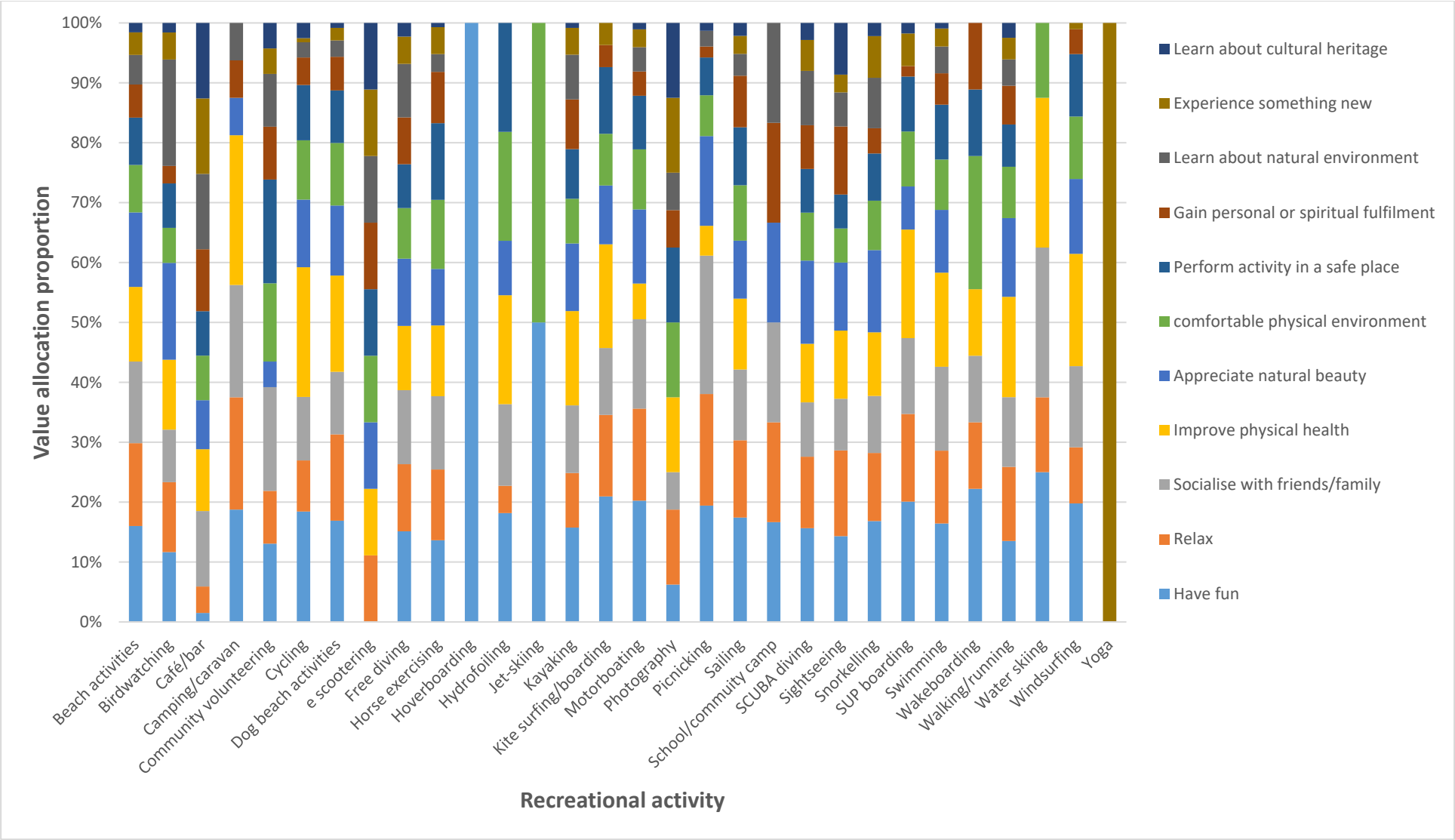

Figure 5: Proportional allocation of values to each recreational activity. The value allocation proportion is the proportion of the total values allocated to each activity by all respondents

4.3 MAPS: Visitation frequencies

A significant proportion of the Sound is accessed for recreation on a weekly basis. There are notable high frequency uses along the length of the Cockburn Sound coastline. The northern end of the Sound has the highest frequency of use for land activities (Figure 6 and Figure 7). Note that the lines mapped across the water probably indicate travel from one location to another for land-based activities. The northern end of Cockburn Sound is also associated with a notable cluster of frequent use for water-based activities (Figure 8 and Figure 9).

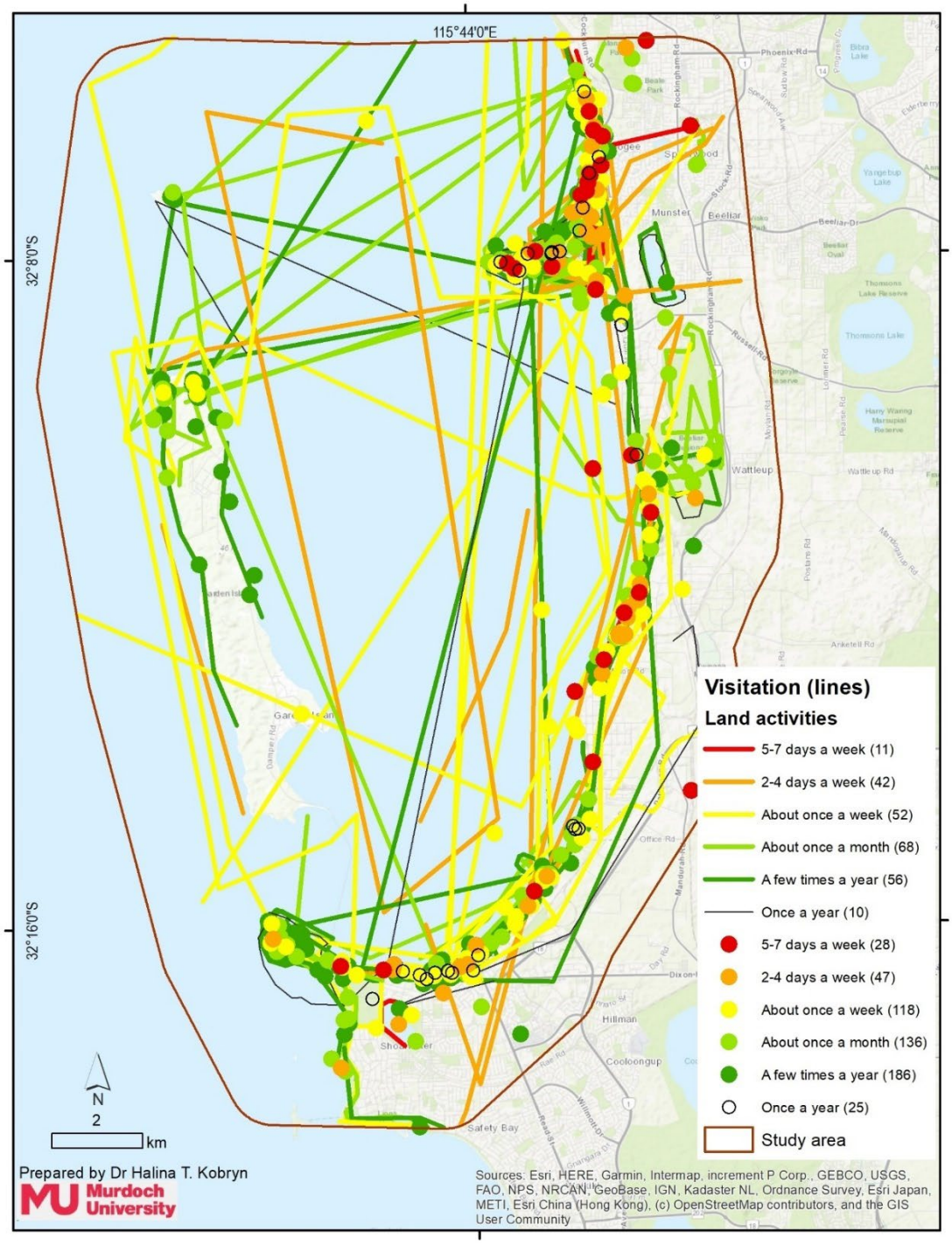

Figure 6: Frequency of visits aggregated for all land based recreational activities in the Cockburn Sound study area. Bracketed numbers in legend indicate number of unique respondents for that category. **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

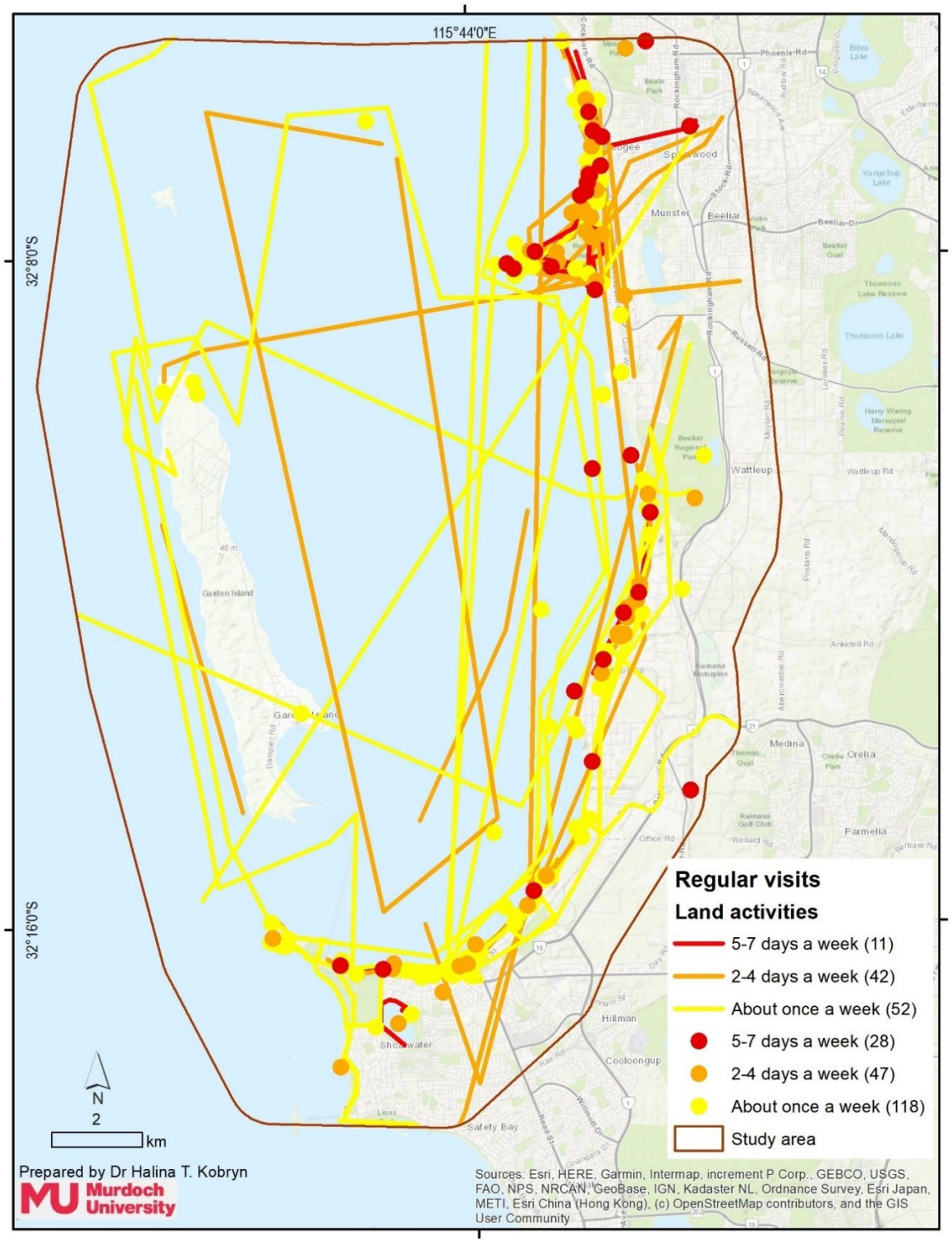

Figure 7: Weekly or more frequent visits aggregated for all land-based recreational activities in the Cockburn Sound study area. Bracketed numbers in legend indicate number of unique respondents for that category. [***Note: refer to the disclaimer on the inside cover regarding mapped activities.***]

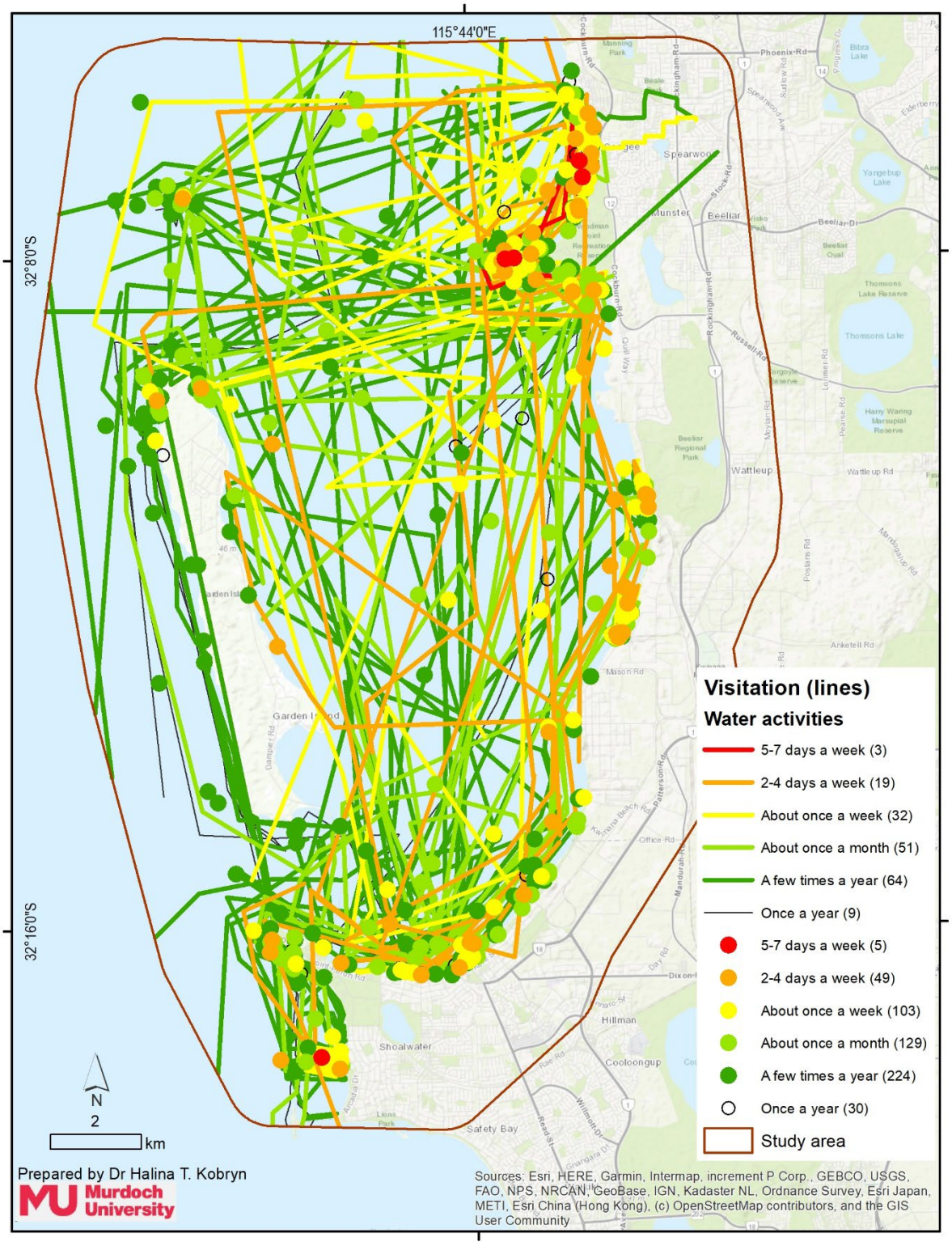

Figure 8: Frequency of visit aggregated for all water based recreational activities in the Cockburn Sound study area. Bracketed numbers in legend indicate number of unique respondents for that category. **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

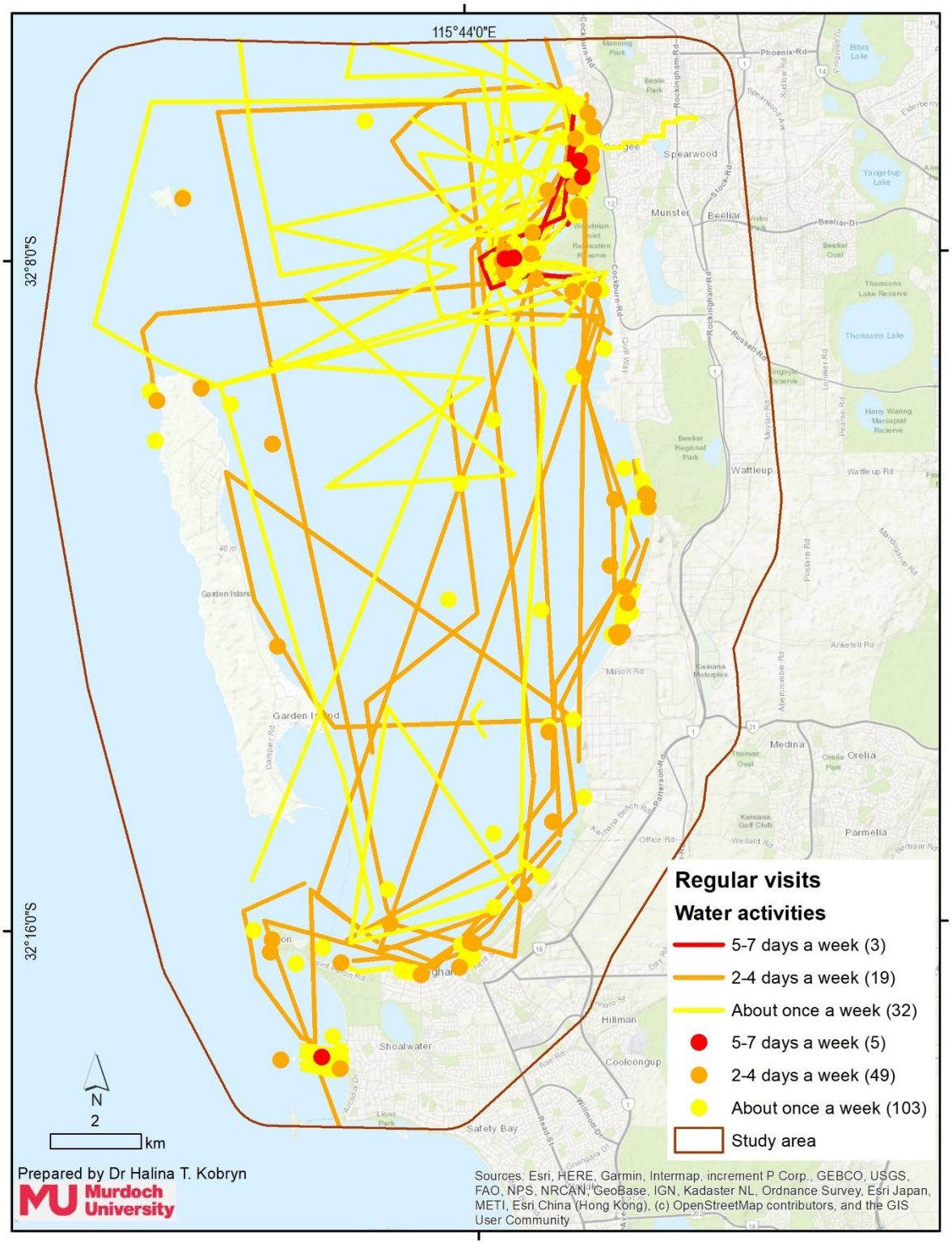

Figure 9: Weekly or more frequent visits aggregated for all water based recreational activities in the Cockburn Sound study area. Bracketed number in legend indicate number of unique respondents for that category. [***Note: refer to the disclaimer on the inside cover regarding mapped activities.***]

4.4 Values associated with recreational activities

The entire area of the Sound is associated with mapped recreational values. However, the highest concentrations of values occur along the coastline at the northern end of the Sound, the central area and to a lesser extent at the southern end. The series of figures show heat maps illustrating the concentrations of mapped values. Figure 10 illustrates the aggregated dispersal of all mapped values. Figure 11 through to Figure 21 illustrate the respective values and their dispersal across the Cockburn Sound study area. Each of the values present a similar pattern of dispersal although some values have a wider spread of higher concentrations of that value (e.g. have fun) relative to the other values. Experience something new (Figure 17) and recreation in a safe space (Figure 19) and spiritual fulfilment (Figure 21) appeared to have relatively lower concentrations.

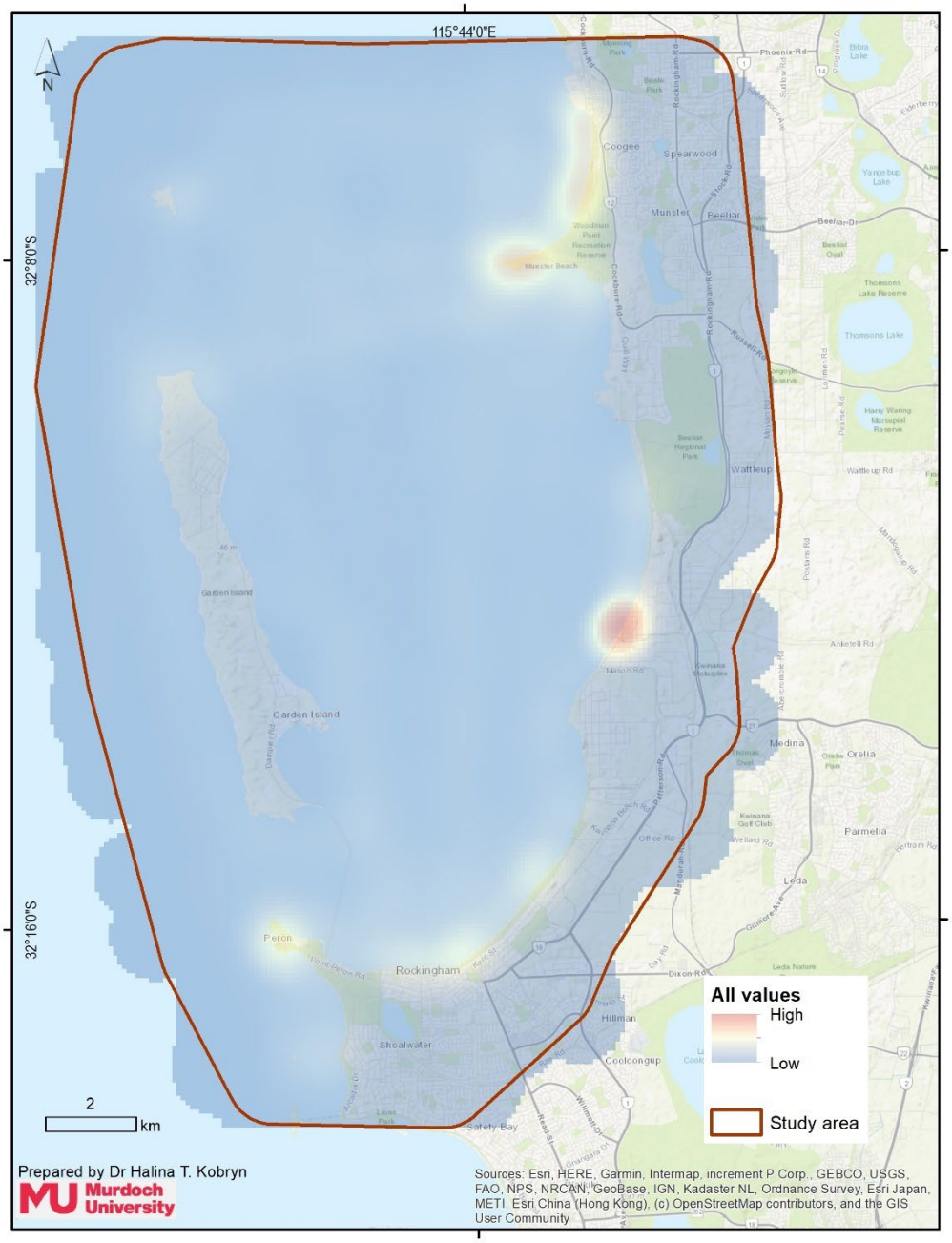

Figure 10: Aggregated heat map of all values associated with non-fishing recreational activities in Cockburn Sound. Red represents a higher concentration of mapped values (n=357). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

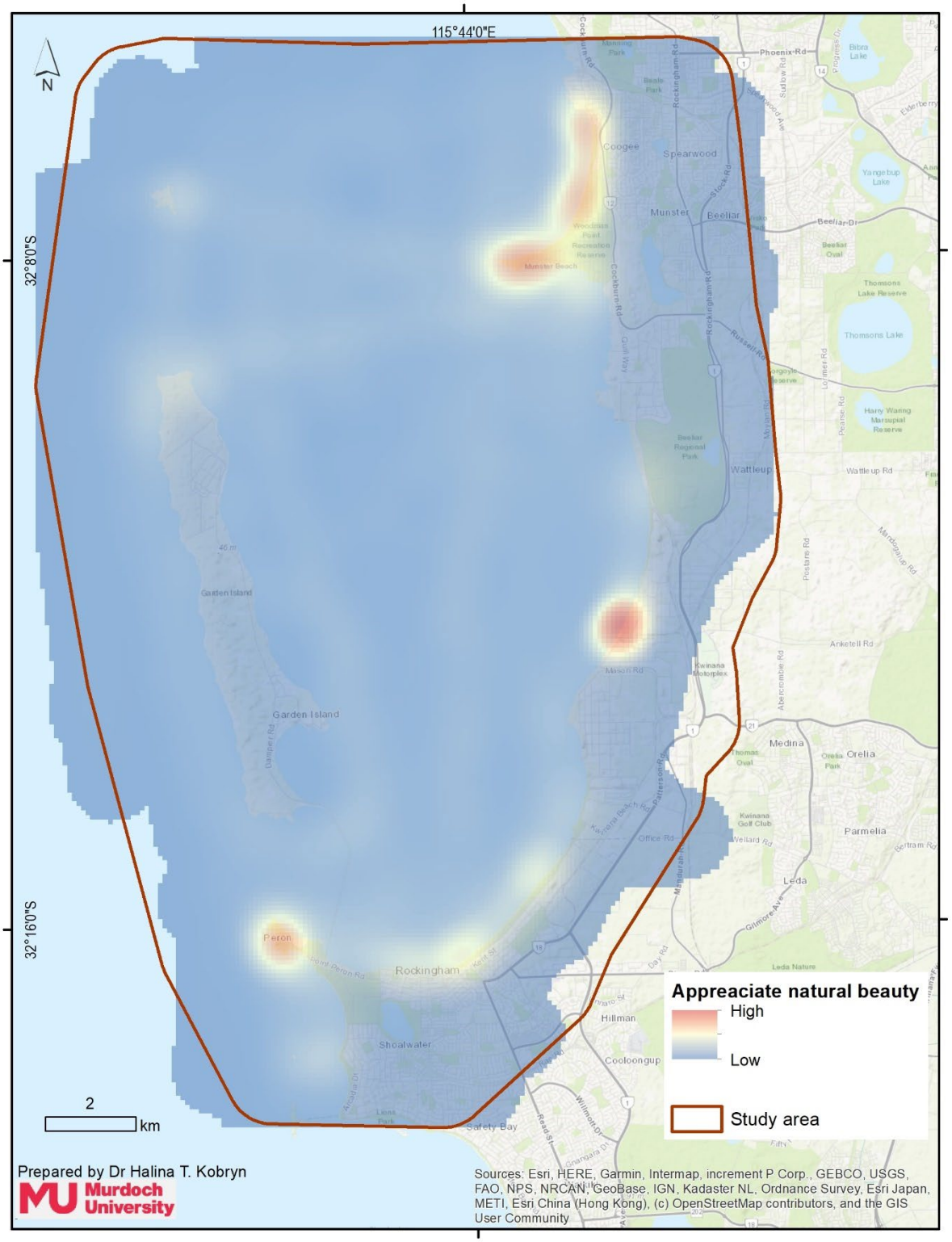

Figure 11: Heat map of the 'Appreciate natural beauty' value associated with non-fishing recreational activities in Cockburn Sound. Red represents a higher concentration of mapped values (n=291). [*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]

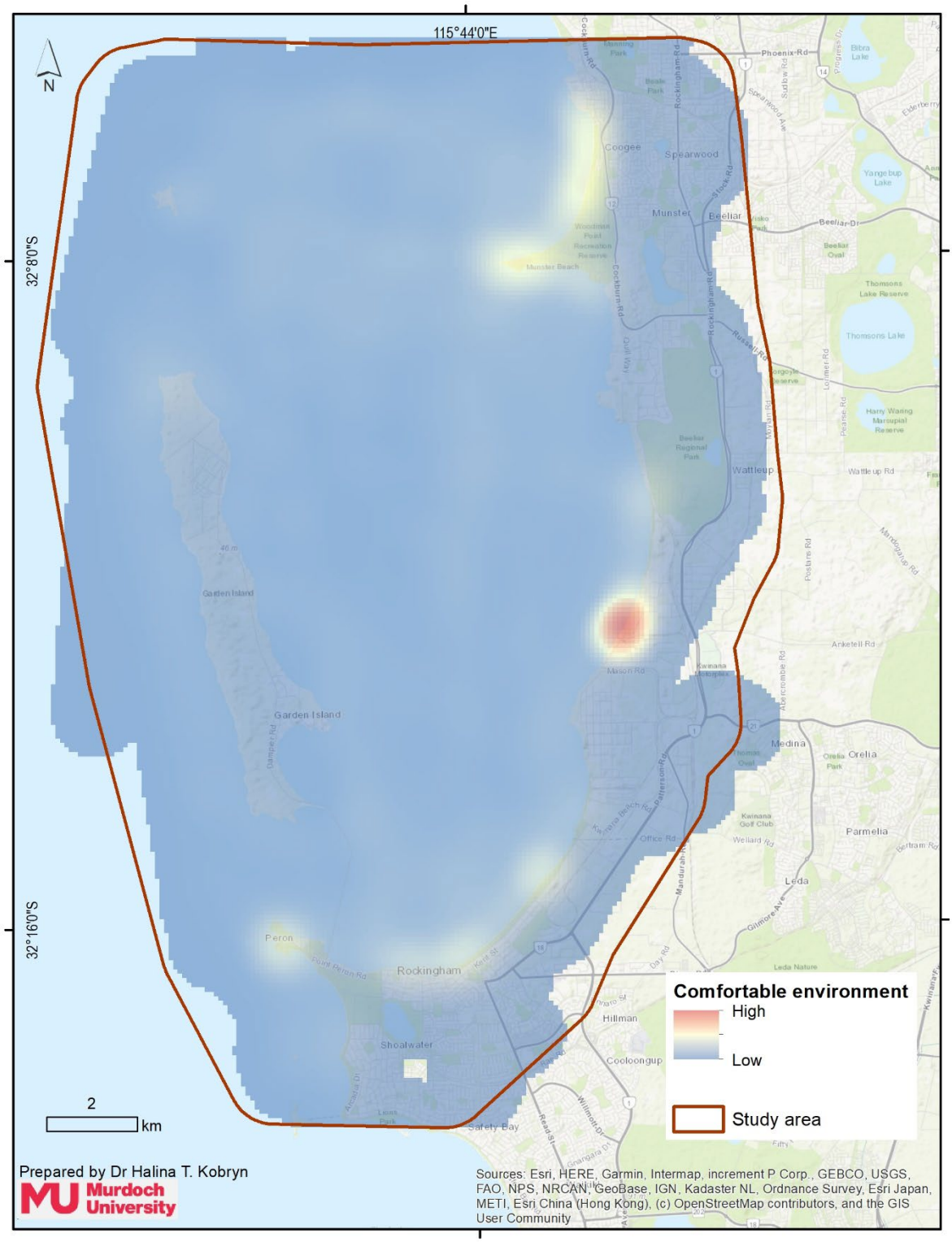

Figure 12: Heat map of the recreate in a 'Comfortable environment' value associated with non-fishing recreational activities in Cockburn Sound. Red represents a higher concentration of mapped values (n=241). [***Note: refer to the disclaimer on the inside cover regarding mapped activities.***]

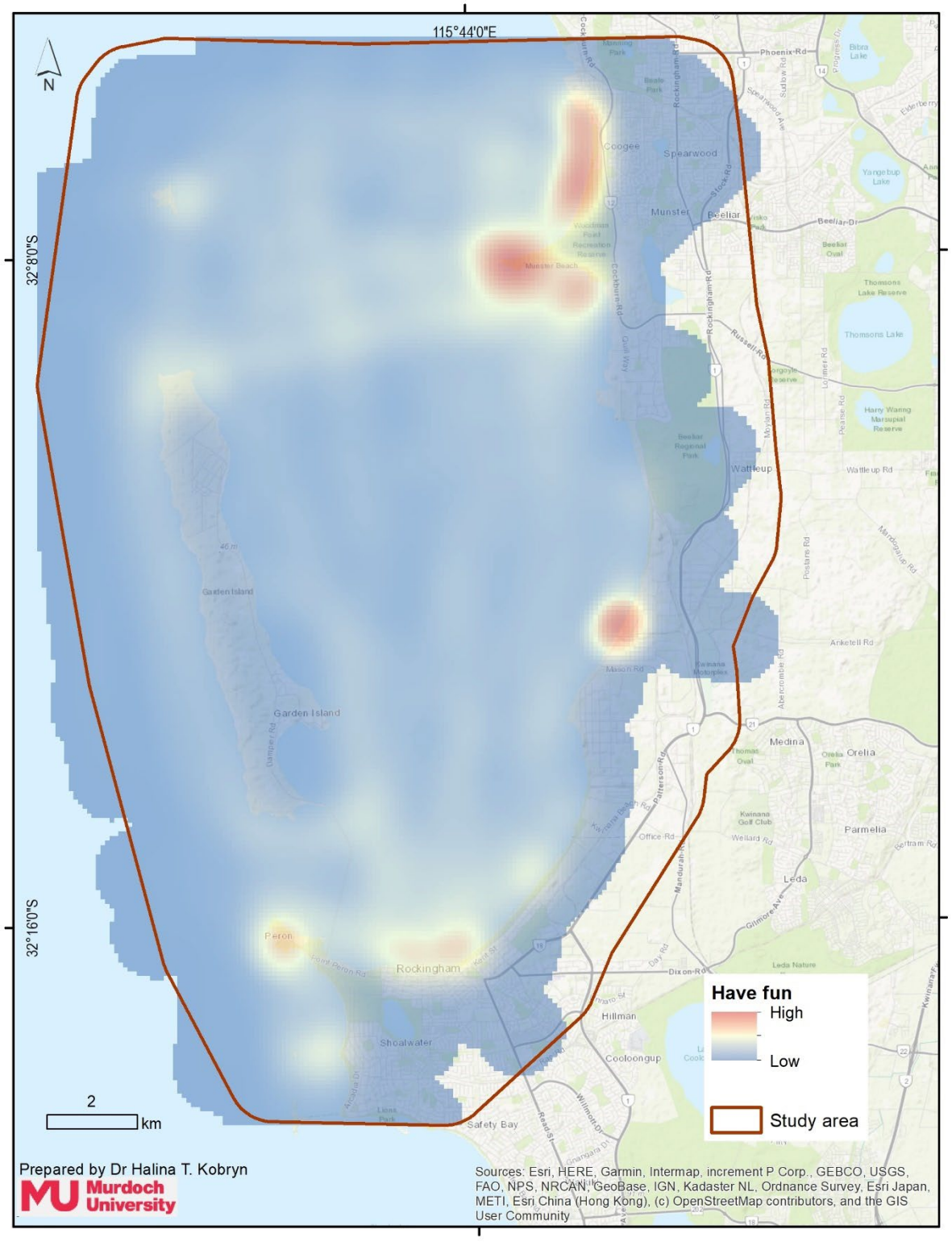

Figure 13: Heat map of the 'Have fun' value associated with non-fishing recreational activities in Cockburn Sound. Red shades indicate higher concentrations of the value (n=357). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

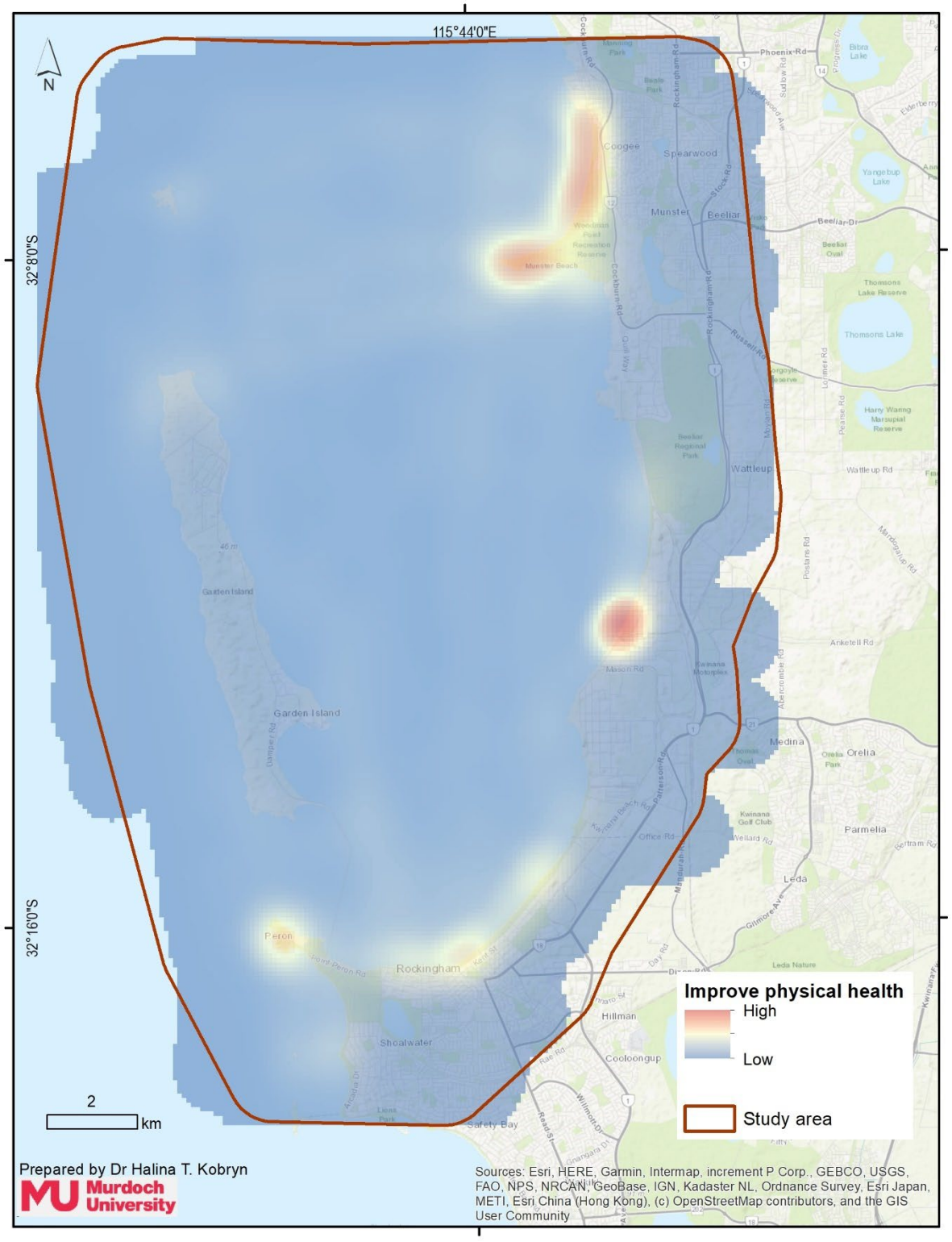

Figure 14: Heat map of the 'Improve physical health' value associated with non-fishing recreational activities in Cockburn Sound. Red shades indicate higher concentrations of the value (n=328). [***Note: refer to the disclaimer on the inside cover regarding mapped activities.***]

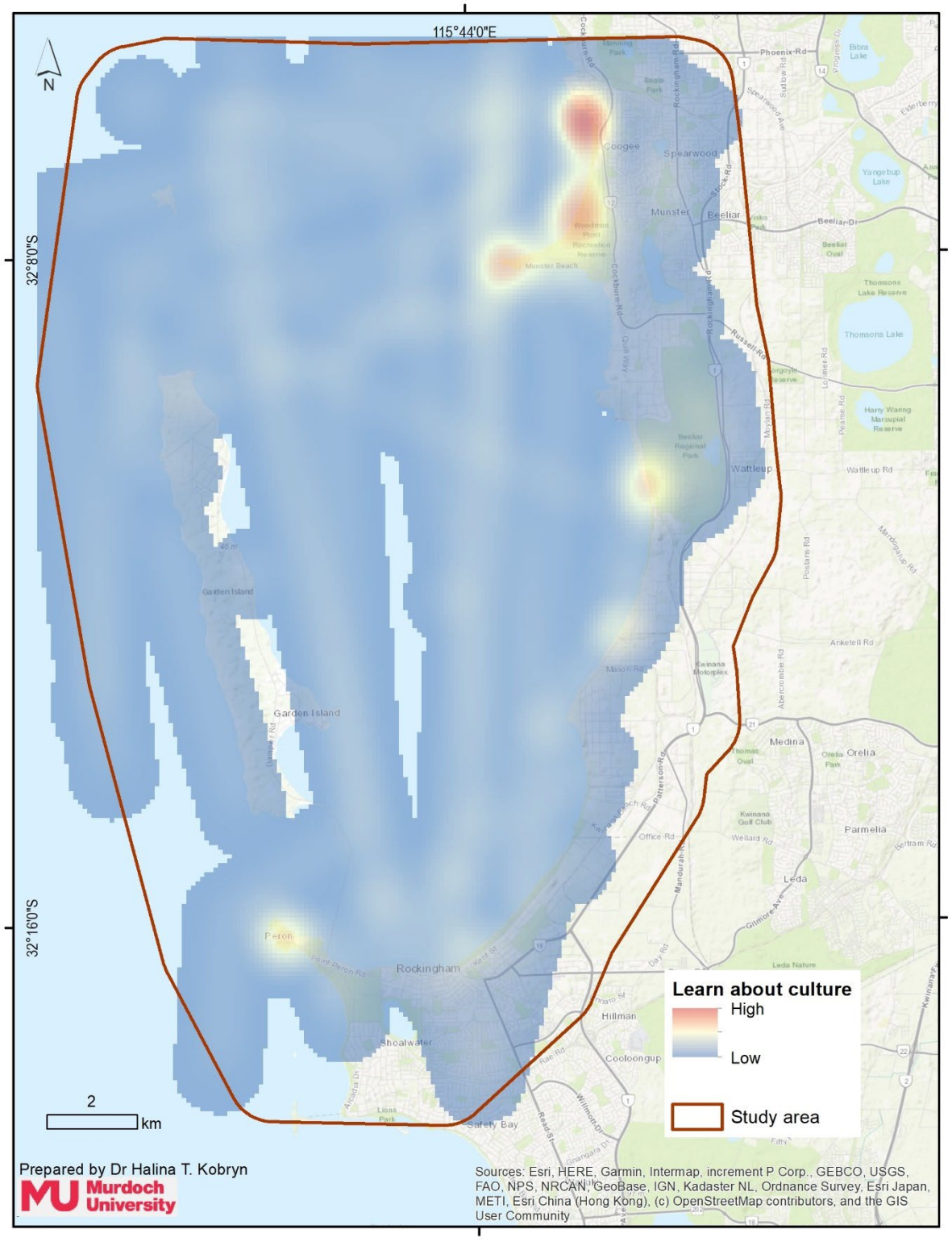

Figure 15: Heat map of the 'Learn about cultural heritage' value associated with non-fishing recreational activities in Cockburn Sound. Red shades indicate higher concentrations of the value (n=53). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

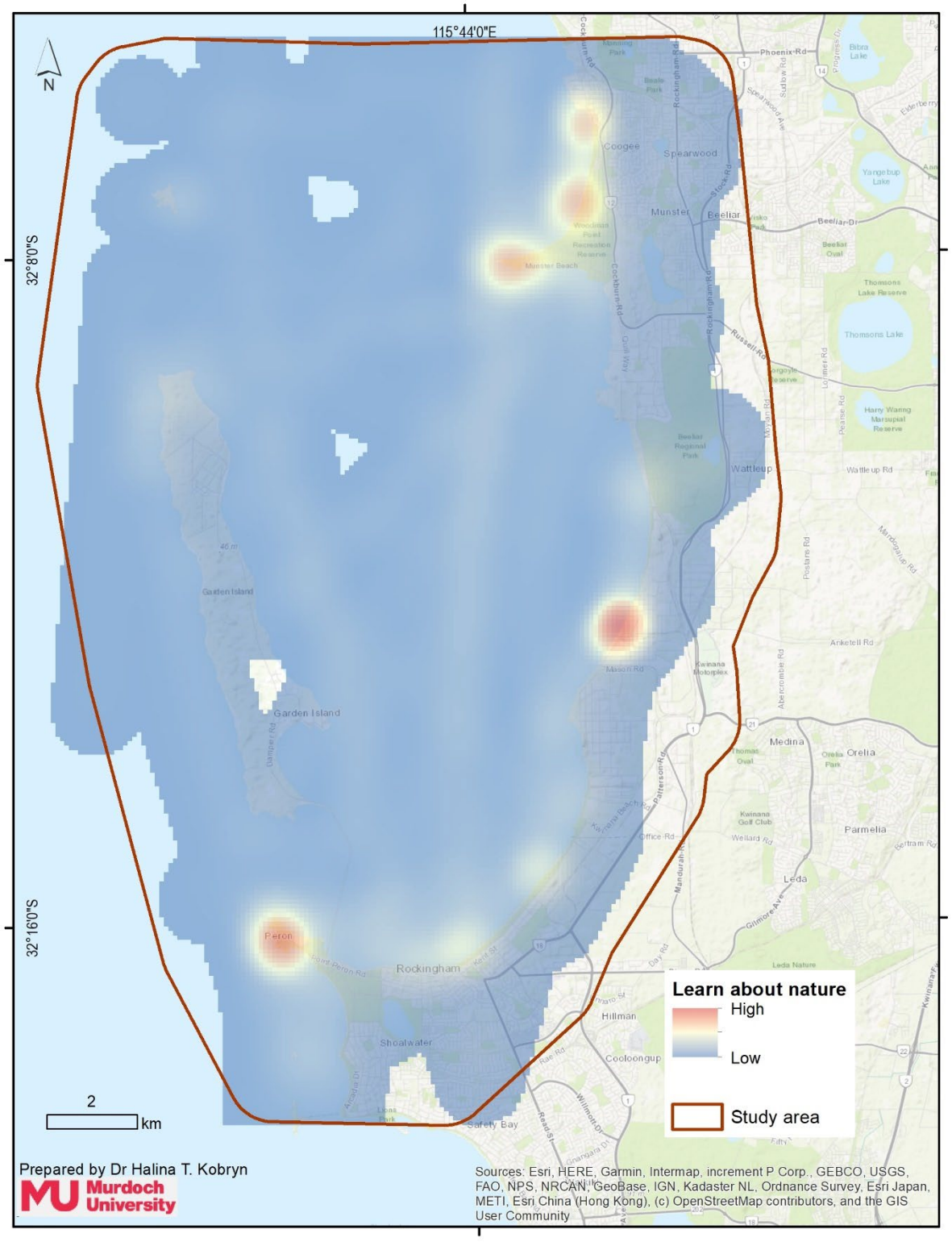

Figure 16: Heat map of the 'Learn about natural environment' value associated with non-fishing recreational activities in Cockburn Sound. Red shades indicate higher concentrations of the value (n=148). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

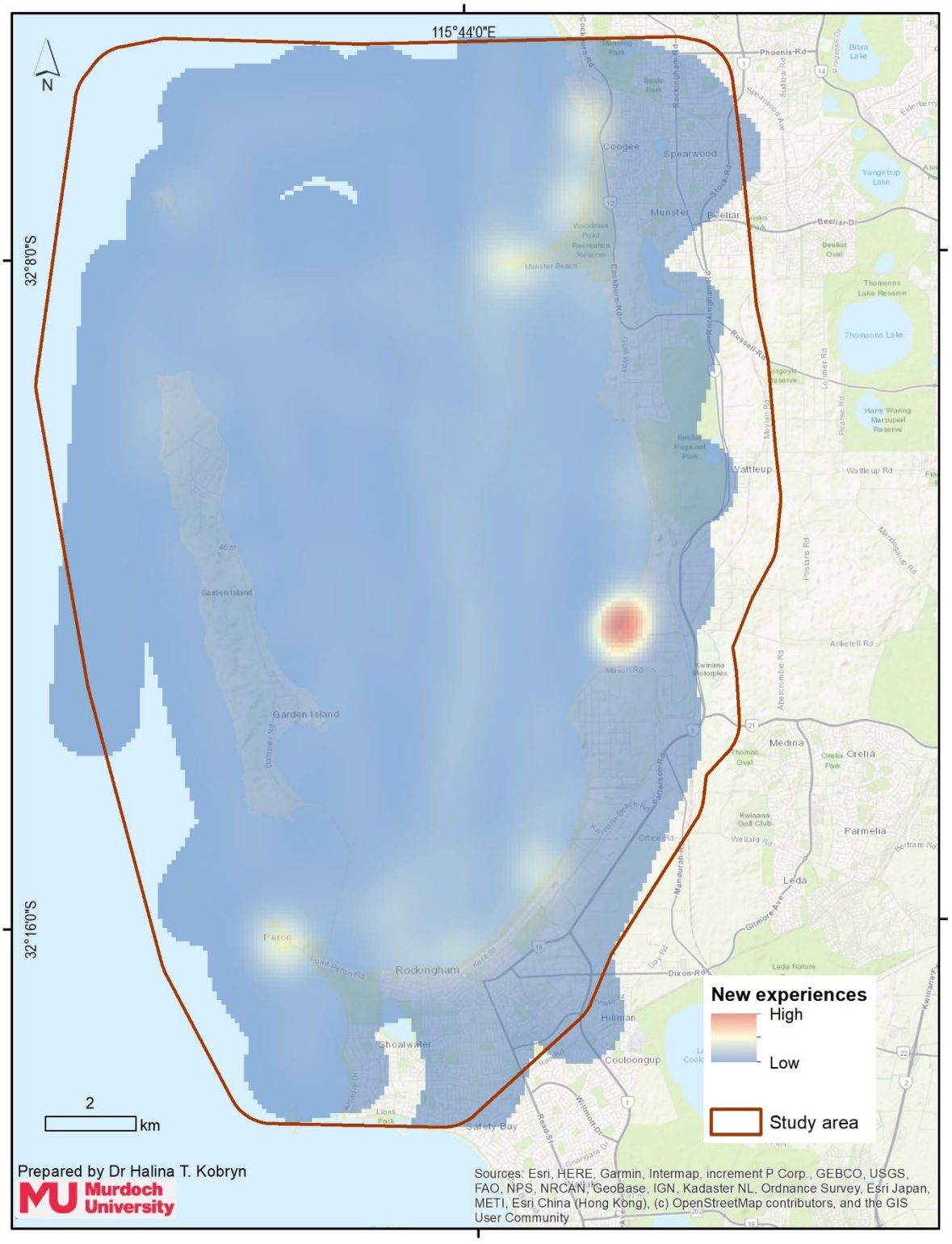

Figure 17: Heat map of the 'Experience something new' value associated with non-fishing recreational activities in Cockburn Sound. Red shades indicate higher concentrations of the value (n=132). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

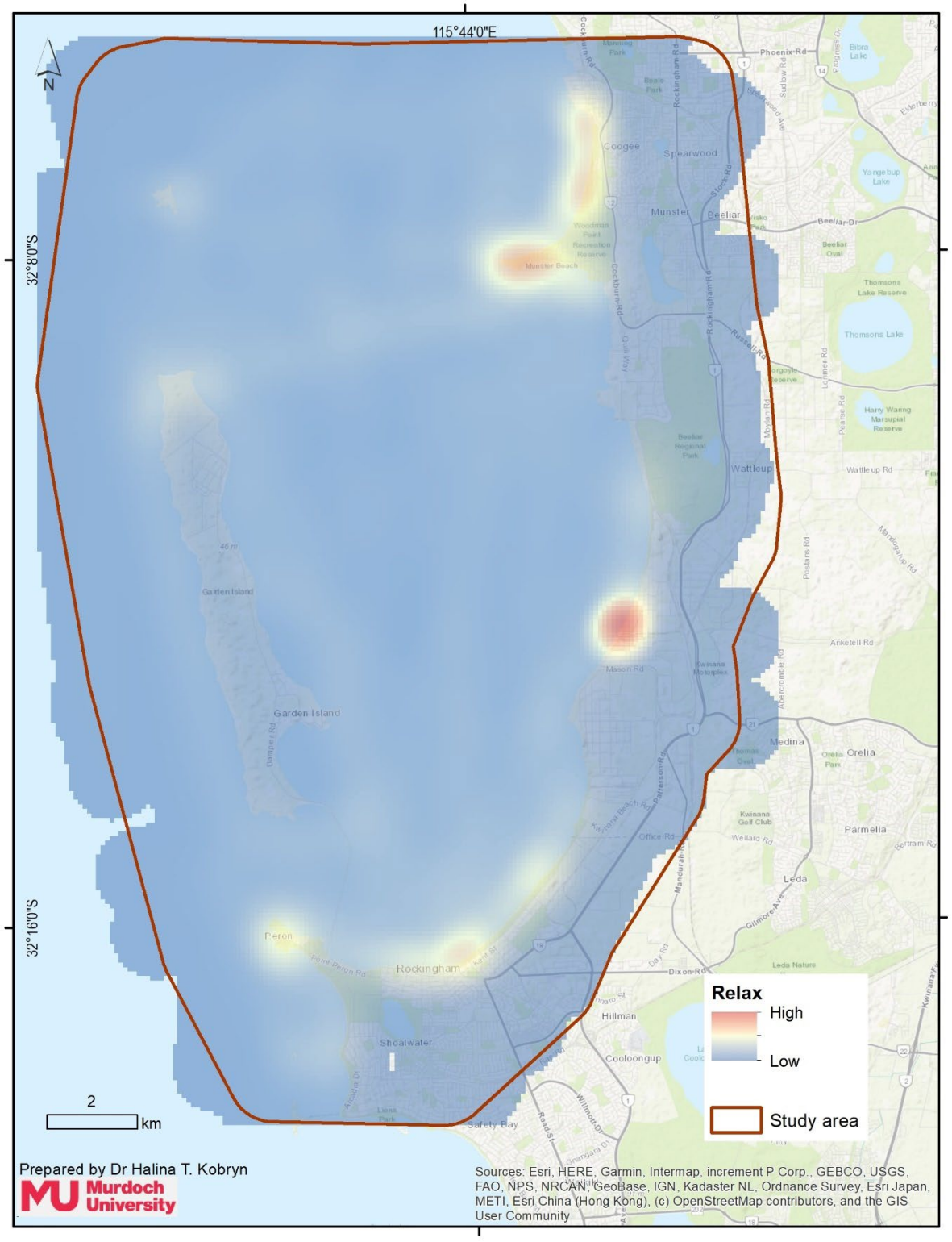

Figure 18: Heat map of the 'Relax' value associated with non-fishing recreational activities in Cockburn Sound. Red shades indicate higher concentrations of the value (n=307). [***Note: refer to the disclaimer on the inside cover regarding mapped activities.***]

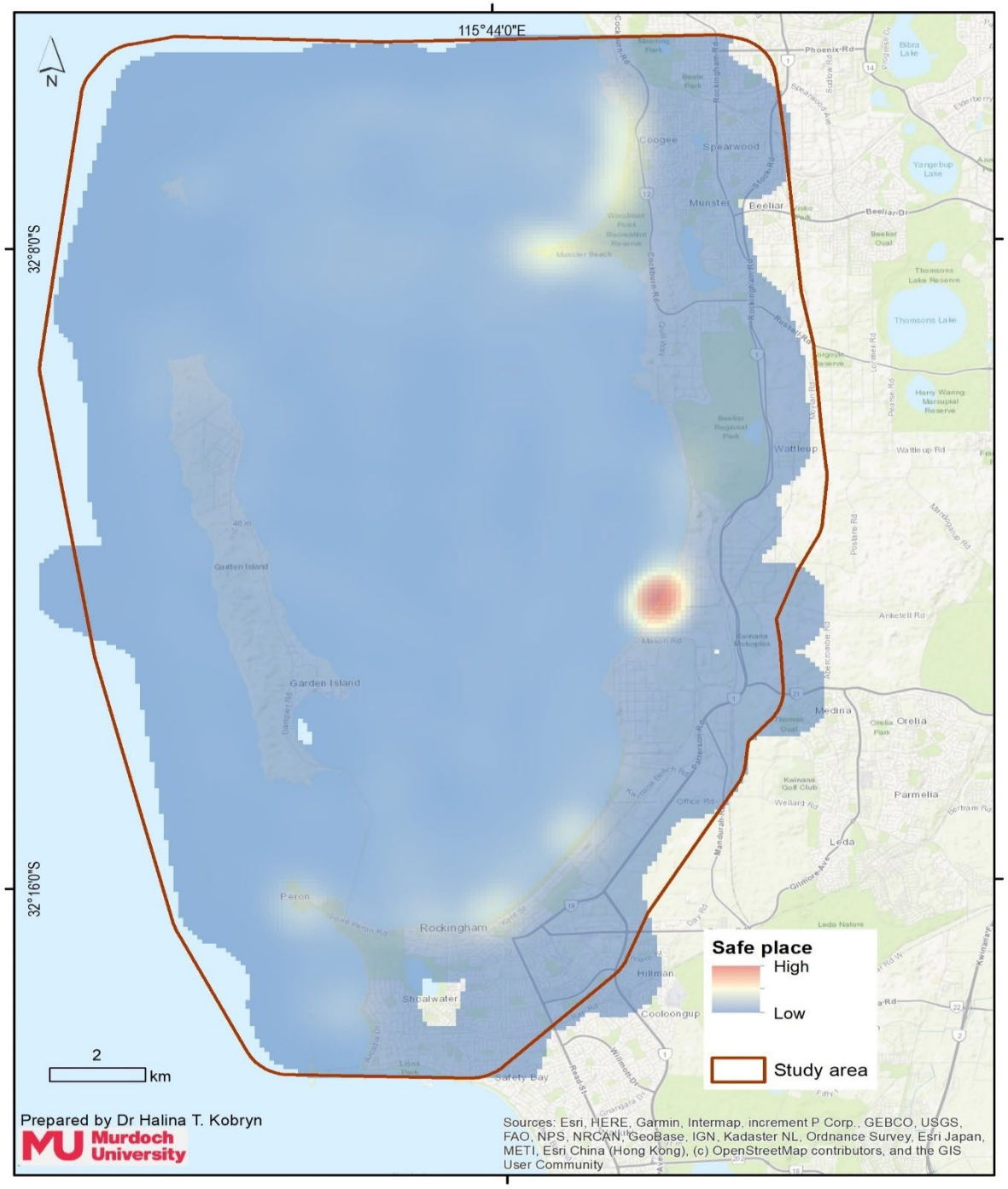

Figure 19: Heat map of the 'Perform activity in a safe place' value associated with non-fishing recreational activities in Cockburn Sound. Red shades indicate higher concentrations of the value (n=249). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

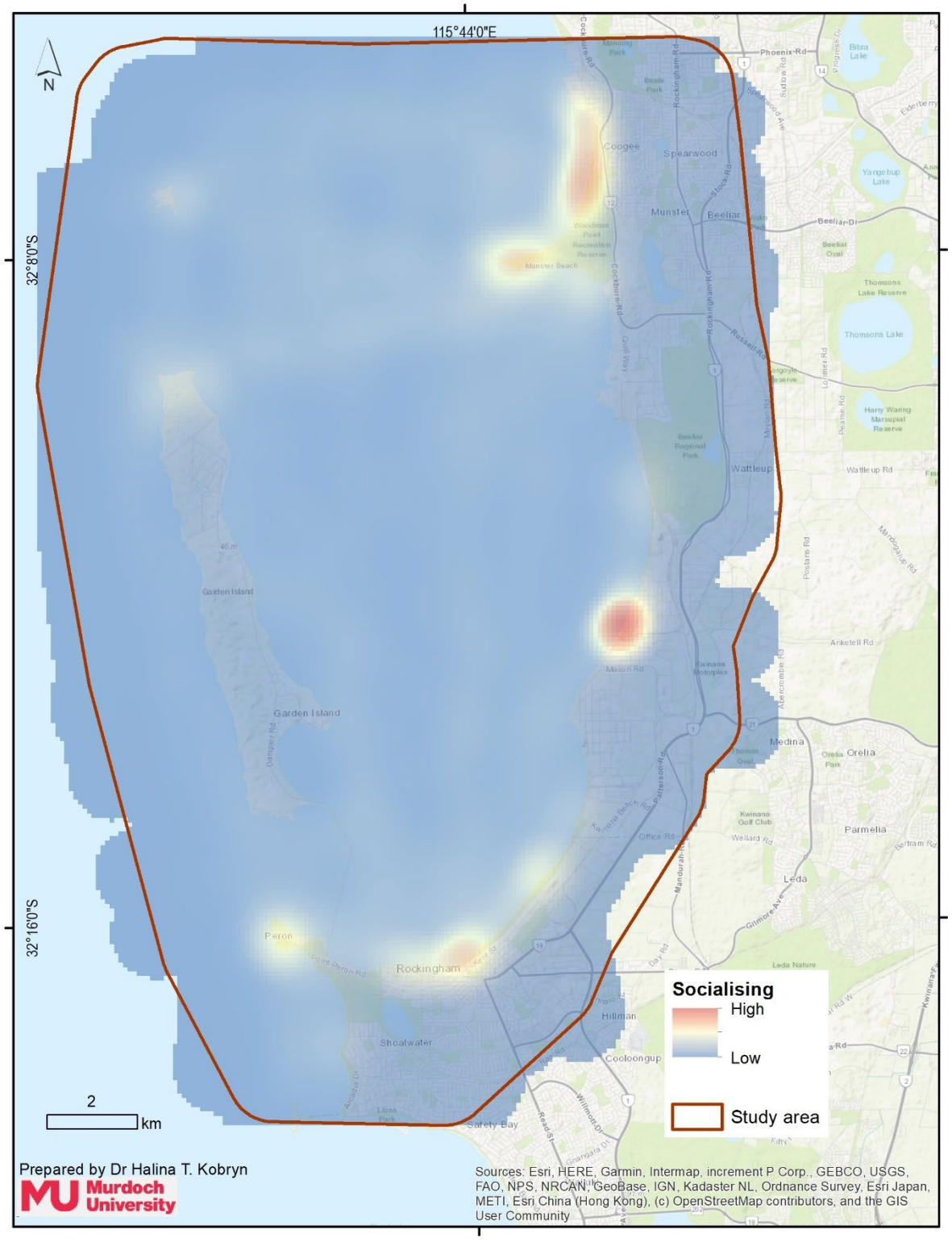

Figure 20: Heat map of the 'Socialise with friends/family' value associated with non-fishing recreational activities in Cockburn Sound. Red shades indicate higher concentrations of the value (n=313). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

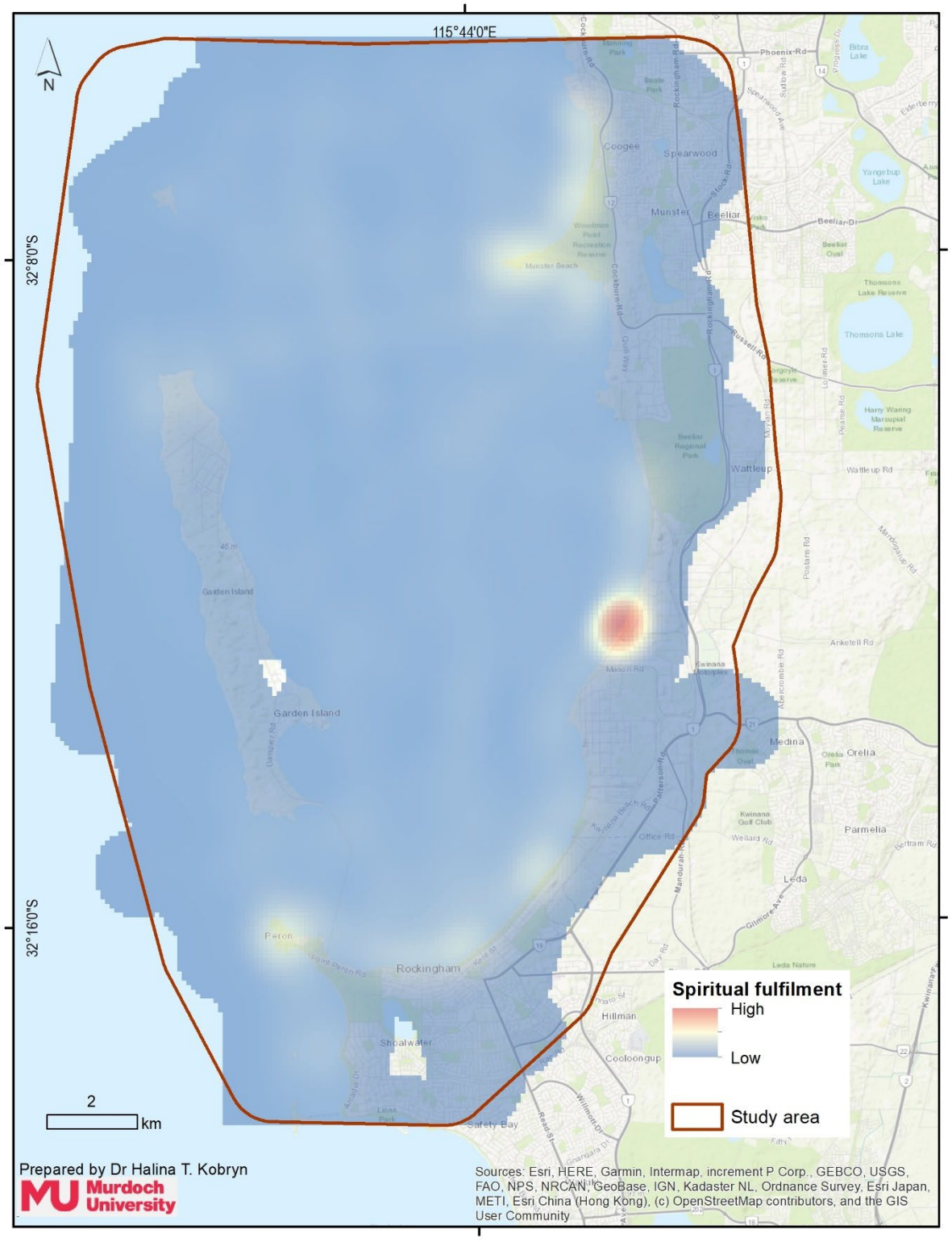

Figure 21: Heat map of the 'Personal or spiritual fulfilment' value associated with non-fishing recreational activities in Cockburn Sound. Red shades indicate higher concentrations of the value (n=172). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

4.5 MAPS: land-based activities

The aggregated heat map of land-based recreational activities reveals three areas of higher activity concentration along the coastline: the northern and southern ends of the Sound and an aggregation in the central area of the Cockburn Sound coastline (Figure 22). Individual activity maps are provided in Figure 23 through to Figure 37. Beach activities appeared to be the most widely dispersed land-based activity with a high concentration along almost the entire length of the coastline and the northern end of Garden Island (Figure 23). Activities such as Birdwatching (Figure 24), café/bar activity (Figure 25) and caravanning and camping (Figure 26), school and community camps (Figure 34) e-scootering (Figure 30) and photography (Figure 32) were focused on specific areas with limited dispersal. Some of these activities require specific infrastructure (such as camps and cafes) located in specific locations in the Cockburn Sound area. Cycling was more concentrated at the northern end of Cockburn Sound (Figure 28) while sightseeing and yoga appeared as several coastal nodes (Figure 35 and Figure 37). Maps detailing the individual features (lines and points) mapped by respondents for land-based recreational activities are included in Appendix 3. It should be noted that the mapped recreational activities with low respondent numbers (e.g. camping and caravanning, e-scootering) are more likely to appear as concentrated hotspots.

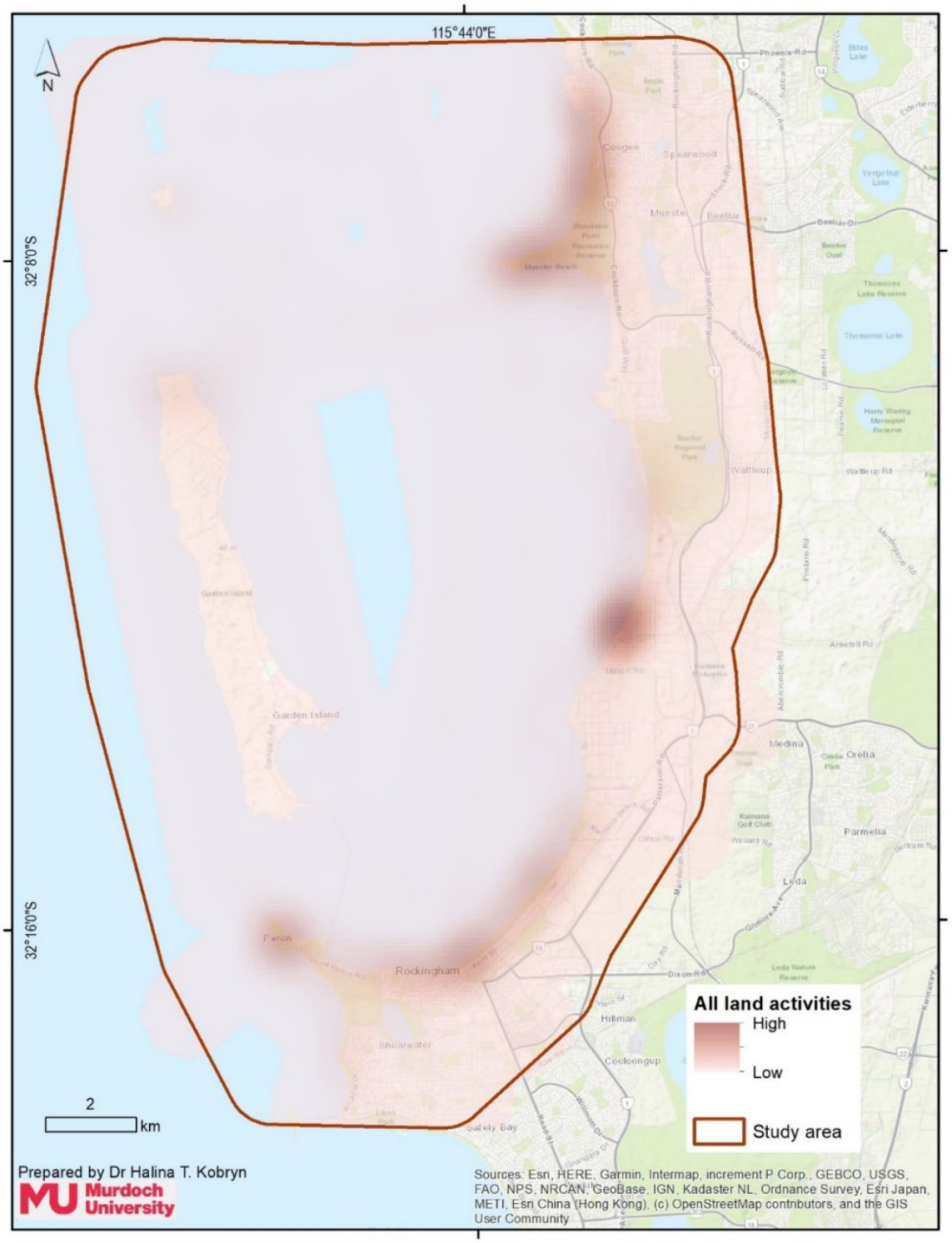

Figure 22: Aggregated heat map of all land based non-fishing recreational activities mapped in the Cockburn Sound study area. Darker shades represent higher concentrations of activities. **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

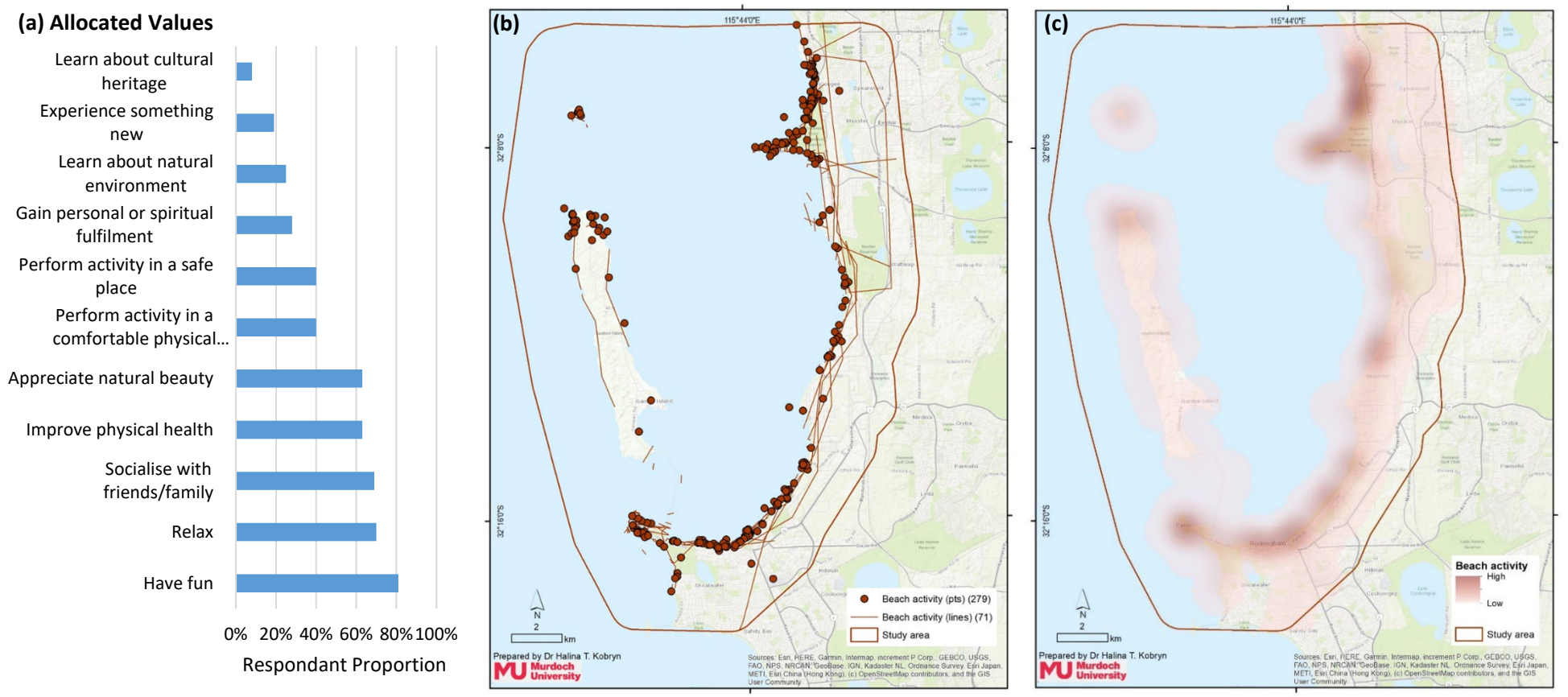

Figure 23: 'Beach activities' in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 340 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 166). [*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]

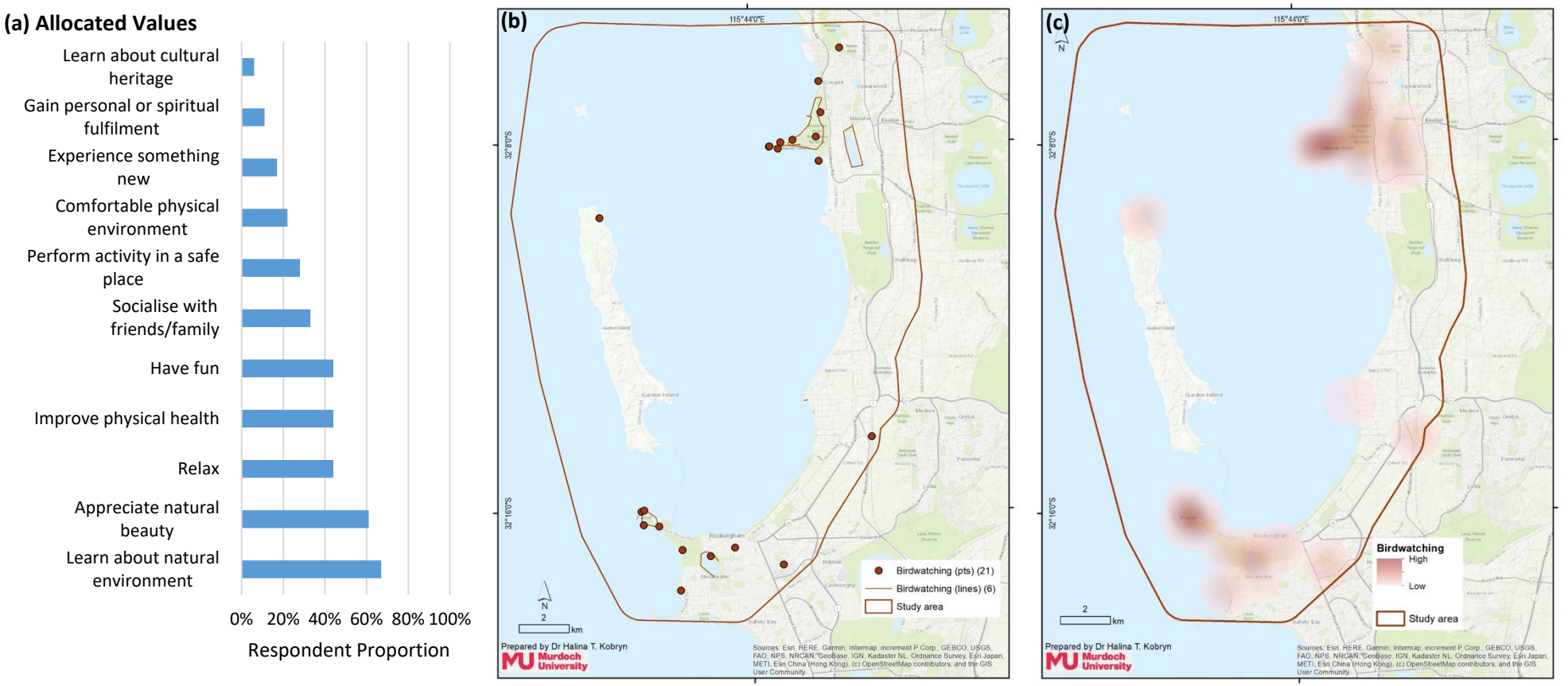

Figure 24: 'Birdwatching' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 27 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 18). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

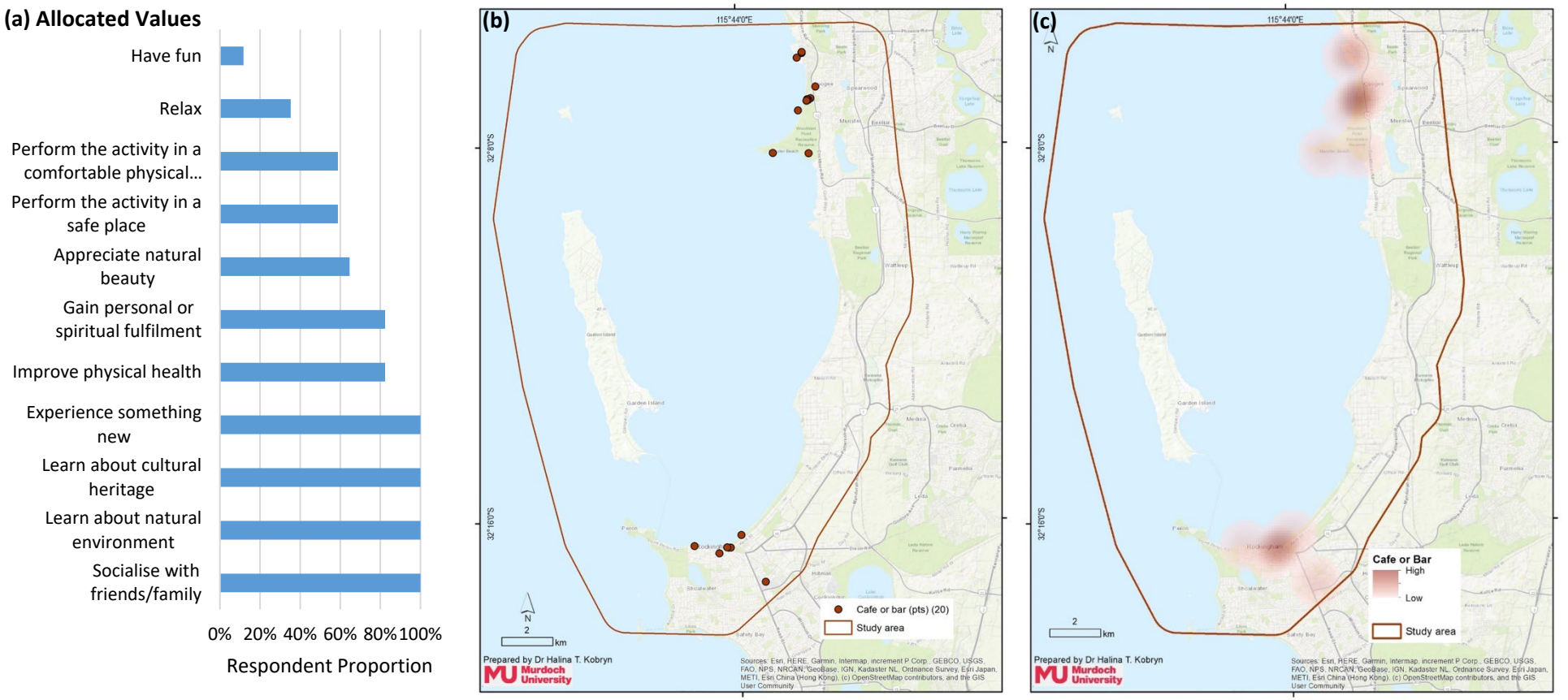

Figure 25: 'Café/Bar' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 20 points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 5). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

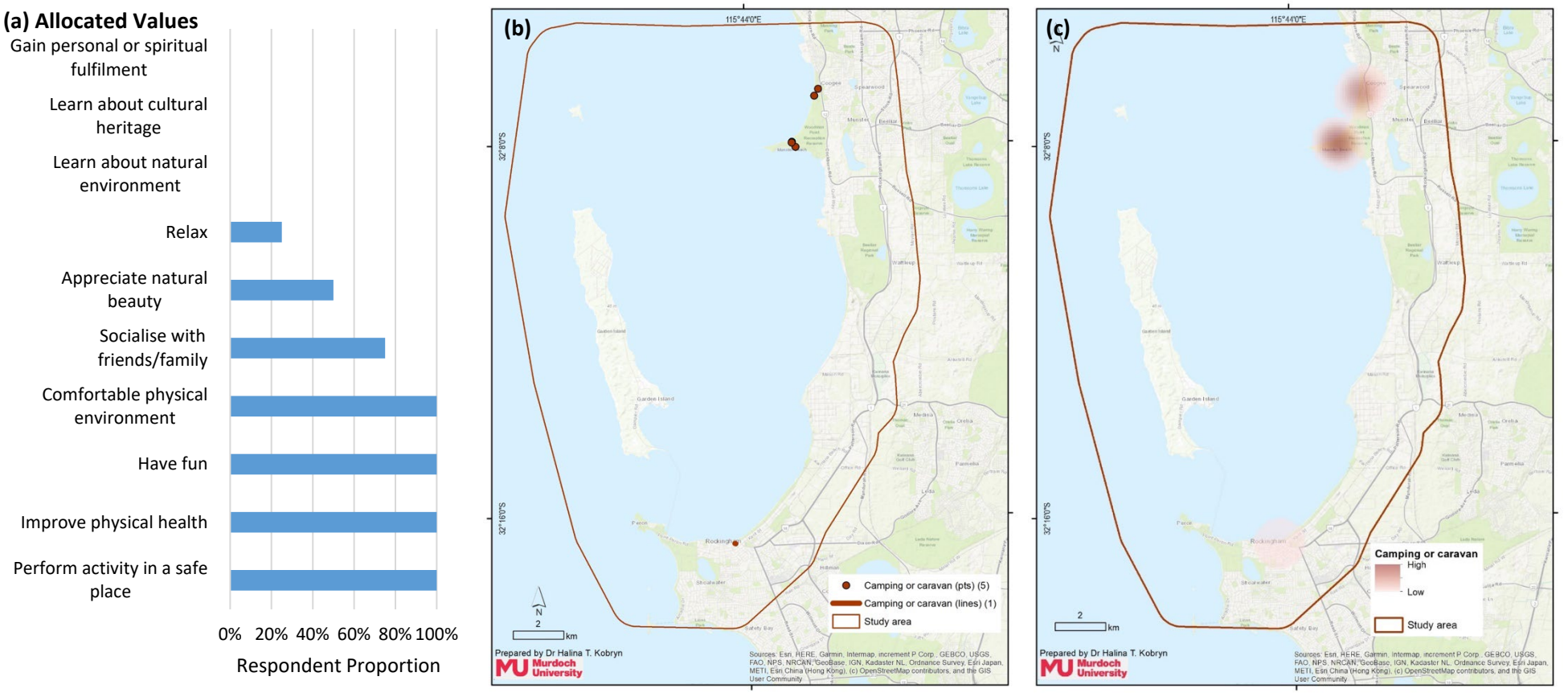

Figure 26: 'Camping and caravanning' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 6 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 4). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

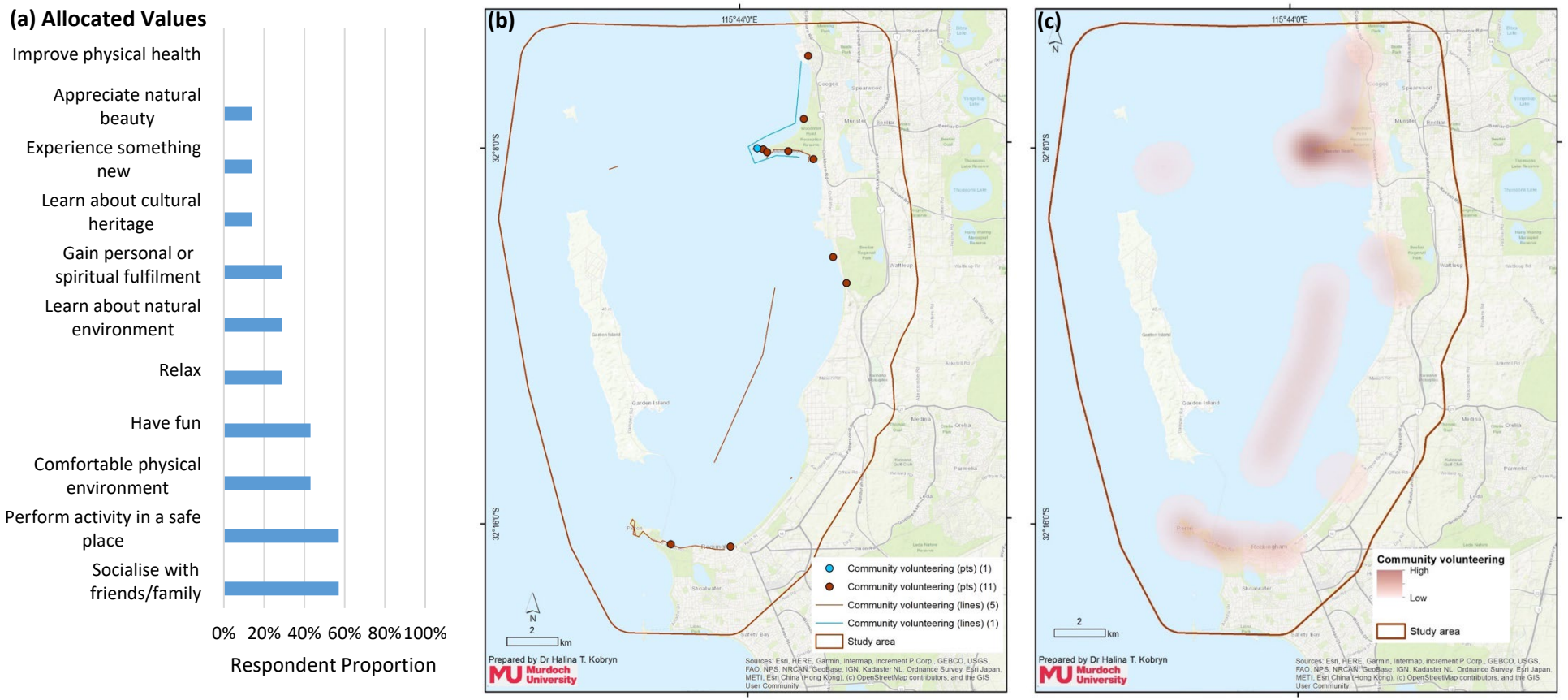

Figure 27: 'Community Volunteering' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 18 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 7). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

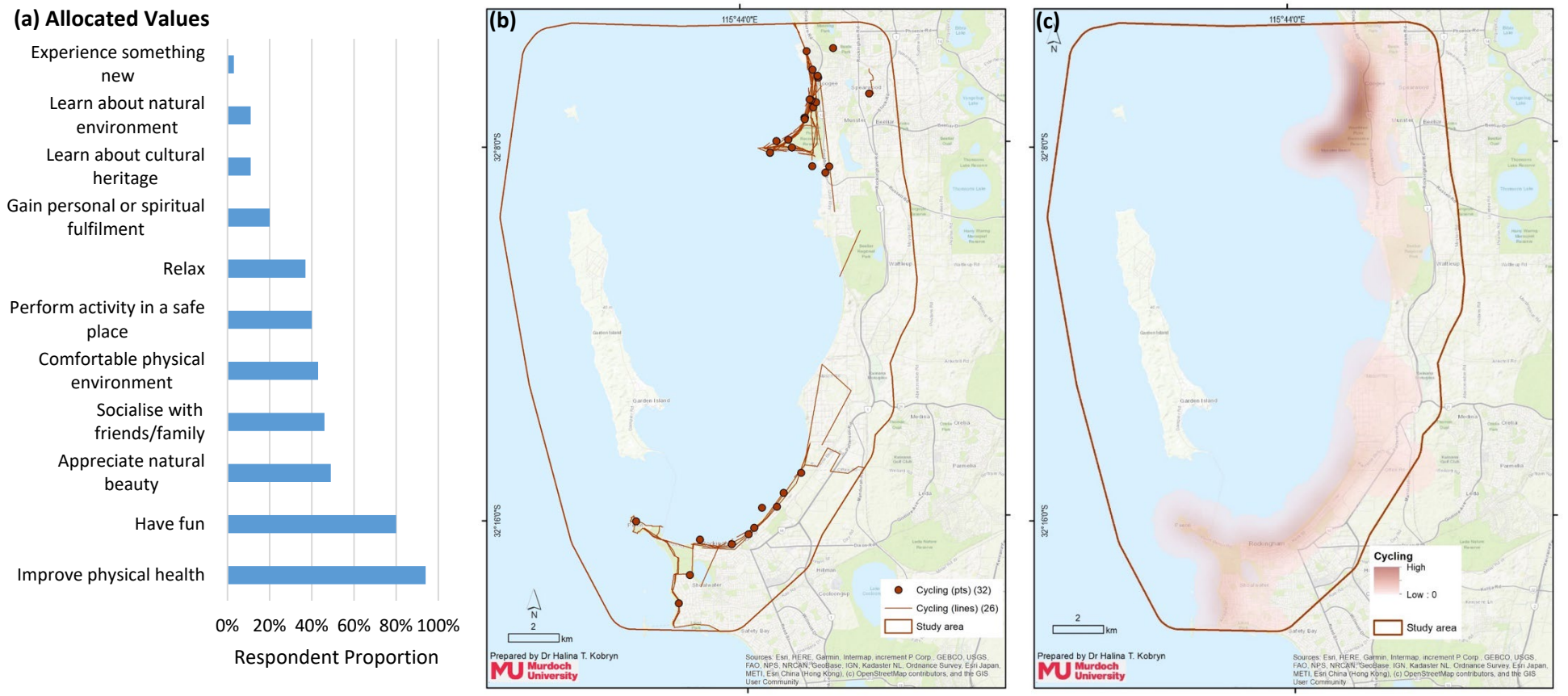

Figure 28: 'Cycling' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 58 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 35). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

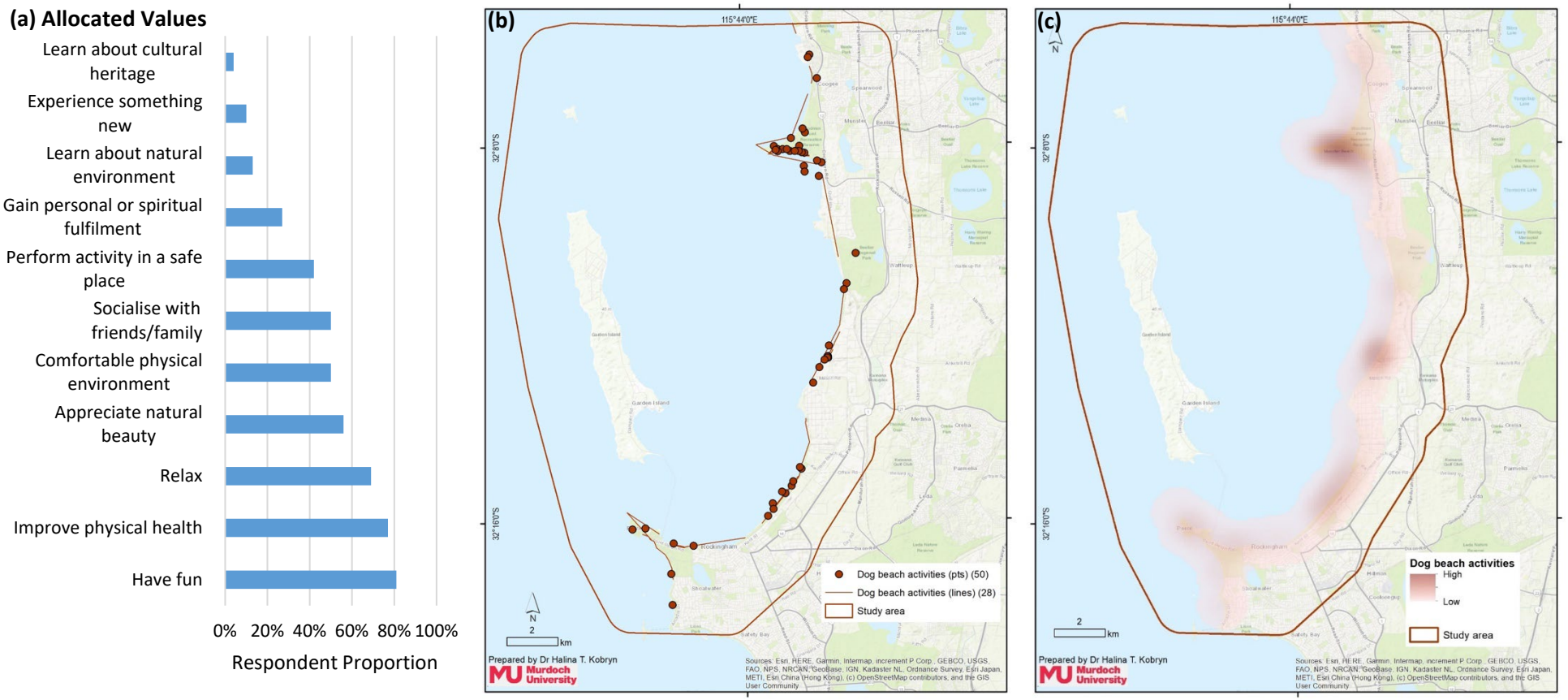

Figure 29: 'Dog Beach' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 78 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 52). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

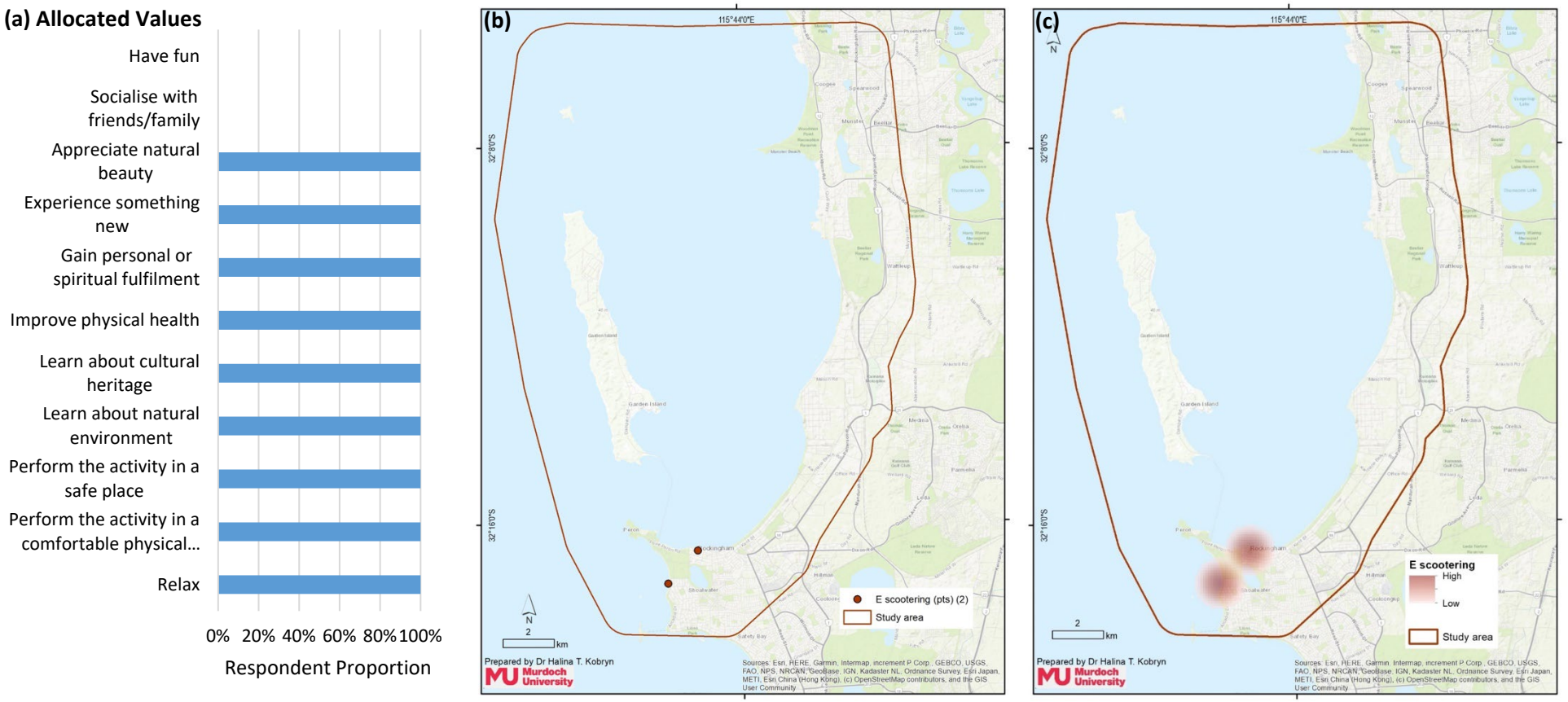

Figure 30: 'E-scootering' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 2 points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 2). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

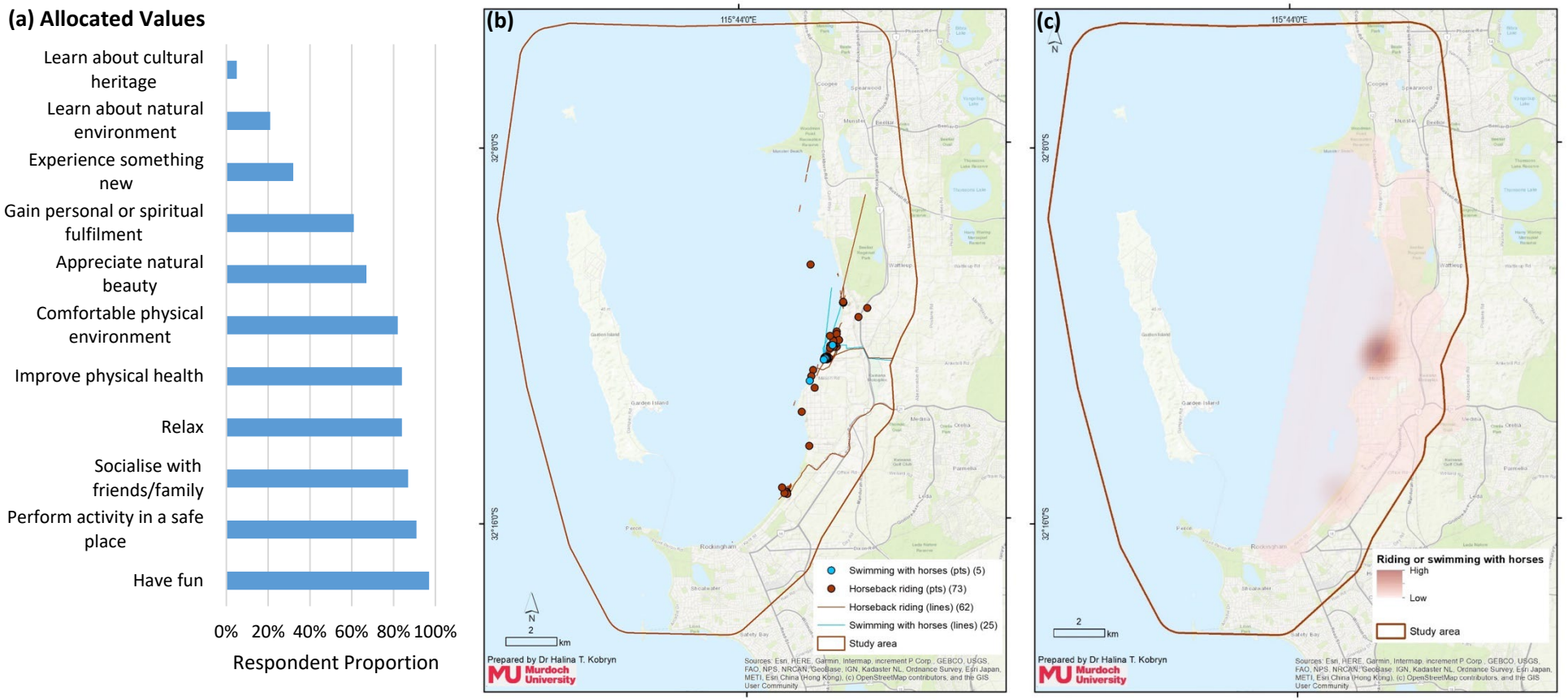

Figure 31: 'Horseback riding and swimming with horses' in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 165 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 87). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

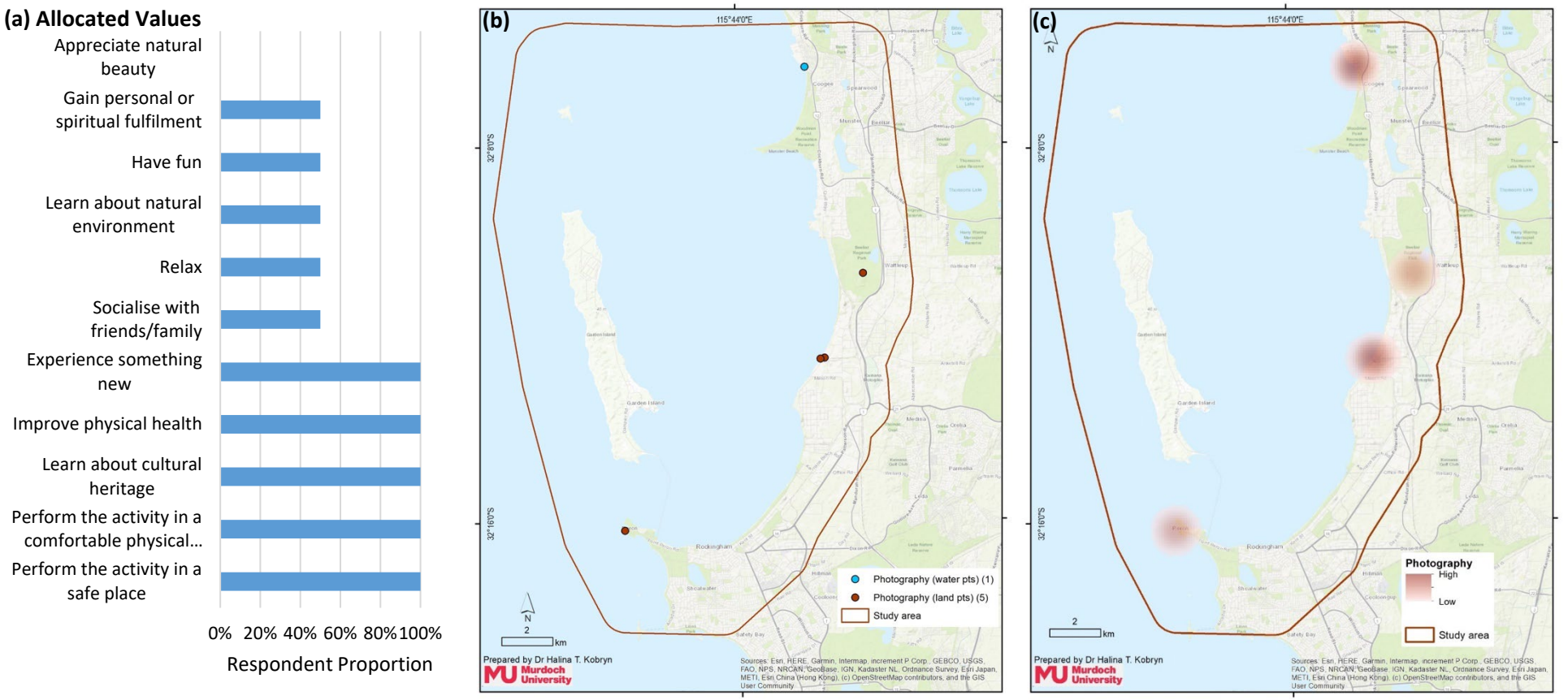

Figure 32: 'Photography' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 6 points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 2). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

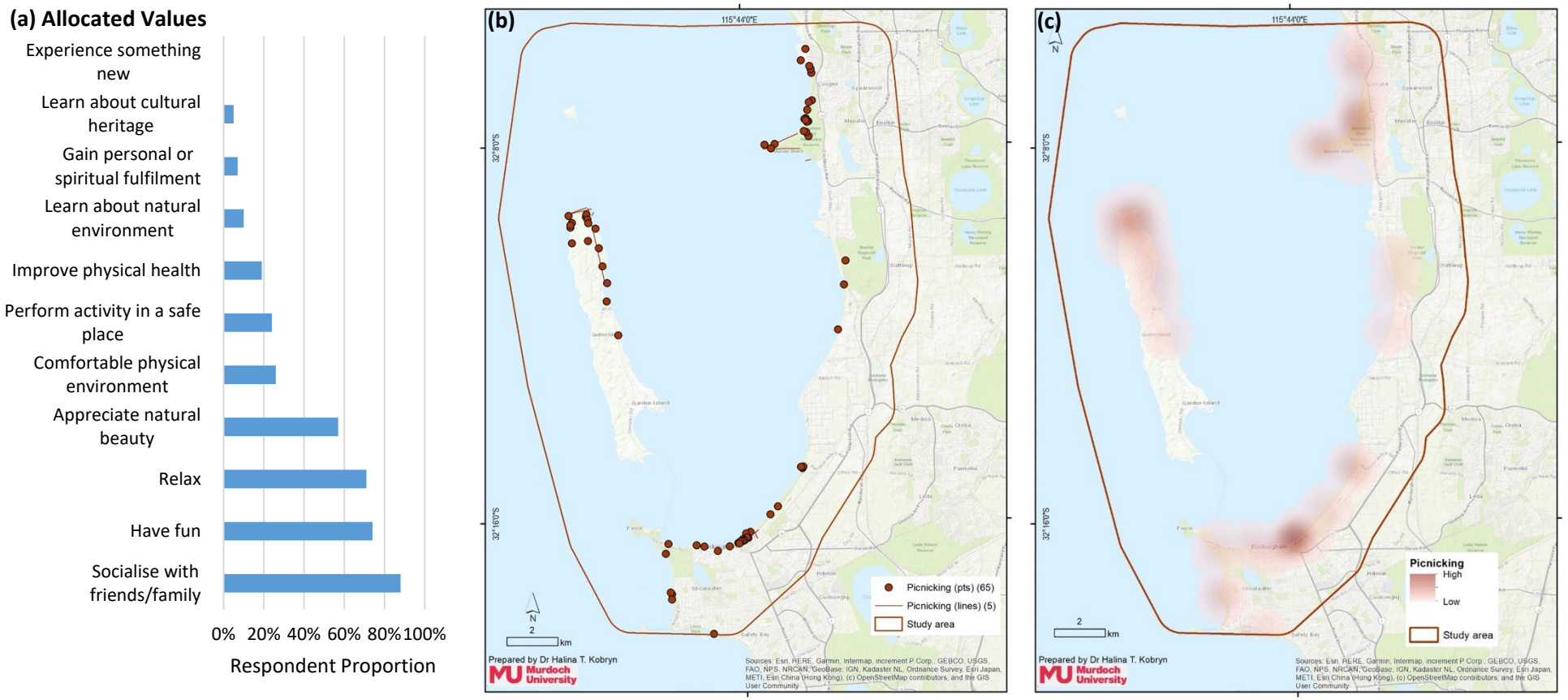

Figure 33: 'Picnicking' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 70 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 42). [***Note: refer to the disclaimer on the inside cover regarding mapped activities.***]

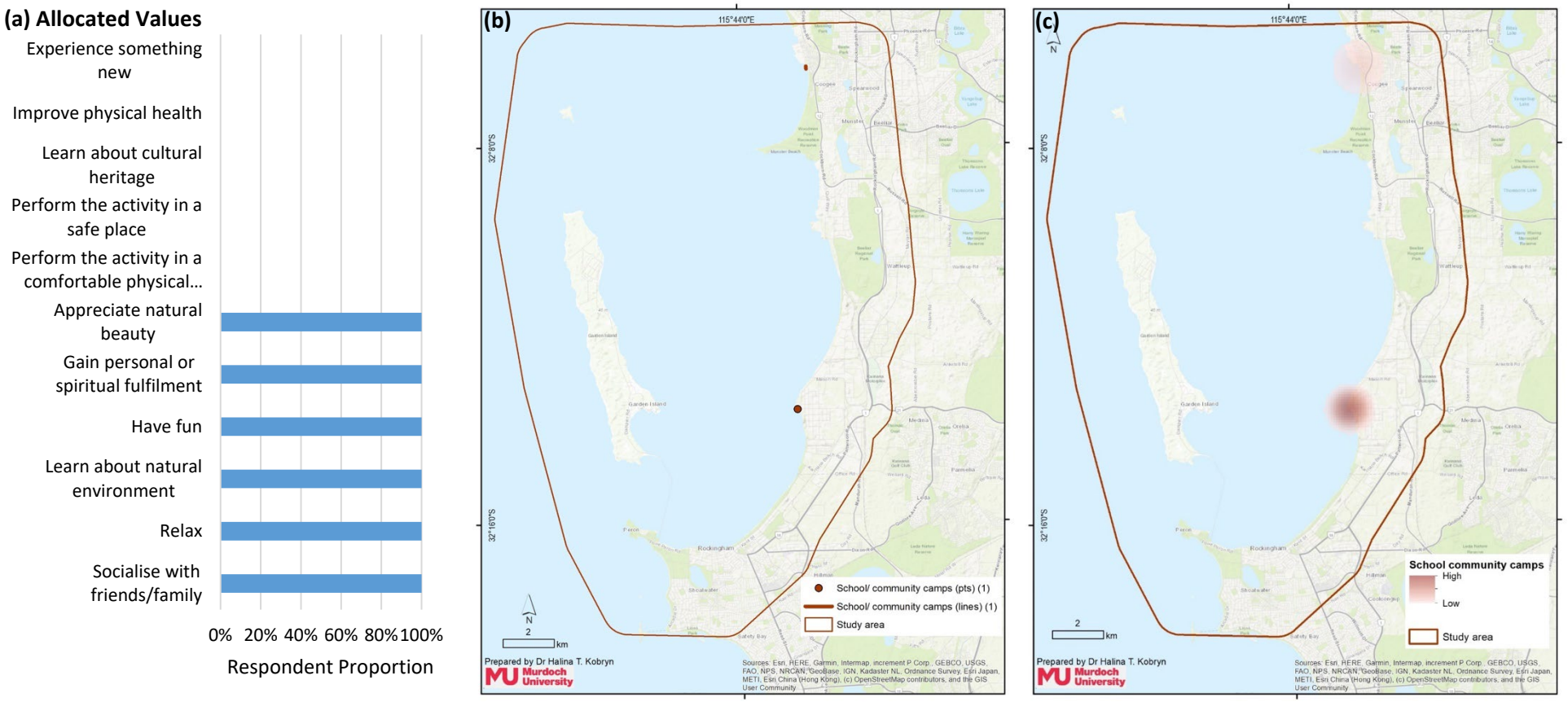

Figure 34: 'School and community camps' in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 2 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 1). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

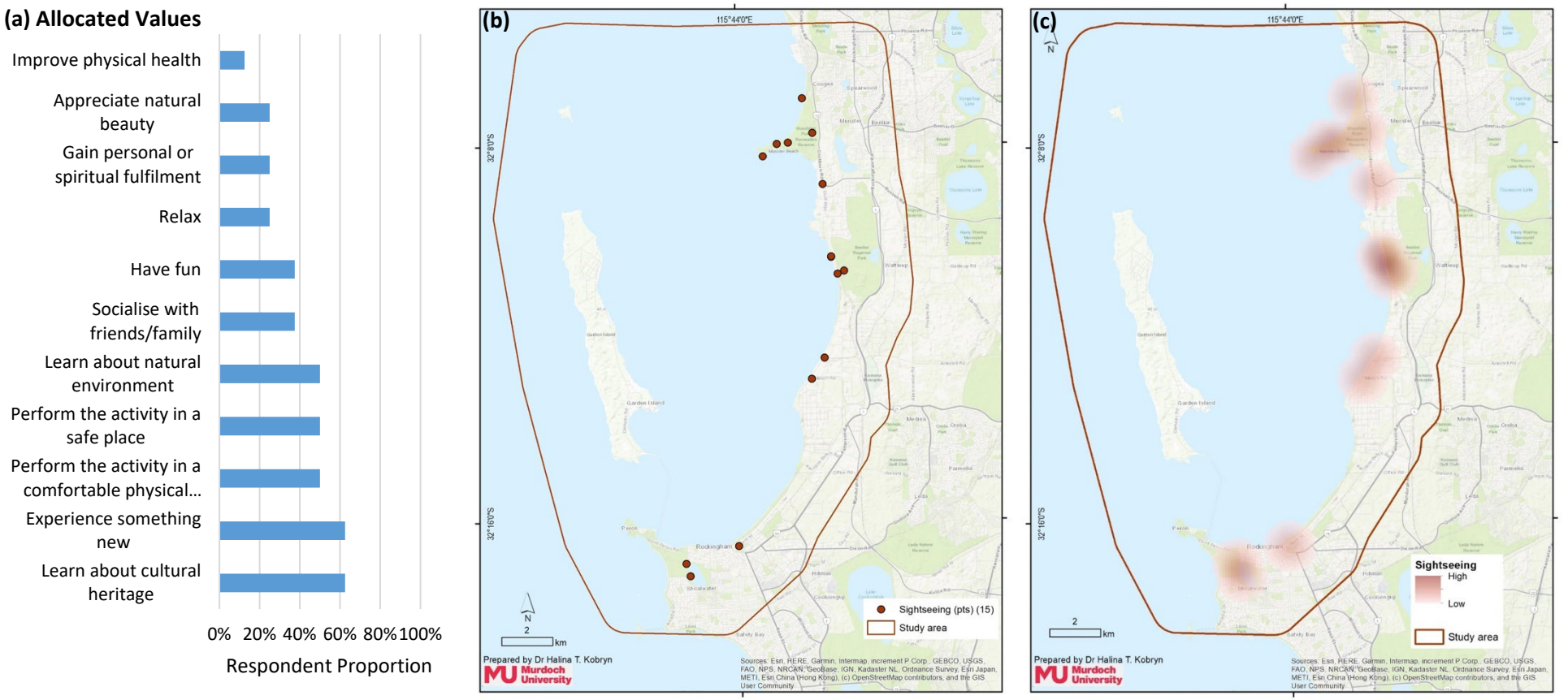

Figure 35: 'Sightseeing' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 15 points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 12). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

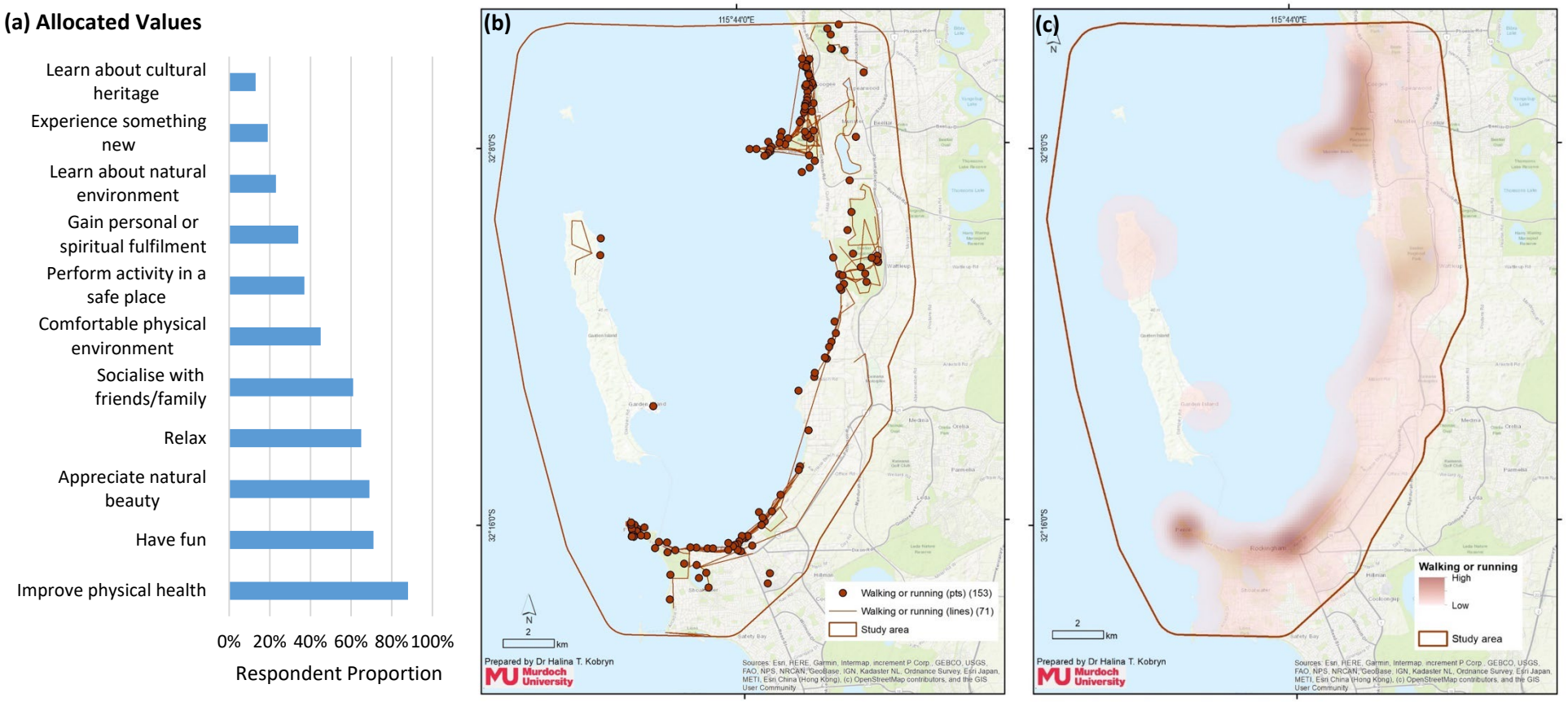

Figure 36: 'Walking/Running' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 224 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 101). [***Note: refer to the disclaimer on the inside cover regarding mapped activities.***]

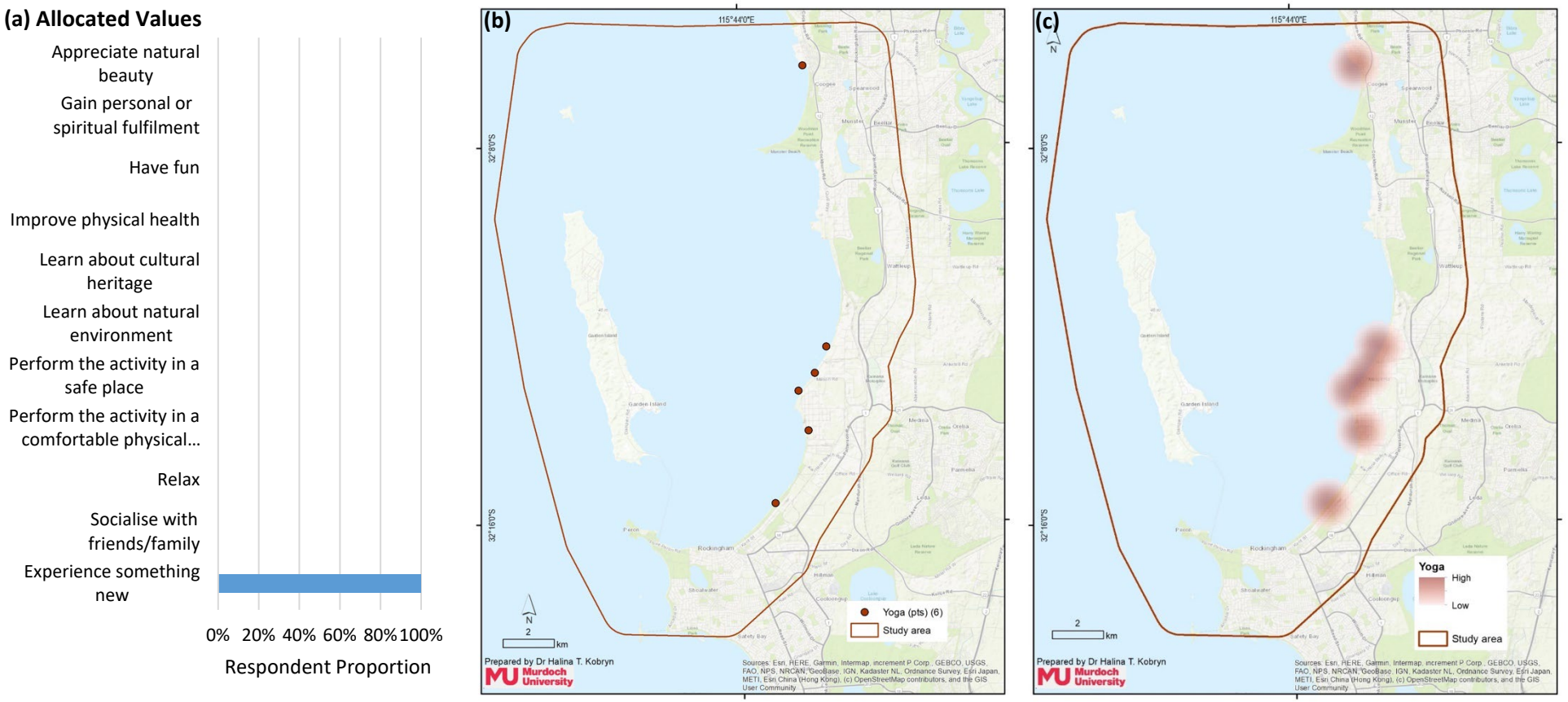

Figure 37: 'Yoga' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 6 points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 2). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

4.6 MAPS: water-based activities

The aggregated map of water based recreational activities indicates a wide dispersal and high concentration of activities across the whole study area (Figure 38). There are higher concentrations at the northern and southern ends of the Sound and across to Carnac Island and the northern end of Garden Island. Individual activity maps are provided in Figure 39 through to Figure 53. Sailing was notable for its widespread and high concentration of activity across the Cockburn Sound area (Figure 46). Motor boating demonstrated wide dispersal but lower concentrations of activity (Figure 45). Some activities appeared to be concentrated in one or more specific areas, such as Wake Boarding (Figure 51), Jet-Skiing (Figure 42), Hydrofoiling (Figure 41) and Hoverboarding (Figure 40). It should be noted that activities with low respondent numbers (e.g. Hoverboarding, Hydrofoiling) tend to appear as concentrated hotspots in specific areas as there is one or two data points determining the kernel density. Appendix 4 includes maps of individual features (lines and points) mapped by respondents for each water-based recreational activity.

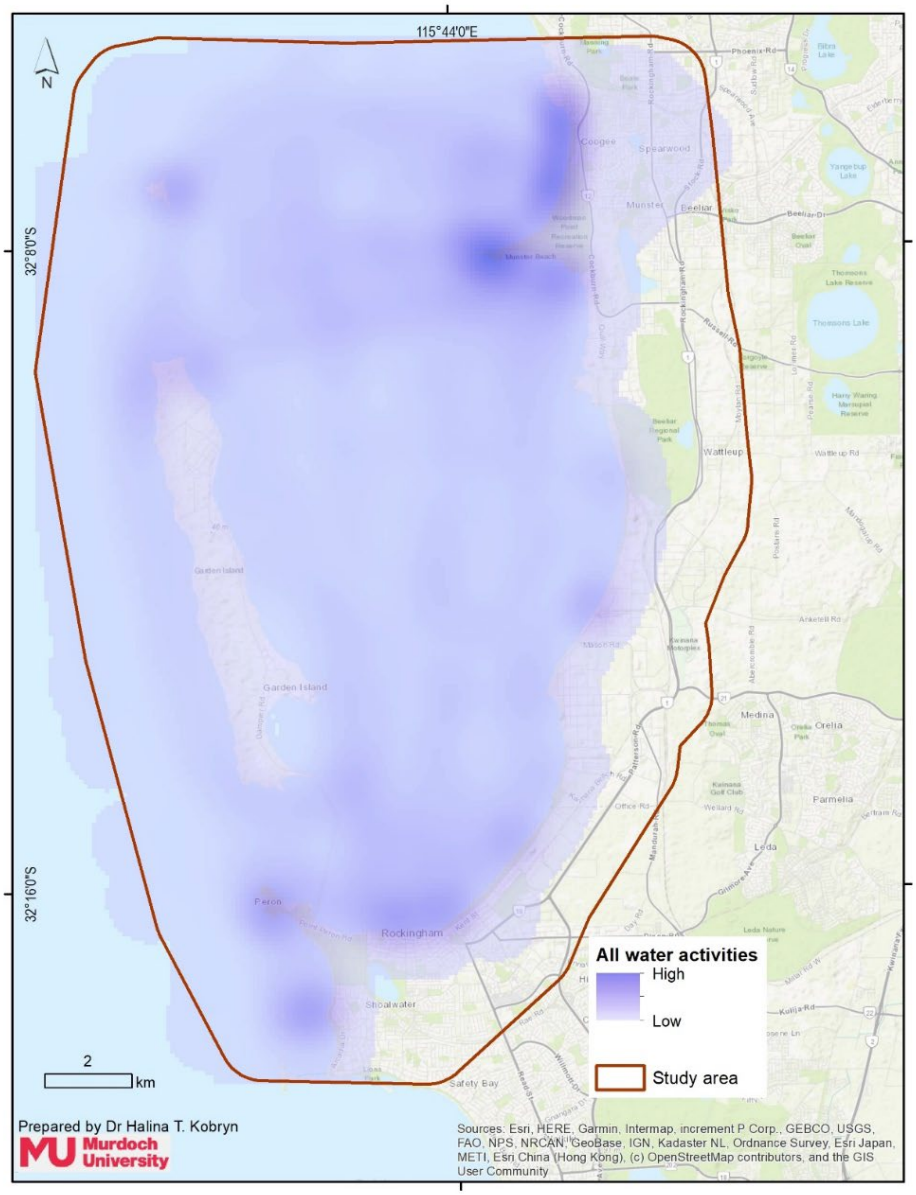

Figure 38: Aggregated heat map of all water based non-fishing recreational activities mapped in the Cockburn Sound study area. Darker shades represent higher concentrations of activities. **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

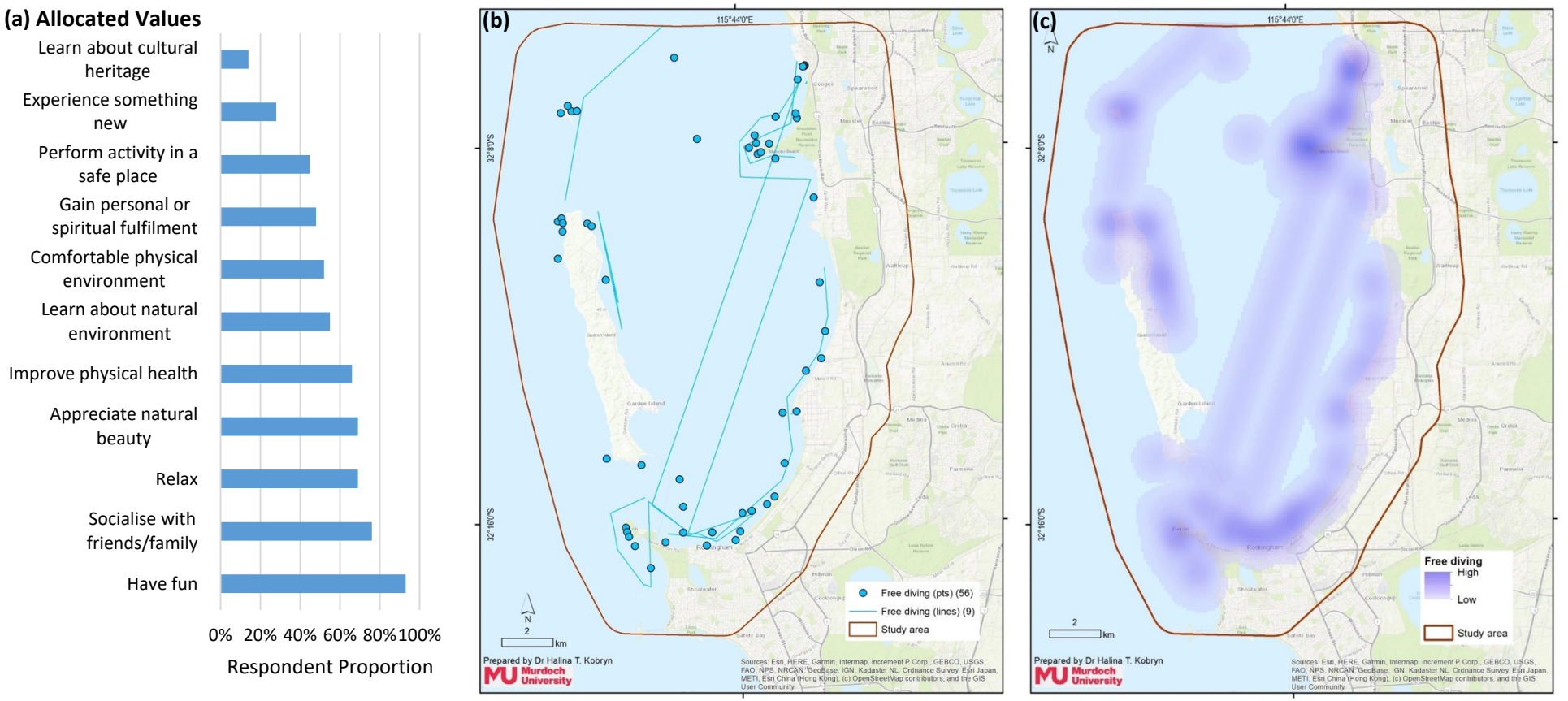

Figure 39: 'Freediving' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 65 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n =29). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

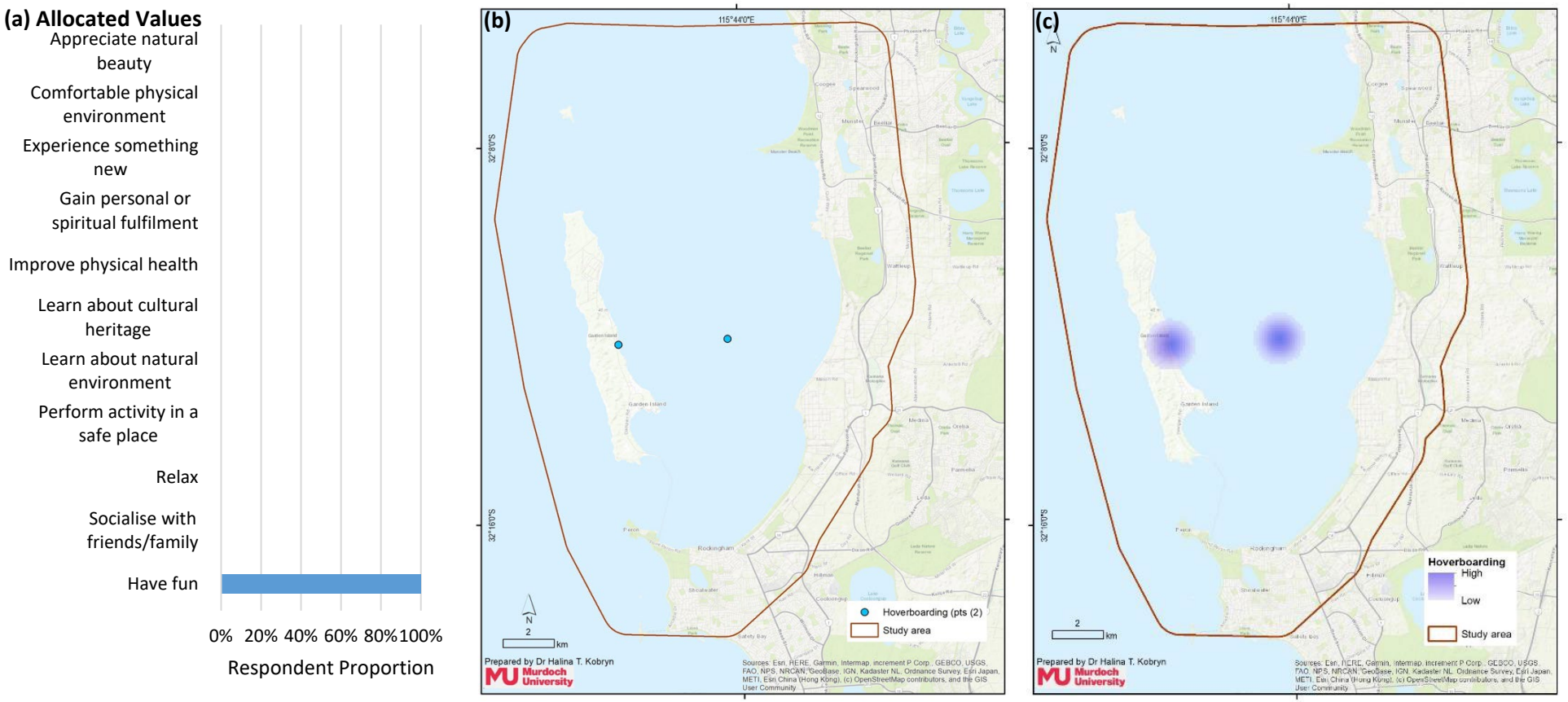

Figure 40: 'Hoverboarding' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 2 points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 1). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

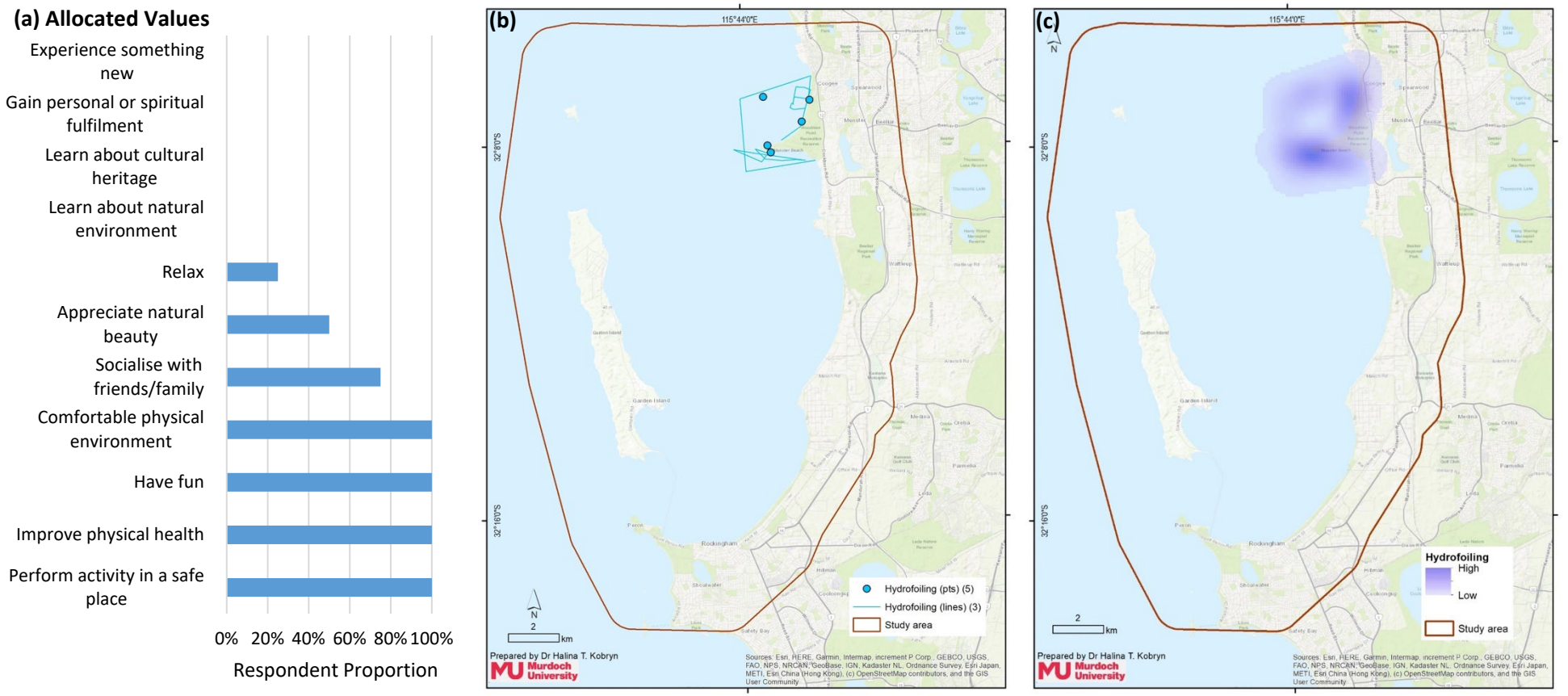

Figure 41: 'Hydrofoiling' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 8 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 4). [***Note: refer to the disclaimer on the inside cover regarding mapped activities.***]

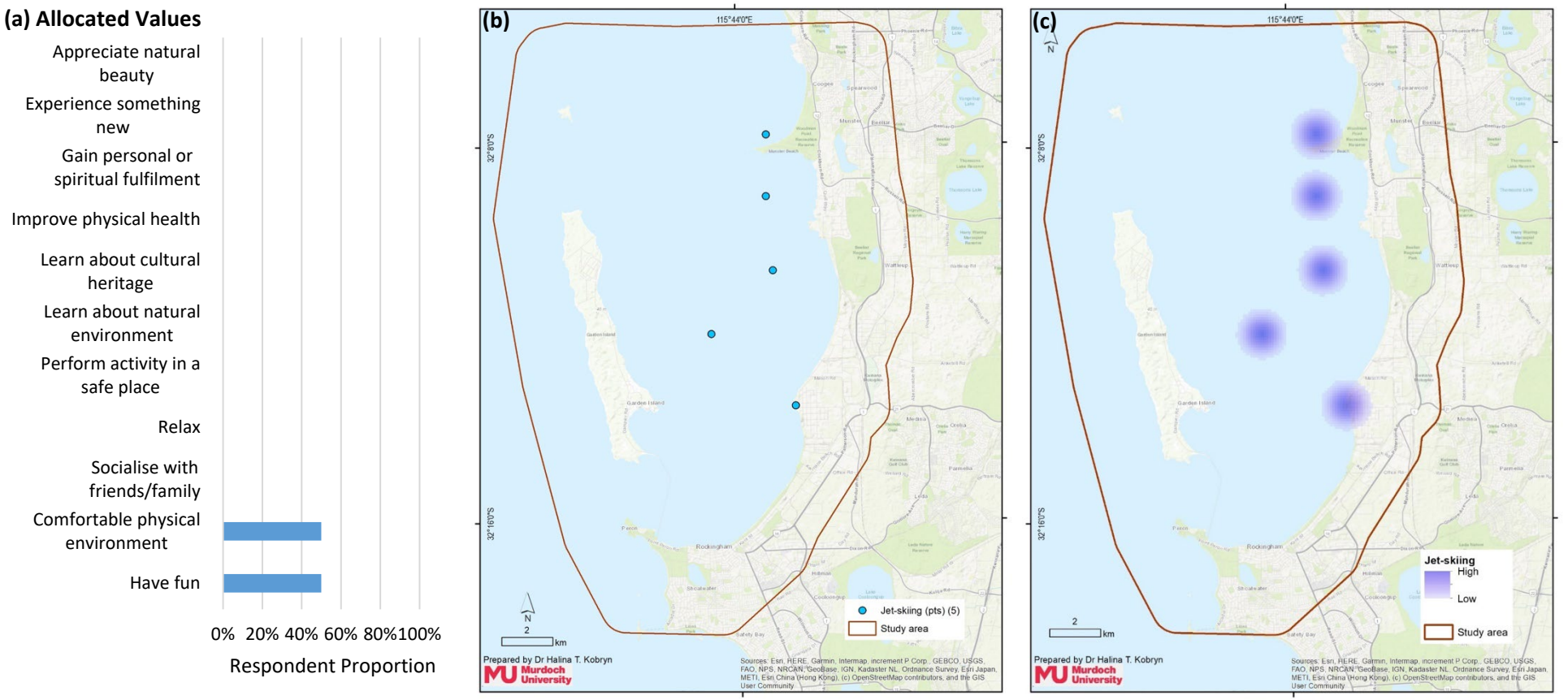

Figure 42: 'Jet-skiing' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 5 points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 2). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

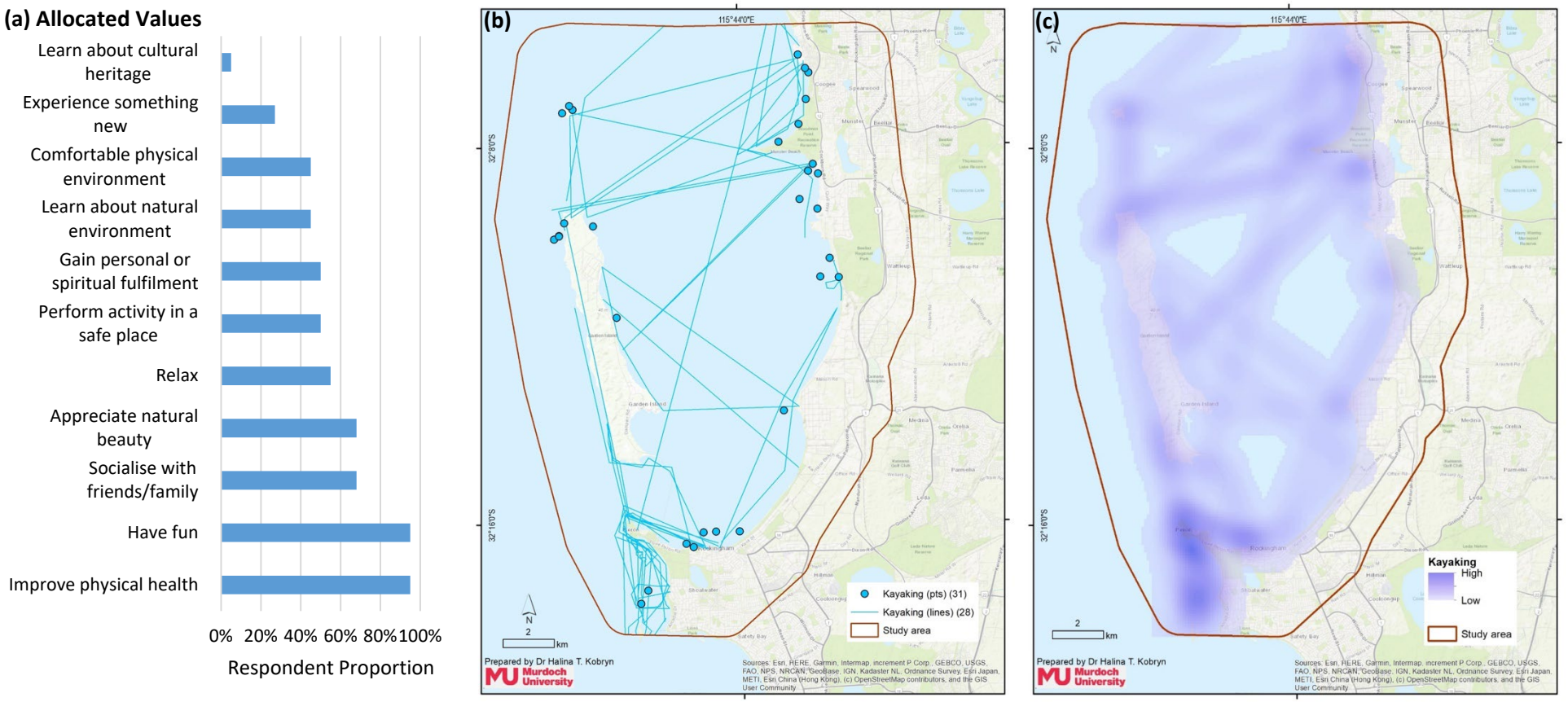

Figure 43: 'Kayaking' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 59 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 22). [***Note: refer to the disclaimer on the inside cover regarding mapped activities.***]

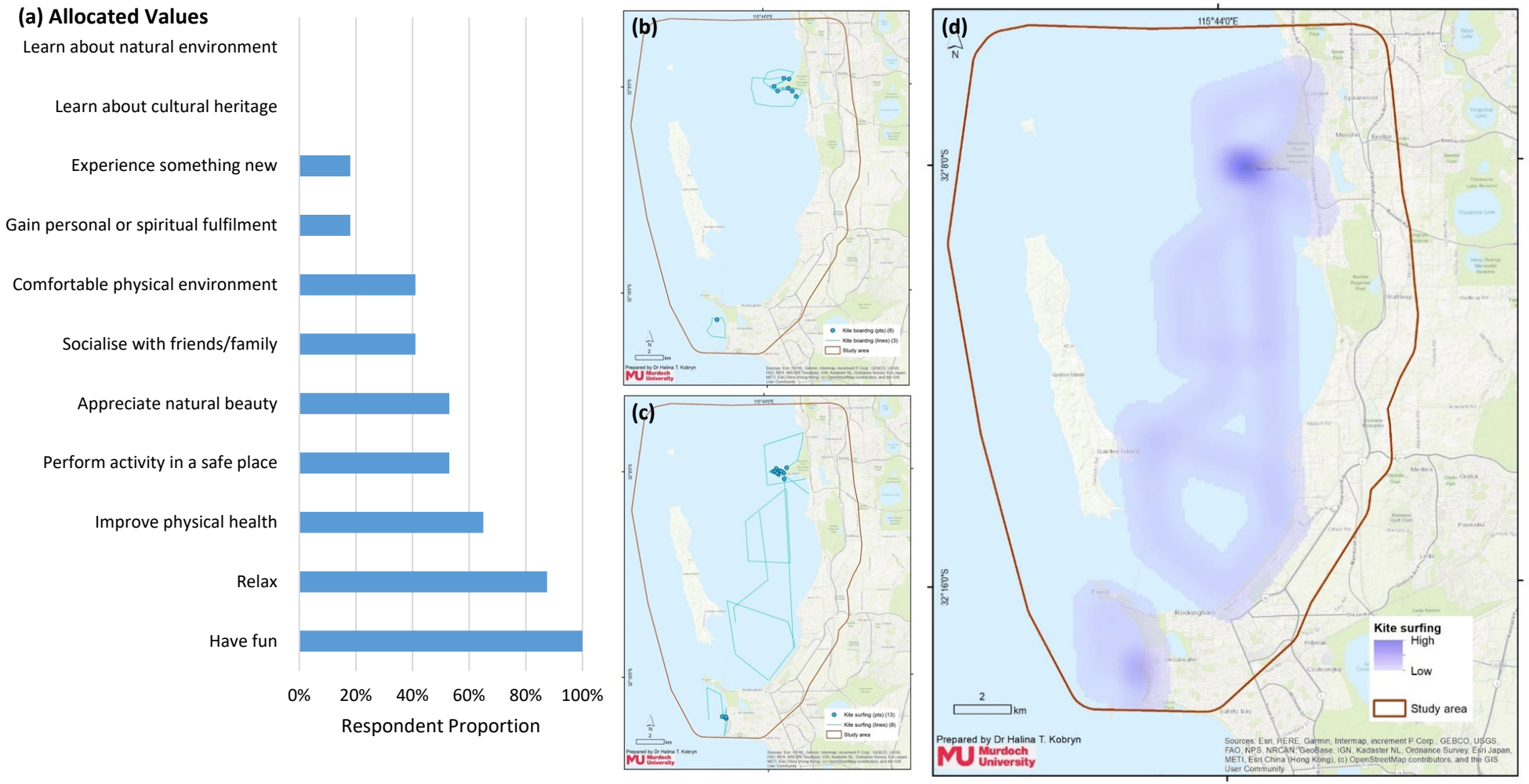

Figure 44: 'Kite boarding/Kite surfing' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map of 'Kite boarding' includes 11 lines/points mapped by respondents. (c) Feature map of 'Kite surfing' includes 22 lines/points mapped by respondents. (d) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 17). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

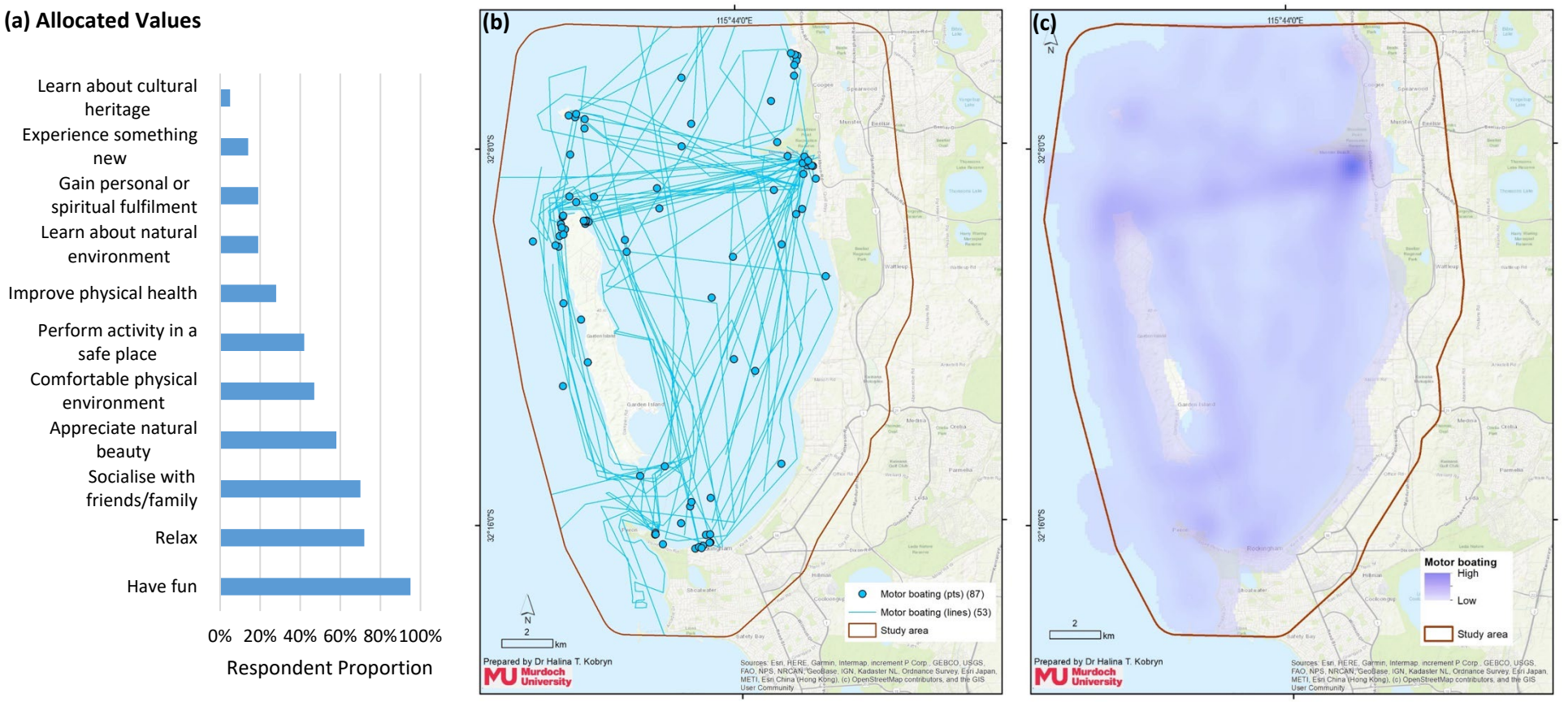

Figure 45: 'Motor boating' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 140 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 43). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

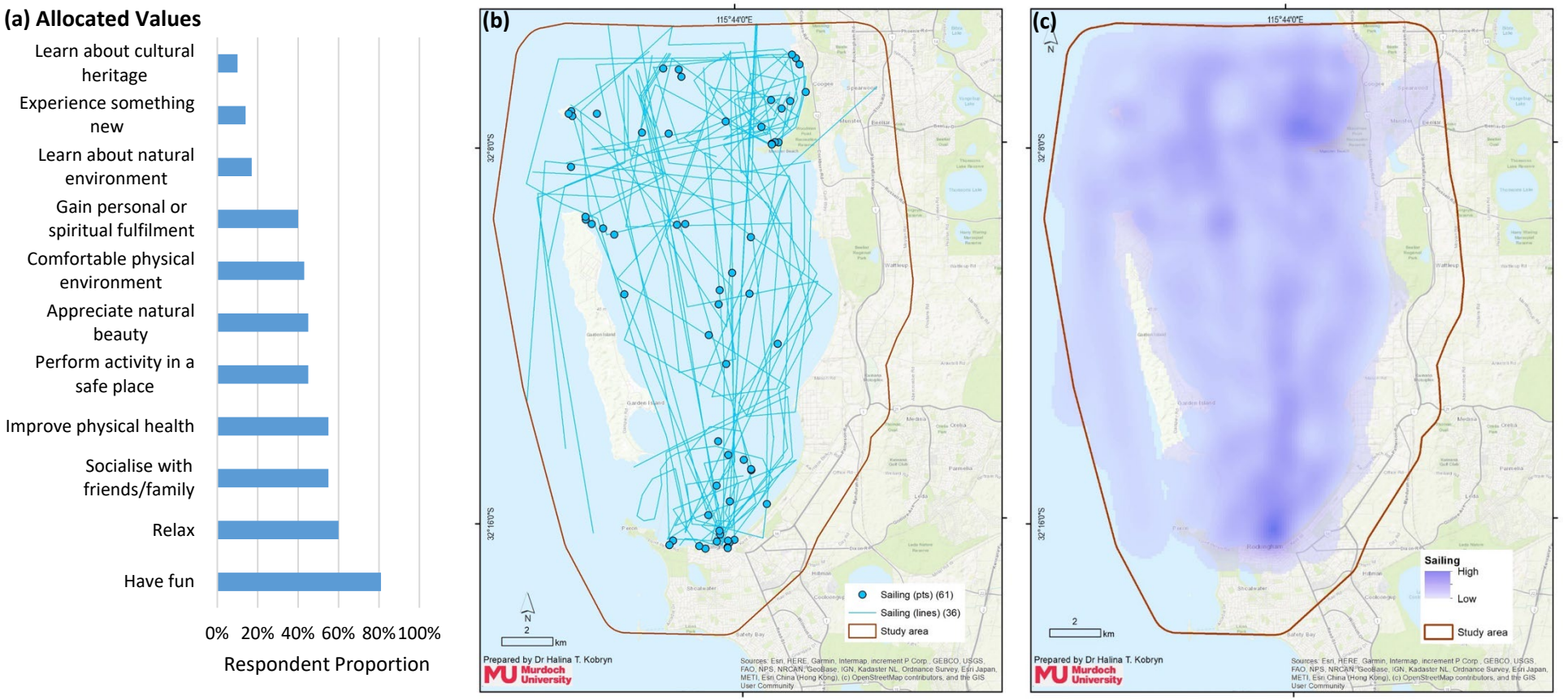

Figure 46: 'Sailing' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 97 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 42). [***Note: refer to the disclaimer on the inside cover regarding mapped activities.***]

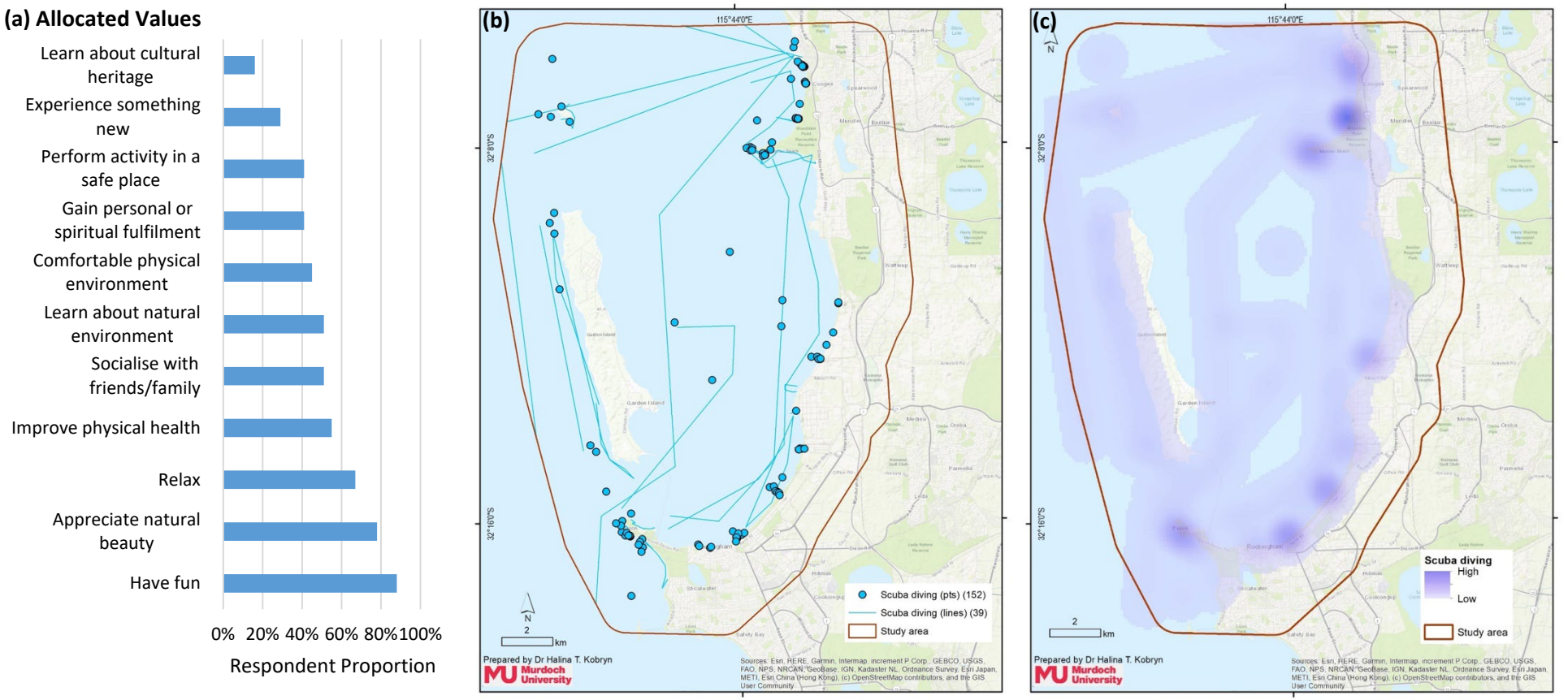

Figure 47: 'Scuba diving' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 192 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 51). [***Note: refer to the disclaimer on the inside cover regarding mapped activities.***]

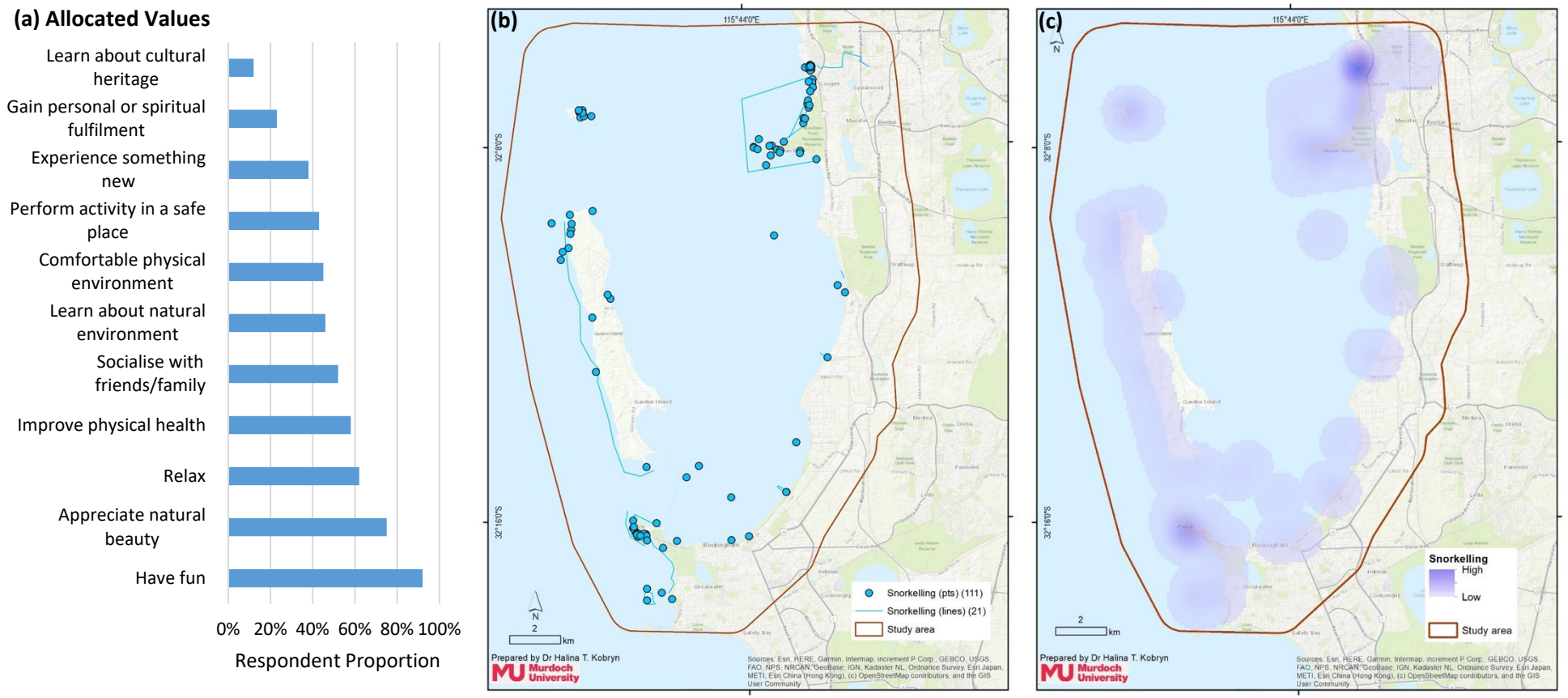

Figure 48: 'Snorkelling' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 132 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 65). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

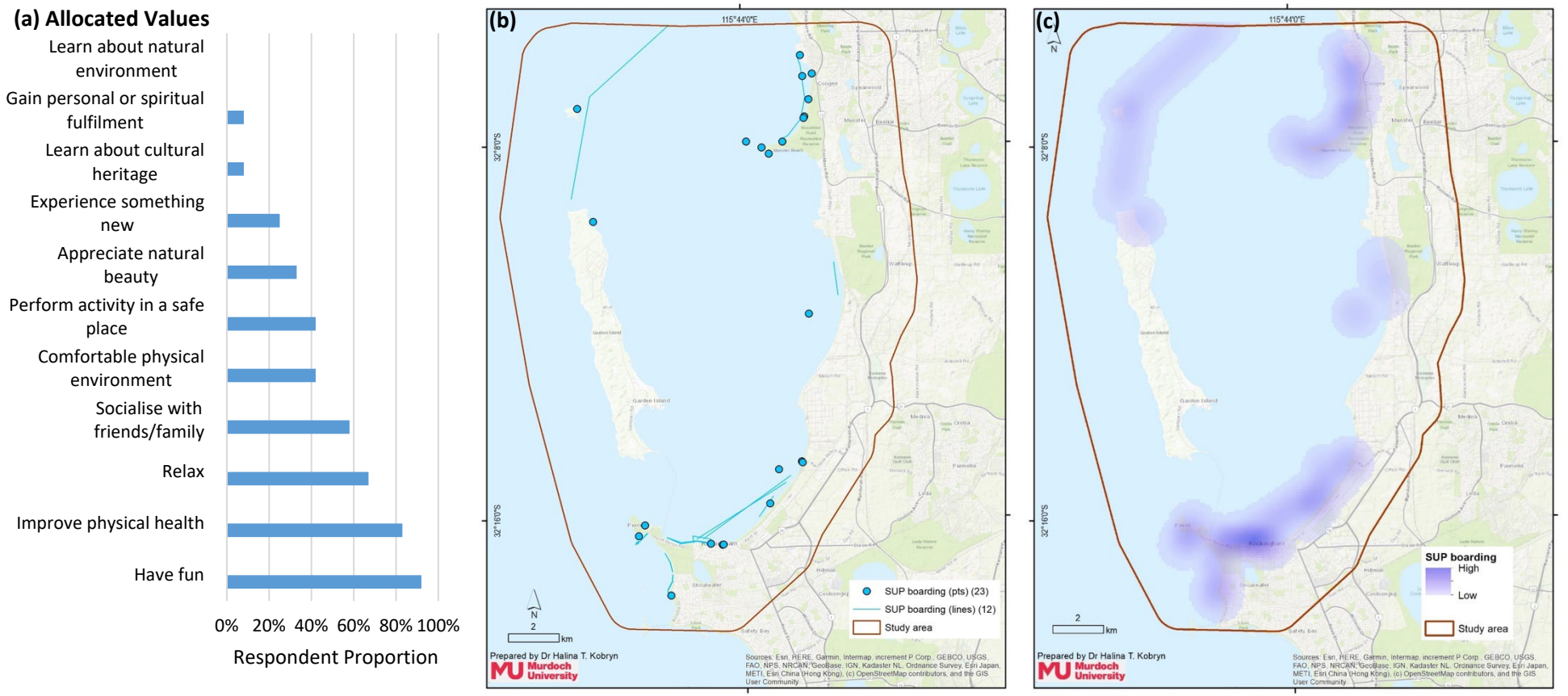

Figure 49: 'Stand-up paddle board (SUP)' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 35 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 12). [***Note: refer to the disclaimer on the inside cover regarding mapped activities.***]

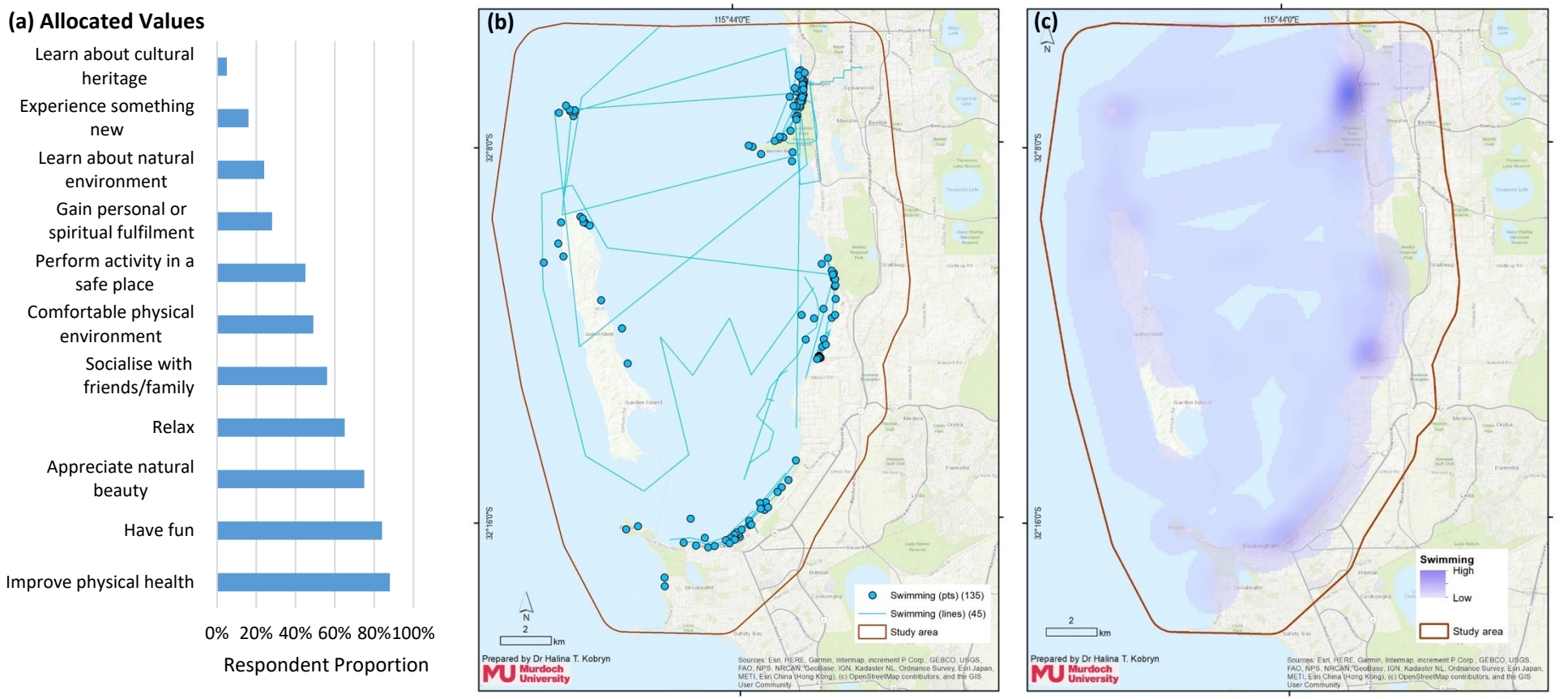

Figure 50: 'Swimming' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 180 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 95). [***Note: refer to the disclaimer on the inside cover regarding mapped activities.***]

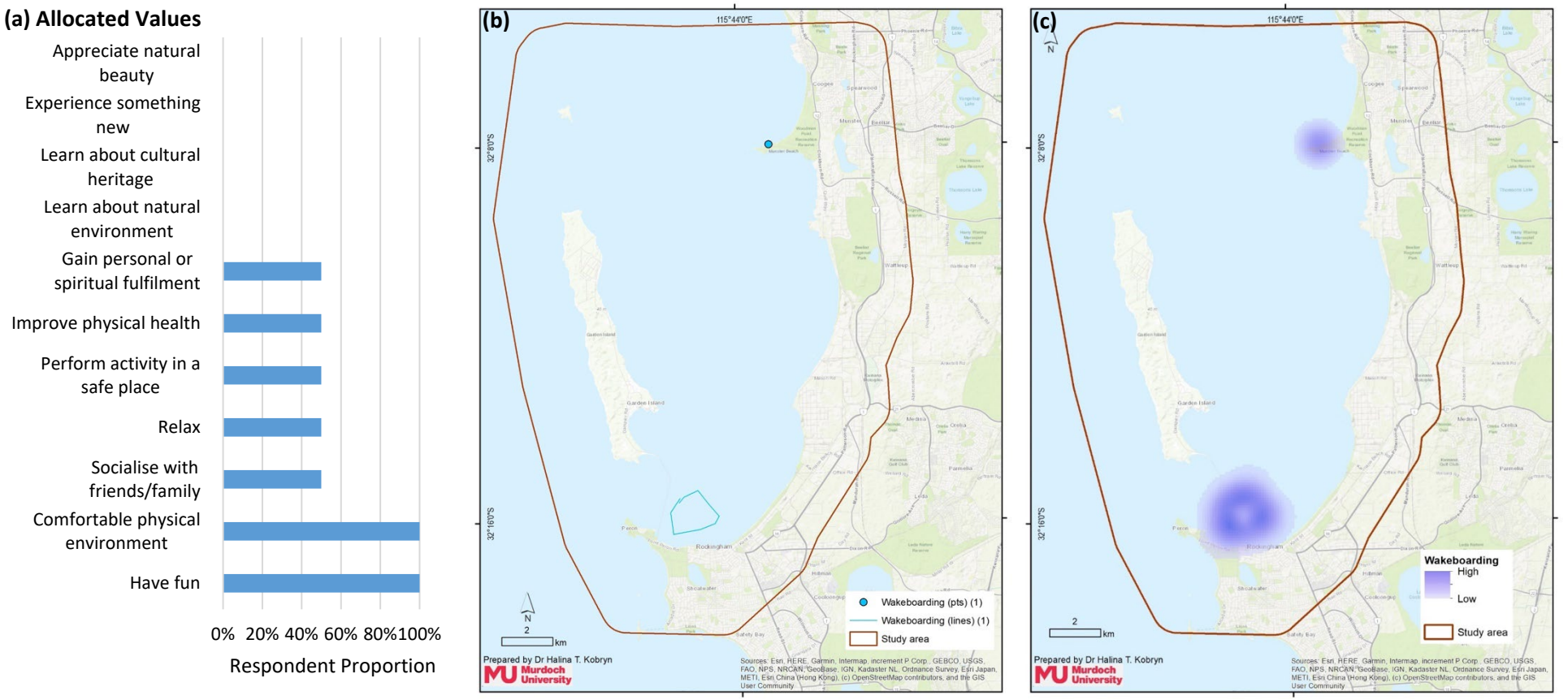

Figure 51: 'Wake Boarding' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 2 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 2). [***Note: refer to the disclaimer on the inside cover regarding mapped activities.***]

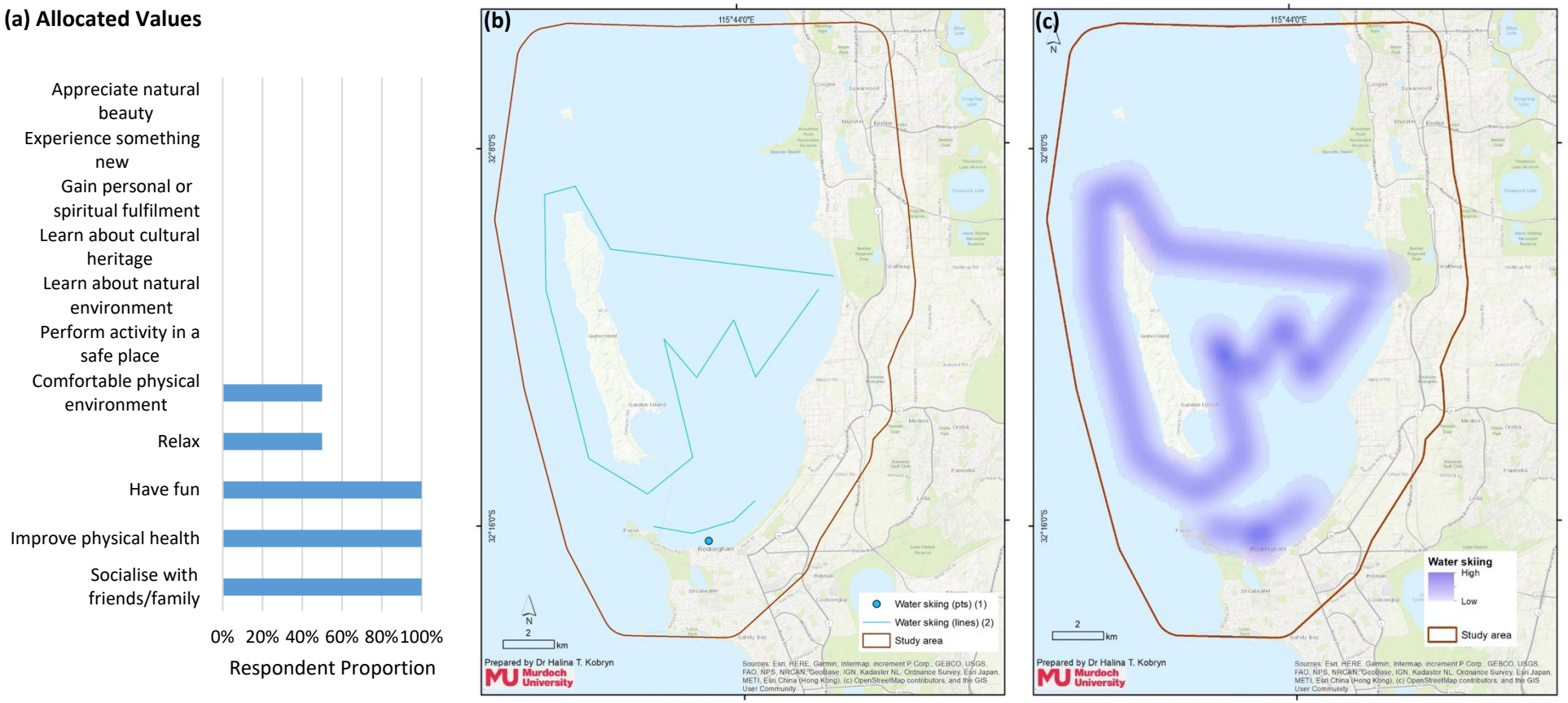

Figure 52: 'Water skiing' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 3 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 2). [***Note: refer to the disclaimer on the inside cover regarding mapped activities.***]

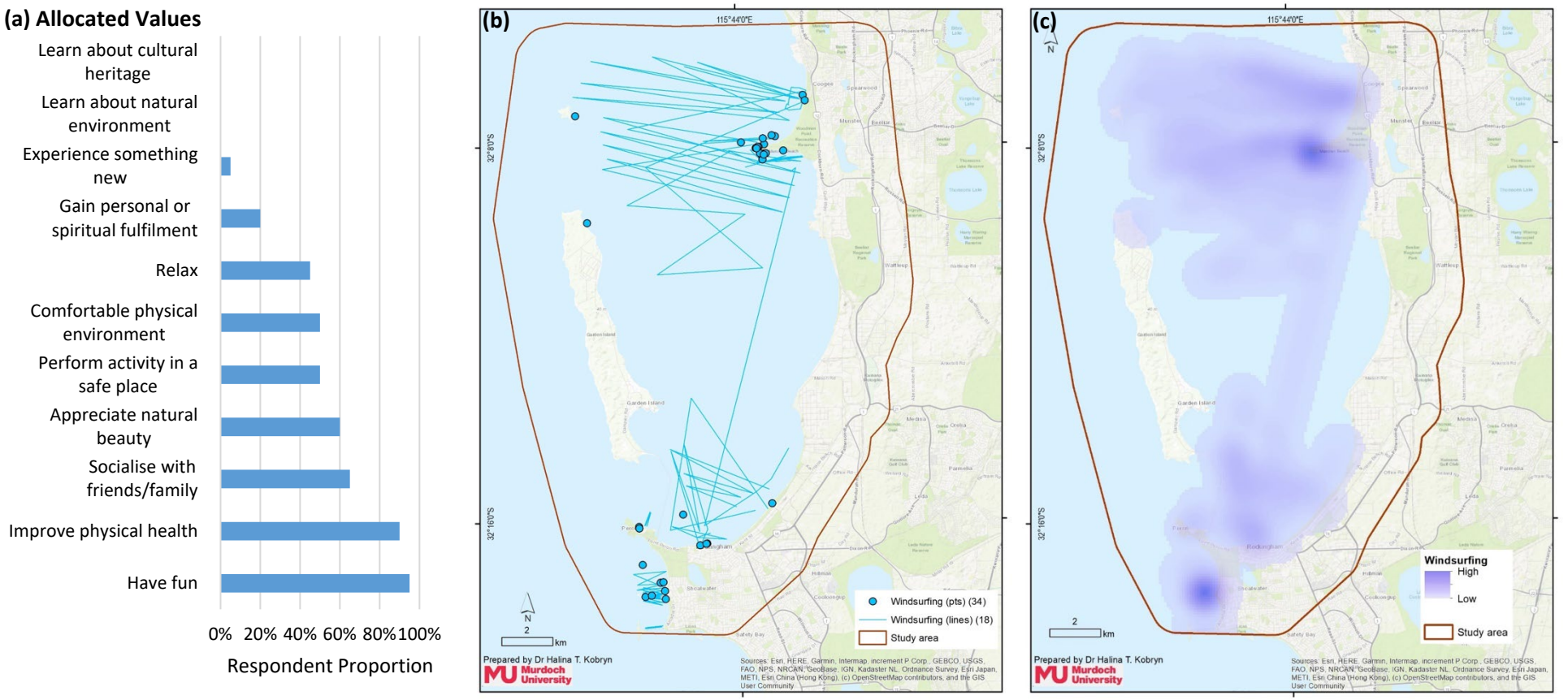

Figure 53: 'Windsurfing' activity in Cockburn Sound. (a) Allocated values graph. Y-axis includes the value options available to respondents to allocate to mapped activity. X-axis indicates the proportion of respondents allocating respective values to the activity. (b) Feature map includes 52 lines/points mapped by respondents. (c) Heat map darker shades indicate higher concentrations of mapped features associated with beach activities (unique respondents n = 20). **[*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]**

4.7 Validation results

The interview method of validation aligned well with the PPGIS results (Appendix 3) with a strong concentration of water-based activities toward the northern end of the Sound. Similarly, the identification of activity hot spots based on the survey activity mapping data and visual comparison with satellite imagery of the hotspot locations indicated that mapped activities aligned with physical features on the ground including access points. This indicates that while the online PPGIS method may have limitations compared to in person methods, the data are demonstrated to be an accurate representation of where recreational activities are occurring in the study area.

The comparison between activity rankings (based on count data) in Table 9 and the WWMSP Project 6.1 data reported at the end of Appendix 3 show some consistency with beach activities ranked most highly, and swimming, snorkelling, dog beach activities, and picnicking all ranking in the top ten reported activities for both survey samples. There are some inconsistencies which may be expected due to sampling strategy and self-interest leading to stronger response rates for some recreational cohorts to this survey, relative to the representative sample collected for Project 6.1. For example, Table 9 shows that walking and running, horseback riding and swimming with horses, scuba diving, motor boating, and sailing all feature in the top ten most reported activities from this survey, but not for the sample collected in Project 6.1.

5 Results: Travel Cost evaluation for key recreation sites

The travel cost approach relies on there being sufficient individuals visiting an area, with sufficient variation in visitation and cost of travel, to enable the relationship between costs and visitation rate to be established.

Table 11 reports the number of individuals undertaking land-based activities for the land zones, and Table 12 for water-based activities in water zones. The numbers include adjustments as outlined in Methods above, where land-based activities recorded in water-based zones are assigned to the adjacent land zone number, and vice versa (such that, for example, zone 24 for beach activities includes all observations recorded in that zone marked as 'Beach activities', as well as any recorded observations for 'Beach activities' that were dropped in the adjacent water-based zone, totalling 85 observations).

Noting that the sample sizes are small for some activities and zones, the following approach was used to determine a selection of models that were worth estimating. A minimum number of 50 observations from unique individuals was required for the relevant activity and area being modelled. For activities that are likely to be spatially restricted (e.g. requiring specific environmental conditions, access or infrastructure), models were estimated either for a single zone, or for multiple aggregated zones where a 'hotspot' identified that the activity took place over a number of adjacent zones. For activities that are not spatially restricted and typically take place throughout the Sound (e.g. sailing, Motor boating), models were estimated that included all observations across all zones.

Table 11: Number of unique individuals who reported undertaking land-based activities in respective zones.

	Zone														
	23	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**2&8^**	**3**	**4**	**5**	**6**	**7**
Beach activities	3	28	85	5	6	18	21	25	55	30	1	15	7	14	1
Birdwatching	1	1	8	1			1		4	4				1	
Camping Caravan			3						1						
Community volunteering	1		6						2	1					
Cycling	2	8	22	3			3	4	4	3					
Dog walking	2	3	24	3		11	4	8	8	3					
Horseback riding			1		1	109	6	13							
Picnicking	1	3	11			1	3	5	19			4		10	1
School/community camps		1													
Walking/running	4	13	45	6	12		3	12	40	30		1		2	
Other	2	6	36	5	6	2	1	2	22	4		2		2	
n/a	4	11	35	2	3	16	7	4	20	9		4	1	2	1

See Figure 2 for definition of zones

^ Note that zones 2 & 8 are combined for the land-based synthesis, representing Cape Peron (the two zone segments are identified separately to assist in the analysis of water-based activities due to the presence of the causeway).

Table 12: Number of unique individuals who reported undertaking water-based activities in respective zones.

Activity	Zone																			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
SUP boarding	1	2							6	5	2	1				3	2			
Freediving		4	1	5	4	2		1	7	4	1	4		1	3	8	7			2
Hoverboarding							1													
Hydrofoiling																3				2
Jet-skiing																1			1	
Kayaking	8	2	2	4		4	1	1	5		1	3	4	4	1	5	2	1	5	
Kite boarding	2														4	5				
Kite surfing	3	1													5	4			1	
Motor boating	1		5	14	7	11	2	5	15		1	1	1	7	6	5	3	1	29	7
Sailing				2	4	7	1		19	3	1				1	12	4	1	29	11
Scuba diving	4	21	4	5	5			2	22	16	9	15	1		12	33	20	1	6	3
Snorkelling	4	18	2	8	8	3		2	4	2	1	5	1		8	11	30		1	
Swimming	3	1		3	5	4	1	1	17	18	2	38	5	1	2	43	11		2	
Swimming with horses											1									
Wake Boarding									1							1				
Water Skiing									2											
Windsurfing	7						1	3	6	1						10			3	2
Other									1	6		40			1	2	1			1
n/a	2	1	1	2		2	2		4	2	1	5		1	2	5	5		3	2

See Figure 2 for definition of zones.

Horseback riding and swimming with horses in Zone 28 is the only area where there are more than 100 respondents, and beach activities in zones 25 and 31 have over 50 respondents; all other zones have less than 50 unique respondents per activity (and note that sample sizes are reduced further when availability of location data and frequency of visit are considered). Where hotspots suggest that combining zones together is appropriate, a larger sample is available. Two approaches to zone aggregation were taken:

i. To pool data from each zone, treating individual observations in different zones as independent;

ii. To treat the combined zones as a single zone for calculating trip frequency per person.

In all cases the negative binomial model was estimated to account for over dispersion in the variance.

5.1 Horse beach (zone 28)

Once missing data on home location and frequency of visit is accounted for, there are 75 individuals who can be included in the model. The observations are all specific to one zone, so no aggregation was required. Travel cost coefficient is statistically significant and negative, as expected. The statistically significant estimate on α implies the negative binomial model is appropriate. The estimate of the value per trip (I.e. the willingness to pay, or WTP, given by -1/cost coefficient) is $14.75 per trip (Table 13)

Table 13: Visitation to Zone 28 for horseback riding and swimming with horses: negative binomial regression model.

	Coefficient	Standard error	z	p	95% confidence interval	
Cost	-0.068	0.031	-2.17	<0.001	-0.129	-0.006
Intercept	4.202	0.235	17.88	<0.001	3.74	4.664
Ln(α)	0.305	0.144			0.024	0.586
α	1.356	0.195			1.023	1.797
Sample	75					
WTP/trip	14.75	6.78	2.17	0.030	1.40	28.01

LR test of α=0: $\chi 2=4631.10$, $p<0.001$

5.2 Beach activities: zone (24:25)

No zone individually has sufficient observations to support a model for beach activities. However, there are clear clusters of locations where beach activities are high: zones 24 and 25 (at the north of the Sound) and zones 30 and 31 (in the south, around Rockingham; discussed in Section 5.4).

When zones have been aggregated this is identified by the following nomenclature: (a:b), where a and b indicate the original zones that have been combined

Two approaches to aggregation were undertaken: *to pool* the data for a group of zones (e.g 24 and 25), treating an individual who visits multiple zones as an independent visitor to each zone, or *to combine* zones 24 and 25 as single zone, and estimate the total visitation rate to the enlarged zone by each individual.

Considering zone (24:25), using the pooled approach, once missing data on home location and frequency of visit is accounted for, there are 72 'individuals' who can be included in the model. Travel cost is statistically significant and negative, as expected (Table 14). The statistically significant estimate on α implies the negative binomial model is appropriate. The estimate of the value per trip (given by -1/cost coefficient) is $6.74 per trip.

Table 14: Pooled visitation to zone (24:25) for beach activities: negative binomial regression model.

	Coefficient	Standard error	z	p	95% confidence interval	
Cost	-0.148	0.046	-3.19	<0.001	-0.239	-0.057
Intercept	4.674	0.212	22.06	<0.001	4.258	5.089
Ln(α)	0.423	0.148			0.132	0.712
α	1.526	0.225			1.142	2.039
Sample	72					
WTP/trip	6.74	2.11	3.19	<0.001	2.60	10.87
LR test of α=0: χ2=5948.45, p<0.001						

Considering zone (24:25), using the combined approach, once missing data on home location and frequency of visit is accounted for, there are 58 individuals who can be included in the model. Travel costs is statistically significant and negative, as expected (Table 15). The statistically significant estimate on α implies the negative binomial model is appropriate. The estimate of the value per trip (given by -1/cost coefficient) is $7.35 per trip.

Table 15: Combined visitation to zone (24:25) for beach activities: negative binomial regression model

	Coefficient	Standard error	z	p	95% confidence interval	
Cost	-0.136	0.048	-2.84	<0.001	-0.230	-0.042
Intercept	4.804	0.212	22.71	<0.001	4.390	5.219
Ln(α)	0.149	0.169			-0.181	0.480
α	0.263	0.166			-0.062	0.588
Sample	58					
WTP/trip	7.35	2.59	2.84	0.005	2.28	12.43
LR test of α=0: χ2=4801.92, p<0.001						

5.3 Walking/running : zone (24:25) and (30:31)

No zone individually has sufficient observations to support a model. There are clear clusters of locations where walking/running is high: (24:25) and (30:31). As with the beach activities, two approaches to aggregation were undertaken: to *pool* the data for a group of zones (i.e. 24 and 25), treating an individual who visits multiple zones as independent observations, or to *combine* zones 24 and 25 as single zone, and estimate the total visitation rate to the enlarged zone by each individual. Note that the numbers in the final models are small due to the missing information on home location, but significant estimates are derived. These results should be taken as indicative only.

Considering zone (24:25), using the pooled approach, once missing data on home location and frequency of visit is accounted for, there are 41 'individuals' who can be included in the model. Travel cost is significant and negative, as expected (Table 16). The significant estimate on α implies the negative binomial model is appropriate. The estimate of the value per trip (given by -1/cost coefficient) is $4.01 per trip.

Table 16: Pooled visitation to zone (24:25) for walking/running: negative binomial regression model

	Coeff	Std err	z	p	95% confidence interval	
Cost	-0.249	0.055	-4.55	<0.001	-0.356	-0.142
Intercept	4.740	0.218	21.72	<0.001	4.311	5.167
Ln(α)	0.317	0.198			-0.072	0.706
α	1.373	0.272			0.931	2.025
Sample	41					
WTP/trip	4.01	0.88	4.55	<0.001	2.29	5.74
LR test of α=0: $\chi2$=3090.24, p<0.001						

Considering zone (24:25), using the combined approach, once missing data on home location and frequency of visit is accounted for, there are 37 individuals who can be included in the model. Travel costs is significant and negative, as expected (Table 17). The significant estimate on α implies the negative binomial model is appropriate. The estimate of the value per trip (given by -1/cost coefficient) is $4.09 per trip.

Table 17: Combined visitation to zone (24:25) for walking/running: negative binomial regression model

	Coeff	Std err	z	p	95% confidence interval	
Cost	-0.244	0.055	-4.41	<0.001	-0.353	-0.136
Intercept	4.740	0.227	20.89	<0.001	4.296	5.185
Ln(α)	0.294	0.210			-0.117	0.705
α	1.342	0.281			0.889	2.023
Sample	37					
WTP/trip	4.09	0.928	4.41	<0.001	2.27	5.91
LR test of α=0: χ2=2876.31, p<0.001						

Considering zone (30:31), using the pooled approach, once missing data on home location and frequency of visit is accounted for, there are 32 'individuals' who can be included in the model. Travel costs is significant and negative, as expected (Table 18). The significant estimate on α implies the negative binomial model is appropriate. The estimate of the value per trip (given by -1/cost coefficient) is $3.43 per trip.

Table 18: Pooled visitation to zone (30:31) for walking/running: negative binomial regression model

	Coeff	Std err	z	p	95% confidence interval	
Cost	-0.291	0.050	-5.83	<0.001	-0.389	-0.193
Intercept	4.635	0.209	22.16	<0.001	4.225	5.045
Ln(α)	-0.257	0.239			-0.726	0.213
α	0.774	0.185			0.484	1.237
Sample	32					
WTP/trip	3.43	0.59	5.83	<0.001	2.78	4.58
LR test of α=0: χ2=1103.85, p<0.001						

Considering zone (30:31), using the combined approach, once missing data on home location and frequency of visit is accounted for, there are 24 individuals who can be included in the model. Travel costs is significant and negative, as expected (Table 19). The significant estimate on α implies the negative binomial model is appropriate. The estimate of the value per trip (given by -1/cost coefficient) is $3.19 per trip.

Table 19: Combined visitation to zone (30:31) for walking/running: negative binomial regression model

	Coeff	Std err	z	p	95% confidence interval	
Cost	-0.314	0.060	-5.25	<0.001	-0.431	-0.197
Intercept	4.961	0.288	17.20	<0.001	4.396	5.527
Ln(α)	0.048	0.267			-0.475	0.572
α	0.048	0.280			0.622	1.771
Sample	24					
WTP/trip	3.19	0.61	5.25	<0.001	2.00	4.38
LR test of α=0: $\chi2$=1564.03, p<0.001						

5.4 Activities investigated but with no significant effects

Following the approach outlined above to consider aggregations of zones for activities that occurred in adjoining 'hotspot' zones or were relevant across the whole of the Sound, models were estimated where the sample size warranted exploration, including for beach activities in zones 30 and 31, for scuba diving in zones 15, 16, 17, and for swimming, sailing and Motor boating for the whole of the Sound. Beach activities at zone (30:31) were considered in the similar way as for beach actives at zone (24:25), but no statistically significant effects were found, noting observation numbers were low: ~40 respondents. For scuba diving, two approaches were taken to increase sample: to pool the visitation to three zones (15:16:17), treating individuals who visited more than one zone as independent observations, or to treat zone (15:16:17) as a single zone, and calculate a single visitation rate for an individual to the combined zone. Neither approach identified a significant relationship for travel cost. In addition, given the similar nature of scuba diving and snorkelling activities with respect to observing underwater amenities, a model was estimated for these two activities jointly for zone (16:17) where there were overlapping hotspots for both activities, but no significant effects were found. Swimming activities for the hotspot zone (16:17) were also modelled but there were no significant effects identified. Similarly for sailing, or Motor boating, taking all of Cockburn Sound as a single zone found no statistically significant relationship with cost.

5.5 Travel cost evaluation summary and validation

The economic values for beach trips in zone (24:25) of $6.74-$7.35 per trip are in line with estimates from other studies. For example, Rogers and Burton (2019) who had a value per beach trip at Yanchep Beach in the north of Perth's metropolitan area of $3.92-$5.95, depending on season. Noting the initial zoning was imposed to enable a granular estimation of travel costs if the number of observations were sufficient, there is no obvious practical or theoretical reason not to aggregate the zones for adjacent and relatively uniform (with respect to types of activities undertaken) geographical areas such as for zones 24 and 25 which straddle Woodman Point. With this in mind, it is fair to assume that the willingness to pay estimate of $7.35 per trip from the 'combined' model approach is suitable for use to inform decision making. Referring to the combined models for walking and running activities, people are willing to pay $4.09 per trip to zone (24:25) and $3.19 per trip to zone (30:31), acknowledging that while these estimates are statistically significant, they are based on a very limited sample size

(potentially indicating there was a fairly homogenous group of people responding to the survey with respect to this activity type).

The estimate of the value of a trip to zone 28 for horseback riding and swimming with horses is higher than that, at $14.75, which given the nature of the activity might be expected. There are relatively few substitutes for the location to undertake this activity, and the individuals undertaking the activity may perceive not only benefits to themselves but also to their horses. However, this estimate is also in line with other literature, including travel costs estimated by Raybould et al. (2013) for beach trips in the Augusta-Margaret River region which ranged from $3.28 to $12.21 per trip depending on model assumptions. It should be noted that these values are likely to be lower bounds, given the definition of travel cost employed, but it is unlikely that the inclusion of additional costs (such as parking) would increase the value by more than an order of magnitude.

6 Discussion

This project identified and mapped 31 non-fishing recreational activities and 11 associated values for Cockburn Sound using PPGIS. Sixteen land-based and 15 water-based activities were mapped. While the whole of the Cockburn Sound study area is valued and used for various recreational activities, there are areas where activities and associated values are more concentrated. These areas of concentration include the northern and southern ends of the Sound, with some focus on the Naval Base Horse Beach area. The northern and southern areas and horse beach have amenities and infrastructure, such as boat ramps, car parks, cafes and picnic areas that enable ready public access for recreational activities. Beach activities was the most frequently mapped activity while 'have fun' was the most frequently allocated recreational activity value. The monetary value of certain non-fishing recreational activities was estimated using a travel cost model where feasible sample sizes were available. Three activities, Beach activities, Horse riding/exercising, and Walking/running were valued on a per trip basis. Horseback riding and swimming with horses was valued at $14.75 per trip to the Naval Base Horse Beach, while beach activities were valued at $7.35 per trip in northern parts of the Sound. Walking and running activities were valued at $4.09 per trip in the northern parts of the Sound, and $3.19 per trip in the southern areas. For other activities, the travel cost analysis was restricted by the relatively small number of individuals who have reported data for each activity, by zone.

6.1 Methodological approach

Public participatory mapping PPGIS is a well-developed and frequently used method for identifying how people use and value defined geographical areas. The method usually involves in-person facilitated mapping using hard copy maps on which participants draw lines, shapes or points and annotate them with the intended meaning. In-person PPGIS may be conducted using community workshops, in which groups of people provide information on maps during a facilitated session. PPGIS may also be conducted on an individual basis, similar to a one-on-one interview format. The in-person approach can work to ensure the task is clearly understood by participants and the meaning of the information added to the maps is understood by the facilitators. In-person mapping can also help improve the quality of information provided, by facilitators asking participants questions, or responding to participant questions, to clarify meaning or encourage provision of responses in sufficient detail regarding the information being provided. In-person PPGIS is effective as it enables a two-way exchange between participants and facilitators that ideally results in a detailed and in-depth dataset.

However, in-person PPGIS requires considerable resources and time to ensure data is representative and reliable. Resources required include venues for community PPGIS workshops, catering, facilitators, consumables such as stationery and maps. Multiple workshops are usually required to ensure inclusivity for all those wishing to participate, as well as promotion and awareness raising of the workshops well before they are scheduled. Given a limited budget and time frame, and COVID concerns and restrictions at the time of planning the research project, it was not feasible to conduct PPGIS in person. This was exacerbated by the area and activities of interest being associated with an unknown and potentially widely dispersed population from which to sample, as with the population accessing Cockburn Sound for recreational activities.

Online PPGIS tools provide an alternative approach that enables collection of spatial activity and value data for a defined geographical area from a large and/or dispersed population within a limited time frame and budget. There is a potential trade-off between acquiring a large enough sample within a short time frame and the depth and quality of the data.

It should also be noted that the project did not have the resources to conduct surveys of a randomly drawn sample of all visitors to the area, that would have then provided a relative measure of visitation

by activity. The requirement to ensure engagement with relevant stakeholders through the means outlined above means that the relative participation in the survey by visitors undertaking different activities will be influenced by the motivation/interest of that group to engage, and their connection with the groups through which the survey was distributed. For example, it is expected that a relatively high proportion of the users of the horse beach will have participated, because that is a relatively small group, at a single location, with an interest in the outcome due to the publicized potential loss of the beach to them. This does not invalidate the results of the analysis of this (or any other groups) use, but it limits the extent to which the results can be interpreted as showing the relative intensity of use of the area across activities. This is also true for the willingness to pay values that are estimated, which are a 'per trip' value (I.e., they validly reflect the value of a single trip to a site to undertake an activity), but what is not known is the aggregate estimate of the recreational value of a site as this would require an understanding of annual visitation rates. That is, a representative estimate of visitation is needed to avoid (under)over-estimating the site value, as a non-representative sample could be biased towards (under)over-representation of a particular group. The per trip values estimated here could be used to estimate aggregate value if visitation rates become available (particularly for the horse beach, where travel cost was estimated using a more robust sample size).

6.2 Activities and values

The results of the survey demonstrate a wide variety of beach-based activities co-existing around the study area. Hotspots of beach-based activity are evident, but these are again present dispersed around Cockburn Sound. The most popular activities (walking, running, and swimming) require little in the way of facilities and are correspondingly more widely dispersed than more specialised activities such as birdwatching or camping. Whilst water-based activities are also dispersed around the Sound, there are more notable hotspots which are associated with infrastructure, such as boat ramps, cafes and carparks, associated with some of these activities. There is also a notable focus of shore and boat-based recreational activity in the north of Garden Island (Figures 23 and 38) which includes the area of private moorings managed by the Garden Island Fishing and Aquatic Association. These comprise 96 moorings in Herring Bay on the western tip of the island and a number of moorings owned by yacht clubs in Pig Trough Bay on the east facing coast. The relative solitude and isolation of these locations clearly present distinct recreational opportunities for boat-based recreational activity within the metropolitan area. Taking both beach and water-based activities together, the survey demonstrates that there are very few areas which are not utilised for recreational purposes around the study area.

Considering the social values attributed by respondents to their recreational activities, it is apparent that socialising, improving one's health and relaxing in a pleasant and safe physical environment, whether in an individual or group context, are most valued by coastal users. As would be expected, these values are present throughout the study area. Values associated with relaxation, socialisation, having fun and improving physical health are common to recreational users of coastal marine areas (see for example, (Cosquer et al. 2019, Le Corre et al. 2021)). It is, however, particularly notable that values associated with learning or interest in cultural and heritage occupy a lower priority amongst respondents. The presence of urban and industrial infrastructure around Cockburn Sound, together with the absence of listed Aboriginal heritage sites around the coastline of the Sound aside from Woodman Point and Cape Peron, would seem to be consistent with this interpretation. There are a significant number of seemingly generally less well-known heritage artefacts in the Sound. For example, the Western Australia Maritime Museum lists 41 wreck sites within Cockburn Sound, including shipwrecks, and submerged historic infrastructure (WAM 2023). Many of these sites are not readily accessible or visible to the general public, meaning they may not function as a focus for interest in heritage by the broader public accessing the Sound. It is, furthermore, interesting to note that learning about the natural environment occupies a low ranking as a value. This could again be consistent with the built-up nature of the coast, whilst the widely documented degradation of

environmental quality, particularly the decline of seagrass beds in the Sound, could also contribute towards this relative lack of interest. The low rating of learning may also be a function of expectations and motivations. Visitors focussed on recreational activities that do not include an environmental educational component tend to rate learning about the natural environmental lowly. For example, a study of visitors to nearby Penguin Island demonstrated that those motivated by activities such as swimming and picnicking were less interested in learning about nature relative to visitors motivated by the Penguin Experience visitor education centre (Hughes & Saunders 2005).

The high willingness to pay (WTP) value associated with horseback riding and swimming with horses reflects the fact that this activity takes place in only one area of Cockburn Sound where a local license to allow horses onto the beach applies. As stated in Section 2.4.3, the costs of travel to the site are a critical determinant of the WTP and thus it would be expected that a single site where an activity is permitted will entail higher travel costs for participants than if multiple sites were available. Furthermore, Table 11 indicates that over 90% of horse riders cited 'safety' as an important factor determining the location of activity. This is far higher than any of the other recreational activities listed, underlining the importance of being able to undertake this activity at a site where safety – both for participants and other beach users – is closely regulated.

The results from this study will complement the analysis being undertaken in complementing projects within the WAMSI Westport Marine Science Program exploring the Perth community's environmental values and the recreational fishing community's values for Cockburn Sound. These studies are ongoing at the time of preparing this report. Where relevant, the findings from this study will be discussed in these subsequent study reports.

7 Conclusions/Implications

- Identify the range and spatial extent of non-fishing recreational activities and associated values

A wide range of non-fishing recreational activities occur across the entire Cockburn Sound study area on a daily or weekly basis. The northern and southern ends of the Sound are particular areas of focus for recreational activities. Both coastal and water-based recreational users value the Cockburn Sound area as a means to fulfil a diverse set of pursuits and hence the recreational carrying capacity of the region may be relatively high in this respect. However, there are a number of more specialised and spatially focused recreational activities which must be accommodated in planning decisions.

- Provide an economic valuation for key recreational sites identified by the PPGIS process

The Travel Cost analysis was restricted by the relatively small number of individuals who have reported data for each activity, by zone. The exception was the Naval Base Horse Beach, where the horse-riding community responded significantly to an invitation to complete the survey. Beach activities and walking/running in specific locations also enabled a cost estimate to be made. Intercept surveys at the beaches would have provided a greater sample of respondents but was not possible to be undertaken because of project budget limitations.

- Provide a detailed understanding of non-fishing recreational activities and values

The variety of non-fishing recreational activities and associated values that coexist in the Sound highlights the importance of Cockburn Sound for a range of different individuals and groups The capacity of the Sound to host such a diverse range of recreational activities suggests that the social and physical carrying capacity is considerable. Respondents across the range of recreational activities primarily focussed on having fun, socialisation, relaxation and improving physical health. While different recreational activity types may have some common values, how these values are expressed through recreation may vary considerably. Furthermore, management decisions and planning will require engagement with a wide range of recreational activity representatives.

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9 Appendices

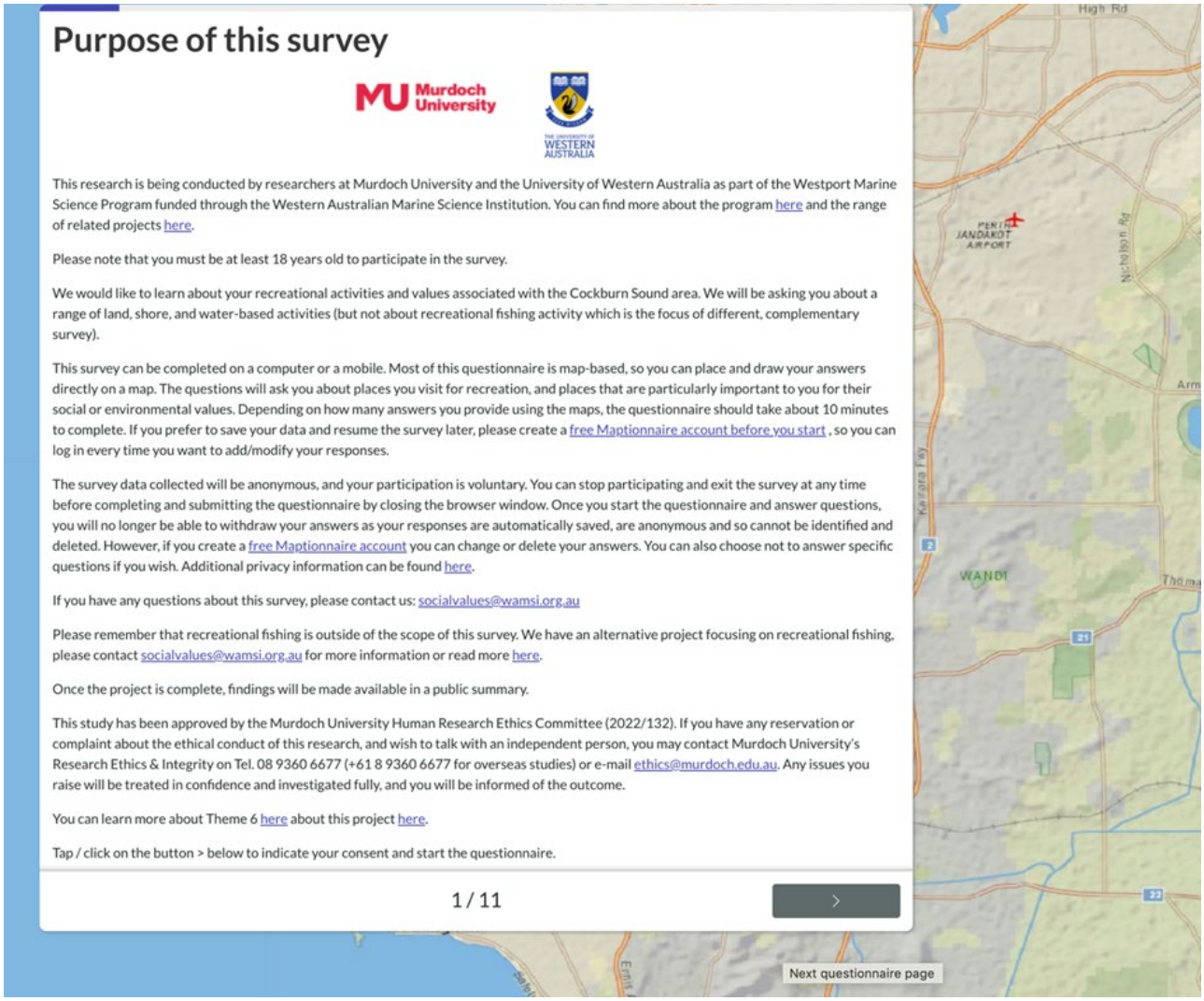
9.1 Appendix 1: Recreational values selection and rational

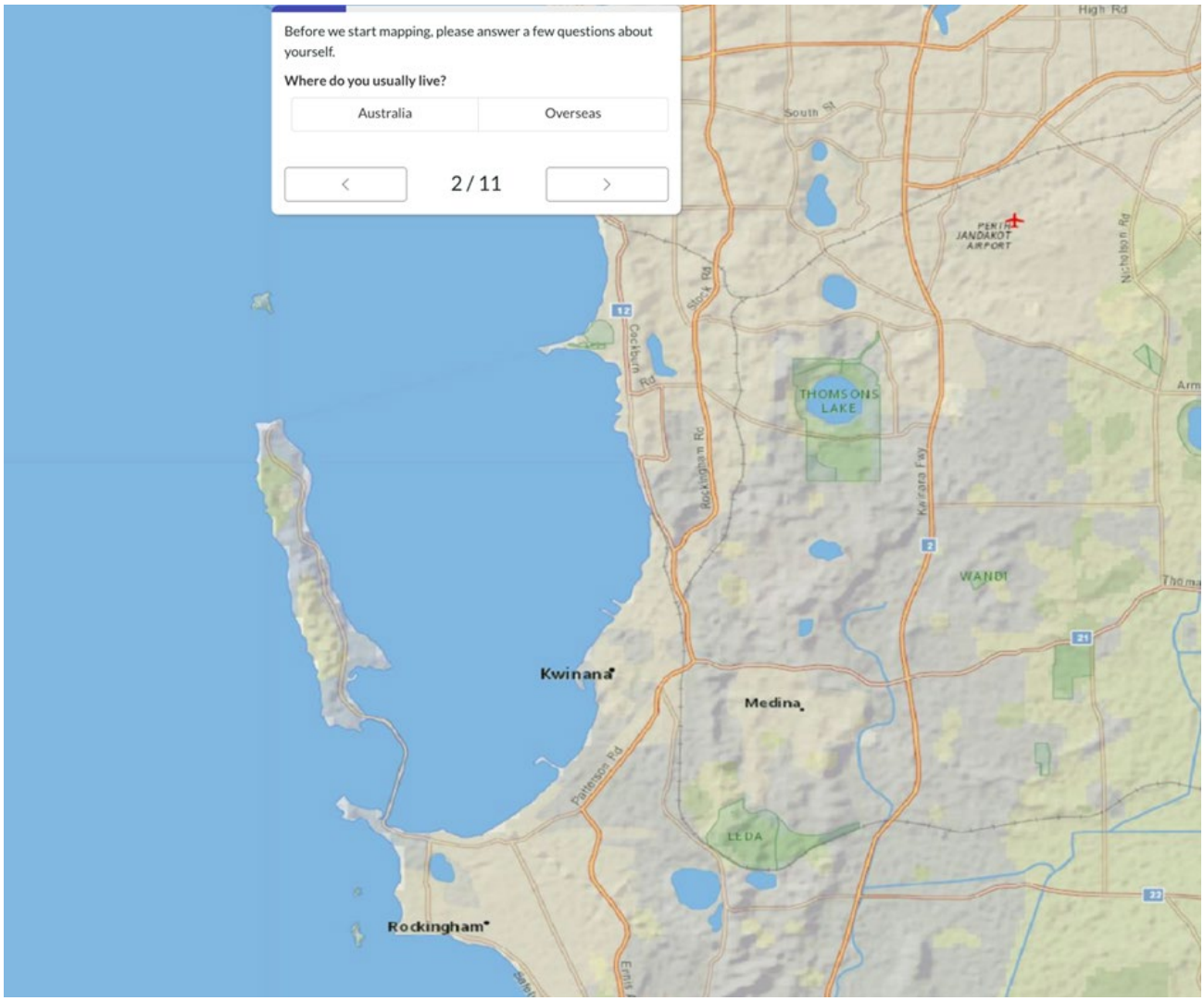
Including relationship with Wallace et al. (2020) framework for end-state values (italicised) in the justification. From Moyle and Weiler (2017)

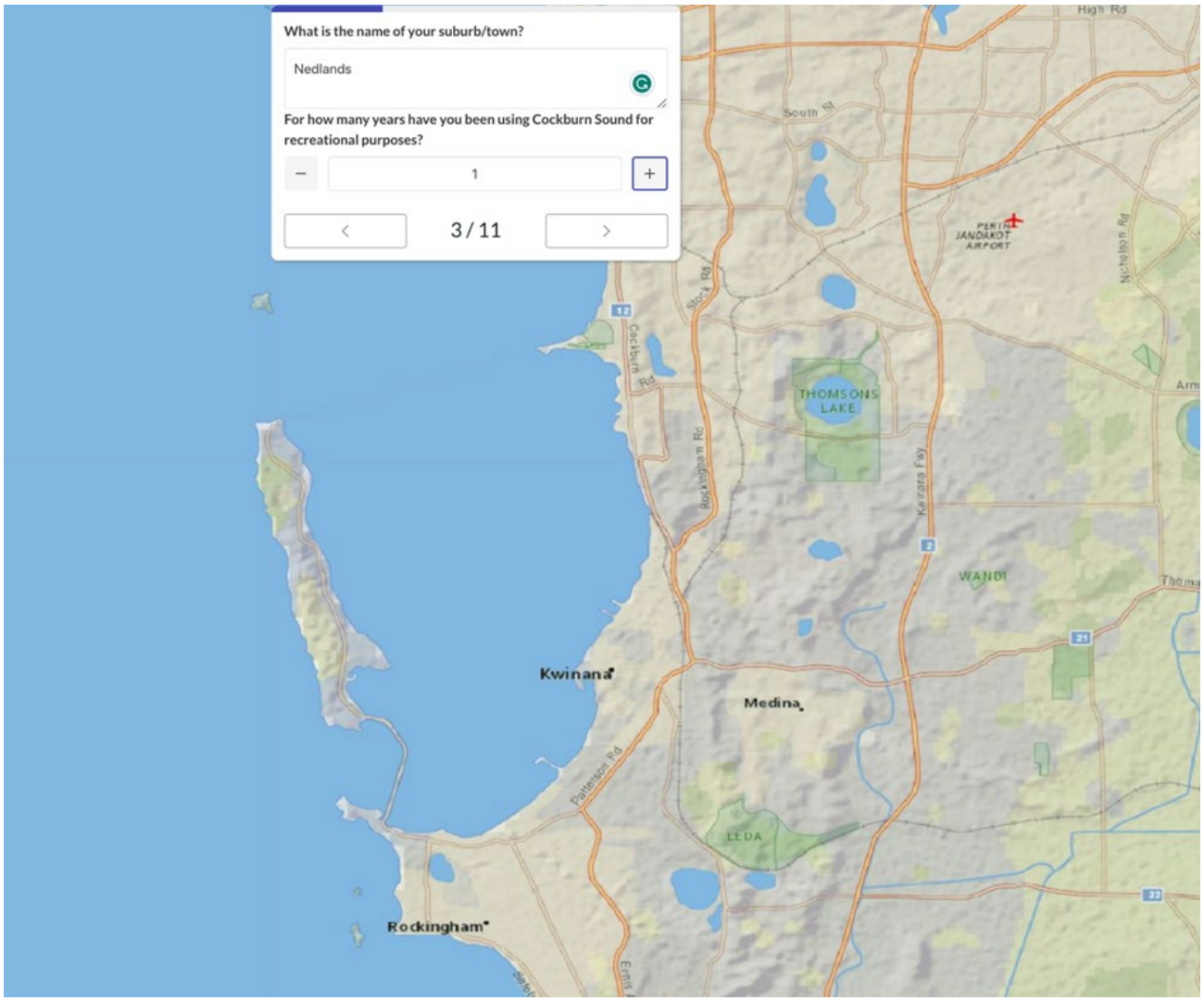
Benefits	**Verdict**	**Justification**
Be in a comfortable and safe place	Include	Disaggregate between comfortable space (*benign physical environment*) and safe place (*Safety*, or *protection from other organisms*)
Achieve mental health benefits	Include	It is a benefit associated with *recreational satisfaction*
Increase self-confidence	Exclude	Merge with mental health
Achieve physical health benefits	Include	It is a benefit associated with *recreational satisfaction*
Experience something new and different, Relax and unwind, Have fun	Include	Contribute to *recreational satisfaction*
Appreciate scenic beauty	Include	Contributes to *aesthetic enjoyment*
Find peace and solitude, reflect on personal values, connect with spiritual side	Include	Contribute to *fulfilling spiritual / philosophical* values
Learn about nature, culture and heritage, Connect with nature, culture and heritage, appreciate biodiversity	Include	Contribute to *knowledge-heritage fulfilment*
Socialise with friends and family, Strengthen social networks, Strengthen family ties, Increased community pride	Include	Contribute to *social fulfilment*
Participate in outdoor recreation activities	Exclude	N/A
Challenge yourself	Exclude	It is an attitude, and thus could be considered as a derived from a principle of behaviour rather than a benefit contributing more or less directly to an end-state value
Escape the urban environment	Exclude	Too specific to national parks
Improve quality of life, Increased community wellbeing	Exclude	Too general (given the link established by Wallace et al. (2020) between end state values and wellbeing)
Protection of biological diversity, Conservation of culture, Conservation of heritage, Improved flood management, Improved fire management, Protection of drinking water, Provision of clean air, Provision of green spaces, Reduction in the effects of climate change	Exclude	These are benefits directly associated with national parks (not recreation)

Access natural experiences	Exclude	Cannot be directly linked to an end state value – needs another 'why' question and then it could be associated with an end state
Generation of employment, Increased business investment, Increased tourism, Reduction in the cost of healthcare	Exclude	Cannot be directly linked to an end state value – need another 'why' question and then it could be associated with, for example, 'meaningful occupation', or a principle of behaviour (e.g. caring for others). Also, the potential wider economic impacts of changes in recreation associated with new developments in the CS (e.g. number of recreation businesses operating in the area, their revenue, etc) are outside the scope of this study.

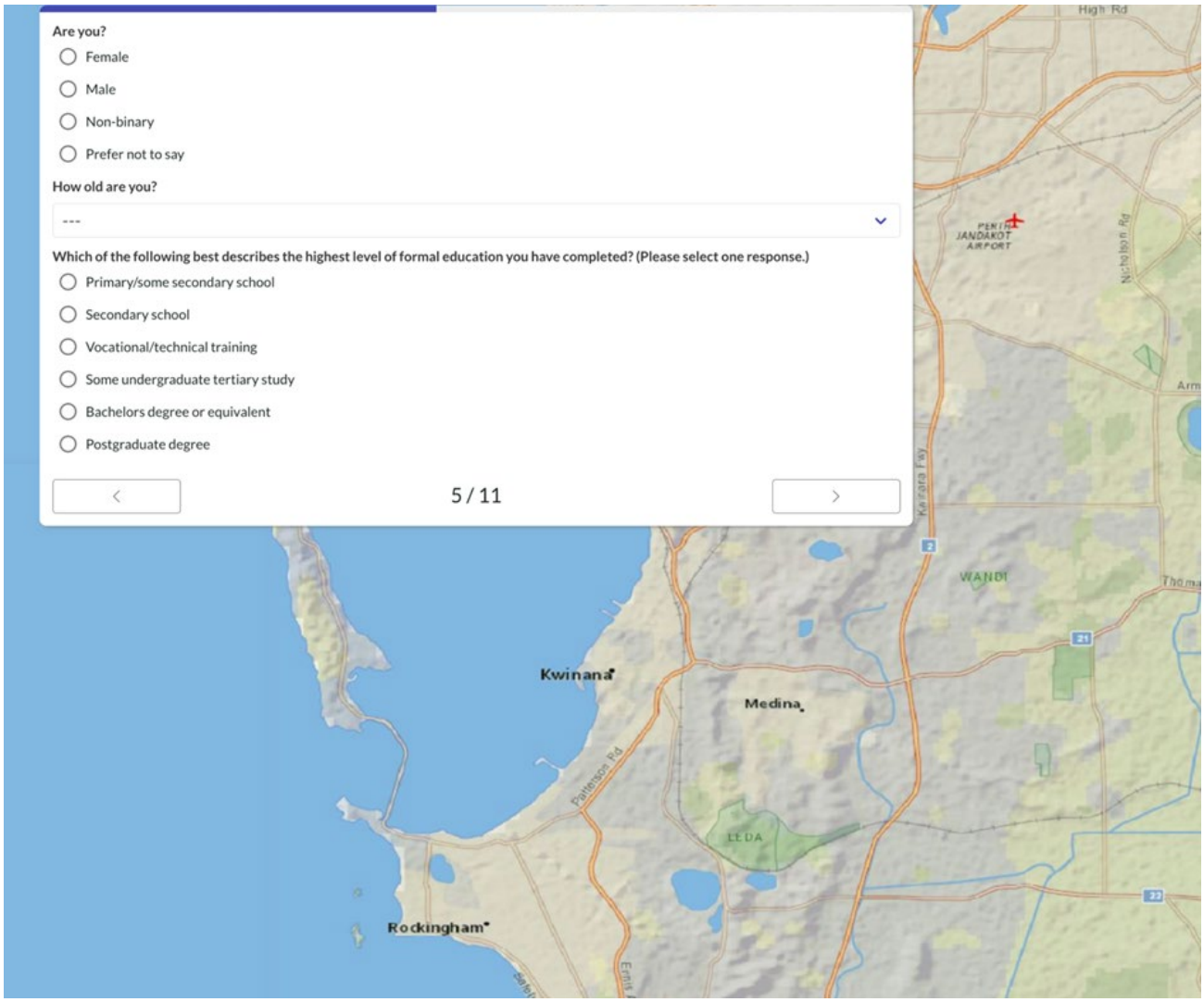
9.2 Appendix 2: WAMSI Westport project 6.3 online survey questionnaire. Pages 1-11.



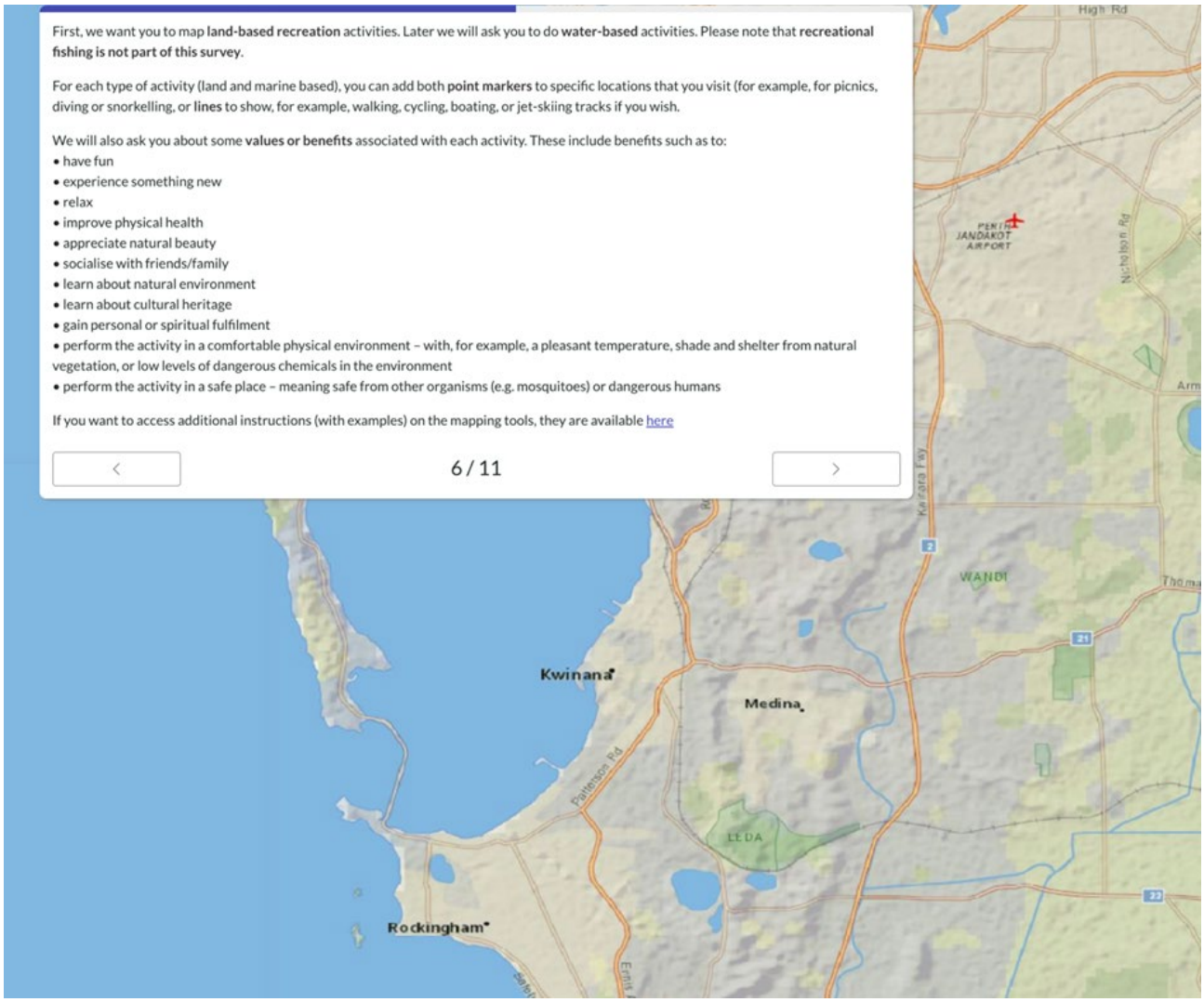

Before we start mapping, please answer a few questions about yourself.
Where do you usually live?
Australia
Overseas
2 / 11
High Rd
South St
PERTH JANDAKOT AIRPORT
Nicholson Rd
Stock Rd
Cockburn Rd
Rockingham Rd
THOMSONS LAKE
Kwinana Fwy
WANDI
Kwinana
Medina
Patterson Rd
LEDA
Rockingham

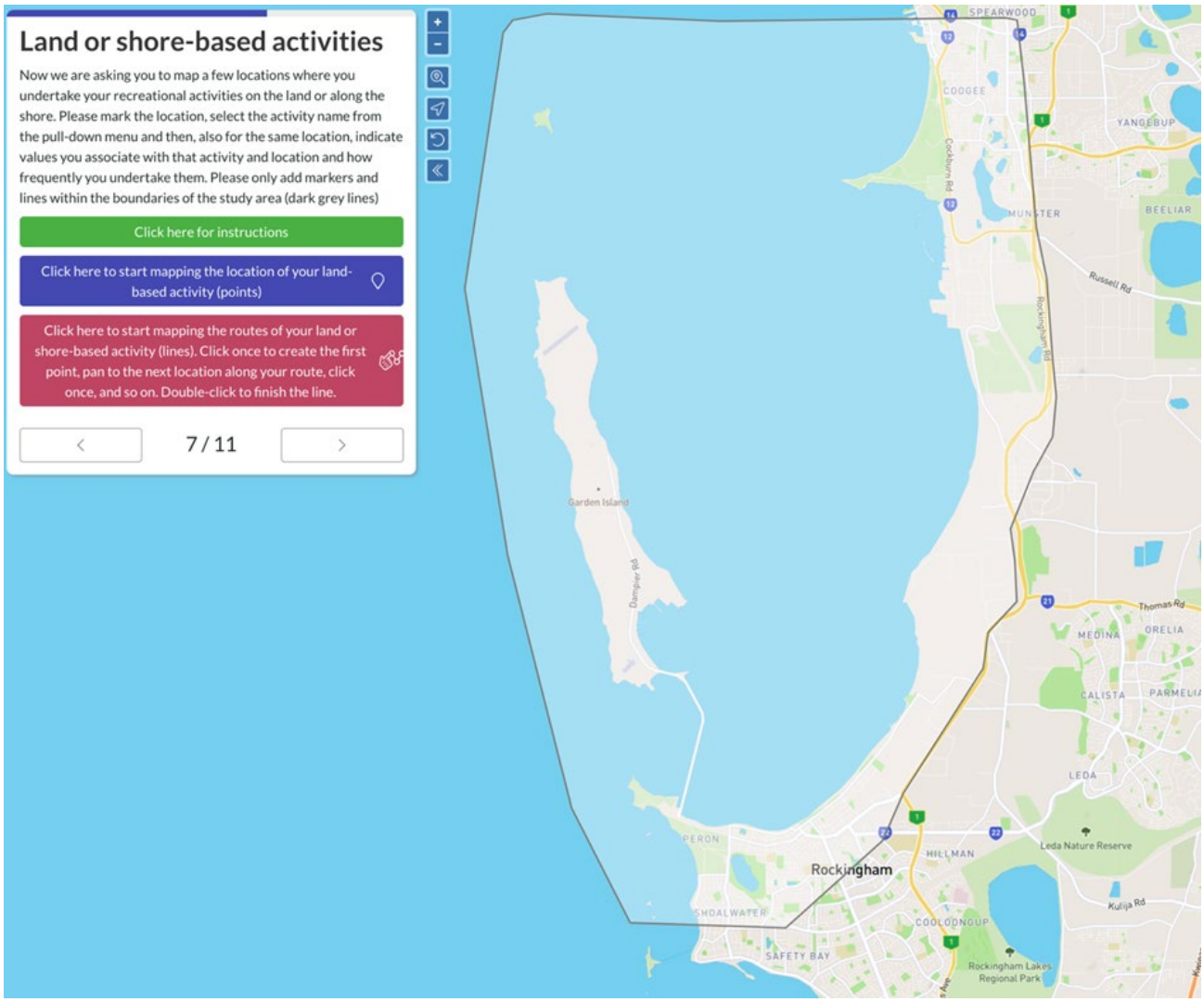

What is the name of your suburb/town?
Nedlands
For how many years have you been using Cockburn Sound for recreational purposes?
1
3 / 11
Kwinana
Medina
Rockingham
THOMSONS LAKE
WANDI
LEDA
PERTH JANDAKOT AIRPORT
Cockburn Rd
Rockingham Rd
Kwinana Fwy
Patterson Rd
South St
High Rd
Nicholson Rd

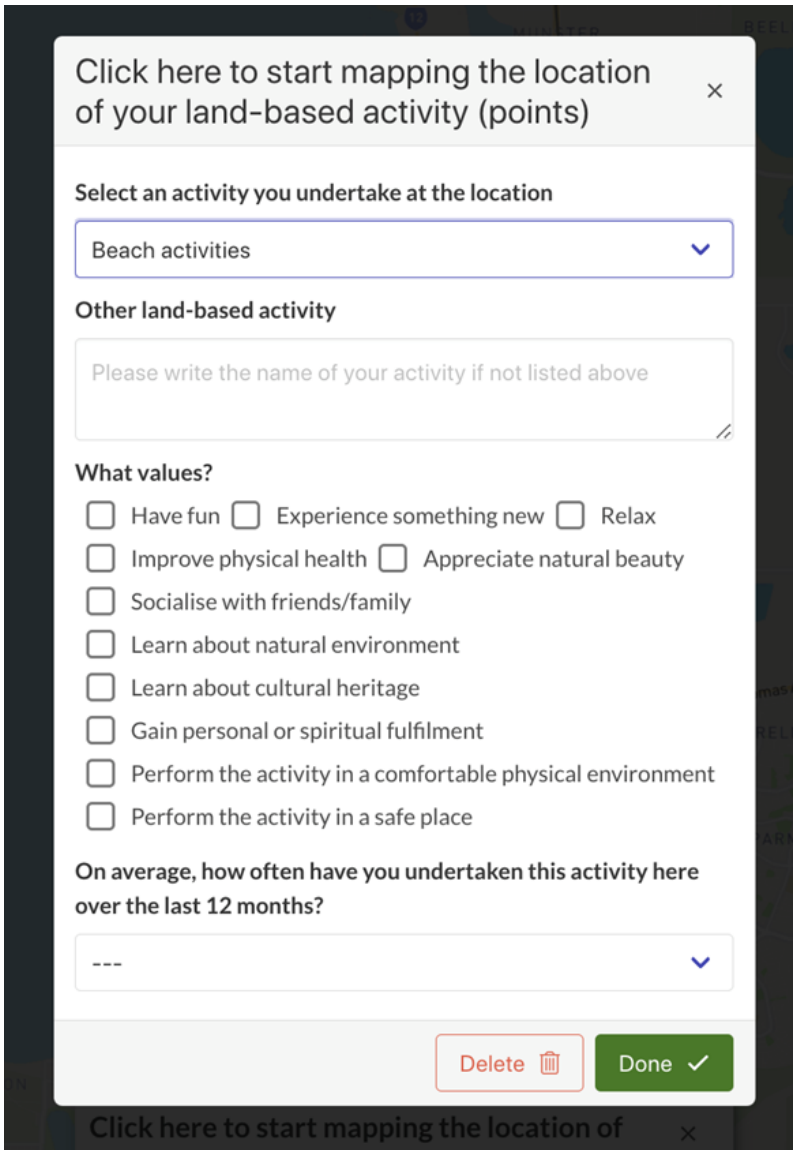

Which country?
Greece
0 / 35
4 / 11


Are you?
Female
Male
Non-binary
Prefer not to say
How old are you?

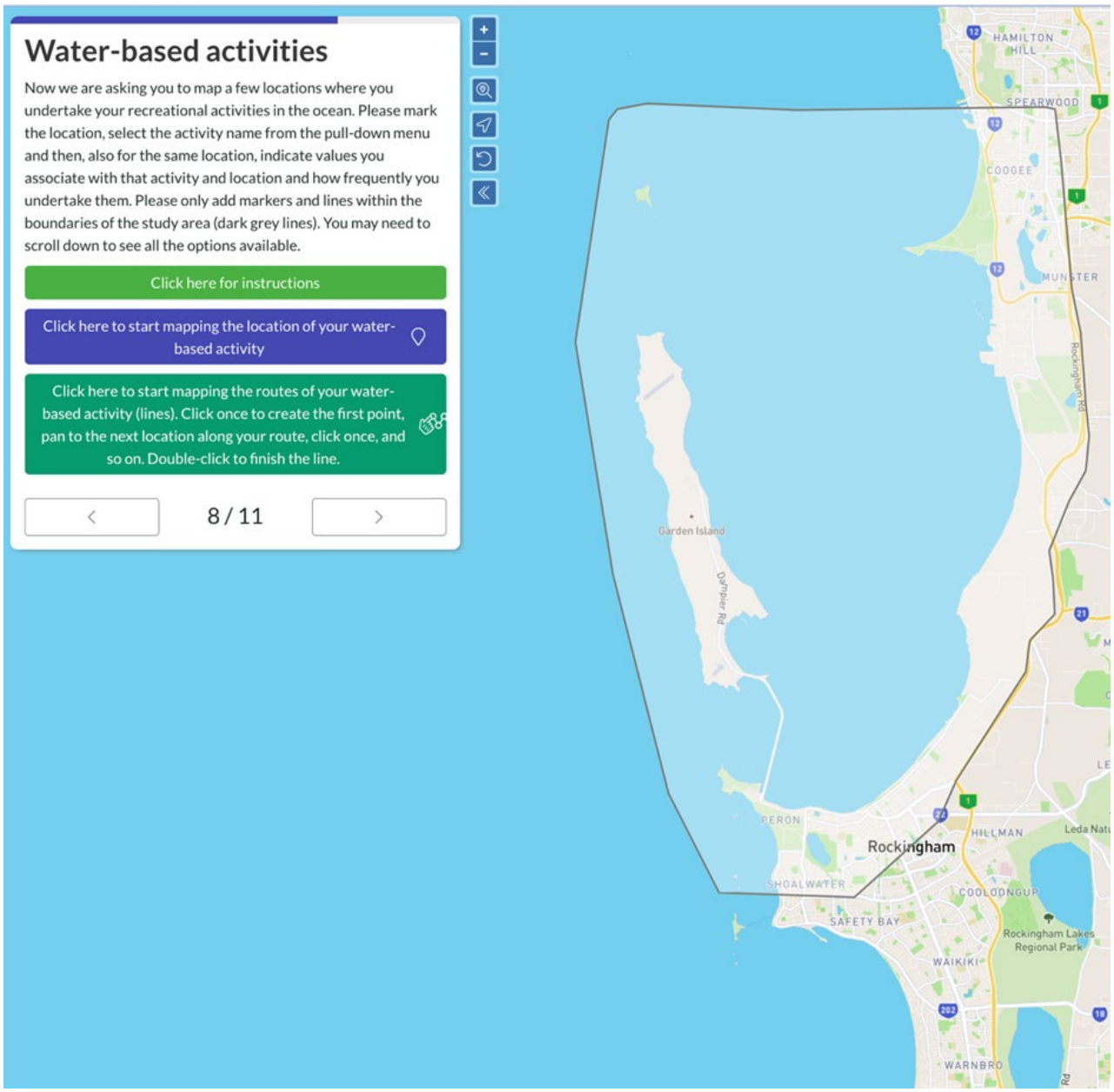
Which of the following best describes the highest level of formal education you have completed? (Please select one response.)
Primary/some secondary school
Secondary school
Vocational/technical training
Some undergraduate tertiary study
Bachelors degree or equivalent
Postgraduate degree
5 / 11
Kwinana
Medina
Rockingham
WANDI
LEDA
Patterson Rd
Karnata Fwy
Nicholson Rd
PERTH JANDAKOT AIRPORT


First, we want you to map land-based recreation activities. Later we will ask you to do water-based activities. Please note that recreational fishing is not part of this survey.
For each type of activity (land and marine based), you can add both point markers to specific locations that you visit (for example, for picnics, diving or snorkelling, or lines to show, for example, walking, cycling, boating, or jet-skiing tracks if you wish.
We will also ask you about some values or benefits associated with each activity. These include benefits such as to:
• have fun
• experience something new
• relax
• improve physical health
• appreciate natural beauty
• socialise with friends/family
• learn about natural environment
• learn about cultural heritage
• gain personal or spiritual fulfilment
• perform the activity in a comfortable physical environment – with, for example, a pleasant temperature, shade and shelter from natural vegetation, or low levels of dangerous chemicals in the environment
• perform the activity in a safe place – meaning safe from other organisms (e.g. mosquitoes) or dangerous humans
If you want to access additional instructions (with examples) on the mapping tools, they are available here
6 / 11
Kwinana
Medina
Rockingham
WANDI
LEDA
Patterson Rd
Kwinana Fwy
PERTH JANDAKOT AIRPORT


Land or shore-based activities
Now we are asking you to map a few locations where you undertake your recreational activities on the land or along the shore. Please mark the location, select the activity name from the pull-down menu and then, also for the same location, indicate values you associate with that activity and location and how frequently you undertake them. Please only add markers and lines within the boundaries of the study area (dark grey lines)
Click here for instructions
Click here to start mapping the location of your land-based activity (points)
Click here to start mapping the routes of your land or shore-based activity (lines). Click once to create the first point, pan to the next location along your route, click once, and so on. Double-click to finish the line.
7 / 11
SPEARWOOD
COOGEE
YANGEBUP
MUNSTER
BEELIAR
Cockburn Rd
Russell Rd
Rockingham Rd
Garden Island
Dampier Rd
Thomas Rd
MEDINA
ORELIA
CALISTA
PARMELIA
LEDA
PERON
HILLMAN
Rockingham
Leda Nature Reserve
Kulija Rd
SHOALWATER
COOLOONGUP
SAFETY BAY
Rockingham Lakes Regional Park


Click here to start mapping the location of your land-based activity (points)
Select an activity you undertake at the location
Beach activities
Other land-based activity
Please write the name of your activity if not listed above
What values?
Have fun
Experience something new
Relax
Improve physical health
Appreciate natural beauty
Socialise with friends/family
Learn about natural environment
Learn about cultural heritage
Gain personal or spiritual fulfilment
Perform the activity in a comfortable physical environment
Perform the activity in a safe place
On average, how often have you undertaken this activity here over the last 12 months?

Delete
Done
Click here to start mapping the location of


Water-based activities
Now we are asking you to map a few locations where you undertake your recreational activities in the ocean. Please mark the location, select the activity name from the pull-down menu and then, also for the same location, indicate values you associate with that activity and location and how frequently you undertake them. Please only add markers and lines within the boundaries of the study area (dark grey lines). You may need to scroll down to see all the options available.
Click here for instructions
Click here to start mapping the location of your water-based activity
Click here to start mapping the routes of your water-based activity (lines). Click once to create the first point, pan to the next location along your route, click once, and so on. Double-click to finish the line.
8 / 11
HAMILTON HILL
SPEARWOOD
COOGEE
MUNSTER
Rockingham Rd
Garden Island
Dampier Rd
PERON
HILLMAN
Rockingham
SHOALWATER
COOLONGUP
SAFETY BAY
Rockingham Lakes Regional Park
WAIKIKI
WARNBRO

We now have a few more questions to better understand your mapping

Which life stage category best describes you? (Please select one response)

- ◯ Single without children
- ◯ Single with children – at least some of the children are still dependent
- ◯ Single with children – with all children independent or having left home
- ◯ Couple without children
- ◯ Mature family (children older than 15 years at home)
- ◯ Couple with children – at least some of the children are still dependent
- ◯ Couple with children – with all children independent or having left home
- ◯ Other

Life stage category 'Other' (specify if you would like to):

What was your average individual income over the last 12 months (before tax)?

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What mode of transport do you usually use to get to Cockburn Sound to undertake your recreation activities? (select the most frequently used if you use multiple modes)

◯ Car, utility, or similar vehicle ◯ Motorcycle ◯ Public transport ◯ Taxi or ride-share ◯ E-scooter, motorised bicycle, or similar
◯ Non-motorised vehicle (bicycle, scooter, skateboard etc.) ◯ Walking ◯ Other

On an average recreation trip to Cockburn Sound, do other people usually travel with you (e.g. in the same car)

- ◯ I usually travel by myself
- ◯ Usually other people travel with me

If you usually travel with other people to Cockburn Sound, how many other people?

– +

On average, which of the following coastal locations you use most often for land-based recreation activities?

- ◯ Mostly Cockburn Sound
- ◯ Mostly another location
- ◯ Not applicable

On average, which of the following coastal locations you use most often for marine-based recreation activities?

- ◯ Mostly Cockburn Sound
- ◯ Mostly another location
- ◯ Not applicable

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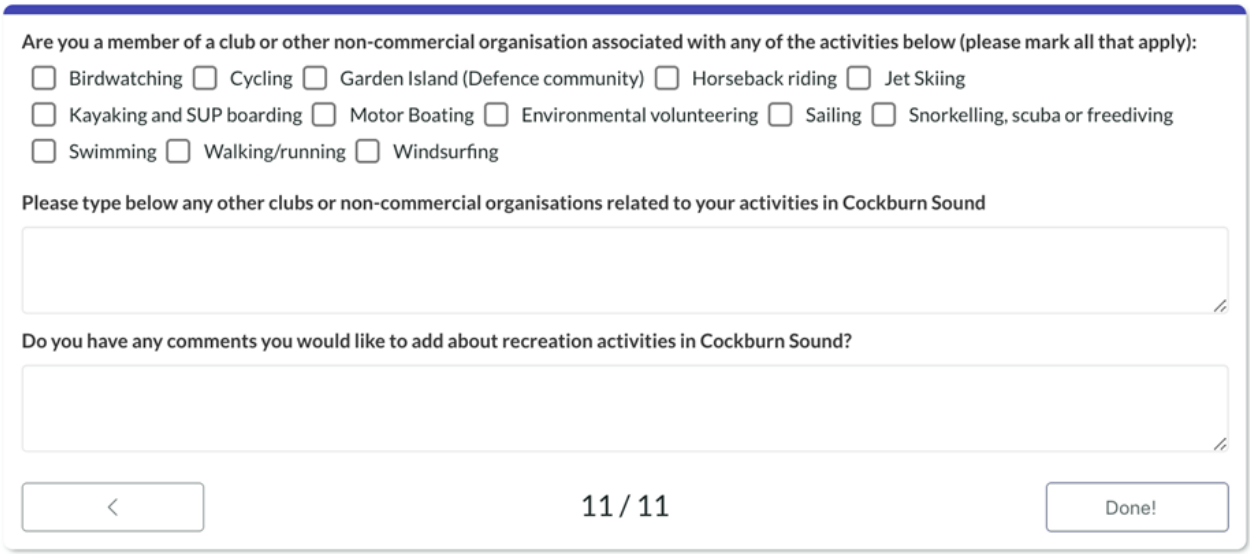
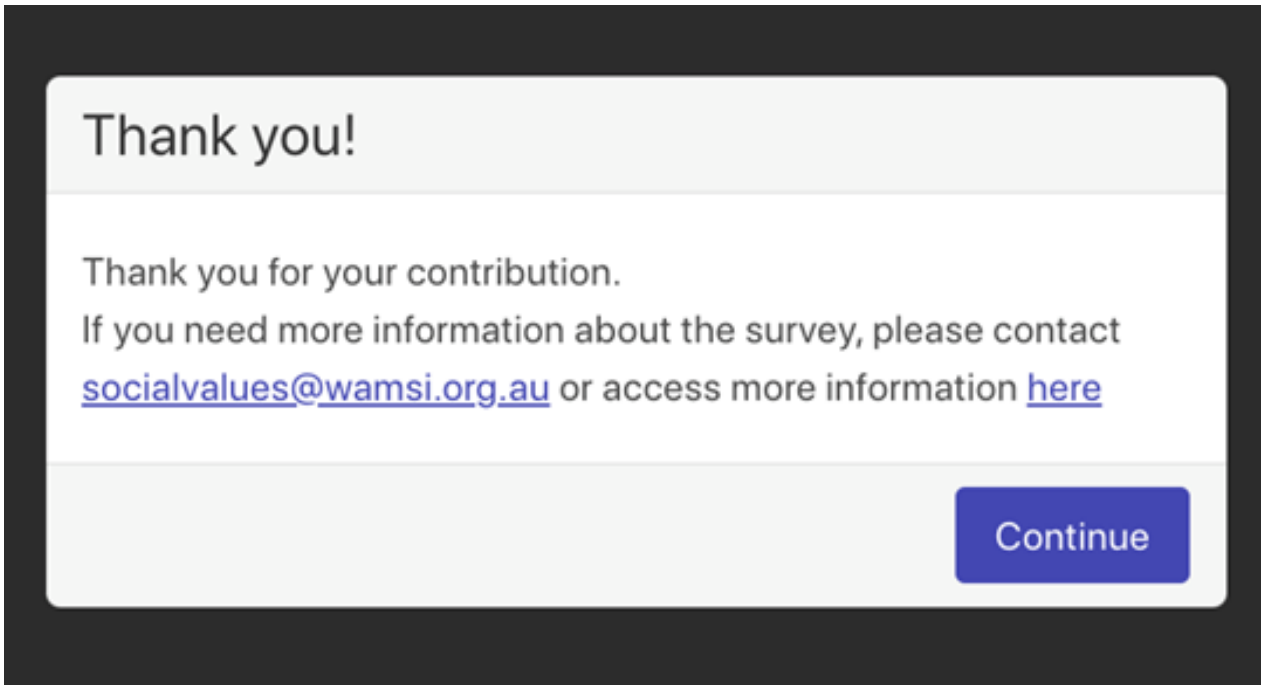
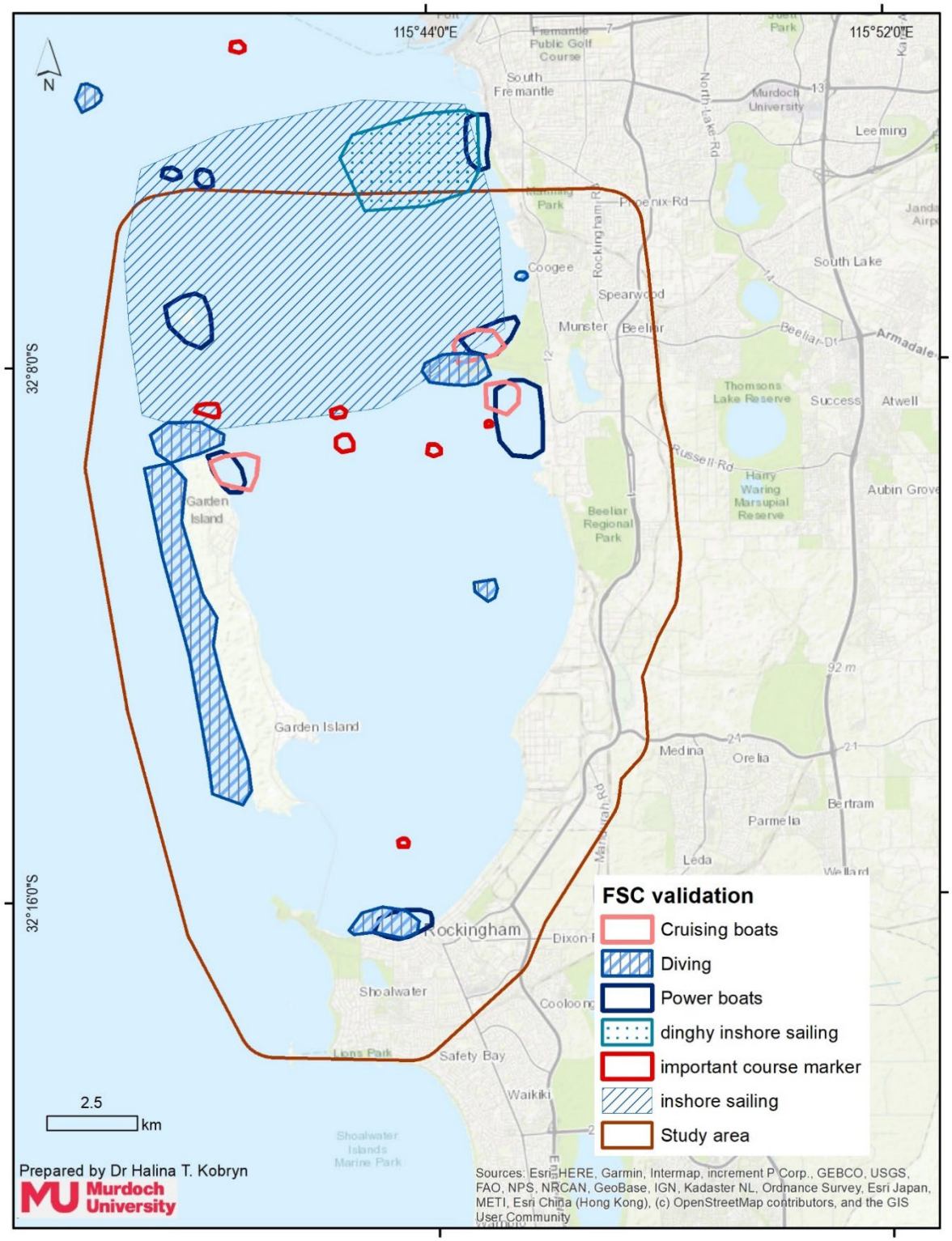

Are you a member of a club or other non-commercial organisation associated with any of the activities below (please mark all that apply):
Birdwatching
Cycling
Garden Island (Defence community)
Horseback riding
Jet Skiing
Kayaking and SUP boarding
Motor Boating
Environmental volunteering
Sailing
Snorkelling, scuba or freediving
Swimming
Walking/running
Windsurfing
Please type below any other clubs or non-commercial organisations related to your activities in Cockburn Sound
Do you have any comments you would like to add about recreation activities in Cockburn Sound?
11 / 11
Done!


Thank you!
Thank you for your contribution.
If you need more information about the survey, please contact socialvalues@wamsi.org.au or access more information here
Continue

9.3 Appendix 3: Data validation maps and tables

Map of activity locations identified in interview with Fremantle Sailing Club representative [*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]



Map of activity hotspots based on analysis of survey mapping data. [*Note: refer to the disclaimer on the inside cover regarding mapped activities.*]

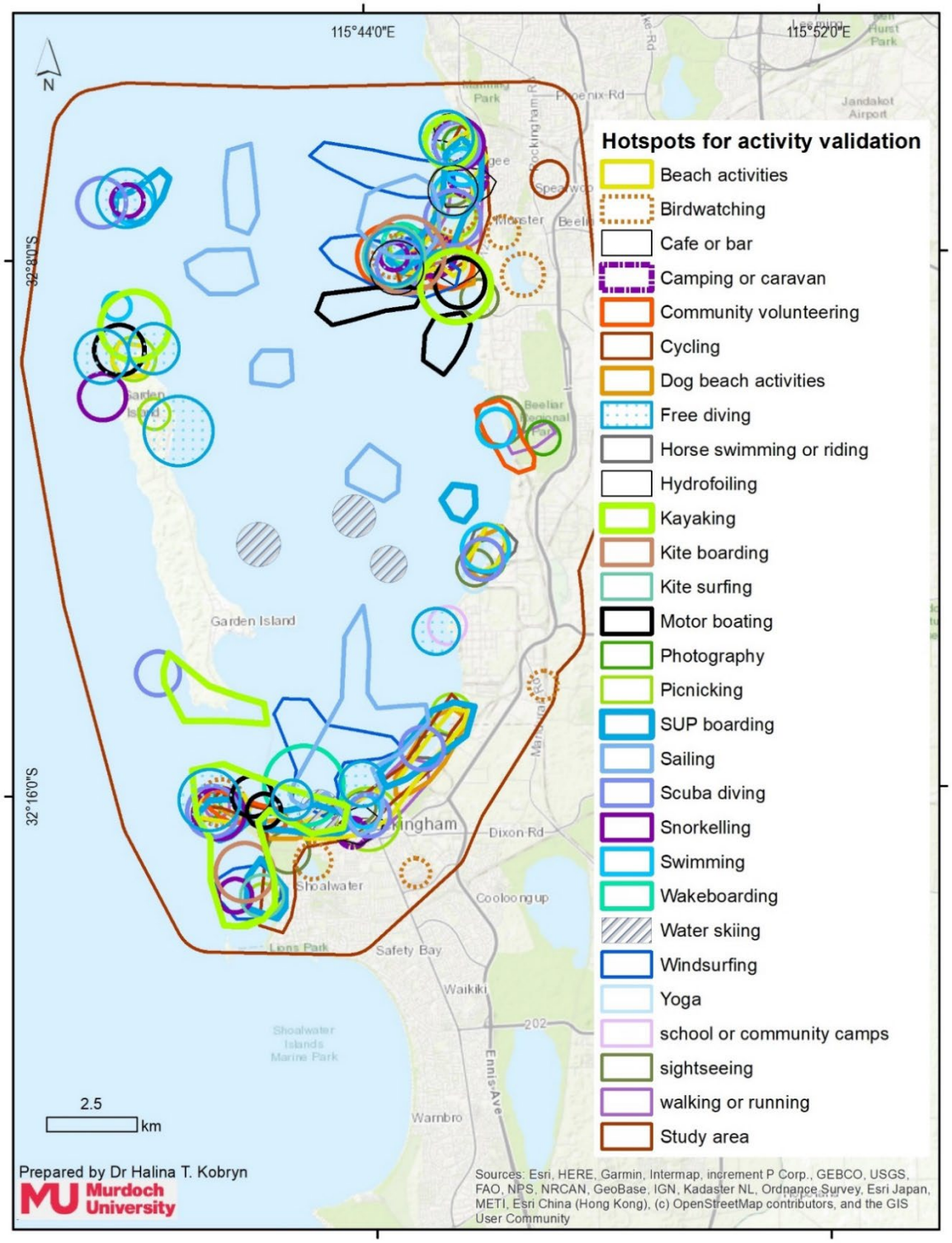


Table validating identified land-based hotspots using proximity to useful infrastructure.

Land-based Recreational Activity	No. Hotspot Polygons	Beach	Parking	Multiple access paths to the beach	Park/Reserve	Jetty	Boat launching	Island/Islet/Rocks	Bike path/Road	Footpath	Designated activity area	Yacht Club	Motorboat Club	Well know area	Total
Beach activities	5	5	4	5	5	3	2	1	5	5	0	0	0	0	35
Birdwatching	9	3	8	3	8	1	0	0	8	8	0	0	0	0	39
Café/bar	5	4	4	4	4	3	2	0	4	4	4	2	1	0	36
Camping/caravan	3	3	3	3	3	1	0	0	3	3	3	0	0	0	22
Community volunteering	4	4	4	4	4	2	2	0	4	4	0	0	1	0	29
Cycling	3	2	3	2	3	2	0	0	3	3	0	0	0	0	18
Dog beach activities	5	5	5	5	5	4	0	0	5	5	5	0	0	0	39
E-scootering	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Horseback riding & Swimming	2	2	2	2	2	1	0	0	2	2	2	0	0	0	15
Photography	4	3	3	3	4	2	1	1	4	4	0	0	0	0	25
Picnicking	8	8	6	8	7	5	2	2	7	8	0	0	0	0	53
School/community camps	2	2	2	2	2	1	1	0	1	1	0	0	0	0	12
Skateboarding	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Walking/running	4	4	4	4	4	0	0	0	4	4	0	0	0	0	24
Yoga	3	3	3	3	1	1	0	0	0	0	0	0	0	0	11

Table validating identified water-based hotspots using proximity to useful infrastructure.

Water-based Recreational activity	No. Hotspot Polygons	Beach	Parking	Multiple access paths to the beach	Park/Reserve	Jetty	Boat launching	Island/Islet/Rocks	Bike path/Road	Footpath	Designated activity area	Yacht Club	Motorboat Club	Well know area	Total
Freediving	10	6	6	6	5	3	1	6	0	0	0	0	0	7	40
Hoverboarding	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrofoiling	2	2	2	2	2	1	2	0	0	0	2	0	0	0	13
Jet-skiing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kayaking	6	6	4	6	6	3	3	3	0	0	0	0	0	2	33
Kite boarding	2	2	2	2	2	1	0	0	2	2	2	0	0	0	15
Kite surfing	2	2	2	2	2	1	0	0	2	2	2	0	0	0	15
Motor boating	6	5	5	5	3	1	5	1	0	0	1	0	3	4	33
Sailing	6	2	2	2	0	2	2	0	0	0	0	2	0	6	18
Scuba diving	9	9	7	8	7	6	1	1	0	0	0	0	0	8	47
Snorkelling	6	6	4	6	6	2	1	5	0	3	0	0	0	5	38
SUP boarding	7	7	6	6	6	4	4	1	0	0	0	0	0	0	34
Swimming	7	6	5	6	5	4	0	2	5	5	0	0	0	0	38
Wake Boarding	2	2	2	2	0	1	2	0	0	0	2	0	0	0	11
Water Skiing	4	4	4	4	0	1	4	3	0	0	1	0	0	0	21
Windsurfing	4	4	4	4	0	1	4	0	0	0	4	0	0	0	21

Table reporting the number of respondents who have undertaken land- or water-based activities in Cockburn Sound, from a representative sample of n=1340 individuals from the Perth Metropolitan community (recruited via an online panel) in WWMSP Project 6.1.

Activity	Count
Beach activities	659
Swimming	378
Picnicking	320
Dog beach activities	163
Cycling	110
Snorkelling	107
Birdwatching	65
Camping/caravan	59
Free diving	53
Kayaking	42
Motor boating	38
SUP boarding	30
Horseback riding and exercising	26
School/community camps	24
Sailing	23
Jet-skiing	21
Community volunteering	17
Scuba diving	15
Water skiing	13
Kite surfing	10
Kite boarding	9
Wakeboarding	7
Hydrofoiling	6
Windsurfing	6
Hoverboarding	1
Walking/running	0

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Submitted as revised draft	17/07/2023
Approved by Science Program Leadership team	23/01/2024
Approved by WAMSI CEO	20/03/2024
Final Report	20/03/2024

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MARINE SCIENCE
INSTITUTION