

# ASSESSING SOCIO-ECONOMIC BENEFITS OF THE ROCKY SHORE ENVIRONMENT OF BURLEIGH HEADS, QUEENSLAND, AUSTRALIA



*R. Brinkman, 2014*

# ASSESSING SOCIO-ECONOMIC BENEFITS OF THE ROCKY SHORE ENVIRONMENT OF BURLEIGH HEADS, QUEENSLAND, AUSTRALIA

ASSESSING FOUR ECOSYSTEM SERVICES DEVIDED OVER NUMEROUS BENEFITS OF  
THE ROCKY SHORE ENVIRONMENT OF BURLEIGH HEADS, QLD, AUSTRALIA. THIS IS  
A THESIS CONDUCTED AS PART OF A BACHELOR IN WILDLIFE MANAGEMENT.

Brinkman, R.

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Thesis

Ocean Connect

Van Hall Larenstein

Okka Bangma-Jansen & Theo Meijer

Leeuwarden, June 2016

## OCEAN CONNECT

Ocean Connect is a non-profit organisation whose aim it is to promote the understanding and enjoyment of the marine and coastal areas of the Gold Coast. It endeavors to achieve this objective through a combination of education, advocacy and networking. The primary focus of Ocean Connect in this work is to connect existing organisations in the city that work towards protecting the marine and coastal environment. In addition, it provides educational tools to schools, local businesses and the wider community to enhance their awareness on a range of current marine and coastal issues as well as biodiversity and coastal recreation. Moreover, it strives to provide a platform for local artists who produce art with environmental themes. The rocky shores of Burleigh Heads are a useful resource for the educational programs implemented by Ocean Connect to teach locals about this particular ecosystem.

### **For more information:**

Maggie Muurmans

Ocean Connect

Gold Coast, Elanora

Tel: +61 7 5534 8604

Email: [info@ocean-connect.org](mailto:info@ocean-connect.org)

Website: [www.ocean-connect.org](http://www.ocean-connect.org)

## SUMMARY

The Gold Coast, situated on the east coast of Australia, is renowned for its vast stretches of sandy beaches, which attract many tourists all year round. A less well-known area is the rocky foreshore situated next to Burleigh Head National Park, part of the suburb Burleigh Heads. Rocky shores are intertidal areas of seacoasts where rocks predominate; it includes habitats like rockpools, boulders, etc. Interest in this specific area was shown by the non-profit organisation Ocean Connect in 2014 when a biodiversity assessment was conducted. Ocean Connect wishes to work towards the involvement of the Gold Coast community and authorities in the enjoyment, protection and education of their coast, particularly for the rocky foreshore of Burleigh Heads. Ocean Connect, therefore, aimed to have a full ecosystem services assessment being performed. This assessment was conducted in order to enhance the knowledge on ecosystem services for this unique environment as well as to provide the City of Gold Coast and other relevant authorities with information as to why this unique natural area should be managed and conserved, hence ensuring that future generations can enjoy the beauty that it holds today. The socio-economic assessment was guided by set frameworks generated by the IEEP and expressed as a toolkit for practitioners. The toolkit includes a rapid assessment where important benefits per ecosystem service (provisioning, cultural, regulating and supporting) are rated on their significance followed by detailed valuation where quantitative, qualitative and monetary values are given; the values and significance have been determined by using the toolkit, literature review, communication with experts in the field and the researcher's own estimates. Data have been processed through set frameworks given in the toolkit. The rapid assessment revealed a high significance for the supporting services, as these services are the basis for the other three ecosystem services; when supporting services are overexploited, other ecosystem services including their benefits will diminish. Cultural services revealed a high significance as the study site is within the urbanised Gold Coast, making the study site easily accessible for locals as well as tourists. Both provisioning services and regulating services show a limited to moderate significance seeing that benefits like food, timber and water purification is limited within a coastal ecosystem. Summarising the detailed valuation, the cultural services included the highest monetary value, as the surfing industry is an important part of the Gold Coast culture. The overall monetary value for the rocky shore environment of Burleigh Heads is currently estimated to be between \$AUD 33,185,936 - 49,185,936. Quantitative and qualitative values were more valuable to spiritual values being presented, as this does not create revenue and therefore no monetary value. The assessment also discusses benefits in danger as a result of climate change and growing world population as well as benefits with potential, which include biochemicals & pharmaceuticals, education, etc. Subjects involving management efforts and promotion of the study site along with suggestions for future actions have additionally been employed within the assessment creating opportunity to enhance coherency with neighbouring natural areas as well as sustainable usage of the study site. Discussing findings and methods used, it can be stated that both the rapid assessment and detailed valuation of the benefits is habitat dependant as well as location dependant; since every location has different cultures and norms. Monetary values can be specified as objective values whereas qualitative and quantitative values are mostly subjective. However, socio-economic studies are generally subjective seeing that you cannot provide objective estimates for spiritual values as everybody experiences an environment differently and has different interests. Highlighting the importance of qualitative and quantitative values is therefore of importance as not all benefits can be expressed in monetary values. Concluding, the assessment revealed that the rocky shore environment of Burleigh Heads delivers socio-economic benefits to a myriad of beneficiaries on local, regional, national and global level and also enhancing knowledge on this particular ecosystem; emphasizing the need for management and protection efforts.

## PREFACE

Firstly, I would like to express my gratitude to mentor and now friend Maggie Muurmans not only for giving me the opportunity to conduct my thesis in the country I call home as well as for the non-profit organisation Ocean Connect that I am so passionate about but also for her guidance, help, comments, critiques, the so needed bicycle and the crucial compliments at times. To Campbell Ford from Ocean Connect for his guidance, help, comments and talks. To Chantal Huijbers from Griffith University for your help, guidance, comments and talks. I would also like to acknowledge Professor Rodger Tomlinson, Dr Darrell Strauss, Daniel Ware, Tom Murray and Derek Todd from the Griffith Centre for Coastal Management for your help with the methodology, literature review, analysis, laughs, desk space and of course the encouraging words. To the Jellurgal Aboriginal Centre for your help and inspirational stories, in particular Coby McAllen and Lexene Busbridge. I would like to acknowledge the City of Gold Coast including all employees that provided me with information and the needed documents and help, and there are many. I would also like to acknowledge my supervisors from Van Hall Larenstein Okka Bangma and Theo Meijer for their knowledge, help, guidance, comments and for always being honest. Thank you to my loved ones, and you know who you are, for your support, talks, discussions over beers and wines and the needed hugs. And lastly, to my parents and sister who have supported me from the beginning, have been there for me throughout my studies and always helped me to pursue my dreams even though you do not always agree with my decisions.

Rosalinde Brinkman

*Leeuwarden, 15<sup>th</sup> of June 2016*

## DEFINITIONS

*Benefit*: something that enhances and promotes someone's wellbeing. In this case, food that has been collected at the rocky shore environment of Burleigh Heads is an example (Millennium Ecosystem Assessment, 2005).

*Biodiversity*: The variety of flora and fauna, including species composition, in the rocky shore environment of Burleigh Heads (Oxford, 2016)

*Cultural services*: services that influence a person by forming their character through the enjoyment derived by humans while experiencing the rocky shore environment of Burleigh Heads. Tourism and recreation are examples of cultural services (Surf Nature, 2012).

*Monetary*: presents a value in numbers, a currency for different benefits of the rocky shore environment of Burleigh Heads (Simpson & Weiner, 1989)

*Provisioning services*: objects that can be obtained from the rocky shore environment of Burleigh Heads to serve as goods for humans, such as food and timber (Surf Nature, 2012).

*Regulating services*: services obtained from ecosystem processes that regulate our natural environment, such as the regulation of floods and waste (Surf Nature, 2012).

*Rocky shore*: also known as the intertidal zone. This is the area that is above water at low tide and under water at high tide (area between tide marks). It includes different types of habitats and organisms (SEQ, 2014).

*Socio-economic*: a field of study that examines social (factors that influences individuals' lifestyle) and economic factors (factors that focus on goods, benefits, costs, etc.) to gain a better understanding of how the combination of both factors influence the rocky shore environment of Burleigh Heads (Eatwell & Milgate, 1989).

*Supporting services*: services that are necessary for the sustainability of all other ecosystem services at the rocky shore environment of Burleigh Heads, for example photosynthesis (Surf Nature, 2012).

*Qualitative*: range and materiality rather than quantity of various benefits provided by the rocky shore environment of Burleigh Heads (Simpson & Weiner, 1989).

*Quantitative*: the amount expressed in number of goods and services provided by the rocky shore environment of Burleigh Heads expressed in numbers instead of currencies (Simpson & Weiner, 1989).

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## 1 INTRODUCTION

The Gold Coast, situated on the east coast of Australia, is renowned for its vast stretches of sandy beaches, which attract many tourists all year round. A less well known, but equally exciting part of this coastal environment, is the rocky foreshore next to Burleigh Head National Park (State of the Environment, 2011). Rocky shores (figure 1) are intertidal areas of seacoasts where rocks predominate; it includes habitats like rockpools, boulders, etc. (Queensland Government, 2015). This area is of importance not only because it is a climate regulator, but also because it supports other habitats and provides landscape opportunities (SEQ, 2014). Interest in this specific area was shown by the non-profit organisation Ocean Connect in 2014 when a biodiversity assessment was conducted. The assessment showed that this small, yet very unique natural area (due to the wave energy (Murray, et al., 2006), which changes the different habitats and conditions continuously (SEQ, 2014)) includes many individual organisms of different species within several orders and families. There were also species found that people were previously unaware of occurring within and around the rocky foreshore of Burleigh Heads, such as the *Umbraculum umbraculum* (Brinkman, 2014).

Unfortunately, no management for this specific area is currently in place, even though it is situated next to the Burleigh Head National Park and is adjoined to some of the most heavily managed (by the Queensland Government and the City of Gold Coast) beaches within Australia. The City of Gold Coast, which is the authorized body of this coastal environment, does have multiple management plans and strategies for shoreline protection; nevertheless, Burleigh Head's rocky foreshore is not included in these plans and strategies either as the City of Gold Coast does not have the resources (set strategy, appointed people to the area, etc.) and knowledge (limited research conducted) available at this current moment.

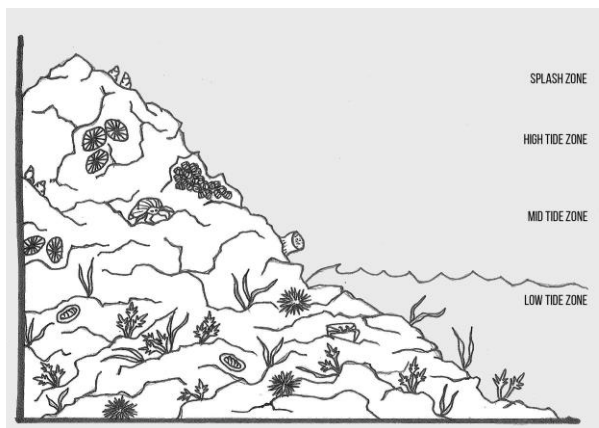


Figure 1: Intertidal zones of rocky shore environments (R. Brinkman, 2015)

Due to the lack of management and conservation efforts, the area now has to deal with major human pressure, seeing that tourism is a key factor for the local economy (City of Gold Coast, 2015). Both tourists and locals are currently using the rocky shores unsustainably as a source of food (Brinkman, 2014), business and leisure (City of Gold Coast, 2015). Across the world, it has been shown that the actual rate of ecosystem degradation, due to unsustainable use, is strongly reducing ecosystems functionality. Consequently, the capacity of these affected ecosystems to supply goods and services to humans decreases (Millennium Ecosystem Assessment, 2005; Ghazanshahi, 1981).

Ocean Connect wishes to work towards the involvement of the Gold Coast community and authorities in the enjoyment, protection and education of their coast (Ocean Connect, 2015), particularly for the rocky foreshore of Burleigh Heads. Ocean Connect, therefore, aimed to have a full ecosystem services assessment done alongside its ongoing biodiversity and human impact assessment. This assessment was conducted in order to provide the City of Gold Coast and other relevant authorities with information as to why this unique natural area should be managed and conserved, hence ensuring that future generations can enjoy the beauty that it holds today. Furthermore, this assessment clarified the advantages and variety of benefits provided by the rocky shore environment of Burleigh Heads.



In Europe, assessing ecosystem services is mostly guided by a readily available toolkit, which has been developed by the Institute for European Environmental Policy (IEEP) (Kettunen, et al., 2009). The toolkit utilises two separate approaches, which are a rapid assessment of the study site, followed by a more detailed assessment on the relevant benefits for the area (Kettunen, et al., 2009). The toolkit is socio-economic based, which means that it examines both social (factors that influences individuals' lifestyle) and economic factors (factors that focus on goods, benefits, costs, etc.) in order to attain a better understanding as to how the combination of these factors influence the area of interest (Business dictionary, 2015), in this case the rocky shore environment of Burleigh Heads. The toolkit has been used in many different case studies since being created by the IEEP, such as when it was used to assess the Bialowieza Forest in Poland (Pabian & Jaroszewicz, 2009). The case studies show that there is a gap in the beneficiaries' knowledge and understanding of the goods and services provided by the different ecosystems, which is of great concern. Benefits are often connected to each other, which means that when beneficiaries overexploit one of the benefits it can jeopardize other benefits or worse still, the whole system (Pabian & Jaroszewicz, 2009).

The toolkit separates ecosystem services into four main categories, which are provisioning, cultural, regulating and supporting services. The provisioning services include, for example, the supply of an array of natural resources such as timber and crops. Regulating services, meanwhile, include several valuable ecosystem processes, such as the ability to purify water (Kettunen, et al., 2009). Culture services incorporate tourism, aesthetic enjoyment and recreation. (Kettunen, et al., 2009). It is relevant that nature forms an important basis for maintaining human health and creates opportunities for recreation and tourism. Additionally, nature including biodiversity and ecosystems is essential in forming our cultural characteristics and values. Finally, supporting services can be seen as services that are necessary for the production of all other ecosystem services, such as photosynthesis (Surf Nature, 2012).

Presenting outcomes and values through this technical report provides relevant information, which can be utilised as a resource when establishing management efforts. The values and outcomes should be supported through monetary, qualitative and quantitative estimates of the benefits. Beneficiaries often focus on monetary values as they are expressed in numbers, which thus provides a clearer picture for them of how the different values can be implemented in an economic fashion. These presented values need to comply with Australian law and legislation, most importantly the Nature Conservation Act 1992, in order to be valid.

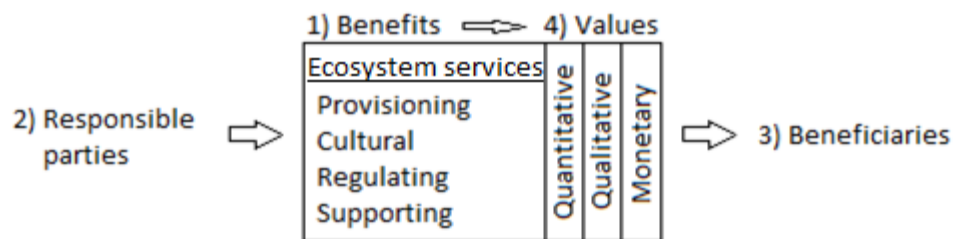
The overall aim is *to preserve and protect the rocky shore environment of Burleigh Heads to ensure that future generations visiting the area will see it for the beauty that it holds today. The **research aim** is to enhance knowledge on the ecosystem services provided by the rocky shore environment of Burleigh Heads in order to provide management recommendations.*

The **main research question** is: What are the socio-economic benefits provided by the rocky shore environment of Burleigh Heads, subdivided into provisioning, regulating, cultural and supporting services?

**Sub questions** for the overall study were given in the toolkit (Kettunen, et al., 2009):

1. What are the important benefits for provisioning services, cultural services, regulating services and supporting services?
2. Who is responsible for managing the benefits?
3. Who are the beneficiaries for each benefit?
4. What is the monetary, qualitative and quantitative value of each benefit?

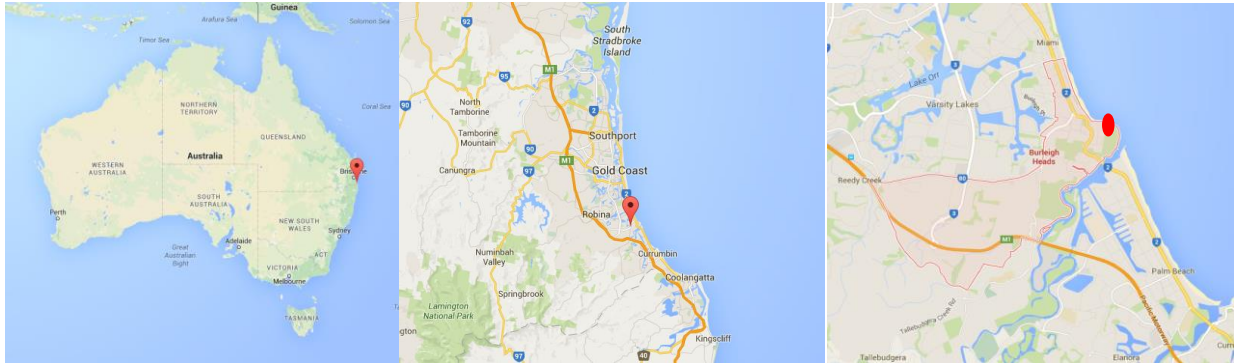
A constructive model is given below to help visualise where each of the sub-questions is situated within this assessment.



## 2 METHODS AND MATERIALS

### 2.1 STUDY SITE

The rocky shores of Burleigh Heads are centrally located on the Eastern side of Australia's Gold Coast (with Burleigh Heads being a suburb). Study site coordinates have a latitude of  $28^{\circ}05'350''$  and a longitude of  $153^{\circ}27'544''$ . The location of Burleigh Heads is shown in figure 2.



**Figure 2: Location of this thesis research, Australia, Gold Coast, Burleigh Heads (Source: Google Maps, 2016)**

The research was focused on the entire Burleigh Heads' rocky shoreline (figure 3).



**Figure 3: Rocky shore environment (between the red lines) of Burleigh Heads, Queensland, Australia. (Google Earth, 2015)**

As part of the biodiversity surveys, the study site was divided into three plots. Coordinates for these plots can be found in table 1. Survey work was employed during the autumn of 2016 (March-April).

### 2.2 RESEARCH POPULATION

The research population, consisting of organisms within the environment as well as beneficiaries of the environment, was very broad because there were a considerable number of benefits to be assessed. Additionally, people who visit the study site were part of the research population. There is a multitude of different nationalities both on the Gold Coast and in Australia as a whole, which contributes to the broad nature of the research population next to the Australian residents themselves. Migrants from New Zealand are the largest cultural group on the Gold Coast and for example accounts 8.6% of its total population. However, the Australian Bureau of Statistics show that there is a plethora of other nationalities in this region next to New Zealand migrants; the United Kingdom with 6.6% and South

Africa with 1.2% being most represented. It is important to note that international students and people that hold a visitor's visa are not unified in these statistics. The estimated resident population displays that Burleigh Heads counted 8256 residents in 2009 growing to 8668 residents in 2014 (City of Gold Coast, 2014). Research population is specified per ecosystem service below:

*Provisioning services:* organisms and materials within the rocky shore environment of Burleigh Heads (Kettunen, et al., 2009). Multiple research institutes and local authorities were of assistance with providing information (SEQ, Griffith Centre for Coastal Management, etc.).

*Cultural services:* Tourists, local residents, education institutes, research institutes, artists, the local aboriginal community and the flora and fauna were part of the research population.

*Regulating services:* organisms and materials within the rocky shore environment of Burleigh Heads (Kettunen, et al., 2009) as well as the City of Gold Coast, institutes and businesses that control regulating services of the rocky shore environment of Burleigh Heads, such as dredging and wildfire control. Additionally, people (tourists, local residents, education institutes, research institutes, artists and the local aboriginal community) are part of the research population.

*Supporting services:* organisms and materials within the rocky shore environment of Burleigh Heads (Kettunen, et al., 2009) as well as tourists, local residents, education institutes, research institutes, artists and the local aboriginal community.

## 2.3 DATA SAMPLING

Firstly, a rapid assessment for possible benefits was utilised to gain insight in the important benefits for each ecosystem service, the parties responsibly for each benefit and the beneficiaries for each benefit. After the rapid assessment, each of the relevant benefits was assessed through different methods and approaches by a detailed valuation to gain quantitative, qualitative and monetary values. The toolkit includes an extensive description of every method used for each benefit in chapter 5 of the toolkit (Kettunen, et al., 2009).

The rapid assessment is based on three questions (does the site provide this service; who benefits from this service; significance of the service) in order to obtain an overview on all relevant benefits and potentially their beneficiaries and authorizing bodies. The rapid assessment was performed by the using table 4.1 of the toolkit (Kettunen, et al., 2009) which divides the benefits per ecosystem service (provisioning, cultural, regulating and supporting) and then provides guidance to significance estimates and beneficiaries level (local, regional, national and global). Benefits examined per ecosystem services were:

- Provisioning services: food, fibre/materials, biomass, natural medicine supplies, ornamental resources, biochemical, water quantity
- Cultural services: ecotourism, recreation, cultural values and inspirational services, education, art, research, landscape and amenity values
- Regulating services: climate, water regulation, flood prevention, aquifer recharge, water purification, waste management, air quality regulation, erosion control, avalanche control, storm damage control, wild fire mitigation, biological control, pollination, regulation of human health, genetic regulation
- Supporting services: primary production, supporting habitats, nutrient cycling, decomposition, water cycling, weathering, erosion, ecological interactions and evolutionary processes.

These significance standards were chosen by the researcher based on the knowledge and expertise gained, supporting reports that also used the toolkit as a source (Bugalho & Rocha, 2009; Kazakova & Pop, 2009; Pabian & Jaroszewicz, 2009), literature and the toolkit giving guidance through table 4.1 (Kettunen, et al., 2009). Table 4.1 of the toolkit gives options that guides the researcher to significance estimates; the valuation of significance depends on the current status of each benefit separated into 3 options (which distinguish available data, management efforts, potential, lack of data, etc.) Significance was expressed in standards from 0 to 5, with 5 being of very high significance. Below an explanation per significance:

- 0 = service is not relevant at the site
- 1 = service is of very limited significance
- 2 = service is of limited significance
- 3 = service is of moderate significance
- 4 = service is of high significance
- 5 = service is of very high significance (Kettunen, et al., 2009)

Literature was available on the Internet as well as a range of documents (papers, reports, annual plans, etc.). Key words important for the assessment, included for example: 'biodiversity resources', 'water', 'biochemicals', 'pharmaceuticals', 'natural medicine', 'ecotourism', 'recreation', 'tourism', 'cultural', 'aboriginal', 'climate/water/air quality/erosion regulation', 'Gold Coast', 'City of Gold Coast', 'education institutes', 'research institutes', 'culture', 'climate change', 'human health', 'rocky shore', 'Burleigh Heads' etc.

The relevant benefits were further examined after finalising the rapid assessment to gain insight in monetary, qualitative and quantitative values for each benefit as well as benefits in potential danger, likeliness of importance to grow in the future, potential of the benefits to be sustainably managed, trade-offs between benefits and potential future actions. The toolkit was the guiding tool which was supported through reviewing of literature as well as personal communication with experts in the field. Experts in the field were: Peter Davie, Daniel Ware, multitude of departments of the City of Gold Coast, Maggie Muurmans, Darrell Straus, SEQ Catchments, Griffith Centre for Coastal Management and Jellurgal Aboriginal Centre. A summary for each ecosystem service explains the different methods used in chapter 2.3.1, 2.3.2, 2.3.3 and 2.3.4. The study of each benefit included a difference in method between monetary, qualitative and quantitative estimates which is explained in chapter 5 of the toolkit (Kettunen, et al., 2009). Chapter 5 separates each benefit per ecosystem service and then provides guidance to formulas needed in order to obtain monetary values and information needed for quantitative and qualitative values and where this information can be gathered.

### 2.3.1 PROVISIONING SERVICES

Literature review was performed through analysing various documents, reports and the Internet. Local authorities, businesses and research institutes were utilised as sources to obtain answers (SEQ Catchments, City of Gold Coast and Griffith Centre for Coastal Management, Jellurgal Aboriginal Centre). Human usage records gathered by Ocean Connect have additionally been used as part of the review. Key words used were: 'number of resources', 'number of jobs created by resources', 'number of visits to collect resources', 'number of people depending on resources' and 'biodiversity hotspots', 'food', 'fisheries', 'fibre', 'materials', 'natural medicines', 'ornamental resources', 'biochemicals' and 'pharmaceuticals'. The toolkit provided formulas to estimate the monetary values for the different benefits.

### 2.3.2 CULTURAL SERVICES

Literature review was performed through analysing various documents, reports, the Internet and with help of the Jellurgal Aboriginal Centre, Griffith Centre for Coastal Management and the City of Gold Coast. Additionally, local authorities, businesses and research institutes were utilised as sources to obtain answers as to why people visit the study site, the number of visitors, the use of study site, duration of visits and jobs that are created through the rocky shore environment of Burleigh Heads, et cetera. Human usage records gathered by Ocean Connect have additionally been used as part of the review. Key words included: 'tourism', 'Gold Coast', 'Gold Coast City Council', 'recreation', 'parks', 'aboriginal', 'culture', 'sports', 'human health', 'activities'. Monetary values were set through formulas given in the toolkit.

### 2.3.3 REGULATING SERVICES

Literature review was performed through analysing various documents, reports and the Internet. Local authorities, businesses and research institutes were utilised as sources to obtain answers on carbon storage and climate conditions (SEQ Catchments, City of Gold Coast and Griffith Centre for Coastal Management). Biodiversity records gathered by Ocean Connect have been utilised as part of the review. Key words were: 'carbon storage', 'climate change', 'temperature', 'rainfall', 'cloud formation', 'household protection', 'floods', 'risks', 'purification', 'air quality', 'fire control'. The toolkit provided formulas to estimate the monetary values for the different benefits.

### 2.3.4 SUPPORTING SERVICES

A literature review was performed through analysing various documents, reports and the Internet. Local authorities, businesses and research institutes were also utilised as sources to obtain valuable information in relation to supporting services (SEQ Catchments, City of Gold Coast and Griffith Centre for Coastal Management)). Biodiversity records gathered by Ocean Connect have been utilised as part of the review. Key words included: 'inter-relationship ecosystems', 'natural state', 'primary production', 'species', 'stock', 'populations', 'ecological composition', etc.

## 2.4 DATA PROCESSING

The literature that was found to be relevant was compiled in this report. This report firstly precedes the rapid assessment. The rapid assessment was analysed through creating a spider diagram, as given within the toolkit (appendix II). This spider diagram was fashioned based on an identifying framework (table 4.1 from the toolkit) (Kettunen, et al., 2009). The spider diagram contains values from 0 to 5; these values were chosen by the researcher based on the knowledge and expertise gained, supporting reports that also used the toolkit as a source (Bugalho & Rocha, 2009; Kazakova & Pop, 2009; Pabian & Jaroszewicz, 2009) and the toolkit given guidance through table 4.1 from the toolkit (Kettunen, et al., 2009).

Following the rapid assessment, the results of the detailed assessment of all relevant benefits were presented through a framework given in the toolkit, which is table 7.1 of the toolkit (Kettunen, et al., 2009). Qualitative, quantitative and monetary values were formed by critically analysing literature review. Relevant information which was presented within the given framework are subdivided as followed:

1. Benefit description
2. Estimated value of the benefit: qualitative, quantitative & monetary
3. Estimated value of the benefit: researcher's own estimate
4. The beneficiaries
5. The current status of the benefit
6. Is the importance of this benefit likely to increase in the future
7. Sum monetary values



### 3 SOCIO-ECONOMIC BENEFITS

#### 3.1 OVERVIEW OF SITE'S SOCIO-ECONOMIC BENEFITS AND THEIR SIGNIFICANCE

This chapter offers a concise introduction on the ecosystem services provided by the rocky shore environment of Burleigh Heads through a rapid assessment. Results are given in the chapter as well as Appendix I.

##### 3.1.1 PROVISIONING SERVICES

###### **Food**

The environment provides food resources for both humans as for the fauna and flora occurring at the study site. Most important goods collected or consumed are fruit, fish and other aquatic resources (Brinkman, 2014). The resources are collected and used by local inhabitants for their own needs (Brinkman, 2014). Also, multiple animal species use the rocky shores as their feeding grounds (SEQ, 2014) as the rocky shores serve as a nursery for juvenile fish (Brinkman, 2014). Aboriginal people (Yugambeh language group: Kombumerri people) made use of the rocky shore environment (Longhurst, 1991) before their grounds were overtaken by the western society (Kijas, 2008). This service has potential for further sustainable development.

###### **Fibre / Materials**

This service provides plant fibre as a good, coming from the pandanus trees and other wood-based resources. Questions arise for the qualitative, quantitative and monetary value of this good, as the number of pandanus trees is limited in density within the rocky shore environment. Multiple animal species used wood stems and leaves for the creation of nests (SEQ, 2014).

###### **Natural medicines**

The goods provided by this service make a small contribution to the local community but used to be of high significance to the indigenous people (Kijas, 2008). Multiple flora species, fauna species and the rocks themselves were of medicinal purpose to the Kombumerri aboriginals. There are still cultures that believe that certain flora and fauna species have a healing substance in them. This benefit could sustainably develop.

###### **Ornamental resources**

This environment provides a range of ornamental resources. Driftwood is often used in fish tanks and therefore of interest to the local community (SEQ, 2014). Furthermore, the roots of the pandanus trees are transformed in didgeridoos (Pickering, 2016). Additionally, shells, corals and rocks make attractive jewelry, photo frames, etc. (SEQ, 2014). Over the years, people have constantly found innovative and creative uses of nature (SEQ, 2014).

###### **Biochemicals & pharmaceuticals**

This particular environment has the potential to contribute for ingredients/components of biochemical or pharmaceutical products but there is no such activity yet. This environment has a range of molluscs, crustaceans and fish (Brinkman, 2014). All of these species have components that are used in medicines (Benkendorff, 2010) or will be used in future medicines (Thomas, 2013).

### **Water quantity**

One of the goods for this service is ocean water, which is a key component (Little, et al., 2009; Denny & Gaines, 2007) that contributes to the creation of the different habitats within this environment (Murray, et al., 2006). There is no substitute for this good. Both flora and fauna occurring within this study site need this good for their survival.

## **3.1.2 CULTURAL SERVICES**

### **Ecotourism & recreation**

The study site is highly visited during low tide (Brinkman, 2014); as the rockpools appear and the observation of wildlife within the different habitats becomes more accessible. Recreational fishing, snorkeling, surfing, bird- and nature-watching are recreational activities occurring at the rocky shore environment of Burleigh Heads (Brinkman, 2014). The study site is actively used for tourism and recreation but these activities do not create revenue expect for the surf industry. Surfing creates a yearly revenue of \$AUD 17 to 33 million (Griffith Centre for Coastal Management, 2012). This benefit is of very high significance due to the human impact the site experiences (Ghazanshahi, 1981).

### **Cultural values and inspirational services (education, art & research)**

The rocky shore environment of Burleigh Heads serves as an educational platform for locals as well as tourists, seen through the human impact assessment performed in 2014 (Brinkman, 2014). Known is that there are multiple organisations that provide environmental education with a focus on the rocky shores of Burleigh Heads (Brinkman, 2014). Schools visit the site for observation as well as fieldwork assignments. In addition, higher education students perform research on this environment (Ocean Connect, 2015). With regards to art, there is a lot of photography performed as well as items collected (Brinkman, 2014; Jellurgal 2016, personal communication, 13 April).

### **Landscape & amenity values**

Preserving this natural environment is of great importance as it attracts a considerable number of visitors. This is due to the landscape's uniqueness, as no rocky shore is the same (due to wave energy and other climatic factors (Murray, et al., 2006)). The environment also knows a diversity in flora and fauna (Brinkman, 2014), the course of natural processes and the cultural heritage values (Kijas, 2008). The cultural heritage values are created through the aboriginal history (Longhurst, 1991) that can still be seen within the study site as well as the connecting Burleigh Head National Park (Kijas, 2008).

## **3.1.3 REGULATING SERVICES**

### **Climate/Climate change regulation**

This service includes the influence of land cover and biological processes that regulate atmospheric processes and weather patterns, which then creates a microclimate in which a range of plants and animals (including locals and tourists) live and function (Kettunen, et al., 2009). There are certain fauna and flora species that generate CO<sup>2</sup>, but this is only small-scaled (Hily, et al., 2013).

### **Water regulation**

The rocky shores provide a flood prevention to the surrounding areas as the rocks break the waves (D Ware 2016, personal communication, 3 March) and slows down the water energy (Little, et al., 2009).

### **Water purification & waste management**

The site is of importance for these benefits but has a lack in existing relevant data, it therefore could be of socio-economic relevance. Certain fauna species are of help in the water purification process. Known is that there is a high abundance in molluscs as well as crustaceans within the study site (Brinkman, 2014); these animals are purifiers.

### **Air quality regulation**

Scientists believe that ocean water can purify air through natural processes in combination with the energy the ocean provides (Rosenfeld, 2002). As the rocky shore environment of Burleigh Heads has fluctuating and constantly moving characteristics caused by wave energy (Murray, et al., 2006) and the tides, this benefit is of limited significance.

### **Erosion control**

The Gold Coast deals with an annual erosion activity due to storm surges together with other impacts. The headland as well as the groyne at Tallebudgera creek causes erosion as these elements stop the movement of sand (Griffith Centre for Coastal Management, 2015). The City of Gold Coast implements dredging around the rocky foreshore on a yearly basis (City of Gold Coast, 2016).

### **Storm damage control**

The rocky foreshore breaks the waves, ensuing in a natural damage control by the study site (Murray, et al., 2006). The natural damage control is of moderate significance during storm surge events as high swells, including high tides, are common during these events (Griffith Centre for Coastal Management, 2015).

### **Biological control**

The site has a high significant role in maintaining natural biological control (SEQ, 2014) in the area through predation, herbivory and other natural mechanisms. The rocky shores have a way of controlling the balance of species without the human input, as it is a continuously changing (P. Davie 2016, personal communication, 4 March) and vulnerable environment (Murray, et al., 2006). Additionally, environmental factors influence the balance of species through for example temperature, availability of water, tides and topography (SEQ, 2014).

### **Pollination**

The site has seed dispersal agents as inhabitants or visitors (feeding or resting ground), known as the Silver Gull, Sooty Oystercatcher, Heron species, Tern species and more (Brinkman, 2014). Also, algae and seagrass utilise underwater flowering and pollination (Denny & Gaines, 2007; Little, et al., 2009).

### **Regulation of human health (physical and mental)**

The site has an important role in regulating human health in the area with regards to the surfing industry (including surfing, kitesurfing, stand-up paddling, etc.). This site also creates support for mental and physical health by creating other outdoor activities as fishing and walking. Aboriginal people and well as people these days find the rocky shores a place to connect with the ocean and themselves (Kijas, 2008).

### **Genetic/species diversity maintenance**

The site hosts a population of variety in occurring flora and fauna (Brinkman, 2014). The site also inhabits species that play an importance role in maintaining genetically healthy populations of species such as the molluscs, fish, bird, etc. The different species all benefit from each other, creating the maintenance themselves.

### 3.1.4 SUPPORTING SERVICES

The supporting services refer to basic processes of ecosystems that form the basis for all the other services, including their benefits. Therefore, the supporting services are overall of high significance (Kettunen, et al., 2009).

#### **Supporting habitats**

The rocky shore environment is a supporting habitat; being a refugia, providing breeding and reproduction possibilities and functioning as a nursing ground for many different species (SEQ, 2014; Denny & Gaines, 2007; Little, et al., 2009).

#### **Soil formation**

Soil formation includes processes that form new minerals and soluble salts through chemical weathering when looking studying the rocky shore environment of Burleigh Heads (Little, et al., 2009; Denny & Gaines, 2007).

#### **Nutrient cycling**

Nutrient cycling includes waste management of inorganic and organic matter as well as other regulating services. Water purification and regulation are also of importance within the study site as water quantity is a high significant component for the different habitats (Kettunen, et al., 2009).

#### **Water cycling**

The rocky shores holds the water, creating different water habitats like rockpools. The rocks within the study site regulating the flow of the water through the ecosystem; this way, fauna can move throughout the study site and find shelter here (Denny & Gaines, 2007; Little, et al., 2009).

#### **Ecological interactions**

Maintenance of flora and fauna composition and biodiversity is of very high significance, as this is considered fundamental for the characteristic functioning of the study's site ecosystem. The species biodiversity has been assessed in 2014 (Brinkman, 2014) where a high amount of species was found.

The spider diagram (figure 4) summarises the given benefits and their significance. The scores are the authors own estimate based on literature review, former studies as well as well information from experts in the field. Additionally, the significance does not define the value of the benefit but defines the current importance of the ecosystem service. The spider diagram indicated that supporting services as well as the cultural services are both the most important at the site; seeing that the supporting services have an average significance of 3.8 as the supporting services are the foundation of all the other services. The cultural services have an average significance of 4.7 whereas regulating services has a significance average of 2.4. Lastly, the provisioning services displays an average significance of 2.5.

## Rapid assessment on the importance of ecosystem services provided by the rocky shore environment of Burleigh Heads, Australia

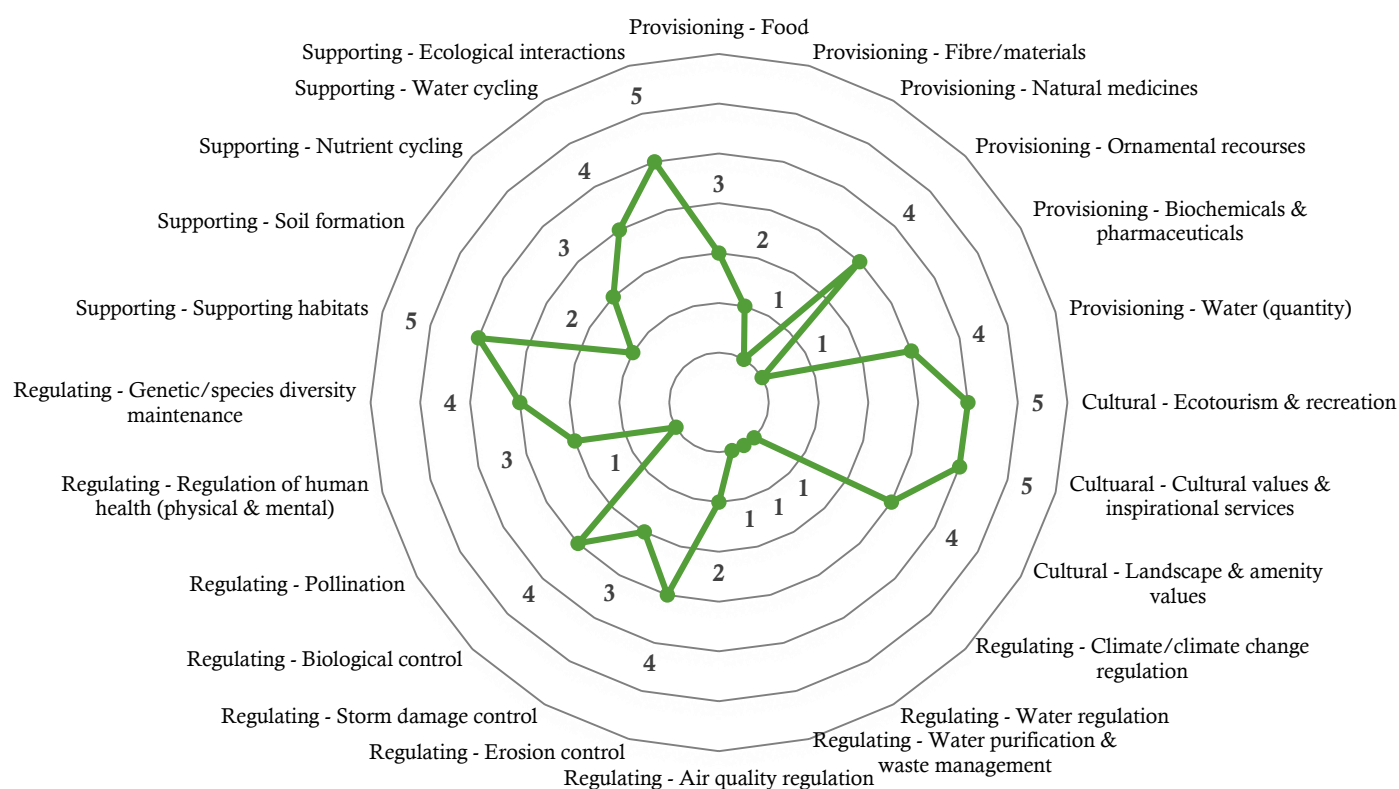


Figure 4: Rapid assessment spider diagram for the rocky shore environment of Burleigh Heads, Australia

Supporting services are commonly important for all stakeholder levels (local, regional, national and global). All benefits concerning biodiversity are globally important as well as climate change factors. Cultural ecosystem services are mostly locally of importance. It is important to understand who the beneficiaries (stakeholders) are when considering which part should pay for the benefits, who has responsibility over a benefit and what options are available to obtaining funding. Table 1 shows the beneficiaries for the different benefits.

Table 1: Responsible parties for each benefit including the possible beneficiaries and scope of the benefit

Service “managers / providers “	Ecosystem service	Possible beneficiaries	Scope of the benefit	Examples
City of Gold Coast and Study site	Food	Local communities Tourists Individuals Households	Local	Collecting sea urchins or sea cucumbers for own use (Asian cultures)
City of Gold Coast and Study site	Fibre/materials	Local communities Tourists Individuals Households	Local	Collecting pandanus leaves for creation of goods
City of Gold Coast and Study site	Natural medicines	Local communities Individuals Households	Local	The use of pumice stones for skin on hands and feet

City of Gold Coast and Study site	Ornamental resources	Local communities Individuals Households Tourists	Local (regional)	Collecting of shells and sell products made of these goods
City of Gold Coast and Study site	Biochemicals & pharmaceuticals	Pharmacies Governmental bodies	National (global)	Sustainably use molluscs for medicine
City of Gold Coast and Study site	Water (quantity)	Flora and Fauna	Local	Part of the environment and therefore crucial to have
City of Gold Coast and Study site	Ecotourism & recreation	Local communities Tourists Individuals Sportsmen Businesses Health sector	Local Regional National Global	The point break creates a great surf environment, attracting people from all over the world.
City of Gold Coast and Study site	Cultural values & inspirational services	Local communities Tourists Individuals Households Aboriginal people Health sector Research institutes	Local Regional National Global	The history of the aboriginal people. Education and research on natural processes and biodiversity
City of Gold Coast and Study site	Landscape & amenity values	Businesses Household Aboriginal people	Local	The history of the aboriginal people. Increases in value of real estate property through location
City of Gold Coast and Study site	Climate/climate change regulation	Local communities Individuals Households Businesses Society large scale Flora and Fauna Governmental bodies	Local Regional National Global	Climate regulation (temperature, including extreme weather events) affecting human well-being, security, health, food production etc.
City of Gold Coast and Study site	Water regulation	Flora and Fauna Local communities Households Individuals Tourists	Local	Natural flood prevention through breaking of waves.
City of Gold Coast and Study site	Water purification & waste management	Flora and Fauna Local communities Households Individuals Tourists	Local	Animals purifying the water resulting in more pleasurable view for visitors of the study site
City of Gold Coast and Study site	Air quality regulation	Local communities Tourists Households Individuals Businesses	Local Regional	Reduced respiratory diseases and increased health
City of Gold Coast and Study site	Erosion control	Local communities Households Tourists Businesses Flora and Fauna	Local Regional	Preventing the degradation of nearby water bodies due to sediments (implementing dredging)

		Businesses Governmental bodies		
City of Gold Coast and Study site	Storm damage control	Local communities Households Tourists Businesses Flora and Fauna Individuals	Local	Reduced damage to public and private buildings and infrastructures due to natural buffer the study site provides
City of Gold Coast and Study site	Biological control	Flora and Fauna Individuals Tourists Local communities	Local	Naturally the species maintain the biodiversity but can be disrupted by human impact
City of Gold Coast and Study site	Pollination	Households Flora and Fauna Individuals Tourists	Local Regional	Availability of biodiversity resources dependent on pollination
City of Gold Coast and Study site	Regulation of human health (physical & mental)	Local communities Individuals Households Tourists Businesses	Local Regional National Global	Decline in health sector's costs as a result of reduced risk for diseases, allergies and mental health problems
City of Gold Coast and Study site	Genetic/species diversity maintenance	Flora and Fauna Individuals Businesses Research institutes	Local Regional National Global	Establishing management efforts for the study site
City of Gold Coast and Study site	Supporting habitats	Local communities Households Tourists Businesses Flora and Fauna Individuals Research institutes Governmental bodies	Local Regional National Global	The study site being a nursery for many fish species and selected bird species
City of Gold Coast and Study Site	Soil formation	Flora and Fauna	Local Regional	Chemical weathering of rocks
City of Gold Coast and Study site	Nutrient cycling	Local communities Households Tourists Businesses Individuals Governmental bodies Flora and Fauna	Local Regional National Global	Transporting, storing and recycling of particles from organic and inorganic waste
City of Gold Coast and Study site	Ecological interactions	Flora and Fauna Research institutes Governmental bodies	Local Regional National Global	Many animal species being observed at the study site that results in a high rate of ecological interactions



## 3.2 DETAILED VALUATION OF THE BENEFITS

This chapter offers detailed information and valuation on the ecosystem services provided by the rocky shore environment of Burleigh Heads through the four ecosystem services. Results are given in the chapter as well as Appendix II.

### 3.2.1 PROVISIONING SERVICES

#### Food

The provisioning of biodiversity resources is heavily influenced by human activities and input in the modern world according to Kettunen (2009). Resources are often overexploited by humans ensuing negative effects on other ecosystem services (Ghazanshahi, 1981). Resources provided by the environment for food are obtained mostly through fisheries, as it is a marine environment. Marine species like sea urchins, sea cucumbers, different crustaceans and molluscs are harvested as a resource for food (Denny & Gaines, 2007); no license is needed for recreational fishing within Queensland. The *Pandanus tectorius* and *Pandanus spiralis* are also known to be edible (Pickering, 2016).

Research performed in 2014 and 2016 noticed the collecting of multiple marine species (Brinkman, 2014; Smith, 2009). Unfortunately, no exact numbers and values are available as a result of unofficial trade and use. Known is that sea urchins are a delicacy within Australia (Mos, et al., 2012). The market value is estimated on \$AUD 19,99 per live sea urchin (thatpetplace, 2015). Sea cucumbers are locally sold in different stores spread over the Gold Coast, but they do not sell the species found within the study site. Sea cucumbers, also known as beche-de-mer, are a delicacy in Asian and some European cultures.

Different mollusk and crustacean species that inhabit the rocky shore environment of Burleigh Heads (Brinkman, 2014; Smith, 2009) are also harvested as a source of food (Brinkman, 2014; Jellurgal 2016, personal communication, 13 April). One of the biggest is the blue swimmer crab fishery, estimated to be a \$AUD 3.8 million for Queensland only (Department of Agriculture, Fisheries and Forestry, 2014). Specific numbers for the Gold Coast region (or Burleigh Heads) are not given in the annual report published by the Queensland Department of Agriculture, Fisheries and Forestry. The Yugambeh people, which were part of Australian aboriginal population, used to harvest the oysters from the rocky shores as well as Tallebudgera creek (Jellurgal 2016, personal communication, 13 April; Longhurst, 1991). Generations later oyster are still being harvested at least once a year by aboriginal people but only consumed by their families or part of unofficial trade (Jellurgal 2016, personal communication, 13 April).

The *Pandanus* species provide seeds and leaves that are used in different meals by both humans (Green, 2016) and animals like birds and crabs (Thomson, et al., 2006). However, no revenue is created by these *pandanus* species as households and individuals are the only ones using the resource.

Additionally, an important note to this benefit is that the organisms within the study site consume each other (Little, et al., 2009; Denny & Gaines, 2007), creating importance to sustain a healthy biological composition (SEQ, 2014).

### **Fibre / material**

Plant fibre, small pieces of timber, shells and rocks are both (Little, et al., 2009) used by other organisms within the study site as part of the for example nests of different bird species (SEQ, 2014). The total amount used by other fauna is not known; also as the vegetation cover in general is marginal at the rocky shore environment of Burleigh Heads (Brinkman, 2014).

### **Natural medicines**

A popular item used and found within the study site is the pumice stone. These volcanic rocks are often utilised for pedicures, toothpaste, soaps, a base for cement, etc. (Geology.com, 2016). No data is available on the number of pumice stones available or the number of stones collected. Known is that aboriginal people used the stones to maintain feet and teeth in their traditional way of living, but continue to utilise the study site for the collection of pumice stones these days (Jellurgal 2016, personal communication, 13 April).

The two pandanus species occurring at the study site were medicinally used by aboriginal people in the last century; especially the young leaves (the basal white section), roots (Thomson, et al., 2006) and residue within the stern (Jellurgal 2016, personal communication, 13 April) when treatment for diarrhoea, stomach pain, aches and sores was needed (Wet Tropics Management Authority, 2006). The Beach bean (*Canavalia rosea*) is also a plant found within the rocky shore environment and utilised for treatment of aches, pains and rheumatism (Aboriginal Communities of the Northern Territory of Australia, 1988). The she-oak (*Casuarina equisetifolia*) is used for the treatment of toothaches (Wet Tropics Management Authority, 2006). As the amount of pumice and plant species is limited within the study site, it is mostly collected and applied by individuals, local communities, households and aboriginal people that still use the different species for medicinal purposes (Jellurgal 2016, personal communication, 13 April). Unfortunately, no data is available on the amount utilised these days.

### **Ornamental resources**

Plant fibre, from the two pandanus species known to be within the study site (*Pandanus tectorius* and *Pandanus spiralis*), is still used for weaving, instrument and tool making, art, etc. (L Busbridge 2016, personal communication, 13 April). These methods are applied in the creation of bags, wallets and mats by the aboriginal people on the Gold Coast (Thomson, et al., 2006; Jellurgal 2016, personal communication, 13 April). An estimated 50 to 100 aboriginal people on the Gold Coast still engage in these practices (L Busbridge 2016, personal communication, 13 April; Jellurgal 2016, personal communication, 13 April) of which these people sell 80 percent of their created goods (L Busbridge 2016, personal communication, 13 April). These goods are sold on local markets as well as the Jellurgal Centre starting at \$AUD 25 a piece (Jellurgal 2016, personal communication, 13 April). No data is available on the quantitative value.

Furthermore, driftwood is collected from the site for the purpose of decoration in fish tanks or creation of furniture (SEQ, 2014). No data is available on goods sold within the area and therefore the revenue created as the trade is unofficial.

The study site is also known for its enormous collection of shells; every day new shells wash ashore. This is therefore a popular activity conducted within the rocky shore environment (Brinkman, 2014; Smith, 2009). Shells are applied in the creation of jewellery (necklaces, bracelets, rings, earrings, etc.) photo frames and other related houseware as well as accessories (bags, clothing, etc.) (SEQ, 2014). These items are then sold on the local markets by the local retailers or utilised for personal use. Jewellery starts at \$AUD 10 a piece on the local village market in Burleigh Heads.

## **Biochemicals & Pharmaceuticals**

There is a high abundance in animals of different orders and families (molluscs, crustaceans, echinoderms and fish) (Brinkman, 2014; Smith, 2009), resulting in a variety of components that could be used in the creation of new medicines for a range of diseases, an example for this is bladder cancer (Benkendorff, 2010). Sea cucumbers for example, have been valued in Chinese medicines for years (Kelly, 2005). Additionally, there is a growing interest in mollusc species as they carry valuable components, which could be considerably beneficial for human health (Benkendorff, 2010). Blue blood as well as the molluscs' slime are natural components proven to have healing power (Kantele, et al., 2011). The rocky shores are already an extremely vulnerable and ever changing environment (P. Davie 2016, personal communication, 4 March); as well as overexploited in many ways (Ghazanshahi, 1981). It is therefore of importance to have set guidelines when implementing activity for this sector in order to maintain a healthy biological composition through sustainable use.

## **Water quantity**

The rocky shore environment or surrounding water bodies (Tallebudgera creek, Burleigh beach) do not play a role in the drinking water supply for the City of Gold Coast and its community; but has potential and is therefore of interest for future developments. Currently, the bulk drinking water for the Gold Coast is supplied by SEQ Water, a Queensland State Government organisation who owns and operates dams, water treatment plants and a desalination plant to supply bulk drinking water to the South East Queensland Region. This bulk water is supplied to retail/distribution organisations such as the Council of the City of the Gold Coast who distributes the water to customers via Council-owned and operated local water networks. The City of the Gold Coast also operates the sewerage systems, which collects and treats sewage (C Owen 2016, personal communication, 31 March). However, the water quantity is of enormous importance for the organisms inhabiting the study site as they need the water in order to survive; it is part of their lifecycle, nutrition, reproduction system, etc. (Little, et al., 2009). The water is irreplaceable as there are no substitutes, however it should be noted that this water quantity is saltwater and not freshwater (SEQ, 2014).

## **3.2.2 CULTURAL AND SOCIAL SERVICES**

### **Ecotourism & recreation**

The rocky shore environment of Burleigh Heads is a highly visited site, especially during low tide (Brinkman, 2014). A total of 2403 records on human impact were recorded in 50 hours of observation in 2014 (Brinkman, 2014). That is an average of 48 visits per hour. Then, when calculating visitors per annum, the following calculation can be used  $48 \text{ (visitors per hour)} \times 3 \text{ (low tide hours)} = 144 \times 7 \text{ (one week)} \times 52 \text{ (weeks a year)} = 52,416 \text{ visitors a year}$ . It should be noted that recreational use of an ecosystem could have negative impacts, especially when the area is over-exploited. This can happen when there is no management for ecotourism (Ghazanshahi, 1981; SEQ, 2014; Kettunen, et al., 2009); protection of a natural area is progressively connected to ecotourism (Kettunen, et al., 2009). There is currently no management plan or specific protection for the study site, creating concern as the study site experiences a high visitors number (Brinkman, 2014). Additionally, the rate of growth for ecotourism has been increasing by 20 to 30 percent per annum, creating further pressure to the ecosystem (International Ecotourism Society, 2016).

Most activities performed are in relation to recreational fishing, snorkeling, surfing and nature-watching (Brinkman, 2014). Some activities are in correlation with a visit to the neighbouring Burleigh Head National Park as the rocky shore environment protects this park (Queensland Government, Department of National Parks, Sport and Racing, 2016) shown by Ocean Connect (2016). Nature-watching, nature-

walking and snorkeling do not create revenue, as this is a free activity. Recreational fishing does create revenue when buying equipment, however, specific quantitative data for Burleigh Heads is missing. Fishermen do not need to apply for a license in Queensland, which creates difficulty in estimating the number of recreational fishers for Burleigh Heads, however, study shows that there are approximately 42,000 recreational fishers on the Gold Coast (Department of Agriculture and Fisheries, 2015). Not all recreational fishers fish onshore, an estimated 50% of these 42,000 recreational fishers employ boat fishing (Department of Agriculture and Fisheries, 2015). Stated is that a recreational fisher spends an estimated \$AUD 1,000 per annum on equipment (Department of Agriculture and Fisheries, 2015; OzCoasts, 2015). It should be noted that this benefit will increase in the future due to the proceedings of the world economics (Tisdell, 2003).

Additionally, there is the surfing industry, creating a revenue valued on \$AUD 3.3 billion a year on the Gold Coast, of this \$AUD 3.3 billion a year (City of Gold Coast, 2013), \$AUD 126 and 233 million is expenditure on equipment (Lazarow & Tomlinson, 2009; Griffith Centre for Coastal Management, 2012). The surfing culture is very extensive on the Gold Coast as the city has a lengthy shoreline with a range of different surfing locations (City of Gold Coast, 2013; City of Gold Coast, 2009); it is therefore that 16 kilometers of the shoreline on the Gold Coast has been declared as a World Surfing Reserve in March 2016, including Burleigh Heads (ABC, 2016). The surfing population on the Gold Coast is estimated to exist out of 120,000 individual surfers and growing yearly (Lazarow & Tomlinson, 2009).

When being more specific for the economic value of Burleigh Point, the expenditure value results in \$AUD 17 to 33 million annually (Griffith Centre for Coastal Management, 2012). Study shows that Burleigh point is one of the most popular surfing location on the Gold Coast; with 14% being third out of 12 locations (figure 5) (Griffith Centre for Coastal Management, 2012; Lazarow & Tomlinson, 2009). The rocky shore environment is a major component for the creation of the popular surf spot as the rocks break the waves (D Ware 2016, personal communication, 3 March).

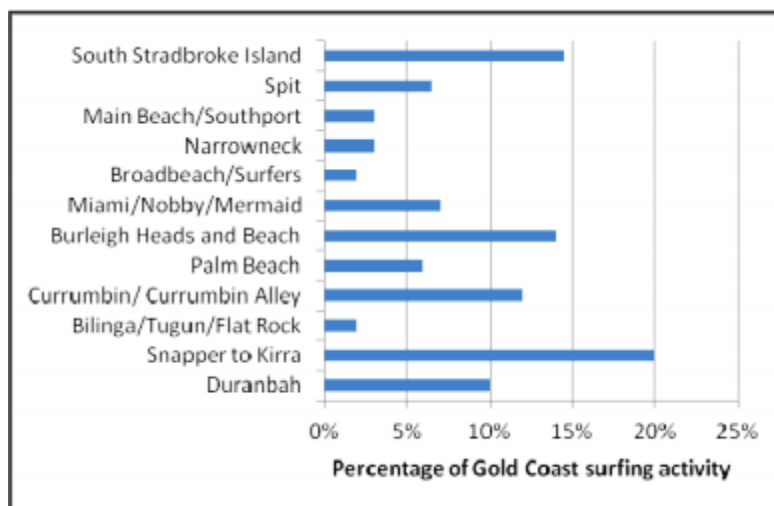


Figure 5: Percentage of Gold Coast surfing activity at each surfing location (source: Griffith Centre for Coastal Management, 2012)

The total expenditure of surfing can be calculated through surfing equipment, food, fuel, travel and accommodation (Griffith Centre for Coastal Management, 2012). Separating Gold Coast residents from tourists coming to the Gold Coast to surf results in different values for both categories. Gold Coast residents spend approximately \$AUD 1942 annually as where tourists spend \$AUD 3948 (figure 6). Tourists spend more on travel and accommodation (\$AUD 1520 annually) (Griffith Centre for Coastal Management, 2012; Lazarow & Tomlinson, 2009).

Additionally, jobs are created through the surfing industry/culture (City of Gold Coast, 2013). Jobs involve employment in surf shops, surf schools, surf hire, etc. An estimated 21,000 people are employed with an average of \$AUD 77,963 annual wage (ABS, 2015). However, it is rather difficult to distinguish jobs per surfing location as surfers go where the waves are. Known is that a multitude of surfing businesses are based in the Burleigh Heads area, as the most popular surf locations start here; then going more south up to Duranbah (City of Gold Coast, 2009).

<b>Category</b>	<b>Gold Coast expenditure per person/year</b>	<b>Total expenditure per person/year</b>
Surfing equipment e.g. boards, wetsuit, leash and accessories	\$786 = \$983.00 x 0.8	\$983.00
Surfing related food and fuel	\$1156 = \$1445 x 0.8	\$1445.00
Surfing related travel and accommodation	n/a	\$1520.00
<b>Total surfing expenditure</b>	<b>\$1942</b>	<b>\$3948</b>

Figure 6: Surfers expenditure on the Gold Coast (source: Griffith Centre for Coastal Management, 2012)

### **Cultural values and inspirational services (education, art & research)**

The rocky shore environment of Burleigh Heads is an easily accessible ecosystem; creating an educational platform (SEQ, 2014; Ghazanshahi, 1981). The study site is known to be part of the Gold Coast' local environmental educational curricula (Brinkman, 2014). Sessions are provided to primary, secondary and university students as well as community groups by a multitude of organisations and businesses. Additionally, the site is visited by both school holiday program groups and individual schools (Brinkman, 2014). During these sessions research methods, species identification and a range of other activities are practiced. As this ecosystem does not have an entry fee, no revenue is created from groups entering the parks. However, revenue is created through the schools, care groups and community groups paying fees for educational sessions. An estimated 136 sessions are provided by seven organisations and businesses annually. Prices for the different sessions range from \$AUD 2 per student to \$AUD 28 per student. Unfortunately, no estimate can be given on the number of students visiting the study site, as there is a lack in available data. An approximate 75 Jobs are created through environmental education on the rocky shore environment. Businesses known to provide rocky shore excursions are: Ocean Connect, Griffith Centre for Coastal Management (CoastEd), Second Nature Asian Pacific, Tallebudgera Beach School, CYC Burleigh and Griffith University – School of Engineering.

Furthermore, university students (both national and international) use the study site for the completion of their studies (Ocean Connect, 2014), an example is a student travelling from overseas on a scholarship for a research project or thesis. However, it is rather difficult to give a value as well as number of students or research institutes performing research to this matter as there are no statistics on the number of students and/or people performing research on the rocky shores; no license is required to perform research on this ecosystem (State of Queensland, 2016). There are three major universities on the Gold Coast that implement environmental courses into different studies.

Photography is an art performed at the study site (Brinkman, 2014) and has a range of subjects being captured. As the site is a popular surf location, shooting surf activity is very popular. Additionally, nature photography is popular amongst photographers as well as fashion. It is challenging to estimate the number of photographers, as there are numerous free-lance photographers as well as hobbyists. However, it is important to note that the study site brings inspiration to artists. Study shows that approximately one photographer per hour visits the study site (Brinkman, 2014).

Aboriginal people still find inspiration at their former 'home' for their artwork (Jellurgal 2016, personal communication, 13 April). The local aboriginal community can often be found on the Burleigh Headland creating art on spot. Aboriginal art can be distinguished as paintings, painted boomerangs, shields, etc. The Jellurgal centre also sells local made aboriginal art in the centre; unfortunately, no yearly revenue given.

### **Landscape & amenity values**

The street closest to the rocky shore environment in Goodwin Terrace. A popular street for property with ocean views. The Gold Coast in general is known for its high-rises; these can also be found in Goodwin Terrace, created a residential space for locals as well as tourists.

The rocky shore environment of Burleigh Heads is a natural landscape, formed by basalt rocks coming from Mount Warning (Jellurgal 2016, personal communication, 13 April; Griffith Centre for Coastal Management, 2011). It is the only official rocky shore environment on the Gold Coast in the urban area (Griffith Centre for Coastal Management, 2011). Every rocky shore is unique due to the dynamics of the oceans; the study site being the only rocky shore in urban area and the only one being easily accessible on the Gold Coast distinguishes its exclusivity and therefore its importance (Griffith Centre for Coastal Management, 2011; Murray, et al., 2006).

The Gold Coast population entails a myriad of nationalities, creating an extensive cultural diversity. Not only can cultural diversity be found within the residential population but also within tourists, which include overseas students and travellers. 34.6 percent of the Gold Coast residential population is born overseas as to where 1.3 percent of the population from Aboriginal origin (ABS, 2011). Having such an extensive cultural diversity in one place creates opportunities for people to experience a multicultural society.

Burleigh heads is known to be the spiritual centre of the Gold Coast (City of Gold Coast, 2010) for all the different nationalities and communities, including the Aboriginal people (City of Gold Coast, 2010; (Jellurgal 2016, personal communication, 13 April). The area embraces many spiritual healers, practices, mediation and yoga centres. Burleigh Heads is acknowledged as the new Byron Bay (Herald sun, 2014) by many papers, emphasising the spiritual character. The Burleigh Headland is particularly of spiritual importance to the Kombumerri people as the headland was their 'country's' gathering place for the seven different Yugambeh tribes. Additionally, new generations were born on the Burleigh Headland as this was a sacred place for giving birth (Jellurgal 2016, personal communication, 13 April).

The Burleigh Headland including the rocky foreshore is part of the Yugambeh country, consisting of seven tribes that spoke the same language, settling from Tweed Heads region up to Logan Area and inland including Mount Tamborine. The tribe called Kombumerri was based on the Burleigh Headland but travelled throughout their Yugambeh country. The Yugambeh country is considered the cultural heritage of Burleigh Heads (Jellurgal 2016, personal communication, 13 April; Longhurst, 1991; Kijas, 2008). This cultural heritage is kept alive by elders passing their knowledge, language, arts, rituals and performances onto the next generation (Jellurgal 2016, personal communication, 13 April; Australian

Government, 2016). The Australian indigenous population is studied and proven the oldest living population in the world; people believe this is a result of the indigenous people's ability to adapt quickly. The quick adaptability is understood to be linked to their affinity with their surroundings (Australian Government, 2016). Aboriginal people feel connected to mother earth and are always educated in such way that they should live a sustainable life, only taking goods needed at that precise moment without exploiting the resources as well as giving back to mother earth (Jellurgal 2016, personal communication, 13 April; Australian Government, 2016).

With regards to myths and believes, the Burleigh Headland is a place where many stories have been told as dreamtime stories was a way to teach aboriginal children about the community's rules. These stories have been passed on from generation to generation and are still told these days. The aboriginal people never wrote anything down but preferred the spoken language as this embraced spirituality and creativity. The well-known story about the creation of the Burleigh Headland is as followed: 'Hot, tired and perspiring after a day's strenuous hunting, and the gorging of kuppal (honey) near what we call 'Little Tallebudgera' came out of the bush on to the ocean beach, which in those days one level and unbroken stretch of sand-dunes right from Kijeragah (kaloon tree), at the mouth of Nerang Creek, to the Tweed. The tumbling waters of the ocean looked very cool and inviting. Casting down his weapons, he swam out to the horizon and back. Coming ashore, he picked up his fighting waddy, which was of titanic size proportionate to the towering bulk of the god who wielded it, and thus sprang into existence the rocky outcrop which we now call Little Burleigh. Feeling the pangs of hunger after his long swim he hunted around until he found another 'sugarbag' which he cut out of the tree and fed greedily upon. His hands and body being smeared with the sticky nectar he returned to the beach to wash himself in the sea (though a 'vulgar' version tells that performed his ablutions by urinating on his hands and this laving his body). After he had cleansed himself he rose up to his full height and stretched his arms skyward. The level ground thereupon rose up to the elevation of his finger-tips, and thus was formed the precipitous headland which we have named Big Burleigh, or Burleigh Head (Jellurgal 2016, personal communication, 13 April; Longhurst, 1991; Kijas, 2008).'

### 3.2.3 REGULATING SERVICES

#### **Climate/Climate change regulation**

The environment has a few organisms that generate CO<sub>2</sub> (Brinkman, 2014). It should be mentioned that this is very limited in general as the flora has a low abundance (Brinkman, 2014). No previous studies are performed on this ecosystem service and therefore, no data is available. Known is that species of the phylum Mollusca and crustacean barnacles produce CO<sub>2</sub> (Hily, et al., 2013) as well as flora present at the study site. Sequestration depends on numerous factors of the study site; including age of stands, species composition, water balance (high quantity, as it is a coastal environment), etc. (Pabian & Jaroszewicz, 2009).

Rocky shores also absorb a high amount of CO<sub>2</sub> through the ocean water (World Ocean Review, 2016); but the amount changes over time, therefore, no estimates can be made. Even more carbon, however, is stored in the rocks present within this study site (World Ocean Review, 2016). The climate change regulating services could be enhanced via appropriate management and obtaining study site's favourable conservation status (Kettunen, et al., 2009).

#### **Water regulation**

The rocky shores create a natural buffer (SEQ, 2014; Little, et al., 2009) and therefore reduce the risk of floods in the surrounding areas (Goodwin Terrace, Burleigh Head National Park). The rocks break the waves (D Ware 2016, personal communication, 3 March) and the rockpools serve as a catchment



for water (Murray, et al., 2006). Additionally, the rocky shore environment and surrounding private properties are not a designated flood area and therefore currently not of interest (City of Gold Coast, 2008), however, circumstances can change as a result of climate change and future developments (Kettunen, et al., 2009). It is rather challenging to give a monetary value of this service.

### **Water purification & waste management**

As a result of increasing numbers of visitors to the study site as well as a continuously growing development of local communities (City of Gold Coast, 2014), the importance of this service is slightly increasing. The rocky shores do not directly contribute to the Burleigh Heads or Gold Coast community with regards to water purification (SEQ, 2014), however, they do contribute to the flora and fauna community of the rocky shores. The water purification and regulation function is required for sustaining the study site as well as the species composition (SEQ, 2014). Molluscs (oyster species) known for inhabiting the study site can purify water (Skeel, 1978) but oyster are only a marginal part of the population (Brinkman, 2014; Smith, 2009).

Waste management involves the intensity to which ecosystems are capable of transporting, storing and recycling particles of organic and inorganic wastes. In natural ecosystems, such as the rocky shore environment, all organic materials are further used, cycled and/or recycled by the environment. Withal, waste management plays an important role in dealing with human impact expressed in pollution by human activities (SEQ, 2014). The study site implies natural waste management through the wave energy (Murray, et al., 2006) along with the presence of the rocks (Ghazanshahi, 1981), though, only in limited ways; this furthermore does not include filtering of micro-plastic.

### **Air quality regulation**

Human as well as flora and fauna wellbeing is genuinely influenced by air quality (Kettunen, et al., 2009; Walsh, et al., 2011), both having beneficial (Powe & Willis, 2002) and deleterious effects (Walsh, et al., 2011) (pollution) (Ghazanshahi, 1981). Firstly, ocean water is believed to have an air purifying mechanism (Rosenfeld, 2002). Stated is that the combination of natural processes and the energy provided by the ocean purifies water (Rosenfeld, 2002) and therefore limits damaging to the ecosystem; resulting in preservation of values for cultural and biological purposes (Kettunen, et al., 2009; SEQ, 2014). Secondly, plants also have the ability to purify air (Powe & Willis, 2002), but this is of limited proportions within the rocky shore environment, considering that the flora cover is marginal (Brinkman, 2014).

### **Erosion control**

The Gold Coast has suffered from multiple severe erosion events throughout the years as a result of errors in sand movement, storm surges, tidal activity and other impacts (City of Gold Coast, 2016). Effects can be seen in damage to infrastructure as well as private structures that are close to the beaches. When these damaging events take place it is of great importance to allow coastal protection works (dredging and beach nourishment).

The beach naturally responds to storm events through shifting of sand from sand-dunes and upper beach to the surf zone resulting in the waves breaking on the parallel bars (which appear through the shifting of the sand) (Department of Environment and Heritage Protection, 2013), however, when erosion is already a daily threat to beaches, the natural shifting of sand is not adequate to serve as a buffer to storm events. The Burleigh Headland (City of Gold Coast, 2016) as well as the groyne at Tallebudgera creek (City of Gold Coast, 2011) cause erosion as these two elements (one natural; one established by humans) block the movement of sand; and therefore the longshore drift (City of Gold Coast, 2016). Longshore drift moves sand along the Gold Coast upwards up to the northern beaches, creating natural movement

of the sand (City of Gold Coast, 2011). Trapped sand obstructs the movement, therefore contributing to erosion on Burleigh Beach, which limits the recreational (Department of Environment and Heritage Protection, 2013; City of Gold Coast, 2011) and buffer services of this beach (City of Gold Coast, 2011). Dredging has been employed since 1975 and now annually since 1990 (figure 7 and 8) (City of Gold Coast, 2011).

Dredging, beach nourishment and erosion create work and therefore contributes to the economy and number of jobs. The City of Gold Coast invests \$AUD 7,673,816 in 2015-2016 for tidal and non-tidal waterways including dredging activities as given in the annual report. This includes advisory, temporary and permanent employment created by this activity (City of Gold Coast, 2015).



Figure 7: Sand is moved from Tallebudgera Creek onto Burleigh Beach (Source: Neumanncontractors, 2015)



Figure 8: Dredging at Tallebudgera Creek (Source: Neumanncontractors, 2015)

### Storm damage control

The site has a natural storm damage control mechanism through the rocks that break the waves, rock pools (Little, et al., 2009) and surrounding parallel bars through shifting of the sand (Department of Environment and Heritage Protection, 2013). These affect the probability and severity of storm damage events as well as the protection of the coastal communities inhabiting the rocky shore environment (figure 9 and 10) (Kettunen, et al., 2009).

The first storm events ever recorded occurred during the 1920s (City of Gold Coast, 2011). The last storm event known in Burleigh Heads was in February 2016 when high swells occurred along all of the Gold Coast beaches (Gold Coast Bulletin, 2016). Impact created through storm surges can be naturally stabilized by movement of the sand during the calm winter season; the recovery process fluctuates depending on the severity per storm event (Department of Environment and Heritage Protection, 2013). Additionally, the impact can be reduced through establishing maintenance and ecological management of the study site (Kettunen, et al., 2009), unfortunately, no management efforts are currently in place, ensuing no specific available data on the topic.



Figure 9: Erosion at the rocky shore environment of Burleigh Heads (Source: Griffith Centre of Coastal Management)



Figure 10: Erosion at Burleigh Beach (Source: Griffith Centre for Coastal Management)

### Biological control

The study site has a well-established natural biological control mechanism through predation, herbivory and other (Little, et al., 2009). The rocky shores are a continuously changing environment (P. Davie 2016, personal communication, 4 March) which are therefore very vulnerable to environmental changes; which then influences the balance of species (Murray, et al., 2006). Environmental factors such as temperature, availability of water, tides and topography are examples of factors that could influence the balances of species (SEQ, 2014). Mobile grazers such as limpets, chitons, snails, etc. (Little, et al., 2009) move throughout the entire intertidal zone to feed on algae and juvenile shellfish (Basic Biology, 2016). By feeding on the algae they contribute to maintaining structure (Basic Biology, 2016) as well as diversity (Denny & Gaines, 2007) through precluding algae from dominating or overgrowing other species (Little, et al., 2009). These natural mechanisms are extremely important to maintain biodiversity values (Denny & Gaines, 2007; Little, et al., 2009).

The flora of the study site inhabits both native species and weeds (Brinkman, 2014). Creating the need to suppress the establishment of invasive species (Kettunen, et al., 2009). The suppressing of weeds and dominating species is utilised by the City of Gold Coast (Queensland Parks and Wildlife Service, 1999) for the surrounding Burleigh Heads National Park through weed control, maintenance of natural species diversity (Queensland Parks and Wildlife Service, 1999) which could be beneficial for the high tide zone of the rocky shore environment. The study site itself does not have appropriate management to have a role in maintaining natural biological control and therefore no relevant data is available.

### Pollination

The study site has seed dispersal agents as inhabitants or visitors (feeding or resting ground), known as the Silver Gull, Sooty Oystercatcher, Heron species, Tern species and more (Brinkman, 2014; Kettunen, et al., 2009). Additionally, there is the aquatic vegetation; ferns, algae, seagrasses, etc. (Brinkman, 2014). These flora species have evolved in such way that they developed methods for underwater flowering and pollination; for sexual reproduction (Denny & Gaines, 2007; Little, et al., 2009). During the sexual reproduction process, the different species produce flowers, which release pollen; these pollen are then transported from the male flower to the ovary of the female flowers (Denny & Gaines, 2007). The fruits that are grown after fertilization are released and carried along with the current and tides and finally discharge their seeds which then attach to other aquatic vegetation (Little, et al., 2009; Denny & Gaines, 2007).

The study site itself does not have appropriate management to have a role in maintaining natural pollinators and seed dispersal and therefore no relevant data is available.

### **Regulation of human health (physical and mental)**

The rocky shores contribute to supporting both physical and mental health (Walsh, et al., 2011; Kettunen, et al., 2009) by providing a variety of activities (Brinkman, 2014) that could be employed by humans visiting the study site as mentioned in ecotourism & recreation section. Quoting Lebreton to enhance Burleigh Head's importance: "Burleigh's popularity will continue to grow because it offers a variety of amenities along with natural beauty".

Firstly, maintaining a good air quality from ocean water is proven to be beneficial (Kettunen, et al., 2009) to human health by sound, smell and sight (Walsh, et al., 2011) as well as the study site being located in a conveniently distance to urban areas; resulting in the site being easily accessible which creates more interest in visiting the area (Kettunen, et al., 2009).

Secondly, due to the study site being close to urban areas it attracts multiple user groups (Brinkman, 2014) as there are multiple recreational possibilities (Kettunen, et al., 2009). Surfing the main activity performed (Brinkman, 2014) at the Burleigh Headland and a significant aspect of the Gold Coast' cultural identity (Griffith Centre for Coastal Management, 2012; Lebreton, 2008). The surfing industry on the Gold Coast includes bodysurfers, kitesurfers, windsurfers, bodyboarders longboarders, shortboarders and stand-up paddle board riders (Griffith Centre for Coastal Management, 2012) greatly contributes to human health, both mental and physical, through appreciation of the environment and landscape (Griffith Centre for Coastal Management, 2012; City of Gold Coast, 2010). Also activities as watching the surf, fishing, collecting of shells and snorkeling add to the general health of humans.

Thirdly, animal-watching is an important activity utilised at the study site (Brinkman, 2014). Watching migrating whales during the months May-November is popular with the general community (Manfredo, 2008; Department of Environment and Heritage Protection, 2016) creating a unique experience to observe majestic ocean creatures and therefore contributing to human health (Department of Environment and Heritage Protection, 2016; Walsh, et al., 2011). Rocky shore exploring is also an important activity performed at the study site as the rock pools hold a variety of flora and fauna (Brinkman, 2014).

Fourthly, there is the indigenous population that hold an historical and spiritual value with the rocky shores and the surrounding Burleigh Head National Park (Longhurst, 1991; Kijas, 2008; City of Gold Coast, 2010). The rocky shores were employed in the daily lives of aboriginal people before the European settlements (Longhurst, 1991). Nowadays, the aboriginal population still consider the rocky shores to be valuable for cultural, social and spirituals reasons as it holds their family's history (Jellurgal 2016, personal communication, 13 April; City of Gold Coast, 2010).

Although human health is an important service provided by the study site, there is no revenue created directly from these activities with regards to the rocky shores, however, it holds an important value as it provides multiple activities that enhance human health both mentally, physically and spiritually.

### **Genetic/species diversity maintenance**

This regulation focusses on the species and genetic diversity and its ability to preserve the genetic variation and overall species compilation. Changes in environment, human impact and loss of habitat contribute to changes in genetic diversity (Balmford, et al., 2008; Kettunen, et al., 2009). The service is of importance for the biodiversity value as the study site is a unique ecosystem and is a nursery ground for many species (Murray, et al., 2006). Losing diversity in both species and genetics would be irreversible resulting in damage to natural selection (Denny & Gaines, 2007; Little, et al., 2009; Kettunen, et al., 2009). Research performed by Ocean Connect (2016) shows a decrease in biodiversity

when comparing biodiversity results to 2014. The study site being a nursery ground helps maintaining healthy population for birds, fish, molluscs, crustaceans and more aquatic creatures (Kettunen, et al., 2009). However, it is rather difficult to provide values to this service as the study sites does not contribute to official trade of goods with regards to food and has currently no management.

#### 3.2.4 SUPPORTING SERVICES

The supporting services are the essential ecosystem processes, which form the basis for all the ecosystem services. The supporting services are therefore always of relevance at all the sites. The values of the supporting services are already comprised through the values and estimates of the other ecosystem services. Therefore, only qualitative values will be given for this ecosystem services (Kettunen, et al., 2009).

##### **Supporting habitat**

The rocky shore environment is a supporting habitat; being a refugia, providing breeding and reproduction possibilities and functioning as a nursing ground for many different species (SEQ, 2014; Denny & Gaines, 2007; Little, et al., 2009). Rocky shores are known as ever changing environments (Murray, et al., 2006; Denny & Gaines, 2007; Little, et al., 2009), the study site ensuing in being a refugia; an area in which organisms can survive during a period of unfavourable conditions. The tidal energy and activity creates many unfavourable conditions for many species such as long exposure to sunlight, drought, etc. However, species do adapt to these circumstances and have evolved in such way that the different species know how to cope with those harsh conditions (Denny & Gaines, 2007; Little, et al., 2009). Additionally, the site is known to function as a breeding ground and provide reproduction possibilities with for example the aquatic pollination (Denny & Gaines, 2007). Also, many fish, crustacean and bird species use the environment as a nursery. The rocks provide shelter for the juvenile fish and the high number in micro-organisms available creates a worthy ecosystem to inhabit.

##### **Soil formation**

The soil formation serves as a facilitation of soil formation processes. These processes include the chemical weathering of the basalt rocks (SEQ, 2014). This chemical weathering is instigated through water, in particularly ocean and rainwater reacting with the mineral grains in rocks. Through this process, new minerals are formed as well as soluble salts (The Geological Society, 2016).

These events occur more rapidly within warm climates, like the tropical climate on the Gold Coast. Chemical weathering is therefore a common process within the study site (SEQ, 2014; The Geological Society, 2016).

##### **Nutrient cycling**

The rocky shore environment of Burleigh Heads does not directly contribute to the water purification process. However, the ecosystem does contribute to the flora and fauna community of the rocky shores through the water quantity, one of the major components creating this environment (Denny & Gaines, 2007; Little, et al., 2009). The water purification and regulation function is required for sustaining the study site as well as the species composition (SEQ, 2014). Molluscs (oyster species) known for inhabiting the study site can purify water (Skeel, 1978) but oyster are only a marginal part of the population (Brinkman, 2014; Smith, 2009).



Additionally, transporting, storing and recycling of particles from organic and inorganic waste is a process that the rocky shores stipulate through nutrient cycling. Organic materials are broadly used within the ecosystem and naturally recycled (SEQ, 2014) as where inorganic waste needs a long time to break down. The rocky shore stores this inorganic waste when it becomes stuck between the rocks as well as when washing ashore through wave energy (Murray, et al., 2006; Ghazanshahi, 1981).

### **Water cycling**

The rocks within the study site play an important role in regulating the flow of water within the ecosystem creating rockpools and the dynamics that makes the environment (Kettunen, et al., 2009; Denny & Gaines, 2007; Little, et al., 2009) and is therefore of very high significance.

### **Ecological interactions**

The rocky shores have a high number of individuals inhabiting the area; 61,541 individuals were found in 2014 divided over 8 different flora and fauna groups (Brinkman, 2014). However, research performed by Ocean Connect (2016) reveals a decrease in biodiversity, especially in echinoderms. Additionally, the total amount of individuals found decreased remarkably to 52,489. There is still a myriad of possibilities to enhance the biodiversity knowledge when focussing on algae and micro-organisms; this would likely increase biodiversity statistics. Species biodiversity provides a platform for other services as touristic attractiveness, food, animal watching, surfing, etc. and enhances the characteristic functioning of the study site's ecosystem (Kettunen, et al., 2009).

## 4 DISCUSSION

This research has been written within the framework of socio-economic assessment for Natura 2000 sites (Kettunen, et al., 2009), being inspired by the Millennium Ecosystem Assessment (MEA) published in 2005. The MEA focusses on the importance of ecosystem services and defines the significance of biodiversity as being the basis for many ecosystem services (Millennium Ecosystem Assessment, 2005).

### 4.1 STATUS AND FUTURE TRENDS OF BENEFITS

It can be affirmed that most benefits are in good status and their significance is likely to increase in the future. The likeliness of importance to increase for a number of benefits is due to human population growth and therefore also development of tourism with regards to real estate, ecotourism, recreation and many other cultural benefits (Millennium Ecosystem Assessment, 2005; Ghazanshahi, 1981). Additionally, assorted benefits will become more important due to climate change like water quantity, storm damage control, erosion control, etc. (SEQ, 2014; Griffith Centre for Coastal Management, 2015; Kettunen, et al., 2009). However, there are threats for a multitude of the benefits creating concern relating to current status and future trends.

Food, storm damage control and genetic/species diversity maintenance are benefits that are currently in poor condition due to lack in management and protection efforts. People taking animals out of the rock pools harms both the food web and genetic/species diversity maintenance. Storm damage control is naturally in place through the rocks that break the waves (SEQ, 2014; Denny & Gaines, 2007; Little, et al., 2009). However, proper management (natural buffers, damage reduction for real estate) for this benefit should be primed having real estate within the study site (Kettunen, et al., 2009).

Research, cultural heritage, myths & believes, refugia, nutrient cycling and ecological interactions are benefits that are currently in a weak condition due to lack of contribution and involvement by the management bodies as well as beneficiaries (Kettunen, et al., 2009; Brinkman, 2014; Benedetti-Cecchi, 2006). Scientific research performed for the study site is limited (Brinkman, 2014). In addition, cultural heritage and myths & believes are topics that have only been implemented within the Australian Curriculum, for the past two years; the benefits' importance is therefore increasing as more people are being reached but currently still weak (Jellurgal 2016, personal communication, 13 April). The current status being weak for the refugia benefit is a result of threats through climate change and the study site not currently being protected and managed (Denny & Gaines, 2007; Little, et al., 2009; Kettunen, et al., 2009). The study site not being protected and managed also creates concern for nutrient cycling and ecological interactions as protection and management are baseline techniques to ensure stability for biodiversity trends as well as waste management for both inorganic and organic matter (Balmford, et al., 2008; Kettunen, et al., 2009; SEQ, 2014).

It is uncertain whether natural landscape, cultural heritage and soil formation's importance is likely to increase in the future. A threat for natural landscape values is the growing world population demanding more property and therefore creating difficulty for the study site (Millennium Ecosystem Assessment, 2005). Additionally, cultural heritage is very much fluctuating due to the different cultures settling in Burleigh Heads and the growing popularity of the suburb (ABS, 2011). Lastly, soil formation is ongoing process; seeing that chemical weathering of rocks is a continuous happening and very much dependant on climatic factors (The Geological Society, 2016; SEQ, 2014).



Biochemicals and pharmaceuticals is a benefit that has great potential to grow in the near future due to new finding over the past years as well as growing interest in innovative ways to create new medicine. Selected species found within the study site could be of great help for these innovative plans (Benkendorff, 2010).

The trade-offs between the benefits could in general be described as the conflict between economy and environment. It is important to find a balance between both, in order to maintain the study site as well as the city's economy which is thrived through tourism (City of Gold Coast, 2015). Additionally, there is the conflict of cultural heritage plus history of the study site and now the growing population in the suburb as well as the suburb's popularity. The study site holds a spiritual value to many people, especially the local aboriginal people as this used to be their elders' homes and feeding grounds. Local aboriginal people are concerned that with the city's focus on development, environment and with that 'their' Burleigh Headland, will be forgotten or overlooked (Jellurgal 2016, personal communication, 13 April).

#### 4.2 THE MOST IMPORTANT BENEFITS PROVIDED BY THE SITE

The most important benefits provided by the study site are ecotourism & recreation, cultural values & inspirational services as well as the supporting services as a whole (rated as highly significant); seeing that the supporting services are the basis for all the other benefits. Ecotourism & recreation is economy-wise highly important as surfing is the main source of income for the study site; resulting in \$AUD 17-33 million. Cultural values & inspirational services are within this report translated into research, education and art. Many school groups of all age level and education levels visit the study site for research purposes or to employ animal watching. Additionally, aboriginal history and culture still holds high relevance to many people.

Furthermore, ornamental resources, water quantity, erosion control, biological control and genetic/species diversity maintenance are benefits of high significance to this study site. Many people collect fibre and materials to create ornamental resources, an example would be the collection of shells that has been observed through the human impact assessment by Ocean Connect (2016). Many locals sell goods created, through resources collected at the study site, at the local markets. An example would be jewellery made out of shells. Water quantity is of high significance, as the study site would not exist without this component (Denny & Gaines, 2007; Little, et al., 2009). The water creates different zones within the study site as well as different habitats, like the rockpools. Additionally, the always-changing circumstances on the rocky shores through for example wave energy created importance to water quantity (P Davie 2016, personal communication, 4 March). Erosion control is a continuous challenge for the City of Gold Coast as the movement of sand finds multiple errors along the coastline. Sand becomes stuck in the Tallebudgera Creek, resulting in limited sand moving to the other side of the Burleigh Headland. Dredging is therefore in place to move the sand to the other side (City of Gold Coast, 2015; Griffith Centre for Coastal Management, 2015). Furthermore, biological control and genetic/species diversity maintenance are highly significant as the environment is ever-changing. However, the study site does not have appropriate management to have a role in maintaining natural biological control or diversity maintenance, creating even more importance for these benefits.

#### 4.3 BENEFITS IN DANGER

Multitudes of benefits are in danger as a result of the supporting services allocating threats like population growth and therefore growth in tourism. Food and biochemicals & pharmaceuticals are benefits which are in danger through overexploiting the study site for resources and therefore disturbing

biological control and genetic/species diversity maintenance as well as limited management and protection efforts (Benkendorff, 2010; Ghazanshahi, 1981; Kettunen, et al., 2009). Landscape & amenity values see threats in natural landscape, cultural heritage and myths & believes as these benefits do not create direct revenue and therefore do not have high priority. In addition, offsetting the loss of cultural identity due to a growing population as well as increasing worldwide mobility. However, aboriginal history being implemented in the Australian curriculum has been a step in the right directly; making people more aware of the land they are living on. Water quantity, water regulation and air quality regulation are in danger as a result of climate change (rising sea level and carbon sequestration) and should therefore be carefully monitored (Denny & Gaines, 2007; Little, et al., 2009). In addition, many inorganic items become stuck between the rocks as well as many micro-plastics being present in ocean water creating concern when examining waste management (Brinkman, 2014). Lastly, pollination is in danger as a result of population growth and tourism growth. Many pollinators, birds and aquatic vegetation, are being disturbed by humans. Pollination is a key aspect in the contribution towards reproduction and therefore diversity maintenance (Denny & Gaines, 2007; Little, et al., 2009; Brinkman, 2014).

#### 4.4 ECOSYSTEMS SERVICES WITH POTENTIAL TO INCREASE THEIR IMPORTANCE

Many benefits have the potential to increase their importance in both a positive and a negative way as a result of more local, regional, national and global awareness for environmental and cultural topics on one side and population growth (including increasing visitor number) and climate change on the other side. Biochemicals & pharmaceuticals have great potential to be sustainably managed in order to serve for the development of new medicine. This benefit is currently not sufficiently recognized, however, new studies show that selected species would be very beneficial to these new developments (Benkendorff, 2010; Kettunen, et al., 2009). The importance of ecotourism & recreation benefits has already increased over the past two years seeing that the average visitors number per hour has shown a growth during new research by Ocean Connect (2016). This increasing number can threaten the study site as well as the provision of the ecotourism & recreation benefits. Managing bodies should validate to not surpass the visitor capacity (Kettunen, et al., 2009; Millennium Ecosystem Assessment, 2005). Climate change regulation's importance is very likely to increase due the continuous rising sea level and carbon sequestration and the global awareness around the topic.

#### 4.5 SUSTAINABLE MANAGEMENT AND PROMOTION OF THE STUDY SITE

Kettunen et al. (2009) constantly states the need for management and protection efforts for many benefits and that without having these efforts in place, benefits will face negative impacts. The provisioning services definitely have the potential to be sustainably managed as this involves management the human population and their need and use for the study site; people are in the end dependant on the rocky shore's resources. The cultural services include the inspirational, educational and mental benefits which in direct connection to natural environments, like the rocky shores. This ecosystem service has high potential to be sustainably managed and promoted as, again, this service involves the management of the human population and their need and use for the study site and surrounding areas. The regulating services involve many natural processes that are sometimes challenging to predict and therefore challenging to manage and promote. The City of Gold Coast has already implemented efforts to support neighbouring areas (like the Burleigh Head National Park); these efforts could be directly translated to a more specific approach for the study site. Supporting services should be sustainable managed and promoted in order to support the other ecosystem services. These

management efforts should be human based as many of the supporting services correlates with human usage of the study site as well as the state of health of the study site. However, the state of health can be influenced both naturally and unnaturally (Denny & Gaines, 2007; Little, et al., 2009), monitoring is therefore of importance so trends can be identified. It is important for each of the ecosystem services to have the quantitative, qualitative and monetary values balanced in order to avoid conflict between benefits, ecosystem services as well as the trade-offs between benefits (economy vs environment). Efforts should imply the *Nature Conservation Act 1992* in order to be lawful.

The rocky shore environment of Burleigh Heads can be seen as a forgotten natural area. Conversely, the area is being subject to a considerable number of visitors annually; enhancing need for management efforts. The Burleigh Head National Park is a neighbouring national park, directly situated next to the rocky shore environment; creating importance for overlaps between management plans when efforts have been established for the rocky shore environment. There is a difference in division of the ecosystem services when comparing this assessment to the Burleigh Head National Park Management Plan (BHNMP) (Queensland Parks and Wildlife Service, 1999). The BHNMP presents only a limited number of benefits, not covering the full extent of ecosystem services of the neighbouring national park. This management plan is moreover quite dated, seeing that the management plan was written in 1999 and should have been revised in 2009. Additionally, there is the Burleigh Green Space Conservation Reserves Management Plan (BGSCRMP) (Gold Coast City Council, 2009); again presenting a different division of ecosystem services, separating socio-economic values as one of the services instead of seeing all other services as part of the socio-economic services. The plan includes limited information and focusses mainly on cultural aspects, as these are of most significant (Gold Coast City Council, 2009). The City of Gold Coast is the authorized body of the rocky shore environment and should therefore be hold responsible for management and promotion of the study site. This socio-economic assessment could serve as a guiding tool to create coherence between the different management plans as connecting natural areas on the Gold Coast is of importance to the City of Gold Coast.

#### 4.6 METHODOLOGY AND ANALYSIS

Kettunen et al. (2009) uses different approached within the toolkit. The rapid assessment was based on table 4.1 given in the toolkit and also being utilised by other case studies in different countries in Europe (Kazakova & Pop, 2009; Pabian & Jaroszewicz, 2009; Bugalho & Rocha, 2009); being presented through a spider diagram. This spider diagram included significance levels for each of the benefits, showing the importance of the benefit, not the actual value (quantitative, qualitative or monetary). Table 3 reveals a difference between the provisioning services of the rocky shores compared to the three other habitats; seeing that the rocky shores do not provide food through agriculture and hunting on game, which the other three habitats do provide (Bugalho & Rocha, 2009; Kazakova & Pop, 2009; Pabian & Jaroszewicz, 2009). Additionally, timber is of much higher significance in the primeval forest, pasture plateau's and montado & agriculture areas; since rocky shores have limited flora cover. The cultural services significance for all ecosystem services are relatively high; seeing that inspirational, educational and human well-being is of high significance to every world population. Regulating services are noticeably fluctuating between the habitats. Rocky shores as well as pasture plateaus have natural components to allocate regulating services; creating less necessity to establish management protocols and therefore being less significant. Air quality regulation, for example, is naturally ascertained by the ocean in case of rocky shores and a habitat being in the mountains in case of pasture plateau. The Millennium Ecosystem Assessment (2005) as well as the toolkit by Kettunen (2009) sets supporting services aside as the basis for the other three ecosystem services, highlighting their significance (Millennium Ecosystem Assessment, 2005) and importance to other ecosystem services. When the

supporting services are overexploited, the other three ecosystem services diminish (Kettunen, et al., 2009; Pabian & Jaroszewicz, 2009; Millennium Ecosystem Assessment, 2005). It is therefore surprising that supporting services significance is rated at 3 for montado & agriculture (Bugalho & Rocha, 2009); being the lowest of all ecosystem services for that particular environment, as supporting services include the benefits that all other ecosystem services need. Additionally, the primeval forest being rated with a significance of 5 rises questions; Pabian & Jaroszewicz (2009) state that the supporting services are very well developed within the primeval forest, however, estimates given have not been discussed within the report or supported by literature. Rocky shore supporting services significance have been rated at 3.8; seeing that ecological interactions and supporting habitats are of very high significance and important to many benefits, however, soil formation is minimal due to low abundance of flora lessening the overall rate of significance for this ecosystem service. The rocky shores being rated with comparable significance levels to Natura 2000 sites emphasises the importance of the study site.

**Table 2: Significance of ecosystem services for different habitats**

<b>Habitat</b>	<b>Provisioning</b>	<b>Cultural</b>	<b>Regulating</b>	<b>Supporting</b>
Rocky shores	2.5	4.8	2.4	3.8
Primeval forest (Pabian & Jaroszewicz, 2009)	3.5	4.0	4.4	5.0
Pasture plateau (Kazakova & Pop, 2009)	3.7	4.0	2.5	4.0
Montado & Agriculture (Bugalho & Rocha, 2009)	3.4	4.0	3.6	3.0

The detailed valuation of the different benefits is very habitat dependant as well as location dependant; since every location has different cultures and norms. The rocky shore environment of Burleigh Heads is not only bordering a national park (Burleigh Head National Park) but also urban areas including real estate (Goodwin Terrace). The environment being close to urbanisation creates more significance to economy based benefits, this is very different to a rocky shore environment being isolated from urbanisation like Point Reyes in the United States where the rocky shores are rich in biodiversity and experiences less human usage of the area (National Point Reyes Seashore California, 2016). Methods utilised for the detailed valuation are based on the toolkit, which gave options on how to find values for each benefit; including quantitative, qualitative and monetary values (Kettunen, et al., 2009) and has been used in a similar fashion by other authors that have employed the toolkit (Bugalho & Rocha, 2009; Kazakova & Pop, 2009; Pabian & Jaroszewicz, 2009). Significance levels have been given based on the researcher's own estimates, the researcher's experience, literature and opinions by experts in the field resulting in the significance levels being subjective. However, socio-economic studies are generally subjective seeing that you cannot provide objective estimates for spiritual values as everybody experiences an environment differently and has different interests. Highlighting the importance of qualitative and quantitative values is therefore of importance as not all benefits can be expressed in monetary values (Millennium Ecosystem Assessment, 2005; Menger, 2007; Kettunen, et al., 2009).

## 4.7 CONCLUSIONS

Concluding, the assessment revealed that the forgotten rocky shore environment of Burleigh Heads delivers socio-economic benefits to a myriad of beneficiaries on local, regional, national and global level enhancing knowledge on this particular ecosystem. Additionally, the assessment shows that benefits are connected to each other; one over-exploited benefit can disturb the whole ecosystem.

Acknowledgement and provision of local authorizing bodies like the City of Gold Coast will enhance sustainable usage of the study site so the study site's characteristics hold or enhance their value and therefore increase resources provided by the study site to the people. Former studies have revealed that beneficiaries often do not see connection between generated income and the ecosystem services (Bugalho & Rocha, 2009; Kazakova & Pop, 2009; Pabian & Jaroszewicz, 2009); it is therefore of great importance to tackle unsustainable use of the study site by promoting the environment. It must be taken into account that not only the monetary value is of importance but also the quantitative and qualitative values as they carry the same weight, economy should balance ecology (Millennium Ecosystem Assessment, 2005). The establishment of a management plan allows for a rounded approach to nature conservation of the rocky shore environment of Burleigh Heads when coherency with the Burleigh Head National Park Management Plan is considered.

#### 4.8 SUGGESTIONS OF FUTURE ACTIONS

Firstly, and of great importance is the development of the study site's management plan. The management can correlate with the Burleigh Head National Park Management Plan, however, this management plan is written back in 1999 and should first be revised in order to establish management efforts that deal with problems currently occurring as environments change over time. Creating parallel management plans will benefit both environments, as coherency and connectivity is important when dealing with neighbouring areas. It is important to comply with the *Nature Conservation Act 1992* when establishing management efforts, in particular to:

- provide for the permanent preservation of the area's natural condition to the greatest possible extent;
- present the area's cultural and natural resources and their values; and
- ensure that the only use of the area is nature-based and ecologically sustainable.

Secondly, biodiversity trends of the rocky shore environment of Burleigh Heads can only be fully understood when numerous other indicators are examined. Indicators as human usage, natural disasters, coastal processes and climate change are needed in decision-making processes towards protection and management of this environment. Biodiversity is of importance for many benefits in order to function properly and to sustainably act. Ongoing monitoring on physical and ecological aspects could increase knowledge on the ecosystem service, which will be beneficial for both flora and fauna and humans.

Thirdly, water quantity and quality can be maintained accurately when ongoing monitoring is established. Maintaining water quantity and quality is highly important to all flora and fauna within the study site as water is such vital component of this environment. Water creates the ever-changing aspect of the rocky shores and generates the catchment areas (rockpools).

Lastly, it is important provide environmental education to local communities in order to establish promotion of the study site. Locals need to be educated on the different benefits the study site provides (being an educational platform) as well as the threats for each of these benefits. Additionally, sustainable usage of the study site as well as other natural areas should be promoted to avoid overexploitation of resources as well as littering of the study site. Implementation of the management will encounter serious impediments when the local community does not have any knowledge on the study site's benefits and then can possibly obstruct the management process. Creating even greater acceptance from the public can be established by organising public consultations, this way, people feel heard.

This case study serves as a guide for identification of the study site's benefit as can be used as a tool in the management making process.



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## APPENDIX I – RAPID ASSESSMENT ESTIMATES

Ecosystem service		Does the study site provide this service	Who benefits from this service?  Local / regional / national / global stakeholders	Significance of this service / service potential?  Own rapid estimate 0– 5	Types of evaluation possible	
					Easy to obtain	Possible but laborious to obtain
Provisioning services						
Biodiversity resource	Food	Yes, option 2	Local stakeholders, Flora and Fauna, national stakeholders	3	Quantitative Qualitative	Monetary
	Fibre/Materials	Yes, option 2	Local stakeholders, Tourists, Flora and Fauna	2	Quantitative Qualitative	Monetary
	Fuel	No	-	0	-	-
	Natural medicines	Yes, option 3	Locals, national stakeholders	1	Qualitative (potential value)	Monetary Quantitative
	Ornamental recourses	Yes, option 2	Local stakeholders	4	Quantitative Qualitative	Monetary
Biochemicals & pharmaceuticals		Yes, option 2	Local stakeholders	2	Qualitative (potential value)	Monetary Quantitative

<b>Water quantity</b>	Yes, option 1	Flora and Fauna, Local stakeholders	4	Monetary Quantitative Qualitative (potential values)	-
<b>Cultural &amp; social services</b>					
<b>Ecotourism &amp; recreation</b>	Yes, option 1	Local stakeholders	5	Monetary Quantitative Qualitative	-
<b>Cultural values and inspirational services, e.g. education, art &amp; research</b>	Yes, option 1	Local stakeholders, Tourists	5	Monetary Quantitative Qualitative	-
<b>Landscape &amp; amenity values</b>	Yes, option 2	Local stakeholders, Tourists	4	Qualitative	Monetary Quantitative
<b>Regulating services</b>					
<b>Climate / climate change regulation</b>	Yes, option 3	Local stakeholders, Tourists, Flora and Fauna, Global stakeholders	1	Qualitative (potential value)	Monetary Quantitative (potential value)
<b>Water regulation</b>	Yes, option 2	Local stakeholders, Tourists, Flora and Fauna	1	Qualitative	Monetary Quantitative (potential value)
<b>Water purification &amp; waste management</b>	Yes, option 2	Local stakeholders, Tourists, Flora and Fauna, Regional stakeholders	1	Qualitative (potential value)	Monetary Quantitative (potential value)
<b>Air quality regulation</b>	Yes, option 2	Local stakeholders Tourists, Flora and Fauna	2	Qualitative (potential value)	Monetary Quantitative (potential value)

<b>Erosion control</b>	Yes, option 1	Local stakeholders, Tourists, Flora and Fauna	4	Monetary Quantitative Qualitative	-
<b>Avalanche control</b>	No	-	0	-	-
<b>Storm damage control</b>	Yes, option 2	Local stakeholders, Tourists	3	Qualitative	Monetary Quantitative
<b>Wild fire mitigation</b>	No	-	0	-	-
<b>Biological control</b>	Yes, option 2	Flora and Fauna Global stakeholders	4	Qualitative	Monetary Quantitative
<b>Pollination</b>	Yes, option 2	Flora and Fauna, Local stakeholders, Tourists	1	Qualitative	Monetary Quantitative
<b>Regulation of human health (physical and mental)</b>	Yes, option 1	Local stakeholders, Tourists	3	Monetary Quantitative Qualitative	-
<b>Genetic / species diversity maintenance</b>	Yes, option 2	Flora and Fauna, Local stakeholders, Tourists, global stakeholders	4	Qualitative	Monetary Quantitative
<b>Supporting services</b>					
<b>Primary production</b>	No	-	0	-	-



<b>Supporting habitats</b>	Yes	Flora and Fauna, Local stakeholders, Tourists, Global stakeholders	5	Monetary Qualitative Quantitative	-
<b>Soil formation</b>	Yes	Flora and Fauna, Local stakeholders, Tourists, Global stakeholders	5	Monetary Qualitative Quantitative	-
<b>Nutrient cycling</b>	Yes	Flora and Fauna, Local stakeholders, Tourists, Global stakeholders	5	Monetary Qualitative Quantitative	-
<b>Water cycling</b>	Yes	Flora and Fauna, Local stakeholders, Tourists, Global stakeholders	5	Monetary Qualitative Quantitative	-
<b>Ecological interactions</b>	Yes	Flora and Fauna, Local stakeholders, Tourists, Global stakeholders	5	Monetary Qualitative Quantitative	-
<b>Evolutionary processes</b>	No	-	0	-	-

## APPENDIX II – DETAILED VALUATION OF THE BENEFITS PER ECOSYSTEM SERVICE

BENEFIT CATEGORY	BENEFIT DESCRIPTION	ESTIMATED VALUE OF THE BENEFIT				WHO ARE THE BENEFICIARIES	WHAT IS THE CURRENT STATUS OF THE BENEFIT	IS THE IMPORTANCE OF THIS SERVICE LIKELY TO INCREASE IN THE FUTURE?	CAN I SUM MY MONETARY VALUES TO FORM AN AGREGATED ESTIMATE?
		Qualitative	Quantitative	Monetary	Relative value				
Ecosystem service related benefit									
Provisioning services									
Food	Sea Urchin	Individuals of the <i>Tripneustus gratilla</i> species are taken for household/in individual use	A total of six individuals were found during the biodiversity assessment.	\$AUD 19.99 per live <i>Tripneustus gratilla</i> . It also needs to be taken into account that there is unofficial trade	3	Local communities Individuals Households Flora and Fauna	A service in poor condition. over-exploitation (no collecting restrictions or management)	Yes, (if management efforts are established) due to observed growth in taking of animals as well as lower abundance.	\$AUD 120
	Sea Cucumber	the <i>Holothuria leucospilota</i> and the <i>Holothuria atra</i> . Both species are taken for household /individual use	A total of 47 individuals were found during the biodiversity assessment.	No, due to unofficial trade	3	Local communities Individuals Households Flora and Fauna	A service in poor condition. over-exploitation (no collecting restrictions or management)	Yes (if management efforts are established) due to observed growth in taking of animals.	No, due to lack in available data.
	Blue swimmer crab	The species is highly popular within the	Seven individuals were found during the	\$3.8 million for Queensland but no	1	Regional Local communities	A service in good condition as restriction and	No, due to the low abundance within the study site.	No, due to lack in specific available data.

		fishing industry.	biodiversity assessment.	specific data available on the Gold Coast (or Burleigh Heads)		Individuals Households Businesses Flora and Fauna	management is in place.		
	Pandanus	The <i>Pandanus tectorius</i> and <i>Pandanus spiralis</i> are both common in the area.	93.8 m2 was logged during the biodiversity assessment.	No data available	1	Local communities Individuals Households Flora and Fauna	A service in good condition	No, due to lack of interest of local community as well as decreasing aboriginal use of the area	No, due to lack in available data
<b>Fibre/ Materials</b>	Plant fibre	Different fibre of a variety of plants, shells and rocks are used by other organisms within the study site for the creation of nests e.g.	No data available	No data available	2	Flora and Fauna	A service in good condition	Yes, when management efforts are established	No, due to lack in available data
<b>Natural medicines</b>	Herbs/ plants	Plant species are used in home remedies by individuals, households, indigenous people.	Not possible to estimate	Not possible to estimate	1	Flora and Fauna Individuals Local communities Households Aboriginal people	A service in good condition with potential to grow	No, due to limited knowledge on bush medicine by the current local community	No, due to lack in available data
	Pumice stones	Pumices stones are the volcanic rocks that have a vesicular rough texture.	No data available	No data available	1	Local communities Individuals Households Aboriginal people	A service in good condition	No, due to the limit amount of this resource	No, due to lack in available data

<b>Ornamental resources</b>	Plant fibre	Pandanus leaves from both species are dried and then used to create bags, mats, etc.	No data available	No data available	3	Local communities Individuals Aboriginal people	A service in good condition	No, due to the reduces number of aboriginal people on the Gold Coast	No, due to lack in available data
	Wood	Driftwood is often used for fish tanks or handcraft	No data available	No data available	2	Local communities Individuals Households	A service in good condition	No, due to the no increase or decrease in use	No, due to lack in available data
	Shells	The rocky shores have a considerable number of shells within the rockpool, beaches and between the boulders.	No data available	Jewellery is sold starting from \$AUD 10 a piece at the local market.	4	Local communities Individuals Households Aboriginal people Businesses	A service in good condition	Yes, due to the growing amount of retailers and interest in these jewelry	No, due to the lack of available quantitative data
<b>Biochemicals &amp; Pharmaceuticals</b>	Marine life	The environment has a high abundance in molluscs, crustaceans, fish and echinoderms	No data available as this is a service that has potential	No data available as this is a service that has potential	1	National Global Health sector	A service with great potential when performed in a sustainable way.	Yes, due to new findings during the past years and a growing interest in new resources for the creation of new medicine.	No, due to the lack of available data as it is a benefit with potential (not currently employed).
<b>Water quantity</b>	Ocean Water	The ocean water is one of the major components of this environment but does not supply to the City of Gold Coast.	No data available as it is not in use for the Gold Coast community.	No data available, though, value is irreplaceable	4	Global National Regional Local Flora and Fauna	A service in good condition	Yes, due to climate change (rising sea level) and ecosystems therefore change	No, due to lack in available data

Cultural services									
<b>Ecotourism &amp; Recreation</b>	Value of tourism	Ecotourism on rocky shore environment has a short-term character,	48 (visitors per hour) x 3 (low tide hours) = 144 x 7 (one week) x 52 (weeks a year) = 52,416 visitors a year	No data available as there is no entry fee	5	Flora and Fauna Local communities Households Individuals Aboriginal people Tourists	A service in good condition for human activity resulting in a poor condition for the flora and fauna	Yes, due to the demand of contacts with untouched nature	No, due to no entry fees to enter the environment
	Value of travel and accommodation related to tourism	Surfing attracts people to travel to Burleigh Point creating revenue through accommodation,	Estimate of 40,000 surfers annually that travel to the Gold Coast, 14% of those go to Burleigh Point = 5600	\$AUD 1520 per person per year.	5	Tourists	A service in good condition	Yes, due to the growth in tourism numbers and growing surfing population	5600 x \$AUD 1520 = \$8,512,000
	Surfing	Surfing creates an enormous income for the Gold Coast, revenue is created through equipment, food, fuel, travel and accommodation.	Estimated 120.000 surfing individuals on the Gold Coast including the tourists travelling to the Gold Coast for surfing. 14% of this 120.000 choose to surf at Burleigh Point = 16800	\$AUD 17-33 million annually for Burleigh Point for expenditure.	5	Tourists Local communities Households Individuals	A service is good condition	Yes, due to the growth in tourism numbers and growing surfing population	\$AUD 17-33 million
		Surfing provides work opportunities on the Gold Coast,	An estimated 21,000 jobs are created as a results of the surfing	Not possible to give an estimate as the jobs created can not be	5	Tourists Local communities Households	A service in good condition	Yes, due to the growth in tourism numbers and growing surfing population	No, due to impossibility

		including Burleigh Heads	industry on the Gold Coast,	separated per surf location		Individuals			
	Recreational fishing	Recreational fishing is a sport that is employed by Gold Coast residents. Study shows that the rocky shore environment is a popular fishing area	The recreational fishing population on the Gold Coast is 21,000 for onshore fishing. No specific numbers for the population in Burleigh Heads are given.	Research states that recreational fishers spend an estimated \$AUD 1,000 per annum	3	Local communities Households Individuals Tourists Aboriginal people Flora and Fauna	A service in good condition	Yes, due to the world's economic proceedings	No, due to lack of available data
	Animal Watching	The rocky shores provide an educational platform for all ages as it is very accessible.	Study shows that an average of 15 visitors per hour come to the rocky shore environment for animal watching	Not possible to give an estimate as it does not create revenue	4	Local communities Households Individuals Tourists Aboriginal people Flora and Fauna	A service in good condition, however, trampling causes a significant impact	Yes, due to growing visitors' numbers	Not possible
	Snorkeling	Snorkelling is an activity performed at the study site around the low tide mark	No data available	No data available	1	Local communities Households Individuals Tourists	A service in good condition	Expected to remain the same	No, due lack of available data
<b>Cultural values &amp; inspirational services</b>	Education	There is a multitude of organisations and businesses on the Gold Coast that provide	There are 5 organisations and businesses known that provide environmental education at the study site.	Prices per student are ranging from \$AUD 2 up to \$AUD 28. Non-profit organisations often ask a	5	Local communities Regional Households Individuals Tourists	A service in good condition	Yes, due to an increase in environmental awareness and the need to teach the new generation about the nature.	No, due to lack in available data on the number of students per annum.

		educational sessions.	Together offering over 136 sessions annually.	gold-coin donation.		Students Schools			
	Photography	Study shows that photography is an important activity performed at the rocky shores.	Not possible to estimate	Not possible to estimate	4	Local communities Regional Households Individuals Tourists	A service in good condition	Yes, due to increase in need for imagery	Not possible to estimate
	Aboriginal art	The Kombumerri people remain to find inspiration for their artwork at the study site	The Jellurgal centre sells local indigenous art at their cultural centre.	No data available	3	Local community Aboriginal people	A service in good condition	Yes, due to more awareness and acceptance on aboriginal history	No, due to lack in available data
	Research	Research is conducted through multiple institutes both on national and international level.	Not possible to estimates as no license is need to perform research; therefore, no statistics.	Not possible to estimate	3	Local community Regional National Global Students Universities Research institutes	A service in weak condition as there is no controlling body.	Yes, due to more environmental awareness	No, due to lack in available data
<b>Landscape &amp; amenity values</b>	Local architecture	The closest street to the study site is Goodwin Terrace. This street has high-rises, which are very common on the Gold	The study site adds value to the properties because of its location.	Not possible to estimate	4	Local communities Households Individuals Tourists	The service is in good condition	Yes, due to the rising popularity of Burleigh Heads	Not possible to estimate



		Coast, restaurants and a public swimming-pool.							
	Natural landscape	The rocky shore environment is a natural landscape, being untouched by humans except for real estate being built at the outer section (swimming pool)	Not possible to estimate	Not possible to estimate	5	Flora and Fauna	The service is in average condition, with a growing world population the demand for more property grows as well creating pressure for the study site	Uncertain, climate change and environmental awareness playing an important role for this service	Not possible to estimate
	Cultural diversity	Burleigh Heads' inhabitants are from a range of countries.	Not possible to estimate	Not possible to estimate	4	Local communities Households Individuals Tourists Aboriginal people	A service in good condition	Yes, due to rising popularity of Burleigh Heads	Not possible to estimate
	Spiritual diversity	Burleigh Heads is known as the spiritual suburb of the Gold Coast.	Not possible to estimate	Not possible to estimate	5	Local communities Households Individuals Tourists Aboriginal people Regional National	A service in good condition	Yes, due to rising popularity of Burleigh Heads as being a spiritual place	Not possible to estimate
	Cultural heritage	Burleigh Headland has been important for decades	Not possible to estimate	Not possible to estimate	4	Local communities Aboriginal people Regional	A service in weak condition, the general awareness and	Uncertain, due to growth of different cultures settling	Not possible to estimate

		for first aboriginal people and then the European settlement since the 1600's				National	knowledge on the region's history is very limited	in Burleigh Heads	
	Myths and believes	There are existing aboriginal historic stories about the rise of Burleigh Headland as well as the so called dreamtime stories.	Not possible to estimate	Not possible to estimate	2	Local communities Households Individuals Tourists Aboriginal people	A service in weak condition	Yes, due to more awareness and acceptance on aboriginal history	Not possible to estimate
<b>Regulating services</b>									
<b>Climate/Climate change regulation</b>	Carbon sequestration	The study site inhabits some flora and fauna species that sequester. However, this is a limited amount as there is not an extended flora cover.	No data available	No data available	1	Local Regional National Global  Global with a focus on greenhouse gases, health services, rising sea level, temperature increase.	The service could be enhanced via appropriate management and obtaining study site's favourable conservation status.	Yes, due to a high global interest in climate change and the importance of this phenomenon	No, due to the lack of available data
<b>Water regulation</b>	Flood prevention	The rocks break the waves; the rockpools serve as a catchment	The rocks and rock-pools are part of the entire environment	No data available	1	Local communities Households Tourists	A service in good condition, but could decrease in the future	Yes, due to rising sea level and therefore new management is perhaps needed	No, due to lack in available data

		area for water							
<b>Water purification &amp; waste management</b>	Water purification	Oyster population (limited) as well as the ocean	The oyster population is limited, the total water surface changes every day	Not possible to estimate	<b>1</b>	Flora and Fauna	A service in good condition, very depended of biological composition	No, due to lack in local interests	No, due to error in estimate process making
	Waste management	Wave energy, natural catchments	No data available	Not possible to estimate	<b>1</b>	Local communities Households Tourists	Not possible to estimate	Yes, due to increasing amount of pollution	No, due to lack in available data
<b>Air quality regulation</b>	Air quality	The ocean water and plants is known to purify water establishing preservation of values for cultural and biological purposes.	Not possible to estimate	Not possible to estimate	<b>2</b>	Local communities Households Individuals Tourists Flora and Fauna	Service in a good condition	Yes, due to climate change and more CO <sup>2</sup> in the air	No, due to the lack in available data
<b>Erosion control</b>	Prevention of negative effects due to erosion	Dredging is implemented in order to establish the movement of sand for longshore drift as both the groyne and the Burleigh Headland block the movement of sand.	Annual average of 38.000m3 sand.	Dredging activities and budget given by City of Gold Coast \$AUD 7,673,816	<b>4</b>	National Regional Local communities Tourists Households Individuals Flora and Fauna	Service in a good condition, the City of Gold Coast has budget as well as a management plan available.	Yes, due to increasing number of tourists, population and climate change.	\$AUD 7,673,816
<b>Storm damage control</b>	Water level, current, swell	The study site is not a designated	No data available due to no	No data available due to	<b>3</b>	Local communities	A service in poor condition, also	Yes, due to increasing number of	No, due to the lack in available data

	and tidal activity	flood area but has natural storm damage control mechanisms.	management plan	absence of management		Tourists Households Individuals Flora and Fauna Aboriginal people	because each storm event is different and therefore hard to prevent the unknown	tourists and population	
<b>Biological control</b>		The study site has a well-established natural biological control mechanism through predation, herbivory and other.	No data available due to absence of management	No data available due to absence of management	4	Flora and Fauna Local community Households Individuals Tourists (global) (national)	Service in good condition	Yes, due to decreasing populations numbers, growing tourism and environmental understanding of the study site	No, due to lack in available data
<b>Pollination</b>	Pollination through aquatic flora and seed dispersal agents	The study site has seed dispersal agents as inhabitants or visitors. Additionally, there are flora species that employ underwater flowering and pollination for sexual reproduction	No data available due to absence of management	No data available due to absence of management	3	Flora and Fauna Local communities Households Individuals Tourists	A service in average condition, there is less aquatic vegetation in 2016 than there was in 2014	Yes, due to decreasing population numbers and growing tourism	No, due to lack in available data
<b>Regulation of human health (physical and mental)</b>	Human health	There is wide variety in activities employed at the study site contributing to human health for different	Not possible to estimate	Not possible to estimate	3	Local communities Households Individuals Tourists	A service in good condition	Yes, due to growing tourism and population	No, due to lack in available data

		stakeholders. The study site also holds a spiritual and cultural value for indigenous communities							
<b>Genetic/ species diversity maintenance</b>	Maintaining diversity	The study site does not contribute to official trade of goods with regards to food and has currently no management .	No data available due to absence of management	No data available due to absence of management	<b>4</b>	Flora and Fauna Global National Regional Local communities Households Individuals Tourists	A service in poor condition	Yes, due to decrease in population numbers	No, due to lack in available data
<b>Supporting Services</b>									
<b>Supporting habitats</b>	Refugia	The flora and fauna are constantly exposed to unfavourable condition through the tidal movements	/	/	<b>5</b>	Flora and Fauna Local	A service in weak condition	Yes, due to climate change and rising sea level	/
	Breeding & reproduction	Different species use the study site as their breeding grounds	/	/	<b>5</b>	Flora and Fauna Local Regional National Global	A service in good condition	Yes, due to decreasing numbers in individuals and therefore the demand for protection efforts	/

	Nursery	The study site functions as a nursery for different species within different orders, particularly for molluscs and fish	/	/	5	Flora and Fauna Local Regional National Global	A service in good condition	Yes, due to decreasing numbers in individuals and therefore the demand for protection efforts	/
<b>Soil formation</b>	Soil formation process	The chemical weathering of rocks is a constant happening.	/	/	5	Local Regional	A service in good condition	Uncertain	/
<b>Nutrient cycling</b>		the transportation and accumulation of organic and inorganic matter as well water purification	/	/	5	Local Households Individuals Aboriginal people Tourists City of Gold Coast Flora and Fauna	A service in weak condition due to littering of many inorganic matter	Yes, due to more awareness of littering	/
<b>Water cycling</b>	Regulating water flow	The rocks hold the water creating rock pools, which is very important for flora and fauna within the study site	/	/	5	Flora and Fauna City of Gold Coast	A service is good condition	Yes, due to fluctuations and dynamics of the ecosystem	/
<b>Ecological interactions</b>	Biodiversity trends	The study site is very rich in the number of	/	/	5	Flora and Fauna Local Regional	A service in weak condition	Yes, due to declining population numbers	/

		organisms inhabiting the rocky shore environment but low in biodiversity.				National Global			
							<b>TOTAL</b>	<b>\$AUD 33,185,936 - 49,185,936</b>	