GOLD COAST SHORELINE MANAGEMENT PLAN

Volume 1: Executive Summary &
Littoral Review Part A — Chapters 1 to 5

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In partnership with Griffith University
### RESEARCH REPORT SERIES

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#### Synopsis:
This report presents the findings of a review of littoral processes and past beach management, and the development of a shoreline management plan for the Gold Coast beaches.

#### Keywords:
Coastal erosion, stakeholder engagement, coastal process modelling, Gold Coast

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There is a mysterious attraction about the coast, something every beach and ocean lover knows. It’s a powerful addiction that we’ve all been hooked on since first climbing a sand dune and squinting through the haze to the beautiful big blue. A timeless myth exists about the beach and the coast, a belief that our actions on the coast and in the coastal zone (land or sea) will always be temporary – like waves washing over footprints. Because of the coast’s ability to constantly refresh and renew itself, there is a feeling that we (humans) can’t actually harm it – the coast is impervious to our actions – and as such, we can act in any manner we choose. This myth has grown into a belief that because our actions on the coast are temporary, we can do whatever we like, because, ultimately, the ocean will be able to refresh itself (Blomberg, 1982).
EXECUTIVE SUMMARY

1 Introduction

The beaches of the Gold Coast have achieved iconic status within Australia and internationally. Gold Coast beaches are exposed to a high wave energy coastline and are regularly subjected to storms and large waves. The maximum wave height recorded by offshore buoys is 17 m. For almost 100 years our beaches, creeks and river entrances have been modified in one way or another in order to deliver maximum utility to the community. The result is that in order to provide the necessary coastal protection, community, economic and even environmental services necessary to sustain the city and a healthy environment, Gold Coast beaches require active management.

The Gold Coast is highly dependent on its reputation for golden sandy beaches, warm turquoise waters and endless sunshine. After extreme damage caused by cyclones in the mid 60s and late 70s, the Gold Coast City Council recognised the beaches as the basis of the tourism industry and quality of life on the Coast, and the crucial need to preserve them (Beard, 2001).

Beaches are important to the Gold Coast for a number of reasons:

- They provide an important coastal protection buffer between the land, which is highly urbanised, and the high energy ocean;
- Gold Coast beaches, which are all publicly owned and accessible, provide an important focus for recreation for the city’s 500,000 residents;
- The beaches form the basis of the region’s tourism industry, which is of significant economic importance to the city; and
- Beaches and the nearshore zone provide valuable environmental habitat.

The beaches are a focal point for local residents of the City for the purposes of swimming, surfing, fishing and various other recreational activities. The beaches also provide an attraction and coastal recreational area for many tourists that visit the Gold Coast (Gold Coast City Council, 2002).

Gold Coast residents made approximately 40 million trips to the beaches and foreshore of the Gold Coast in 2007 and visitors made at least an additional 7 million trips. Most Gold Coasters are proud of the city’s beaches and encourage friends and family to visit our beaches (Raybould & Lazarow, 2009). Access, amenity and beach health play a crucial role in the social fabric of the community.

Coastal protection programs such as Palm Beach Protection Strategy (PBPS) and the Tweed River Entrance Sand Bypassing Project highlighted a lack of understanding and acceptance of coastal works within the community. Concerns from the public include changed: beach profiles; beach widths; loss of amenity including, degraded surfing conditions, loss of safe swimming areas; and the impacts on natural reef systems. This highlighted the need to undertake a major community engagement process in conjunction with the littoral review as proposed options for managing our beach environment need to be socially acceptable as well as
technically sound. This rationale underpinned the development of the Gold Coast Shoreline Management Plan.

Gold Coast City Council is the authority that currently deals with the day-to-day management of the beach or littoral system. The Gold Coast littoral environment can be described as a high-energy open coast. Large amounts of sediment are transported along the shore with a net annual transport rate of 500,000 m³. In the 50-year planning period this system is basically in equilibrium with the major impact coming from the cross-shore movement of sand during large events such as cyclone.

As well as the foreseeable challenges, adapting to or mitigating the impacts of climate change, in particular increased storms and flooding, presents a significant challenge for a city in which much of the built environment is constructed over swamp and wetland areas and is located very close to sea level – and the people that live and work in this vicinity place a significant premium on being located so close to the coast.

Over the past century, extensive development has occurred on the sand dunes of the Gold Coast, which limits the beach's ability to cope with natural storm erosion events. Active involvement in managing the beach system is required. However, the community has begun to question the current activities undertaken to manage the beach and a review of the current approach was needed.

In 2004, GCCC in conjunction with the Griffith Centre for Coastal Management prepared a discussion paper titled ‘A Way Forward in Managing the Gold Coast Littoral Environment’ (Stuart & Tomlinson, 2004), which intended to act as a catalyst for a review of our understanding of the Gold Coast littoral environment, including the need to identify key gaps and how information and decision-making could be better synthesised to improve decision-making. The discussion paper identified a number of gaps in existing knowledge and policy structure. The Littoral Review identified a range of elements that needed to be included in a review of the management of Gold Coast beaches. In general, these covered:

1. The need to improve our understanding of the physical environment;
2. The need to improve our understanding of beach and coastal ecological process;
3. The need to improve our understanding of the economic value of Gold Coast ocean beaches;
4. The need to better understand community values, how to engage with stakeholder and how to incorporate local knowledge in decision-making more effectively;
5. The need to improve our understanding of disaster management planning; and
6. Determining the appropriate policy and program responses for coastal planning and management over a 50-year period.

A program of review and plan development commenced in 2005 and is referred to as the Gold Coast Shoreline Management Plan (GCSMP). It is a review of the social, environmental and economic processes that impact on the way we manage our sandy beaches. The major outcome of the review is the development of a new shoreline management plan to guide coastal works for the next 50 years. The GCSMP focuses research and planning on how we manage our beaches and shoreline and provides a mechanism to review all available previous investigations, identify knowledge gaps, undertake new research and identify priority areas for
action. Supporting the sustainability of the natural environment will underpin our lifestyles and economy into the future.

The GCSMP focuses on the management of the sandy beach environments from Pt Danger to Jumpinpin, concentrating on the littoral zone, defined as the area from the rear dune fence or boulder wall alignment to the offshore zone where sand deposits for beach nourishment may be. This takes in the active zone of littoral transport but also those areas outside the active zone that may act as sediment sources. The key focus is on the sandy beach environment. The purpose of the GCSMP is to:

1. Ensure that beaches continue to contribute to coastal lifestyles [Social] and our tourism economy into the future;
2. Sustainably manage our sandy beach environment; and
3. Develop coastal protection measures to deal with current erosion issues and forecasted effects as a result of both natural trends and climate change predictions.

In summary, the GCSMP provides coastal management and protection guidelines for GCCC to deal with current erosion issues and forecasted effects as a result of both natural trends and climate change predictions without compromising our way of life. The GCSMP will update findings from the previous (and only) whole-of-coast study, that being the Delft Report (Delft Hydraulics Laboratory, 1970), which provided a detailed assessment of physical beach processes at work in the 1960s, and set out recommendations for beach management. These recommendations form part of the currently implemented Coastal Management Plan.

The partnership model between GCCC and GCCM is intended to help achieve the principle of coordinated management as described in the State Coastal Management Plan. Importantly, there is significant synergy between the Gold Coast Shoreline Management Plan and the Regional and State Coastal Management Plans. The Gold Coast Shoreline Management Plan is structured around five major themes and complements the Queensland Coastal Management Plan. These themes are:

1. Coastal physical processes;
2. Coastal ecological processes;
3. Economic values of Gold Coast beaches;
4. Community values and stakeholder engagement; and
5. The development of a beach management plan.

The GCSMP satisfies the requirements by the Department of Environment and Resource Management (previously the Environmental Protection Agency) for the development of a Shoreline Erosion Management Plan (SEMP), which is the State Government’s preferred method for local government to address shoreline erosion issues at the local level. The primary purposes of a SEMP are to enable local government to proactively plan for erosion management in hotspot areas in a way that is consistent with the government policies; investigate and address the underlying causes of shoreline erosion and likely future progression at the local scale; and to determine cost effective and sustainable erosion management strategies that maintain natural coastal processes and resources and consider community needs in both the short- and long-term (Government of Queensland, 2006, pp. 1-2). The EPA states that SEMPs can:
Identify significant coastal erosion issues;

Develop an understanding of the underlying coastal processes contributing to erosion problems;

Develop and evaluate options for erosion protection and management;

Facilitate community input on coastal erosion issues;

Plan for the delivery of selected erosion protection and management options; and

Ensure erosion protection and management measures are consistent with State and Regional Coastal Management Plans and other government policies (Government of Queensland, 2008).

Shoreline Management Plans, however, are not limited to a consideration of coastal physical processes issues and may cover a range of ecological and socio-economic considerations also.

2 History

The ocean beaches of the Gold Coast beach extend for approximately 50km from Jumpinpin at the north of South Stradbroke Island through to Point Danger on the NSW border. The Gold Coast area is a West-to-East sloping basin of pre-Pleistocene bedrock. Close to the coast this bedrock is covered by a band of low elevation sand and swamps fringed by coastal dunes. Today, with the exception of Burleigh Heads National Park and The Spit, the majority of the area has been taken up for residential development, including significant infilling and modification of the adjacent coastal swamp area.
Records documenting modifications to the ocean beaches and foreshores of the Gold Coast date back over 100 years. The high energy wave climate and frequent storms and cyclones throughout the 20th Century are characteristic of a highly dynamic beach zone. Development within the active coastal zone during relatively calm periods (which can often last for over a decade) in the first half of last century meant that many properties that were originally constructed too close to the water were put under threat during cyclones and flooding events. There is a well-documented historical record of major events causing significant damage to both public and private property on the coast, including the loss of public reserves along the beachfront (Tomlinson, 2001).

Local government, in some cases with the financial assistance of State and Federal governments, has undertaken a range of coastal protection works over the years. Major hard infrastructure works in this region include the construction of rock sea walls along most of the Gold Coast shoreline, major training walls at the Tweed River and Gold Coast Seaway, groynes at Kirra and Palm Beach, sand bypassing systems at the Tweed and the Seaway and the construction of Narrowneck artificial reef. Gold Coast City Council (GCCCC) has also undertaken beach nourishment and reprofiling works on all of the Gold Coast beaches and dredging of Currumbin and Tallebudgera Creeks and continues to undertake these works as required (Stuart & Tomlinson, 2004). A summary of the current works being undertaken is given in Table 1.

3 Status of Gold Coast beaches (pre May 2009)

Southern beaches

The first beach beyond the Tweed River, Duranbah would solely rely on shoreward accretion of sediment from the ebb tide delta during low swell events if it were not periodically nourished from the sand bypassing system. It is unlikely that there would be a beach at all if this were not the case. The exposed location of Cook Island and adjacent reefs and shoals ensure refraction of arriving south and south-east swell enroute to Point Danger. At Snapper Rocks – and the start of the Gold Coast Beaches - there is a marked change in coastal orientation and refraction is very strong but not complete resulting in a longshore current and a breaking zone which runs parallel to the coast. This wave induced current is very effective at transporting sediment alongshore under most swell events. Very large swell events can deposit slugs of sediment offshore northwards of Snapper Rocks resulting in an interruption to the other-wise uniform sandbar.

Coolangatta currently holds the largest profile volume of the Gold coast beaches and the surf zone behaves as an extension of the Snapper Rocks point break. The influence of Greenmount headland on wave refraction is minimal. The western end of Coolangatta is less obliquely oriented to the refracted swell and sediment transport rates are likely to decrease slightly here. Wave heights generally decrease from Kirra Point to Bilinga during S to ESE swell events and then increase again as exposure increases northwards.
Table A: Current activities related to beach protection and management on the Gold Coast

<table>
<thead>
<tr>
<th>Number</th>
<th>Location</th>
<th>Type of work</th>
<th>Estimated cost per year</th>
<th>Lead agency</th>
</tr>
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<tr>
<td>1</td>
<td>NSW Border – North Kirra</td>
<td>Sand bypassing of the Tweed River (dredging and sand bypassing)</td>
<td>$8,000,000</td>
<td>NSW Government</td>
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<td>2</td>
<td>Currumbin Creek – southern Palm Beach</td>
<td>Dredging (and associated beach nourishment) for flood mitigation and water quality</td>
<td>$400,000</td>
<td>GCCC</td>
</tr>
<tr>
<td>3</td>
<td>Tallebudgera Creek – Burleigh Heads</td>
<td>Dredging (and associated beach nourishment) for flood mitigation and water quality</td>
<td>$400,000</td>
<td>GCCC</td>
</tr>
<tr>
<td>4</td>
<td>The Spit – South Stradbroke Island</td>
<td>Sand bypassing of the Gold Coast Seaway</td>
<td>$1,000,000</td>
<td>Qld Government (Dept of Transport)</td>
</tr>
<tr>
<td>5</td>
<td>Numerous locations</td>
<td>Beach nourishment from construction sources</td>
<td>Site specific</td>
<td>GCCC</td>
</tr>
<tr>
<td>6</td>
<td>Whole of coastline</td>
<td>Beach profile surveys</td>
<td>80,000</td>
<td>GCCC</td>
</tr>
<tr>
<td>7</td>
<td>Tweed to Kirra, Palm Beach, Surfers Paradise to Seaway</td>
<td>Video monitoring of beach width</td>
<td>$150,000</td>
<td>GCCC, private contractor</td>
</tr>
<tr>
<td>8</td>
<td>Whole of coastline</td>
<td>Beach cleaning (tractors on beaches)</td>
<td>GCCC</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Various locations</td>
<td>Shark netting</td>
<td>DPI&amp;F</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Whole of coastline, other regions</td>
<td>CoastEd education program General community education program</td>
<td>$35,000</td>
<td>GCCM</td>
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<td>11</td>
<td>Whole of coastline</td>
<td>Lifeguards</td>
<td>GCCC</td>
<td></td>
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<tr>
<td>12</td>
<td>Various locations</td>
<td>Beach Care, dune planting</td>
<td>GCCM, GCCC, NGOs</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Various locations</td>
<td>“A-Line seawall upgrade</td>
<td>GCCC, private property owners $2,000 per lineal metre</td>
<td></td>
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<td>14</td>
<td>Whole of coastline</td>
<td>Oceanway/foreshore parks re-development</td>
<td>GCCC</td>
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<tr>
<td>15</td>
<td>Various locations</td>
<td>Natural area management</td>
<td>GCCC</td>
<td></td>
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<tr>
<td>16</td>
<td>Various locations</td>
<td>Beach access infrastructure management</td>
<td>GCCC</td>
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<td>17</td>
<td>Whole of coastline</td>
<td>Research and development (funding of GCCM research program)</td>
<td>GCCM, GCCC, other       $700,000</td>
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<tr>
<td>18</td>
<td>Whole of coastline</td>
<td>Stormwater</td>
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The large volumes of sediment at Coolangatta and Kirra do not appear to support an increased beach width at Bilinga and the beaches northwards around Tugun. The 1990’s nourishment did not remain in the area for very long at all and the offshore profile appears to be steepening (i.e. losing sediment). The most recent survey data from 2008 does suggest however that the outer bar is widening in this area and
becoming shallower.

**Palm Beach – Currumbin**

Dredging of Currumbin Creek usually results in an interruption to the sediment supply to south Palm Beach as sediment infills the dredged area from the bar. A return circulation cell in the lee of the north training wall of the creek also assists the infilling. During large wave events, particularly those from the south and south-east, sediment bypassing Currumbin Rock can be deposited north of the rock rather than transported shoreward in the lee with the refracted breaking waves of the point break sandbar.

Under extended low wave conditions this slug should provide a slow shoreward supply for central Palm Beach, however the predominantly southeast wave direction ultimately results in natural bypassing around the training wall of Tallebudgera Creek and Burleigh Headland at the northern end of the beach. Easterly extreme wave conditions resulting in the removal of upper beach sand to the offshore storm bar leaves Palm Beach vulnerable to wave attack from successive storms.

The compartment was subject to investigation for the proposed Palm Beach Protection Strategy (PBPS). Community concerns were raised at the time and as a result parts of the strategy were put on hold, with only the initial beach nourishment being carried out. The Littoral Review was also commissioned as an outcome of the concerns, and as a key component of the review, an update on the PBPS was prepared in 2007 and is presented here in Volume 4. As part of the development of the PBPS, approval was sought from the QEPA to amend the Coastal Management Plan. This approval was received in March 2004 and is shown in Volume 4.

**Burleigh compartment**

The Tallebudgera Creek estuary enters the ocean directly to the south of Burleigh Headland. The entrance was stabilised with a training wall in 1981, however, it is still dangerous for navigation (Jackson, 1995). This zone is recognized as a site of great value for educational activities and research.

The presence of the headland influences sediment dynamics and littoral supply to Burleigh Beach. Dominant swells from the south are largely refracted and the headland controls the longshore sediment supply according to the directions of swells and state of Tallebudgera creek entrance. Burleigh main beach has one of the smallest buffer in front of the A-Line Boulder wall (60m). Further north, North Burleigh beach is similarly narrow, but has a dunal system fronting onto parkland reserve. At Burleigh main beach there is a requirement for regular nourishment from Tallebudgera Creek to maintain an adequate width. Natural processes on the beach are constrained by major foreshore infrastructure and parkland on which the community has placed a high value.

**Northern Beaches**

This is the area covered by the Northern Gold Coast Beach Protection Strategy developed in the late 1990s. Beach health in the compartment is influenced by the nourishment and reef construction at Narrowneck. The video beach monitoring shows consistent beach widening, and rapid recovery after storms for the beaches south to Surfers Paradise. Further to the south the beach and foreshores are healthy with partial dunal systems developing in places. However at the southern end of this compartment near Nobbys and Miami the beaches are narrow with oceanfront
development potentially at risk. Despite the more northern beaches being relatively wide, the GCSMP has shown that they record quick and important upper beach recession during storms. Intense development on the overall natural dune system has reduced beach capacity to cope with extreme storm events. Dune preservation is a key strategy for the coastal protection program in this area in the short-medium term.

Although there are some parks and esplanades fronting the foreshore in this compartment there are also significant areas where there is no public reserve and private property adjoins the dune/beach.

South Stradbroke Island

This part of the Gold Coast remains the last natural dune area and has the largest sand stock reserve of all Gold Coast beaches. There has been little or no investigation of shoreline dynamics in the past, and limited hydrographic surveys have been carried out since the 1960s. With the exception of the training of the Gold Coast Seaway walls, there is no shoreline development and the beach and dune systems are allowed to respond naturally to coastal erosion events.

At the southern end, the beach is supplied with the average littoral drift via the Gold Coast Seaway sand-bypassing system. The combined processes of ebb-delta formation and the bypassing deposition have created a popular surfing break. At the northern end of South Stradbroke Island, Jumpinpin entrance is currently displaying previously unseen morphological characteristics which suggest the entrance behaviour may be nearing the end of a natural cycle. The northern end of the island is vulnerable to entrance channel breakthrough and overtopping during extreme events.

4 Overview of key findings by theme

Coastal physical processes

Sandy beaches are the geographically dominant type of shore along the Gold Coast coastline. They underpin a substantial part of the city’s economy and are of immense socio-cultural significance to Australians. A range of research projects were undertaken through this theme, including: a review of coastal physical processes and knowledge gaps; data collection; understanding local wave conditions at each beach; the development of sediment transport models; review of extreme events and their impact; better understanding of the impact of the Tweed River Entrance Sand Bypassing Project on Gold Coast beaches; and the development of physical beach health indicators. A number of key findings are described below:

- The practice of beach nourishment over the past 30 years has been effective as a coastal protection strategy, however, the high costs associated with hydraulically relocating sand, the long-term availability of sand supply, differing community views on coastal management priorities, and the environmental impacts of coastal engineering strategies, indicates that a balance between coastal protection and community values must be found.

- Many Gold Coast beach profiles are quite well accreted and possess an adequate buffer to withstand an erosive event typical of those occurring since 1967. However, a succession of extreme wave events without suitable intervening periods of recovery could erode beaches to the defined A-line. Boulder walls have yet to be constructed or completed in some erosion hot-spot areas like Palm Beach. Dune
care policies and public awareness are key issues for the effectiveness of Gold Coast protection strategies.

- The central beaches of the Gold Coast i.e. Currumbin, Palm Beach and Burleigh are the most eroded beaches at present. Proactive beach protection is required at Palm Beach and Burleigh while reactive post storm nourishment would be suitable for Currumbin and North Burleigh.

- The construction of rock or geotextile groynes on the upper beach has been successful in restoring a usable beach to some areas over the years. Now, however, these highly visible structures are not generally accepted by the public due mainly to their impact on beach amenity and due the transferring of an erosion problem to another location. New options need to be considered for the future protection of Gold Coast beaches. Submerged artificial reefs combined with beach fill programs are one example of more acceptable options recently implemented to protect Gold Coast beaches. Ongoing monitoring and design studies are necessary to demonstrate their effectiveness. In turn this will assist with gaining support from the community for implementation on Gold Coast beaches.

- The long term record of coastal monitoring at the Gold Coast has allowed a detailed investigation into physical coastal processes. This monitoring program should be maintained and expanded to ensure that future investigations have the necessary scientific data on which to base good policy decisions.

A Gold Coast Coastal Network Information System was established as part of this research project to assist GCCC with its coastal management program.

Coastal ecological processes

The Gold Coast's vast sandy beaches provide Gold Coast City Council with an enormous natural asset. The ecological health of the Gold Coast's littoral system is under increasing pressure. The main anthropogenic pressures are coastal development, beach nourishment and reprofiling, mechanical beach cleaning and human trampling. With the exception of large areas of South Stradbroke Island, which remains in a relatively natural condition, these pressures have led to a reduction in the size of natural areas, the loss of habitat corridors and significant modification and degradation along most of the Gold Coast's coastal fringe. Key findings from the ecological processes study are:

- Sand dune systems in the area have been heavily altered by human intervention. Coastal development is without doubt one of the main factors responsible for sand dune degradation as the development of parkland and private property has in many cases led to a loss of natural habitat and a decreased resilience of natural communities. The study into the health of sand dunes found that it is crucial to maintain a wide dune system. These areas need to be managed in order to increase plant biodiversity and keep exotic species under control. The study also found that a wide beach area does not necessarily support a healthy dune ecology.

- The Gold Coast beaches are serviced by major sand bypassing systems at the Tweed and Nerang Rivers. Smaller operations dredging and bypassing operations are also undertaken at Currumbin and Tallebudgera Creeks. Sand from construction sites is also currently placed on the beach at Miami, Broadbeach and Surfers Paradise and periodic beach fill programs have taken place at other beaches. The study into the environmental impacts of beach nourishment at Palm Beach found that the abundance and species richness of intertidal invertebrates are significantly affected by beach nourishment practices in the short term with a
recovery time of up to 5 months. Due to the importance of intertidal invertebrates as a food source and nutrient recycling agents, beach nourishment may have far reaching impacts that may extend to local fish stocks and shorebirds. The longer term impacts are not yet fully understood. Other sources of threat to intertidal invertebrates include mechanical beach cleaning and trampling. Currently there is no information available on the ecological impacts of either of these two activities.

- The study into shorebird populations found that Kirra, Currumbin and South Stradbroke Island were the primary roosting sites for Crested Turns. Overall, however, the Gold Coast region supports low numbers of shorebirds. Major factors in the decline of shorebird populations in the area are loss of habitat due to coastal development and human disturbance. There is anecdotal evidence to suggest that the number of birds that visit the Gold Coast have considerably decreased over the years.

- Rocky reefs in the Gold Coast provide: habitat and shelter for many plants; invertebrates and fish communities; help protect the coast from strong currents and waves; help sustain commercial and recreational fisheries; and provide recreational amenity for diving and snorkelling. Because many of the Gold Coast's reefs are located close to shore, they are often affected by human activities from land or in nearshore areas. Human activities that are likely to be having an impact on reef communities include: beach nourishment practices; alteration of coastline habitats (seawall construction, removal of mangroves); urbanisation and coastal development; domestic and agricultural pollution; oil pollution from boats; stormwater runoff (especially where this carries debris and pollutants) and boat anchoring and over fishing. It was also found that the species abundance and biodiversity of these reefs systems is not currently well documented, understood or managed.
Economic values of Gold Coast beaches

Ocean beaches are a valuable recreation asset for local residents and are an important part of the tourism product for many resort destinations. Loss or damage to them, whether caused by human disasters such as oil spills, or natural disasters such as cyclones, results in diminished utility for users (Raybould & Mules, 1999, p. 121).

The interconnectedness of the coast means that many of the values we associate with the coast are common across resources – and include scenic amenity; recreational amenity; freshwater flows; coastal protection; habitat and biological productivity; sediment sink and source; Indigenous values; spiritual significance; cultural heritage; and nursery habitat.

The study into the economic and social values of beach recreation on the Gold Coast reported that:

- On average residents visited 10 beaches per month during summer and 6 per month during winter – but visitation was strongly influenced by the distance people lived from the beach. Residents use the beach regularly at all hours of the day. Gold Coast residents made a total of just over 40 million beach visits in 2007 and spent somewhere between $21.5 million and $91 million in total (between $64 per adult and $270 per adult) accessing the beach in 2007, however, the non-use values are likely to be significantly higher.

- Approximately 4.9 million day visitors and 4.4 million overnight tourists aged 15 and over visited the Gold Coast in 2006 and accounted for approximately 23 million visitor nights in commercial and non-commercial accommodation. Approximately 30% of day visitors, 49.5% of domestic overnight visitors, and 82.3% of international overnight visitors use the beach at some point during their stay (Tourism Research Australia, 2004, 2006a, 2006b). The study estimated that tourists made just over 7 million visits to Gold Coast beaches in 2006. Based on the information available the researchers estimated of the gross value of Gold Coast beaches to tourists alone was between $106 million and $319 million in 2006.

The study into the economic impact of recreational surfing on the Gold Coast reported that:

- The number of surfers on the Gold Coast ranges between 65,000 and 120,000, of which approximately 35% are visitors. Surfers make between 6 – 15 million person visits to Gold Coast beaches each year.

- The total reported expenditure by recreational surfers on the Gold Coast in 2007 was between $126 and $233 million. If non-use values such as the social and community benefits or costs associated with surfing are included, the economic value of surfing to the Gold Coast is likely to be significantly higher.

- Coastal engineering works have altered surf quality on the Gold Coast over the years (both positively and negatively) and this continues to have a significant economic and social impact on the region.

Community values and stakeholder engagement

As part of this study, GCCM developed a Beach Health Report card for the Gold Coast. The inaugural report found that:
• Services and amenity at most beaches are believed to be of a high standard.

• While the beaches provide important and valuable amenity for both residents and visitors, changes to amenity, overcrowding and conflict at certain locations may require management interventions.

• The Gold Coast beaches have been significantly modified over time. High usage, ongoing infrastructure works and urban squeeze continue to impact on environmental quality and as a result the condition of the natural environment of the dunes, beaches and nearshore zone varies considerably along the coastline.

Public involvement in coastal management programs is integral to both the success and the legitimacy of programs. The benefits of greater public involvement are now well recognised, however the means by which to achieve greater participation and stewardship is not always clear. A number of strategies were developed in order to better understand and engage with key stakeholders and the broader community on coastal issues. Key findings from these investigations are summarized below:

• The Gold Coast is home to a number of small, medium and large community and environmental groups that perform a valuable role in protecting and managing the coastline. These groups participate in a range of activities such as on-ground conservation works, advocacy, education and awareness raising.

• GCCC funding for CoastED and BeachCare provides a good opportunity for students and the community to learn more about coastal management and protection. The programs also help to build stewardship.

• Early and ongoing engagement with the community has significantly improved the ability of GCCC to progress its coastal management program.

The study into the economic and social values of beach recreation on the Gold Coast reported that:

• Gold Coasters undertake a range of active and passive outdoor activities on the beach and foreshore. These include: being outdoors; walking and jogging; spending time with family and friends; swimming and waveriding (e.g. surfing and bodysurfing); bonding with nature; and simply relaxing.

• The three most important factors influencing a resident’s decision to use a beach or foreshore area are directly related to the quality of the environment: cleanliness of the beach (93%); cleanliness of the park areas adjacent to the beach (88%); and water quality (87%).

• Many residents believe that GCCC is doing a good job in the provision of beach management services overall - 52% of residents either strongly agreed or agreed that the natural character of their most visited beach was being well-maintained; and 45% of respondents strongly agreed or agreed that the dune system at their most visited beach appeared to be healthy. By contrast, at their most visited beach, only 25% of respondents strongly agreed or agreed that GCCC appeared to be listening to the concerns of the community.

• The most important issues for beach and foreshore management identified by residents are: coastal protection (including sea level rise and climate change), environmental service provision and traffic, transport and parking related issues.
5. Recommendations

By 2021, the residential population on the Gold Coast is projected to increase by approximately 200,000 to slightly under 700,000 (Gold Coast City Council, 2008) and the 50 year prediction is for the population to grow to approximately 1.2 million residents (Gold Coast Water, 2005). In 2006, approximately 9.3 million (day and overnight) tourists over the age of 15 visited the Gold Coast and they were responsible for approximately 23 million visitor nights (Raybould & Lazarow, 2008). Nationally, international tourism is forecast to grow by approximately 5% per annum until 2016 (latest year that is forecast) and domestic tourism (visitor nights) is forecast to decrease marginally over this same time period (Tourism Forecasting Committee, 2007). No predictions are made about changes to day visitation, which comprises approximately half of the current tourism visits to the Gold Coast.

In the post-Delft Report era, studies by Helman (2007) have shown that the Gold Coast has experienced a period of relative calm in terms of storminess as part of a cycle of climate variability known as the Inter-Decadal Pacific Oscillation which manifests itself primarily in cycles of storminess and elevated sea level. As will be seen in a later section, this corresponds to the period of incredibly rapid population and development growth resulting in ever increasing percentages of the community not having a memory of the Gold Coast during periods of storminess. As a result the community cannot readily identify with the need for beach protection and long term planning, and the infrastructure put in place in response to the Delft Report recommendations has yet to be fully tested with conditions similar those which lead to their design. Exacerbating this is the impending impact of greenhouse-induced climate change which is seeing accelerated rates of sea level rise and changes to the intensity and frequency of storms.

A major challenge for the Gold Coast will be how to maintain quality of life experiences for the rapidly expanding residential population and the balance of nature and tourism that has attracted high numbers of visitors for so many years. This is especially pertinent in a city where despite significant growth to the west, a large proportion of the population and economy is located on a low-lying coastal strip in a relatively hazard prone area.

It is expected that future long term changes in wave climate will result in changes to the rates of erosion and accretion presently encountered. Coastline recession is to be expected from a rise in sea level. Moreover, the combined effect of a possible increase in frequency and intensity of extreme events should encourage preparation for sequences of erosive events such as have occurred in the past. It is anticipated that ongoing beach nourishment will be required over the next 50 years even in the absence of major storms. Whilst this is manageable with appropriate nourishment and structural measures, sources of nourishment sand will diminish making the adaptation strategies proposed here less and less viable in the longer term. Under these circumstances the Gold Coast community will face the likelihood of needing to decide on whether to maintain a beach through a planned retreat process or whether to maintain the current level of coastline development and protect it with hard coastal protection structures. There may of course be options to maintain sections of beach interspersed with protected shoreline development.

The GCSMP has produced a suite of recommendations that will assist GCCC with the progression of best practice coastal management. These recommendations include:
1. Major Capital Works
2. Operational Works
3. Design and Management Guidelines
4. Natural Area Management
5. Community Engagement
6. Resourcing
7. Further Studies

Table B below provides an overview of the beach management and policy recommendations set out in the GCSMP. The key recommendations are highlighted and briefly discussed here. Based on our current understanding of coastal processes and the anticipated changes over the next 50 years, a seawall, built to standard, in conjunction with adequate control structures and a significant sand buffer seaward of the boulder wall, are expected to be able to provide the level of safety that is predicted to be required to protect public and private property (recommendations 7.6, 7.9, 7.15 provide the core recommendations for GCCC’s coastline protection strategy). An increase in the occurrence of major storm events is anticipated and ongoing research and monitoring will be required in order to ensure that GCCC has the knowledge and capacity to adapt its coastal program as required so that beaches can continue to support our lifestyles, the economy and the natural environment (recommendations 7.7 and 7.8 support this). Timely implementation of the Gold Coast coastline management program requires that the EPA endorse the GCSMP as a SEMP (recommendation 9.1). At the local government level, funding and support for the GCSMP must compete with a range of other important priorities. The implementation of the GCSMP, including the provision of advice and recommendations across GCCC directorates can be best achieved if the valuable role that ocean beaches perform on the Gold Coast is fully appreciated by government, business and the community (recommendation 9.3).

**Recommendation 7.6:**

Adopt the preferred option for beach management of nourishment in combination with a continuous seawall at the A-line, with coastal control structures utilised where needed.

**Recommendation 7.7:**

Maintain a skills base in coastal management and engineering within GCCC (and in partnership with the local research and consulting community) to ensure effective implementation of all Shoreline Management Plan recommendations.

**Recommendation 7.8:**

Ensure the viability of the Council’s Hydrographic survey team as the key unit providing physical process information for monitoring and future strategy development.

**Recommendation 7.9:**

Continue to implement the BPA Design Profile for beach nourishment, based on a default value for storm cut of 414m$^3$/m above RL -3m AHD until more sophisticated
storm erosion modelling is developed.

**Recommendation 7.15:**
Retain and maintain existing coastal control structures.

**Recommendation 9.1**
Continue to engage with the EPA to ensure the smooth introduction and implementation of the GCSMP as a state endorsed SEMP.

**Recommendation 9.3**
Provide resources to support a full-time person (either as an employee or consultant) to oversee the implementation of the Ocean Beaches and Foreshores Strategy and the implementation of the Gold Coast Shoreline Management Plan.

### Table B: Beach management and policy recommendations

<table>
<thead>
<tr>
<th>Recommendation Grouping</th>
<th>Recommendation Reference Number</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>POLICY</td>
<td>7.2</td>
<td>Undertake any future coastline management strategy development in the context of whole-of-coastline physical process interactions, and address social, economic and environmental issues in a holistic fashion.</td>
</tr>
<tr>
<td></td>
<td>7.3</td>
<td>Implement a 10-year capital works program to address the infrastructure needs described in this report.</td>
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<tr>
<td></td>
<td>7.5</td>
<td>Undertake a review of the findings of the Shoreline Management Plan in light of the results of this proposed research in 4 years time at the end of the current Capital Works Planning Cycle and again in 10 years at the end of the Service Planning Cycle.</td>
</tr>
<tr>
<td></td>
<td>7.6</td>
<td>Adopt the preferred option for beach management of nourishment in combination with a continuous seawall at the A-line, with coastal control structures utilised where needed.</td>
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<tr>
<td></td>
<td>7.19</td>
<td>Enforce the use of the A-Line (with its associated setbacks) as the seaward limit of foreshore development.</td>
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<tr>
<td></td>
<td>7.27</td>
<td>Adopt a Whole-of-Council approach to management of GCCC’s ocean beaches and foreshores, including a shared vision and strategy for beach and foreshore management. This should be progressed through the development and refinement of the Ocean beaches and Foreshore Strategy.</td>
</tr>
<tr>
<td></td>
<td>7.28</td>
<td>Develop, through GCCM, research partnerships with the State and Federal Government on the impact of climate change to the city and region.</td>
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<td></td>
<td>7.40</td>
<td>Ensure that coastal protection strategies maintain or improve the health of nearshore reefs.</td>
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<td></td>
<td>7.47</td>
<td>Prohibit any development of parkland or other amenity infrastructure on the immediate shoreline (seaward of the A-line) in areas where there is an over-supply of sand from the TRESBP until the beaches reach an equilibrium position.</td>
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<tr>
<td></td>
<td>9.1</td>
<td>Continue to engage with the EPA to ensure the smooth introduction and implementation of the GCSMP as a state endorsed SEMP.</td>
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<td>Recommendation Grouping</td>
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<td></td>
<td></td>
<td>endorsed SEMP.</td>
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<td></td>
<td>9.2</td>
<td>Continue to develop the Ocean Beaches and Foreshores Strategy.</td>
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<td></td>
<td>9.4</td>
<td>Review both the OBFS and the GCSMP within 5 years.</td>
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<td></td>
<td>9.5</td>
<td>Continue to be a strong advocate for coastal management at the local level through membership in and leadership of the QCCG.</td>
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<tr>
<td>MAJOR CAPITAL WORKS</td>
<td>7.17</td>
<td>Complete construction of the “A-Line” seawall.</td>
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<td></td>
<td>7.42</td>
<td>Implement a short term program of offshore dredge spoil transfer from Coolangatta Bay to Palm Beach.</td>
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<td></td>
<td>7.45</td>
<td>Seek commitments from Governments to construct additional outlets for the TRESBP at North Kirra/Bilinga.</td>
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<td></td>
<td>7.49</td>
<td>Implement recommendations of future protection strategies at Palm Beach to be developed by GCCM.</td>
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<td></td>
<td>7.55</td>
<td>Establish a permanent discharge line for the dredging infrastructure (at Tallebudgera Creek).</td>
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<td></td>
<td>7.58</td>
<td>Construct a sea wall at Burleigh main beach as the main coastal protection strategy.</td>
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<td></td>
<td>7.63</td>
<td>Develop a multi-functional artificial reef research and development facility at the Spit as part of a climate change response initiative for shoreline protection.</td>
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<tr>
<td></td>
<td>9.7</td>
<td>Establish a fund with the support of the state and federal governments to purchase coastal lands to return to dunes or public park space to accommodate future climate change impacts.</td>
</tr>
<tr>
<td>OPERATIONAL WORKS</td>
<td>7.13</td>
<td>Continue to monitor and analyse littoral processes through video imaging and hydrographic survey.</td>
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<td></td>
<td>7.15</td>
<td>Retain and maintain existing coastal control structures.</td>
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<td></td>
<td>7.33</td>
<td>Continue building and maintaining fences around sand dune vegetation.</td>
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<td></td>
<td>7.37</td>
<td>Erect signs at locations such as Kirra and Currumbin Alley in order to raise awareness of the importance of shorebirds and the detrimental effects of disturbance.</td>
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<td></td>
<td>7.39</td>
<td>Establish a program to collect data and ongoing monitoring for the natural reefs of the Gold Coast in conjunction with government, the dive industry and NGOs.</td>
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<tr>
<td></td>
<td>7.46</td>
<td>Seek commitments from Governments to relocate the TRESBP offshore dredge disposal areas further to the west.</td>
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<td></td>
<td>7.61</td>
<td>Place appropriate conditions on development approval to ensure that building spoil is taken to Hythe Street Miami instead of margaret Street and Higman Street.</td>
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<td></td>
<td>7.62</td>
<td>Implement a detailed monitoring program for the sand back-passing system from the Gold Coast Seaway to south of Cavil Avenue supported by an enhanced research program addressing sand budget of the northern beaches.</td>
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<tr>
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<td>7.67</td>
<td>Continue to support the monitoring of and research into marine turtles in the area (at South Stradbroke Island).</td>
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<td></td>
<td>7.70</td>
<td>Establish a monitoring program specifically aimed at assessing climate variability and climate change impacts on beach health (at South Stradbroke Island).</td>
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<tr>
<td></td>
<td>7.71</td>
<td>Establish a beach health monitoring program specifically aimed at the impact of sand back-passing on the littoral supply to South Stradbroke Island.</td>
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<tr>
<td>Recommendation Grouping</td>
<td>Recommendation Reference Number</td>
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<tr>
<td>DESIGN AND MANAGEMENT GUIDELINES</td>
<td>7.9</td>
<td>Continue to implement the BPA Design Profile for beach nourishment, based on a default value for storm cut of 414m³/m above RL -3m AHD until more sophisticated storm erosion modelling is developed.</td>
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<tr>
<td></td>
<td>7.12</td>
<td>Develop a “management model” for entrance by-passing schemes.</td>
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<td></td>
<td>7.20</td>
<td>Design coastal protection strategies during the next 50 year period to incorporate both nourishment and control structures. This is on the proviso that the Gold Coast community continues to require wide sandy beaches, and the climate change projections of accelerating sea-level rise and increase storminess continue to be validated.</td>
</tr>
<tr>
<td></td>
<td>7.21</td>
<td>Continue socio-economic investigation of Gold Coast beaches as environmental and recreational resources.</td>
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<tr>
<td></td>
<td>7.24</td>
<td>Clearly define recreational amenity in general and recreational surfing amenity in particular, and set a series of management goals. Where achievable, coastal protection and management strategies need to be developed that incorporate strategies to improve recreational / surfing amenity whilst not compromising coastal security.</td>
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<td></td>
<td>7.32</td>
<td>Develop guidelines for an optimal spacing of beach access paths based on dune ecological integrity.</td>
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<td></td>
<td>7.41</td>
<td>Adopt the Beach Condition Indices for assessment of the need for coastal works and update them as new survey data are available.</td>
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<tr>
<td></td>
<td>7.48</td>
<td>Develop and seek endorsement from Governments for a decision support model to assist in the management of TRESBP dredge spoil and bypassing discharge both in the short and longer term with the aim of maximising community, environmental and coastal protection outcomes.</td>
</tr>
<tr>
<td></td>
<td>7.51</td>
<td>Adopt a post-event nourishment management strategy for Currumbin Beach.</td>
</tr>
<tr>
<td></td>
<td>7.53</td>
<td>Develop and implement a Tallebudgera/Burleigh dredging management plan consistent with expectations for long-term beach protection at Burleigh (including social, economical, physical and ecological monitoring and the establishment of a local community consultative committee).</td>
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<td></td>
<td>7.60</td>
<td>Implement a post-storm nourishment strategy for North Burleigh.</td>
</tr>
<tr>
<td></td>
<td>7.68</td>
<td>Develop appropriate management actions to address the disturbance and damage caused by human 4WD vehicles during marine turtles nesting period (at South Stradbroke Island).</td>
</tr>
<tr>
<td>NATURAL ASSET MANAGEMENT</td>
<td>7.29</td>
<td>Enforce GCCC’s dune vegetation policy subject to revisions, if appropriate in light of recent studies.</td>
</tr>
<tr>
<td></td>
<td>7.30</td>
<td>Undertake a detailed ecological assessment of Gold Coast beaches and develop of a zoning scheme for Gold Coast beaches, where some beaches are given a higher ecological value and managed accordingly.</td>
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<td></td>
<td>7.31</td>
<td>Limit the use of sand dunes and other natural sand systems for parklands.</td>
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<td></td>
<td>7.38</td>
<td>Undertake on-ground management interventions such as</td>
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<td>Recommendation Grouping</td>
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<tr>
<td></td>
<td></td>
<td>seasonal/part beach closures, walkways / interpretive trails, zoning should be incorporated in the South Stradbroke Island Natural Area Management Plan.</td>
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<td></td>
<td>7.59</td>
<td>Develop a dune preservation and education program at North Burleigh.</td>
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<tr>
<td></td>
<td>7.1</td>
<td>Provide the community with information relating to the broad scale nature of coastal processes and the climatic variations which can be expected and their outcomes.</td>
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<td></td>
<td>7.23</td>
<td>Develop new community engagement programs targeting climate change and climate variability impacts and to ensure the continuing success of existing community education programs such as CoastEd and BeachCare.</td>
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<td></td>
<td>7.25</td>
<td>Develop community consultative committees as required in localities along the coast in order to improve dialogue between government and stakeholders.</td>
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<td></td>
<td>7.26</td>
<td>Adopt the Beach Health Report (BHR) as part of its annual reporting process. The BHR provides a mechanism to conduct an annual assessment of our beaches, incorporating the themes ‘people and play’, ‘services’ and ‘beach health’. The BHR can provide GCCC with a litmus test by which to measure the success of its beach management program and community engagement efforts.</td>
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<td></td>
<td>7.34</td>
<td>Support community driven sand dune re-vegetation programs. Expand the existing BeachCare program through increased financial and technical support.</td>
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<td></td>
<td>7.56</td>
<td>Develop a community education program highlighting the diversity of shoreline features and condition, management options and beach safety (at North Burleigh).</td>
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<tr>
<td></td>
<td>7.65</td>
<td>Conduct, promote and support education initiatives eg. talks, guided walks and interpretive trails in order to improve community engagement with natural ecosystem management (at South Stradbroke Island).</td>
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<tr>
<td></td>
<td>9.6</td>
<td>GCCC become an affiliate member of the Australian Coastal Society.</td>
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<tr>
<td></td>
<td>7.7</td>
<td>Maintain a skills base in coastal management and engineering within GCCC (and in partnership with the local research and consulting community) to ensure effective implementation of all Shoreline Management Plan recommendations.</td>
</tr>
<tr>
<td></td>
<td>7.8</td>
<td>Ensure the viability of the Council’s Hydrographic survey team as the key unit providing physical process information for monitoring and future strategy development.</td>
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<td></td>
<td>9.3</td>
<td>Provide resources to support a full-time person (either as an employee or consultant) to oversee the development of the Ocean Beaches and Foreshores Strategy and the implementation of the Gold Coast Shoreline Management Plan.</td>
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<tr>
<td></td>
<td></td>
<td>Fund a program of research to address issues raised in this report, and that it be implemented as part of the 10 year strategic service plan. In particular, GCCM research should continue to be funded in order to investigate the likely changes in climatic forcing relating to shoreline erosion; to develop better models for predicting shoreline change, and to immediately engage with the community in</td>
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<td>Recommendation Grouping</td>
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<td>7.10</td>
<td>Enhance storm erosion modelling to accommodate storm sequences and predicted sea-level rise;</td>
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<td>7.11</td>
<td>Analyse long-term littoral processes under climate change;</td>
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<td>7.14</td>
<td>Complete the conversion of archived Hydrographic survey to digital form as a matter of urgency, to enable a number of analyses, reviews and model developments to be completed or instigated.</td>
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<td></td>
<td>7.16</td>
<td>Investigate the integrity of the wall (A-Line), particularly at locations where either it has been in place for more than 2 decades, or where it has been known to have been exposed during recent storms.</td>
</tr>
<tr>
<td></td>
<td>7.18</td>
<td>Conduct a review of the design of the A-Line seawall in light of alternative construction techniques such as geotextile mega-containers, and in terms of sea-level rise and wave climate predictions under climate change. Recommendations for design upgrades will be made to Council as a matter of urgency.</td>
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<td></td>
<td>7.22</td>
<td>Undertake a socio-economic analysis of options, benefits and costs for climate change adaptation on the Gold Coast.</td>
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<tr>
<td></td>
<td>7.35</td>
<td>Conduct baseline research on the impacts of the Nerang and Tweed River permanent sand by-passing systems and the Tallebudgera andCurrumbin Creek dredging programs on intertidal organisms, recommend, and where possible implement changes in the dredging and nourishment regimes.</td>
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<td></td>
<td>7.36</td>
<td>Determine the degree of impact that mechanical beach cleaning is having on the ecology of the area and find ways to mitigate these impacts.</td>
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<td></td>
<td>7.43</td>
<td>Undertake a study of the cost associated with the extension of the TRESBP outlet to North Kirra, with aim of implementing the use of this outlet for the majority of sand discharge over the next 4 years.</td>
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<tr>
<td></td>
<td>7.44</td>
<td>Undertake a study of the cost associated with the relocation of the approved dredge disposal areas, with the aim of disposing the majority of dredged sand to sites further to the west off Bilinga.</td>
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<tr>
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<td>7.50</td>
<td>Fund and complete the Currumbin Entrance Research Program to establish a more effective dredging program.</td>
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<td>7.52</td>
<td>Fund a Tallebudgera/Burleigh research program.</td>
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<td></td>
<td>7.54</td>
<td>Undertake a socio-economic study to inform the development future beach management strategies, including climate change scenarios (at Burleigh).</td>
</tr>
<tr>
<td></td>
<td>7.57</td>
<td>Undertake a design study for upgrading the A-line at Burleigh Main beach to a standard capable of being the only protection measure for the parkland and ocean front infrastructure during extreme events.</td>
</tr>
<tr>
<td></td>
<td>7.64</td>
<td>Undertake research to support the establishment of seasonal/part beach closures during shorebird breeding seasons (at South Stradbroke Island).</td>
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<td></td>
<td>7.66</td>
<td>Complete research on social and recreational values at South Stradbroke Island.</td>
</tr>
<tr>
<td></td>
<td>7.69</td>
<td>Undertake an entrance dynamics study for Jumpinpin aimed at developing a long-term natural area management plan.</td>
</tr>
</tbody>
</table>
REFERENCES

Beard, N. J. (2001). *An Investigation into Sediment Transport and Beach Dynamics at Burleigh Beach, Gold Coast, Australia*. Gold Coast: Griffith University.


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CHAPTER 1 - OVERVIEW

1.1 Introduction

A lifestyle by the coast represents something more than the prospect of food, clothing and shelter – it has become synonymous with the modern dream in so many nations. Indeed, Dutton (1985 p.13) writes,

“the tradition of Australians at the beach, in its many ways, is of profound importance to the national character.”

The beaches of the Gold Coast have achieved iconic status within Australia and internationally. Gold Coast beaches are exposed to a high wave energy coastline and are regularly subjected to storms and large waves. For almost 100 years, Gold Coast beaches have been modified in one way or another in order to deliver maximum utility to the community. The result is that in order to provide the necessary coastal protection, community, economic and even environmental services necessary to sustain the city and a healthy environment, Gold Coast beaches require active management.

The absolute importance of the beaches to the city may in fact lead to a perception that because the beach is so important, it is the responsibility of many and management may be taken for granted. While it is true that many organisations and people are involved in managing the littoral environment on the Gold Coast, it could be argued that there has been a lack of communication on management goals and strategies across all levels of government, industry and the community.

![Figure 1: Ariel View of Gold Coast](image)

1.2 Importance of coasts and beaches

Coastal areas contain some of the world's most diverse and productive resources, including intensive areas of complex and specialised ecosystems such as mangroves, coral reefs and seagrasses, which are highly sensitive to human intervention (Underwood & Chapman, 1995). People all over the world have concentrated on the coastal margins of continents for a variety of reasons, some of which have changed over time:

- The seas provided a source of food;
• Rainfall is generally greater and more reliable on the coast than inland;
• Coastal lands are usually suitable for a wide range of uses;
• The coastal climate is milder than the extremes found in the interior of the continent;
• Transport was initially easier by sea than across land or in the skies;
• The demand for coastal real estate and ocean views has grown significantly in recent years;
• Changes to our lifestyles have given many people greater flexibility as to where they live and work; and
• Increased leisure time, resulting from greater affluence has changed working conditions and holidays by sea have become attainable (Government of New South Wales, 1989; Harvey & Caton, 2003; OECD, 1991).

As well as regions of high abundance and great beauty, coastal areas are also subject to intense natural variation and vulnerability. Cyclones and monsoons are regular climatic features in tropical and sub-tropical regions of the world. In the temperate regions, low pressure systems deliver storms that can last for weeks, resulting in damage to infrastructure and loss of life. In recent years, two tsunami’s in south-east Asia resulted in tidal waves that destroyed villages and towns in a number of countries. The estimated loss of life from the December 26, 2004 Asian Tsunami is over 200,000 with more than half-a-million people injured and up to five million people are estimated to have lost homes or secure access to food and water (New Scientist, 2005). On the east coast of Australia the last major cyclone season was in 1974. Since that time there has been extensive migration to and development adjacent to the coast, much of it in the last decade (Burnley & Murphy, 2004; Salt, 2001). The risks believed to be associated with this ‘coastal squeeze’ are not necessarily restricted to humans and our way of life, but can have significant anthropogenic effects as natural systems are restricted and modified. Harvey and Caton (2003, p. 3), in their book titled ‘Coastal Management in Australia’ write that

The coast is naturally dynamic at a variety of time scales. Important changes are not only brought about by human use, but also by natural forces. For example, coastal wetlands are lost through local relative sea level change as well as through reclamation and development. Coasts are eroded by wave action, as well as through human activities such as harbour construction. Sand dunes are destabilised by storms or fires, as well as by vehicle impact.

Globally, there are a number of commonalities that can be ascribed to coastal areas early in the Twenty-First Century. These are:

• Most of the world’s population lives on or near the coast. Harvey and Caton (2003) quote Agenda 21 (Chapter 17.3 Section 3), which stated that in ‘1992 more than half the world’s population lived within 60km of the coast, and that by the year 2020 this proportion could rise to two-thirds’;
• People have traditionally chosen to live near the coast because coastal resources have been reliably abundant, which meant that populations were able to settle and grow;
• Increasing development and population growth in the coastal zone combined with an increasing dependency on the coastal resource base is placing significant pressure on coastal systems; and
1.2.1 Population growth and development on the Gold Coast

Understanding the coast and the challenges facing coastal management on the Gold Coast is best understood in the context of population growth and development. The population on the coast has grown significantly in recent years (see Figure 2). As described in Table 1, in the period 2001-6, the population grew at an average of 3.3% per annum (Australian Bureau of Statistics, 2007a). This slowed slightly to 2.8% in the 2005-6 year, when 26% of the population was aged 55 and older and the age group 25-54 comprised 41.8% of the population.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>1996</th>
<th>2001</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>375,175</td>
<td>441,736</td>
<td>507,876</td>
</tr>
<tr>
<td>Males</td>
<td>182,810</td>
<td>215,104</td>
<td>248,740</td>
</tr>
<tr>
<td>Females</td>
<td>192,365</td>
<td>226,632</td>
<td>259,136</td>
</tr>
<tr>
<td>Ages 0-4</td>
<td>6.2%</td>
<td>6%</td>
<td>5.8%</td>
</tr>
<tr>
<td>5-14</td>
<td>12.4%</td>
<td>13.1%</td>
<td>12.5%</td>
</tr>
<tr>
<td>15-24</td>
<td>6.3%</td>
<td>13.2%</td>
<td>13.4%</td>
</tr>
<tr>
<td>25-54</td>
<td>49.5%</td>
<td>42.1%</td>
<td>41.1%</td>
</tr>
<tr>
<td>55-64</td>
<td>9.4%</td>
<td>10.4%</td>
<td>11.9%</td>
</tr>
<tr>
<td>65 and over</td>
<td>16.1%</td>
<td>15.2%</td>
<td>15.3%</td>
</tr>
</tbody>
</table>

Gold Coast City’s population is expected to grow by an average of 2.4% per year between 2001 and 2026, compared with SEQ (1.7%) and Qld (1.5%). The city is expected to account for 20.4% of the State’s growth over this 25-year period (Government of Queensland, 2003a). Queensland’s population is projected to grow by 46% between 2001 and 2026, from 3.6 million to 5.3 million, compared to Australia’s projected growth of 25% (Australian Bureau of Statistics, 2004).

![Gold Coast Population Growth 1996 - 2006](image)

**Figure 2: Gold Coast Population Growth 2001 – 2006 (Australian Bureau of Statistics, 2007b).**

While many perceive the Gold Coast population to be highly transitory, a recent survey of Gold Coast residents found that 85% of respondents had been living on the Gold Coast for more than 5 years and 70% of respondents had been living in the city for more than 10 years (Raybould & Lazarow, 2008). These figures, however, do not account for internal migration.

Professor Paul Burton (pers. comm. May 2008) of the Urban Research Program at Griffith University comments that growth over the past 50 years has come in waves, with the peaks related to the successive publicity campaigns to position the Gold Coast as a desirable place to live. Burton adds that

> [C]ertain legislative and policy changes have made moving to and buying property on the Gold Coast more attractive including the policy of removing death duties which has made the Gold Coast population growth uneven. Political and economic factors have been associated with those peaks.

Some of the major infrastructure responses to population growth over the past generation have been:

- The expansion of the Pacific Highway between the Gold Coast and Brisbane to four lanes by 1970;
- The rail link from Robina to Brisbane and plans to extend the link to Coolangatta within the next 10 years (note a rail link to the NSW border existed until the early 1960s);
- The opening of the Gold Coast airport in 1981 and current plans for expansion;
Construction of the Gold Coast Seaway in 1986, which allows vessels safer access to the ocean; and

Water infrastructure including the Hinze dam, construction of the south east Queensland water grid and the desalination plant at Tugun (Gold Coast City Council, 1993; Wikipedia, 2008).

1.2.2 The rise and rise of tourism on the Gold Coast

For the year ending June 2004, the Gold Coast received a total of 4.3 million overnight tourists with 65% declaring the purpose of their visit was for holiday/leisure. Further research into nature-based tourism on the Gold Coast (Gold Coast City Council, 2003) has shown that 56% of all overnight visitors and 30% of all day-trippers go to the beach during their stay on the Gold Coast.

More recently a report into tourism on the Gold Coast estimated that in 2006 approximately 9.3 million domestic and international tourists over the age of 15 visited the Gold Coast (day and overnight visitors). These visitors made an approximate 7 million beach and foreshore visits. Domestic overnight visitors on the Gold Coast stay for an average of approximately 5 nights while international visitors stay for an average of approximately 7 nights (Tourism Research Australia in Raybould & Lazarow, 2008).

1.3 The need for a comprehensive investigation

The south east Queensland area extends from north of the Tweed River to Fraser Island and comprises wetlands, offshore sandy islands (South Stradbrooke Island, North Stradbrooke Island and Moreton Island), Moreton Bay, long sandy beaches, rocky headlands, tidal mudflats, salt marshes and estuaries. The region has provided data for study by natural resource scientists, but in particular the Moreton Bay area has been a magnet for study. The area was recognized by the Ramsar Convention and Moreton Bay was declared a Marine Park in 1993 and the Marine Park (Moreton Bay) Zoning Plan was declared in 1997. By contrast, the area south to the border has received a limited amount of investigation and significant gaps in our knowledge base on issues such as physical coastal processes, environmental and economic values and current and predicted human use of the region. Research reports related to the development of Gold Coast City Council’s Nature Conservation Strategy, catchment and waterway management planning have made significant progress towards improving our understanding of the natural environment, however there remained a gap in our understanding of the coastal zone.
As one of Australia’s premier tourist resort cities, the Gold Coast is highly dependent on its reputation for golden sandy beaches, warm turquoise waters and endless sunshine. After extreme beach damage in the mid 60’s and late 70s, the Gold Coast City Council recognised the beaches as the basis of the tourism industry and quality of life on the Coast, and the crucial need to preserve them (Beard, 2001). Not only are Gold Coast’s beaches important to the city, they are also an important asset for Queensland. Using the figures in the Qld State of the Environment Report it is apparent that the Gold Coast received the same number of tourists in 2002 as the area of coast from Mackay to the Northern Territory border.

![Figure 4: Beach nourishment at Burleigh Beach](image)

### 1.3.1 Coastal works

The predominantly sandy coastline is exposed to high energy waves for much of the year and over time there has been significant damage to public and private infrastructure as a result of intense weather events. Records documenting management approaches involving significant works programs along the coastline, date back over 100 years and include the construction of seawalls, river training walls, groynes, beach nourishment campaigns, sand bypassing systems and an artificial reef.

The Queensland Government has a long history of involvement in planning for and managing the Gold Coast littoral environment. For example, after a series of storm events in the 1950s threatened buildings and roads, the government invited the Delft Hydraulics Laboratory (DHL) to advise them on ways of minimising erosion problems. In 1965 a report was received detailing the data required for good management of erosion on beaches (Delft Hydraulics Laboratory, 1965; Gourlay, 1996). Following more cyclones in 1967 and the accumulation of a limited amount of data, a report (Delft Hydraulics Laboratory, 1970) on sediment transport patterns and recommendations for coastal protection works was presented to the state government. Gold Coast City Council and the Queensland Government have implemented many of the recommendations in the report. DHL and the Queensland Government have also updated the sediment transport calculation for the southern end of the Gold Coast based on an improved data set (Delft Hydraulics Laboratory, 1992; Gourlay, 1996).

There is a well-documented historical record of major events causing significant damage to both public and private property on the coast, including the loss of public reserves along the beachfront. Local government, in some cases with the financial assistance of State and Federal governments has undertaken a range of coastal
protection works over the years. Table 2 describes the value and type of expenditure related to beach management in 2007-08. At $13.54 million, this equates to just over 1% of GCCC’s budget for the year.

Table 2: Gold Coast City Council beach management costs in 2007-08

<table>
<thead>
<tr>
<th>GCCC Activity</th>
<th>Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Coastal Protection Works</td>
<td>$2.85M</td>
</tr>
<tr>
<td>Beach Maintenance</td>
<td>$2.1M</td>
</tr>
<tr>
<td>Capital Works (primarily beach access projects)</td>
<td>$1.57M</td>
</tr>
<tr>
<td>Lifeguard Service</td>
<td>$7.02M</td>
</tr>
<tr>
<td>Total</td>
<td>$13.54M</td>
</tr>
</tbody>
</table>

Source: GCCC

Coastal projects undertaken by in the region include the construction of rock sea walls along most of the Gold Coast coastline; the construction of major training walls at the Tweed River, Gold Coast Seaway, Tallebudgera and Currumbin Creeks; rock groynes at Kirra and Palm Beach; offshore sand dredging campaigns at a number of locations; sand bypassing systems at the Gold Coast Seaway and Tweed River; and the Northern Gold Coast Beach Protection Strategy, which included the construction of the Narrowneck artificial reef. As well as this, regular dredging occurs at Tallebudgera and Currumbin Creeks.

Major foreshore redevelopment projects providing access to and along the beach have occurred as part of the Gold Coast Oceanway program. Ongoing maintenance projects include: renewal of beach fencing; beach cleaning; and boardwalk and beach shower maintenance. Council also has a very strong commitment to providing safe, enjoyable beaches through the provision of a professional lifeguard service.

To the visitor and to the untrained eye, the beaches of the Gold Coast are often described as looking healthy, however the significant infrastructure works on the coastline over time has led to a highly modified coastline where environmental values have been given secondary consideration as the beaches, dunes and foreshores have been squeezed between an often angry and rising sea and a growing population that places an extraordinary value on the benefit of living very close to the ocean.

Figure 5: Aerial view of Palm Beach groyne

1.3.2 Public perceptions

Recent coastal protection works such as Palm Beach Protection Strategy (PBPS) 2001 – 2004 and the Tweed River Entrance Sand Bypassing Project have highlighted a lack of understanding and acceptance of coastal works within the
community. Concerns from the public include changed beach profiles, beach widths, changes to recreational amenity and the degradation of environmental values such as impacts on natural reef systems.

The consultation process of the PBPS demonstrated that there is a lack of understanding of coastal processes and sediment transport at a ‘whole-of-city’ scale. The process also highlighted differing views held by GCCC compared to some sectors of the local community, community values and how best to communicate with key groups in the local community. These shortcomings highlighted the need to undertake a major community engagement process in conjunction with any littoral review in order to ensure that the proposed options for managing the Gold Coast beach environment are socially acceptable as well as technically sound.

1.3.3 Current management context

Local government is a product of State government legislation and has a significant set of responsibilities for day-to-day management of the Australian coastline including authority for planning, development, certain infrastructure, water (in some cases), pollution, environmental protection and recreation management. Over the years, the role of the state government in coastal management has changed and since the introduction of the Coastal Protection and Management Act in 1995, coastal planning has become a focus of the Environmental Protection Agency (EPA). Management of Gold Coast Beaches must take the State Coastal Management Plan (SCMP) as well as other key planning and legislative instruments including: the Integrated Planning Act (1997); the South East Queensland Regional Plan (2004); and the Southeast Queensland Regional Coastal Management Plan into consideration.

Gold Coast City Council is the authority that currently deals with the day-to-day management of the littoral system. As well as the foreseeable challenges, adapting to or mitigating the impacts of climate change, in particular increased storms and flooding, presents a significant challenge for a city in which much of the built environment is constructed over swamp and wetland areas and is located very close to sea level – and the people that live and work in this vicinity place a significant premium on being located so close to the coast.

Large amounts of development have occurred on the sand dunes of the Gold Coast, which limits the beach’s ability to cope with natural storm erosion events. Active involvement in managing the beach system is required. However, the community has begun to question the current activities undertaken to manage the beach and a review of the current approach was needed.
In summary the Gold Coast littoral environment can be described as a high-energy open coast. Large amounts of sediment are transported along the shore with a net annual transport rate of 500,000 m³. In the 50-year planning period this system is basically in equilibrium with the major impact coming from the cross-shore movement of sand during large events such as cyclone.

In 2004, GCCC in conjunction with the Griffith Centre for Coastal Management prepared a discussion paper on ‘A Way Forward in Managing the Gold Coast Littoral Environment’, (Stuart & Tomlinson, 2004), which intended to act as a catalyst for a review of our understanding of the Gold Coast littoral environment, including the need to identify key gaps and how information and decision-making could be better synthesised to improve decision-making. The discussion paper identified a number of gaps in existing knowledge and policy structure. For example, the authors identified a number of examples of environmental reporting that identified coastal issues such as water quality, estuarine health environmental but not factors such as the volume of sand available to act as a buffer zone during stormy periods or the importance of the biological environment in the nearshore environment and the sand. The report identified a gap across the major policies – despite the importance of beaches, they did not neatly fit into the current natural resource management schematics and this presented a number of challenges for Gold Coast City Council.

1.3.3.1 An holistic approach to coastal management

In response to the specific issues affecting the coastal zone, the practice of coastal zone management or coastal management has emerged as a distinct sub-branch of natural resource management. Coastal management as a recognised and independent academic and planning discipline is almost forty years old. Records of course go back to at least the time of Emperor Justinian in 530A.D.

Many of the key coastal management issues faced today are common across borders and between nations and hence many countries face similar planning and management concerns for the coastal zone (there are, however, some marked differences between nations’ ability to successfully deal with coastal management issues). It is now widely accepted that coastal planning and management, as with most other streams of natural resource management, requires a focus on both resource outcome and management processes (RAC 1993, Kay and Alder 1999, Thom and Harvey 2000, Lazarow 2002). This implies an interaction between all levels of government, industry and the community for how we plan, manage, live, work and recreate in the coastal zone. This integrated and coordinated approach to management has been a common imperative across most NRM policy development in Australia over the past decade and is underpinned by the National Strategy for Ecologically Sustainable Development (Commonwealth of Australia, 1992), which states that as a nation we should be:

> using, conserving, and enhancing the community’s resources so that ecological processes, on which life depends, are maintained and quality of life for both present and future generations is increased.

The dimensions of coastal management were outlined in the early 1990s by Kenchington and Crawford (1993) – see Table 3. Central to this is the concept of integration – for understanding problems, treating issues holistically and also for breaking down previously sectoralised management approaches that were characteristic of many government agencies (e.g. see Harvey & Caton, 2003; Kay & Alder, 1999). As well as government specific legislation, policies and manuals, a
number of well-known manuals or guides have been prepared to assist with the
development of coastal programs ((Cician-Sain & Knecht, 1998; J. Clarke, 1996; Kay
& Alder, 2005).

Table 3. Dimensions of Integrated Coastal Management

<table>
<thead>
<tr>
<th>Focus</th>
<th>Connectivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inter-governmental integration</td>
<td>All levels of government are required to be involved in planning and management decisions that will impact upon the coastal environment (otherwise known as vertical integration).</td>
</tr>
<tr>
<td>Inter-sectoral integration</td>
<td>Prior to ICM efforts coastal management suffered from fragmentation between sectors of government and the ‘tyranny of small decisions’ (otherwise known as horizontal integration).</td>
</tr>
<tr>
<td>Systems approach</td>
<td>The interconnection between the land-water interface and that an understanding of ecological processes is important.</td>
</tr>
<tr>
<td>An interdisciplinary and holistic approach to management</td>
<td>Natural and human systems and their component parts and interrelationships are included in management decisions and are inclusive of traditional, cultural and historical perspectives and input from key stakeholders at the community level.</td>
</tr>
</tbody>
</table>

Source: (Kenchington & Crawford, 1993)

Harvey (2004, p. 568) defines Integrated Coastal Management (ICM) as follows:

>a continuous and dynamic process incorporating feedback loops which aims to manage human use of coastal resources in a sustainable manner by adopting a holistic and integrative approach between terrestrial and marine environments; levels and sectors of government; government and community; science and management; and sectors of the economy.

In the context of the development of the GCSMP, an holistic approach has three significant requirements:

1. That the best science available be used in the development of the GCSMP and this requires on dialogue and partnership between all levels of government, industry, the NGO community and the general public;
2. That the community is involved in a meaningful way; and
3. That decisions are made in the best interests of the environment, the community and the economy.

The existing policy framework provides a set of guidelines for the development and implementation of coastal programs. This framework has been used to development Gold Coast City’s approach to coastal planning and management.

At present many of the major policies that direct coastal planning and management are under review. This will be discussed in more detail in Chapter Two.

1.3.4 Defining the coast

The coastline of mainland Australia is 36,000km long, not including external
territories, it spans more than 5000kms from the tropics (90S) to temperate latitudes (470S) and includes approximately 12000 islands within its Exclusive Economic Zone (EEZ) (Commonwealth of Australia, 2006; Ward & Butler, 2006).

State governments in Australia have the primary responsibility for establishing legislation to define, manage, use and protect the coast. The coastal zone can be defined in a number of ways:

1. Cadastrally, that is using existing jurisdictional boundary lines;
2. Geographically, that is using existing natural boundaries such as rivers or catchments;
3. Spiritually, that is by understanding what it means to be a coastal person or community;
4. Naturally, that is by using and habitat or species range such as migratory species (e.g. birds) or habitat corridors; or
5. By a combination of these methods.

Signed in 1979, the Offshore Constitutional Settlement defines the seaward boundary for each of the States as being three-nautical miles out to sea (except in some cases where State jurisdiction extends out to sea to include islands e.g. the Recherche Archipelago in Western Australia) and provides the States with management authority for this region. Definitions of the landward boundary of the coastal zone, however, vary significantly from state to state. This suggests two important points. Firstly, there are large differences in the respective legislative arrangements for coastal planning across the states; and secondly, that the coastal zone is a highly contested space.

In Queensland, the coast is defining with the State Coastal Management Act (1995) as including ‘coastal waters or all areas to the landward side of coastal waters in which there are physical features, ecological or natural processes or human activities that affect, or potentially affect, the coast or coastal resources.’ The coastal zone or the littoral zone, however, is described as the narrow band that straddles the land / sea divide.

For the purposes of this report, the littoral environment is considered to be from the rear dune fence or boulder wall alignment to the offshore zone where sand deposits for beach nourishment may be. This takes in the active zone of littoral transport but also those areas outside the active zone that may act as sediment sources.
1.4 Recent background to this review

The Littoral Review Discussion Paper (Stuart & Tomlinson, 2000) identified a range of elements that needed to be included in a review of the management of Gold Coast beaches. In general, these covered:

1. The need to improve our understanding of the physical environment;
2. The need to improve our understanding of beach and coastal ecological process;
3. The need to improve our understanding of the economic value of Gold Coast ocean beaches;
4. The need to better understand community values, how to engage with stakeholder and how to incorporate local knowledge in decision-making more effectively;
5. The need to improve our understanding of disaster management planning; and
6. Determining the appropriate policy and program responses for coastal planning and management over a 50-year period.

1.4.1 Current policy setting

The SEQ Regional Coastal Management Plan (2006) established the key coastal management outcomes for South East Queensland. The Littoral Review Discussion Paper (Stuart & Tomlinson, 2000) considered that there was a lack of information about the Gold Coast and priority management areas for this region. The authors concluded that ‘there remains a significant threat to the tourism industry, livelihoods and lifestyles of the region from beach erosion.’

In response to this discussion paper GCCC determined that it was necessary to undertake a Littoral Review of the current state of knowledge of the sandy beach environment. The most appropriate way forward was to incorporate a Littoral Review into a Shoreline Management Plan which would complement the existing SEQ Regional Coastal Management Plan in order to address the additional management requirements needed to maintain or protect the coastal resources and their values on
open coastlines such as the Gold Coast that are under pressure from high recreational use, development and natural coastal processes.

*The current scheme of works or coastal management plan, prepared by the Beach Protection Authority in 1973 and last updated in 2004, is the current shoreline management plan and it is expected to continue to be the relevant approval under the new RCMP. As the recommendations of the Delft Reports that made up the existing plan are now close to completion, it was considered timely to prepare a new shoreline management plan.*

Many traditional and innovative beach protection projects have been undertaken on the Gold Coast using the information and recommendations included in the Delft reports (Boak et al., 2001). As these recommendations are now close to being fully implemented it would appear to be an appropriate time to reflect on how the Coast has been managed.

This review is intended to satisfy the requirements by the Environmental Protection Agency for the development of a Shoreline Erosion Management Plans (SEMPs), which is the EPA’s preferred method for local governments to address shoreline erosion issues at the local government level. The primary purposes of a SEMP are to enable local government to proactively plan for erosion management in hotspot areas in a way that is consistent with the government policies; investigate and address the underlying causes of shoreline erosion and likely future progression at the local scale; and to determine cost effective and sustainable erosion management strategies that maintain natural coastal processes and resources and consider community needs in both the short- and long-term (Government of Queensland, 2006a, pp. 1-2).

Shoreline Management Plans, however, are not limited to a consideration of coastal physical processes issues and may cover a range of ecological and socio-economic considerations also. The EPA has the responsibility for ensuring that the final management strategy is consistent with all relevant policies and guidelines. SEMP’s are discussed in more detail in the following chapter.

1.4.2 **Determining who should be involved**

The Discussion paper identified a range of key stakeholders that needed to be involved. These included:

- Personnel involved in operational tasks
  - Capital Works
  - Maintenance
  - Encroachment
  - Clean Beaches
  - Access
  - Facilities such as showers, toilets, changing rooms
  - Event management
  - Lifeguard services
- Personnel involved in planning and stakeholder engagement
Community engagement programs
Educational programs
On-ground works
Community groups
Key stakeholder groups such as sporting and lifesaving organisations
Advocacy groups

- Government bodies
  - Gold Coast City Council
  - Other Local Government bodies e.g. Local Government and Shires Association
  - State Government e.g. Environmental Protection Agency, Department of Primary Industries and Fisheries and the Department of Natural Resources and Water
  - Commonwealth Government e.g. Commonwealth agencies and South East Queensland Catchments

In 1999, the Griffith Centre for Coastal Management and Gold Coast City Council formalized a strategic partnership whereby the Centre provided GCCC with independent advice on coastal planning and management as well as undertaking a range of coastal educational initiatives in conjunction with GCCC. This partnership has proven to be highly effective and GCCM was asked to work with GCCC to undertake the Littoral Review and to develop the Gold Coast Shoreline Management Plan.

1.5 Objectives of the study

The three year program of review and plan development was commenced in 2005 and is referred to as the Gold Coast Shoreline Management Plan (GCSMP). It is a review of the social, environmental and economic processes that impact on the way we manage our sandy beaches. The major outcome of the review is the development of a new shoreline management plan to guide coastal works for the next 50 years.

The GCSMP focuses research and planning on how we manage our beaches and shoreline and provides a mechanism to review all available previous investigations, identify knowledge gaps, undertake new research and identify priority areas for action. Supporting the sustainability of the natural environment will underpin our lifestyles and economy into the future.

The GCSMP focuses on the management of the sandy beach environments from Pt Danger to Jumpinpin, concentrating on the littoral zone, defined as the area from the rear dune fence or boulder wall alignment to the offshore zone where sand deposits for beach nourishment may be. This takes in the active zone of littoral transport but also those areas outside the active zone that may act as sediment sources. The key focus is on the sandy beach environment.

The purpose of the GCSMP is to:
1. Ensure that beaches continue to contribute to coastal lifestyles [Social] and our tourism economy into the future;
2. Sustainably manage our sandy beach environment; and
3. Develop coastal protection measures to deal with current erosion issues and forecasted effects as a result of both natural trends and climate change predictions.

In summary, the GCSMP provides coastal management and protection guidelines for GCCC to deal with current erosion issues and forecasted effects as a result of both natural trends and climate change predictions without compromising our way of life. This is consistent with the objectives of a SEMP.

The partnership model between GCCC and GCCM is intended to help achieve the principle of coordinated management as described in the State Coastal Management Plan. Importantly, there is significant synergy between the Gold Coast Shoreline Management Plan and the Regional and State Coastal Management Plans.

The Gold Coast Shoreline Management Plan is structured around five major themes and complements the State Coastal Management Plan (see Section 2.6.3). The key tasks for each of the GCSMP themes is described in Table 3 below.

1. Coastal physical processes;
2. Coastal ecological processes;
3. Economic values of Gold Coast beaches;
4. Community values and stakeholder engagement; and
5. The development of a beach management plan.

The first four of these are presented here in the form of the Littoral Review prescribed by Stuart & Tomlinson (2001). The fifth theme takes the knowledge described in themes 1 to 4, and sets out a series of recommendations for a shoreline management plan. This is complimented by additional discussion of policy and emergency management frameworks.
Table 4. GCSMP Theme Overview

<table>
<thead>
<tr>
<th>Theme</th>
<th>Key tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Beach Processes</td>
<td>1. Determine the nature and geographic distribution of the physical processes and resources of open ocean sandy beaches of the Gold Coast.</td>
</tr>
<tr>
<td></td>
<td>2. Develop a sandy beach assessment matrix based on a qualitative conceptual model of ecosystem function based on quantitative field data, sandy beach morphology (eg sand transport and sand budgets) and the identification and modelling of pressures (recreation, coastal engineering, encroaching development etc)</td>
</tr>
<tr>
<td></td>
<td>3. Identify best management practices for sandy beaches of the Gold Coast and develop implementation plans that initiate a number of on-ground works.</td>
</tr>
<tr>
<td>Ecological Beach Processes</td>
<td>1. Undertake a literature review to determine our existing knowledge and understanding of ecological processes and habitat on Gold Coast beaches.</td>
</tr>
<tr>
<td></td>
<td>2. Develop an implement a number of projects that determine the nature and geographic distribution of the key ecological resources of open ocean sandy beaches of the Gold Coast.</td>
</tr>
<tr>
<td></td>
<td>3. Identify best management practices for sandy beaches of the Gold Coast.</td>
</tr>
<tr>
<td></td>
<td>4. Contribute to GCCC’s understanding of the ecological importance of open ocean beaches, including the development of beach health assessment tools.</td>
</tr>
<tr>
<td>Economic Value of Beaches</td>
<td>1. Use existing research and information to provide an overview of the importance of sandy beaches to the Gold Coast economy.</td>
</tr>
<tr>
<td></td>
<td>2. Undertake a range of studies to determine the economic value of Gold Coast beaches and to establish the impact of beaches on the Gold Coast’s economy.</td>
</tr>
<tr>
<td></td>
<td>3. Explore and recommend strategies to help improve the economic value of the beaches the local community and to visitors to the Gold Coast without compromising coastal security</td>
</tr>
<tr>
<td>Community Values</td>
<td>1. Determine the values the community currently places on the Gold Coast beaches and those that they wish to see protected into the future.</td>
</tr>
<tr>
<td></td>
<td>2. Increase the level of trust the community has in the coastal decision makers.</td>
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<tr>
<td></td>
<td>3. Develop community based beach health indicators by engaging with the community and key stakeholders on a number of strategic projects.</td>
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<tr>
<td></td>
<td>4. Help develop a shared vision for Gold Coast beaches.</td>
</tr>
<tr>
<td></td>
<td>5. Development of a community engagement strategy to ensure the clear definition of the values that the community currently places on the Gold Coast beaches and what values they wish to see protected into the future.</td>
</tr>
<tr>
<td>Beach Management</td>
<td>Establish best practise management techniques on provide support to officers charged with the responsibility of day-to-day and long-term management of the Gold Coast beach environment.</td>
</tr>
<tr>
<td></td>
<td>Interpret the technical information from the other project themes (ecological and physical beach processes, community and economic values) and provide support for making management decisions.</td>
</tr>
</tbody>
</table>

1.6 Structure of this report

The GCSMP is structured around a series of chapters covering each of the five themes. In Volumes 1 and 2, there are 6 chapters providing a Littoral Review of
Chapter Two provides a geographical, historical and legislative overview of the Gold Coast area as it relates to coastal planning and management, including regional meteorology and an historical overview of climate change as well as the identification of beach condition and some of the key problem areas on the Gold Coast. Chapter Three describes the Community Values Theme of the GCSMP. Chapter Four describes the Ecological Processes Theme of the GCSMP. Chapter Five describes the Economic Value of Beaches Theme of the GCSMP. Chapter Six presents the Physical Processes Theme of the GCSMP.

Volume 3 encompasses the three chapters which together form the frameworks of the shoreline management plan. Chapter Seven presents the recommendations for the GCSMP. Chapter Eight presents an overview of current GCCC policies. Chapter Nine is the Emergency and Disaster Action Plan.

In addition there are two more volumes:
- Volume Four is the Appendix; and
- Volume Five is a compilation of reports, studies, papers and publications that were produced as part of the GCSMP.

1.7 Chapter Summary

The beaches of the Gold Coast have achieved iconic status within Australia and internationally. Beaches are important to the Gold Coast for a number of reasons:

1. They provide an important coastal protection buffer between the land, which is highly urbanised, and the high energy ocean;
2. Gold Coast beaches, which are all publicly owned and accessible, provide an important focus for recreation for the city’s 500,000 residents;
3. The beaches form the basis of the region’s tourism industry, which is of significant economic importance to the city; and
4. Beaches and the nearshore zone provide valuable environmental habitat.

Gold Coast beaches are exposed to a high wave energy coastline and have a long history of being subjected to storms and large waves. The Gold Coast’s population has grown rapidly in recent years and many newer residents are unfamiliar with the type of storm and cyclone impacts that have the potential to cause significant damage to the coastline.

The high value placed on the Gold Coast beaches and the historically high level of intervention requires that a forward thinking management plan be developed – the Gold Coast Shoreline Management Plan.

For the purposes of the GCSMP, the littoral environment is considered to be from the rear dune fence or boulder wall alignment to the offshore zone where sand deposits for beach nourishment may be. This takes in the active zone of littoral transport but also those areas outside the active zone that may act as sediment sources. The Gold Coast Shoreline Management Plan is structured around five major themes and complements the State Coastal Management Plan. These are:

1. Coastal physical processes;
2. Coastal ecological processes;
3. Economic values of Gold Coast beaches;
4. Community values and stakeholder engagement; and
5. The development of a beach management plan.

The GCSMP is underpinned by an holistic approach to management. This requires that:

1. Best science available be used in the development of the GCSMP and this requires ongoing dialogue and partnership between all levels of government, industry, the NGO community and the general public;
2. The community is involved in a meaningful way; and
3. Decisions are made in the best interests of the environment, the community and the economy.

In summary, the GCSMP provides coastal management and protection guidelines for GCCC to deal with current erosion issues and forecasted effects as a result of both natural trends and climate change predictions without compromising our way of life. This report is consistent with the guidelines set out by the EPA for the preparation of a SEMP and will be adopted as GCCC’s SEMP.
CHAPTER 2 - THE STUDY AREA

2.1 Introduction

The Gold Coast, a city of approximately 500,000 people, is located 75km south of Brisbane in Queensland’s south east. The ocean beaches of the Gold Coast beach extend for approximately 50km from Jumpinpin at the north of South Stradbroke Island through to Point Danger on the NSW border. A number of large submarine reefs exist offshore (McGrath & Robinson, May 1971).

Historically, Gold Coast beaches had typically distinct topographical features or lush vegetation. The Gold Coast area is a West-to-East sloping basin of pre-Pleistocene bedrock. Close to the coast this bedrock is covered by a band of low elevation sand and swamps fringed by coastal dunes. Extensive development of the coastal fringe over the past 100 years has significantly modified or destroyed this coastal dunal system.

Today, with the exception of Burleigh Heads National Park and The Spit, the majority of the area has been taken up for residential development, including significant infilling and modification of the adjacent coastal swamp area.

2.2 Major geographical features

2.2.1 Volcanoes on the Gold Coast Hinterland

The rocks that form most of the hills on and behind the Gold Coast are ancient (Paleozoic) rocks about 300–350 million years old (Wilmot, 1992). These rocks were laid down in deep water as mud and sand and in some places as gravel. A great thickness was deposited and over time it compressed and squeezed, converting mud into shale and siltstone and then into roughly cleaved slate. Some sands, mud and coarser material transported by submarine landslides, were deposited on the continental slope to form greywacke, a kind of sandstone. Under the earth’s pressure these rocks folded and tipped on edge and were squeezed up into high mountain ranges, which run from NSW through the Gold Coast to Brisbane and beyond. Large shallow freshwater lakes also formed over much of QLD on the inland side of the mountain range in later periods. These ancient lakes provided us with:
Coal – ancient forests grew in swamps,
Natural gas and some oil, trapped in porous sandstone,
Artesian water, confined to coarse sandy layers, which extend underground.

The ancient mountains of the Gold Coast wore down unevenly over time. Bally Mountain in the Nimmel Range, 15km South-West of Burleigh, is 500m high. Whereas the long hill behind Palm Beach is just over 130m high, being partly composed of erosion resistant greywacke conglomerate. Apart from these higher spots, by 25 million years ago (Oligocene period) most of the ancient bedrock in the Gold Coast area had been eroded down to a coastal plain. This plain was 80 – 90m above the present level of coast. It sloped west to east out beyond the present coastline and would have included creeks like the Nerang, Tallebudgera, Currumbin, and Tweed. The riverbeds were about 60m above present sea level, reaching the ocean well to the east of present coastline (Chapman, 1981).

2.2.2 Historical sea level rise and coastline variations

During the last ice age (17,000 years ago) the mean sea level on the Gold Coast was about 100m lower than it is now, and the shoreline was about 10km further out to sea. The current interglacial warm period commenced approximately 10,000 years ago and by 6,000 years ago, sea level had risen to its present level (or higher). On the Gold Coast, the ocean advanced over the ice age shoreline very rapidly with an average of 1m per year lost to sea (Grimstone, 1974). Dredging off Bilinga in the late 1980s found stumps of paperbark forest, submerged by the sea. Studies in Moreton Bay have shown that sea level reached approximately 1m above present level about 6,000 years ago. This higher level would have flooded the low-lying country behind the beaches and sand dunes. The ocean shoreline would have been a few hundred metres inland from its present location (Grimstone, 1974). Figure 9 shows the positions of the Gold Coast coastline from this period to the present day.

The significant natural variations in sea level have produced features of erosion and deposition over different time periods. Wave cut platforms of rock at Currumbin, Elephant and Snapper Rocks were formed during one of the higher sea level periods, possibly the last interglacial period (120,000 years ago). A fall in sea level probably began about 3,500 years ago, causing the shoreline to move eastward again, toward the present position. This left behind the latest (easternmost) shore-parallel rows of sand dunes, now mostly covered by development.

Northern hemisphere records indicate a cool period (little ice age) from 1400 – 1800 A.D and a warmer period during the past century (especially 1920 – 1960). The later period caused a sea level rise as the NZ and Alaskan Glaciers retreated (Chapman, 1981). Moreton Bay studies (Herbert & Stevens, 1983) suggest evidence in recent times of a slight rise (several cm) in the first half of the 20th century. This may have been a factor in the recorded recession of the shoreline.

Historical evidence emphasises how mobile the beach line and the hind dune areas are, and their susceptibility to minor changes in sea level and sediment supply (see Figure 9). With the concern that the “greenhouse effect” could significantly raise sea levels within a generation, further shoreline recession is predicted. Studies undertaken in the 1960s and 1970s (Gordon et al., 1978) all indicated recessionary trends along the coastline in the vicinity of the Gold Coast. Anecdotal evidence suggests that shorelines have been stable for the last three decades except in specific areas where coastal structures have been built. Of particular note is the fact that the majority of coastal areas such as the Gold Coast were initially subdivided.
prior to the 1920s i.e. during a period of predominantly calm weather when the shoreline was considerably further seaward of its current position.

**Figure 9: Position of coastline over the ages**

Note: The above map was reproduced from “The Ancient History of the Gold Coast” by Herbert, & Stevens (1983). It shows positions of the Ice Age coastline and the coastline approximately 6000 years ago, relative to the present coastline. The green area indicates valley margins, the area within was swamp, lagoon and rivers of 5000-6000 years ago, behind the barriers of sand ridges. The blue area indicates the progression of the coastline to its present location.

### 2.3 Early history and settlement

Unless otherwise cited, Sections 2.3 & 2.4 have been adapted from (Gold Coast City Council, 1993).

The Gold Coast area, originally inhabited by the Kombumerri people of the Nerang region, was sighted in 1770 by Captain James Cook as he sailed north along the coastline, naming landmarks such as Point Danger and Mount Warning following dangerous experiences there. Locality names such as Bundall, Benowa and Carrara
are a strong reminder of the Aboriginal presence in this region.

Whilst much of the eastern portion of the city is coastal plain (less than 10m above sea level), the landscape rises through rolling foothills to the escarpments to the west (up to 1010m above sea level at Springbrook). Beaches and dunes, river deltas, bays, estuaries and wetlands, rolling foothills and low mountain ranges are included in the coastal plain, and this wide range of landscapes results in a unique environment.

The early settlers were timber getters (cutting out cedar and pine) and runaway convicts from Moreton Bay. They were soon followed by the pastoralists working the narrow areas of fertile land between the coastal strip and the hinterland. The beaches at this stage were used by travellers on horse and coach enroute to the Tweed. The beach areas were considered useless dune country, comparatively poor land and difficult to access. Sugar plantations were established in the area around the Nerang River by 1866 and plantations in Beenleigh and the Pimpama island area continues to be productive today, with a rum distillery at Beenleigh and Rocky Point Mill still operating.

At the northern end of the coast, by the early 1880's a thrice weekly coach service ran from Southport to Brisbane and tourism had arrived on the South Coast as it was then known, and by 1884 a daily steamer or paddle boat service ran from Brisbane. In 1885 the first land sales in Surfers Paradise (then known as Elston) went through and by 1925, Jim Cavill had built the Surfers Paradise Hotel, which included a private zoo.

In 1888 a regular coach service operated between Southport and Tweed Heads, with accommodation at Coolangatta and a connection available by steam boat to Murwillumbah. Coolangatta, named after a schooner that was wrecked in 1846, was formally established as a township in 1914. The rail line connecting Nerang to Tweed Heads was opened in 1903 and was intended for the farmers in the Currumbin, Tallebudgera and Tweed valleys who were engaged in dairying and banana farming, however Brisbanites took the opportunity to access the open surf beaches at Coolangatta as distinct from the still waters of Southport and Coolangatta began to rival Southport as the destination of choice for holiday makers from Brisbane. The rail line to Coolangatta was closed in 1961 and the line from Beenleigh to Southport closed in 1964.

The term "Gold Coast" was first used in the 1940's by Brisbane newspapers referring to the real estate opportunities on the South Coast, while the name 'City of the Gold Coast' was established in 1959 but not gazetted until 1980. Whilst the Nerang Shire Council firstly had responsibility for the region, the Albert Shire Council was formed in 1949 to oversee the administration of the hinterland, Beenleigh and Mudgeeraba until final amalgamation in 1995 as Gold Coast City Council.

The growth in popularity and affordability of the motor car made the coast more accessible than ever before, however motorists were forced to use car ferries at Southport, Tallebudgera and Currumbin until bridges were constructed. These roads formed the basis of the Pacific Highway, allowing road access to Coolangatta and by 1935 with bridges constructed over the Coomera and Logan rivers, Brisbane was only a few hours away by motor car. Improved access also encouraged development along the length and breadth of the Coast with villages en route to the coast developing their own specialties, whilst the hinterland resorts of Springbrook, Beechmont, Mount Tambourine and Binna Burra also benefited from the improved access.
2.4 Development of the coastal area

Construction on the first of the Gold Coast's famous canal estates commenced at Florida Gardens in 1956 and sand pumped from the Nerang River was used to form estates such as Paradise Island, Chevron Island, Isle of Capri, Rio Vista, Miami Keys and Sorrento. The first high rise apartments in Surfers Paradise were built in 1960. With population increasing threefold between the 70's and 80's, a push for more land for development led to the reclamation of much of the old 'Great Swamp' from Burleigh Waters to Nerang. The area had lost significant amounts of wetlands to agriculture and this was intensified through the development of housing subdivisions. In the hinterland, however areas such as Springbrook and Numinbah, because of their relative inaccessibility and the existence of National Parks, retained more of their natural values.

In the late 1960s and 1970s, large shopping centres were constructed at Southport and the Broadbeach. With the opening of the Dreamworld and Movie World theme parks as well as Jupiters Casino in the 1980s, the Gold Coast firmly established itself as one of the premier coastal holiday destinations in Australia. In recent years the growth of the tertiary education sector with Bond and Griffith University student population approaching 15,000 has signified a diversification of the Gold Coast's economic base.

The Gold Coast Highway has had a dominant influence on the growth and expansion of the city, in part, by the creation of a narrow residential strip along the beach (Stuart, 2004). Residential and commercial areas first concentrated in sections along the Gold Coast Highway from Surfers Paradise to Coolangatta and in more recent years started spreading to the west. Lacking any detailed city planning scheme in earlier years, the growth of the city is somewhat fragmented in design and layout.

There are a number of major west–east arterial roads that link the western parts of the city with the Gold Coast Highway and the beachfront. Beach access is generally good with most of the foreshore area adjacent to the beach in public ownership, however, there are a number of coastal stretches where private property directly abuts the beach. This is a result of private property boundaries being established during periods of relative calm (seaward of the natural coastline) and the public reserve seaward of the private property boundaries eroding. Development adjacent to the beach and foreshore areas ranges from older style dwellings, newer style mansions, multi-storey unit and apartment blocks to high-rise apartment blocks.

The growth of volunteer surf lifesaving clubs on the Gold Coast was facilitated by Town Councils who bought cheap land and constructed small timber and fibrolite bungalows during the Depression when building costs were reduced. Today, there are 23 surf life saving clubs along the oceanfront. Most of these clubs have expanded their original footprint and today offer a range of commercial services such as coffee shops, restaurants and gambling facilities, which are used to partially fund the operation of the volunteer lifesaver services.

Today, Gold Coast City still shows clear evidence of how the growth of small villages and townships gradually merged to form a larger city. Many in the local community still identify with these localities and commonly describe themselves as residents of Currimbun or Burleigh Heads for example, rather than as being citizens of the Gold Coast. This strong sense of local identity is both a challenge and an opportunity for coastal managers and will be discussed in more detail in Chapter Three.
2.5 Beach use and value

The beaches of the Gold Coast form an integral part of the social fabric on the city. From quiet early morning walks and swims through to hosting major events such as the Quiksilver Pro surfing competition, the beach is vital to our way of life and the economy. Paradoxically, little is known about beach use, community values and priorities for beach management, the major focus of previous studies being coastal physical processes. Nevertheless, the beaches of the Gold Coast are recognised as being of high value and underpin the lives and lifestyles of many Gold Coast residents and have been identified as a significant component of the tourist industry. On average, the Gold Coast tourism region is estimated to host over 75,000 visitors every day. This figure includes international, domestic overnight and daytrip visitors and represents approximately 16% of all people in the Gold Coast region on any given day. For the year ending June, 2004 the Gold Coast received a total of 4,285,000 tourists with 65% declaring the purpose of the visit was for holiday/leisure. Further research into nature-based tourism on the Gold Coast (Gold Coast City Council, 2003) has shown that 56% of all overnight visitors and 30% of all day-trippers go to the beach during their stay on the Gold Coast. Raybould and Mules (1998) identified a number of key gaps in the benefit-cost analysis that was used to support the development of the Northern Gold Coast Beach Protection Strategy:

- Little was known about how local residents used and valued the beach;
- Little was known about how tourists used and valued the beach;
- Little was known about what effect the existence of beach and beach quality had on property values in the region; and
- Little was known about the direct and indirect economic benefits to government and the private sector from having beaches in good condition.

Figure 10: Beach Walkers

The GCSMP incorporates the findings from a number of recent studies into beach use and the market and non-market value of beach use by residents and visitors.
The findings of these reports are presented in Chapters Three and Five.

2.6 The role of government in coastal planning and management

2.6.1 Federal Government

The Federal Constitution determines how powers are divided between the Commonwealth and State Governments in Australia primarily through Section 51 that lists 39 heads of power held concurrently with the States. The Commonwealth government has legislative power only in relation to those matters specified in the Constitution while the remainder of power rests with the States. Although the Constitution does not specifically refer to environmental matters, the Commonwealth has used its Constitutional powers in other areas to regulate matters relating to the environment (see Figure 11).

Hughes, (in T. F. Smith, 2002) points out that change to the Commonwealth Constitution may occur through; (i) the States giving up some of their powers; (ii) interpretation by the High Court; or (iii) a formal amendment through a referendum. Before going to the people, a referenda proposal must first be passed by both Federal Houses of Parliament before being accepted by a majority vote in a majority of States. Smith (2002, p. 113) writes that:

[[The limited power of the Federal government is especially true in terms of environmental matters, that were largely not popularised until the latter part of the 20th century, thus not referred to in the 1900 Commonwealth Constitution.]]

Clarke (2003), however, argues that the Commonwealth has considerable financial powers that give it the capacity to take a leadership role in coastal planning through, for example, the development of national standards. Clarke suggests that this can be best accomplished through Section 96 of the Constitution, through which the Commonwealth can assist the States financially. Over the past 30 years, Australia has developed a suite of national environmental legislation and during that time also became signatory to a number of international marine and environmental protection agreements that have effect coastal regions. Fearon et al. (2006, pp. 23-24) write:

[[There is no coordinated coastal legislation or coastal policy but rather a complex mix of legislation, plans and policies of the Environment. The Commonwealth Government has sovereignty over the ocean from the low-water mark seawards, while the state and territory governments have jurisdiction over catchments, coastal developments, offshore islands and many of the commercial, recreational and Indigenous fisheries.]]
2.6.2 Evolution of Commonwealth Coastal Policy

In 1995, in response to the Resource Assessment Commission inquiry into the coastal zone, the (then) Federal Government released Australia’s first National Coastal Policy, titled Living on the Coast: Commonwealth Coastal Policy (Commonwealth of Australia, 1995). Harvey and Caton (2003) write that the RAC made 69 recommendations, involving all spheres of government, including recommendations involving an integrated approach between governments. Twenty-one of the recommendations related to a national approach involving integration, coordination and consistency; 34 related to the Commonwealth; 25 to the States and 15 to local government.

Many components of the proposed national approach did not receive political support, including a Coastal Resource Management Act and a National Coastal Management Agency. This may well have been a matter of timing as well as a lack of clear constituency for such initiatives. The recommendations were at a time when governments were reducing rather than increasing numbers of agencies, and there were no political or lobby groups to raise the priority of a national approach to coastal management. The lack of follow-through on a national approach reflected the problems of the democratic system in dealing with a complex long-term issue (Harvey & Caton, 2003, pp. 209-210)
The policy, though widely criticised as an inadequate response to the findings of the RAC, was seen by many as an important first step in the development of a national coastal management program. This process is well described by Kay and Alder (1999), Harvey and Caton (2003), Clarke (2003) and also by Lazarow (2002b). Harvey and Caton (2003, p. 210) write:

The purposes of the policy were ‘to provide a framework and guide for Commonwealth activities’ and ‘to provide a clear statement of the Commonwealth’s position’. The policy also set out a number of management initiatives on funding, involving the states, local government, community groups and various institutions. Specific objectives were given, including sustainable resource use, resource conservation, and public participation.

The Federal Labor Government, under the leadership of Prime Minister Keating was defeated the following year, in the 1996 elections and in 1997, the Howard Government revised the policy to include a number of new initiatives such as the State of the Marine Environment Report and the expansion of the Coastcare program through the introduction of the Natural Heritage Trust program.

2.6.3 National Cooperative Approach to Integrated Coastal Zone Management Framework and Implementation Plan

In the context of a much reduced focus on coastal issues and a smaller Federal coastal program (see B. Clarke, 2006), the Howard Government’s national environmental agency was given the task of developing the National Cooperative Approach to Integrated Coastal Management (National Framework), which was released in 2003. This was followed by the release of the National Cooperative Approach to Integrated Coastal Management (Framework and Implementation Plan) in 2006.

In October 2003, the NRMMC endorsed the National Cooperative Approach to Integrated Coastal Zone Management, which identified issues that were of:

1. National scale and scope; and
2. Where complimentary arrangements could work better (Commonwealth of Australia, 2006).

The key issues that the National Framework sought to address were:

1. Land and marine-based sources of pollution;
2. Managing climate change;
3. Introduced pest plants and animals;
4. Allocation and use of coastal resources; and

In substance, the 2003 National Framework was a step forward from the 1995 Coastal Policy. The 1995 National Coastal Policy essentially described the Commonwealth’s activities (against the recommendations of the RAC and other reports including the House of Representatives Standing Committee on Environment, Recreation and the Arts (HORSCERA 1991) (Commonwealth of Australia, 1991) that recommended the Federal Government take a much more proactive approach
towards coastal management), whereas the 2003 Framework attempted to go further by addressing issues that while important, were also unlikely to cause significant concern over power cooption from the States. The 1995 policy endorsed and supported the Coastcare program but by 2003 Coastcare had been co-opted into the NHT / Envirofund process and was no longer a unique coastal focused program.

In 2006, the Federal Government released the Implementation Plan that was to accompany the National Framework. The introduction to the document (released as a compendium with the Framework) stated:

*The Framework was developed to protect coastal and estuarine water quality, coastal biodiversity and the economic base of coastal areas around Australia. Coastal values and resources are vital to the Australian way of life. The wide ranging climatic, geological and oceanographic regimes and interaction of terrestrial, estuarine and marine ecosystems support a wealth of biodiversity. Coastal biodiversity underpins the resource base for a broad range of commercial and non-commercial uses and activities…. The Implementation Plan … sets out, under strategic priority areas, implementation objectives and actions required to address coastal management issues that are of national scale or scope, or where issues will benefit from complimentary arrangements between jurisdictions. As far a possible, the implementation objectives and actions are consistent with, and build on coastal zone planning and management initiatives in each jurisdiction (Commonwealth of Australia, 2006, p. 22).*

Based on the National Framework, the Implementation Plan contains seven ‘Priority Areas’:

1. Integration across the catchment-coast-ocean continuum;
2. Land and marine-based sources of pollution;
3. Climate Change;
4. Pest Plants and Animals;
5. Planning for Population Change;
6. Capacity Building; and

### 2.6.4 Commonwealth Coastal Policy in 2008

The election of a new Federal Government in December 2007 has brought with it a number of changes and possible changes to coastal management programs at the Federal level.

A number of changes in the Commonwealth’s coastal management program have recently occurred, or are likely to occur in the near future. These include, but are not limited to:

- The Federal House of Representatives ‘Inquiry into climate change and environmental impacts on coastal communities’. At the time of writing, this inquiry was still ongoing.
- The number of commitments from the Federal Government to:
  - Work with State Governments, coastal councils, coastal NRM groups and
experts to develop a national coastal policy, with greater Federal Government involvement in policy and planning.

- Establish a $100 million, five year Community Coast Care Program to better protect our precious coastal environment from unallocated Phase Three Natural Heritage Trust funds.

- Embark on a national consultation with coastal councils, coastal Natural Resource Management Councils, capital city mayors, academics, community groups and State and Territory Governments to develop a blueprint for coastal cities and towns to meet current and future climate challenges.

- Labor will work with the National Sea Change Task Force and other stakeholders in developing broad, national principles for coastal management, consistent with its commitment to sustainable development. (Garrett & George, 2007).

The change in government has resulted in the cessation of the Natural Heritage Trust program and the introduction ‘Caring for our Country’, the Federal Government’s new natural resource management initiative, which commenced on July 1, 2008. Caring for our Country has absorbed existing NHT projects and operates in a similar fashion to the NHT program.

The new funding structure reduces the emphasis on the Regional NRM Bodies, instituted to devolve funds under NHT2, and allows more direct application for various proponents to access funding. Whilst this change in the funding program means that local governments and other stakeholders can now access funds directly through thematic project application rounds, they need to be cognizant of the high emphasis placed on regional and local collaboration in the assessment of successful applications, and attempt to coordinate their efforts to reflect this.

The federal Program continues to support the Regional Bodies and their program of work and regional coordination, though without the primary responsibility of devolving funds, delivered under the NHT2 Model.

Figure 12: Aerial photograph of South Stradbroke Island
2.7 Queensland’s coastal management program

*The Queensland coastline (including offshore islands) stretches for more than 7400km and accounts for approximately one-fifth of Australia’s coastline. The coastal zone is home to more than 2.65 million people (85% of the State’s population). It’s living and non-living resources support the State’s economic wealth (Edmondson, 2007).*

2.7.1 Queensland Coastal Management and Protection Act 1995

Queensland’s coastal management program is underpinned by the Coastal Protection and Management Act (1995 revised 2003) and the State Coastal Plan (SCMP) (Government of Queensland, 2001). The Plan has statutory effect (the effect of a State Planning Policy) under Section 50 of the Act and applies to the coastal zone in Queensland. The determination of the coastal zone depends on the existence of a link with the coast or coastal resources. Part Two of the Act describes the objects and how coastal management is to be achieved.

Figure 13: Queensland’s coastal zone (Government of Queensland, 2001, p. 2)

2.7.2 Role of the lead agency

Section 3.4 of the SCMP identifies the role of the lead agency – in this case, the EPA. The major responsibilities for the EPA are:

- To coordinate the preparation of the SCMP and RCMP’s;
- To administer licencing and enforcement of coastal permits;
- To provide advice to local government, other agencies and persons regarding best practice; and
- To prepare a State of the Coastal Zone report.
The EPA also plays an important role as both a referral and a concurrence agency in the coastal zone. As the lead agency, the EPA is responsible for coordinating the review of the SCMP within seven years of commencement. At the time of writing this process was underway and is due to be completed by 2009.

Table 5. Objects and achievement of coastal management in Queensland

<table>
<thead>
<tr>
<th>Section 3: The main objects of this Act are to—</th>
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<tbody>
<tr>
<td>a) provide for the protection, conservation, rehabilitation and management of the coast, including its resources and biological diversity; and</td>
</tr>
<tr>
<td>b) have regard to the goal, core objectives and guiding principles of the National Strategy for Ecologically Sustainable Development in the use of the coastal zone; and</td>
</tr>
<tr>
<td>c) provide, in conjunction with other legislation, a coordinated and integrated management and administrative framework for the ecologically sustainable development of the coastal zone; and</td>
</tr>
<tr>
<td>d) encourage the enhancement of knowledge of coastal resources and the effect of human activities on the coastal zone.</td>
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</table>

Section 4: How coastal management is to be achieved

Coastal management is to be achieved by coordinated and integrated planning and decision making, involving, among other things, the following—

- a) Coastal management plans
  - Preparing coastal management plans that—
    - state principles and policies for coastal management
    - identify key coastal sites and coastal resources in the coastal zone and planning for their long term protection or management
    - are developed in consultation with the public
    - have regard to Aboriginal tradition and Island custom of Aboriginal and Torres Strait Islander people particularly concerned with land affected by the plans.

- b) Coastal management districts
  - Declaring coastal management districts in the coastal zone as areas requiring special development controls and management practices.

- c) Use of other legislation

- d) Using other relevant legislation wherever practicable to achieve the object of this Act.

Source: (Government of Queensland, 1995).

The Coastal Act incorporates the functions of previous acts including the Harbours Act 1955, the Canals Act 1958 and the Beach Protection Act 1968) and was amended in 2003 to repeal these three pieces of legislation. Section 30 of the Act states that:

*The Minister must prepare a State coastal management plan for the coastal zone...*

which must describe how the coastal zone is to be managed; consider public access to the foreshore; and may include a statement of the principles and policies by which the coastal zone and its designated areas are to be managed and a map or series of maps showing coastal resource information (Government of Queensland, 1995). All persons with responsibilities in the coastal zone are bound by the provisions of the State Coastal Management Plan (SCMP) including: State government agencies who have coastal management responsibilities (the lead agency is the Queensland Environmental Protection Agency); local governments through their planning responsibilities; and non-government groups whose roles include ‘environment and land management activities, preparing codes of practice, strategic industry programs and integrated catchment management plans and strategies.
2.7.3 State Coastal Management Plan (Coastal Policy) 2001

The SCMP is centred across ten broad themes, all of which have outcomes, principle and specific policies attached to them. The themes are:

1. Coastal use and development;
2. Physical coastal processes;
3. Public access to the coast;
4. Water quality;
5. Indigenous traditional owner cultural resources;
6. Cultural heritage;
7. Coastal landscapes;
8. Conserving nature;
9. Coordinated management; and

The Act (S35) requires that Regional Coastal Management Plans (RCMP) be produced for the coastal zone. The SCMP identifies 11 coastal regions in Queensland. These are pictured in 13. At the time of writing, RCMP’s have been completed in four regions: Wet Tropical Coast (2003); Cardwell – Hinchinbrook (2003); Curtis Coast (2003); and South-east Queensland (2006). RCMP’s are currently under development for the Mackay-Whitsunday, Wide Bay and Dry Tropical Coast regions.
RCMP’s are required to be consistent with (or better than) the SCMP. RCMP’s implement the SCMP at the regional level and also identify key coastal sites at the regional level that require specific management interventions. The principal route for State government management has been through the development of Coastal Management Districts (CMD), which provides the State with regulatory control over development proposals (B. Clarke, 2003).

The EPA has a regulatory role in development assessment through Coastal Management Districts (CMD’s):

These areas have traditionally been identified in regional coastal plans. In areas where a regional coastal management plan has not yet been prepared, the erosion prone areas and coastal management control districts previously designated under the now repealed Beach Protection Act 1968 are taken to be the transitional or interim coastal management district (Government of Queensland, 2008a).
Under the Act and area may be declared a CMD if the area is covered by a regional plan or the area is not covered by a regional plan and the Minister considers that it requires protection. CMD’s over coastal waters, foreshores and land up to 400m inland from the high water mark, along tidal deltas or over an island in coastal waters (Government of Queensland, 1995 S55). When declaring CMD’s the following issues must be considered:

1. The area’s vulnerability to erosion by the sea or to wind induced effects;
2. Whether the area should be kept in an undeveloped state to maintain or enhance the coast or coastal resources;
3. Public access to a foreshore in the area;
4. Foreseeable human impacts and natural hazards in the area;
5. The existing tenure of, interests in, and rights to, land in the area;
6. Aboriginal tradition and Island custom of Aboriginal and Torres Strait Islander people particularly concerned with land in the area;
7. Planning and development management of the area (Government of Queensland, 1995S 56).

The SCMP was written with a distinct bias towards the protection and management of natural areas – traditionally the EPA’s core strength. For example, the policy states that:

> the State Coastal Plan is likely to be most relevant where the coastal resources are significant, or where potential impacts on coastal values may be on a scale that threatens those values. Therefore, many of the policies will have greater application to those undeveloped areas along the coast which are predominantly in their natural state and where future development may be proposed. Urban areas often represent a highly modified natural environment where past decisions and approvals constrain the ability of agencies involved in coastal management to fully achieve the principles put forward in the State Coastal Plan (Government of Queensland, 2001, p. 3).

Given the charter of the lead agency, the Environmental Protection Agency, this focus is not at all surprising. The reality for Gold Coast City though, which in the first instance required assistance in the development of studies and plans to protect the coast, the dismantling of the Beach Protection Authority in the mid-1990s and the shift of the EPA away from providing specialist coastal process advice, meant that Gold Coast beaches, which had lost much of their original natural values due to significant modification, were not given significant consideration in the SCMP and this has implications for the ongoing management of Gold Coast beaches.

The Act also formally established the Coastal Protection Advisory Council (CPAC). The primary function of CPAC is to advise the Minister about coastal management issues in Queensland (Government of Queensland, 1995).
2.7.4 **Relationship between the State and Regional Coastal Plans and the Integrated Planning Act**

The coastal plans have the effect of State Planning Policies (SPP’s) under the Integrated Planning Act (IPA) (Government of Queensland, 1997) and are required to be considered during the making or amending of local government IPA planning schemes or in the assessment of development applications (Government of Queensland, 2008b). Section 50 of the Coastal Management Act states that:

1. The assessment manager, or a referral agency, for a development application under the Integrated Planning Act 1997 must assess the application as if a relevant coastal plan were a State planning policy under that Act.
2. Also, the following provisions of the Integrated Planning Act 1997 apply as if a coastal plan were a State planning policy—
   a. Section 2.1.4;
   b. Schedule 1, section 18;
   c. Section 2.6.7.3 (Government of Queensland, 1995).

The requirement only for the SCMP to be considered during the planning process has been a significant stumbling block for the progression of ICM in Qld. For those interested in preventing development, the policy is somewhat of a toothless tiger and for those interested in developing planning schemes or progressing development, the lack of clarity in the policy has not provided a definitive set of policy statements on which to base local planning schemes. To assist in part with this process, the EPA recently published two Interim Guidelines: State and Regional Coastal Management Plans Queensland’s Coastal Policy: Implementation Guideline for Planning Schemes (Government of Queensland, 2007b), which is aimed at assisting local government implementing the policy outcomes of the SCMP’s and RCMP’s through local government planning schemes; and State and Regional Coastal Management Plans Queensland’s Coastal Policy: Implementation Guideline for Development Assessment (Government of Queensland, 2007a), which is aimed at assisting local government implementing the policy outcomes of the SCMP’s and RCMP’s for development assessment.

2.7.5 **The role of local government**

Local government is a product of State government legislation and has the lion’s share of responsibilities for day-to-day management of the Australian coastline including authority for planning, development, certain infrastructure, water (in some cases), pollution, environmental protection and recreation management. There are a number of excellent reports and papers that describe the role and challenges of local government in ICM in Australia (Harvey & Caton, 2003; Low Choy, 2006; Stuart et al., 2006) and in particular, the work of the Australian Local Government Association (Australian Local Government Association, 2005; Australian Local Government Association & Shephard, 2005), the peak body for local councils in Australia and the National Sea Change Taskforce (Gurran et al., 2007; Gurran et al., 2005, 2006) in recent years has exposed and explored many of these issues in great detail and the reader is referred to these publications.

Low Choy (2006) states that while there is general agreement that local government services have tended to be associated with property management, there is an acknowledgement that these functions are now broadening. Stuart et al. (2006, p. 35)
list the major roles of local government in coastal planning and management:

- Land-use planning and development control for infrastructure developed by others;
- Planning, construction and management of specific coastal management infrastructure;
- Planning, construction and management of other civil infrastructure in the coastal zone;
- Planning, construction and management of water quality management infrastructure;
- Management of public access to and use of the foreshore;
- Community awareness, development and engagement; and
- Environmental protection, enhancement and management.

Local government then has within its powers the ability to use State government legislative directions to create specific local laws that regulate how the coast is used (from settlements, to reserves, to density, to type of use) and this continues to change over time and in most cases, has an increasing impact on the natural environment. Local governments are often faced with the challenges of interpreting state legislation as it applies to specific areas (knowing that their decisions may be overridden by State Government). Harvey and Caton (2003) write that local councils make the majority of planning and development decisions at the coast and this is done in two ways:

- Through strategic and local plans; and
- Through individual decisions in response to development applications.

As well as the requirement for local councils to manage issues such as population growth, migration, infrastructure management and development and environmental and community services, there is an increasing expectation that strategic planning, an underlying principle of ICM, should be incorporated into local government planning processes. Harvey and Caton (2003 p.228) write that

> Most councils face difficult and chronic problems in managing coastal resources, and most non-metropolitan councils lack the expertise and financial base to properly address the problems.

While strategic planning has been a subject of discussion at the local government level for many years, the application of this concept to environmental and community issues has raised the stakes once again for local government. The coastal strip is a highly contested space with a strong expectation amongst the public that access to the coast around the country is guaranteed.

> This part of the coastal ‘commons’ is vigorously defended and incursions into it have been the cause of conflict around the continent (Harvey and Caton 2003 p.229).
2.7.6 **Relationship between the SCMP, SEQ RCMP and the GCSMP**

The coastal management outcome for Theme Two of the State Coastal Management Plan (SCMP) ‘Physical Coastal Processes’ is that ‘the coast is managed to allow for natural fluctuations to occur, including any that occur as a result of climate change and sea level rise, and provide protection for life and property’ (Government of Queensland, 2001, p. 27).

Direction is provided on five policy areas with the ‘physical coastal processes’ theme of the SCMP. These are:

1. Adaptation to climate change;
2. Erosion prone areas;
3. Shoreline erosion management;
4. Coastal hazards; and
5. Beach protection structures.

The Southeast Queensland and Regional Coastal Management Plan (SEQ RCMP) provides further advice on ‘erosion prone areas’ and ‘shoreline erosion management’. A requirement under Section 2.2.3 of the State Coastal Management Plan is that Regional Coastal Management Plans identify any priority areas for erosion management. Section 2.2.3 of the SEQ RCMP states that

> Relevant local governments in conjunction with State agencies should prepare shoreline erosion management plans for all priority shoreline erosion management areas, which set out an agreed process to manage the foreshores and lands neighbouring the foreshores. In areas requiring shoreline erosion management, preference should be given to those options that maintain natural coastal processes and visual and recreational amenity. Where erosion control structures such as seawalls and groynes are considered necessary as part of a shoreline erosion management plan, beach nourishment, revegetation or similar actions are to be investigated to mitigate any adverse impacts of the erosion control structures on adjacent coast.

Shoreline erosion management plans should consider and address the policies of the State and SEQ Coastal Plans.

> The relevant local government and the EPA may use such plans as a basis for agreeing on how erosion on a particular section of coast is to be managed in the future. It can be considered as a pre-lodgement action in the development assessment process under the IPA, and, where future works are consistent with the plan, should simplify the development assessment process, given that the plan will have demonstrated consistency with the relevant principles of the State and SEQ Coastal Plans.

State funding and resources for coastal management should be preferentially directed to the preparation of such plans and to assist those projects consisting of or including options that maintain natural coastal processes, rehabilitate degraded coastal areas and preserve or enhance visual and recreational amenity (Government of Queensland, 2006b, p. 36).
Shoreline Erosion Management Plans (SEMPs) are the EPA’s preferred method for local governments to address shoreline erosion issues at the local government level. The EPA states that SEMPs can:

- Identify significant coastal erosion issues;
- Develop an understanding of the underlying coastal processes contributing to erosion problems;
- Develop and evaluate options for erosion protection and management;
- Facilitate community input on coastal erosion issues;
- Plan for the delivery of selected erosion protection and management options; and
- Ensure erosion protection and management measures are consistent with State and Regional Coastal Management Plans and other government policies (Government of Queensland, 2008c).

By preparing a shoreline erosion management plan, or in this case a shoreline management plan, the Gold Coast is eligible for technical support from the EPA as well as a subsidy of up to 50% of the total project costs of preparing the plan through the Environmental Infrastructure Program, which is administered by the Department of Local Government, Planning, Sport and Recreation. Further funding has also been made available by the State Government to assist LGAs in cyclone-affected areas. The EPA has prepared a guidebook to assist LGAs prepare SEMPs. The guideline states that:

A Shoreline Erosion Management Plan (SEMP) is a non-statutory planning document that sets out an agreed framework and management strategy for responding to current erosion or potential future erosion problems. SEMPs provide a framework for the sustainable use, development and management of land vulnerable to erosion by considering the environmental, social and economic values of the land and the physical coastal processes acting on the foreshore. SEMPs also outline the appropriate uses of erosion prone land, and long term management goals as agreed upon by governments and the community.

The purpose of a SEMP is to:

1. Enable local government to proactively plan for erosion management in hotspot areas in a way that is consistent with the policies of the State Coastal Management Plan 2001 and the relevant Regional Coastal Management Plan (where applicable).
2. Investigate and address the underlying causes of shoreline erosion and likely future progression at the local scale;
3. Determine cost effective and sustainable erosion management strategies that maintain natural coastal processes and resources and consider community needs in both the short- and long-term (Government of Queensland, 2006a, pp. 1-2).

Shoreline Management Plans are not limited to a consideration of coastal physical processes issues and may cover a range of ecological and socio-economic considerations also. The EPA has the responsibility for ensuring that the final management strategy is consistent with all relevant policies and guidelines.
2.8 Current reforms to the coastal management and planning process

As of the time of writing, IPA, the SCMP and the SEQ Regional Plan are all concurrently under review. Realistically, the review of and amendments to the Integrated Planning Act in 2008-09 as well as the development of statutory regional plans across the state will be of the utmost significance to coastal planning and management in Queensland. The review of the SCMP must and is proceeding with these other legislative and planning changes. It is likely that a revamped IPA and the development of regional plans throughout Queensland will see the end of the RCMP’s as planning tools and a much stronger focus on environmental issues rather than ESD as an outcome from the review of the SCMP. It is also likely that the SEQ Regional Plan will be strengthened in the areas of climate change impacts on the coast.

2.9 Beaches and beach systems on the Gold Coast

The littoral system is distinguished by two broad types of coast, the rocky shore and the low sandy shore, commonly called "beaches". This latter geomorphological form characterises the littoral plains and is significantly influenced by wave action, littoral drift and the coastal currents. Processes responsible for changes at the coast include:

- Slowly varying long-term processes (e.g. subsidence and rise in the sea level for example); and
- Occasional phenomena (extreme storm events, storm tides, earthquakes...) (Pointeau, 2008).

In addition to natural processes, human modification of the coastline and coastal systems can cause a range of impacts that disturb natural coastal processes. Examples of such actions include:

- Reduced river flows;
- Modification to estuaries;
- Construction within erosion prone areas;
- Construction of harbour works and structures for coastal protection;
- Destruction of dune and marine vegetation; and
- Mining of resources and groundwater effects.

The Gold Coast littoral environment can be described as a high-energy open coast. Large volumes of sediment are transported along-shore with an estimated long-term net annual transport rate of 500,000m³ (Delft Hydraulics Laboratory, 1970; Roelvink & Murray, 1992; Tomlinson & Foster, 1986). Within a 50-year planning period this system is largely considered to be in equilibrium with the major impacts attributed to the cross-shore transport of sand during high energy wave events. The period since 1974 has been a relatively calm period for Gold Coast beaches with isolated and few severe beach erosion events (Helman, 2007). During this time there has been significant development on the coastal fringe.
2.9.1 Sediment dynamics

Littoral drift, or the along-shore transport of sand, occurs in the sub-tidal to outer surf zone region on coasts with oblique angles of wave incidence. The narrow continental shelf and natural topographical features of the southeast Queensland coast results in incomplete wave refraction for certain swell directions. This results in a long-shore current generated by the waves as they approach the shore.

Sediment transport rates can vary along the coast due to interactions between:

- Natural topographic features such as headlands, reefs, beach slope;
- Coastal structures such as jetties, boulders, seawalls, dredging or nourishment schemes;
- Variation of environmental forcing from swell, tidal currents and low frequency phenomena;
- Physical factors such as water temperatures, sand grain geometry and water density (Pointeau, 2008).

The Gold Coast is situated at the Northern end of a 300 km long coastal unit starting at the Clarence River and ending at Moreton Island in Queensland. It is assumed that the existing sediment in this area is derived from the Clarence and Richmond Rivers and has accumulated along the coasts of Moreton and Stradbroke islands (Chapman, 1981). It is generally accepted that the average rate of the longshore transport of the Gold Coast is around 500,000 m$^3$/year, but this rate can vary from 250,000 m$^3$/year (1991) to 800,000 m$^3$/year (1993) (WBM Oceanics, 1997). Between the sedimentary source and the final deposition zone, there is pulsate transport which modifies the coastline in response to climatic events, topographic effects, coastal developments and estuaries.

Storm bars on Gold Coast beaches can be established at around 400 m offshore of the mean sea level shoreline. The seabed at this distance offshore can vary by up to 3m in the creation of these storm bars. The redistribution of sediment impacts upon
wave refraction and energy dissipation. The upper beach volume and inter-tidal area present the most visible part of the erosion/accretion cycle however extreme storm wave events can lead to significant transport between depths of 10 to 20m, without apparent erosion or accretion of the shoreline (A. W. Smith & Jackson, 1990).

Field based studies by Wright and Short (1984) conclude that beach morphology at any particular time is dependent upon the region’s sediment characteristics, tide regime, wave climate and the pre-existing beach state. With so many variables affecting beach morphology, research results often produce different theories about the role of each of the coastal processes. This tends to become pronounced when results are transferred to a different location where the mixture of hydrodynamic and morphodynamic processes may differ. From a synthesis of the literature on nearshore sandbar morphology and movement, it is apparent that site-specific field observations and measurements are required to better understand the range of processes that operate in an area.

2.9.2 Types of nearshore sandbars

Nearshore sandbars form in a wide variety of shapes, sizes and orientations (Davis & Fox, 1972). Studies of nearshore sandbars have considered both the longshore and cross-shore variability, as beaches are essentially three dimensional in form. The cross-shore variability of beach profiles has been extensively researched in the literature through the analysis of beach profiles e.g. (Bruun, 1954; Dean, 1977; P. D. Komar & McDougal, 1994). A ‘storm profile’ is characteristic of the beach response to high energy wave events such as those generated by tropical cyclones, whereas as the ‘accretion profile’ characterises beach response during low energy wave conditions. To eliminate the seasonal bias in this classification scheme Larson et al. (1999) adopted the terms of bar profile and berm profile.

Although beach profiles are helpful in characterising beach response and calculating cross shore sediment transport rates, they only provide a cross sectional view of the beach which is representative of one location at a particular time (P.D. Komar, 1998).

A number of theories and numerical models have been derived from the ‘equilibrium’ beach profile, but this profile does not account for the role nearshore sand bars play. Unfortunately the equilibrium beach profile is encountered less than 1% of the time on a sediment rich dynamic beach (Birkemeier, 1991). The concept of a dynamic equilibrium beach profile is in fact a misnomer as beaches are constantly changing in response to morphological and hydrodynamic interactivity. Many beaches, however, experience a prevailing wave climate from a particular direction, and although this varies depending upon the season, it results in the beach exhibiting a recurring beach state.

2.9.3 Nearshore sandbar dynamics

Wright and Short (1984) propose perhaps the most advanced beach state model (Figure 18), which is empirical in nature and describes beaches as either dissipative, intermediate (comprising - longshore bar trough, rhythmic bar and beach, transverse bar and rip, ridge-runnel and low tide terrace) or reflective.

With the advent of video imaging techniques and their application to the coastal zone, researchers have been able to gain further insight into the longshore variability of nearshore sand bars (T. Lippmann & Holman, 1990). This prompted an expansion of the Wright and Short model to include an additional two beach states allowing further characterisation of the intermediate beach states, as bar morphology in the
longshore direction could be assessed with greater confidence.

Essentially, beach state transitions were found to proceed in a sequential manner during decreasing wave conditions, when a beach is accreting, thus supporting sequential modelling of beach processes. Up state beach transitions (increasing wave energy) were found to occur relatively quickly lending support to the concept of equilibrium modelling. Both of the beach state models described highlight the dynamic nature of nearshore sandbar forms and the different types likely to be encountered.

Figure 17: Aerial view of Tallebudgera Creek
Nearshore sandbar formation

The dynamic changes that sandbars experience in the nearshore zone cannot be realistically studied without consideration of hydrodynamic processes. It is often the mutual adjustment between beach morphology and the hydrodynamic conditions that drives sediment transport changes. Sediment in the nearshore zone can either move offshore to provide a protective barrier against storm events (typically associated with increasing higher wave energy) or move onshore to nourish the visible beach (typically associated with decreasing lower wave energy). Sandbars in the nearshore zone may also migrate alongshore depending upon the magnitude of the longshore current induced by obliquely incident wave directions.
A general consensus among coastal researchers is that during storm events (i.e. under increasing wave heights), a linear outer bar is formed and under decaying wave conditions the beach morphology changes to a more three dimensional form. Despite the formative processes that contribute to nearshore sandbar development remaining largely unresolved (Boczar-Karakiewicz et al., 1993), recent studies have linked these observations to many different factors, some of which include:

- Undertow currents (Masselink & Black, 1995);
- Wave groups and long waves (O'Hare & Huntley, 1994);
- Thresholds of wave height and wave period (A. W. Smith, 1992);
- Infragravity standing waves (Aagaard & Greenwood, 1994);
- Rip currents (Brander, 1996); and
- Crescent sand bar morphodynamics (Castelle, 2004).

It is often a mixture of processes that contribute to bar development, making it difficult to isolate the magnitude of the different hydrodynamic processes at play. Coastal researchers are yet to agree upon even an empirical approach to the formative process of bar development.

### 2.9.5 Nearshore sandbar stability

Komar (1998) states that understanding the response of the beach profile to changes in the wave climate is a necessary step to understanding the causes of beach erosion. Many factors and relationships have been proposed in the literature that relates nearshore sandbar stability to the likelihood of erosive or accretionary transitions. These relationships have usually been derived from the analysis of beach profiles.

The time scales associated with onshore-offshore bar movement are something we know little about. Lippmann and Holman (1989) suggest that offshore, erosive transitions under increasing wave energy conditions are more rapid than the time scales associated with onshore, accretionary transitions under decaying wave conditions. Studies by Goldsmith et al. (1982) and Jackson (1993) suggest that the time scales for onshore and offshore bar movements are essentially the same. This is likely to be dependent upon the severity and duration of the storm event and the preceding beach morphology. A classification scheme based on wave height and storm duration would therefore be useful in order to relate these different events. These findings lend support to the idea that different beaches in different geographical settings have a different mixture of coastal processes operating. To define a region's morphodynamic and hydrodynamic processes, site-specific field studies are necessary and should consider a wide range of measurable variables.

### 2.10 Coastal ecosystems on the Gold Coast

The Gold Coast's 52km (including South Stradbroke Island) of mainly sandy coast (Short, 2000) provide Gold Coast City Council with an enormous natural asset. Sandy beaches are high energy environments. Waves strike the shores, moving sediments and eroding particles. This unstable environment makes life difficult for plants and animals. However, there are some organisms that can cope with mobile sediments and can exploit the supplies of oxygen and nutrients available in such habitats (Little, 2000). Beaches may appear barren and largely devoid of life but in reality beaches support a great diversity of fauna (Jones et al. 2002). Moreover,
sandy beaches provide a wide range of ecosystem services and serve as a link between the ecology of sand dunes, the surf zone (Short and Hesp, 1982), and nearshore rocky reefs. Chapter Four provides an overall review on the ecological aspects of coastal sand dunes, sandy beaches, nearshore reefs and associated biota.

2.10.1 Sand dunes

Coastal dunes are an integral part of the coastal environment (NSW DLWC, 2001). They not only protect coastal property from storms, but also are the basis of important ecosystems supporting valuable communities of plants and animals (NSW DLWC, 2001). Coastal dunes are characterized by the exchange of sand with beaches and by the influence of wind forces. Many plant species are able to colonize supralittoral sands, despite initially poor nutrient conditions, lack of moisture, and sometimes very high temperatures (McLachlan and Brown, 2006). On undisturbed beaches such colonization may begin at or just above the strandline aided by accumulations of wrack which reduces the sand temperature and increase its moisture content (McLachlan and Brown, 2006). Wrack is the build-up of debris consisting of seagrass, algae, weeds, marine organisms and other material deposited on the beach by the wind and waves. Vegetation is by far the most important component of the biota on sand dunes because it is directly involved in establishing the dune forms and creating the structure of the dune habitat. Microorganisms and fungi are the primary colonizers of sand along the coast. Fungi are most important in this regard, followed by bacteria and algae. The presence of such colonisers reduces wind erosion, increases soil moisture, and increases the nutrient amount of the sand (McLachlan and Brown, 2006).

Sand dunes are usually classified as an incipient dune, foredune or hinddune (NSW Government 1990). Incipient dunes are the most seaward and immature dune of the dune system and it’s vegetation is characterised by grasses. On an accreting coastline, the incipient dune will develop into a foredune (NSW Government 1990). A foredune is the larger and more mature dune lying between the incipient dune and the hinddune area. Foredune vegetation is characterised by grasses and shrubs. Foredunes provide an essential reserve of sand to meet erosion demand during storm conditions. Hinddunes are characterised by mature vegetation including trees and shrubs (NSW Government 1990).

Figure 19: Typical Sand Dune Profile
2.10.2 **Sandy beaches**

Sandy beaches play an important ecological role by providing habitat for numerous plants and animals. Beaches harbor unique and diverse suites of species not found in any other marine habitat (Jones et al., 2003). The intertidal zone of beaches features a constant exchange of sand, organic matter and nutrients, inputs that influence the distribution and growth of beach organisms (Jones et al., 2003). Food is mainly imported from surf-zone in the form of phytoplankton and algae (Jones et al., 2003). The former are consumed by filter-feeders and the latter are decomposed by bacteria and fragmented by the grazing of small invertebrates such as isopods, amphipods and insect larvae (Jones et al., 2003). The nutrient-rich faeces of these invertebrate consumers are used by the beach bacterial community or transported back to the sea. These bacteria support various beach fauna, which in turn support more conspicuous beach species such as many important birds, reptiles and other animals which nest, breed, feed and rest on the dunes or open beach (Clark, 1998). As well, many fish species use surf zones as nurseries and feed on beach invertebrates (Jones et al., 2003).

2.10.3 **Subtidal nearshore reefs**

The subtidal rocky reefs of the Gold Coast support communities of benthic fauna and flora and fish that represent a transition between the tropical waters of the Great Barrier Reef and the temperate waters characteristic of the mid-New South Wales coast (Cannon et al., 1987; Done 1982). Rocky reefs in the Gold Coast provide: habitat and shelter for many plants, invertebrates and fish communities; help protect the coast from strong currents and waves; help sustain commercial and recreational fisheries; and provide recreational amenity for diving and snorkelling. Because many of the Gold Coast’s reefs are located close to shore, they are often the first diverse marine habitat to be affected by human activities from land or in nearshore areas.

2.10.4 **Megafauna**

Several groups of vertebrates make use of sandy beaches for foraging, nesting, and breeding (McLachlan and Brown, 2006). Birds are the most important vertebrates commonly encountered on sandy beaches (McLachlan and Brown, 2006). Commonwealth law such as, the *Environment Protection and Biodiversity Conservation Act* 1999, and several treaties such as Japan-Australia Migratory Bird Agreement (1974), and the China-Australia Migratory Bird Agreement (1986) aim to protect shorebirds from further population decline. Another popular vertebrate that visits Gold Coast’s beaches are marine turtles, which come ashore to lay their eggs in the dry beach above the high water mark. Globally, marine turtle populations are under threat. The two species that nest on the Gold Coast (*Chelonia mydas* and *Loggerhead turtles Caretta caretta*) are listed as 'endangered' by the World Conservation Union.

2.11 **Meteorology**

2.11.1 **Climatic summary**

The Gold Coast experiences a mainly sub-tropical climate with moderate rainfall during the warmer months. Extreme events are usually associated with tropical cyclones, east coast lows or smaller scale localised thunderstorms. The eastward passage of mid-latitude high pressure systems results in prevailing south-easterly winds throughout the warmer months.
The increasing moisture of the southeast air-stream over the northern Tasman results in atmospheric conditions conducive to the formation of east coast lows. While tropical cyclones are generally restricted to the months between December and April and weaken as they move over cooler waters or cross the coast the depressions caused by low pressure troughs can occur at any time of year but occur more frequently between March and July (Allen & Callaghan, 2000).

Throughout the cooler months the northward movement of the high pressure transit allows cold fronts extending from large low pressure areas to the south of continent to produce periods of drier westerly winds and cooler temperatures.

2.11.2 Winds

![Figure 20: Mean 9am Wind Speed at Coolangatta and the Gold Coast Seaway](image-url)

This figure shows the mean 9am wind speed at Coolangatta and the Gold Coast Seaway over a year. The data indicates that the wind speed generally ranges from 5 to 20 km/h, with a slight increase in December and January, and a decrease in July and August.
Figure 21: Mean 3pm Wind Speed at Coolangatta and the Gold Coast Seaway
Figure 22: Mean Annual 9am Wind speed and direction at Coolangatta

Figure 23: Mean Annual 3pm Wind speed and direction at Coolangatta
Figure 24: Mean Annual 9am Wind speed and direction at Gold Coast Seaway

Figure 25: Mean Annual 3pm Wind speed and direction at Gold Coast Seaway
2.11.3 Rainfall

Figure 26: Mean Rainfall at Coolangatta and the Gold Coast Seaway

Figure 27: Mean Number of days with rainfall of 1mm or more at Coolangatta and the Gold Coast Seaway
2.11.4 Temperature and relative humidity

Figure 28: Mean Maximum temperatures at Coolangatta and the Gold Coast Seaway

Figure 29: Mean Minimum Temperatures at Coolangatta and the Gold Coast Seaway
Figure 30: Mean 9am Relative Humidity at Coolangatta and the Gold Coast Seaway

Figure 31: Mean 3pm Relative Humidity at Coolangatta and the Gold Coast Seaway
2.11.5  **Tropical cyclones**

Tropical cyclones bring destructive winds, high seas, heavy swells, storm tides and localised flooding due to the combined effects of elevated sea levels and heavy rainfall. The long term average occurrence is for 1.2 cyclones to pass within 500km of Brisbane each year (Harper et al., 2000). While cyclones passing over the coast or approaching close by create the most destructive conditions, those that remain further offshore have the potential to generate heavy cyclonic swells and extreme wave events resulting in erosion of Gold Coast beaches.

<table>
<thead>
<tr>
<th>Category</th>
<th>Maximum Wind Gust (km/h)</th>
<th>Potential damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt;125</td>
<td>minor</td>
</tr>
<tr>
<td>2</td>
<td>125-170</td>
<td>moderate</td>
</tr>
<tr>
<td>3</td>
<td>170-225</td>
<td>Major</td>
</tr>
<tr>
<td>4</td>
<td>225-280</td>
<td>Devastating</td>
</tr>
<tr>
<td>5</td>
<td>&gt;280</td>
<td>extreme</td>
</tr>
</tbody>
</table>

Cyclones forming in the Coral Sea generally move towards the southeast steered under the influence of northwest winds associated with mid latitude troughs.

Upper level troughs may also give rise to East Coast Lows forming near the Southeast Queensland coast. While regarded as a separate entity to a Tropical Cyclone they can produce similar intense winds and seas and often the conditions giving rise to an east coast low may persist and result in a succession of similar events. Such a sequence of east coast lows occurred following 3 consecutive tropical cyclones in 1967 and was the trigger for much of the research to date in the region. The history of storms has been collated by the late Sam Smith from GCCC and is presented here as Table 7.

2.11.6  **Climate change and greenhouse effect**

The most critical issue facing coastal communities in the long-term (in 50 to 100 years) will most likely be the impact of climate change on sea-level storminess. The following description of the impact of greenhouse gases and global warming is taken from a public information sheet (CSIRO, 2002).

> Since the time of the Industrial Revolution, greenhouse gas and sulphate aerosols concentrations in the atmosphere have increased as a result of human activities such as agriculture, deforestation and the use of fossil fuels. Future global emissions will depend on population growth, energy sources and regional and global economic growth. The Intergovernmental Panel on Climate Change (IPCC) has used this information to produce emission scenarios that are used to determine future greenhouse gas concentrations. These future greenhouse gas concentrations are input to computer models of the global climate to provide estimates of future climate. From these model estimates, the IPCC projects a globally averaged warming of 1.4 to 5.8°C by 2100, relative to 1990. Over the past century the Earth has warmed 0.6 ±0.2°C.
### Table 7. History of Gold Coast Storms

<table>
<thead>
<tr>
<th>Year</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1770</td>
<td>Area peacefully inhabited by Aborigines of the Yugambeh Families</td>
</tr>
<tr>
<td>1770</td>
<td>Area sighted and roughly chartered by Captain Cook; Point Danger named</td>
</tr>
<tr>
<td>1822</td>
<td>Southport Bar chartered</td>
</tr>
<tr>
<td>1823</td>
<td>Tweed River chartered</td>
</tr>
<tr>
<td>Mid 1800’s</td>
<td>Cedar and sugar cane industries brought permanent settlers</td>
</tr>
<tr>
<td>1874</td>
<td>Town of Southport subdivided into 1 acre lots by Queensland Government and subsequently holiday homes constructed</td>
</tr>
<tr>
<td>1875-89</td>
<td>Good beach conditions; Cobb &amp; Co., coach service to Nerang, Southport and Coolangatta traveled along beach and across the mouth of Currumbin Creek and around Kirra at low tide</td>
</tr>
<tr>
<td>1880/1910</td>
<td>Tweed walls constructed by NSW Government</td>
</tr>
<tr>
<td>1883</td>
<td>Coolangatta subdivided (by Queensland Government)</td>
</tr>
<tr>
<td>1888</td>
<td>Surfers Paradise Hotel constructed to cater for increasing number of visitors</td>
</tr>
<tr>
<td>1889</td>
<td>Brisbane to Gold Coast Railway built to cater for visitors (primary producers)</td>
</tr>
<tr>
<td>1894</td>
<td>Serious erosion recorded at Main Beach</td>
</tr>
<tr>
<td>1897</td>
<td>Junupimbun bar inadvertently created</td>
</tr>
<tr>
<td>1903</td>
<td>Railway extended to Coolangatta (rapid growth followed) with stops at West Burleigh and Currumbin, surf-life saving clubs were established at Coolangatta, Kirra, Burleigh and Southport (Main Beach) and the “resort” nature was emerging</td>
</tr>
<tr>
<td>1912</td>
<td>Currumbin Hotel constructed</td>
</tr>
<tr>
<td>1912-19</td>
<td>Good Beach conditions</td>
</tr>
<tr>
<td>1920</td>
<td>Minor erosion recorded, main road constructed at Narrowneck and protection required and timber wall constructed; esplanades at Currumbin lost, north of Elephant Rock</td>
</tr>
<tr>
<td>1922/23</td>
<td>Currumbin and Palm Beach subdivided (extended into active zone) with seven chains of beach</td>
</tr>
<tr>
<td>1923</td>
<td>Only two houses at Palm Beach</td>
</tr>
<tr>
<td>1929</td>
<td>Houses destroyed at Palm Beach</td>
</tr>
<tr>
<td>1931</td>
<td>Cyclone erosion and flooding recorded, Birch Island completely eroded as Currumbin Creek Mouth breached southward at Currumbin Creek</td>
</tr>
<tr>
<td>1936</td>
<td>Cyclone and extensive erosion recorded; timber walls were constructed at Coolangatta, Kirra, Currumbin and Narrowneck; spit breached</td>
</tr>
<tr>
<td>1937</td>
<td>Severe erosion, Rainbow Beach</td>
</tr>
<tr>
<td>1938</td>
<td>Severe erosion, Main Beach and South Stradbroke Island – houses threatened</td>
</tr>
<tr>
<td>1940’s</td>
<td>Dune stabilisation works at Coolangatta to reduce wind blown sand</td>
</tr>
<tr>
<td>1948</td>
<td>Erosion noted</td>
</tr>
<tr>
<td>1949</td>
<td>Erosion protection, boulder walls, to Currumbin and Kirra; foreshore improvements Burleigh, visiting Prime Minister (Fadden) to inspect problems – rejected federal assistance</td>
</tr>
<tr>
<td>1950</td>
<td>Erosion noted</td>
</tr>
<tr>
<td>1951</td>
<td>Spit breached and closed with bulldozer, Kindler and O’Connor report – no action</td>
</tr>
<tr>
<td>1954</td>
<td>Direct hit by cyclone, severe erosion, houses moved westward (e.g. Main Beach, Mermaid), Narrowneck wall reinforced with boulders; Tallebudgera Creek blocked</td>
</tr>
<tr>
<td>1962/64</td>
<td>Tweed River training walls extended by NSW Government</td>
</tr>
<tr>
<td>1964</td>
<td>Delft Laboratories commissioned to prepare a report and recommendation</td>
</tr>
<tr>
<td>1965</td>
<td>Boulder wall constructed at Main Beach by Main Roads Department (benefited area scheme)</td>
</tr>
<tr>
<td>1967</td>
<td>Geophysical mapping carried out; seven cyclones and severe erosion (worst in recorded history; esplanades lost (e.g. Surfers)</td>
</tr>
<tr>
<td>1968</td>
<td>Boulder walls constructed at Coolangatta, Broadbeach, Surfers, Beach Protection Authority (BPA) established</td>
</tr>
<tr>
<td>1969</td>
<td>Dune stabilisation works – Burleigh and Kurrawa</td>
</tr>
<tr>
<td>1970</td>
<td>“Delft” report completed</td>
</tr>
<tr>
<td>1972</td>
<td>Several cyclones (Wendy and Daisy) and severe erosion; Coolangatta (Kirra point) groynes constructed by State Government to alleviate loss of Coolangatta Beach;</td>
</tr>
</tbody>
</table>
Currumbin groyne to stabilise Currumbin. “Shrapnel” economic report prepared recommending 40% federal, 40% state, 20% local funding

1973
Kira camp ground eroded and boulder wall constructed to prevent loss of highway; scheme for restoration of Gold Coast beaches approved by Qld Government

1974
Several cyclones and severe erosion (Wanda and Pam); Kira groyne constructed to stabilise beach at surf life saving club

1974/75
Surfers/Main Beach nourished (1.4 Million m³) and dune stabilisation works ($1.5 million); Kira nourished (1.0 million m³ / $1.0 million); Kira boulder wall constructed; Palm Beach nourished (210 000m³ / $160 000); Palm Beach and Burleigh nourished every year from now on

1975
Breakthrough at Currumbin Creek; spit repaired

1976
Spit strengthened (90 000m³ / $40 000); Palm Beach nourished (100 000m³ / $90 000); Burleigh nourished (80 000m³ / $80 000); Tallebudgera groyne (stage 1) constructed to stabilise north Palm Beach and reduce possibility of blocking of Tallebudgera Creek

1980
Tallebudgera groyne (stage 2) constructed; Palm Beach mini groyne and Miami groyne constructed by State Government

1981
Currumbin Creek training wall constructed to stabilise creek mouth and allow further sand reserves to be removed; Palm Beach nourished (325 000m³ / $850 000)

1983
Storm attack and erosion

1983/84
Extensive dune fencing works; Point Danger investigation commenced

1984
Storm (cold core cyclone) attack and extensive erosion; Kira wall damaged and repaired; investigations of Kira erosion;

1985
North Kira groyne, nourishment ($4.9 million):
- Kira 100 000m³ nearshore
- 215 000m³ onshore
- Palm Bch 100 000m³ nearshore
- Burleigh 183 000m³ nearshore
- 200 000m³ onshore
- Surfers 140 000m³ nearshore
- Narrowneck 300 000m³ from Broadwater
- Nerang River training walls and sand bypass completed

1986
Mild conditions, beach fencing works; completion of construction of the Gold Coast Seaway

1987
Mild conditions, beach fencing works

1988
Kira / Bilings nourishment (stage 2) ($2.5m) – 1.5 million cubic metres nearshore; Burleigh Beach nourishment (from Tallebudgera Creek) 100 000m³ onshore ($135 000); Southern Gold Coast Beach Protection Scheme underway (1988-1992)

1989
Severe erosion southern beaches; Southern Gold Coast beach nourishment project – stage 1 commenced, 3.6 million m³ implemented by Queensland Government (QLD 75% / GCCC 25%)

1990
Review of Delft report commissioned; negotiations re joint Tweed River bypass scheme;

1991
Mild weather conditions

1992
Relatively mild weather conditions

1993
Cyclone Roger affected the coastlines in March

1996
Cyclones in May accentuated vulnerability of Gold Coast beaches to erosion; Northern Gold Coast Beach Protection Scheme underway (1996-2000); shortening of Miles Street and Kira Point Groynes

1998
Establishment of first internet cameras for Gold Coast beaches

1999
Series of storms in April – May reduced capacity of dune system to withstand erosion; dredging of Broadwater / nourishment for NGBPS commenced in February; Construction of artificial reef commenced in August; establishment of the Griffith Centre for Coastal Management; Palm Beach Beach Protection Strategy developed

2000
Dredging / nourishment for NGBPS completed in October

2000-2001
Burleigh Beach Beach Protection Strategy anticipated
Associated with global warming will be a rise in sea level. The IPCC estimates a rise in sea level of between 0.09 and 0.88 m by 2100 relative to 1990, or 0.8 to 8.0 mm per year. The largest source of sea-level rise is due to the expansion of the oceans as they warm. Contributions can also be expected from the melting of glaciers and ice sheets. Other factors such as the storage of water in dams or increased snowfall over Antarctica will slightly offset some sea-level rise. In addition, coastal subsidence or uplift can influence local sea level. Lastly, on seasonal, inter-annual, and decadal time-scales, sea level responds to changes in atmospheric and ocean dynamics, with the most striking example occurring during El Niño events, when the sea level rises in the eastern Pacific and falls in the western Pacific. Regional variations from the global average can be expected due to regional differences in weather patterns and ocean current.

As sea level rises, material on sandy shorelines is eroded from the upper beach and deposited on the near-shore ocean bottom. Consequently the ocean moves landwards or, in other words, the shoreline recedes. It is generally accepted that the coastline will retreat horizontally 50 to 100 times the vertical sealevel rise. Hence, the predicted global sea-level rise would cause a coastal recession of sandy beaches of 4.5 to 88 metres by 2100. The rate of sea-level rise relative to the land is important for impacts. Australia’s oldest sea level records are from Port Arthur, Fremantle and Sydney. They show that relative sea level has risen 0.86±0.12 mm per year at Fremantle for the period 1915–1998, and 1.38±0.18 mm per year at Sydney between 1897 and 1998. At Port Arthur, sea level is estimated to have risen 1.2±0.2 mm per year since 1890. Over the past 50 years, global-average sea level has risen 1 to 2 mm per year.

The strongest natural fluctuation of climate from year to year is the El Niño-Southern Oscillation (ENSO). In El Niño years, eastern Australia tends to be drier and hotter than normal and in La Niña years, eastern Australia tends to be wetter and cooler. Changes associated with ENSO often have a profound impact on society because of associated droughts, floods, heat waves and other changes that can affect agriculture, fisheries, energy demand and fire risk. ENSO affects the region of formation of tropical cyclones in the South Pacific and their tracks. During La Niña years, tropical cyclone activity is located closer to the coast of north-eastern Australia than during El Niño years. ENSO also affects the frequency of severe weather such as hailstorms and east coast lows. Such variations are expected to continue under enhanced greenhouse conditions, though possibly with greater hydrological extremes in Australia as a result of more intense rainfall in La Niña years and more intense drought during El Niño years. ENSO has been observed to vary over the past century with an increase in the frequency of El Niño conditions over the past decade.

Tropical cyclones bring severe winds and rainfall and can have devastating impacts on society. Since 1967, 46 tropical cyclones each causing more than A$10 million damage, have impacted communities of northern Australia. The Bureau of Transport and Regional Economics estimates the total cost of cyclones to have been A$8.8 billion since 1967. The most devastating tropical cyclone to affect Australia in the last 30 years was tropical Cyclone Tracy. Tracy devastated Darwin in December 1974, resulting in 65 deaths, A$4 billion in total damages and an insured loss of A$837 million. Therefore, accurate estimates of future changes in their frequency, intensity and location would be of great value.

Climate variability has a significant impact on the frequency of these events and there is some evidence of long-term variations in the characteristics of tropical cyclones in the Australasian region. A decrease in tropical cyclone numbers occurred in the Australian region between 1969 and 1996 but in the same period there has
been an increase in the frequency of intense tropical cyclones with central pressures of less than 970 hPa. No significant global trends have been detected in the frequency of tropical cyclones to date. Projections are difficult since tropical cyclones are not well resolved by global or regional climate models. Present indications are:

- Maximum wind speeds may increase by 5–10% and precipitation rates may increase by 20–30%. More intense tropical cyclones would have serious implications for storm surge heights, wind damage, flooding and landslides on the steep escarpments of eastern Australia.
- Regions of origin are likely to remain unchanged.
- Preferred paths and poleward extent may alter, but changes remain uncertain. If they were to travel further poleward they would be more likely to impact on coastal regions in south-west Western Australia, southern Queensland and northern NSW.
- Future changes in frequency will be affected by changes in ENSO.

Mid-latitude storms also may increase in intensity, and their frequency and location may change as a result of changes in the westerlies and ENSO. Recent decades have seen a reduction in the numbers of mid-latitude storms to the south of Australia, but the intensity of these storms has on average increased. Climate models also indicate a future decrease in the number of storm centres over southern Australia but an increase in their intensity. These changes are likely to affect the coasts in the south-east of the continent that are vulnerable to shifts in wave direction and energy. They will also impact the return periods for mid-latitude storm surges, landslides, high winds, coastal erosion and other phenomena.

A storm surge is a region of elevated sea level at the coast caused by the combined effect of falling atmospheric pressure and intense winds of severe weather events such as tropical cyclones. The rise in sea level is about 10 mm per hectopascal fall in pressure (the so-called inverse barometer effect) although the larger contribution is due to wind that, in effect, pushes the water against the coast. Factors influencing the storm surge include the wind strength, its direction relative to the coast and how the storm moves in relation to the coast. For example, a tropical cyclone-induced storm surge would be most intense over the region of strongest onshore winds as the cyclone moves onshore. The shape of the sea floor and the proximity to bays, headlands and islands also affects the storm surge height. Wide and gently sloping continental shelves amplify the storm surge, and bays and channels can funnel and increase the storm surge height. Storm systems such as tropical cyclones and mid-latitude storms and their associated cold fronts are the main cause of storm surges. The most severe storm surges in Australia several metres in height, and occur as a result of tropical cyclones. Storm surges can interact with other ocean processes such as tides and waves to further increase the coastal sea levels and flooding. A storm surge will have maximum impact if it coincides with high tide. Breaking waves at the coast can also produce an increase in coastal sea levels known as wave setup.

Recent research (Helman and Tomlinson, 2008) has identified the key climatic indicator for storminess and hence coastal erosion as being the Inter-decadal Pacific Oscillation (IPO). The correlation has demonstrated that in the Gold Coast region there have been cycles of stormy years followed by decades of relative calm. As an example the period from the mid-1950s to the mid-1970s was characterised by numerous major storms and very significant coastal erosion. Since 1974, the Coast has not experienced any major storm of comparable strength. Regardless of greenhouse gas-induced climate change it is most likely that the next few decades will see a return to extreme storminess.
2.12 Specific beach condition and problem areas on the Gold Coast

The GCSMP considers Gold Coast beaches at a number of different scales, the most important of which is the macro or system wide scale. A range of macro-scale issues have been identified in the preceding sections of this chapter and include natural and human processes. The second level of consideration for beaches and beach management is a series of zonal type scales. These are broadly based around changes to the natural system and for the purposes of this plan are referred to as (from south to north):

1. NSW border (city boundary) to Flat Rock;
2. Flat Rock to the south wall of Tallebudgera Creek;
3. South wall of Tallebudgera Creek to Little Burleigh (Nobby);
4. Little Burleigh (Nobby) to the Gold Coast Seaway; and
5. South wall of the Gold Coast Seaway to Jumpinpin (city boundary).

Throughout this report, discussion will generally focus on these compartments or an aggregation of these where appropriate.


Individual beaches form the third and smallest system level for consideration. In 2006, a draft Beach Health Report was prepared by GCCM for Gold Coast City. A full version of the report including a description of the indicators and process used to adjudge beach health can be found in Volume 4 of this publication. Each of the beaches in Gold Coast City was scored against a specific set of indicators. The indicators covered three broad themes:

1. **Services** - This theme captures issues related to beach management. It assesses the health of a beach from a management point of view and will give an indication which beaches need special attention;

2. **People and play** - This theme captures issues related to the market and non-market value of beach use by locals and visitors, including our understanding of and connection to place; and

3. **Beach Health** - This theme assesses physical and ecological processes. Physical processes assesses beach health in relation to the resilience of the beach to uncertainty and the risk of the beach in terms of requiring nourishment or other engineering action to preserve public interest and environmental values. Ecological processes assess issues related to ecological beach processes including the beach area, intertidal and nearshore zones in terms of the flora and fauna communities.

**Table 8** provides an overview of the findings from the report and **Table 9** provides an overview of beach condition and score against the set criteria. A number of key issues are worth mentioning:

- Services and amenity at most beaches are believed to be of a high standard.
While the beaches provide important and valuable amenity for both residents and visitors, changes to amenity, overcrowding and conflict at certain locations may require management interventions.

The Gold Coast beaches have been significantly modified over time. High usage, ongoing infrastructure works and urban squeeze continue to impact on environmental quality and as a result the condition of the natural environment of the dunes, beaches and nearshore zone varies considerably along the coastline.

Table 8. Summary of findings - Beach Health Report 2006

Services
Services and amenity at most of the Gold Coast beaches is of a good standard. Access is generally good to excellent with a number of exceptions including Palm Beach, the northern end of Main Beach and South Stradbroke Island. Full-time lifeguard services operate at most of the Gold Coast beaches. All beaches have summer holiday and summer weekend lifeguard / lifesaver services. The Gold Coast Oceanway Masterplan is currently in progress and this has seen the redevelopment of foreshores and promenades at a number of beaches. Water quality is generally good with the major issues being potential health problems at Coolangatta Creek as a result of stormwater and at the Gold Coast Seaway from the sewage outfall.

People and Play
With close to 500,000 residents and over 4,000,000 visitors each year and a climate that encourages beach use all year round, our beaches receive very high patronage. Some beaches are more popular than others for locals and others are more popular tourist destinations. The point break beaches at the Southern end of the coast as well as South Stradbroke Island remain popular with board riders. The loss of recreational amenity (surf breaks, lagoon areas, safer swimming and more family friendly beaches) as a result of the Tweed River Entrance Sand pumping program continues to be an issue of concern for residents and visitors to the southern beaches. There has been a growth in the number of groups and individuals taking an interest in their local coastal areas, especially at the southern beaches, Palm beach and The Spit. Beach going, walking, jogging, fishing, boating and volleyball are all popular activities. At both Currumbin Alley and the Seaway there have been a number of conflicts between users and these areas may need to be more actively managed into the future. Parklands adjacent to the beaches remain popular for families. The redevelopment and extension of some of these areas has proved popular, however there has been a rapid growth of commercial activities taking place in public space and a balance between passive / recreational and commercial activities must be considered. Volunteer SLSC’s operate at most of the beaches and there are also a number of board riding clubs and informal swimming and walking groups. At most beaches there are relatively few natural hazards except in large swells, however, our ocean facing beaches are exposed to high energy conditions and rip channels and dangerous currents are common and this can make swimming very dangerous at times.

Beach Health
Beach Health varies considerably along the Gold Coast beaches. As a result of the Tweed River Entrance Sand Bypassing Project, extensive amounts of sand have been delivered to the beaches and nearshore system at the southern end of the coast and they are considered to be very healthy in terms of their ability to withstand big storms. Unfortunately, this same project has seen the smothering of Kirra Reef with sand and an important marine habitat area has been all but lost. Dredging programs operate out of Currumbin and Tallebudgera Creeks placing sand on Palm Beach and Burleigh Heads respectively and this assists in maintaining beach width. Palm Beach as well as beaches to the north are all open to the prevailing conditions and are at high risk from erosion as a result of storm and cyclonic events. This places public and private infrastructure at risk. In general, dune (the primary buffer from storms) health is moderate – poor with a number of weed species, incidences of vandalism and limited space the key issues and more work needs to be undertaken. There are, however, some areas with good primary dunal systems and vegetation.
### Table 9. 2006 Beach Health Report - Individual Beach Summaries

<table>
<thead>
<tr>
<th>Beach Name</th>
<th>Description</th>
<th>Score</th>
<th>People &amp; Play</th>
<th>Beach Health</th>
</tr>
</thead>
</table>
| **Froggies** | 1. Good public access but limited for maintenance purposes, parking is limited, currents can be hazardous;  
2. Aesthetically beautiful beach, popular for weddings, provides good protection from wind, popular with bodyboarders;  
3. Rocky shores are exposed to large swells and the beach area comes and goes, beach affected by sand pumping from the Tweed River Entrance Sand Bypassing Project (TRESBP) which can cause the small beach to grow quickly at times but also leads to a smothering of the intertidal rocky foreshore. | D     | C^1           | C            |
| **Rainbow**   | 1. Good public access, amenities and maintenance services, full-time lifeguard services provided, parking is limited and unlikely to expand;  
2. Very popular beach for swimmers, families and surfers, but the intensity of use can lead to conflict in the surf zone due to overcrowding, an increased volume of sand due on the beach and in the nearshore zone as a result of the TRESBP has resulted in the loss of the lagoon system and the amenity it provided, swimming is more difficult because of the shallower bay, home to Snapper Rocks / Superbank a world class surf break, strong contingent of older people use this beach and there have been complaints drop off into surf zone and strong current; Snapper Rocks Boardriding Club, volunteer SLSC;  
3. Dunal vegetation lacks diversity and the dunes are generally not healthy, dunes have been sacrificed to extend the area of parkland; the beach should be able to recover from large erosion events due to TRESBP, water quality is good, very little information exists on beach ecology. | B^+   | B             | B            |
| **Greenmount** | 1. Excellent access, amenities, maintenance services, full-time lifeguard services, few hazards present except in large swells, adjacent retail precinct provides good amenity, adjacent parkland will be redeveloped as part of the Oceanway Masterplan;  
2. Popular with surfers, swimmers, walkers, fishers and families who use the adjacent parkland area but there have been many complaints that the beach is too wide as a result of the TRESBP and the shallower bay means that swimmers go out more exposed and dangerous waters and the beach is less popular than it used to be, Greenmount Headland is unique and beautiful and offers protection from the southerlies, the loss of the lagoon area and charm of beach has disappeared making it less pretty than before; volunteer SLSC;  
3. Beach is highly exposed to extreme events but the large buffer currently provides good protection from energetic swells, the dune area has been brought shoreward and parkland extended to provide greater amenity, there is some weed presence on the headland. | A^+   | C             | B^+          |
<p>| <strong>Coolangatta</strong> | 1. Excellent access, amenities, maintenance services, full-time lifeguard services, few hazards present except in large swells, adjacent retail precinct provides good amenity, lifeguard tower surveillance has been impeded due to beach berm near the waters edge, area is being upgraded in accordance | A^-   | D^2           | B            |</p>
<table>
<thead>
<tr>
<th>Beach Name</th>
<th>Description</th>
<th>Services</th>
<th>People &amp; Play</th>
<th>Health</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kirra</td>
<td>Excellent access, amenities, maintenance services, full-time lifeguard services, few hazards present except in large swells, adjacent retail precinct provides good amenity, beach area continuing to grow as a result of TRESBP, parking can be limited, Oceanway around the Point and through to North Kirra is popular;</td>
<td>B+</td>
<td>D+</td>
<td>C+</td>
</tr>
<tr>
<td>Nth Kirra</td>
<td>Excellent access, good amenities and maintenance services, parking limited during summer months, seasonal lifeguard services (8 months p/y) SLSC has crept forward + claimed the foreshore, can develop strong sweep current during southerly swells, no significant hazards;</td>
<td>C+</td>
<td>B-</td>
<td>C+</td>
</tr>
<tr>
<td>Bilinga</td>
<td>Excellent access at southern end, but limited to the north, few amenities and limited parking but adequate to cater to current use levels, lifeguard services summer weekends and school holidays, good maintenance service, no significant hazards except in large swells; Active Beachcare group, relative low beach use with limited exposure to tourists, aesthetically pleasing balance of beach width and vegetation, volunteer SLSC; Recurrent dune vegetation vandalism, good quality seaweed, good resilience to prevailing swell direction and prone to erosion, deep nearshore gutter, high exposure to prevailing swell direction and prone to erosion;</td>
<td>C+</td>
<td>B+</td>
<td>C+</td>
</tr>
<tr>
<td>Beach Name</td>
<td>Description</td>
<td>Score</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
<td>-------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tugun</td>
<td>1. Fair pedestrian access, good amenities and reasonable parking, Oceanway currently being upgraded, lifeguard services summer weekends and school holidays, good maintenance services, no significant hazards except in large swells; 2. Active Beachcare group, local village feel and high level of local usage, significant community concern about impacts of the desalination plant, presence of SLSC, volunteer SLSC; 3. Wide dune buffer with excellent potential for revegetation, Strong native groundflower vegetation with good resilience for natural regeneration (with weed control program required), stable beach but exposed to prevailing swell conditions and high potential for erosion, no beach widening as a result of TRESBP at this stage.</td>
<td>C+ C C+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flat Rock</td>
<td>1. Moderate access due to private property adjoining beach, no lifeguard services, beach can be hazardous due to rocks and currents, adjacent parkland and facilities are well used, some vandalism, beach are is prone to storm debris from flooding from the Creek outlet, park area currently in need of an upgrade; 2. High level of local use, aesthetically beautiful beach with a more rugged and natural looking area, beach has high recreational value and is used by surfing park has heavy use on weekends and is popular with families, fishing, kite surfing, swimming and walking, Kropp Park is popular with families and has high weekend use including for weddings and other celebrations; 3. Weed problems on northern side including Maderia vine which requires ongoing weed maintenance, there is a poor community perception of the value of dune vegetation, after major storm events the bird sanctuary empties aquatic weed onto beach, on the northern side of the creek the area is turfed up to the creek and this encourages undercutting and erosion.</td>
<td>C+ B C+</td>
<td></td>
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</tr>
<tr>
<td>Currumbin</td>
<td>1. Excellent access on the south side but limited to the north, amenities, maintenance and services are good but toilet block could be upgraded, full-time lifeguard services, parking is generally good but gets overcrowded during summer holidays and on some weekends, twice yearly creek dredging program with spoil being placed on Palm Beach, entrance and estuary can be dangerous, Oceanway needs to be upgraded; 2. diverse range of activities including beach / sand pumping / dredging, SLSC at Elephant Rock dominates the area and is too big and bulky for the environment; 3. Beach, creek and estuary support a wide range of recreational activities (probably the most diverse on the coast) including surfing, boating, fishing, kite surfing, kayaking, swimming, dog-walking, there have been a number of conflicts between recreational users in this increasingly popular place including complaints about too many groups using the beach for commercial purposes, well used adjacent parkland but complaints about having to cross busy road, beach platforms popular, area has a good natural aesthetic, Boardriding club and volunteer SLSC; 4. High inflow of sand across bar makes the river mouth difficult to maintain, area to north of the creek is at risk of breaking through, beach is exposed to strong currents and consistently changing</td>
<td>B A- C+</td>
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<tr>
<td>Beach Name</td>
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<tr>
<td>Palm Beach</td>
<td>Poor beach access except for street ends, very limited parking and limited facilities, twice yearly dredging from Currumbin Creek onto Palm Beach and occasional offshore sand deposits to assist with nourishment, (proposed) extension of Oceanway at Northern end, rock groynes on beach, boulder wall prominent in some areas, seasonal lifeguard services, limited public space; Active beachcare group, limited access and parking means this is mostly a &quot;locals&quot; beach, popular with surfers, fishing on bait reef and offshore reef, aesthetics for private landowners are important (viewlines to Elephant Rock and to Burleigh Headland), community wary after 'no reef' campaign, Boardriding club and 3 volunteer SLSCs Exposed narrow beach, major erosion and risk of erosion in storm events, encroachment of weeds from residential properties, private landholders in some areas have reclaimed dune areas, good marine habitat on offshore reefs, beach can be hard to maintain.</td>
<td>C-(^4) C C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burleigh Heads</td>
<td>Excellent access, amenities, maintenance, full-time lifeguard services, few hazards except in large swells, adjacent parkland and retail precinct provides good amenity, good pathways &amp; viewing decks, some concerns over limited parking, shade from buildings encroaching onto beach and dunal area limits activities; Burleigh is an 'icon' beach and the Burleigh Heads National Park is unique and a great contributing drawcard, the southern beach area still has an old town feel and helps to create strong local feeling for the area, Burleigh is one of the best surfbreaks on the east coast and very popular for boardriders, the walkways are heavily used and swimming, jogging and cycling are also popular, boardriding and volunteer SLSC, the expansion of the surfclub at the north is an issue of concern as it will block community open space, there are many festivals, markets and other activities in the parkland and on the beach and this places substantial demands on both parks and beaches; There is a presence of good quality native vegetation but there are weed problems on the headland, the beach is vulnerable to erosion especially at the southern end and each year the area is nourished from Tallebudgera Creek, dredge pipes over headland are unsightly and there has been damage to rocky headland ecology from dredging, good quality water, rocky headland area provides a marine ecosystem but there is a risk from oversupplying dredge sand, beach revegetation is going well, beach profile is currently good.</td>
<td>A+ A- B</td>
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<tr>
<td>Miami</td>
<td>Good beach access, very well maintained beach and park area, sometimes hard to park, full-time lifeguard services, caravan park, location for sand deposit site, New Oceanway path system is popular but hill crossing is not disability compliant, few hazards except in large swells; Another mainly 'locals' beach popular with fitness groups, surfers, swimmers, walkers and surf club use, much busier in summer, viewlines along oceanfront parkland are important for local residents, picnic areas are popular, area has a comfortable local village feel, beach is exposed and can be</td>
<td>B+ B B-</td>
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</tbody>
</table>
**Nobby**

1. Limited access and services, limited access for debris removal, full-time lifeguard service, limited parkland, parking can be difficult, few hazards except in large swells;
2. South Nobby Hill is a picturesque and popular landmark, beach and adjacent area is popular with walkers, surfers and has high use in the mornings, kite surfing is becoming more popular at this beach, strong local feel to beach, views impacted by residences (houses too close to beach), rip channels are common and this can make swimming very dangerous, MNM Boardriding club, volunteer SLSC;
3. Good current beach profile, but risky, exposed beach with limited buffer zone, problems with weeds from residential areas encroaching onto dunes, very thin dunes and limited vegetation cover.

**Mermaid**

1. Well maintained, limited access at street ends only, some parking problems, good amenities, parkland close by, good viewing platforms, full-time lifeguard service, few hazards except in large swells, private property developed right to the A-line (boulder wall), surf club across the road on western side;
2. Public views impacted by residences, heavy pedestrian use, very popular, locals' beach with some tourist use, viewing platforms well utilised, popular for swimming and boardriding with fishermen use nearshore gutters, MNM Boardriding club, volunteer SLSC;
3. Dunes wider than Nobbys, currently stable but has previously had erosion back to the boulder wall, Dunes exposed to high levels of erosion, very vulnerable beach but has ability to recover quickly, significant scarping in last storm event (2-3m), problems with weeds from residential areas encroaching onto dunes.

**Broadbeach**

1. Excellent access, amenities, facilities and maintenance, full-time lifeguard services at Margaret Ave, Kurrawa and Broadbeach, few hazards except in large swells, adjacent parkland and retail precinct provides good amenity, Margaret Ave is a sand deposit area;
2. One of the most popular beaches, the boardwalk is a focus for tourists, very popular beach, parkland and playgrunds at Kurrawa with swimming, surfing, walking, joggers and beachgoing popular activities, volunteer dunecare group, site for major events such as markets and markets, New Years Eve celebrations, Broadbeach BluesFestival and surf lifesaving competitions (surf events impact on dune vegetation), beginning of the highrise precinct, some issues about the growth of commercial activities taking place in public space and a balance between passive/ recreational and commercial activities must be considered, volunteer SLSC;
3. Areas are well fenced to assist with revegetation and some sites have a strong resilience with a good seed bank, wide dunes and park present a good buffer zone from the ocean, 'open' beach that can
<table>
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<th>Beach Name</th>
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<th>Score</th>
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<td></td>
<td>face erosion on large swells, good natural profile to the south, dumping spot for sifted sand from local highrise construction can cause erosion due to steep profile, major erosion evident following storms, presence of rip currents often.</td>
<td>B+ B C+</td>
</tr>
<tr>
<td>Surfers Paradise</td>
<td>1. Excellent access, amenities, and maintenance, full-time lifeguard services, few hazards except in large swells, adjacent parkland and retail precinct (downtown surfers paradise) provides good amenity, Esplanade is looking dated and is earmarked for an upgrade as part of the Oceanway Masterplan, parking close to the beach can be very difficult, area could do with more public toilets and a change room, GCCC works closely with Surfers Paradise Management; 2. Surfers Paradise is the highest use beach on the Gold Coast and an internationally recognised icon with swimming, boardriding, beachgoing and kitesurfing popular activities, this is a resort style beach that caters mainly for tourists and has a distinct aesthetic feel, there are many activities and events that utilise the beach and adjacent parkland area including Indy, Schooliesm markets and NYE festivals placing significant pressure on both the parks and the beach areas, the Esplanade is very popular for walkers, the many highrises along the beachfront create unpleasant building shadows in the afternoons, high visitor numbers also attract petty thieves and there have also been a number of incidents of undesirable photos taken of unsuspecting people, the open beach and strong rips currents can make swimming very dangerous, volunteer SLSC; 3. Low dunal species diversity and limited ecological value but this meets local community / tourist expectations, foredunes at northern end have good primary stabilisers, no room for any tolerance for beach loss due to tourism demand, open beach vulnerable to erosion and has suffered severe erosion in extreme conditions, steep beach face, relatively wide beach but beach width can change significantly (upto 20m) per year under natural conditions, scarping toward the northern end, good water quality.</td>
<td>B+ B C+</td>
</tr>
<tr>
<td>Main Beach</td>
<td>1. Generally easy public access but restricted at some street ends, good amenities and maintenance, full-time lifeguard services, good parking, Oceanway partially built in some places, location of Narrowneck artificial reef – an offshore submerged coastal protection structure, good parkland area; 2. Beach very popular with locals and visitors, day trippers from Brisbane use this area regularly, beach and walkway popular for walkers and beach and ocean popular with surfers and fishers, good, historical Southport SLSC, strong rip currents prevail especially at the northern end of the beach can make swimming dangerous, waves can break in very shallow water over Narrowneck reef and this can be dangerous for boaters and boardriders, Boardriding club and volunteer SLSC; 3. Excellent remnant stand of Beach Alectryon, some good quality native vegetation, residential encroachment is an issue resulting in weed problems and protection from development pressures needs to be considered, erosion at Cable St, high dune scarps following 2006 storms, high exposure to strong onshore winds, some instability from artificial reef, strong rips and undertows can change the nearshore environment frequently.</td>
<td>B+ B C+</td>
</tr>
<tr>
<td>Beach Name</td>
<td>Description</td>
<td>Services</td>
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</table>
| **The Spit**      | 1. Moderate access appropriate for beach type, well maintained but relatively few amenities and services, traffic and parking issues at times, seasonal lifeguard service, sand-pumping jetty, few hazards except in large swells;  
2. The last 'nearly natural' beach on the Gold Coast provides breathing space from the intensely developed areas for many residents and visitors to the area, popular surfing location, fishing off jetty, dogs off leash area, usage is growing, dirt biking, jogging, fishing, kitesurfing, jetskis, area can provide solitude on uncrowded beaches, Friends of Federation Walk, some instances of 'undesirable' activities taking place in the dunes, strong rip currents prevail especially at the northern end of the beach can make swimming dangerous, Save our Spit Alliance, plans to develop cruise ship and port facilities recently abandoned but proposal for superyacht marina in marine stadium still active;  
3. Only undeveloped tertiary dune system and littoral rainforest on the mainland, vegetation diversity is good but some revegetation is required as there is a large weed presence, low fauna diversity, beach is exposed to erosion problems but is protected at northern end by Seaway wall, dunes suffer from scarping but has a very large buffer zone. New walkways are currently being developed.                                                                                                                                                                           | D\(^5\)   | B             | B-           |
| **South Stradbroke Island** | 1. Excellent amenity, very limited access (paddle, boat, jetski), current services and maintenance meet existing needs, full time lifeguard service at Couran Cove;  
2. Surf break rated as one of the best and most consistent on the east coast and is very popular with surfers and bodyboarders, feeling of escapism, potential conflict / risk in the Seaway between paddling surfers and motorised craft, popular with fishers and beach walkers, existing development is set well back from beach;  
3. Sediment bypass deposits sand onto the beach and helps to create a wide and healthy beach at the southern end, turtle nesting sites increasing, presence of native animals (mammals, reptiles and birds) on beach and in dunal area, fairly steep beaches that can get eroded, some weeds and vegetation lacks diversity, treated sewerage outlets in the Seaway, debris washing up on the island, regular sightings of sharks by surfers and ski paddlers.                                                                                                                                                                                      | D         | B             | B            |

\(^1\) Respondents evenly split over D,C & B rankings, \(^2\) Respondents evenly split over D & B rankings, \(^3\) Respondents evenly split over D - A rankings, \(^4\) Respondents evenly split over C & D rankings, \(^5\) Respondents split over B & D rankings
2.14 Chapter Summary

The Gold Coast is situated at the Northern end of a 300 km long coastal unit starting at the Clarence River and ending at Moreton Island in Queensland. The beaches of the Gold Coast extend for approximately 52km from the NSW border in the south through to Jumpinpin at the northern end of South Stradbroke Island. Within a 50-year planning period the coastal system is largely considered to be in equilibrium with the major impacts attributed to the cross-shore transport of sand during high energy wave events.

The period since 1974 has been a relatively calm period for Gold Coast beaches with isolated and few severe beach erosion events. During this time there has been significant population growth, increasing tourism and high levels of development on the coastal fringe. The littoral system has been significantly modified in the past and continues to be heavily managed in order to protect coastal frontage and maintain beach quality.

The Gold Coast’s sandy beaches provide a wide range of ecosystem services and serve as a link between the ecology of sand dunes, the surf zone (Short and Hesp, 1982), and nearshore rocky reefs.

The Gold Coast experiences a mainly sub-tropical climate with moderate rainfall during the warmer months. Extreme events are usually associated with tropical cyclones, east coast lows or smaller scale localised thunderstorms.

Funding and legislative arrangements for coastal management in Queensland are currently under review and this is likely to have an impact on Gold Coast City Council’s beach management program.

In 2006, the first Beach health Report on the Gold Coast was completed. In general it was found that services and amenity at most beaches were of a high standard; overcrowding and conflict at certain locations may require future management interventions; environmental quality varies considerably along the coastline; and while a number of beaches are relatively well prepared for storm events, there remains significant concerns about the ability of many of the Gold Coast beaches to withstand a series of significant storm events.
CHAPTER 3 - COMMUNITY VALUES

3.1 Introduction

Public involvement in Integrated Coastal Zone Management (ICZM) programs is nowadays viewed as integral to both the success and the legitimacy of programs. The benefits of greater public involvement are now well recognised, however the means by which to achieve greater participation and stewardship is not always clear. In practice though, public involvement in ICZM programs has not been well defined, its parameters often being hard to categorise and therefore difficult to monitor and evaluate. In recent years, an important step forward in this area has been the development of a number of frameworks for broader and more effective public involvement (e.g. Fien et al., 2006).

The scope of this theme was to investigate and understand how the beach is used and what the key stakeholder issues are; to undertake a range of projects and implement strategies to; increase community knowledge about the Gold Coast’s ocean beaches; and to develop mechanisms for communication and ongoing community engagement in the management of the Gold Coast’s beaches.

This chapter presents the findings of a number of research projects including the Beach Health Report, Kirra Wave Amenity Study, Socio-economic study of recreational surfing on the Gold Coast, the SEQ Catchments Coastal Volunteer Audit and a study on the Economic and Social Values of Beach Recreation on the Gold Coast.

3.2 The challenge of community involvement: some views from the literature

James (1991, in Conacher & Conacher, 2000) argues that it is wrong to assume a lack of interest on the part of those who do not participate or who have not previously made their views known. It is much more likely that there are other reasons – including a lack of awareness of the issue, shyness, feelings of inadequacy and so on – which prevent people from participating. Or it may be that a particular public participation strategy is limited in its scope and therefore cannot elicit certain types of information or tap into certain 'publics'.

As described, there are various objectives for involving the community in environmental decision-making and no single technique can attain all of them. The range of techniques available is considerable. Each has advantages and disadvantages and some are more appropriate in certain circumstances than others.

The greatest degree of behaviour change occurs when different strategies combine (Gardner, G.T. & Stern, 1996).

One example of a resource that can help design and improve communication strategies is the Urban Research Program (URP) Toolbox (https://www3.secure.griffith.edu.au/03/toolbox/). The URP is

A free resource of principles and strategies to enhance meaningful stakeholder involvement in decision-making. Stakeholders include not only communities, but also scientists and decision-makers. Meaningful involvement of all stakeholders occurs through a commitment to social learning - learning on the part of communities, other stakeholders and
institutions. One of the key elements of using the Toolbox is that strategies need to be tailored to fit unique issues and stakeholders (Fien et al., 2006).

The URP Toolbox helps practitioners understand that with so many competing stimuli, a blue sky approach to environmental literacy is rarely going to hit the mark and better success is more likely if a key group, activity or area is identified and specific strategies are developed to target groups, issues or locales.

The following discussion provides an overview of the key challenges for public involvement in NRM programs across a continuum from on ground works through to education and involvement in decision-making.

![Community group involved in BeachCare Dune Planting](image)

**Figure 32: Community group involved in BeachCare Dune Planting**

### 3.2.1 Barriers to effective community involvement

The importance of and need for partnerships between the expert scientists and the lay community has been well documented (e.g. Thomsen, 2003; Wescott, 2002), however, the process by which to develop, nurture and maintain successful partnerships is an issue that is hotly debated, and many problems have been identified.

A number of authors write about the disparity in power relationships between the community and those in power and cite the differing objectives of these groups as one of the significant hurdles to greater community involvement (e.g. A. J. L. Carr, 2004; Foxwell-Norton, 2006; Thomsen, 2003; Whelan & Oliver, 2004). Rockloff and Lockie's (2006, p. 206) research with Aboriginal participants in central Queensland found that interactions were often dominated by Agency or non-indigenous participants, creating a 'disempowering environment'.

Thomsen (2003) suggests that there is also a high likelihood of limited community awareness of and participation in environmental issues, leading to a certain amount of apathy, in turn resulting in a rapid rate of burnout amongst those who do participate because of a lack of support.

As part of an investigation into collaborative NRM in south east Queensland, Oliver et al (2005) found that there were a number of factors that prevented more effective involvement in the Natural Heritage Trust (NHT) I program, including: time constraints; lack of indigenous involvement; lack of flexibility within programs; and tension between deliberative and procedural governance. As well as this, Clarke
(2006) suggests that a significant disincentive for many community groups to participate has been the seemingly continuous restructure (and insecurity) of the programs.

Human resources in community groups are finite. Oftentimes people within community groups are already stretched to the limit (Whelan & Oliver, 2004). This is not helped when governments act to reduce their expenditure by shifting responsibilities to community groups - as Eckersley (2003 in Whelan & Oliver, 2004) has suggested occurred with the National Landcare Program. Similar problems may be occurring with Coastcare, but a lack of data limits our understanding of how effective this program has been in motivating and retaining participants.

Clarke (2006) argues that the Coastcare program failed to collect data on participant motivation and it is not at all clear how the Coastcare program invoked a sense of stewardship among stakeholder groups as there were no benchmarks to determine success or to identify areas for improvement.

### 3.2.2 Bridges

There are many advantages to working with community groups. For example, Wescott (2002) identifies the advantages of community groups working in partnership with local authorities, which led directly to capacity building of local communities through the Coastcare program. The program kick started community projects based on partnerships where coastal expertise already existed. Clarke (2006) suggests that the national Coastcare program facilitated an integrated approach to coastal management in Australia by attracting over 60,000 people to undertake a considerable amount of activity through caring for their respective patches of coastline. Oliver and Whelan (2003, p. 7) report that community groups were able to successfully use a number of complex modelling tools, which were previously only used by expert engineers and Carr (2004) argues that community science is able to supplement conventional methods of data collection (it is often low cost and has a geographically broad approach), complement, extend or refine conventional interpretation, and redesign field science.

Foxwell-Norton (2006) and Thomsen (2003) suggest that the framework of ‘cultural geography’, which focuses on the manner in which people relate to place and space is likely to lead to a better understanding by practitioners of what motivates people to become involved in programs at the local level. To support the concept of public benefits, Table 10 describes a range of tangible advantages public participation in NRM programs.
Table 10. Accepted benefits of public involvement programs

<table>
<thead>
<tr>
<th>Benefit</th>
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<tbody>
<tr>
<td>Generates a better knowledge base and therefore delivering better management decisions;</td>
</tr>
<tr>
<td>Helps to break down traditional institutional arrangements which hinder effective natural resource management;</td>
</tr>
<tr>
<td>Facilitates participatory democracy;</td>
</tr>
<tr>
<td>Addresses the concerns of all interested and affected parties;</td>
</tr>
<tr>
<td>Identifies new alternatives to be considered;</td>
</tr>
<tr>
<td>Provides a means of identifying and resolving issues before programs are finalised;</td>
</tr>
<tr>
<td>Focuses planning on issues of concern;</td>
</tr>
<tr>
<td>Improves credibility;</td>
</tr>
<tr>
<td>Helps reduce opposition/conflict provided the process is fair and neutral to all parties;</td>
</tr>
<tr>
<td>Reduces the level of misconception/misinformation;</td>
</tr>
<tr>
<td>Helps meet government requirements;</td>
</tr>
<tr>
<td>Acceptance and compliance is increased;</td>
</tr>
<tr>
<td>Creates a better understanding of the program and its objectives;</td>
</tr>
<tr>
<td>Provides additional sources of expertise and information.</td>
</tr>
</tbody>
</table>

(See Coenen et al., 1998; Conacher & Conacher, 2000; Dovers & Lindenmayer, 1997; Lazarow, 2002a).

3.2.2 Motivation & communication

The motivation for members of the community to become involved in a volunteer program can come from a number of sources. It is worth noting, however, that government agencies and staff can also be motivated by a range of factors. Both Wescott (2002) and Thomsen (2003) agree that there is no shortage of enthusiasm and commitment for capacity building partnerships to continue to grow in the next decade based on an underlying desire for sustainability.

Scientific experts will be more motivated to be involved in community groups when they are able to use the community to further research (and this can be done in a number of ways and for a number of reasons). Many scientists are also motivated by a desire to educate the broader community. Table 11 lists the type of factors that motivate members of the community and experts.

Table 11. Motivation for involvement in NRM activities

<table>
<thead>
<tr>
<th>Community</th>
<th>Experts</th>
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<tr>
<td>Making a difference locally;</td>
<td>Further research</td>
</tr>
<tr>
<td>Making a difference for future generations;</td>
<td>- Access to community data;</td>
</tr>
<tr>
<td>Previous or desired environmental vocation;</td>
<td>- Using the community to collect or validate data; and</td>
</tr>
<tr>
<td>Desire for environmental skills and knowledge;</td>
<td>- Need to rely on volunteer labour.</td>
</tr>
<tr>
<td>Personal fulfilment;</td>
<td>Requirement to engage with community.</td>
</tr>
<tr>
<td>Social learning; and</td>
<td></td>
</tr>
<tr>
<td>Social reasons.</td>
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</table>

Source: (A. J. L. Carr, 2004; Lazarow, 2002b; Oliver & Whelan, 2006; Thomsen, 2003)

There are many pressures that compete for our time and attention (e.g. work, family, recreation and personal health) and within environmental and sustainability causes,
managing the coast is but one issue. Consequently, low levels of community involvement in activities like Coastcare may reflect people’s rational choices not to participate in collaborative environmental governance (Whelan & Oliver, 2004). But a powerful motivator for community involvement, argues Foxwell-Norton (2006), is that many in the community may want to be involved in environmental projects because they have strong memories of the coast prior to development. In other words, inappropriate development - or the perception of inappropriate development by government and industry - may motivate community members to care for ‘their’ coast.

3.2.4 Towards solutions

A range of solutions have been identified in the literature. Both Fisher (2000) and Oliver and Whelan (2003) suggest that the expert-client relationship be reconstituted to better facilitate the skills and knowledge of the citizen and how this might be incorporated into the decision-making process. Wescott (2002) also stresses the importance of relationships, communication and the need for ongoing financial support for groups and programs as central tenets in the development of groups. Oliver (2003), in his work on NRM groups in south east Queensland identifies a number of significant differences between ‘cooperation’, ‘partnerships’ and ‘collaboration’ and argues that the nature of the relationship needs to be clearly articulated as early on in the process as possible. Lazarow (2006) also emphasises the need for the relationship and power base - the ‘negotiation lines’ - to be firmly established at the commencement of any process. An important consideration for NRM practitioners to take into account is that many participants realise the benefits of collaborative effort (i.e. many hands make light work) as an important factor in bringing individuals together but also want to know how their involvement contributes to the bigger picture.

Oliver (2003), however, is somewhat circumspect and urges caution in thinking that all problems can be solved by partnerships owing to constraints of legislation, social, economic, political and cultural contexts. A guide, he suggests might be to adopt a simple 3-way test to assess the efficacy of a stakeholder engagement process. This test has been described by Wondolleck and Yaffe (2000), who advocate that any resource management advice, decision or project undertaken that involves citizen participation should be subject to the following scrutiny:

- **Is it legally and politically legitimate?** That is, does it comply with relevant legislative requirements, including provision for public review and opportunities for comment?

- **Is it fair and just?** That is, have all parties who may be affected by the matter been invited to be involved in the citizen participation process? Are the processes they are using in their deliberations open and transparent? Are the requests that are being placed on citizens in terms of their participation reasonable and in proportion to the significance of the resource management problem under scrutiny? And have the interests of affected parties who were not able to participate also been taken into consideration?

- **Is it wise?** That is, have adequate sources of knowledge been identified and brought to bear on the matter at hand? Do the participants understand areas of uncertainty in this regard?

Foxwell-Norton (2006, pp. 204, 227), who reviewed the national Coastcare program argues that this process is quite complex, however, a path forward might be to
reconceptualise the problems with a 'society to science' framework rather than the still firmly entrenched 'science to society' framework. This approach, she argues ‘places the onus on the ‘experts’ to be educated about ‘community’ and to explore their relations between culture and nature,’ (Foxwell-Norton, 2006, p. 223).

3.2.5 Continuity

Continuity, another important factor, can come in a number of forms. For example, it could be the longevity of a program, funding or the fact that a single coordinator is in place for the life of a program. Continuity builds trust and can lead to the development of long-term partnerships, even once a program has terminated (Lazarow, 2006).

3.2.6 Measuring success

Clarke (2006) suggests that more attention should be paid to the development of appropriate indicators to monitor outcomes, including the need for secure long-term funding guarantees to support the efforts of volunteer work on public land. She identifies the gap between policy makers and volunteers at the local level, urging that policy makers need to be aware of how their decisions translate at the local level.

*There is a fundamental conflict between the ways in which experts and communities fashion the coastline, which can be largely ignored until community participation programs are established. The fundamental ingredient missing from Coastcare – and other community participation programs – is a descent from the clear heights of environmental science to the messy, complex and contradictory milieu of the ‘community’* (Foxwell-Norton, 2006, p. 204).

The questions – ‘where does the work that I’m doing’ or ‘where does the program that I’m helping to develop’ fit into the policy spectrum - are often asked by NRM volunteers and it is important that they not only be answered but that a metric be developed to gauge the success of the intervention or program. This view is supported by Lockie et al. (2005) who argue that positive benefits to stakeholders need to be quantified in order to justify changes in NRM. Only in this way can successful outcomes be claimed and the way forward clarified.

3.3 Coastal stakeholders

With over 500,000 residents and millions of visitors to our beaches year each year it was important to develop a strategy to target key stakeholders and groups as well as the general public. The Broker – Local – Tourist Model (BLT) (see Figure 33) provides a framework for thinking about the different sectors of the community and how to best approach a particular sector of the population. This is especially useful for a region like the Gold Coast, which is a growing city and has a vast range of groups and individuals with an interest in the beach and coastline. While the BLT model was originally conceived to describe the relationship of tourists to a place and its citizens, it can be adapted to describe the different relationships people in a locale have with the beach and this in turn provides an important reference point for establishing how GCCC might make contact with groups and individuals. The following section describes the range of stakeholder groups, as well as the groups that are involved in coastal and marine activities on the Gold Coast.
3.3.1 **Brokers**

There are three main types of brokers: government, the private sector; and the non-government sector. Each of these sectors plays an important role in the management, use and development of our coastline.

3.3.1.1 **Gold Coast City Council**

At the level of government, the major player is Gold Coast City Council, with close to 3,000 employees in the municipality. GCCC is the primary manager of the coastal zone, including the provision of year-round lifeguard services. It is through the development of management plans such as the GCSMP, Bold Futures and the Oceanway Plan that GCCC engages with residents of the Gold Coast.

At an informal level, many of GCCC’s staff live on the Gold Coast because of the lifestyle opportunities the area provides and care passionately about the natural environment and participate in a wide of formal and informal coastal recreational activities, social and cultural activities.

3.3.1.2 **Business & tourism sectors**

Business and tourism are vital to the Gold Coast’s economy. It was estimated that 9.3 million tourists visited the Gold Coast in 2006, accounting for 23 million visitor nights. Almost one-third of day visitors and half of all international overnight visitors used the beach at some point in their stay (Tourism Research Australia, 2004, 2006a, 2006b). Nature-based tourism (terrestrial and aquatic) forms an important component of the industry and relies on good environmental quality. Businesses rely on and use our ocean beaches in a number of different ways, for example:

- Direct beach users such as surf schools;
- Groups that indirectly rely on a healthy looking coastline such as hotels and the real estate / development industry; and
- Umbrella bodies such as Gold Coast Tourism and Tourism Queensland.

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**Figure 33: Broker - Local - Tourist Model, adapted from Miller.**

Examples of Brokers are:
- Public sector such as GCCC, lifeguards, university
- Private sector such as tourism operators, small business
- Non-government sector such as environmental organisations

Locals are described as people who live in the community but are not involved in the tourism industry and do not rely on this industry for their income

Tourists are described as visitors to the region

**Broker**

**Local**

**Tourist**
(Note: Tourism Queensland and the development industry are represented on the Coastal Protection Advisory Council, the peak council responsible for progressing the State Coastal Plan).

3.3.1.3 Kirra Business Group

As an example of a Gold Coast based business group which is taking an interest in the management of the coastline, the Kirra Business Group (KBG), was formed in early 2008. The KBG is a loose affiliation of local business owners and traders in the Kirra precinct on the southern Gold Coast. The primary focus of he KBG is to advocate for improving business opportunities in the area. The KBG has a keen interest in the development of the local precinct, including beach and foreshore amenity.

3.3.1.4 Academia

Universities and schools play an important role in the Gold Coast community. GCCC’s existing relationship with Griffith University demonstrates the benefit of cooperative relations between Local Government, the scientific community, eNGOs and the general public.

A range of school-based programs currently operate on the Gold Coast. One example of this is the CoastEd program. Friends of Federation Walk, a local environmental non-government organisation (eNGO), works with individual schools at The Spit and Gecko-Gold Coast Hinterland Environment Council Association Inc (Gecko) recently commenced an education strategy whereby their programs are promoted within schools. In previous years, Surfrider Foundation (another eNGO) has run a number of school-based education programs. As well as this, many schools have developed environmental education programs, for example, Southport High School and Palm Beach High School have worked with the Marine Teachers Association of Queensland to develop marine education curricula. In recent years, there has been some discussion about the development of a marine education centre on the Gold Coast.

3.3.1.5 Non-government sector

The non-government sector provides a wealth of opportunities for involvement in coastal planning and management program. These are listed below. A more detailed discussion describing partnerships with many of these groups is provided further on in this chapter.

- Environmental Groups such as GECKO, Surfrider Foundation, Friends of Federation Walk, Coastal Alliance, and community action groups such as Friends of Currumbin, Fix Currumbin Creek, Save Our Spit Association, WWF and Tallebudgera Catchment Care Group, BeachCare.
- Sport and recreation clubs such as surf-lifesaving clubs, boardriding clubs, sailing clubs, fishing clubs, diving clubs, Volunteer Marine Rescue, ocean swimming and triathlon clubs and outrigger canoe clubs.
- Professional and other groups such as the Marine Teachers Association of Qld, the Kirra Business Group, the Australian Coastal Society and local Chambers of Commerce.
- Community and progress associations for specific beach localities, Lions Club, Rotary etc
3.3.2 **Locals**

In a city whose culture is embedded within a theme of renewal there is still significant debate about the socially acceptable limits of change. Understanding the environmental limits of change, however, is arguably more important. With the Gold Coast home to 500,000 people, many of whom have been here for some time, improving residents’ environmental literacy, raising the profile of environmental issues and developing strategies to involve people in coastal planning and management programs is important.

While many strategies are available, it is worth noting the significant diversity within the community and thinking about how particular sectors may be best targeted. Two important questions are:

1. Do you want to target people by locality, user group or both?
2. How do you intend to hold the attention of your target group?

One aspect of identifying passionate locals who may be able to take on a role as coastal stewards is to understand the concept of serious leisure and to use this to help design communication strategies (Stebbins, 1979). Most beach use takes place on an individual basis or in small, organised but often unaffiliated groups. Nevertheless, the passion or dedication that these beach users have for both their activity and the location is high and this can be used to help build ‘coastal stewards’. Each activity, be it surfing, fishing, swimming, beach walking or another beach-based activity has active (or serious) and passive users who have a personal stake in the ongoing management of their ‘local area’. An active user may be an ideal candidate to groom as a champion or link in a particular area.

3.3.3 **Tourists**

The Gold Coast is a popular vacation destination for intrastate, interstate and international visitors. Working with the umbrella organisations; industries that interact directly or indirectly with tourists; or developing education programs and opportunities for visitors (in partnership with local groups), are just some strategies for advertising and encouraging visitors to become more aware of the value and importance of the coast. Local development an existing international program that already has a significant profile may present a good avenue to promote the importance of environmental quality on the Gold Coast to international visitors. Examples of international programs that could be readily adapted for people who visit the Gold Coast are Reef Check (which already operates on the Gold Coast), Surfrider Foundation's State of the Beaches program and the international Blue Flag Program. Activities with an environmental focus that are run by local organisations or businesses could also be promoted to attract the attention of visitors.
3.4 Overview of coastal community groups on the Gold Coast

The Gold Coast is home to a number of environmental not-for-profit groups whose area of focus ranges from the top of the catchment out to sea and whose interests range from single issue through to national and international activities. Similar to many eNGOs, the Gold Coast eNGOs discussed were all originally formed to combat or promote one or a series of issues. For example, Friends of Rainbow Bay Beach has a specific interest in a range of issues related to Rainbow Bay. Similarly, Friends of Federation Walk takes an interest in environmental issues along The Spit. Friends of Currimbin on the other hand, focuses its attention on a broader area of catchment to coast from Flat Rock through to Tallebudgera Creek, but also takes an interest in external issues that may affect their ‘home ground’. The Gold Coast and Hinterland Environment Council Association Inc. (Gecko), has an interest in the whole of the Gold Coast. The Surfrider Foundation’s national office is based on the Gold Coast and as well as taking an interest in local issues, the organisation has a national and international presence. In a similar manner, Gecko is a member of the Queensland Conservation Council, which is the umbrella organisation for eNGOs in Queensland and engages with them in state-wide campaigns. Residents of the Gold Coast also belong to national and international eNGOs such as the Australian Conservation Foundation, Greenpeace, The Wilderness Society and the Sea Shepherd Conservation Society, however, these groups don’t regularly undertake activities on the Gold Coast.

As well as eNGOs, surfing and surf lifesaving organisations also participated in this research project. These groups, whose primary activities take place on the beach and in the nearshore zone, have a strong interest and affinity with the coast in general and more often than not, with specific coastal localities. Like many of those who are members of eNGOs, individuals who are involved with surfing and the surf lifesaving movement interact with the coast at a formal and informal level.

Groups or organisations can be categorised as small, medium or large. This qualitative classification is based on an evaluation of both the size and current level of activity of groups on the Gold Coast. Within each categorisation, groups are listed
alphabetically.

### 3.4.1 Large organisations

- Friends of Federation Walk (FoFW) originally began as a committee of the Main Beach Progress Association that was concerned about the level of development taking place on The Spit. The group incorporated in 2001 and has as its main objective the preparation of “a Master Plan for the regeneration of the vegetation on The Spit and [the creation of] public access for passive recreation, to ensure present and future generations of the community have access to enjoy, appreciate and care for The Spit (Friends of Federation Walk, 2008).”

- Gecko-Gold Coast and Hinterland Environment Council Association Inc. (Gecko) was founded in 1989, when 6 local conservation groups came together. Gecko’s vision is for “a vibrant Gold Coast community where people, animals, plants, water, air and earth all form a healthy, harmonious system.” According to its mission statement, Gecko’s aim is “To actively promote, protect, conserve and restore the natural environment and improve the sustainability of the built environment of the Gold Coast region in partnership with our member groups and the wider community (Gold Coast & Hinterland Environment Council, 2008).”

### 3.4.2 Medium organisations

- Friends of Currumbin (FoC) began in 1979, when concerned local residents fought to protect the area from a major development at the mouth of Currumbin Creek. “FoC seeks to enhance, protect and beautify natural features and public open space spaces, and seek ways to improve, further, the quality of life for all who live in, or who visit Currumbin (Friends of Currumbin, 2008).”

- Save Our Spit Alliance (SOS) was formed in 2004 in opposition to the State Government’s proposal to proceed with the development of a cruise ship terminal, superyacht marina and associated commercial development on The Spit. SOS’s goal is “to work, with the Gold Coast community sectors, for the development of an integrated and holistic vision and management plan for the conservation and sustainable use of the natural environment of the Southport Spit, Broadwater, its foreshores and islands (Save Our Spit Alliance, 2008).”

- Surfrider Foundation (Surfrider) began in the United States in 1984 and an international affiliate, Surfrider Foundation Australia, commenced operations on the Gold Coast in 1991. The organisation’s national office is currently based on the Gold Coast, however, local environmental issues are generally progressed through the activities of a local Chapter, where possible. Surfrider’s mission is to work for the “protection and enjoyment of the world’s oceans, waves and beaches for all people.”

### Small groups and organisations

- Coastal Alliance was formed in 2006 to act as a voice for the community on coastal environmental issues on the Tweed and Gold Coasts. Within the Gold Coast municipality, the group is active on a range of issues including access, coastal environmental protection, marine habitat (in particular Kirra Reef) and recreational amenity.

- Reef Check is the United Nations’ official community-based coral reef monitoring program. In Australia Reef Check operates through the work of volunteer recreational scuba divers who monitor the health of reefs in Australia and the Indo-Pacific region. Reef Check Australia partners with marine research
organisations, tourism companies and dive operations, universities, government, local and international volunteers and a variety of other businesses and organisations. On the Gold Coast, Reef Check currently partners with Griffith University, Sea World, SEQ Catchments and Diving the Gold Coast. Reef Check “aims to educate the public about the value of coral reefs and the crisis facing the world’s reefs. The information we collect is used by community groups, governments, universities and businesses to design and implement ecologically sound and economically sustainable coral reef management (Reef Check Australia, 2004).”

- With headquarters in Cairns, Seagrass Watch is a community-based habitat assessment program that regularly monitors seagrass health in locations throughout the Asia-Pacific region. Surveys help guide decision-making in areas such as Marine Park planning and ecosystem health monitoring. The 15 currently trained Gold Coast Seagrass Watch volunteers undertake monitoring three times per year at specific sites in the Broadwater and other locations on the Gold Coast. Seagrass Watch is currently coordinated through Gecko.

- The Wildlife Preservation Society of Queensland (WPSQ) was formed in 1964 and has a number of branches throughout Queensland, including one on the Gold Coast. The aims of the WPSQ are to “preserve the flora and fauna of Australia by all lawful means; educate the community in an understanding of the principles of conservation and preservation of the natural environment; discourage by all legal means, the possible destruction, exploitation and unnecessary development of any part of the natural environment; and encourage rational land use and proper land planning of existing and future development, and the use of the natural environment and its management.” WPSQ released a policy on coastal development in 2005. The policy sets out goals, actions and guiding principles to provide an effective balance in the development of coastal areas and the conservation of coastal resources.

- Unaffiliated and / or unincorporated groups. There are a number of informal groups comprised of members of other organisations and individuals, who seek to pursue particular agendas. Examples of such groups are Friends of Rainbow Bay Beach and ‘Fix Currumbin Creek’. Fix Currumbin Creek is primarily concerned with issues related to the health and safety of Currumbin Creek, including navigation, dredging, siltation and water quality (Brad Smith pers. comm. June 2008).

- As well as eNGOs, a number of groups use the beach primarily for recreational purposes but also undertake environmental activities. Two groups in particular, boardriders and surf lifesavers play an important role in this respect.
  - There are 12 surfing clubs on the Gold Coast, all of whom are affiliated with the state body, Surfing Queensland, which in turn is affiliated with the national body, Surfing Australia.
  - Surf lifesaving Queensland’s (SLSQ) primary activities are to “save lives, develop practices in education, prevention, emergency care and rescue.” SLSQ has 21 operational clubs from Rainbow Bay to Southport on the Gold Coast.

### 3.4.4 Establishment of working groups

Forming ongoing and purposeful relationships with key stakeholder groups is a critical component of the GCSMP. An example of the successful development of a working group is the Kirra Point Committee.
Kirra Point Committee

The Kirra Point Committee (KPC) was formed in early 2007. The formation of the Committee was facilitated by GCCM and arose in response to the Kirra Wave Amenity Study and related issues. The KPC is comprised of the key stakeholders groups that represent the community (surfing organizations, business, environmental groups, sporting clubs) on the issue of improving wave amenity at Kirra. The KPC recently launched a website (www.kirrapoint.org) with the intention of bolstering support for the improvement of recreational surfing amenity on the southern Gold Coast.

The KPC acts as a peak group for recreational surfers on a specific set of issues on the southern Gold Coast.

3.5 Types of activities and areas of interest for eNGOs

Environmental NGOs on the coastal areas of the Gold Coast conduct their operations almost exclusively on public land (or water) that is owned by the State Government or by Gold Coast City Council. As part of the surveys and interviews, groups and individuals were asked to describe the types of activities they engaged in. These are now discussed generally and illustrated with specific examples.

3.5.1 Coastal conservation (on-ground) activities

Friends of Federation Walk, with a specific focus on the Federation Walk Coastal Reserve at The Spit, undertakes a number of vegetation rehabilitation projects within the Federation Walk area. FoFW works closely with GCCC. FoFW holds monthly planting days and also works with schools and industry groups on the site.

Gecko has a whole of Gold Coast focus but the ‘Fieldwork Team’ focuses its attention on a number of regeneration sites, including Nicoll Scrub and the Tarrabora Reserve. Gecko also undertakes vegetation surveys and partners with Elanora Wetlands Bushcare. As well as work on public lands on the coast, Gecko has also previously partnered with landholders further up the catchment to conduct work on privately owned property. Campaigning, servicing members and education and outreach initiatives are currently more important than on-ground activities for Gecko. Appendix 4 describes Gecko’s organisational structure and provides a good example of how a wide range of activities are related to the organisation’s mission.

Gecko coordinates the Seagrass Watch program at a number of locations on the Gold Coast, including Currumbin Creek and the Broadwater. Reef Check has been active in SEQ since 2006 and undertakes coral reef surveys, education and training activities. As well as these groups, Surfrider Foundation runs approximately 4-5 beach clean-ups each year.

Friends of Currumbin share a number of members in common with Gecko. At present FoC doesn’t directly coordinate on-ground activities, however, members join with other groups such as the Currumbin Creek Catchment group to undertake projects, work in the Tarrabora Reserve and work with Elanora Bushcare. FoC also participates in Clean Up Australia Day.

A number of other on-ground environmental activities also take place on the Gold Coast. In the coastal vicinity, the BeachCare program currently runs revegetation programs at five sites: Paradise Point, Runaway Bay, Mermaid Beach, Palm Beach and Bilinga. This program is open to the general public and sites are visited approximately once every eight weeks.
3.5.2 Advocacy

Advocacy, along with education, is possibly the activity that most groups undertake on the Gold Coast. This is undertaken both proactively and in response to particular issues as they arise.

Save Our Spit, for example, was established with the specific aim of lobbying for the retention of a particular area of public land as public open space. The group does not undertake on-ground activities, however, many of its members also belong to Friends of Federation Walk and Gecko and may participate in on-ground activities through these groups.

Friends of Currumbin lobbies government on a range of issues including landuse zoning, infrastructure, planning, transport, power and visual amenity. FoC use ‘talking points’ based around key strategies in order to summarise issues and deliver the organisation’s key messages to their intended audience.

For Gecko, advocacy is the organisation’s number one priority. This is undertaken through campaigns, lobbying and through representation on various committees. Gecko’s advocacy activities cover a broad range of issues in line with the organisation’s philosophy. These include but are not limited to: campaigning on climate change; fire management; national parks; population growth; renewable energy; and a range of marine issues. Gecko also has a keen interest in quality of life issues and is involved in a number of regional growth and development fora.

Surfrider Foundation is active on a number of local environment and conservation programs, including Kirra Reef, water quality issues, recreational amenity issues such as wave quality, open space and beach access and coastal protection. The Coastal Alliance campaigns on a number of related issues in the Gold Coast region and also pursue coastal issues in the Tweed.

Smaller organisations or affiliations such as Fix Currumbin Creek and Friends of Rainbow Bay Beach regularly feature in local newspapers as a means of promoting particular issues. It is through advocacy that groups also seek higher exposure and therefore try to attract new members and supporters and ultimately influence decision-makers and the policy agenda.

3.5.3 Community education and awareness raising

Community education is a priority for all eNGOs on the Gold Coast. This is undertaken in a number of different ways.

Save Our Spit makes good use of a website for the purposes of distributing its messages to a broad audience. Gecko, Surfrider and Friends of Federation Walk also rely on the use of websites to communicate information to a general audience. For all of these groups, supporters have provided web services free or at cost. Diving the Gold Coast, a commercial dive operation is a key supporter of Save Our Spit, Seagrass Watch and Reef Check programs. Their website (http://www.divingthegoldcoast.com.au) provides an important resource library for people and groups interested in the underwater marine environment of the Gold Coast.

Community education activities are undertaken in a variety of forms by all of the eNGOs on the Gold Coast. For example, in June 2008, Surfrider partnered with Wet Paper Publications and ran a Marine Educators (teach the teacher) Workshop as part
of the World Surfing Day celebrations. Gecko, Friends of Currumbin, Friends of Federation Walk and the Coastal Alliance hold regular meetings to which guest speakers are invited. Gecko also coordinates ‘Green Day Out’, the World Environment Day fair that is held in Currumbin each June. Reef Check organises and runs training programs for volunteer scuba divers who then participate in the reef monitoring program in the region.

Most groups also produce regular newsletters and e-bulletins that are posted on their websites and sent to members and supporters.

3.5.4 Other activities

Alley Boardriders (a recreational surfing club), based out of Currumbin and Palm Beach have previously been involved in a number of environmental activities such as beach cleanups.

Surf lifesaving clubs are required to develop ‘best practice’ operational plans. On an informal level, clubs are guided by a number of strategies to lessen their impact on the environment. These include:

- Minimising the use of vehicles and vehicle tracks on beaches;
- Ensuring that access is by defined paths and not through dunes;
- Ensuring that competition sites are constructed away from fragile dune systems (where possible); and
- Judicious use of water for cleaning vehicles and equipment.

3.6 Major challenges for eNGOs

Many of the challenges for the eNGOs on the Gold Coast are common to most not-for-profit groups. They can be summarised as:

1. The need to effectively and efficiently service members;
2. Capacity;
3. Currency (staying relevant);
4. Funding; and
5. Maintaining or increasing their constituency.

While these issues are common across all of the groups that participated in this project, they present different challenges for each of the groups. These challenges are now discussed in more detail.

3.6.1 Servicing members

Most eNGOs are generally run by an ‘executive’ that is elected by members and operates through a democratic process. Membership of eNGOs can fluctuate over time for a number of reasons and this can be a problem if a group relies on membership fees to cover or subsidise its operating budget. Membership may grow one year due to a particular issue in the community or because of a successful membership drive, but the challenge remains for organisations to hold onto these members.

Traditionally, eNGO members are serviced through the provision of newsletters,
emails, e-bulletins and phone conversations; events such as on-ground activities and public lectures; and through personal involvement in specific campaigns and committees. These latter activities are often open to the general public also. Reef Check provides a members’ section on their website which provides a calendar of events and updates.

Gecko and Surfrider Foundation both have paid coordinators, Gecko one full-time staff member and Surfrider one part-time staff member (3-days per week). Organisations often rely on a core group of volunteers (usually made up of the executive, general volunteers and occasionally interns) to carry out many of the administrative and operational activities. A major challenge for most groups is finding staff or volunteers to capably fulfil these duties. Friends of Federation Walk and Friends of Currumbin are completely staffed by volunteers, although Friends of Federation Walk receives some administrative and operational support from GCCC through the provision of a ranger.

For Gecko and Surfrider, a significant amount of the paid coordinator’s time and effort goes into training and supervising volunteers. In the case of Surfrider, the volunteers who work in the national office are generally involved in tasks that relate to the administration of the organisation and not its operational and governance activities.

3.6.2 Capacity and currency

Getting heard is central to the longevity and currency of most environmental groups on the Gold Coast. This can take a number of forms, including:

- Media releases;
- Grant funding for programs;
- Educational initiatives;
- On-ground works;
- Campaigns and awareness raising;
- Influencing government (e.g. lobbying, demonstrations and rallies); and
- Public recognition.

The capacity within organisations to fulfil one or all of these activities is highly dependent on the existing skills and networks of those members who play an active role in the organisation’s executive.

With the exception of Surfrider Foundation, a feature of all of the groups that participated in this investigation is that the majority of members and supporters are over 50 years old. This presents both benefits and challenges. In some cases, the large number of semi-retired or retired people means that organisations have a willing volunteer base upon which to call. Further, many individuals bring with them a range of useful skills that have been developed through a lifetime of work and experience. On the other hand, for some of the smaller groups, the age of volunteers can mean that they are not equipped with the necessary technological skills that the organisation needs at any particular point in time. This is an issue that could be addressed through the provision of specific training courses for computers or particular software applications. Another issue limiting the potential growth of eNGOs is that young people may be put off becoming involved with groups because they
would prefer to mix with people their own age or across a mix of ages.

Another challenge faced by the organisations is how best to deliver their message to the community. Two issues that were raised during the interview process are that:

- The Gold Coast is generally missing the tier of tertiary educated professionals, and according to some, this tier presents the best opportunity to deliver important environmental messages to the community. In 2006, it was estimated that 11.2% of Gold Coasters had a bachelors or higher degree, compared to a national average of 15.6% (Australian Bureau of Statistics, 2006a). It is not clear whether this difference is significant as there may be other factors at play.

- With full employment, people often do not volunteer. The loss of the work for the dole scheme has also meant a reduction in volunteers for environmental groups. Those who participated in the phone interviews were asked why so few people volunteered their time to participate in on-ground activities. Answers varied and included: lack of awareness; difficulty in communicating messages to youth; challenges on people’s time e.g. it clashes with leisure time; and a lack of personal responsibility for the area that people live in.

Managing volunteers in order to get the best result for the organisation and the best outcome for the volunteer can often be a time consuming job. For example: matching people’s skills with tasks can often be challenging; handover processes need to be developed; consistency and standards need to be maintained; and most importantly, volunteers need to be supervised. Gecko has a volunteer ‘volunteer coordinator’ who works in this role, however, much of this responsibility still rests with the organisation’s paid coordinator.

The promotion of volunteers and the growth of an eNGO need to be carefully matched against the capacity of an organisation to cope with recruitment, orientation, supervision and support. The job of coordinating volunteers is often undervalued and a number of groups have indicated that greater support from government in this area is urgently needed.

Activity across a wide range of issues can stretch volunteer based organisations very thinly and the requirement for specialist knowledge on an issue can often be a challenge on an organisation’s resources. When issues are based around common agendas, a number of groups have taken the initiative of engaging in cross-promotional activities and advertising of events. A number of groups have good working relationships, however, this is not always the case. In some instances, groups may have philosophical differences and in other cases, personality differences have resulted in situations where people don’t get along and choose not to work with each other. Lastly, some groups may choose to pursue issues on their own. While partnerships can be rewarding, a good understanding of how people and groups interact is important.

The common ingredient across most of the groups whose activities are discussed in this report is that a small number of highly dedicated individuals form the nucleus of these organisations. In some cases, these individuals commit up to 30 hours of volunteered time per week. This incredible donation of time has enabled all of the groups profiled in this report to ‘punch well above their weight’. There is no doubt that the skills and dedication of a few individuals who volunteer their time have been responsible for a large part of the growth of environmental awareness and action on the Gold Coast.
3.6.3 **Funding and funding opportunities**

eNGOs generally use grant funding for the following types of activities:

- Purchase of materials (e.g. plants, equipment, water quality monitoring equipment) for on-ground works;
- Administrative support (e.g. office staff);
- Technical support (e.g. ranger activities at The Spit);
- Small equipment grants (e.g. for computers and audio-visual equipment);
- Preparation of education material;
- Running education and awareness raising initiatives; and
- Office rental.

Self-funding, where possible, has been a goal that many eNGOs strive towards. For example, Gecko has developed a commercial enterprise in order to assist the organisation raise the funds necessary for its operation. Gecko Regen, a bush regeneration business has grown considerably in recent years and now provides the organisation with a small but steady income stream. Surfrider Foundation has traditionally used a model whereby one-third of funding came through membership; one-third through philanthropy, sponsorship and donations; and one-third through government funding programs, however, with the majority of membership funds held by the National Office and Chapters spread across the country, this model may not be applicable to other organisations.

Friends of Federation Walk President Lyn Wright states that “I didn’t like the idea of tying myself to a tree in order to argue for the conservation and protection of The Spit.” Wright comments that based on her experience, the best way of moving forward is to work towards a solution whereby everybody gets some sort of benefit. This non-confrontational style has proven to be very successful for FoFW over the past 10 years, during which time they have secured the site as a coastal reserve as well as regular grant funding from Federal, State and Local Governments to undertake rehabilitation works. By contrast, groups like Gecko, Friends of Currumbin, Surfrider Foundation, Coastal Alliance and Save Our Spit have found on many occasions the only way to be heard and to achieve outcomes has been to publicly confront and challenge government on certain issues.

An issue that was raised by many of those interviewed was that the transaction costs involved in preparing and administering funding applications for environmental projects was significant and in some cases not worth the effort. There are a number of reasons for this, but primarily it came down to the fact that it takes 20-30 hours to prepare an application (including finding partners, which is often a requirement) and with the risk that the application would be unsuccessful, many participants felt that their time could be better utilised on other organisational business. The rub is this – most of those interviewed believe that grant writing has become a very technical process - there are only a small number of people within the respective organisations who have the time and skills to collate an application. These people are already committed or over-committed in terms of the time that they invest and in the interest of making the best use of their time, prefer to stick to activities that they believe have a higher rate of success. It is possible that with greater security or surety in grants and the funding process, some organisations may switch their focus to include the scope of activities that are commonly eligible for funding under a grants scheme.
A challenge for some of the smaller groups is to simply survive. Once a group starts to grow, a greater proportion of resources are required to simply run the organisation, which can limit the time volunteers have to get involved in the issues that first prompted them to take an interest in the environment. Some eNGOs have staff that perform dedicated administrative functions and other eNGOs have volunteers who specialise in these important roles. Where greater organisational funding or resources are not available, an alternative may be to fund and outsource a combined role across a number of groups.

### 3.6.4 Attracting more volunteers to coastal environmental programs

Organisations on the Gold Coast use a number of strategies to attract people to participate in coastal environmental programs. When asked how best to attract volunteers to coastal environmental programs, a number of useful suggestions were provided:

- Focus on young people – those whose future is linked to the city’s environmental health. However, the beauty of the natural environment, not just its environmental importance, should also be emphasised.
- Programs should be developed that allow people to slip in and out of commitments or participate on an ad hoc basis. This would create an opportunity for both residents and visitors to the city to become involved in environmental programs.
- People are often attracted by issues as they seek some pathway for action or resolution. More effective communication channels will provide groups with the opportunity to break this cycle and become more proactive and deliver positive messages to a wider audience. For example, film nights have previously attracted large crowds and the use of a strong and interesting visual medium (e.g. underwater footage of marine life on the Gold Coast) can be an extremely powerful mechanism to get people interested in an issue.
- Partnerships are essential to success. The ability of Friends of Federation Walk to establish good working relationships with both Gold Coast City Council and Griffith University has enabled the organisation to work with scientists and managers. These partnerships have also helped to establish the legitimacy of FoFW and greatly assist the organisation when it comes to applying for grant funding. Where possible, FoFW also seeks to develop good working relationships with politicians at all levels of government and this has assisted the organisation achieve broad buy-in to its agenda.
- Good media coverage (and by default good relationships with the media) is essential for many strategies to be successful. Good media coverage can often help to raise the profile of issues that might otherwise go unreported in the mainstream media.
- The ability to cross-promote issues based on the geographic extent of activities can be a useful way to promote issues and attract support. Surfing and Surf lifesaving clubs have a strong interest in the coastal environment and involvement in environmental programs would assist the clubs to promote their involvement in a range of beach based community activities outside of strictly ‘lifeguarding’ or ‘boardriding’ activities.

The coast, however, is a contested space and not everyone has the same set of goals or vision for the coastline. A group’s position on a particular issue may
resonate with some in the community but may also create fierce opposition on the part of others. For example, the potential loss of public open space and access acted as a major membership and support drawcard for the Save Our Spit Alliance who campaigned against the proposal to construct a cruise ship terminal and port facilities at the northern end of the Gold Coast. By contrast, the major local newspaper, the Gold Coast Bulletin, actively supported the proposal and negative publicity towards their cause was an issue that SOS had to contend with.

The relationship between increased visibility and a corresponding growth in support and membership is by no means direct. President of Friends of Federation Walk, Lyn Wright, believes that having a plan or a vision and proactively working on growing the support for that is the most important task for an organisation. By working to this strategy, FoFW has been able to maintain a strong support base as well as increase the political support for their program at both the Local and State Government level. Much of their success is due to the ability of the organisation’s executive committee to help develop a vision for the area that has been well-received by the community and Government.

3.7 CoastEd and BeachCare programs

There are a number of related projects currently underway in the Gold Coast region. Gold Coast City Council and the Griffith Centre for Coastal Management at Griffith University are jointly working on the following projects and programs:

![CoastEd Session at the Spit](image)

**Figure 35: CoastEd Session at the Spit**

**CoastED**

GCCM staff deliver a range of environmental education programs to school and community groups each year as part of the CoastEd service. The primary goal of the program is to increase the knowledge of participants about coastal planning and management issues and solutions on the Gold Coast. Funding for the program is provided by GCCC and delivery is undertaken by GCCM. This allows schools and community groups to participate at no cost. Education sessions are held in classrooms or outdoors within coastal environments and there are opportunities for participants to become involved in ongoing coastal activities such as dune planting or beach clean-ups through the BeachCare program.

Some facts about the CoastEd program:
- In 2007, staff from the CoastEd program delivered 61 sessions to 47 schools and
approximately 2551 students, of which 80% of sessions were to high schools. As of September 2008, the program had delivered 60 sessions with more sessions planned for the last school term of the year. The 2008 program will be the biggest program thus far. The program has doubled in size since it commenced in 2002.

- In 2007, just over half of all participating schools were from the Gold Coast region (54%), 35% from Brisbane and Logan, 8% Toowoomba, and 2% from NSW.
- As well as the schools program, CoastEd has also undertaken day and vacation programs and community information days in conjunction with SEQ Catchments.
- CoastEd undertakes two mail outs per year to all schools on the Gold Coast and all high schools in Brisbane. The program also has a database of contacts for teachers who have participated in or expressed interest in the program.
- CoastEd staff work closely with teachers to understand the specific class requirements and prepare information that the students will require on the day and for assignments.
- CoastEd provides a range of resources for further information including the GCCM website, CoastEd dvd/cd-rom, teacher lesson plans, information sheets, posters, BeachCare newsletter and the CoastEd newsletter.

The program is currently fully subscribed, however, with an increase in funding or ‘user-pays’ programs, the program could expand to address the currently unmet demand for this service.

BeachCare

Figure 36: Dune planting activity during BeachCare session

The BeachCare program is funded by GCCC and managed by GCCM. The program focuses on involving the broader community in the on-ground management and rehabilitation of the coastal dunal system within GCCC. The main aims of the BeachCare program are to: encourage community participation in beach management; improve the quality of native vegetation communities on Gold Coast beach dunes; increase the community’s awareness on beach management issues; and encourage and assist in enabling existing community groups to become increasingly self-sufficient.

Some facts about the BeachCare program:

- BeachCare runs regular community planting days and occasionally does an extra session either with a school group (about 10 a year) or in partnership with the dune contractors (about 8 a year).
- BeachCare activities are undertaken at five beaches (north to south): Paradise Point, Runaway Bay, Mermaid Beach, Palm Beach and Bilinga Beach. Each beach is attended approximately once every two months. Depending on community interest, the program has the capacity to expand to include new areas.
- Excluding school groups, the number of participants who attend BeachCare community planting varies from 3 to 25 with an average of 6 participants per session.
- BeachCare advertises for volunteers through: community radio and their associated website event pages; GCCC, GCCM and the Coastalwatch websites; by emailing BeachCare dates to all students in the Griffith University School of Environmental Science; advertising in the Sun newspaper; registering with Gold Coast Volunteers and Conservation Volunteers Australia; by word-of-mouth (e.g. Uni events, CoastEd), and through other events GCCM is involved in such as the Clean Beach Challenge, World Environment Day and Clean Up Australia Day. BeachCare brochures are also available on site at all community planting days. The brochures include information about BeachCare as well as a copy of the latest newsletter.
- The BeachCare Coordinator has recently been placing a big green flag at the top of the dune system during activities and this has served to attract the attention and interest of passers-by.
- BeachCare currently has over 200 participants on its mailing list. The BeachCare Coordinator distributes a bi-monthly newsletter to all participants in the mail-out list as well as using the media described above to inform the wider public about upcoming events.

See Volume Four for a copy of the BeachCare brochure and newsletter.

3.8 Report on economic and social values of beach recreation on the Gold Coast

(A full copy of this report is provided in Volume 5)
In 2007-08, the Cooperative Research Centre for Sustainable Tourism and Griffith University partnered with GCCC to work on a project that investigated local resident’s activities on the Gold Coast’s ocean beaches and foreshore, including priorities for the ongoing management of the area. In early 2008, a survey was randomly distributed to 8,000 residents on the Gold Coast, to which the overall response rate was approximately 1,850 or 25%. It is worth discussing the answers to a number of questions as they have some relevance to this report.

3.8.1 Visitation
In 2006, Gold Coast residents were estimated to have made just over 40 million visits to the beach and foreshore in 2007 (visitors were estimated to have made a further 7 million visits). On average, residents visited Gold Coast beaches 10 times per month during summer and six times per month during winter. As Table 12 describes, visitation was strongly influenced by the distance people live from the beach (Raybould & Lazarow, 2008).
Table 12. Number of beach visits each month for residents

<table>
<thead>
<tr>
<th>Distance people live from nearest ocean beach</th>
<th>Visits per month in summer</th>
<th>Visits per month in winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1km</td>
<td>21</td>
<td>14</td>
</tr>
<tr>
<td>1 – 5 km</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td>6 – 10 km</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>10 + km</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Average</td>
<td>10</td>
<td>6</td>
</tr>
</tbody>
</table>

Source: (Raybould & Lazarow, 2008)

As Figure 37 shows, sunrise to 8am, 8am to 10am, and 4pm to 6pm were all popular visiting times for residents. A surprisingly large number of people reported visiting the beach in the middle of the day (10am to 2pm). However, this question did not ask respondents to differentiate between visitation patterns during summer and winter, or between mid-week and weekend (Raybould & Lazarow, 2008).

Figure 37: Most popular times for visiting the beach

Multiple response options mean that values add up to more than 100%

3.8.2 Residents’ relationship to the beach and foreshore

CRC survey results report that beaches, foreshores, coastal health and the coastal environment are of great importance to Gold Coast residents. The survey found that approximately 65% of respondents indicated that the beach was very important or important to them; approximately 75% of respondents indicated that the parks and foreshore areas adjacent to the beach were very important or important to them; and almost 75% of respondents are very proud of Gold Coast beaches and encourage friends and visitors to go to the beach (see Figures 38 and 39).
3.8.3 Activities at the beach and popularity of beaches

Gold Coasters undertake a range of active and passive outdoor activities on the beach and foreshore. These include: being outdoors; walking and jogging; spending time with family and friends; swimming and waveriding (e.g. surfing and bodysurfing); bonding with nature; and simply relaxing.

Overall, the most popular beach and foreshore area is Burleigh Heads, followed by The Spit, Main Beach, Currumbin and Broadbeach / Kurrawa. Some locations, for example Snapper Rocks, Rainbow Bay and Currumbin Alley are popular both for...
general beach goers and for specific activities such as surfing.

Almost 25% of respondents to the survey indicated that they were members of a group (surf-lifesaving, surfing or environmental) that interacts with the beaches and foreshore for some or all of its activities and 6.2% of respondents indicated that they were members of an environmental group.

The three most important factors influencing a resident’s decision to use a beach or foreshore area are directly related to the quality of the environment: cleanliness of the beach (93%); cleanliness of the park areas adjacent to the beach (88%); and water quality (87%).

### 3.8.4 Beach management

#### 3.8.4.1 Social atmosphere

The social atmosphere is an important component of every beach visit. With so many activities taking place on the beach or foreshore there is a risk that some individuals or groups might conflict with each other or compete for space in some of the more popular locations. When asked whether there was a good social atmosphere at their most visited beach, most respondents (82.3%) answered positively and when asked whether different user groups got along at their most visited beach / foreshore, most respondents (76%) also answered positively (see Figure 40). The issue of overcrowding at surfbreaks did not factor as an issue. There are a number of possible reasons for this, but the most likely explanation may be that the high average age of respondents meant that they were less likely to participate in active outdoor recreational activities.

![Figure 40: Social atmosphere and compatibility of uses at Gold Coast Beaches](image)

#### 3.8.4.2 Attitude to commercial activities on the beach

A key issue for beach management is the need to preserve and possibly enhance the beach going experience for all beach and foreshore users, be they locals or visitors.
On any given day there is likely to be a request for some type of private use of the Gold Coast’s publicly owned beaches. This may be for a one-off event or for an ongoing activity. There have also been occasions where individuals or organisations seek to profit privately from the use of the beach or foreshore without formal permission from Gold Coast City Council. Private use of the beach, especially when it is exclusive can detract from the general welfare of beach users and this is an issue that requires ongoing management. It is also worth noting that public sentiment can change over time and for a range of reasons. For example, a wide range of commercial activities took place on Gold Coast beaches throughout the 1950s and 1960s, ranging from spray on sunscreen and surfmat hire through to weekly carnivals. In order to understand a little more about residents’ views on private use of the beach and foreshore, three questions were included in the survey.

When asked whether they were happy with the current level of commercial activities at the beaches and / or foreshores that they used most, 47.8% of respondents either agreed or strongly agreed, with 70% of respondents answering positively (see Figure 41).

When asked whether they would be happy to see a limited number of mobile vendors (e.g. ice-cream, drinks, sunscreen, hats) on their most visited beach / foreshore, 26.6% of respondents either strongly agreed or agreed, with 50.6% of respondents answering positively. 31.2% of respondents remained neutral on the issue and a total of 18.1% of respondents answered the question negatively (see Figure 41).

When asked whether they would be willing to see a small increase in the level of private use of their most visited beach / foreshore (e.g. for weddings, skydiving, equipment rental and bootcamps), 32.7% of respondents either strongly disagreed or disagreed, with 43% of respondents indicating that they were not in favour of an increase. 25.1% of respondents remained neutral on the issue. A total of 31.9% of respondents indicated that they were in favour of the idea, however, only 14.7% of respondents strongly agreed or agreed with the idea (see Figure 41).

The answers to these three questions suggest that an upscale in certain beach / foreshore based commercial activities, if managed correctly, may be acceptable to local residents. This would have to be assessed on a beach by beach basis.
3.8.4.3 Natural character of the beach

When asked whether the natural character of their most visited beach was being well-maintained: 52% of residents either strongly agreed or agreed; and 45% of respondents strongly agreed or agreed that the dune system at their most visited beach appeared to be healthy. By contrast, at their most visited beach, only 25% of respondents strongly agreed or agreed that GCCC appeared to be listening to the concerns of the community (see Figure 42). The significant positive response by respondents to the question of whether the natural character of their most visited beach was being well-managed can be interpreted as an indication that despite some negative feedback, most residents believe that GCCC is doing a good job in the provision of beach management services.
3.8.4.4 Community involvement

Community participation is an important part of Gold Coast City Council’s coastal planning and management process and a number of programs are currently underway that engage with the community at various levels, from on-ground works such as dune revegetation through to community involvement in the Bold Future, a program that aims to incorporate the community’s vision for a sustainable city into a blueprint for the Gold Coast for the next three decades to the year 2037.

The CRC survey found that almost 25% of Gold Coast residents have illustrated a willingness to participate in on-ground activities and between 15 – 25% of survey participants responded that they would also participate in planning and ideas sharing forums. These responses suggest that Gold Coasters have a keen interest in their coastal environment and given the right incentives, are keen to take on a more active role in the stewardship of the coast (see Table 13).

Table 13. Gold Coast residents’ willingness to take an active role in coastal issues (N=1854)

<table>
<thead>
<tr>
<th>Would you be willing to take an active role in coastal issues relating to the areas you visit most?</th>
<th>Yes</th>
<th>No</th>
<th>Don’t Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participate in a local planning and management committee</td>
<td>17.4%</td>
<td>60.9%</td>
<td>21.7%</td>
</tr>
<tr>
<td>Share ideas, knowledge and register issues (e.g. through emails and focus groups)</td>
<td>27.1%</td>
<td>53.7%</td>
<td>19.1%</td>
</tr>
<tr>
<td>Attend public meetings</td>
<td>25.3%</td>
<td>57.6%</td>
<td>17%</td>
</tr>
<tr>
<td>Attend council meetings</td>
<td>15.9%</td>
<td>66.3%</td>
<td>17.8%</td>
</tr>
<tr>
<td>Participate in a dune care (dune revegetation) program at your local beach / foreshore</td>
<td>24%</td>
<td>56.8%</td>
<td>19.3%</td>
</tr>
</tbody>
</table>

3.8.5 Priorities for the future

Many Gold Coast residents highly value their quality of life and the lifestyle that the city offers them. As part of the planning process, Gold Coast City attempts to balance...
environmental, social and economic issues and each year, produces a report titled “Our Living City” that measures the City’s progress towards sustainability. Importantly, systems need to be developed that allow GCCC to regularly check with citizens to find out whether there have been changes in long-term concerns. This survey provided a mechanism for GCCC to ask residents what the most important issues are for Gold Coast beaches and foreshores in the next 20 years.

The CRC survey found that the most important issues for beach and foreshore management for Gold Coast residents were (see Figure 43):

- Coastal protection issues (27%), which included issues such as erosion, coastal protection and management programs such as beach nourishment, storm damage, cyclones, climate change and sea level rise;
- Environmental service provision (18%), which included issues such as pollution, water quality and the cleanliness of beaches and foreshores (e.g. litter, rubbish);
- Traffic, transport and parking issues (15%), which included issues such as the lack of parking, traffic congestion and public transport;
- Population growth and overcrowding (14%), which included issues such as overcrowding, overpopulation and overuse of areas;
- Provision of amenities and facilities (7%), which included issues such as surf quality and overcrowding, provision of showers, toilets and BBQs and safe swimming areas;
- Inappropriate development (5%), which included issues such as too many developments and highrises too close to the beach;
- Security issues (5%), which included issues such as vandalism, the homeless, theft and discarded needles;
- Beach safety issues (5%), which included issues such as the importance of safety, lifeguards, sharks and the risks of rips and drowning; and
- Environmental issues (3%), which included issues such as the importance of sand dunes and native vegetation.

It is worth noting that the three most important individual issues for Gold Coast residents were beach erosion (22%), followed by parking (19%) and issues related to overcrowding (13%)

It is useful to attempt to distinguish between ‘environmental service provision’ and ‘environmental issues’ for the purposes of this analysis. Environmental service provision is intended to capture the management issues related to providing good environmental quality, such as pollution and litter control programs (which might also include community education) and the overall natural character of the city. Environmental issues describe respondents’ concerns about more specific issues such as the importance of dune vegetation, wildlife, the impact of water quality on marine life and issues related to the removal of trees.
Environmental issues (cleanliness of the beach, cleanliness of the park and ocean water quality) were rated as the most important factors for a resident’s decision to use a particular beach or foreshore area. The significant positive response by respondents to the question of whether the natural character of their most visited beach was being-well managed can be interpreted as an indication that despite some negative feedback, most residents believe that GCCC is doing a good job.

3.9 Report on the socio-economic importance of recreational surfing on the Gold Coast

(A full copy of this report is provided in Volume 5)

In 2005, Gold Coast City requested that the GCCM investigate the recreational value of the multiple surfing breaks on the Gold Coast. A survey was designed to collect this information and from 2006-07 a total of 471 surveys were collected, of which 225 were face-to-face and 246 were internet based surveys. Research was undertaken in conjunction with the Australian National University.

A survey was designed and piloted and data collection was undertaken using a mixed-mode survey strategy. Mixed mode survey strategies, where combinations of techniques are used to collect information, has proven an efficient strategy for collecting data from a diverse user group over time and across different locations (Dillman, 2007). The techniques used were face-to-face surveys and an internet based survey instrument. An initial survey was piloted at in February 2006.

Surveys were undertaken at the following locations: Duranbah, Coolangatta Bay (Snapper Rocks – Kirra), Currumbin Alley, Palm Beach (Laceys Lane, 19th Ave, 24th Ave and Tallebudgera), Burleigh Heads, Miami - Broadbeach, Narrowneck and South Stradbroke Island (for the latter surfbreak, surveys were undertaken at the Seaway...
carpark). Figure 45 shows the surfbreaks on the Gold Coast.

Initially the scope of the project was to focus only on the existing pointbreaks (Snapper, Greenmount, Currumbin, Burleigh and South Stradbroke Island) and the web-based instruments reflect this, however, the face-to-face survey instruments attempted to pick up surfing effort at locations across the Gold Coast.

Duranbah, although technically not within Gold Coast City boundaries, is an important part of the local surfing scene. In order to fully understand use and expenditure patterns, it was important to include Duranbah and also the surfbreaks of Northern NSW in this analysis.

Figure 44: Surfers at Snapper Rocks
3.9.1 **History of surfing on the Gold Coast**

Recreational surfing has been practiced on the Gold Coast for over 50 years. Recreational surfing is practiced along the entire length of the Gold Coast and the Gold Coast is home to a number of world renowned surf breaks including Snapper...
Rocks, Kirra, Currumbin Alley, Burleigh Heads and South Stradbroke Island. A number of past and current world surfing champions including as Wayne ‘Rabbit’ Bartholomew, Mark Occhilupo, Stephanie Gilmore and Mick Fanning choose to live on the Gold Coast and Billabong, publicly listed on the Australian Stock Exchange and the second largest surfing company in the world, is based at Burleigh Heads. As well as this there are many medium and small surf industry operators who choose to call the Gold Coast home.

Notably, almost all of Gold Coast beaches have been altered in some way through engineering and coastal protection works. This in turn has impacted surf quality – both positively and negatively.

As well as an important region for professional competition surfers, the Gold Coast has 17 registered board-riding clubs that run regular surfing competitions at many of the City’s surf breaks. The Gold Coast continues to be a popular holiday destination for recreational surfers and many surfers choose to live in the city because of the lifestyle and access to the beach and good surf that is on offer here. Prior to the commencement of this study, there was little information about the value of and participation in recreational surfing on the Gold Coast. A 1992 report by the Australian Surfing Association identified that the value of surf related air travel into Coolangatta was approximately $46 million per annum (Atkins, 1992). More recently, Gold Coast City Council (2002) reported that over 1500 surfcraft riders per day were using the Gold Coast’s most popular beaches, the majority of whom were concentrated on the southern end of the coast (over 700 surfcraft riders at Rainbow Bay and Greenmount).

3.9.2 Demographics of Gold Coast surfers

For the purposes of this analysis all respondents to the survey are treated as Gold Coast surfers whether they are permanent residents or short or long-stay visitors. This survey does not distinguish between stand-up surfing and other types of surfing such as sailboarding, bodyboarding, kite-surfing, paddle-surfing or bodysurfing. There is significant anecdotal evidence to suggest that many visiting surfers take up temporary residence on the Gold Coast, seek and often find employment and even engage in further education.

Most surfers on the Gold Coast are male (90%) and continue to surf as they get older, with 31% of surfers are aged 18-30, with 21% aged 31-40 and 20% aged 41-50 years. When compared with Gold Coast population estimates the under 18 / 20 age group is significantly under represented in the survey data (Australian Bureau of Statistics, 2006a). Ethics Committee restrictions around this project required that anyone under 18 years of age needed to be interviewed with the consent of or in the presence of a legal guardian. This is the most likely explanation for this result and any interpretation of the results needs to be aware of this shortcoming in the data collection process.

At any one time, there are significant numbers of non-resident surfers on the Gold Coast (37%). These may be short-term or longer-term visitors. At any one time, there are significant numbers of non-resident surfers on the Gold Coast (37%). These may be short-term or longer-term visitors. The under representation of those under 20 years of age in the survey sample (most of whom are likely to be residents) may also lead to a lower estimation of the number of resident surfers compared to visitor surfers.

Gold Coast surfers are better educated than the average south-east Queenslander,
Queenslander or Australian with 38% having either a bachelors degree (25%) or postgraduate qualifications (13%), compared to combined State average of 13.1% and a national average of 15.6% in 2006 (Australian Bureau of Statistics, 2006).

Most survey respondents claimed to be employed (78%), with 29% employed part-time, 28% self-employed and 21% employed full-time. The high number of self-employed and part-time employed respondents in the survey sample suggests that many surfers have made specific lifestyle choices that allow them to surf more frequently. If self-employed and full-time employed respondents who were also residents of the Gold Coast (this may include people who live in Northern NSW and don’t consider themselves to be visitors to the region) are compared with Australian Bureau of Statistics data, the results are similar: 56% of respondents; compared to 58.5% of Gold Coast residents; and 60.7% of people Australia wide claim to be employed full-time. Part-time employment for respondents who were residents was 35%, compared with 33.9% for Gold Coast City and 31.5% nationally. Unemployment for those respondents who are also residents (5%) is also similar to the Gold Coast (5.2%), Queensland (4.7%) and National (5.2%) averages (Australian Bureau of Statistics, 2006b).

Before tax household income amongst those surveyed varied considerably, with 33% of surfer households earning under $40,000 per year, 35% of surfer households earning between $41,000 - $60,000 per year and approximately 25% of surfer households earning over $80,000 per year. The survey results are almost very similar those for household income in Gold Coast City, with the exception of the $61,000 - $80,000 income bracket, which was 2% higher for the survey. When compared to the national average, the survey results returned a slightly higher response rate in the $41,000 - $60,000 and $61,000 - $80,000 income brackets: 20% and 15% respectively compared to national averages of 17.5% and 12%. For those households who earn over $100,000 per year, the survey responses returned a slightly lower rate than the national average: 14% compared to 16% (Australian Bureau of Statistics, 2006b).

13% of surfers travelled less than 1km to go surfing, 30% of surfers travel between 1 to 5 km to go surfing and 60% of surfers travelled 10kms or less on average to go surfing and many surfers stated that the majority of their surfing effort takes place on the Gold Coast. Most Gold Coast surfers choose to drive to the beach when they go surfing (82%), although a sizeable minority of surfers walk to the beach.

On the whole, Gold Coast surfers rate their skill level highly, with 43% of respondents indicating that they were advanced and 46% of respondents rating themselves as of intermediate level. This level of response is expected considering almost 60% of respondents have been surfing for over 10 years.

As well as their high level of experience, Gold Coast surfers continue to surf frequently with over 50% of respondents to the survey saying that they surf 2-3 times per week or more and surf for an average of 2 hours each session. This is significantly higher than the national average of approximately once every 11 days (Surfing Australia, 2006).

Most surfers enjoy surfing on the Gold Coast for a variety of reasons. The most important reasons given for surfing were ‘for relaxation’ (66%) and ‘to be outdoors’ (66%); with ‘fitness’ (52%); ‘bonding with nature’ (47%) and ‘for sport’ (45%) also ranking highly. Respondents understood there to be a clear difference between ‘sport' and 'competition', which motivated approximately 10% of surfers. It is not known what percentage of surfers are members of board riding clubs (see Figure
Notably, over 50% of Gold Coast surfers that were interviewed have performed at least one rescue while surfing, with most surfers having performed multiple rescues over the years.

![Graph showing motivation for surfing for Gold Coast surfers.](image)

### 3.9.3 Environmental and social considerations for surfers

Respondents were asked to rank a number of issues in order of priority to see whether they would still go surfing. Three biophysical and three socio-cultural questions were asked. In response to the biophysical questions (see Figure 47):

- When faced with the risk of contracting a skin rash, 35% of respondents indicated that they would still definitely go surfing and 20% of respondents indicated that after some hesitation they would still probably go. On the other hand, 21% of respondents indicated that there was no chance they would go surfing if there was a chance they would contract a skin rash and a further 13% indicated that they might think about it for a while but would most likely decide not to go surfing.

- When faced with the risk of contracting an ear infection, 31% of respondents indicated that they would still definitely go surfing and 20% of respondents indicated that after some hesitation they would still probably go. On the other hand, 20% of respondents indicated that there was no chance they would go surfing if there was a chance they would contract an ear infection and a further 15% indicated that they might think about it for a while but would most likely decide not to go surfing.

- When faced with the risk of contracting gastroenteritis, 28% of respondents indicated that they would still definitely go surfing and 15% of respondents indicated that after some hesitation they would still probably go. On the other hand, 21% of respondents indicated that there was no chance they would go surfing if there was a chance they would contract gastro and a further 23% indicated that they might think about it for a while but would most likely decide not to go surfing.

In response to the socio-cultural questions (see Figure 48):

- Even if they needed to walk a long way to get to the surf, 38% of respondents indicated that they would still definitely go surfing and 23% of respondents
indicated that after some hesitation they would still probably go. On the other hand, 17% of respondents indicated that there was no chance they were going surfing if they had to walk a long way to get to the surf and a further 12% indicated that they might think about it for a while but would most likely decide not to go surfing.

- When faced with the risk of their car being vandalised, 30% of respondents indicated that they would still definitely go surfing and 21% of respondents indicated that after some hesitation they would still probably go. On the other hand, 20% of respondents indicated that there was no chance they would go surfing if there was a chance their car would be vandalised and a further 18% indicated that they might think about it for a while but would most likely decide not to go surfing.

- If there was likely to be aggression, surf rage or very crowded conditions in the lineup, 20% of respondents indicated that they would still definitely go surfing and 22% of respondents indicated that after some hesitation they would still probably go. On the other hand, 16% of respondents indicated that there was no chance they would go surfing if there was likely to be aggression, surf rage or very crowded conditions in the lineup and a further 27% indicated that they might think about it for a while but would most likely decide not to go surfing.
3.9.4 Locations for recreational surfing on the Gold Coast

With good wave quality in a number of locations, surfing effort is spread widely over the coast (see Figures 45 and 50). In order to determine the level of surfing effort at each of the surfbreaks / beaches, survey participants were asked to rank their top three surfbreaks. In order to provide some level of weighting to the answers, the first listed surfbreak was given a multiplier of 3 and the second listed surfbreak was given a multiplier of 2. The third listed surfbreak was counted once. For example, if a person ranked ‘Burleigh’ as their first choice, ‘The Spit’ as their second choice and ‘Currumbin’ as their third choice then Burleigh received 3-points, The Spit received 2-points and Currumbin 1-point. In this way total scores were created. Naturally the surfbreaks with better quality and more consistent waves were more popular, however, a significant amount of surfing also takes place along the open beach breaks of the Gold Coast (see Figure 46).

Many Gold Coast surfers regularly surf outside of the Gold Coast (e.g. Duranbah, Tweed Coast and Far North Coast of NSW), however, as Figure 50 demonstrates, surfing effort on the Gold Coast is only marginally lower if surfing effort on the Tweed and NSW north coast is included in the analysis, which includes surfbreaks as far
south as Ballina (about as far as one might travel on a day-trip). This suggests that most surfing effort takes place on the Gold Coast. It is worth noting that with Duranbah and Coolangatta Bay account for over 30% of total surfing effort on the Gold Coast. At peer review, however, it was suggested that this figure was likely to be on the low side with a number of experts indicating that the number of surfers at Snapper through to Coolangatta was often two or three times greater than Burleigh Heads.

Predictably, both Currumbin Alley and Burleigh Heads (the point) were also rated as being very popular surfbreaks, however, it is also worth noting the high (mostly local resident) surfing effort through Palm Beach and the Miamii-Nobby-Mermaid stretches of coastline. South Stradbroke Island or ‘Straddie’ is commonly regarded as one of the most consistent surfbreaks on the Gold Coast and continues to remain very popular. It is worth noting that a large number of Straddie surfers come from Brisbane. At Burleigh, a combined value is given for both the Point and the Beach. This is similar to Currumbin, where the value includes both Currumbin Alley and Currumbin Beach. Nevertheless, the Peer Review Group also strongly indicated that there was more surfing activity at Duranbah than at Burleigh Heads or Currumbin.

Figure 49: Surfboard rider entering water
Figure 50: Where do we surf on the Gold Coast?
3.9.5 **Participation in recreational surfing on the Gold Coast**

No previous studies estimated the number of recreational surfers on the Gold. At the national level, two sets of data exist that estimate participation in surfing Australia-wide. These are the Sweeney Report and the Australian Bureau of Statistics. In 2006, the Sweeney Report found that approximately 12% of Australians surfed at least once per year, with many people surfing more often (Surfing Australia, 2006). For example, the Sweeney Report states that on a national level, the average surfer 'hit the waves' 33 times per year or once every 11 days, however, 88% of those who participated in that study claimed to surf 36 times per year or more (Surfing Australia, 2006). The Griffith University / Australian National University survey found that Gold Coast surfers 'hit the waves' an average of slightly more than twice a week with 87% of all respondents claiming to surf weekly or more frequently. On the other hand, the Australian Bureau of Statistics (ABS) estimated the total number of Australians who participated in surf sports for the 2005-2006 year to be 269,700 (Commonwealth of Australia, 2007). In the ABS study, surf sports include surfing and windsurfing but not surf-lifesaving, which is accounted for separately. The significant differences between the ABS and Sweeney report are discussed in a 2001 ABS report (Australian Bureau of Statistics, 2001). Significantly, the Sweeney Report only surveys people in capital cities and it is likely that the per capita involvement in surfing on the Gold Coast is, for example, much higher than that of Brisbane residents.

Three separate methods were used to calculate the number of surfers on the Gold Coast, each of which has advantages and disadvantages. These are discussed in detail in the full report in Volume 5. The first method is based on the Sweeney Report and adjusted for Gold Coast population and visitation; the second method relied on GCCC lifeguard records from 2002; and the third method was based on answers from survey participants. All three methods count both resident and visitor surfers. The results range from approximately 65,000 to 120,000 (see Table 13). In the peer review process, significant doubt was placed on the reliability of the lower estimate because it was unlikely to account for the large perceived difference in participation between Gold Coast residents compared to those from capital cities. Further to this, Surfing Queensland reports that each year over 50,000 individuals participate in surfing lessons with registered surf schools on the Gold Coast. Participation through surf schools alone is likely to account for the lowest estimation of the total number of surf sessions, which suggests that the lowest estimates are also unlikely to be accurate.

The large range in estimations for the number of resident and visitor surfers to the Gold Coast meant that it was inevitable that a large range for the number of surf sessions was likely. At the lower bound, Sweeney Report indicates that on average surfers 'hit the waves' 11 times per year, however, many surfers went surfing more often than this. At the upper bound, this survey reported that average participation rates were a little over twice per week, however, there is likely to be self-selection bias amongst respondents that places the responses above the city-wide average (see Table 14). With approximately 47 million individual visits to Gold Coast beaches and foreshores each year (Raybould & Lazarow, 2008), surfing is likely to be a well represented component of this total. While it may appear that just about everyone on the Gold Coast surfs, it is in fact unlikely that surfers comprise almost one-third of all beach and foreshore visits, which is what the highest estimate in Table 14 suggests. While there was no consensus in the peer review process, a majority of reviewers indicated that the likely range was somewhere 6-10 million person-visits or surf session per year.
Table 14. Estimated number of surfers and surf sessions on the Gold Coast

<table>
<thead>
<tr>
<th>Source</th>
<th>Total number of surfers</th>
<th>Estimated number of surfing sessions per year (method 1 = 11 sessions per year)</th>
<th>Estimated number of surfing sessions per year (method 2 = 130 sessions per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimation 1 (based on Sweeney Report)</td>
<td>64,770</td>
<td>712,470*</td>
<td>8,420,100+</td>
</tr>
<tr>
<td>Estimation 2 (based on GCCC collection data)</td>
<td>74,703</td>
<td>821,733*</td>
<td>9,711,390+</td>
</tr>
<tr>
<td>Estimation 2 (based on GCCM collection data)</td>
<td>120,012</td>
<td>1,320,132*</td>
<td>15,601,560+</td>
</tr>
</tbody>
</table>

* Using the Sweeney Report estimated national level of participation = 11 sessions per surfer per year.
+ Using the results from this study = approximately 130 sessions per surfer per year.

3.9.6 Surfing study recommendations

The report made a number of recommendations. Those that relate to the economic value of recreational surfing and the surfing industry are considered in Chapter Five of this report. It was widely acknowledged that the Gold Coast beaches are of significant social and economic value of both residents and visitors of the Gold Coast.

A high number of respondents surf frequently and are either part-time employed or self-employed and it is thought that many surfers have structured their working lives around being able to access the surf on a regular basis. The report recommended further investigation into the concept and practice of ‘serious leisure’ (Stebbins, 1979) as an influence on community, recreation and amenity management with the specific intention of tapping into local knowledge and local community stewardship at particular beaches in order to improve beach management.

A high number of surfers have performed rescues while surfing. An offer by the Surflifesaving movement, Gold Coast City Council or Surfing Queensland to provide free or subsidised first aid training for surfers would greatly improve the capacity of surfers to be more effectively involved in rescues if and when the need arose.

While the beaches perform an invaluable coastal protection role, they also serve as our most important playground. To date, little attention has been placed on the importance of beach character and the impact that ongoing coastal protection and modification can have on the natural and social character of a beach. The impact of a coastal protection program on surf quality at Kirra and surrounding surfbreaks is discussed in the following report titled ‘Kirra Wave Amenity Study’. In response to the issue of surf quality, the socio-economic study made the following two recommendations:

1. Recreational amenity in general and recreational surfing amenity in particular must be clearly defined and a series of management goals created and worked towards for each beach. Where achievable, coastal protection and management strategies need to be developed that incorporate strategies to improve surfing amenity whilst not compromising coastal security. A number of innovative strategies could be linked in with existing coastal protection programs on the southern Gold Coast, at Currumbin, Palm Beach and at Burleigh Heads and based on the value and importance of recreational surfing to the Gold Coast, these issues warrant further attention.
2. As well as the maintenance and improvement of existing surfbreaks through coastal protection mechanisms, the potential viability of new surfbreaks could be considered where the placement of offshore control structures is considered as a viable means of protecting the coast. The use of offshore submerged control structures is likely to remain on the coastal management agenda for the Gold Coast into the foreseeable future and the use of these structures to create high quality surfbreaks should continue to be discussed and where possible implemented. It is also worth noting that the development of private-public partnerships for the construction of artificial surfing reefs might be worth considering, especially if this can service the City’s coastal management agenda at the same time as providing much needed expansion of the provision of recreational amenity. A number of locations including Bilinga and The Spit (near the Sheraton) may provide the best possible locations for surfing specific offshore artificial reefs.

![Figure 51: Kirra Point](image)

3.10 Kirra Wave Amenity Study

(A full copy of this report is provided in Volume 4)

In late 2005, the Griffith Centre for Coastal Management developed a project proposal to investigate and develop options that would lead to improved surf quality at Kirra and the surrounding surf breaks whilst maintaining coastal integrity. The project received support from the local community, industry, local government and elected officials. The development of this project coincided with a request from GCCC for GCCM to undertake an investigation and report on options to ‘improve the surfing banks and crowd conditions at the southern points by changing the effects of the Tweed Bypass sand pumping. This could include, but not limited to, techniques such as repumping sand north from Kirra and dredging Coolangatta bay to allow the northward flow of sand during big swell conditions.’ The following section provides an overview of this report, known as the ‘Kirra Wave Amenity Study’.

3.10.1 Background to the report

Over the past 13 years, a combination of factors has resulted in the decline in quality of surf quality at Kirra Beach, up to a point where the wave seldom breaks in a manner suitable for surfing. A modification to the Kirra Point groyne in 1996 combined with the effects of the Tweed River Entrance Sand Bypassing Project has significantly altered the local geomorphology resulting in improved coastal security.
but at the same time a loss of the surfbreak at Kirra, a significant recreational asset, as well as the deterioration of the Kirra Reef ecosystem due to smothering. The loss is believed to have had a serious affect on amenity, ecology and safety as well as community well-being and the economic flow-on effects that ‘Kirra’ delivers.

The ‘Kirra Wave Study’ was a community-initiated study to investigate and develop options that are anticipated to lead to improved surf quality at Kirra and the surrounding surf breaks whilst maintaining coastal integrity and was part of the stakeholder engagement process within the GCSMP.

The project had three primary tasks:

1. Run a series of community meetings to canvass ideas and options that those in the community believed would lead to an anticipated improvement in surf break amenity and safety on the southern Gold Coast, specifically Kirra beach.
2. Undertake computer modelling based on the shortlisted options to see which would be the best possible approach while at the same time not having a detrimental affect on coastal protection.
3. To document (film) the process, create a short film/documentary of the process and to make the documentary available for education and publicity purposes, including screening the documentary on TV (note – the documentary is being progressed outside of the GCSMP).

3.10.2 Methodology

GCCM worked with the local community to investigate a series ‘community’ options that were expected to lead to an improvement in surf quality in Coolangatta Bay, with a specific focus on Kirra Point. The goal of this Griffith University project was to present a series of options to the local community on how surfing amenity might be improved at Kirra. The central focus of the research was to determine if any extra works over and above the current Tweed River Entrance Sand Bypassing Project (TRESBP) would lead to an improvement in wave quality within a given time period.

In order to determine the range of options for investigation, two public meetings were held in 2006. The meetings were well attended with over 250 people at the first meeting and approximately 150 people at the second meeting. Following a presentation to the community and general discussion, it was agreed that the following options would be investigated:

1. Modifications to Big Kirra Point Groyne (leaving it as it is, extending it and removing it);
2. Construction of a supplementary outlet to the west;
3. Extension the ‘grid system’ for dredged sand to be placed further to the west;
4. Realignment of the beach profile at Kirra; and
5. No changes to the current system (TRESBP operates according to current management plans).

Combinations of these five options were also investigated.

All models were run using Delft3D (a coastal process modelling program) simulations based on an input of 1.8m SE swell conditions entering the bay at 1.2m. All models were run over a 12-month scenario. Using a prescriptive and limited set of variables means that the results should be interpreted with some sensitivity. For example, a
prediction from the model that indicates it may take 12 months to reach a particular scenario, may actually take somewhere between 9-18 months depending on conditions. This is on top of any time needed to conduct further studies, design, approve and construct extra infrastructure.

3.10.3 **Major findings from the Kirra Wave Amenity Study**

Investigations by the research team at GCCM reported that:

1. A supplementary outlet to take at least 75% of the bypass slurry to the west of North Kirra SLSC was most likely to assist in returning and maintaining favourable surf quality to Kirra Point in the shortest period of time. Other factors will of course assist in this process.

2. When the Kirra Point groyne was shortened in the mid-1990s not all of the foundation stones were removed. Removing these stones or adding a short length to the end of the groyne will create a ‘smoother’ end to the groyne which will allow sand to flow more smoothly around the point and also provide a safer structure.

3. Moving the dredge spoil drop locations further to the north will also assist in ‘clearing out the bay’.

4. The extension of Kirra Point Groyne to its pre-1996 length (+30M) will have little effect on surf quality in the short to medium term if the sand bypass and dredging operations continue as they currently are. In the event of the bypass system being turned off, the impact of a groyne extension would be more beneficial.

5. Realigning the beach profile at Kirra which may involve beach scraping and the construction of a ‘lagoon’ type hole that would encourage the shoreline to erode landwards at an angle is likely to have a high short-term effect but is unlikely to hold over the longer term. Further, this strategy will not assist greatly in deepening the nearshore sand banks, a critical component needed to improve wave quality.

6. Turning off the sand bypass system will, in the short term, achieve a similar result for improved wave quality at Kirra, to redirecting the sand through a supplementary outlet to the north.

7. A large storm event or sequence of storm events will assist in moving sand further to the north and out of Coolangatta Bay but this will also see a loss in the sandbanks for a period of time.

3.10.4 **Recommendations from the Kirra Wave Amenity Study**

The report made three primary recommendations:

1. GCCC investigate options and costs associated with extending the location for dredge spoil deposits to the west of the current grid system. An agreement would need to be reached between the two state governments, Council and the contractor to make changes to existing contractual arrangements. If funding is available, it may be possible for an arrangement to be in place prior to the 2007 Tweed River dredging campaign. It will cost approximately $500,000 - $800,000 p/a to ship 200,000m³ of sand (amount dredged in 2006) further west, depending on how far west the sand was deposited. If the area immediately west of Coolangatta Creek was chosen as the deposit site, then the cost would be less than $500,000. An alternative option is for the TRESBP project EIS to be revised with the intention of expanding the grid system. Revising the EIS would also
permit an investigation of sand placement to the south of the Tweed River as well as the investigation of other improvements to the Act (for example defining recreational amenity) and project agreement. Funding would also need to be sourced for revising the EIS.

2. An investigation into the feasibility of constructing a supplementary sand bypass outlet and booster station should be undertaken, including the acceptability of this option to the NSW Government, Qld Government and Gold Coast City Council. Such a system will most likely cost in the vicinity of $4,000,000 to construct and approximately $100,000 per year to operate and maintain based on at least 75% of the sand volume (excluding the sand being pumped to Duranbah) being discharged at this new outlet for approximately 2 years. In consultation with the community, the project management team may make a decision to readjust the volumes of sand being pumped to the various outlets. An extra benefit of a supplementary outlet is the potential for a ‘new’ wave or series of waves to be created in the vicinity of the outlet, similar to the benefit of the outlet at South Stradbroke Island. A supplementary outlet will give the project the scope to adjust volumes over time and maximise the benefit of the project, not just for safe navigation of the Tweed but also with a stronger concern for an improvement in safety and recreational amenity on the southern Gold Coast beaches.

3. Kirra Point Groyne will need to be addressed. As part of this investigation, the value of cleaning up the end of the groyne or in time removing the groyne altogether should be considered.

The findings and recommendations were presented to the community in a public meeting in early 2007. There was a strong consensus on recommendations 1 & 2. The community consensus was that recommendation 3 be modified to specifically call for Big Groyne to be extended to its pre-1996 length (+30m). A fourth recommendation from the community was that Gold Coast City Council commission the Griffith Centre for Coastal Management to continue its investigations.

The draft findings were presented at a scientific meeting, which included personnel from the TRESBP, the NSW and Qld State governments, Tweed Shire and Gold Coast City Council, in late 2006. There was significant concern by many of those who attended the meeting that the lack of calibrated data in the modelling process meant that the results were unreliable. Further to this, the TRESBP management team indicated that they were confident that significant changes to the Coolangatta Bay morphology were likely to occur in the near future as the bay attempted to find a natural equilibrium and this would also improve surf quality at Kirra.

The scope of the Kirra Wave Amenity Report was limited to considering if further alterations to the physical processes may lead to an improvement in surf quality at a rate faster than if TRESBP continued as usual over the next few years. The construction of infrastructure along the coastline raises a number of issues including environmental and community concerns, the need for changes to legislation and funding. These issues were flagged in the report.

### 3.10.5 GCCC action on the Kirra Wave Study

The report was considered by GCCC in May 2007 and the following was resolved:

1. That the report by Griffith Centre for Coastal Management (GCCM) into the wave conditions at Kirra be noted.

2. That the Chief Executive Officer be delegated the authority to begin negotiations
with the TRESBP to change the site for the deposition of the sand dredged from within the TRESBP area to north of North Kirra.

3. That monitoring of the sand volumes and surfing conditions in Coolangatta Bay continue through the TRESBP.

4. That a project to widen the park and dune areas at Kirra in line with the Draft Coolangatta to Bilinga Foreshore Master Plan, funded through developer’s contributions be considered in 2007/08 budget discussions.

5. That the Chief Executive Officer be authorised to enter into discussions with the State Government to ascertain the State’s interest in improving beach amenity through the progression of Option 2 (of Griffith Centre for Coastal Management) in this report and seeking a commitment from the State towards the funding of the required studies.

It should be noted that item 4 was not a recommendation of the project. As of October 2008, GCCC had commenced discussions with the EPA regarding the pre-approvals process for items 2 and 5, which were the major recommendations from the GCCM report. It is worth noting that the community is also working on privately raising funds for further investigations.

3.10.6 Beach Health Report

As part of the GCSMP, GCCM developed a Beach Health Report (BHR) program for GCCC. This program was piloted with GCCC staff in 2006 and is discussed in some detail in Chapter Two of the GCSMP and the reader is referred to Table 8, which summarises the theme ‘People and Play’. A full version of the Beach Health Report is provided in Volume 4.

It is recommended that the BHR project will be adopted by GCCC and a long-term monitoring and evaluation program linking to the ‘Our Living City’ report be established.

3.11 Update on the Palm Beach Protection Strategy

(A full copy of this report is provided in Volume 4)

There has been continuing concern that the Palm Beach section of the coastline does not have a sufficient storm buffer to prevent loss of beach and property damage in the event of a major storm in the future. As a result Council resolved to develop a strategy for the protection of the Palm Beach foreshore areas. Erosion events in 1996 and 2000 exposed the oceanfront boulder wall along sections of Palm Beach. Over time, climate change is expected to increase the risk to Palm Beach. The TRESBP will ensure that the littoral supply to Palm Beach is maintained, however it will not act as a source of new sand for Palm Beach that is above and beyond natural supply rates for the whole Gold Coast [despite there being some popular public opinion to the contrary]. A “do nothing” approach will not be adequate if it is expected that a beach be maintained during large storm events. In response to the need to defend and manage Palm Beach, GCCM began the preparation of the Palm Beach Protection Strategy (PBPS) in 2000.

Stage One of the PBPS incorporated the development of a Masterplan for Palm Beach, which was adopted by GCCC in 2001. The works program included a short-term program to: upgrade sub-standard boulder walls; continue the dredging program from Currumbin and Tallebudgera Creeks; increase hydrographic surveys of the area; construction of a geotextile reef in the vicinity of 19th Avenue in conjunction with a beach nourishment program; and the commencement of a series of detailed
studies to optimise the dredging program, identify offshore reserves, design the reef structure and associated nourishment and to develop a better understanding of the socio-economic framework for a long-term foreshore improvement scheme combined with coastal protection.

As well as this, a long-term program would allow for the preparation of plans for foreshore improvement and coastal protection (e.g. three offshore reefs plus nourishment).

Stage Two involved the preparation of a number of reports including the approvals process for works. Stage Three was the implementation process. Once approvals had been obtained, tender documents for beach nourishment and construction of the control structures [to prevent loss of the widened beach] were prepared. Tenders were advertised on 9/8/03. Tenders were received from eight different contractors and the contract was awarded on merit to McQuade Marine on 12th December 2003.

3.11.1 Community reaction to the strategy

A series of community awareness campaigns and documents regarding the details of the works formed an integral part of the PBPS. It was not until after the announcement of start of construction that the first opposition to the project became evident. The community opposition was generated by local surfers and was bolstered by significant press involvement as well as a well-funded “no reef” campaign (see Figure 52).
Save Our Surf Incorporated commissioned New Zealand-based consultants ASR Ltd to review the design (Mead et al., 2004). Their report was strongly critical of the proposed strategy. Their study was undertaken quickly and was based heavily on output from numerical models developed by ASR. Since this time, their modelling has been replicated by GCCM using the well-respected and widely used numerical model DELFT 3D using GCCC survey data from 2002 to create the bathymetry. GCCM determined that the ASR Ltd research was limited in scope and included significant inaccuracies and assumptions. These are discussed in the report included in Volume 4.

3.11.2 PBPS Consultative Committee

In February 2004, GCCC formed a consultative committee to resolve community concerns. In August 2004, the PBPS Consultative Committee resolved to:

1. Implement programs to upgrade substandard public and private boulder walls;
2. Continue dredging fromCurrumbin and Tallebudgera creeks, continue associated beach nourishment proposal and review funding levels;
3. Increase environmental study and hydrographic surveys of Palm Beach and complete a littoral review and biodiversity study;
4. Implement vegetation protection strategies;
5. Pass a resolution through Council to delete the submerged coastal control structure [artificial reef] in its present form from the current PBPS; and
6. Continue consultation through a consultative committee, particularly in view of Council entering into long-term contracts for PBPS.

3.11.3 Independent review of the PBPS

As a result of the community reaction to the project, GCCC also commissioned Prof Colin Apelt [BE, DPhil[Oxon], FIEAust, CPEng, RPEQ] in February 2004 to undertake a detailed review of the planning and design activities undertaken by GCCM relative to the Palm Beach Artificial Reef.

This review was completed in July 2004 and determined that:

\[
\text{GCCM [had] expended a very large effort on community consultation, with a limited budget and as directed by GCCC, and that it had done a careful and thorough job.}
\]

The review effectively endorsed the PBPS, however, a number of recommendations were made with respect to progressing the development of an offshore submerged control structure. These are discussed in more detail in the report presented in full in Volume 4. Notably, the author of the review indicated that questions about defining and measuring surf quality as well as potential changes to surf quality (good or bad) would need to be addressed. The review, however, did not present any solutions to these issues. The Kirra Wave Amenity Study and the study on the socio-economic importance of surfing to the Gold Coast also consider this issue and recommend that further work be undertaken to define and measure surf quality (see recommendation 3 in Table 16).

3.11.4 2004 GCCC resolution on the PBPS

In November 2004, GCCC resolved to delete the reef at 19th Avenue from the PBPS
Masterplan. The CEO was directed to write to the Qld EPA to request that the issue of whether a reef should form part of a future beach protection strategy for Palm Beach should be included in the Gold Coast Littoral Review (the GCSMP). GCCM has determined that a reef should form part of the PBPS. This is discussed in more detail in the report in Volume 4 and in Chapters 6 and 7.

3.12 GCCC parallel programs and strategies

3.12.1 Ocean Beaches and Foreshores Strategy

The Ocean Beaches and Foreshores Strategy (OBFS) is a work in progress that was initiated by GCCC in 2006 in order to clarify the overall objectives for beach and foreshore planning. The area of interest excluded The Broadwater and river foreshores areas.

The goal of the project is to create a whole-of-city approach to coastal planning and management that was integrated with areas such as transport, park management, tourism, environment / nature conservation, governance and economic development and planning. Key outcomes for the OBFS are: a rational basis for investment by Local, State and Federal Government in beach management; improved planning outcomes; improved communication with beach users; improved understanding by policy-makers; better knowledge connections within GCCC; improved conservation outcomes; and enhancement of coastal values for current and future generations (Stuart, 2006).

As a starting point, the OBFS is intended to incorporate the GCSMP, but have a much stronger emphasis on policy integration across directorates (within GCCC) and jurisdictions (external to GCCC); the value of the beach and user profiles; and a review of infrastructure and investment in beaches and foreshores for the city (Stuart, 2006).

Ultimately, the project is intended to deliver a strategy document and implementation plan to meet the infrastructure and management needs for beach and foreshore management, including day-to-day operations.

As part of the development of the OBFS, a report into the economic and social values of beach and foreshore recreation was undertaken in 2008 (Raybould and Lazarow 2008), however, progress of the OBFS was put on hold as a result of the implementation of the Bold Future Plan (discussed briefly below).

3.12.2 Bold Future

Bold Future is a Gold Coast City Council blueprint or vision for the city for the 30-year period to 2037. The goal is to work towards a sustainable lifestyle, economy and environment. The program is broken into 9 key themes, including, ‘Our Beaches Future’.

The primary purpose of the ‘Bold Future’ reports are to: provide a suite of technically accurate and contemporary background information; to highlight key issues, challenges and opportunities; to provide a range of best practice examples; to provide examples of potential visions and outcomes; and to provide questions for the Bold Futures committee to consider.

Key topics for this theme include: beach access; land use (tall buildings/coastal development); waterway and catchment health; beach demand; lifestyle value;
tourism; climate change (sea level rise/climate variability); beach health (physical beach health/beach ecosystems); and community engagement in coastal management.

As of the time of writing, the Bold Future plan was in preparation with an expected launch in late 2008.

3.13  General outreach and education program

As well as through the reports and programs described above, a number of important community issues were also progressed as part of the GCSMP through the establishment of working groups (described earlier in this chapter); a general outreach and education program; and participation and involvement in existing committees. The types of activities undertaken include:

- Attendance at community meetings;
- Regular phone and email correspondence with key groups and members of the community;
- Attendance at conferences and the production of academic articles including journal papers (journal papers presented in Volume 4);
- Popular media publications such as articles for electronic media and magazines;
- The production of information sheets (presented in Volume 4);
- Presentations to community groups and at public meetings; and
- Regular radio, TV and newspaper articles.

Table 15 provides an overview of the type and number of engagement activities undertaken through the 'Community Values' theme of the GCSMP.

Table 15: GCSMP stakeholder engagement overview 2005 - 2008

<table>
<thead>
<tr>
<th>Activity type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Book chapters and journal papers</td>
<td>7</td>
</tr>
<tr>
<td>Technical Reports</td>
<td>4</td>
</tr>
<tr>
<td>Popular media / literature (Internet and magazine articles)</td>
<td>&gt;20</td>
</tr>
<tr>
<td>Information Sheets</td>
<td>5</td>
</tr>
<tr>
<td>Conference presentations</td>
<td>10</td>
</tr>
<tr>
<td>Presentations to community &amp; stakeholder groups</td>
<td>&gt;30</td>
</tr>
<tr>
<td>Radio, TV &amp; Newspaper</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Stakeholder meetings</td>
<td>&gt;100</td>
</tr>
</tbody>
</table>

Some of the more complex community issues that were dealt with through the stakeholder engagement program include: the loss of beach fishing amenity; conflict and access at Currumbin; the Palm Beach Protection Strategy; the proposal for the development of a cruise ship terminal at The Spit; the Gold Coast Oceanway; proposals for the development of offshore fishing and diving reefs on the Gold Coast; the impacts of the Tweed River Entrance Sand Bypassing Project on stakeholders further up the coast; the Broadwater to Moreton Bay Infrastructure Master Plan; the impacts of the desalination plant at Tugun; and community concerns about localised impacts of climate change and variability.

The stakeholder engagement program has delivered a range of positive results for the Gold Coast region. Scientific papers, technical reports and conference
presentations all serve to promote and discuss the Gold Coast’s ICM challenges with
the broader research community. This helps to ensure that the research taking place
here is equivalent to the best in Australia and it also provides Gold Coast City
Council with a level of surety as to the quality and application of the research to the
region. The importance of being able to deliver often complex scientific discussions
to a lay audience cannot be understated. Over the past few years, the use of
information and fact sheets, popular media articles, public meetings and
presentations to deliver key messages and to promote greater interest by the
community in ICM has been very successful, with over 200 people attending some
meetings. This has been complemented by the use of radio, TV and newspapers.
There is no doubt that public debate about coastal management on the Gold Coast
has broadened over the past few years. Public meetings, workshops and regular
meetings with key stakeholder groups have also provided an important avenue for
the collection of local knowledge, experience and expertise on ICM issues across the
Gold Coast. This very important facet of coastal management has helped to inform
decision-making about how we manage the coast.

While the engagement program has been successful on a number of levels, the
nature of coastal management and the high values placed by so many people on the
beach, suggest that regular engagement with stakeholders and the broader
community will go a long way to improving outcomes.

3.13.1 Participation in government committees and reviews.

The progression of GCCC’s coastal management agenda is important at all levels of
government and community. GCCC and GCCM staff have participated in a number
of committees and review processes, including:

- Tweed River Entrance Sand Bypassing Advisory Committee;
- Qld Coastal Protection Advisory Council;
- Aust Government Inquiry into Climate Change and environmental impacts on
  coastal communities;
- Qld Coastal Conference Steering Committee; and
- Qld Coastal Councils Group.

- As well as this, GCCM has participated in a number of important review
  processes for coastal planning and management, including:

  - Review of the State Coastal Management Plan; and a
  - Submission to the House of Representative (Federal Government) Inquiry on the
    impacts of climate change to the coast.

Participation in government committees and reviews is important for the Gold Coast.
The contested nature of ICM implies that coastal management is often a very political
process. Participation in committees and review processes ensures that Gold Coast
issues are consistently brought to the table and that local issues are not lost in the
broader debate. For example, GCCM’s submission and the recent appearance of two
staff members as witnesses to the Federal Government’s inquiry into the
environmental impacts of climate change on coastal communities provided an
important perspective for the Commonwealth as it assesses how the Federal
Government is best placed to assist the States and Local Government in ICM.
3.14 Discussion

The scope of this theme was to investigate and understand how the Gold Coast’s ocean beaches are used and valued, both socially and culturally, by residents and visitors to the Gold Coast. The Broker - Local – Tourist framework provided a useful mechanism by which to carry out this investigation. This section of the chapter discusses the outcomes of the various initiatives and the chapter concludes with a series of recommendations to GCCC about how to best communicate with, and listen to the concerns of the community on the issue of beach management.

Over the past three years a number of projects and activities were developed in order to improve community understanding of the beach and coastal management issues and to help inform GCCC about community priorities for coastal management, including:

- A report into the economic and social values of beach use on the Gold Coast;
- A report on the socio-economic importance of recreational surfing to the Gold Coast;
- A report on the options to improve wave (surfing) amenity at Kirra;
- The inaugural Beach Health Report for Gold Coast City Council;
- An update on the Palm Beach Protection Strategy;
- The Bold Futures engagement program for beaches;
- GCCM’s involvement on relevant committees and reviews; and
- An overview of the general outreach program for the GCSMP, including the successful development of working groups and local committees.

A number of these individual reports have specific recommendations. These are summarised in Table 16.

<table>
<thead>
<tr>
<th>Report</th>
<th>Recommendation</th>
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</thead>
<tbody>
<tr>
<td>Beach Health Report</td>
<td>1. It is recommended that the BHR project be adopted by GCCC and that a long-term monitoring and evaluation program linking to the ‘Our Living City’ report be established.</td>
</tr>
<tr>
<td>Surfing Socio-economic Study</td>
<td>2. Further investigation into the concept and practice of ‘serious leisure’ as an influence on community, recreation and amenity management.</td>
</tr>
<tr>
<td></td>
<td>3. GCCC, the surfing and surf lifesaving peak bodies provide free or subsidised first aid training for surfers would greatly improve the capacity of surfers to be more effectively involved in rescues if and when the need arose.</td>
</tr>
<tr>
<td></td>
<td>4. Recreational amenity in general and recreational surfing amenity in particular must be clearly defined and a series of management goals created and worked towards for each beach. Where achievable, coastal protection and management strategies need to be developed that incorporate strategies to improve recreational / surfing amenity whilst not compromising coastal</td>
</tr>
</tbody>
</table>
5. As well as the maintenance and improvement of existing surfbreaks through coastal protection mechanisms, the potential viability of new surfbreaks could be considered where the placement of offshore control structures is considered as a viable means of protecting the coast.

Kirra Wave Amenity Study

6. GCCC investigate options and costs associated with extending the location for dredge spoil deposits to the west of the current grid system.

7. An investigation into the feasibility of constructing a supplementary sand bypass outlet and booster station should be undertaken, including the acceptability of this option to the NSW Government, Qld Government and Gold Coast City Council.

8. The role of Kirra Point Groyne as a recreational asset be investigated.

GCCC currently seeking advice on the pre-approvals process for 5 & 6.

Many Gold Coast residents are passionate about the coast and have a detailed knowledge of their local beach area. The results from the 2008 CRC for Sustainable Tourism report into the economic and social values of beach use indicates respondents were generally happy with the social atmosphere at their most visited beach and 76% of participants strongly agreed or agreed that different user groups got along at their most visited beach. When asked whether the natural character of their most visited beach was being well-maintained: 52% of residents either strongly agreed or agreed; and 45% of respondents strongly agreed or agreed that the dune system at their most visited beach appeared to be healthy. By contrast, at their most visited beach, only 25% of respondents strongly agreed or agreed that the GCCC appeared to be listening to the concerns of the community (see Figure 42). The generally positive response by respondents to the question of whether the city’s beaches are being well-managed can be interpreted as an indication that despite some negative feedback, most residents believe that GCCC is doing a good job in the provision of beach management services.

3.14.1 Importance of the beach

The CRC report estimated that residents made approximately 40 million visits to the beach and foreshore in 2007. Visitors were estimated to have made a further 7 million visits in 2006 (the latest year for which data is available). The surfing survey reported a likely range for surf sessions to be between 6 and 15 million per year, two-thirds of which are likely to be made by local residents. While these figures will be subject to revision in the future, they nevertheless indicate the significant importance that beaches have for residents, visitors and those whose livelihoods rely on people who use the beach and foreshore for recreation.

The relationship between people and place is complex and targeted strategies (by group, activity or by location) are required in order to communicate with and involve residents and brokers in the ongoing management of the Gold Coast’s ocean beaches. The 2006 Beach Health Report states that ‘there has been a growth in the number of groups and individuals taking an interest in their local coastal areas, especially at the southern beaches, Palm Beach and The Spit.’

Much can be learned from the responses to the questions on beach management from the 2008 CRC study. Many respondents indicated that they often visited one or a few beaches but relatively few would used all of the Gold Coast’s 52kms of
beaches on a regular basis and may not have a strong overall vision for, or affinity with the whole coast. This is important from a management perspective and it is this attachment to place, this 'love for the coast', that provides a good opportunity for GCCC to engage with beach users and coastal residents on a more personal level. At the whole-of-city level, strategies must also be developed to engage with key stakeholder groups and individuals.

The CRC study reported that up to 25% of residents were interested in taking a more active role in coastal issues within the City, including attending meetings and participating in on-ground activities. This contrasts with the relatively low level of engagement in the Bold Futures project and suggests that a blanket approach to engagement is unlikely to be successful. For example, the high level of interest and engagement from surfers in the two surfing related projects indicates that a targeted approach is more likely to capture the interest of coastal stakeholders. It is interesting to note, however, that surfing did not feature very highly as a recreational activity in the CRC survey. There are a number of possible reasons for this, which may be explained by differences in the samples. For example, the high average age of respondents to the CRC survey may indicate that they are less likely to participate in active outdoor recreational activities.

3.14.2 Major challenges and issues

The CRC study reported that the three most important individual issues for beach and foreshore management for Gold Coast residents were beach erosion (22%), followed by parking (19%) and issues related to overcrowding (13%). By grouping the issues in categories, researchers found that the most important management categories were (from most to least important):

- Coastal protection issues (27%), including erosion, coastal protection and management programs such as beach nourishment, storm damage, cyclones, climate change and sea level rise;
- Environmental service provision (18%), including pollution, water quality and the cleanliness of beaches and foreshores (e.g. litter, rubbish);
- Traffic, transport and parking issues (15%);
- Population growth and overcrowding (14%);
- Provision of amenities and facilities (7%), including surf quality and overcrowding, provision of showers, toilets and BBQs and safe swimming areas;
- Inappropriate development (5%), including too many developments and highrises too close to the beach;
- Security issues (5%), including vandalism, the homeless, theft and discarded needles;
- Beach safety issues (5%), including the importance of safety, lifeguards, sharks and the risks of rips and drowning; and
- Environmental issues (3%), including the importance of sand dunes and native vegetation.

Many Gold Coast residents place a high value on their quality of life, the lifestyle that the city offers them and are proud of their beaches. Environmental service provision (cleanliness of the beach, cleanliness of the park and ocean water quality) was rated as the most important factors for a resident's decision to use a particular beach or
The relatively low level of knowledge or interest from many respondents on more specific environmental issues such as the importance of native dune vegetation, wildlife, the impact of water quality on marine life and issues related to the removal of trees indicates that more needs to be done to raise the level of environmental awareness amongst residents. It is worth, however, considering that many residents may have made a conscious decision to trade-off some level of environmental quality for other benefits such as coastal protection, proximity (e.g. living close to the beach or in sensitive areas) and access. Further investigation into these issues is recommended.

The coast is not only highly valued, it is also a highly contested space and not everyone has the same set of goals or vision for the coastline. A group's position on a particular issue may resonate with some in the community but may also create fierce opposition on the part of others. Foxwell-Norton (2006) writes that

There is a fundamental conflict between the ways in which experts and communities fashion the coastline, which can be largely ignored until community participation programs are established. The fundamental ingredient missing from Coastcare – and other community participation programs – is a descent from the clear heights of environmental science to the messy, complex and contradictory milieu of the 'community'

(Foxwell-Norton, 2006, p. 204)

For example, the potential loss of public open space and access acted as a major membership and support drawcard for the Save Our Spit Alliance who campaigned against the proposal to construct a cruise ship terminal and port facilities at the northern end of the Gold Coast. Many in the community, however, supported the concept of cruise ship terminal and it is likely that this proposal, while settled for now, will once again become an issue for discussion in the coming years.

A number of coastal eNGOs are active on the Gold Coast with Friends of Federation Walk and Gecko being the largest and most active of the groups. The CRC survey reported that approximately 6% of survey respondents were members of environment groups. A recent report into the activities of coastal eNGOs on the Gold Coast found that groups were active across a range of issues, including:

- The preservation of public open space;
- Issues related to inappropriate development;
- Impacts of population growth;
- The loss of terrestrial and marine environmental quality (flora and fauna);
- Climate change; and
- Water quality.

Section 3.4 of this chapter discusses in greater detail the types of activities that coastal eNGOs on the Gold Coast generally engage in and also what some of the major challenges are for these groups. The growth of community groups is an important component in the development of the community and ongoing engagement by GCCC with these groups is encouraged.

An issue that has been regularly debated for some time is that of access to the beach and foreshore for commercial activities and whether this would have a negative impact on public use of a highly valued public asset. The Beach Health Report stated
that ‘the redevelopment and extension of some of these [foreshore] areas has proved popular, however there has been a rapid growth of commercial activities taking place in public space and a balance between passive / recreational and commercial activities must be considered.’ The CRC survey asked three questions on this topic and the answers suggest that an upscale in certain beach / foreshore based commercial activities, if managed correctly, may be acceptable to local residents. This would have to be assessed on a beach by beach basis.

At the southern end of the coast, the impact of the Tweed River Entrance Sand Bypassing Project has been an issue of intense debate and scrutiny for a number of years. The project has successfully led to the rapid widening of the beaches and infilling of Coolangatta Bay and this has created a significant coastal protection buffer along this stretch of coastline. In recent years there has been rapid commercial and residential development within this coastal node. Without doubt, some level of developer confidence is attributable to the greater level of coastal security now offered by wider beaches. However, many in the community believe that a more hands on management approach as well as actual modifications to the system is required. Many surfers, while happy with an improvement in surfing at Snapper Rocks, lament the loss of good quality surf at Kirra, Greenmount and some of the other surf breaks in the area as well as the constant overcrowding that now occurs at Snapper Rocks. The smothering of Kirra Reef, more dangerous swimming conditions in Coolangatta Bay and a loss of intimacy in the small pocket beaches within Coolangatta Bay have also been raised as negative consequences of the TRESBP. It was these issues that encouraged GCCM to undertake the Kirra Wave Amenity Study – a study that investigated options that would lead to improved surf quality at Kirra and the surrounding surf breaks whilst maintaining coastal integrity - and led to the development of the Kirra Point Committee and the Kirra Business Group, two working groups that were established to progress recreational amenity and business interests in the Kirra area. These initiatives have been complemented by an investigation into the socio-economic importance of recreational surfing on the Gold Coast.

Figure 53: Off-leash beach at The Spit
3.14.3 Maintaining and improving recreational amenity

While the beaches perform an invaluable coastal protection role, they also serve as our most important playground. The lifestyle benefits of living on the Gold Coast have been widely promoted for many years. The study on the socio-economic impact of recreational surfing found that many surfers had structured their working lives around jobs that gave them the flexibility to surf more often. The study also recommended further investigation into the concept and practice of ‘serious leisure’ as an influence on community, recreation and amenity management with the specific intention of tapping into local knowledge and community stewardship at particular beaches in order to improve beach management. To date, little attention has been placed on the importance of beach character and the impact that ongoing coastal protection and modification can have on the natural and social character of a beach. The study on the socio-economic importance of surfing made two important recommendations in this regard (see Table 16 for more detail).

The Kirra Wave Study made two primary recommendations: (1) that options and costs associated with relocating the dredge spoil further to the west be investigated; and (2) that an investigation into the feasibility of constructing a supplementary sand bypass outlet and booster station should be undertaken including the extra benefit of a supplementary outlet being the potential for a ‘new’ wave or series of waves to be created in the vicinity of the outlet, similar to the benefit of the outlet at South Stradbroke Island. As of October 2008, GCCC had commenced discussions with the Qld EPA regarding the pre-approvals process for both of these recommendations. As well as improving surf quality, these recommendations are anticipated to lead to a faster recovery of Kirra Reef as well as improved coastal protection options for the Gold Coast. This latter point is particularly important given that Bilinga and Palm Beach, two of the most vulnerable beaches on the Gold Coast, are likely to benefit from such a scheme. The community at Currumbin and Palm Beach have expressed concern about what impact a large quantity of sand would have on navigation, amenity and reef health in that area – and these issues will need to be investigated in more detail should these recommendations be acted on.

It is worth noting that contrary to the GCCM findings for this report, many in the community believed that extending the Kirra Point Groyne to its pre-1996 length (it was shortened by 30m) would lead to a demonstrable long-term improvement in recreational amenity at Kirra. This issue is being discussed with GCCC, however, it is not part of the formal GCSMP recommendations.

The 2007 GCCM ‘Update on Recommendations for the PBPS’ were broadly consistent with the original recommendations from the PBPS – that a control structure is needed at Palm Beach and that the proposed design of the structure, constructed using a staged approach, will effectively meet the GCCC design requirements. A number of issues including environmental concerns, access, dune vegetation, dredging programs, health of the reefs at Palm Beach and the need for a more detailed socio-economic understanding of the community at Palm Beach will need to be progressed as this issue is once again tested with the local community. The lessons from Palm Beach in 2004 were unfortunately not taken on board by the State Government when it put forward plans to develop a cruise ship terminal on public land at The Spit in 2005. While it is clear that GCCC is listening to the community on these issues, it is apparent that the complexities of decision-making for coastal management are frustrating many. In situations like these, local committees can be most beneficial to maintaining an open dialogue between government and the community.
With a heavily managed coastline, the use of offshore submerged control structures as a coastal protection strategy is likely to remain on the coastal management agenda for the Gold Coast into the foreseeable future. The recommendation in Chapter 6 for the establishment of a trial area for offshore control structures at the northern end of the coast takes on-board community concerns that we need to learn more about the impact and benefit of control structures on existing recreational amenity and marine habitat. An adaptive approach to managed coastlines is necessary in order to progressively manage changes to the system. An adaptive approach provides a framework of learning by doing and encourages the adoption of management strategies as new data and knowledge come to hand. A trial reef at the northern end of the coast, if successful, may provide evidence to the community at Palm Beach and at other locations on the Gold Coast that offshore coastal protection structures (e.g. artificial reefs) can successfully balance a range of factors, including the preservation of ecological habitat and recreational amenity.

3.14.4 Importance of the Gold Coast for coastal managers

The Gold Coast has an important place within the coastal planning and management community in Australia and internationally. The need to manage coastal development and population growth in an area that is very close to sea level provides GCCC with a unique set of challenges. Innovative coastal protection strategies such as the two sand-bypassing facilities and the artificial reef at Narrowneck have also made the Gold Coast the subject of investigation and interest for coastal managers in other regions. GCCC and GCCM staff’s involvement in State and Federal Government committees, inquiries and research projects such as the Qld Coastal Protection Advisory Council, the Federal Government’s inquiry into climate change and environmental impacts on coastal communities and the Future Coastlines project ensure that the issues that the Gold Coast faces are brought to the attention of decision-makers at all levels of government.

Researchers involved in the GCSMP have written and presented their research within the academic community through conference presentations and peer reviewed publications on topics including: coastal physical processes; climate change; coastal vulnerability and risk assessment; ecological processes; recreational amenity; the value of beaches; and policy development. This process ensures an important level of quality control on research as ideas get rigorously tested and refined.

3.15 Recommendations

A number of key coastal management issues remain ongoing challenges for GCCC, including managing and improving coastal-based recreational amenity, in particular surf quality, and marine habitat. Concern over surf quality and the loss of Kirra Reef in Coolangatta Bay; water quality issues related to the desalination plant; concern about the efficacy of the Palm Beach Protection Strategy; access and safety issues at Currumbin; sand nourishment at Burleigh heads; and preferred use activities at The Spit are all examples of conflicting agendas about what the best possible use of the coast and coastal resources are. The results of the Beach Health Report suggest that a management approach that trades off coastal protection benefits against environmental and recreational benefits at all costs is not wholly acceptable to the community and should be revisited.

Funds will need to be allocated and hard decisions will need to be made about how we fashion our coastline in the years to come. No doubt this will be a hotly contested and contentious debate as many discussions on quality of life are. If not managed effectively and in a timely manner, the issues such as those described above have
the potential to delay and possibly derail GCCC’s coastal management program. With the community onside, however, the progression of the coastal management agenda is likely to proceed much more smoothly. Further to specific recommendations from the individual studies referred to in this chapter (see Table 16), a number of recommendations are made in this regard.

1. Existing high profile issues need to be managed effectively. As well as the work that is currently being undertaken by GCCC, there is a need for more effective partnerships between GCCC directorates and between GCCC and the State government on a number of issues.

2. The importance of eNGOs and groups such as the Palm Beach Protection Strategy Consultative Committee, the Kirra Point Committee and the Kirra Business Group and the Currumbin Estuary Dredging Group Committee cannot be understated. These groups enable key stakeholders to share knowledge, debate issues and take information back to the community. Importantly, they also provide a valuable conduit for planners to incorporate local knowledge and experience into the decision-making process. The establishment of similar groups at other locations on the Gold Coast (including goals for these groups) is recommended.

3. GCCC must actively engage with the community and industry on the issue of climate change. The development of public-private partnerships should be considered, especially if this can service the GCCC’s coastal management agenda at the same time as providing a benefit to the community.

4. In late 2007 both the Federal and Qld Government established climate change agencies. Both agencies have an interest and adaptation driven approach towards dealing with the impacts of climate change on coastal cities, the environment, communities and the coastal economy and partnerships with these agencies is encouraged. This will be complemented by the Griffith University Climate Response Program, which brings together a diverse range of expertise on climate adaptation. Research partnerships with all levels of government on the socio-economic impacts of climate change to this region should be promoted.

5. Further investigation in a number of key areas is recommended:
   a. The socio-economic value of the coast; to define the amenity value of the beaches relative to their coastal protection and real estate value.
   b. Future-coast scenarios that examine the type of city and community that residents hope to live in;
   c. The acceptability of an upscale in certain commercial activities on the beach and foreshore; and
   d. Improve the environmental awareness of Gold Cost residents. Locally, the general outreach and education program associated with the GCSMP has been able to raise the profile of coastal planning and management issues amongst the community. This has been well complemented by the CoastEd and BeachCare programs. An important goal for the future will be the development of detailed indicators to continue to measure the success of community engagement programs and progress towards sustainability.

6. It is recommended that the Beach Health Report (BHR) be adopted by GCCC and linked to the ‘Our Living City’ report be established. The BHR provides a good mechanism to conduct an annual assessment of our beaches, incorporating the themes ‘people and play’, ‘services’ and ‘beach health’. Through the inclusion
of a monitoring and evaluation program, the BHR can provide GCCC with a litmus by which to measure the success of its beach management program and community engagement efforts. In conjunction with the Beach Condition Index (discussed in Chapter 7), the Beach Health Report can provide a valuable management tool for GCCC.

3.16 Chapter summary

The scope of this theme was to investigate and understand how the beach is used and what the key stakeholder issues are; to undertake a range of projects and implement strategies to increase community knowledge about the Gold Coast’s ocean beaches; and to develop mechanisms for communication and ongoing community engagement for the management of the Gold Coast’s beaches.

Gold Coast residents use the beach on a regular basis and the results from a number of projects indicate that Gold Coast residents place a high value on the beaches and the activities they undertake there. Many residents have a strong attachment to a particular beach or coastal suburb. The results of a recent survey suggest that this attitude directly affects the overall opinion of residents who scored GCCC’s management of the Gold Coast’s beaches overall as quite good, but were concerned about issues at their local beach where they rated GCCC’s management less highly. The initiation of a number of key projects and strategies has raised the profile of coastal issues within GCCC and the interest of residents in coastal planning and management.

Community participation is an important part of GCCC’s coastal planning and management program and a number of programs are currently underway that engage with the community at various levels, from on-ground works such as dune revegetation through to community involvement in the Bold Future project. Additionally, there are numerous coastal eNGOs that are active on the Gold Coast and there is potential for these groups to expand.

Brokers, locals and tourists place a premium on Gold Coast beaches. In the past few years, groups and stakeholders have been actively involved in a number of coastal issues. This has led to direct confrontation with GCCC and the State Government on a number of occasions. The success of a number of local committees in bridging the gap between GCCC and the broader community suggests that with the right structures in place local residents and businesses can make a significant positive contribution to coastal management on the Gold Coast.

The coast is highly valued and highly contested. It is also naturally dynamic and subject to large changes in a relatively short period of time. A number of recommendations are made that are likely to lead to an improvement in community engagement, education and feedback to GCCC on its ocean beach management program. The GCSMP has been developed as the vehicle for the management of the coast for the next 50 years, however, it will be the public, decision-makers and politicians who ultimately decide the appropriate balance of environmental, social and economic issues.
CHAPTER 4 - ECOLOGICAL PROCESSES

The Gold Coast's vast sandy coast provides Gold Coast City Council with an enormous natural asset. Sandy beaches are high energy environments. Waves strike the shores, moving sediments and eroding particles. This unstable environment makes life difficult for plants and animals. However, there are some organisms that can cope with mobile sediments and can exploit the supplies of oxygen and nutrients available in such habitats (Little, 2000). Beaches may appear barren and largely devoid of life but in reality beaches support a great diversity of fauna (D. Jones & Morgan, 2002). Moreover, sandy beaches provide a wide range of ecosystem services and serve as a link between the ecology of sand dunes, the surf zone (A. D. Short & Hesp, 1982), and nearshore rocky reefs. This chapter provides an overall review on the ecological aspects of coastal sand dunes, sandy beaches, nearshore reefs and associated biota.

Figure 54: Stradbroke Island Sand Dunes

4.1 Coastal Sand dunes

Coastal dunes are an integral part of the coastal environment (NSW Department of Land and Water Conservation., 2001). They not only protect coastal property from storms, but also are the basis of important ecosystems supporting valuable communities of plants and animals (NSW Department of Land and Water Conservation., 2001). Coastal dunes are characterized by the exchange of sand with beaches and by the influence of wind forces. Many plant species are able to colonize supralittoral sands, despite initially poor nutrient conditions, lack of moisture, and sometimes very high temperatures (McLachlan & Brown, 2006). On undisturbed beaches such colonization may begin at or just above the strandline aided by accumulations of wrack which reduces the sand temperature and increase its moisture content (McLachlan & Brown, 2006). Wrack is the build-up of debris consisting of seagrass, algae, weeds, marine organisms and other material deposited on the beach by the wind and waves. Vegetation is by far the most important component of the biota on sand dunes because it is directly involved in establishing the dune forms and creating the structure of the dune habitat. Microorganisms and fungi are the primary colonizers of sand along the coast. Fungi are most important in this regard, followed by bacteria and algae. The presence of
such colonisers reduces wind erosion, increases soil moisture, and increases the nutrient amount of the sand (McLachlan & Brown, 2006).

Sand dunes are usually classified as an incipient dune, foredune or hinddune (New South Wales Government., 1990). Incipient dunes are the most seaward and immature dune of the dune system and its vegetation is characterised by grasses. On an accreting coastline, the incipient dune will develop into a foredune (New South Wales Government., 1990). A foredune is the larger and more mature dune lying between the incipient dune and the hinddune area. Foredune vegetation is characterised by grasses and shrubs. Foredunes provide an essential reserve of sand to meet erosion demand during storm conditions. Hinddunes are characterised by mature vegetation including trees and shrubs (New South Wales Government., 1990).

4.1.1 Food web

Dune food chains are driven by primary production of the dune flora, organic inputs from the sea, and inputs from land. A high proportion of plant biomass, both living and dead, may occur below ground where it is more available to the interstitial biota (meiofauna, bacteria and fungi) than to the macrofauna (organisms of at least 1mm in length) (McLachlan & Brown, 2006). Moist conditions and a high proportion of buried organics favour the development of a rich interstitial community (McLachlan & Brown, 2006). Broadly, three main food chains may be recognized in coastal dunes (McLachlan & Brown, 2006). These are:

- A grazing pathway consisting primarily of macroscopic herbivores (insects, mammals, and fruit-and-seed-eating birds).
- A detritus pathway consisting of macroscopic animals (insects) feeding on vegetation detritus (litter), which may accumulate in the lee of vegetation hummocks, at the base of slip faces, and elsewhere.
- The interstitial biota, feeding on buried detritus, and in the case of plant parasitic nematodes on the roots themselves (McLachlan & Brown, 2006).

4.1.2 Gold Coast’s sand dunes

Coastal sand dunes have often been regarded as marginal land which is available to the public for recreation (Gadgil & Ede, 1998) or other human uses. Gold Coast sand dune systems have been heavily altered by human intervention over many years. Coastal development is without doubt one of the main factors responsible for the degradation of sand dune system in the area. Environmental problems associated with coastal development include loss of natural dune habitat, threats to natural species, reduction in seed sources, and decreased resilience of plant communities following loss by storms (Nordstrom et al., 2000). Other factors that also affect the natural growth of dune systems are beach cleaning operations and mechanical grading that is done to improve the appearance of the beach for recreational use and increase ease of access (Nordstrom et al., 2000). Finally, the introduction of exotic species also has detrimental effects on the native vegetation and fauna.

4.1.3 Current Management of Gold Coast’s sand dunes

Gold Coast City Council through its “Planning Scheme Policy 15: Management of Coastal Dune Areas” aims to “promote the establishment and retention of appropriate vegetation as the preferred form of dune stabilisation; preserve the function and sustainability of natural dunal systems; provide community guidance on sustainable
Sand dune management in the Gold Coast fits into two categories; Capital Investment Program and the Maintenance Program (Challenger, 2007 pers.com). The goal of the Capital Investment Program is to provide large scale dune quality improvement. The program hires external consultants to conduct rehabilitation of sand dunes on specific sites (Challenger, 2007 pers.com). Currently there are 5 contractors in charge of rehabilitation works. Rehabilitation of sites takes effect by:

- councillor request;
- direct community request;
- development and/or re-development that affects sand dune areas and;
- dune assessment program.

The latter is a program developed by council to assess sand dunes and determine priority areas for maintenance. The program's Dune Maintenance Form and Dune Assessment Method can be found in Appendix A. The program was first conducted in some areas of the coast in 2007 with the help of Griffith University students and community volunteers. The Maintenance Program deals with weed reduction, sand dune establishment and aesthetics such as trimming and pruning. The allocation of works to external consultants is done through an open tender process. Contractors and anyone that is considering working on sand dunes need to follow a Vegetation Management Plan (VMP). Guidelines and examples of VMP's are provided by GCCC.

4.1.4 Vegetation surveys and vegetation mapping on the Gold Coast

Sattler and Williams (1999), conducted a study to report on the conservation status of Queensland's bioregional ecosystems. The report suggests that the regional ecosystems of Queensland should be the primary basis for planning the conservation of biodiversity. Regional ecosystems are defined within a hierarchical framework commencing with the classification of Queensland into bioregions and ending with species. This study represents a continuation of work commenced in 1974 when the bioregions of Queensland were first described together with their major vegetation communities (Stanton & Morgan, 1977). The report proposes regional ecosystems as a tool to describe biodiversity and to plan conservation in Queensland. However, the report acknowledges that regional ecosystems are not a good surrogate for all species and do not necessarily address the conservation needs of many rare and threatened species and species with patchy distributions (Sattler & Williams, 1999). The report also acknowledges that planning for the conservation of biodiversity should also include other complementary strategies that address the specific requirements of species (Sattler & Williams, 1999). The study classifies sand dunes mainly as regional ecosystems 12.2.13 (Open or dry heath) and 12.2.14 (Strand and fore dune complex). A detailed description of each regional ecosystem is available in
Sattler and Williams (1999) and from the EPA website (www.epa.qld.gov.au).

The Queensland Herbarium was commissioned by Gold Coast City Council to conduct a vegetation mapping review of the local government area (T. S. Ryan et al., 2003). The aim of the project was to review and refine the existing Gold Coast City Nature Conservation Strategy maps. Mapping was undertaken at a scale of 1:20,000, with a minimum polygon size of 0.5 hectares, or 30 meters width for linear features. Map coverage was derived through photo interpretation of aerial photographs at scales ranging from 1:10,000 to 1:31,000. Field surveys and information from existing studies were also used. The report divides Gold Coast vegetation into regional ecosystems. The regional ecosystems classification scheme is part of the biodiversity planning framework that has been developed to assist the EPA to plan for biodiversity. The framework has been incorporated into several planning initiatives such as the Vegetation Management Act 1999. Regional ecosystems were defined by Sattler and Williams (1999) as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. The regional conservation status of vegetation communities within South-east Queensland has been determined by the EPA, and is listed in the Regional Ecosystem Description database Version 5 (EPA., 2005a) available from the EPA website. This listing outlines the regional status of vegetation communities, based largely on the remaining proportion of their natural coverage in the region prior to clearing and settlement.

In 2006, GCCC conducted a flora survey and habitat mapping project for the South Stradbroke Island Management Area. The management area consists of a series of properties purchased by GCCC (Searle & Maden). The properties form a continuous land holding to the immediate south of the Couran Cave resort and associated marina development (Searle & Maden). Mapping for this study was conducted based on 1:8,000 colour aerial photography from 2005. Preliminary mapping was ground-truthed and reviewed using the flora field sites surveyed by the Queensland Herbarium plus other additional sites. ‘Foredune’ or beach-strand and ‘Sandblow’ are the only two types of regional ecosystems identified which fall within the coastal scope of this Littoral Review. The survey report found that foredune or beach-strand communities on coastal sand are considered to be adequately represented throughout both the Gold Coast area and the QLD region overall, however, many of the remaining areas of this community are highly modified or in poor condition with a high incidence of exotic weed infestation, particularly when found adjacent to coastal development. On South Stradbroke Island, an area with no or little coastal...
development, foredunes generally show healthy regrowth and low incidence of infestation by exotic weeds. Hence foredunes at South Stradbroke Island should be considered as having an elevated conservation status (Searle & Maden). On the other hand, sandblow communities have limited remaining abundance within the Gold Coast local government area and the QLD region (Searle & Maden). Moreover, they are classified as ‘Of Concern’ under the regional framework (Searle & Maden). The survey report outlines that the current status of this community is a result of many of these areas being stabilised by plantations of *Casuarina equisetifolia* and/or other vegetation, in association with sand mining activities in and adjacent to these dunal areas. Alternatively, it was found that although these communities effectively restrict the representation of ‘natural’ sandblow they contribute to an increase in habitat stability and complexity, and flora and fauna diversity (Searle & Maden).

### 4.1.5 Threats to sand dune health

There are a number of human actions that threaten sand dune health on the Gold Coast. Some of these problems are associated with coastal development which include loss of natural dune habitat, threats to natural species, reduction in seed sources, and decreased resilience of plant communities in developed areas following loss by storms (Nordstrom et al., 2000). Other factors that also affect the natural growth of dune systems are beach cleaning operations, mechanical grading (Nordstrom et al., 2000) and the introduction of exotic species.

#### 4.1.5.1 Weeds

Weeds cause many problems in coastal environments since they often grow faster than native plants and successfully compete for sunlight, water, nutrients and pollinators (NSW Department of Land and Water Conservation., 2001). Their capacity to establish and spread leads to invasion and displacement of native plant communities thus reducing biological diversity (NSW Department of Land and Water Conservation., 2001). A variety of weed control techniques have been described in the manual developed by the NSW Department of Land and Water Conservation titled “Coastal Dune Management”.

In Queensland, the *Land Protection (Pest and Stock Route Management) Act 2002* classifies pest plants as declared plants class 1, 2 or 3. These plants are targeted for control because they have, or could have, serious economic, environmental or social impacts. For example, Bitou bush a weed present in the Gold Coast has been declared a Class 1 plant under the act. Lantana, Fountain Grass and Singapore Daisy three common weeds present on Gold Coast’s sand dunes have been declared a Class 3. Specific weed information sheets have been developed by the Department of Natural Resources and Water (Department of the Environment and Water Resources., 2007).

In 1997 the Department of Natural Resources and Mines invited interested parties to come together to develop a strategy for the management of environmental weeds in south east Queensland. These parties became the Environmental Weeds Working Group (EWWG). The Environmental Weeds Working Group developed a document titled “South-east Queensland Environmental Weeds Strategy”. This strategy is designed to give more weight to environmental issues, in contrast with previous approaches to weed management, which emphasised the impacts of pest plants upon the economy and human health (EWWG., 2002).

The CRC for Australian Weed Management (Weeds CRC) is a Commonwealth funded body which aims to reduce the risks posed by current and new weed
incursions through programs in research, education and information delivery across Australia. The Centre has published a variety of documents regarding weeds that are present in Gold coast’s sand dunes. Some of these documents are the Best Practice Management Guide and the Weed Management Guide (CRC for Australian Weed Management, 2007).

In general, although coastal and other weeds have captured the attention of government bodies there is little information published in scientific journals on the impacts that weeds cause to native sand dune vegetation. On the Gold Coast, a list of some of the common weed species present in the Gold Coast area is outlined in the GCCC Planning Scheme “Policy 15: Management of Coastal Dune Areas”. In addition, Gold Coast City Council as part of their “Dune Management Program” has developed a dune assessment program form. One of the aims of this dune assessment form is to quantify the percentage coverage of weeds in particular areas of the coast. With the help of trained volunteers this assessment program is performed every couple of years in some Gold Coast sand dunes (Challenger, 2007 pers.com). Excluding this assessment and other sporadic surveys conducted by consultancy firms there has been no general assessment of weed coverage for the whole coast. Furthermore no detailed studies have been conducted to determine the impact that weed coverage is having on native vegetation and fauna.

4.1.5.2 Mechanical beach cleaning

Mechanical beach cleaning, by means of removing wrack, eliminates habitat for nesting birds, seed sources for pioneer dune colonizers and food for fauna (Nordstrom et al., 2000). Moreover, mechanical beach cleaning can result in the removal of pioneer dune stages and associated specialist species. Hence it can inhibit the accretion of new dunes.

A recent study by Hayasaka and Fujiwara, 2005 looked at the relationship between species composition and human activities such as beach cleaning. The study found that rural beaches with no beach cleaning showed high proportions of coastal species. The number of weeds was higher in beaches with active beach management. Thus, it was found that the diversity of coastal vegetation was enhanced by discontinuing beach cleaning and mowing (Hayasaka & Fujiwara, 2005).

Gold Coast City Council has three mechanical beach cleaning machines in operation. The machines operate on all Gold Coast beaches. High use beaches such as Burleigh Heads, Coolangatta and Surfers Paradise get cleaned everyday. Lower use beaches get cleaned at least once a week.

4.1.5.3 Trampling and 4WD vehicles

The detrimental impact of human trampling on sand dunes is a well documented issue (Hylgaard & Liddle, 1981; Moffet et al., 1998; Page et al., 2004; Rozé & Lemauviel, 2004; Slatter, 1978). Dunes are highly sensitive to trampling, which often leads to vegetation destruction. Sand dune vegetation has evolved to withstand harsh environmental conditions such as extreme temperature, lack of nutrients, drought and sand burial. However, it does not tolerate trampling very well. Only a few passes can kill the vegetation. The loss of vegetation (e.i. groundcover) de-stabilises the dunes making them more vulnerable to wind erosion. Gold Coast City Council maintains dedicated public access ways to direct beach users away from damaging the dune vegetation (Stuart, 2007 pers.com). This involves building new fences as the dunes build up and replacing older and broken fences (Stuart, 2007 pers.com).
There is a growing body of evidence on the nature and extent of environmental degradation caused by 4WD vehicles on dune vegetation (Schlacher & Thompson, 2008). Vehicle use of beaches is a controversial issue within most coastal communities where it is still permitted (DLWC, 2001). Fragile dune vegetation is easily destroyed by vehicles (Godfrey & Godfrey, 1980). It can be said that next to the destruction of habitat through development, driving of 4WD vehicles is the most harmful of all human activities on sandy beaches. 4WD vehicles cause the sand to become more compacted. The degree of sand compaction influences factors such as soil moisture, run-off, erosion and as a result has effects on vegetation and micro-organisms. Hosier and Eaton, 1980 documented the impact of 4WD on dune vegetation and grassland in North Carolina in the United States and Rickard, McLachlan and Kerley, 1994 documented the effects of vehicular traffic on dune vegetation in South Africa. In addition, a detail description of the geomorphic and ecological impacts that 4WD vehicles cause on sand dune vegetation has been compiled in the NSW Coastal Dune Management manual (DLWC, 2001).

Gold Coast beaches (with the exception of South Stradbroke Island) are not open to recreational four wheel driving. Only emergency vehicles or those related to beach dependent activities such as life saving, beach management and limited commercial fishing licenses are allowed on beaches. There are designated vehicle access points that restrict the damage to dune vegetation.

### 4.2 Sandy beaches

Sandy beaches play an important ecological role by providing habitat for numerous plants and animals. Beaches harbour unique and diverse suites of species not found in any other marine habitat (A. Jones et al., 2003). The intertidal zone of beaches features a constant exchange of sand, organic matter and nutrients, inputs that influence the distribution and growth of beach organisms (A. Jones et al., 2003). Food is mainly imported from surf-zone in the form of phytoplankton and algae (A. Jones et al., 2003). The former are consumed by filter-feeders and the latter are decomposed by bacteria and fragmented by the grazing of small invertebrates such as isopods, amphipods and insect larvae (A. Jones et al., 2003). The nutrient-rich faeces of these invertebrate consumers are used by the beach bacterial community or transported back to the sea. These bacteria support various beach fauna, which in turn support more conspicuous beach species such as many important birds, reptiles and other animals which nest, breed, feed and rest on the dunes or open beach (Clark, 1998). As well, many fish species use surf zones as nurseries and feed on beach invertebrates (A. Jones et al., 2003).

#### 4.2.1 Meiofauna

Meiofauna is defined as those metazoan animals passing undamaged through a 500 μm sieve but trapped on a 42 μm sieve (Kennedy & Jacoby, 1999). On most beaches, the meiofauna is rich and diverse, even exceeding the macrofauna (McLachlan & Brown, 2006). However, there are few studies concerned with the species composition of sandy-beach meiofaunal communities (McLachlan & Brown, 2006). There is also little information on large-scale patterns in sandy-beach meiofauna distribution, such as latitudinal effects or overall responses to the range of beach types (McLachlan & Brown, 2006). Meiofaunal species are known to be sensitive indicators of environmental perturbations and pollution (Schratzberger et al., 2000). Thus the state of meiofauna assemblages may reflect the overall health of the marine benthos (Kennedy & Jacoby, 1999). To date, this abundant and ubiquitous group of invertebrates has been largely neglected in sampling programs.
(Kennedy & Jacoby, 1999). This omission is potentially counterproductive because much interaction between pollutants and the biosphere occurs at low levels of phylogenetic organisation (Kennedy & Jacoby, 1999). Even though the use of meiofauna as biological indicators has proven viable, there are number of shortcomings associated with their use (Kennedy & Jacoby, 1999). These are complexities related to the design of sampling programs to overcome levels of spatial and temporal variation and the processing difficulties that can make the use of meiofauna more expensive when compared with macrofauna (Kennedy & Jacoby, 1999). Studies of meiofauna on the Gold Coast have been limited to estuarine environments. No meiofauna sampling has taken place on open shores.

4.2.2 Macrofauna

The invertebrate macrofauna is the most well studied component of sandy beaches and comprises benthic forms too large to move in the space between sand grains (McLachlan & Brown, 2006). The benthic macrofauna of sandy beaches includes representatives of many phyla, but crustaceans, molluscs and polychaetes are usually dominant making up more than 90% of species and biomass on ocean beaches (Brown & McLachlan, 1990). Their most pronounced characteristic is a high degree of mobility, including the ability to burrow rapidly (McLachlan & Brown, 2006). Their habitat is dynamic and defined by 3 factors: tides, waves and sand characteristics (Defeo & McLachlan, 2005). Other associated factors that influence faunal assemblages include the erosion/accretion dynamics of the sediment, freshwater discharge, food supply, slope of the beach, aeolian transport mechanisms and storm events (Brown & McLachlan, 2002; McLean, 2006).

4.2.3 Human impacts on beach ecology and current management practices

Human influence such as recreational activities, coastal development, pollution, chemical spills and freshwater inputs have been shown to considerably reduce the abundance and diversity of faunal assemblages on sandy beaches (Carlson & Godfrey, 1989; McLean, 2006).

On the Gold Coast, beaches are under increasing pressure due to population growth and increasing number of visitors to the area. The main anthropogenic pressures on Gold Coast’s sandy beaches are coastal development, disruption of sand transport (sea walls and groynes), mechanical beach cleaning, beach nourishment and reprofiling, 4WD vehicles and human trampling.

Figure 56: Mechanical beach cleaning at Surfers Paradise
4.2.3.1 Beach cleaning

Mechanical cleaning of beaches provides a beach free of rubbish and natural debris to improve safety and aesthetic appeal for people. Beach cleaning machines lift and filter the sand, capturing not only debris, but also small organisms (Brown & McLachlan, 2002). As a result, mechanical beach cleaning severely disrupts the natural ecological processes and modifies the function and structure of the beach ecosystem (Brown & McLachlan, 2002). Cleaning machines can kill organisms near the sand surface and can crush deeper-living invertebrates inside their burrows (Brown & McLachlan, 2002). Wrack (the build-up of debris consisting of seagrass, algae, weeds, marine organisms and other material deposited on the beach with the wind and waves), which is removed by beach cleaning, is a vital element in maintaining the ecology of sandy beaches (A. Jones et al., 2003). Wrack provides essential habitat for intertidal organisms and is an important food source for many animals. In essence, beach cleaning is suspected to play a crucial role in reducing the number and type of organisms living in the beach.

4.2.3.2 Trampling and 4WD vehicles

Trampling on the intertidal zone typically has much less impact than in the dunes, although it is measurable and, even in the lower intertidal, may injure delicate crustaceans and juvenile bivalves (Moffet et al., 1998).

Driving of 4WD vehicles is one of the most harmful of all human activities on sandy beaches (Godfrey & Godfrey, 1980). Besides the impact caused by 4WD vehicles on large animals such as birds and turtles, many buried invertebrates of the beach may also be impacted by beach traffic. A recent study on beaches in South-East Queensland showed that beaches open to 4WD vehicles have substantially fewer species of invertebrates and these occur at much reduced densities (McLean, 2006). Further studies on the effect of 4WD vehicles on sandy beach invertebrates have been conducted on North Stradbroke Island by Schlacher and Thompson (2008) and Schlacher et al. (2007).

4.2.3.3 Invertebrate fisheries

There are several commercial invertebrate fishing licenses in the Gold Coast area. The Queensland Commercial Harvest Fishery licence allows commercial fishers to collect blood worms and beach worms. Molluscs such as pipis (D. deltoides), beach and blood worms can also be collected with a recreational licence, however bag limits apply.

Sandy beach animals are well adapted to environmental variability but not to predation impacts, particularly fishing losses (Schlacher & Thompson, 2008). Fishers can easily target and serially deplete dense segregations (Defeo, 2003).

Invertebrate fisheries not only remove organisms from the environment, but they also physically disturb the habitat sometimes causing lasting damage (Schlacher, Thompson et al., 2007). The act of disturbing or removing sediment from beaches has the potential to change species richness and abundance (Schlacher, Thompson et al., 2007).

4.2.3.4 Beach nourishment practices

Coastal engineers typically rely on three types of strategies to protect structures from shoreline erosion: hard stabilization; non-structural alternatives, such as relocation or retreat; and soft stabilisation (Pilkey & K. Dixon., 1996). The ecologically ideal
solution is to allow for the natural landward migration of shorelines. Such non-structural alternatives mandate the removal of structures or relocating them further landward. This solution may not necessarily be acceptable because of valuable infrastructure being located too close the beach, but the very real prospect of “coastal retreat” is starting to gain currency in Australia, especially in face of predicted shoreline migrations caused by global climate change (Schlacher & Noriega, 2007).

There is mounting evidence that hard engineering solutions (e.g. seawalls, groynes) are generally the most ecologically harmful interventions in shore management (Schlacher & Noriega, 2007). Consequently, “soft solutions” in the form of beach nourishment are seen as more environmentally friendly (Schlacher & Noriega, 2007). However, these interventions can also have a range of negative ecological consequences which affect all levels of ecological organisation on beaches (Greene, 2002). Beach nourishment can bury shallow reefs, degrade other beach habitats including those of endangered vertebrates, and reduce invertebrate prey for shorebirds and surf fishes (Peterson & Bishop, 2005; Speybroeck et al., 2006). Natural storm events such as Tropical Cyclones or East Coast Lows may have similar impacts to “soft solutions” (Schlacher & Noriega, 2007). However, these are relatively rare events to which the sandy beach is adapted through evolution, whereas frequent nourishment is a more continuous form of disturbance and acts in addition to natural disturbance events (Schlacher & Noriega, 2007).

The ecological damage caused by beach nourishment is poorly understood and often not documented. Beach nourishment may impact beach invertebrates through the following actions:

- The slurry deposited on beaches or nearshore environment increases turbidity, as a result penetration of light decreases making primary production by photosynthesis difficult (Rice, 2006). This is not considered to be a significant issue on the Gold Coast due to the low frequency of nourishment.
- The manmade beach substrate lacks the internal stratification and geomorphology of the natural beach, burying invertebrate fauna and hindering reconstruction of burrows (Rice, 2006).
- Heavy equipment on the beach compacts, crushes and obstructs movement of fauna (Rice, 2006).

On the Gold Coast beach nourishment has been carried out by GCCC and the Queensland Government. There are two permanent sand bypassing systems that are able to provide constant beach nourishment to Coolangatta bay and South Stradbrooke Island. Beach nourishment also takes place at Palm Beach and Burleigh Heads. At Burleigh Heads, sand dredged from Tallebudgera Creek is used to nourish Burleigh Heads beach. At Palm Beach, sand dredged from the adjacent Currumbin Creek is used to fill a section of the beach in order to relieve erosion problems. At least once a year and for the past three decades, a dredging program has been undertaken in the internal delta of the creek mouth and excess sand has been used to nourish the southern end of Palm Beach (See section 5.5.1).

### 4.2.4 Future challenges and climate change

Human induced alterations to coastal sediment supply and transport processes (P.D. Komar, 1998), together with climate change and climate variability factors such as sea level rise and increased storminess are increasing the trend of beach erosion. In other words coastlines are migrating inland (Schlacher, Dugan et al., 2007). Ideally “natural retreat” is the solution. However, in highly populated areas this is generally
not possible. As a result, natural shoreline retreat is today constrained along most developed coastlines by human infrastructure (Schlacher, Dugan et al., 2007). Therefore, we can predict future compression and loss of critical coastal ecosystems and habitat including not only dunes, but also beaches (Schlacher, Dugan et al., 2007). As a consequence there is an urgent need to make appropriate and scientifically founded decisions on how to manage beach environments.

Some of the climate change induced threats to sandy shore ecosystems are temperature increases, climate variability and sea level rise (Brown & McLachlan, 2002; M. A. Jones et al., 2005). Temperature increases will probably change species distribution and assemblage composition. The mechanisms of ecological change include physiological disruption, reduced dissolved oxygen, greater desiccation and changes in marine productivity (A. Jones, 2005). Climate change means that storms will become more intense and frequent as a result enhanced erosion would probably be locally disastrous for both beach and dune biota (A. Jones, 2005). This would also have an effect on rainfall and water acidity. If the pH of ocean waters decreases, shelled species would find it more difficult to extract calcium carbonate from seawater. Thus, meiofauna may be also at risk from the toxic effects of low pH (A. Jones, 2005). In addition, sea-level rise will cause the erosion of sand from the upper beach causing the shoreline to recede. Hence, if these changes are accompanied by alteration to dunes, grain size and beach slope, the ecological effect would be large (A. Jones, 2005).

4.3 Gold Coast’s nearshore reefs

The subtidal rocky reefs of the Gold Coast support communities of benthic fauna and flora and fish that represent a transition between the tropical waters of the Great Barrier Reef and the temperate waters characteristic of the mid-New South Wales coast (Cannon et al., 1987; Done, 1982). Rocky reefs in the Gold Coast provide: habitat and shelter for many plants, invertebrates and fish communities; help protect the coast from strong currents and waves; help sustain commercial and recreational fisheries; and provide recreational amenity for diving and snorkelling. Because many of the Gold Coast's reefs are located close to shore, they are often the first diverse marine habitat to be affected by human activities from land or in nearshore areas.

4.3.1 Palm Beach Reef

Palm Beach Reef is made up of a series of rocky ridges and gullies covered by extensive growths of hard and soft coral, anemones, ascidians and sponges. This reef is also home to Wobbegong sharks and a range of other fishes and invertebrates. Palm Beach Reef is a popular site for fishing and diving and ranges in depth from 8-24 metres.

4.3.2 Palm Beach Bait Reef

Palm Beach Bait Reef is located very close to shore and, as the name suggests, often supports large schools of bait fish. For this reason, it is popular with local fishers. The marine life on the reef includes a range of animals that thrive where there are lots of suspended food particles (hydroids, sponges and sea-squirts) as well as large patches of seaweeds and the small animals associated with them.

4.3.3 Gretas Reef

Gretas Reef is 30-50m long and has an average depth of 20 metres. It is located about 200 metres from the sand collection jetty at The Spit. The reef is covered by soft corals, sponges, anemones and colourful molluscs including nudibranchs.
4.3.4 Mermaid Beach Reef

This reef is located off Mermaid Beach and the deepest section is approximately 27 metres. The reef is covered by organisms such as ascidians, tunicates, nudibranchs, sea stars and feather stars.

4.3.5 Narrowneck artificial reef

This artificial reef was initially designed as a coastal protection structure but has also proved to be an ideal surface for brown seaweeds to become established.

The subtidal assemblages associated with the geotextile reef at Narrowneck were studied by Edwards & Smith (2005). Surveys took place three years after the completion of the reef, which was built between August 1999 and July 2000. Narrowneck was compared to Palm Beach, Kirra and Cook Islands reefs. Results showed that the artificial reef was dominated by macroalgae and supported fewer benthic categories while the natural reefs were characterised by a diverse range of sessile invertebrates (Edwards & Smith, 2005). Benthic demersal fish assemblages were less diverse on Narrowneck, but pelagic fish assemblages were similar on both reef types (Edwards & Smith, 2005). It was found likely that the key determinants of the biotic patterns observed in this study are interactions between the age of Narrowneck and the physical properties of a geotextile substratum (Edwards & Smith, 2005).

4.3.6 Anthropic threats to Nearshore reefs

Many of the Gold Coast's reefs are located close to shore, as a result, they are often the first marine habitat to be affected by human activities on land or in nearshore areas. Some human activities that are known to have an impact on reefs include: beach nourishment and dredging practices, alteration of coastline habitats (seawall construction, removal of mangroves), urbanisation and coastal development, domestic and agricultural pollution, stormwater runoff, boat anchoring and over fishing.

4.3.6.1 Commercial and recreational fishing

The rocky reef finfish fishery comprises a number of demersal and pelagic species associated with inshore rocky reefs, including Snapper, Pearl Perch and Teraglin Jew (DPI and F., 2007). The fishery is restricted mainly to the southern part of Queensland (DPI and F., 2007). Other minor species in the fishery include Black Kingfish, Dolphin Fish, Yellowtail Kingfish, Amberjack, Samson Fish and Silver Trevally (DPI and F., 2007). Management of the rocky reef fishery is the responsibility of the Queensland Department of Primary Industries and Fisheries (DPI and F., 2007). The department enforces control over size limit, number of landings, number of hooks that can be use by recreational and commercial fishermen and number of commercial operators with the potential to access the fishery (DPI and F., 2007). The Queensland Rocky Reef Finfish Fishery annual status report 2007 indicates that the recreational sector harvests a little over the half of the catch (56%) (DPI and F., 2007). In 2006 the commercial sector harvested approximately 37% of the total harvest (DPI and F., 2007).

There is anecdotal evidence that commercial fishing has affected numbers of non-migratory fish on certain Gold Coast reefs (De Paiva., 2007 pers.com). The 2007 Queensland Rocky Reef Finfish Fishery annual status report states that "neither habitat use by rocky reef fish species nor the ecology of rocky reefs is well understood". In addition, concern has been expressed by the Reef Line Fishery...
Management Advisory Committee (ReefMAC) that rocky reef fin fish that once inhabited the Gold Coast area can no longer be found and that areas of inshore and offshore rocky reef habitat in these area may have been smothered with sand as a result of the Tweed River sand bypass project (DPI and F., 2007). ReefMAC is comprised of representatives from each of the relevant stakeholder groups who provide expert advice to the Queensland Department of Primary Industries and Fisheries.

4.3.6.2 Pollution

Human impact on the marine environment can be divided into general categories such as alteration to bottom substrate through dredging, introduction of toxic substances, release of sewage rich in nutrients and heating and release of heated water by power plants (Levinton, 2001). In other words, pollution can be described as the introduction by humans of substances, materials, or heat energy that decreases the quality of the environment (Castro & Huber, 1997).

In the Great Barrier Reef 10 years of monitoring and modelling has demonstrated that sediment and nutrient exports have increase over the last 200 years and that flood events are critical in transporting these pollutants to the reef (Furnas, 2003). Pollutants accumulate in both nearshore sediments and marine mammals (Hutchings & Haynes, 2005). The main causes for a decrease in water quality are urban development, vegetation clearance, cattle grazing and agriculture (Hutchings and Haynes, 2005).

Several studies have documented the impact that increased runoff has had on inshore coral reef communities (Fabricius et al., 2005; Schaffelke et al., 2005). In addition, Hutchings et al (2005) presents a comprehensive review of papers which deal with the impacts of runoff on inshore marine ecosystems, water quality and management. Some issues of concern are nutrient runoff through groundwater (Rasiah et al., 2005), impacts of sedimentation on coral recruitment (Birrell et al., 2005), herbicide impacts on algae photosynthesis (Harrington et al., 2005) and elevated levels of heavy metals in biota, water and sediments (A. Jones, 2005).

The coastal environment of the Gold Coast and the whole South-east Queensland has been subjected to pressures associated with increasing coastal development (EPA., 2006). This has impacted on the water quality of coastal water (EPA., 2006). On the Gold Coast the coastal aquatic ecosystems are under pressure from human activities through urbanisation, waste disposal, and consumptive exploitation of natural resources.

The South east Queensland Ecosystems Health Monitoring Program (EHMP) delivers a regional assessment of the ambient ecosystem health of South east Queensland creeks, rivers and Moreton Bay. The EHMP is managed by the South East Queensland Healthy Waterways Partnership on behalf of its various partners and is implemented by a large team of experts from the Queensland Government, universities and CSIRO (EHMP, 2008). As part of the program report cards have been produced to highlight improvements or declines in the health of the waterways. A number of catchments and estuaries are tested within the Gold Coast area, scores range from C- to A-. Grades are based on the Queensland Water Quality Guidelines 2006 (EHMP, 2008).

At present Nathan Waltham (PhD Candidate, Griffith University) is investigating heavy metal and pesticide contamination in fish collected from canal estates, estuaries, artificial tidal lakes, marinas and the Broadwater on the Gold Coast
Waltham is analysing different tissue types (liver, gills and muscle) to determine the uptake pathway of pollutants in Mullet, Garfish, and Bream. The study has been sponsored by Gold Coast City Council and the Griffith Centre for Coastal Management.

### 4.3.6.3 Ornamental fish trade

The Department of Primary Industries and Fisheries (DPI and F) manages the Queensland Marine Aquarium Fish Fishery (MAFF) under the *Fisheries Act 1994 and Fisheries Regulation 1995*. The Marine Aquarium Fish Fishery (MAFF) is a harvest fishery that is focussed on a diverse suite of species (S. Ryan & Clarke, 2005). Consumptive users include commercial and recreational fishers that collect marine aquarium fish species for display in either private or public aquariums (S. Ryan & Clarke, 2005). Non-consumptive users of the fish stocks include divers and others viewing fish stocks either recreationally or as part of non-manipulative research or commercial tourism activities (S. Ryan & Clarke, 2005). The aquarium fishery operates along the Queensland coast from the tip of Cape York to the New South Wales border (CRC Reef., 2005). The fishery area also comprises five Special Management Areas (SMAs) that have been established to protect stocks from localised depletion (CRC Reef., 2005). One of these Special Management Areas includes waters within Moreton Bay Marine Park and stops at the northern rock wall of the Gold Coast Seaway.

Most of the fish that are commercially harvested for the aquarium trade (more than 60 per cent) belong to a few fish families including: Damselfish and Anemone fish (Family Pomacentridae); Butterfly fish (Chaetodontidae); Angelfish (Pomacanthidae); Wrasse (Labridae) and Gobies (Gobiidae) (CRC Reef, 2005). There is anecdotal evidence to suggest that at some Gold Coast dive sites the abundance of ornamental fish has declined due to collection of specimens by the aquarium trade or by recreational fishermen and divers. Local dive operators have expressed concern to government authorities about the issue.

### 4.3.6.4 Climate change

Worldwide, warm and cold water coral species are threatened by an increase in seawater temperatures and altered water chemistry caused by global climate change (Guinotte et al., 2006; Hutchings & Haynes, 2005). Seawater chemistry changes have the potential to alter the abundance of marine organisms (corals, plankton, etc) and the species that depend on them for survival such as fish and marine mammals (Guinotte et al., 2006). Moreover, the existence of warm coral species into the future is dependent on minimising the rate and magnitude of further warming. Gold Coast rocky reefs contain tropical and temperate marine organisms. The degree to which increased water temperature or changes in water chemistry are having on the health of corals and to other marine organisms is unknown. Hence, research is needed to quantify the effects of climate change on Gold Coast rocky reef’s.
4.3.6.5 Beach nourishment

In an attempt to improve navigation at the Tweed River entrance, the New South Wales Government constructed training walls at the river mouth in the early 1900s. These walls were extended between 1962 and 1965. Although the extension of the training walls improved navigation for a period, the entrance sand bar reformed again and created ongoing navigation difficulties (Hyder Consulting Pty Ltd, 1997). As a result of the construction of entrance training walls, natural patterns of erosion and accretion were significantly altered in the region. Accretion occurred to the south of the southern training wall, resulting in a build up of sand along Letitia Spit and subsequent significant erosion resulted along the southern Gold Coast beaches (Hyder Consulting Pty Ltd, 1997).

In order to maintain a safe navigable entrance to the Tweed River and to restore and maintain the amenity of the beaches on southern Gold Coast, the New South Wales and Queensland state governments agreed to implement a permanent sand bypassing system at the mouth of the Tweed River (Hyder Consulting Pty Ltd, 1997). The project involved dredging to be carried out in New South Wales (NSW) and beach nourishment in Queensland and NSW (Hyder Consulting Pty Ltd, 1997).

The EIS/IAS for the Tweed River Entrance Sand Bypassing Project was completed in June 1997. The EIS/IAS documents addressed environmental issues related to the construction and operation of the Tweed River Entrance Sand Bypassing Project which involved the implementation of a permanent artificial system to capture and remove sand prior to it entering the entrance of the Tweed River and to use it to re-establish and maintain the eroded southern Gold Coast beaches. Kirra reef was identified as an environmentally sensitive area which could be affected by the sand bypassing system. The report recommended monitoring programmes to ensure both that negative impacts were limited and that the project objectives were met. As a result, a series of monitoring studies were conducted.

The last monitoring event of Kirra reef took place in February 2005. It was determined that the most obvious and ecologically significant change in the flora and fauna of Kirra Reef was the loss of large areas of benthic floral and faunal communities, due to continuous burial by sand (FRC Environmental., 2005). Hence, the reduction in the area of exposed reef resulted in the loss of approximately 80% of the 1995 extent of Kirra Reef (FRC Environmental., 2005). It was also reported that a commensurate proportion of ecologically valuable habitat had been lost, and it was likely that habitat diversity had been reduced (FRC Environmental., 2005). In addition, the report stated that at the time of the survey the floral and faunal
communities of Kirra Reef were likely to be more susceptible to influence by storms than they have been over the past 6 decades (FRC Environmental., 2005). This was because the currently exposed reef was found to be surrounded by deposited sand that had both reduced the depth of water, and brought the surf zone seaward and closer to the reef (FRC Environmental., 2005).

4.3.6.6 Desalination plant

The Gold Coast Desalination Alliance (GCDA) is a group setup to work on the Gold Coast desalination project. The group is formed by Veolia Water, John Holland Group, Gold Coast Water and SKM Consulting. The alliance is in the process of constructing and operating a reverse osmosis water treatment plant at Tugun. Waste brine, a by product of the desalination process will be returned to the marine environment. The rate of brine return will be a maximum of 206 ML / day (Natural Solutions., 2007). The brine will essentially contain concentrated seawater (concentrated up to 1.8 -1.9 times) and small quantities of process additives (Natural Solutions., 2007). Potential impacts to the marine environment consist of increases in salinity and decreases in dissolved oxygen (Natural Solutions., 2007). These impacts can result in toxicity to benthic fauna from hypersaline waters, suffocation of infauna, changes to fauna abundance, diversity and community composition, release of sediment-bound metals to the water column, and release of nutrients to the water column, which could stimulate plant growth (Natural Solutions., 2007).

The 2006 Gold Coast Desalination Project Environment Report states that tolerance to hypersaline conditions was obtained from a range of studies based mainly on North American studies (GCD Alliance., 2006). In relation to concerns related to dissolved oxygen concentrations, the 2006 Gold Coast Desalination Project Environment Report states that no impacts to marine organisms are expected from reduced dissolved oxygen conditions (GCD Alliance., 2006). This conclusion is based on oxygen levels presented by Diaz and Rosenberg (1995). No experimental studies have been conducted to test the individual and combined impacts that hypersaline conditions, low levels of oxygen, additives and metals could have on local species.

4.4 Megafauna

Several groups of vertebrates make use of sandy beaches for foraging, nesting, and breeding (McLachlan & Brown, 2006). Birds are the most important vertebrates commonly encountered on sandy beaches (McLachlan & Brown, 2006). Commonwealth law such as, the Environment Protection and Biodiversity Conservation Act 1999, and several treaties such as Japan-Australia Migratory Bird Agreement (1974), and the China-Australia Migratory Bird Agreement (1986) aim to protect shorebirds from further population decline. Another popular vertebrate that visits Gold Coast’s beaches are marine turtles, which come ashore to lay their eggs in the dry beach above the high water mark. Globally, marine turtle populations are under threat. The two species that nest on the Gold Coast (Green turtle *Chelonia mydas* and Loggerhead turtle *Caretta caretta*) are listed as 'endangered' by the World Conservation Union.

4.4.1 Shorebirds

Shorebirds are typically gregarious and often occur together in very large numbers. Many shorebirds undertake annual migrations of thousands of kilometres between their breeding and non-breeding areas (Barter, 2002). Shorebirds require specific habitat conditions for migration and breeding (EPA., 2006). Migratory birds must
have space, food and protection from predators and disturbances to recuperate from long flights. Resident shorebirds need similar conditions for breeding (EPA., 2006). Some shorebirds use beaches only for roosting (McLachlan & Brown, 2006), others (including shorebirds, waders, and raptors) forage in the intertidal and supralittoral zones, and several lay their eggs and nest on the upper beach or in the dunes (Clark, 1998; McLachlan & Brown, 2006).

4.4.1.1 Foraging habits

Foraging birds can be divided into three general groups: probers that use tactile cues to locate prey below the surface of the sand, including deep probers with long bills such as oystercatchers and curlews, and shallow probers with short bills such as sanderlings; surface feeders and peckers that forage using visual cues, such as many small plovers and even wagtails and passerines; and scavengers that feed on stranded carrion, typically gulls and raptors (McLachlan & Brown, 2006). Birds that commonly roost on beaches but do not feed in the intertidal zone include terns, cormorants, and pelicans which mainly feed offshore or in other coastal habitats (McLachlan & Brown, 2006). Birds that nest on the backshore include species that also forage on the beach, such as plovers and oystercatchers and others, such as terns (McLachlan & Brown, 2006).

The presence and abundance of birds on sandy beaches fluctuates considerably due to movements of migrants and variations in numbers of resident species (McLachlan & Brown, 2006). Birds are an important component of the sandy beach macrofauna, playing a significant role as predators in beach food chains (McLachlan & Brown, 2006). The relationship between shorebirds in intertidal areas and patterns of prey availability has been studied by Smart and Gill (2003); Dugan et al., (2003); and Hubbard and Dugan (2003). Also, in 1991 the International Wader Study Group organised a congress that brought together shorebird ecologists working on food web systems in intertidal areas and invertebrate biologists working on the abundance and distribution of beach organisms. A summary of the papers presented at the conference has been compiled by Piersma & Beukema (1993).

4.4.1.2 Common threats to shorebirds

The population decline of shorebirds in a particular area could have several causes such as inadequate intertidal resources (Smart & Gill, 2003), constant human disturbance when foraging or roosting (Rogers et al., 2006; Weston & Elgar, 2007; Yasue, 2006), lack of suitable habitat for roosting, disturbance by 4WD vehicles (Watson et al., 1996; Williams et al., 2004), general habitat loss and degradation (Barter, 2002; EPA., 2006) and disease.

Beach nesting birds require specific consideration due to their high sensitivity to changes in their habitat, introduced predators and recreational activities that occur on their nesting ground (Maguire, 2008). Commonly, past and current management of beach nesting birds has focused on areas with high abundance of breeding pairs which tend to be isolated or of difficult access. However, when the current state of development of Australia’s coast is considered, it becomes clear that isolated and inaccessible areas with few human caused threats are already rare and will become more so in the future (Maguire, 2008). Hence, a single pair or nest management approach can significantly boost breeding success and fecundity rates for the whole population (Maguire, 2008).
4.4.1.3 Shorebirds on Gold Coast’s beaches

A number of shorebird species present on Gold Coast beaches are protected by commonwealth law and several treaties such as the Environment Protection and Biodiversity Conservation Act 1999, Japan-Australia Migratory Bird Agreement (1974) (JAMBA), and the China-Australia Migratory Bird Agreement (1986) (CAMBA).

In 1997, Miller (1997) conducted a study titled “Wader Site Data Collation and Survey Project for south-east Queensland”. The report was prepared for the Queensland Environmental Protection Agency. The purpose of the study was to show the distribution of wader birds and their preferred habitat throughout the coastal areas of South East Queensland. The objectives of the project were to: collate existing information on the distribution and abundance of shorebirds in South East Queensland, conduct field surveys of localities where existing shorebird distribution and abundance data was incomplete and to assess the levels of disturbance that shorebirds and their habitat were subject to. The dataset for this report can be obtained from the Environmental Protection Agency through a licensing agreement. The mapping component of this report that corresponded to the Gold Coast area was later refined by Francis et al. (2005), as part of the Gold Coast City Council Nature Conservation Mapping Review. This review also produced a series of management recommendations for species such as the Little Tern, Beach Stone-curlew, Sooty Oystercatcher and Easter Curlew (Francis et al., 2005).

GCCC is currently conducting a monthly count of shorebirds at four roosting sites at SSI (Bell, 2007 pers.com). The council has also installed information signage at SSI roosting sites which are also popular weekend recreational areas (Bell, 2007 pers.com).

The degree in which factors such as intertidal resources and shorebird disturbance affect bird diversity and abundance is unknown. Currently, shorebird disturbance of is suspected to be one of the main threats affecting their survival. Details of disturbance on Gold Coast beaches are given in section 5.5.2.

4.4.2 Marine turtles

Marine turtles spend most of their life in the ocean and exist primarily in warm, tropical seas. All marine turtle species have the same general life cycle, most are slow growing and take decades to reach sexual maturity. For example loggerhead turtles take 20-25 years and green turtles take up to 30-50 years to reach sexual maturity (GBRMPA., 2001). Females do not breed every year and in some species
such as green turtles have been known to exhibit non-breeding periods of between 5-8 years (GBRMPA., 2001). This means that marine turtles require high annual survivorship of adults and near-adults in order for populations to be maintained (GBRMPA., 2001).

4.4.2.1 Conservation status

Globally, marine turtle populations are under threat. Green and Loggerhead turtles, two species that nest in the Gold Coast, are listed as endangered by the International Union for the Conservation of Nature (IUCN). In Australia, marine turtles are also considered threatened and are listed under the Federal Government’s Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act 1999) and Queensland’s Nature Conservation Act 1992.

The Department of the Environment and Water Resources has developed a “Recovery Plan for Marine Turtles in Australia” (Department of the Environment and Water Resources., 2007) which outlines the major impacts associated with each turtle species in Australia. The report identifies coastal development, habitat loss, marine debris and deteriorating water quality as some of the main threats to these species. Other causes of population decline are incidental mortality from commercial fisheries, incidental mortality from recreational activities (e.g. vehicle traffic on beaches), boat strike, entanglement in nets and disease (e.g. Green Turtle Fibropapiloma) (EPA., 2006).

4.4.2.2 Gold Coast’s studies

During 2005-2006, a marine turtle monitoring program was undertaken by GCCC on South Stradbroke Island, in an effort to monitor and record marine turtle nesting activity and to identify threats to these turtles (GCCC., 2007a). The study was carried out on the eastern beach of SSI, Gold Coast. Beach surveys involved driving the entire length of the beach looking for turtle tracks. When encountered, the turtle track characteristics were used to identify the species and indicate whether a successful nesting event had occurred (Van De Merwe & Cuttriss, 2006). GPS readings of each nest location were recorded and data loggers were placed in the sand at a depth of 60cm adjacent to the nests (Van De Merwe & Cuttriss, 2006). During the surveys five nests were identified. Three of the nests corresponded to loggerhead turtles and two were green turtle nests (GCCC., 2007a). South Stradbroke Island is potentially the southern-most breeding location for these species of marine turtles in Australia (GCCC., 2007a).

Another component of this project was to identify threats to marine turtles and their nests. Some of the threats identified include native and introduced species that prey on turtles eggs, 4WD vehicles, offshore threats such as boat strikes and entanglement in nets and fishing lines and the consumption of plastic when mistaken for squid or jelly fish. The disturbance caused by pedestrians and 4WD vehicles (Hosier et al., 1981), the impacts of marine debris ingestion (Bjorndal et al., 1994; A. Carr, 1987; Mascarenhas et al., 2004; Tomás et al., 2002) and the impacts caused by introduced and native fauna who are known to prey upon marine turtle eggs and hatchlings (Lutz & Muscick, 1997; Morris, 1997) are all disturbances that have been well documented and are common to marine turtles in various locations around the world.

In 2007, GCCC released a report on its 2006/2007 Marine turtle nesting densities and trends, post nesting movements and marine turtle threats. The report provides a review of marine turtle monitoring and research activities undertaken on South
Stradbroke Island (SSI) between December 2006 and March 2007 (Cuttriss, 2007). During this time one Loggerhead turtle nest and three sets of Loggerhead turtle tracks were observed in SSI. Also, the number of nests on previous marine turtle seasons suggested that tagging of turtles on SSI could be possible however, researchers were unsuccessful in attaching a satellite transmitter or tagging a marine turtle due to the low numbers of turtles emerging during this period (Cuttriss, 2007). It was concluded that the research conducted during this time resulted in a comprehensive community-based marine turtle monitoring program on SSI (Cuttriss, 2007). The local community conducted surveys during 113 consecutive days covering 3882 kilometres (Cuttriss, 2007). Also during the 2006/2007 season an unknown species of marine turtle was observed laying a nest near Northcliffe Surf Club at Broadbeach and a total of 11 dead marine turtles were also recorded within the Gold Coast city boundary (Cuttriss, 2007).

As a response to the South Stradbroke Island 2005/2006 Marine turtle monitoring program report and the 2006/2007 Marine turtle nesting densities and trends, post-nesting movements and marine turtle threats report, a memorandum of understanding was developed between GCCC and Griffith University. Researchers will undertake the project titled Marine turtle ecology within southern Moreton Bay (Gold Coast region). The project will aim to assess the ecology of marine turtles in the southern Moreton Bay, Gold Coast region with an emphasis on foraging behaviour, habitat use, mortality associated with boating activity and how this might affect mortality rates (Cuttriss, 2007). The project will also assess the values of community management conservation in protecting marine turtles in the region (Cuttriss, 2007).

4.5 Case studies

4.5.1 Environmental impacts of beach nourishment at Palm Beach

4.5.1.1 Introduction

Gold Coast beaches are under great pressure from natural and man-made erosion. Beach nourishment is the primary strategy used by Gold Coast City Council to protect coastal infrastructure from shoreline erosion. Although beach nourishment is a common worldwide practice, there are uncertainties concerning the environmental impacts on the marine and beach environment. This study investigates the impacts of beach nourishment on the diversity and abundance of macrobenthic fauna at Palm Beach. Beach nourishment at the southern end of Palm Beach occurs once or twice a year. During this process sand dredged from Currumbin Creek is deposited on the upper section of southern Palm Beach (Figure 59). Following dredging operations a bulldozer is used to distribute the sand along the beach, a process called reprofiling.

4.5.1.2 Background Information

Currumbin Creek is located at the south extremity of Palm Beach (47). Due to the weak river discharges, the creek is characterised as a tidal inlet rather than an estuary with a persistent freshwater flow. The area is exposed to energetic swells. Prior to the 1970’s, the entrance was highly variable, in terms of position and morphology. The Currumbin entrance acted both as a sediment source and sediment sink, as the sand drift that filled the entrance during high littoral transport was released into the beach system during flood events (Castelle et al., 2007). The meandering of Currumbin Creek mouth also caused periodic erosion of the southern end of Palm Beach (Castelle et al., 2007). In 1973 a seawall was constructed to address the need to stabilise the entrance. However, erosion and entrance
instabilities continued after the seawall construction (Castelle et al., 2007). A second groyne was added at the end of the spit in 1980 yet erosion at Palm Beach is still highly problematic (D'Agata & Tomlinson 2001). Since the 70’s a series of dredging programs have been undertaken in the internal delta of the mouth. After the construction of the second groyne in 1980, dredged sand from Currumbin Creek has been used to nourish the southern end of Palm Beach.

Figure 59: Photos of Currumbin Creek dredging and associated beach nourishment, November 2007.
4.5.1.3 Aims

This study investigates the effects of beach nourishment on macrofauna. On the Gold Coast, beach nourishment is carried out by Gold Coast City Council (GCCC) on several beaches along the coast. To date, there has been no attempt to quantify the environmental impact caused by these operations on macrofauna.

![Figure 60: Map showing Currumbin Creek and sand deposition area](image)

4.5.1.4 Ecology

Most invertebrate phyla are represented on sandy beaches (McLachlan & Brown, 2006), either as meiofauna (invertebrates less than 500μm) or macrofauna. The invertebrate macrofauna is the most well studied component of sandy beaches and comprises benthic forms too large to move in the space between sand grains (McLachlan & Brown, 2006). The benthic macrofauna of sandy beaches includes representatives of many phyla, but crustaceans, molluscs and polychaetes are usually dominant making up more than 90% of species and biomass on ocean beaches (McLachlan & Brown, 2006). Their habitat is dynamic and defined by 3 factors: tides, waves and sand characteristics (Defeo & McLachlan, 2005). Other associated factors that influence faunal assemblages include the erosion/accretion dynamics of the sediment, freshwater discharge, food supply, slope of the beach, aeolian transport mechanisms and storm events (Brown & McLachlan, 2002; McLean, 2006).

4.5.1.5 Methods

For the purpose of this study a total of three beaches (sand deposition site/impact site and two control sites) were sampled on three occasions, the first two sampling events corresponding to before and after the dredging of Currumbin Creek and...
associated nourishment of the southern end of Palm Beach, in October and December 2007 respectively. A third sampling event took place in May 2008. Palm Beach (27th Avenue) and Tugun (Dune Street) were used as control sites (Figure 61).

Figure 61: Control sites and sand deposition site

4.5.1.6 Fauna sampling

At each beach the macrofauna was sampled at 10 randomly selected points at the upper shore, middle shore and lower shore (Figure 62). At each sample point, five cores (inner diameter 154 mm and 200 mm deep) were excavated and pooled into a composite sample. The sediment was washed from the fauna in the swash zone through a 1 mm mesh sieve, the fauna was then preserved in 80% ethanol. All macrofauna was identified to the lowest possible taxonomic group, usually distinct species or operational taxonomic units (OTUs). Total sampling effort was 270 sample units (3 sampling events x 3 beaches x 30 samples per beach). This comprehensive sampling coverage equates to 5 m³ of sand that was processed manually for macrobenthic fauna.
4.5.1.7 Physical beach attributes

Beach profiles were measured with a total station from the base of the foredunes to the low-water mark. All beach profiles were measured at low tide. Wave height (cm) was estimated visually, and wave period (s) was calculated from visual counts of the number of waves breaking in the surf zone over a three-minute period. All measurements were taken at the time of low tide. Four compound indices of beach morphodynamic state were calculated: (1) Dean’s Parameter, (2) Beach State Index (BSI) and (3) Beach Index (BI) (Defeo & McLachlan, 2005). Dean’s parameter (Ω) was calculated according to Jaramillo and McLachlan, (1993).

Dean’s Parameter = wave height (cm)/wave period (s) x sand fall velocity (cm s⁻¹)

Thirty sediment samples (cores of 30 mm diameter, 100 mm deep) were excavated from each beach (10 at each level) for the analysis of sediment granulometry and moisture content. In the laboratory, the sediment was dried to constant weight (65°C for 48 hours) to determine sand moisture content. Sediment was then manually sieved for 15 minutes to determine granulometric properties. Mesh sizes used were: 4000 µm; 2000 µm; 1000 µm; 500 µm; 250 µm; 125 µm; 63 µm and <63µm). Sediment statistics (mean grain size, sorting, skewness and kurtosis) were calculated using GRADISTAT software, according to the Folk and Ward method (Blott & Pye, 2001).
4.5.1.8 Statistics

A Kruskal Wallis test was used to compare the mean grain size of all beaches over time. Comparisons among sample events were conducted using the Mann-Whitney U Test. A one-way analysis of variance (ANOVA) was used to compare macrafauna density and richness among sites over time. Comparisons among groups were conducted using the Games Howell test. Density and richness data was log transformed. Non-parametric Spearman’s rank correlations were used to test the relationship between fauna and physical factors.

4.5.1.9 Results

4.5.1.9.1 Physical processes

A full characterisation of physical variables and morphodynamic indices of all three sites is given in Table 17 and 18. All beaches surveyed during October 2007 were moderately wide at 56-60 m, with an intermediate slope of 3.0-3.3º (Table 17, Figure 63, Figure 64, Figure 65). At this time beach profiles were similar between the two control sites and the impact site. The second beach profile was conducted during early December 2007, immediately after beach nourishment operations were completed. The slope of the impact site changed from 3.2º in October to 1.6º in early December (Table 17 and 63). Variation in slope can be explained by the approximately 30,000 m³ of sand deposited on the area (Figure 63). The third beach profile was conducted during May 2008. During this time, all sites show steeper beach profiles when compared to the profiles of early December. At the impact site the beach slope changed from 1.6º in December to 2.7 º in May, which suggests that the beach suffered considerable erosion and most of the sand deposited during the nourishment was lost. Tugun and Palm Beach also suffered from erosion. The steepest beach profiles for Tugun and Palm Beach were recorded in May. The period between late December and January was characterised by heavy storms that eroded most beaches along the coast.
All sandy beaches have different shapes and wave properties yet three common morphodynamic types are widely recognized (A. Short, 1996). These are reflective, dissipative and intermediate (Figure 66). Reflective beaches usually form under microtidal conditions and coarse sands. They tend to be steep and narrow. Small waves break directly on the beachface with the majority of energy being reflected back towards the sea (A. Short, 1996). Dissipative beaches form under large waves and fine sands and tend to be wide with a gentle slope. Wave energy tends to dissipate in broad surf zones. Lastly, intermediate beaches fall between these two
categories and have characteristics of both. A characteristic of intermediate beaches is that their Dean’s parameter value falls between 1 and 6 (Wright & Short, 1984). All sites surveyed in this study fall into the intermediate beach category (Table 18). Waves at the time of the two sampling events ranged from 60 - 100 cm with a period of 6 - 8 seconds (Table 18).

<table>
<thead>
<tr>
<th>Waves</th>
<th>Sand</th>
<th>Surf zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>Fine</td>
<td>Wide</td>
</tr>
<tr>
<td>Variable</td>
<td>Variable</td>
<td>Troughs and bars</td>
</tr>
<tr>
<td>Small</td>
<td>Coarse</td>
<td>Absent</td>
</tr>
</tbody>
</table>

Figure 66: Three morphodynamic states of beaches (Adapted from Wright & Short 1984 and McLachlan 2001)
Table 17. Physical and morphodynamic characteristics of the sites sampled.

<table>
<thead>
<tr>
<th>Month</th>
<th>Site</th>
<th>Beach slope (°)</th>
<th>Wave height (cm)</th>
<th>Wave period (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct 2007</td>
<td>Palm Beach</td>
<td>3.03</td>
<td>60</td>
<td>6.7</td>
</tr>
<tr>
<td>Oct 2007</td>
<td>Tugun</td>
<td>3.34</td>
<td>70</td>
<td>7</td>
</tr>
<tr>
<td>Oct 2007</td>
<td>Sand deposition site</td>
<td>3.24</td>
<td>60</td>
<td>6.2</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Palm Beach</td>
<td>3.28</td>
<td>90</td>
<td>7</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Tugun</td>
<td>3.73</td>
<td>80</td>
<td>6.5</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Sand deposition site</td>
<td>1.58</td>
<td>80</td>
<td>7</td>
</tr>
<tr>
<td>May 2008</td>
<td>Palm Beach</td>
<td>3.86</td>
<td>50</td>
<td>5</td>
</tr>
<tr>
<td>May 2008</td>
<td>Tugun</td>
<td>4.79</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>May 2008</td>
<td>Sand deposition site</td>
<td>2.70</td>
<td>60</td>
<td>5.2</td>
</tr>
</tbody>
</table>

Table 18. Dean’s parameter, Beach State Index (BSI), Beach Index (BI) and Beach Deposit Index.

<table>
<thead>
<tr>
<th>Date</th>
<th>Site</th>
<th>Dean’s parameter</th>
<th>BSI</th>
<th>BI</th>
<th>BDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct 2007</td>
<td>Palm Beach</td>
<td>4.07</td>
<td>1.05</td>
<td>2.03</td>
<td>68.46</td>
</tr>
<tr>
<td>Oct 2007</td>
<td>Tugun</td>
<td>3.76</td>
<td>1.02</td>
<td>1.99</td>
<td>63.82</td>
</tr>
<tr>
<td>Oct 2007</td>
<td>Sand deposition site</td>
<td>4.89</td>
<td>1.12</td>
<td>2.01</td>
<td>67.72</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Palm Beach</td>
<td>3.22</td>
<td>0.96</td>
<td>2.00</td>
<td>64.10</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Tugun</td>
<td>3.89</td>
<td>1.03</td>
<td>1.95</td>
<td>58.64</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Sand deposition site</td>
<td>4.48</td>
<td>1.09</td>
<td>2.31</td>
<td>130.41</td>
</tr>
<tr>
<td>May 2008</td>
<td>Palm Beach</td>
<td>2.51</td>
<td>0.86</td>
<td>1.91</td>
<td>50.67</td>
</tr>
<tr>
<td>May 2008</td>
<td>Tugun</td>
<td>1.78</td>
<td>0.74</td>
<td>1.85</td>
<td>47.52</td>
</tr>
<tr>
<td>May 2008</td>
<td>Sand deposition site</td>
<td>3.36</td>
<td>0.97</td>
<td>2.08</td>
<td>78.85</td>
</tr>
</tbody>
</table>
Table 19. Mean grain size (SD in parentheses) and moisture content.

<table>
<thead>
<tr>
<th>Month</th>
<th>Beach level</th>
<th>Site</th>
<th>Mean grain size (μm)</th>
<th>Moisture content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct 2007</td>
<td>Lower shore</td>
<td>Palm Beach</td>
<td>315.0 (11.0)</td>
<td>17.95</td>
</tr>
<tr>
<td>Oct 2007</td>
<td>Lower shore</td>
<td>Tugun</td>
<td>292.6 (10.2)</td>
<td>18.4</td>
</tr>
<tr>
<td>Oct 2007</td>
<td>Lower shore</td>
<td>Sand deposition site</td>
<td>280.1 (8.2)</td>
<td>18.1</td>
</tr>
<tr>
<td>Oct 2007</td>
<td>Middle shore</td>
<td>Palm Beach</td>
<td>275.0 (5.5)</td>
<td>3.4</td>
</tr>
<tr>
<td>Oct 2007</td>
<td>Middle shore</td>
<td>Tugun</td>
<td>268.6 (5.0)</td>
<td>9.4</td>
</tr>
<tr>
<td>Oct 2007</td>
<td>Middle shore</td>
<td>Sand deposition site</td>
<td>255.9 (13.5)</td>
<td>2.1</td>
</tr>
<tr>
<td>Oct 2007</td>
<td>Upper shore</td>
<td>Palm Beach</td>
<td>263.2 (3.8)</td>
<td>3.1</td>
</tr>
<tr>
<td>Oct 2007</td>
<td>Upper shore</td>
<td>Tugun</td>
<td>261.9 (0.9)</td>
<td>1.1</td>
</tr>
<tr>
<td>Oct 2007</td>
<td>Upper shore</td>
<td>Sand deposition site</td>
<td>276.8 (31.3)</td>
<td>0.5</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Lower shore</td>
<td>Palm Beach</td>
<td>301.4 (3.5)</td>
<td>22.47</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Lower shore</td>
<td>Tugun</td>
<td>270.1 (5.2)</td>
<td>18.2</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Lower shore</td>
<td>Sand deposition site</td>
<td>312.9 (30.7)</td>
<td>15.4</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Middle shore</td>
<td>Palm Beach</td>
<td>299.4 (19.8)</td>
<td>11.70</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Middle shore</td>
<td>Tugun</td>
<td>266.4 (17.4)</td>
<td>2.4</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Middle shore</td>
<td>Sand deposition site</td>
<td>244.4 (8.2)</td>
<td>2.7</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Upper shore</td>
<td>Palm Beach</td>
<td>266.6 (2.7)</td>
<td>18.7</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Upper shore</td>
<td>Tugun</td>
<td>314.0 (2.1)</td>
<td>18.0</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Upper shore</td>
<td>Sand deposition site</td>
<td>292.7 (2.0)</td>
<td>15.2</td>
</tr>
<tr>
<td>May 2008</td>
<td>Lower shore</td>
<td>Palm Beach</td>
<td>258.6 (6.4)</td>
<td>13.8</td>
</tr>
<tr>
<td>May 2008</td>
<td>Lower shore</td>
<td>Sand deposition site</td>
<td>246.1 (6.3)</td>
<td>5.5</td>
</tr>
<tr>
<td>May 2008</td>
<td>Middle shore</td>
<td>Palm Beach</td>
<td>286.3 (3.4)</td>
<td>3.0</td>
</tr>
<tr>
<td>May 2008</td>
<td>Lower shore</td>
<td>Tugun</td>
<td>251.8 (5.5)</td>
<td>2.8</td>
</tr>
<tr>
<td>May 2008</td>
<td>Lower shore</td>
<td>Sand deposition site</td>
<td>273.2 (8.5)</td>
<td>1.5</td>
</tr>
</tbody>
</table>

All beaches sampled are comprised of fine to medium sands ranging in mean size from 217 to 326 μm. At Tugun and Palm Beach mean grain size was found to be coarser at the top level and finer towards the upper beach (Table 19). At the impact site the coarsest sediment was found at the lower shore followed by the upper shore and middle shore (Table 19, Figure 67). A Kruskal-Wallis Test and a series of Mann-Whitney U tests were conducted to detect any differences between sediment size. During October there was no significant difference between the grain size of all sites (Table 20). In December and May there were significant grain size differences between all sites. The impact site and Tugun were significantly different during December but regained likeness in May. In December the coarser sediment found at
Palm Beach was not significantly different to sediment found at the impact site, however this changed in May where a significant difference was found between Palm Beach and the impact area.

**Table 20. Kruskal-Wallis results of sediment size between sites.**

<table>
<thead>
<tr>
<th>Month</th>
<th>Chi square</th>
<th>df</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct 2007</td>
<td>3.316</td>
<td>2</td>
<td>0.1910</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>34.102</td>
<td>2</td>
<td>0.000</td>
</tr>
<tr>
<td>May 2008</td>
<td>34.102</td>
<td>2</td>
<td>0.000</td>
</tr>
</tbody>
</table>

**Table 21. Mann Whitney test sediment size between sites for December and May (there were no significant differences between sites in October).**

<table>
<thead>
<tr>
<th>Month</th>
<th>Site</th>
<th>Site</th>
<th>Z</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec 2007</td>
<td>Impact</td>
<td>Tugun</td>
<td>-5.330</td>
<td>0.000</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Impact</td>
<td>Palm Beach</td>
<td>-0.341</td>
<td>0.733</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Tugun</td>
<td>Palm Beach</td>
<td>-4.738</td>
<td>0.000</td>
</tr>
<tr>
<td>May 2008</td>
<td>Impact</td>
<td>Tugun</td>
<td>-2.043</td>
<td>0.41</td>
</tr>
<tr>
<td>May 2008</td>
<td>Impact</td>
<td>Palm Beach</td>
<td>-2.236</td>
<td>0.025</td>
</tr>
<tr>
<td>May 2008</td>
<td>Tugun</td>
<td>Palm Beach</td>
<td>-6.663</td>
<td>0.000</td>
</tr>
</tbody>
</table>
4.5.1.10 Macrofauna abundance and diversity

A total of 1744 individuals were collected in the 270 samples, comprising 23 species (Figure 68, Table 22, Table 23, Table 24). Of all species found at Tugun during October, 75% were polychaeta, 24% crustaceans and 1% mollusca. During December 51% were polychaeta, 49% crustaceans and 1% mollusca and during May 93% were crustaceans and 7% polychaeta. At Palm Beach, during October, 87% of all species were polychaeta, 11% crustaceans and 2% mollusca. During December 46% were crustaceans and 54% polychaeta and during May half were crustaceans and half polychaeta. At the impact area, during October, 84% were crustaceans, 15% polychaeta and 1% crustaceans. During December 77% were polychaeta and 23% crustaceans. During May 94% were crustaceans and 6% polychaeta.
Table 22. Occurrence of macrobenthic classes across sites over time.

<table>
<thead>
<tr>
<th>Site</th>
<th>Month</th>
<th>Crustacea ((%) (%)</th>
<th>Mollusca</th>
<th>Polychaeta</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tugun</td>
<td>Oct 2007</td>
<td>40</td>
<td>1</td>
<td>124</td>
<td>165</td>
</tr>
<tr>
<td>Palm Beach</td>
<td>Oct 2007</td>
<td>13</td>
<td>2</td>
<td>100</td>
<td>115</td>
</tr>
<tr>
<td>Impact</td>
<td>Oct 2007</td>
<td>174</td>
<td>2</td>
<td>31</td>
<td>207</td>
</tr>
<tr>
<td>Tugun</td>
<td>Dec 2007</td>
<td>280</td>
<td>4</td>
<td>291</td>
<td>575</td>
</tr>
<tr>
<td>Palm Beach</td>
<td>Dec 2007</td>
<td>18</td>
<td>0</td>
<td>21</td>
<td>39</td>
</tr>
<tr>
<td>Impact</td>
<td>Dec 2007</td>
<td>0</td>
<td>3</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Tugun</td>
<td>May 2008</td>
<td>381</td>
<td>0</td>
<td>30</td>
<td>411</td>
</tr>
<tr>
<td>Palm Beach</td>
<td>May 2008</td>
<td>26</td>
<td>0</td>
<td>26</td>
<td>52</td>
</tr>
<tr>
<td>Impact</td>
<td>May 2008</td>
<td>157</td>
<td>0</td>
<td>10</td>
<td>167</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1744</td>
</tr>
</tbody>
</table>

Table 23. Abundance of most common species at all sites over time.

<table>
<thead>
<tr>
<th>Site</th>
<th>Month</th>
<th>Pseudola\nus concina (Isopoda)</th>
<th>Glycera sp. (Polychae\nta)</th>
<th>Pseudolan\nus elegans (Isopoda)</th>
<th>Urohaustorio\nus halei (Amphipoda)</th>
<th>Lobochesis sp. (Polychaeta)</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact</td>
<td>Oct 2007</td>
<td>111</td>
<td>19</td>
<td>60</td>
<td>0</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>Impact</td>
<td>Dec 2007</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Impact</td>
<td>May 2008</td>
<td>144</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>PB</td>
<td>Oct 2007</td>
<td>6</td>
<td>79</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>28</td>
</tr>
<tr>
<td>PB</td>
<td>Dec 2007</td>
<td>2</td>
<td>21</td>
<td>6</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>PB</td>
<td>May 2008</td>
<td>7</td>
<td>23</td>
<td>0</td>
<td>15</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Tugun</td>
<td>Oct 2007</td>
<td>19</td>
<td>57</td>
<td>3</td>
<td>18</td>
<td>60</td>
<td>8</td>
</tr>
<tr>
<td>Tugun</td>
<td>Dec 2007</td>
<td>148</td>
<td>82</td>
<td>37</td>
<td>75</td>
<td>197</td>
<td>16</td>
</tr>
<tr>
<td>Tugun</td>
<td>May 2008</td>
<td>314</td>
<td>19</td>
<td>3</td>
<td>32</td>
<td>0</td>
<td>21</td>
</tr>
</tbody>
</table>
Table 24. List of macrofauna species found at all sampling events.

<table>
<thead>
<tr>
<th>Phylum</th>
<th>Class</th>
<th>Order</th>
<th>Family</th>
<th>Genus</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crustacea</td>
<td>Malacostraca</td>
<td>Amphipoda</td>
<td>Urohaustoriidae</td>
<td>Urohaustorius</td>
<td>halei</td>
</tr>
<tr>
<td>Crustacea</td>
<td>Malacostraca</td>
<td>Amphipoda</td>
<td>Exoedicerotidae</td>
<td>Exoediceros</td>
<td>sp.</td>
</tr>
<tr>
<td>Crustacea</td>
<td>Malacostraca</td>
<td>Amphipoda</td>
<td>Platyischnopidae</td>
<td>Tittakunara</td>
<td>katoa</td>
</tr>
<tr>
<td>Crustacea</td>
<td>Malacostraca</td>
<td>Amphipoda</td>
<td>Exoedicerotidae</td>
<td>Exodiceros</td>
<td>maculosus</td>
</tr>
<tr>
<td>Crustacea</td>
<td>Malacostraca</td>
<td>Isopoda</td>
<td>Cirolanidae</td>
<td>Pseudolanus</td>
<td>concina</td>
</tr>
<tr>
<td>Crustacea</td>
<td>Malacostraca</td>
<td>Isopoda</td>
<td>Cirolanidae</td>
<td>Pseudolanus</td>
<td>elegans</td>
</tr>
<tr>
<td>Crustacea</td>
<td>Malacostraca</td>
<td>Mysida</td>
<td>Mysidacea</td>
<td>Gastrospaccus</td>
<td>sp.</td>
</tr>
<tr>
<td>Mollusca</td>
<td>Bivalvia</td>
<td>Veneroidae</td>
<td>Mesodesmatidae</td>
<td>Paphies</td>
<td>elongata</td>
</tr>
<tr>
<td>Mollusca</td>
<td>Bivalvia</td>
<td>Veneroidae</td>
<td>Donacidae</td>
<td>Donax</td>
<td>deltoides</td>
</tr>
<tr>
<td>Mollusca</td>
<td>Bivalvia</td>
<td>Veneroidae</td>
<td>Donacidae</td>
<td>Donax</td>
<td>deltoides</td>
</tr>
<tr>
<td>Mollusca</td>
<td>Bivalvia</td>
<td>Veneroidae</td>
<td>Donacidae</td>
<td>Donax</td>
<td>deltoides</td>
</tr>
<tr>
<td>Mollusca</td>
<td>Bivalvia</td>
<td>Veneroidae</td>
<td>Donacidae</td>
<td>Donax</td>
<td>deltoides</td>
</tr>
<tr>
<td>Mollusca</td>
<td>Bivalvia</td>
<td>Veneroidae</td>
<td>Donacidae</td>
<td>Donax</td>
<td>deltoides</td>
</tr>
<tr>
<td>Mollusca</td>
<td>Gastropoda</td>
<td>Hypsogastropoda</td>
<td>Naticidae</td>
<td>Polinices</td>
<td>sp.</td>
</tr>
<tr>
<td>Annelida</td>
<td>Polychaeta</td>
<td>Aciculata</td>
<td>Eunicidae</td>
<td>Marphysa</td>
<td>sp.</td>
</tr>
<tr>
<td>Annelida</td>
<td>Polychaeta</td>
<td>Phyllocida</td>
<td>Nephtyidae</td>
<td>Nephtys</td>
<td>longipes</td>
</tr>
<tr>
<td>Annelida</td>
<td>Polychaeta</td>
<td>Phyllocida</td>
<td>Nephtyidae</td>
<td>Nephtys</td>
<td>sp.</td>
</tr>
<tr>
<td>Annelida</td>
<td>Polychaeta</td>
<td>Phyllocida</td>
<td>Nephtyidae</td>
<td>Nephtys</td>
<td>australensis</td>
</tr>
<tr>
<td>Annelida</td>
<td>Polychaeta</td>
<td>Phylodoicoda</td>
<td>Glyceridae</td>
<td>Glycera</td>
<td>sp.</td>
</tr>
<tr>
<td>Annelida</td>
<td>Polychaeta</td>
<td>Phylodoicoda</td>
<td>Lumbridae</td>
<td>Lumberinarius</td>
<td>sp.</td>
</tr>
<tr>
<td>Annelida</td>
<td>Polychaeta</td>
<td>Scolecida</td>
<td>Opheliidae</td>
<td>Lobocheosis</td>
<td>sp.</td>
</tr>
<tr>
<td>Annelida</td>
<td>Polychaeta</td>
<td>Scolecida</td>
<td>Opheliidae</td>
<td>Ophelia</td>
<td>sp.</td>
</tr>
<tr>
<td>Annelida</td>
<td>Polychaeta</td>
<td>Spionida</td>
<td>Spionidae</td>
<td>Scolepsis</td>
<td>sp.</td>
</tr>
<tr>
<td>Annelida</td>
<td>Polychaeta</td>
<td>Spionida</td>
<td>Spionidae</td>
<td>Polydora</td>
<td>sp.</td>
</tr>
</tbody>
</table>
Figure 68: Graph showing the occurrence of crustaceans, molluscs and polychaetas at all sites.

Total macrofauna density at the sediment deposition area decreased from 72.98 Ind.m⁻² (before nourishment) to 4.56 Ind.m⁻² (after nourishment) (Figure 69, Table 25). During the last sampling event in May density recovered to 58.60 Ind.m⁻². At the control sites density remained relatively stable over time, with the exception of Tugun where density showed to be higher in December (Figure 69, Table 25). The beach level most affected by the nourishment event was the middle shore (Figure 70).
Figure 69: Macrofauna density per m$^2$, all beach levels combined.
Figure 70: Macrofauna density (Ind.m⁻²). Lower shore (L), Middle shore (M), Upper shore (T).
Total species richness at the sediment deposition area decreased from 12.98 (before nourishment) to 2.46 (after nourishment) (Figure 71, Table 25). During the last sampling event in May species richness recovered to 8.42. At Tugun species richness increase during December and remained relatively stable over time (Rable 26). Palm Beach showed lower species richness in December (Table 27).

Table 25. Macrofauna characteristics of sand deposition site

<table>
<thead>
<tr>
<th>Date</th>
<th>Species richness</th>
<th>Simpson Diversity</th>
<th>Shannon Diversity</th>
<th>Hill’s N1</th>
<th>Hill’s N2</th>
<th>Density (Ind.m-2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct 2007</td>
<td>12.98</td>
<td>0.38</td>
<td>1.26</td>
<td>3.51</td>
<td>2.62</td>
<td>72.28</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>2.46</td>
<td>0.62</td>
<td>0.54</td>
<td>1.72</td>
<td>1.63</td>
<td>4.56</td>
</tr>
<tr>
<td>May 2008</td>
<td>8.42</td>
<td>0.72</td>
<td>0.73</td>
<td>2.07</td>
<td>1.39</td>
<td>58.60</td>
</tr>
</tbody>
</table>
Results show that before nourishment, macrofauna densities at the lower and middle shore were significantly different between sites (Table 28). No significant difference was found at the upper level. Prior to nourishment, Tugun had similar densities to the impact site. In contrast, Palm Beach density was significantly lower when compared to Tugun and the impact site (Table 29). After nourishment, density at the impact site was greatly reduced. The middle shore was the area of the beach that was most affected. At this time no significant difference was found between the impact site and Palm Beach at the middle or lower shore (Table 29). Tugun showed higher densities during this time on both beach levels. On the other hand, Palm Beach remained low. Hence Tugun had a significant higher density compared to Palm Beach and the impact site (Table 29). During May, no significant difference was found between sites at the lower shore. In the middle shore, despite the increased density at the impact site, no significant difference was found when compared to Palm Beach which remained low during all sampling events. Tugun continued to show the highest density being significantly higher to Palm Beach and the impact site.
### Table 29. Results from Games Howell tests.

<table>
<thead>
<tr>
<th>Month</th>
<th>Beach level</th>
<th>Site</th>
<th>Site</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct 2007</td>
<td>Lower shore</td>
<td>Impact</td>
<td>Tugun</td>
<td>0.943</td>
</tr>
<tr>
<td>Oct 2007</td>
<td>Lower shore</td>
<td>Impact</td>
<td>Palm Beach</td>
<td>0.022</td>
</tr>
<tr>
<td>Oct 2007</td>
<td>Lower shore</td>
<td>Tugun</td>
<td>Palm Beach</td>
<td>0.007</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Lower shore</td>
<td>Impact</td>
<td>Tugun</td>
<td>0.001</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Lower shore</td>
<td>Tugun</td>
<td>Palm Beach</td>
<td>0.315</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Lower shore</td>
<td>Palm Beach</td>
<td>Palm Beach</td>
<td>0.032</td>
</tr>
<tr>
<td>May 2008</td>
<td>Lower shore</td>
<td>Impact</td>
<td>Tugun</td>
<td>0.400</td>
</tr>
<tr>
<td>May 2008</td>
<td>Lower shore</td>
<td>Impact</td>
<td>Palm Beach</td>
<td>0.992</td>
</tr>
<tr>
<td>May 2008</td>
<td>Lower shore</td>
<td>Tugun</td>
<td>Palm Beach</td>
<td>0.498</td>
</tr>
<tr>
<td>Oct 2007</td>
<td>Middle shore</td>
<td>Impact</td>
<td>Tugun</td>
<td>0.861</td>
</tr>
<tr>
<td>Oct 2007</td>
<td>Middle shore</td>
<td>Impact</td>
<td>Palm Beach</td>
<td>0.013</td>
</tr>
<tr>
<td>Oct 2007</td>
<td>Middle shore</td>
<td>Tugun</td>
<td>Palm Beach</td>
<td>0.047</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Middle shore</td>
<td>Impact</td>
<td>Tugun</td>
<td>0.000</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Middle shore</td>
<td>Impact</td>
<td>Palm Beach</td>
<td>0.088</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>Middle shore</td>
<td>Tugun</td>
<td>Palm Beach</td>
<td>0.000</td>
</tr>
<tr>
<td>May 2008</td>
<td>Middle shore</td>
<td>Impact</td>
<td>Tugun</td>
<td>0.018</td>
</tr>
<tr>
<td>May 2008</td>
<td>Middle shore</td>
<td>Impact</td>
<td>Palm Beach</td>
<td>0.890</td>
</tr>
<tr>
<td>May 2008</td>
<td>Middle shore</td>
<td>Tugun</td>
<td>Palm Beach</td>
<td>0.000</td>
</tr>
</tbody>
</table>

4.5.1.11 Correlations

There is no correlation (Spearman’s rank $r = 0.044$, $P > 0.05$) between grain size and species richness and a weak negative correlation (Spearman’s rank $r = -0.138$, $P < 0.05$) between grain size and density (Figure 72).
4.5.1.12 Discussion

The macrofauna of the sediment deposition area was heavily affected by beach nourishment activities. However, it is unknown if the decrease in abundance was caused by increased turbidity, sediment change or compaction, direct crushing or a combination of factors. Samples collected in May (five months after the nourishment event) show that macrofauna numbers and species richness appear to have almost returned to pre-nourishment numbers. Thus, it can be inferred that macrofauna was able to recover within five months although it is unknown at what stage within those five months the recovery took place.

It is widely acknowledged that grain size plays an important role in controlling the community structure of macrofauna (Defeo & McLachlan, 2005; McLachlan, 2001; McLachlan & Dorvlo, 2005). Usually, due to aeolian transport, finer sand grains are located at the upper shore becoming coarser towards the lower shore. At the impact site sand samples collected in October show that the upper shore and the middle shore are very similar and are both coarser than the lower shore (Table 19, Figure 67). In December and May the upper shore continued to be coarser than the middle shore. This suggests that past and the present nourishment events have altered the normal sediment distribution across the beach face. Overall, results found a weak significant negative correlation between grain size and macrofauna density (Figure 72). Tests found a significant difference between sediment samples taken before and after the nourishment event. Hence the coarser sand present after the nourishment event could be one of the factors responsible for the decrease in total abundance and species richness.

The mechanisms of recovery are different among species. Some species have pelagic juvenile life stages (polychaetans, bivalves and gastropods) and others like most crustaceans (isopods and amphipods) brood their young and release fully developed juveniles (Speybroeck et al., 2006). The sediment deposition area is mainly composed of isopods *P.concina* and *P.elegans* (Table 23). Such populations, that brood their young, tend to recover at a much slower rate compared to species with pelagic stages (Speybroeck et al., 2006). Recovery can also be affected by seasonality of reproduction. Species with continuous reproduction may be less sensitive to the timing of nourishment activities than species with strong seasonal reproduction (A. Jones et al., 2008). Currently, there is no information on the time of...
reproduction of macrofauna species present on the Gold Coast area. This information is urgently needed in order better plan nourishment events.

The overall higher macrofauna density found at Tugun could be explained by the site’s finer sediment and its more sheltered location in regards to the dominant south-eastern swells. The increase in macrofauna density and richness during December suggests a seasonal pattern where richness and density increases during the summer months. The low macrofauna density and richness found at northern Palm Beach during the three sampling events could be attributed to several factors such as coarser sediment, erosion problems and wave activity. It is suspected that the coarser sediment found at northern Palm Beach originates at Palm Beach Reef which is located approximately 1km south east from the site (Figure 73). In addition, it is possible that the reef contributes to wave focussing patterns which intensify erosion issues at the control site. Finally, past nourishment events could also be the cause for coarser sediment. In 2005, 22,800m$^3$ of sand dredged from the Tweed River was deposited in the area (Hunt, 2008 pers.com). All the sediment was deposited within a small area. Commercial fishermen have expressed some concern in regards to a “pile of sediment” on the bottom sea floor which they blame for a lower fish catch.

![Figure 73: Location of natural reef and 2005 nourishment zone.](image)

At least once a year the internal mouth of Currumbin Creek and Tallebudgera Creek is dredged and sediment is deposited on Palm Beach and Burleigh Heads respectively. On the rest of the Gold Coast there are two permanent sand bypassing systems that are able to provide ongoing sand supply to Coolangatta Bay and South...
Stradbroke Island. Thus, it can be said that approximately a third of Gold Coast beaches are indirectly affected by beach nourishment activities. If macrofaunal communities are negatively affected by the two permanent sand-bypassing systems in a similar manner to how they are affected by localised nourishment, it could be inferred that a great amount of macrobenthic communities on Gold Coast beaches are under pressure.

4.5.1.13 Conclusion

Public and private infrastructure has been constructed on land previously occupied by sand dunes. As a result sand dunes no longer protect beaches as they used to. Worldwide, beach nourishment is the most widely accepted way to combat the effects of coastal erosion. On the Gold Coast beach nourishment is seen as the only currently viable solution to maintain beaches with sand. Although beach nourishment has occurred in the area for the past 30 years, this study is the first attempt to determine its environmental impacts on the sub-aerial beach. Other studies have focused on the impact of nourishment on the nearshore natural reefs, and the impact at the nourishment source location (NGCBPS). Results from this study show that beach nourishment at Palm Beach has detrimental effects on macrobenthic communities, hence it may also have detrimental effects on fish and shorebird populations. As a result, we recommend that monitoring be continued at Palm Beach and similar studies be conducted at other nourished sites such Coolangatta Bay and South Stradbroke Island. Further research is also needed on the distribution, density and reproduction of local species along the coast. Locally and Australia wide there is a lack of knowledge on the biology, abundance and distribution of macrofauna. Sandy beach organisms are at great risk due to climate change, the risk of stronger and more frequent storm events and the added detrimental impacts of anthropogenic disturbance. Traditionally, beach management has focused on erosion mitigation via engineering solutions. The current trend of management perspective broadening beyond property protection to also include ecological considerations and conservation priorities should be applauded and increased.

4.5.2 Ghost Crab (Ocypode cordimanus) as a potential indicator of human impact along Gold Coast beaches

4.5.2.1 Introduction

Gold Coast beaches have been and are being impacted by a variety of human activities (eg. removal of sand dunes, beach nourishment, trampling, mechanical beach cleaning and shore armouring (eg. sea walls). This study evaluates the use of ghost crab (O. cordimanus) density as a biological indicator of the health of Gold Coast beaches. The use of ghost crab burrows as an indicator of human impact in coastal areas has great potential for beach conservation (Barros, 2001) and has previously been used for similar studies around Australia (Table 30) and overseas. This report presents data collected from September 2007 to June 2008. Six Gold Coast beaches were surveyed to determine ghost crab density. A total of 54 surveys were conducted.
Table 30. Summary of Australian studies dealing with human impacts on ghost crabs.

<table>
<thead>
<tr>
<th>Species</th>
<th>Locality</th>
<th>Title</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>O. cordimana</em></td>
<td>NSW</td>
<td>Ghost crabs as a tool for rapid assessment of human impacts on exposed sandy beaches</td>
<td>Barros 2001</td>
</tr>
<tr>
<td><em>Ocypode spp.</em></td>
<td>WA</td>
<td>Human Impacts on Cable Beach, Broome (Western Australia)</td>
<td>Foster-Smith et al. 2007</td>
</tr>
<tr>
<td><em>Ocypode spp.</em></td>
<td>QLD</td>
<td>Monitoring human impacts on sandy shore ecosystems: a test of ghost crabs (<em>Ocypode spp.</em>) as biological indicators on an urban beach.</td>
<td>Lucrezi et al 2008</td>
</tr>
<tr>
<td><em>O. cordimana</em></td>
<td>QLD</td>
<td>The impacts of recreational four-wheel driving on the abundance of the Ghost crab (<em>Ocypode cordimanus</em>) on a subtropical sandy beach in SE Queensland.</td>
<td>Moss and McPhee 2006</td>
</tr>
<tr>
<td><em>O. cordimana</em></td>
<td>QLD</td>
<td>Vehilces versus conservation of invertebrates on sandy beaches: mortalities inflicted by off-road vehicles on ghost crabs.</td>
<td>Schlacher et al. 2007</td>
</tr>
</tbody>
</table>

### 4.5.2.2 Ecology

The upper areas of exposed sandy beaches are typically inhabited by several species of amphipods, isopods, insects and decapods (Brown & McLachlan, 1990). Because of their size and activity, decapods such as crabs are often the most obvious invertebrates on these areas (Barros, 2001). One of the most common decapod species on open ocean beaches of sub-tropical eastern Australia is the ghost crab *Ocypode cordimana*. This species is found from the Kimberley coast (Western Australia), across the north of Australia, and east to northern New South Wales (D. Jones & Morgan, 2002). It occurs on sandy beaches at or above the high-tide level with records on burrows extending inland up to 200m from shore (D. Jones & Morgan, 2002). Large specimens can exceed 35mm in carapace width (Jones and Morgan, 2002). Ghost crabs from the same genus (*O. cursor*) have been recorded to dig galleries of up to 630 mm in length, and 590 mm depth (Strachan et al., 1999). Through the maintenance of galleries the crabs aerate, move and recycle an important amount of nutrients in the sandy shores (Valero-Pacheco et al., 2007). Studies on *Ocypode Quadrata* report that ghost crabs feed on intertidal macrofauna as well as organic matter found among the sand grains (Wolcott, 1978). They also have been found feeding on dead fish and other dead marine organisms (Wolcott, 1978). With few predators in their habitat, ghost crabs tend to be placed at the top of the food chain, however they can be preyed upon birds and small mammals (Wolcott, 1978).

### 4.5.2.3 Methods

This study was conducted on Gold Coast beaches between September 2007 and June 2008. Based on preliminary sampling carried out in September and October 2007, six sandy beaches were selected (62). All selected beach sites exhibit different degrees of human impact. On some beaches sand dunes have been removed and replaced by lawn and parkland infrastructure. Other beaches sustain lower levels of recreational activities and, typically, their vegetated sand dunes are in better condition. A seawall is present at all beaches sampled. On the Gold Coast the bottom of seawalls are built below ground and are 15m wide and 5m deep (63).

For the purpose of this study, beaches were categorised according to their level of human impact (31).
Table 31: Beach name and recreational use level

<table>
<thead>
<tr>
<th>Level of human impact.</th>
<th>Beach name</th>
<th>Nearest street address</th>
</tr>
</thead>
<tbody>
<tr>
<td>High use</td>
<td>Surfers Paradise</td>
<td>Cavil Avenue, Surfers Paradise</td>
</tr>
<tr>
<td>High use</td>
<td>Burleigh Heads</td>
<td>First Avenue, Burleigh Heads</td>
</tr>
<tr>
<td>Medium use</td>
<td>Main Beach</td>
<td>Woodroffe Avenue, Main Beach</td>
</tr>
<tr>
<td>Medium use</td>
<td>Rainbow Bay</td>
<td>Ward Street, Rainbow Bay</td>
</tr>
<tr>
<td>Low use</td>
<td>Miami</td>
<td>Riviera Road, Miami</td>
</tr>
<tr>
<td>Low use</td>
<td>Bilinga</td>
<td>Surf Street, Bilinga</td>
</tr>
</tbody>
</table>

The term “High use” was allocated to beaches which lack or exhibit little native dune vegetation, are mechanically cleaned everyday and support a great number of visitors. They occur adjacent to town centres and have many amenities such as showers, barbeques, playgrounds and car parks. The term “Medium use” was used to describe beaches where native dune vegetation is in better condition compared to that of ‘high use’ beaches. These beaches tend to get mechanically cleaned once or twice per week, support a lower number of visitors, and are generally located further away from busy centres. “Low use” beaches are those where native dune vegetation is in relatively good condition, get mechanically cleaned once a week, support low number of visitors and are relatively far away from facilities such as barbeques, showers and toilet blocks.

Figure 74: Map showing the location of sites
4.5.2.4 Ghost Crab sampling methodology

Sampling was conducted at early morning hours (usually before sunrise) before pedestrians or beach cleaning machines disturbed sites. Early morning sampling also reduced or eliminated the effect of overlooking ghost crab burrow openings due to them plugging the openings during the heat of the day (Moss D. & McPhee D.P., 2006). At medium and low beaches, it was unknown whether mechanical beach cleaning took place the previous day or a couple of days earlier. Each sampling event took approximately 45 minutes. Each month, all sites were sampled during the same week to minimise variations in environmental conditions. All surveys were conducted at approximately the same tide cycle (Figure 76). Sampling took place close to low tide on mornings where the previous night’s high tide did not cover the sampling site. All surveys were conducted on weekdays in order to avoid changes in trampling amounts.
To determine the amount of ghost crabs present at each beach, it was assumed that the number of burrows present at each beach was the same as the number of crabs. This relationship has been described in previous studies (Warren, 1990; Wolcott, 1978). Burrows need to be maintained daily or they collapse, thus it is reasonable to suppose that the presence of a burrow corresponds to the presence of a crab (Valero-Pacheco et al., 2007).

To determine the optimum quadrat size and which sections of the beach to sample, preliminary sampling was conducted during September and October 2007. The results of these sampling efforts indicated that a 15m\(^2\) (5 x 3m) quadrat was the optimum size. This survey also indicated that there are no burrows present at the lower shore, almost no burrows at the middle shore and that abundance increases towards the dune vegetation.

Sampling was conducted by counting the number of burrows present in each quadrat. At each beach eight (15m\(^2\)) replicate quadrats were sampled at the upper shore (adjacent to dune vegetation). Quadrats were placed parallel to the shore, with a 5m interval between replicates (Figure 77). The lower and middle shore was not sampled since previous observation indicated that no burrows are present in this section of the beach. Despite the presence of burrows among the dune vegetation, surveys were not conducted in this area. The dense ground cover present at some sites would have made surveys extremely difficult and may have caused unnecessary damage to vegetation.

![Figure 77: Schematic representation showing configuration of quadrats](image-url)
4.5.2.5 Physical beach attributes

Physical processes associated with beach morphodynamics may affect ghost crab population parameters. This has been shown from spatial comparisons of different beach types (J. E. Dugan et al., 1991; Jaramillo & McLachlan, 1993; McLachlan & Jaramillo, 1995). As a result several physical beach attributes were considered.

Beach profiles were measured with a total station from the end of dune vegetation (usually the seawall) to the low water mark. Profiles were taken during November, 2007, February 2008 and May 2008. Wave height (m) was assessed visually, and wave period was obtained by counting the number of waves breaking in the surf zone over a three minute period.

On each beach, drift lines, effluent lines and dry zones were identified and measured (66).

Sediment samples were taken from each beach. Three sediment cores (3mm x 20cm) were excavated at each beach and later used to determine granulometry and moisture content. In a laboratory, the sediment was dried to constant weight (65°C for 48hrs) to determine sand moisture content. Sediment was then sieved through a nested series of sieves with mesh sizes of 4000µm, 2000µm, 1000µm, 500µm, 250µm, 125µm and 63µm. Sediment statistics (mean grain size, sorting, skewness and kurtosis) were calculated using the GRADISTAT software, according to the Folk and Ward method (Blott & Pye, 2001).

Air temperature was obtained from the Bureau of Meteorology. Water temperature data was also obtained from Bureau of Meteorology. Sediment temperature was measured with an alcohol thermometer at 25cm below the sand surface.

4.5.2.6 Sand Dune Vegetation

All sites were surveyed during April 2008. One surveyor determined the length (80m) and width (variable) of the site while a second surveyor collected data following the Walker & Hopkins (Walker & Hopkins, 1990) method of vegetation assessment. Each
site was surveyed and described as one continuous plant community despite different plant communities sometimes being present on one site (e.g. *Spinifex sericeus* grassland closer to the ocean and woodland landwards). Data collected during the survey included length and width of the site, height and percentage cover in each vegetation stratum, dominant species, additional species observed on site, weeds percentage, bare sand percentage and leaflitter cover. Cover percentages in each stratum and the different components of the ground stratum were reached by consensus of the surveyors.

4.5.2.7 Data Analysis

A repeated measures analysis of variance (ANOVA) was used to compare burrow density at all beach sites. The factors in this analysis were site and month. The data was square root transformed where required to correct for normality. Post-hoc pairwise comparisons were used to determine significant differences among sites and months respectively. Spearman rank tests were used to assess the relationship between environmental factors such as grain size, slope, wave height and period and burrow density. A series of Kruskal-Wallis tests were used to compare environmental factors between sites.

4.5.2.8 Results

4.5.2.8.1 Physical attributes

Beach slopes ranged from 1.65 degrees at Rainbow Bay in November to 3.69 degrees at Miami in February (Figure 79, Table 32). Main Beach and Surfers Paradise presented slopes between 2.46 to 2.87 degrees (Figure 79, Table 32). Burleigh Heads showed slopes between 1.87 and 2.01 degrees. Bilinga slopes ranged from 2.6 to 3.04 degrees (Figure 79, Table 32).
Figure 79: Beach profiles of (a) Main Beach, (b) Surfers Paradise, (c) Rainbow Bay, (d) Bilinga, (e) Miami and (f) Burleigh Heads. All profiles were taken during November 2007 and February and May 2008.
Table 32. Beach slope at six beaches in November 2007, February and May 2008.

<table>
<thead>
<tr>
<th>Site</th>
<th>Month</th>
<th>Beach slope (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Beach</td>
<td>November</td>
<td>2.46</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>2.84</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>2.58</td>
</tr>
<tr>
<td>Surfers Paradise</td>
<td>November</td>
<td>2.65</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>2.83</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>2.87</td>
</tr>
<tr>
<td>Miami</td>
<td>November</td>
<td>3.44</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>3.69</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>3.60</td>
</tr>
<tr>
<td>Burleigh Heads</td>
<td>November</td>
<td>2.01</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>2.17</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>1.87</td>
</tr>
<tr>
<td>Bilinga</td>
<td>November</td>
<td>2.60</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>3.04</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>2.72</td>
</tr>
<tr>
<td>Rainbow Beach</td>
<td>November</td>
<td>1.65</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>1.70</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>1.66</td>
</tr>
</tbody>
</table>

Mean grain size differed by a maximum of 28% between sites (Table 33, Sand from all sites fell into the medium sand category and ranged from 173.7 μm at Rainbow Bay to 245.2 μm at Burleigh Heads (Figure 80). The low sediment size found at Rainbow Bay (the widest beach sampled) is consistent with aeolian transport.

Wave height ranged between 30 and 160cm (Figure 80), a significant difference was found between wave heights observed at all sites (Kruskal-Wallis p <.05). Recorded wave height was slightly smaller at Rainbow Bay and Bilinga. These areas are located at the southern end of the Gold Coast and are relatively sheltered from the prevailing south and south-eastern swells and the dominant southeast wind. Wave period remained relatively constant at all sites with values ranging from 6 to 9 s.

Sediment temperature did not vary greatly between sites (Kruskal-Wallis p >.05) (Figure 81 and Table 33). The lowest and highest sediment temperature recorded was 21°C and 23.8°C respectively (Figure 81). Sediment temperature was positively correlated to air temperature (Spearman = 0.653, p <.001) and to sea water temperature (Spearman = 0.91, p <.001). Air temperature at the time of surveys (04:00 – 05:30) fluctuated between 14 and 23°C. Average wind speed overnight (21:00 – 04:00) fluctuated between 0 and 23.82 Km/hr. There was no significant difference between wind speed and sites (Kruskal-Wallis p >.051) (Table 33).

Due to the physical habitat similarities between sites it is unlikely that physical variations are a primary cause for differences in density of burrows.
Figure 80: (a) Wave height (8 surveys) at each site, (b) Sediment mean grain size (µm).

Figure 81: (a) Air temperature (°C), (b) Sand temperature (°C) at time of survey, (c) Wave height (cm) at time of survey, (d) Mean overnight wind speed (km/hr).
Table 33. Kruskal Wallist test results. Variables tested were site (dependable variable) and air and sand temperature (Cº), wave height (cm), wind speed (km/hr) and grain size (µm) (independent variables).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Chi-square</th>
<th>df</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air temperature (Cº)</td>
<td>3.782</td>
<td>5</td>
<td>0.581</td>
</tr>
<tr>
<td>Sand temperature (Cº)</td>
<td>5.586</td>
<td>5</td>
<td>0.349</td>
</tr>
<tr>
<td>Wave height (cm)</td>
<td>21.309</td>
<td>5</td>
<td>0.001</td>
</tr>
<tr>
<td>Wind speed (km/hr)</td>
<td>11.573</td>
<td>5</td>
<td>0.051</td>
</tr>
<tr>
<td>Grain size (µm)</td>
<td>289.213</td>
<td>5</td>
<td>0.000</td>
</tr>
</tbody>
</table>

4.5.2.9 Ghost Crab Density

The density of active ghost crabs burrows differed significantly among sites (ANOVA p<0.001). The density of ghost crabs was significantly higher at Bilinga and Miami (p<0.001) compared to all other sites (Figure 82). Similarly density of Ghost crabs was significantly higher at Southport and Rainbow Bay (p<0.001) compared to high use beaches such as Surfers Paradise and Burleigh Heads (Figure 82). No significant difference was found between Main Beach and Rainbow bay (p=0.5) and between Surfers Paradise and Burleigh Heads (p=0.3).

The highest ghost crab density (31.8 burrows per 15m²) was recorded during March at Miami and the lowest abundance (0.1 burrows per 15m²) was recorded during January at Burleigh Heads (Figure 82). At Surfers Paradise the ghost crab density from eight monthly surveys shows a variation from 0.5 burrows per 15m² in January to 1 burrow per 15m² in November, February and May (Figure 82). Similarly, at Burleigh Heads the ghost crab density varied from 0.1 burrows per 15m² in January to 1.1 burrows per 15m² in December. Main Beach, a middle use beach, showed a variation from 1.5 burrows per 15m² in December to 7.4 burrows per 15m² in May. Rainbow Bay, the other middle use beach, showed a density variation from 2 burrows per 15m² in December to 8.9 burrows per 15m² in November. Finally, Miami, a low use beach, showed a ghost crab density from 16 burrows per 15m² in December to 31.8 burrows per 15m² in March. Bilinga, also a low use beach, showed a ghost crab density of 9 burrows per 15m² in December to 22.8 burrows per 15m² in May (Figure 82). December was the month with the lowest overall burrow density. During early December a number of big storms occurred in the area, hence heavy machinery was employed to clean beaches of debris. Increased erosion was also observed during this time.
Figure 82: Mean burrow density at six Gold Coast locations over time
4.5.2.10 Correlation between burrow density and physical factors

A very weak negative correlation was found between wave height and burrow density at all sites (Table 34). Wave height was most influential at Main Beach and Rainbow bay. No correlation was found between air temperature and burrow density at any of the sites. However, a negative correlation was found between burrow density and air temperature at Main Beach and Bilinga (Table 34). Wind speed showed to have an effect on burrow density at Bilinga and Rainbow Bay (Table 34). Sand temperature and grain size were not found to have an effect on burrow density at any of the sites. Finally, beach slope was found to be positively correlated to burrow density. However, it is unlikely that these mild slope variations are a cause for density differences. For example, sites such as Bilinga and Surfers Paradise exhibit very similar slopes but the density of burrows is significantly different.

Table 34. Correlations between mean burrow density per quadrat (15m²) of all sites and air and sand temperature (C°), wave height (cm), wind speed (km/hr) and grain size (µm). Sand samples were collected only once during the study.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Site</th>
<th>Spearman</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air temperature (C°)</td>
<td>All sites</td>
<td>-0.093</td>
<td>0.071</td>
</tr>
<tr>
<td></td>
<td>Main Beach</td>
<td>-0.660</td>
<td>0.000*</td>
</tr>
<tr>
<td></td>
<td>Surfers Paradise</td>
<td>-0.103</td>
<td>0.419</td>
</tr>
<tr>
<td></td>
<td>Miami</td>
<td>-0.404</td>
<td>0.002*</td>
</tr>
<tr>
<td></td>
<td>Burleigh Heads</td>
<td>-0.100</td>
<td>0.430</td>
</tr>
<tr>
<td></td>
<td>Bilinga</td>
<td>-0.329</td>
<td>0.008*</td>
</tr>
<tr>
<td></td>
<td>Rainbow Bay</td>
<td>-0.171</td>
<td>0.177</td>
</tr>
<tr>
<td>Sand temperature (C°)</td>
<td>All sites</td>
<td>-0.027</td>
<td>0.608</td>
</tr>
<tr>
<td></td>
<td>Main Beach</td>
<td>-0.185</td>
<td>0.144</td>
</tr>
<tr>
<td></td>
<td>Surfers Paradise</td>
<td>-0.129</td>
<td>0.310</td>
</tr>
<tr>
<td></td>
<td>Miami</td>
<td>0.064</td>
<td>0.638</td>
</tr>
<tr>
<td></td>
<td>Burleigh Heads</td>
<td>-0.240</td>
<td>0.056</td>
</tr>
<tr>
<td></td>
<td>Bilinga</td>
<td>-0.245</td>
<td>0.051</td>
</tr>
<tr>
<td></td>
<td>Rainbow Bay</td>
<td>-0.223</td>
<td>0.076</td>
</tr>
<tr>
<td>Wave height (cm)</td>
<td>All sites</td>
<td>-0.180</td>
<td>0.000*</td>
</tr>
<tr>
<td></td>
<td>Main Beach</td>
<td>-0.458</td>
<td>0.000*</td>
</tr>
<tr>
<td></td>
<td>Surfers Paradise</td>
<td>-0.118</td>
<td>0.352</td>
</tr>
<tr>
<td></td>
<td>Miami</td>
<td>-0.098</td>
<td>0.472</td>
</tr>
<tr>
<td></td>
<td>Burleigh Heads</td>
<td>-0.199</td>
<td>0.115</td>
</tr>
<tr>
<td></td>
<td>Bilinga</td>
<td>0.168</td>
<td>0.186</td>
</tr>
<tr>
<td></td>
<td>Rainbow Bay</td>
<td>0.303</td>
<td>0.015*</td>
</tr>
<tr>
<td>Wind speed (km/hr)</td>
<td>All sites</td>
<td>0.014</td>
<td>0.781</td>
</tr>
<tr>
<td></td>
<td>Grain size (μm)</td>
<td>Slope (°)</td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td>----------------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td>Main Beach</td>
<td>-0.160</td>
<td>0.206</td>
<td></td>
</tr>
<tr>
<td>Surfers Paradise</td>
<td>-0.093</td>
<td>0.463</td>
<td></td>
</tr>
<tr>
<td>Miami</td>
<td>0.275</td>
<td>0.041*</td>
<td></td>
</tr>
<tr>
<td>Burleigh Heads</td>
<td>-0.170</td>
<td>0.179</td>
<td></td>
</tr>
<tr>
<td>Bilinga</td>
<td>-0.381</td>
<td>0.002*</td>
<td></td>
</tr>
<tr>
<td>Rainbow Bay</td>
<td>-0.322</td>
<td>0.009*</td>
<td></td>
</tr>
</tbody>
</table>

Grain size (μm)

<table>
<thead>
<tr>
<th></th>
<th>All sites</th>
<th>All sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain size (μm)</td>
<td>-0.183</td>
<td>0.000*</td>
</tr>
<tr>
<td>Slope (°)</td>
<td>0.493</td>
<td>0.000</td>
</tr>
</tbody>
</table>

4.5.2.11 Vegetation Surveys

4.5.2.11.1 Rainbow Bay

The plant community of this site can be defined by the presence of *Banksia integrifolia/Pandanus tectorius* isolated plants with a groundstratum of *spinifex sericeus* (Table 35 and 36). The sandy beach is separated from the dune vegetation by a shade cloth/dune building fence. The vegetation within the site is divided by two beach access paths (Figure 83). Width of the vegetation between the study area and the parkland ranges from 24m to 25m.
Table 35. Rainbow Bay structural data and weeds cover.

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Height</th>
<th>% Cover</th>
<th>Cover class</th>
<th>Weeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tallest</td>
<td>0.5-2m</td>
<td>&lt;1%</td>
<td>IP</td>
<td></td>
</tr>
<tr>
<td>Mid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground</td>
<td>0-0.5m</td>
<td>90%</td>
<td>D</td>
<td>25%</td>
</tr>
<tr>
<td>Bare Sand</td>
<td></td>
<td>10%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cover classes: D=dense; MD=mid dense; S=sparse; VS=very sparse; IC=isolated clumps; IP=isolated plant.

Table 36. Rainbow Bay plant records.

<table>
<thead>
<tr>
<th>Plant records</th>
<th>Dominant species (by stratum)</th>
<th>Additional species (by stratum)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tallest</td>
<td>Middle</td>
</tr>
<tr>
<td>Banksia integrifolia</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Bidens pilosa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caprobrotus glaucescens</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chrysanthemoides monilfera subsp. rotundata</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cocos nucifera</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conyza sp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crotalaria sp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cynodon dactylon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ipomoea brasiliensis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macroptillium atropurpureum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pandanus tectorius</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Spinifex sericeus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stenotaphrum secundatum</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Dominant species: the species that together make up 50% of cover in a stratum (up to six species). Additional species: other species present.
4.5.2.11.2 Bilinga

Figure 84: Photograph of Bilinga, March 2008

The plant community of this site can be defined by the presence of *Casuarina equisitifolia/Hibiscus tiliaeceus* low woodland with a groundstratum of *Spinifex sericeus/Cynodon dactylon* (Table 37 and Table 38). The width of the vegetated area ranges from 38m to 39.3m. There is an old fence post that runs through the middle of the dune vegetation parallel to the ocean (Figure 84). This was the previous dune boundary fence. Currently there is no fence or shade cloth between the beach and the dune vegetation.

Table 37. Bilinga structural data and weeds cover.

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Height</th>
<th>% Cover</th>
<th>Cover class</th>
<th>Weeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tallest</td>
<td>1 - 6m</td>
<td>40%</td>
<td>MD</td>
<td>10%</td>
</tr>
<tr>
<td>Mid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground</td>
<td>0-1m</td>
<td>70%</td>
<td>D</td>
<td>40%</td>
</tr>
<tr>
<td>Bare Sand</td>
<td></td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaflitter</td>
<td></td>
<td>10%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cover classes: D=dense; MD=mid dense; S=sparse; VS=very sparse; IC=isolated clumps; IP=isolated plant.
Table 38. Bilinga plant records.

<table>
<thead>
<tr>
<th>Plant records</th>
<th>Dominant species (by stratum)</th>
<th>Additional species (by stratum)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tallest</td>
<td>Middle</td>
</tr>
<tr>
<td>Banksia integrifolia</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Casuarina equistifolia</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Conyza sp.</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Crotalaria linifolia</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Cynodon dactylon</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Euphorbia drummondii</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Hibiscus tiliaeceus</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Ipomoea brasiliensis</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Ipomoea cairica</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Ipomoea indica</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Macroptillium atropurpureum</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Protasparagus aethiopicus</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Sphagneticola trilobata</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Spinifex sericeus</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Vigna marina</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Dominant species: the species that together make up >50% of cover in a stratum (up to six species). Additional species: other species present.
4.5.2.11.3 Burleigh Heads

Figure 85: Photograph of Burleigh Heads, March 2008.

The plant community of this site can be defined by the presence of *Araucaria heterophylla* closed forest with a midstratum of *Pandanus tectorius* and a groundstratum of *cynodon dactylon* (Table 39 and 40). The vegetated area on this site ranges from 0.5m to 1.5m wide (Figure 85). The area is highly developed. There is a concrete path that runs parallel to the beach. There is almost no sand dune vegetation within the site.

Table 39. Burleigh Head structural data and weeds cover.

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Height</th>
<th>% Cover</th>
<th>Cover class</th>
<th>Weeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tallest</td>
<td>5 - 25m</td>
<td>90%</td>
<td>D</td>
<td>90%</td>
</tr>
<tr>
<td>Mid</td>
<td>0.5-1.5</td>
<td>40%</td>
<td>MD</td>
<td></td>
</tr>
<tr>
<td>Ground</td>
<td>0-0.5m</td>
<td>5%</td>
<td>S</td>
<td>5%</td>
</tr>
<tr>
<td>Bare Sand</td>
<td></td>
<td>95%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaflitter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cover classes: D=dense; MD=mid dense; S=sparse; VS=very sparse; IC=isolated clumps; IP=isolated plant.
Table 40. Burleigh Head plant records.

<table>
<thead>
<tr>
<th>Plant records</th>
<th>Dominant species (by stratum)</th>
<th>Additional species (by stratum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Araucaria heterophylla</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Eleusine indica</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Cynodon dactylon</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Pandanus tectorius</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Tetragonia tetragonoides</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

Dominant species: the species that together make up 50% of cover in a stratum (up to six species). Additional species: other species present.

4.5.2.11.4 Miami

The plant community of this site can be defined by the presence of Banksia integrifolia/Casuarina equiustifolia/Hibiscus tiliaeceus/Pandanus tectorius mid-high woodland with a groundstratum of Spinifex sericeus/Cynodon dactylon (Table 41 and Table 42). The site has a fence between the beach and the sand dune vegetation and another fence between the vegetation and walkway (Figure 86). The width of the vegetated area ranges between 24.4m to 28.8m.

Figure 86: Photograph of Miami, March 2008.
Table 41. Miami structural data and weeds cover.

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Height</th>
<th>% Cover</th>
<th>Cover class</th>
<th>Weeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tallest</td>
<td>0.5 - 12m</td>
<td>20%</td>
<td>S</td>
<td>10%</td>
</tr>
<tr>
<td>Mid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground</td>
<td>0-0.5m</td>
<td>80%</td>
<td>D</td>
<td>40%</td>
</tr>
<tr>
<td>Bare Sand</td>
<td></td>
<td>10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaf litter</td>
<td></td>
<td>10%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cover classes: D=dense; MD=mid dense; S=sparse; VS=very sparse; IC=isolated clumps; IP=isolated plant.

Table 42. Miami plant records.

<table>
<thead>
<tr>
<th>Plant records</th>
<th>Dominant species (by stratum)</th>
<th>Additional species (by stratum)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tallest</td>
<td>Middle</td>
</tr>
<tr>
<td>Banksia integrifolia</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Caprobrotus glaucescens</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Casuarina equisitifolia</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Commelina cyanea</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crinum pedunculatum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eragrostis interrupta</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hibiscus tiliaeceus</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Ipomoea brasiliensis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isolepis nodosa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leptospermum laevigatum</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Macroptillium atropurpureum</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Melanthera biflora</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myoporum insulare</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Oenothera drummondi</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Oxalis sp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pandanus tectorius</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Protasparagus aethiopicus</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Sphagneticola trilobata</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Spinifex sericeus</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Stephania japonica</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Tetragonia tetragonoides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vigna marina</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Westringia fruticosa</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

Dominant species: the species that together make up 50% of cover in a stratum (up to six species). Additional species: other species present.
4.5.2.11.5 Surfers Paradise

The plant community of this site can be defined by the presence of *Casuarina equisitifolia/Pandanus tectorius* mid high woodland with a groundstratum of *Spinifex sericeus/Ipomoea brasiliensis* (Table 43 and Table 44). The site has a fence between sand dune vegetation and the walkway/park. There is no fence or shade cloth between beach and sand dune vegetation (Figure 87). The vegetation within the site is divided by one walkway. Width of the vegetated area between beach area and the walkway/park ranges from 13.9m to 21.5m.

Table 43. Surfers Paradise structural data and weeds cover.

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Height</th>
<th>% Cover</th>
<th>Cover class</th>
<th>Weeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tallest</td>
<td>0.5 - 10m</td>
<td>30%</td>
<td>MD-S</td>
<td>25%</td>
</tr>
<tr>
<td>Mid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground</td>
<td>0-0.5m</td>
<td>70%</td>
<td>MD</td>
<td>40%</td>
</tr>
<tr>
<td>Bare Sand</td>
<td></td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaffitter</td>
<td></td>
<td>10%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cover classes: D=dense; MD=mid dense; S=sparse; VS=very sparse; IC=isolated clumps; IP=isolated plant.
Table 44. Surfers Paradise plant records.

<table>
<thead>
<tr>
<th>Plant records</th>
<th>Dominant species (by stratum)</th>
<th>Additional species (by stratum)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tallest</td>
<td>Middle</td>
</tr>
<tr>
<td>Caprobrotus glaucescens</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Casuarina equisitifolia</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Eleusine indica</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cynodon dactylon</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Eragrostis interrupta</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hibertia scandens</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ipomoea brasiliensis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macroptillium atropurpureum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myoporum insulare</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oenothera drummondii</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oenothera stricta</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxalis sp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pandanus tectorius</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Spinifex sericeus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tetragonia tetragonoides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Westringia fruticosa</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Dominant species: the species that together make up 50% of cover in a stratum (up to six species). Additional species: other species present.
The plant community of this site can be defined by the presence of *Casuarina equisitifolia* low open forest with a midstratum of *Vitex trifolia* and a ground stratum of *Spinifex sericeus* (Table 45 and Table 46). A shade cloth/dunebuilding fence separates the sandy beach from the vegetated area (Figure 88). The average width of the vegetated area between the park and the beach area is 21.7m.

**Table 45. Main Beach structural data and weeds cover.**

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Height</th>
<th>% Cover</th>
<th>Cover class</th>
<th>Weeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tallest</td>
<td>1.5-6m</td>
<td>40%</td>
<td>MD</td>
<td>40%</td>
</tr>
<tr>
<td>Mid</td>
<td>0.5-1.5</td>
<td>5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground</td>
<td>0-0.5m</td>
<td>50%</td>
<td>MD</td>
<td>30%</td>
</tr>
<tr>
<td>Bare Sand</td>
<td></td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaf litter</td>
<td></td>
<td>30%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cover classes: D=dense; MD=mid dense; S=sparse; VS=very sparse; IC=isolated clumps; IP=isolated plant.
Table 46. Main Beach plant records.

<table>
<thead>
<tr>
<th>Plant records</th>
<th>Dominant species (by stratum)</th>
<th>Additional species (by stratum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tallest</td>
<td>Middle</td>
<td>Ground</td>
</tr>
<tr>
<td>Caprobrotus glaucescens</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Casuarina equisitifolia</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Conyza sp.</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Cynodon dactylon</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Eragrostis interrupta</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Imperata cylindrical</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Ipomoea brasiliensis</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Macroptillium atropurpureum</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Oenothera drummondii</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Oxalis sp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spinifex sericeus</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Tetragonia tetragonoides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vigna marina</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitex trifolia</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

Dominant species: the species that together make up 50% of cover in a stratum (up to six species). Additional species: other species present.

4.5.2.12 Correlations with vegetation

Species richness and weed ground cover was significantly higher at wider dunes (Table 47). Similarly, native species ground cover and overall ground cover were also significantly higher at wider dunes (Table 47).

Table 47. Correlations between dune width (m) and sand dune traits.

<table>
<thead>
<tr>
<th>Variable (Dune width)</th>
<th>Spearman value</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species richness (natives)</td>
<td>0.529</td>
<td>0.000</td>
</tr>
<tr>
<td>Native species ground cover (%)</td>
<td>0.230</td>
<td>0.000</td>
</tr>
<tr>
<td>Weeds ground cover (%)</td>
<td>0.690</td>
<td>0.000</td>
</tr>
<tr>
<td>Vegetation ground cover and organic litter cover (%)</td>
<td>0.301</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Burrow density was found to be positively correlated with the width of dune vegetation, species richness, percentage of native ground cover and percentage of weed ground cover (Table 48). Also, there was a moderate negative correlation respectively between burrow density and bare sand percentage and beach width (Table 48). Beach width was measured from the end of dune vegetation to the effluent line at the time of each survey.
Table 48. Correlations between burrow density at all sites and average width of dune vegetation (m), number of native species present and average beach width (m).

<table>
<thead>
<tr>
<th>Variable (density per 15m²)</th>
<th>Spearman</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average width of dune vegetation (m)</td>
<td>0.753</td>
<td>0.000</td>
</tr>
<tr>
<td>Average beach width (m)</td>
<td>-0.442</td>
<td>0.000</td>
</tr>
<tr>
<td>Species richness (natives)</td>
<td>0.377</td>
<td>0.000</td>
</tr>
<tr>
<td>Weeds ground cover (%)</td>
<td>0.579</td>
<td>0.000</td>
</tr>
<tr>
<td>Native species ground cover (%)</td>
<td>0.410</td>
<td>0.000</td>
</tr>
<tr>
<td>Vegetation ground cover and organic litter cover (%)</td>
<td>0.501</td>
<td>0.000</td>
</tr>
<tr>
<td>Bare sand (%)</td>
<td>-0.501</td>
<td>0.000</td>
</tr>
</tbody>
</table>

4.5.2.13 Discussion

Results suggest that anthropogenic disturbance affects ghost crab (Ocypode spp) density. Beach sites with low human impact exhibit greater density of ghost crab burrows compared to highly impacted beaches. These results are similar to those found by Barros (2001) and Monteiro-Neves and Bemvenuti (2006) where significantly fewer burrows were found in urban beaches with higher human impact.

4.5.2.13.1 Trampling and mechanical beach cleaning

Beaches that experience the highest amount to trampling (e.g. Surfers Paradise and Burleigh Heads) showed the lowest ghost crab density. Similar results have been found for *O.quadrata* (Christoffers, 1986; Steiner & Leatherman, 1981) and for *Ocypode spp* (Lucrezi et al., 2008). Likewise, the density of ghost crab burrows was significantly higher in the two sites that received the least mechanical cleaning (Miami and Bilinga) compared to the two sites that get cleaned everyday (Surfers Paradise and Burleigh Heads). The degree to which mechanical beach cleaning affected the results is unknown. The beach cleaning machines used in the study area are small 4WD tractors weighing 4720kg (shipping weight) plus a trailed sand filtering attachment of approximately 600kg. Tyres used are 540mm wide. A normal 4WD vehicle weighs approximately between 2200 and 3000kg (gross vehicle weight). Tyre width is usually over 200mm. Gold Coast beaches (with the exception of South Stradbroke Island) are not open to recreational four wheel driving. Only emergency vehicles or those related to beach dependent activities such as life saving, beach management and limited commercial fishing licenses are allowed on our beaches. There is evidence that 4WD vehicles have an impact on ghost crabs (Moss D. & McPhee D.P., 2006; Schlacher, Thompson et al., 2007) and other invertebrates (Schlacher & Thompson, 2008). Burrows offer only partial protection from crushing by 4WD vehicles with crab mortality being strongly dependent on burrow depth (Schlacher, Thompson et al., 2007). It is possible that the damaged caused by a beach cleaning machine is similar to that caused by a recreational 4WD. Low density at sites that get mechanically cleaned everyday could also be a response to low levels of prey availability also caused by beach cleaning. It has been suggested that the absence of ghost crab burrows from sites impacted by 4WD vehicles could be a response to human disturbance causing a change in activity rhythms and burrow architecture (Schlacher, Thompson et al., 2007). Hence, further research is needed to determine the impact of mechanical beach cleaning on ghost crab density and behaviour.

4.5.2.13.2 Burrow distribution

The location of burrows with respect of the drift line is another factor that may be
influenced by anthropogenic disturbance. Human disturbance has been recorded to both lower the density of ghost crab burrows and shift their distribution across the beach face (Lucrezi et al., 2008). Ghost crabs have been reported to construct their burrows according to the position of the high water mark (Strachan et al., 1999; Valero-Pacheco et al., 2007), and to migrate with low tides (Wolcott, 1978). At Mooloolaba Beach, approximately 100km north of the Gold Coast, Lucrezi et al (2008) found that burrow (Ocypode spp) density was greater in the mid shore areas notably decreasing further upshore. Quijon et al (2001) found that in Chile burrows (O. gaudichaudii) are located over the drift line, where waves and swash climates define the lower limit for the building of burrows.

On the Gold Coast ghost crabs build their burrows in sand dunes and adjacent to the dunes along an approximately 6m wide band. The position of this band varied little between months. We suspect that regular mechanical beach cleaning combined with trampling could be an anthropogenic limit to burrow construction and could explain the absence of burrows in the middle and lower shore. A possible reason why burrows are found in higher densities adjacent to dune is that mechanical beach cleaning operators try to avoid newly established dune vegetation. Due to the branching growth of Spinifex grass (a common coloniser of the area) there are sections in between these branches which are difficult for beach cleaning machines to access without destroying newly established shoots. This leaves a buffer zone between vegetated areas and bare sand which is where burrows occur in higher concentrations (Authors, personal observation).

4.5.2.13.3 Importance of sand dune vegetation

A strong positive correlation was found between burrow density and vegetation width (Table 48). This result highlights the importance of sand dune vegetation for ghost crab O.cordimanus. Results coincide with (Barros, 2001) who found that ghost crab numbers are greater where sand dunes have been preserved. At Burleigh Heads, a site where all the sand dunes have been removed to accommodate parklands, ghost crab burrows are almost not existent. The use of sand dunes as feeding grounds is a possible explanation for the absence of burrows at sites with narrow or no sand dune vegetation. Currently there is no information on the feeding habits of O.cordimanus in the area. Wolcott (1978) reported that in the United States (North Carolina) ghost crabs (O. quadrata) mainly feed on intertidal macrofauna which make up to 90% of their diet. However, the feeding habits of ghost crabs are known to be highly flexible and opportunistic. Ghost crabs have also been recorded to feed on a variety of dead animals and vegetable material. There is the possibility that the abundance of food found in the dune area is higher compared to that found in the intertidal zone.

The effect that weeds versus native ground cover have on burrow density could not be clearly determined due to their positive correlation with dune width (The positive correlation between burrow density and weed cover and the negative correlation between burrow density and bare sand cover suggests that sand dunes with high densities of weed cover are better than dunes with low vegetation cover or no vegetation at all (eg. Burleigh Heads). However, despite weed cover being positively correlated with burrow density some weeds do have a clear detrimental effect on density. For example, no burrows were observed where the grass Cynodon dactylon was present. It is suspected that due to the dense ground cover of this grass, ghost crabs find it difficult to construct burrows (Author personal observation) (Figure 89).

Results also show that vegetation richness is positively correlated with burrow density (Table 47). Miami and Bilinga have very similar bare sand and vegetation cover percentages (natives and weeds), however Miami has considerably more
native species than Bilinga and also has the highest density of burrows.

Figure 89: *Cynodon dactylon* at Miami

4.5.2.13.4 Beach width

Beach width (measured from dune vegetation to low water mark) was found to be negatively correlated with ghost crabs numbers. The widest beach sampled was Rainbow Bay which exhibited very low ghost crab density. Low density could be explained by the ghost crabs inability to construct burrows in the middle shore where they could be closer to the water’s edge to moisten their gills in order to breath and for females to release their eggs. Even though there are records of adult ghost crabs constructing burrows up to 200m from the waters edge (D. Jones & Morgan, 2002), the construction of burrows on the upper shore could be particularly challenging for younger crabs, which tend to live closer to the water’s edge (Strachan et al., 1999; Turra et al., 2005) and need to moisten their gills more often than adults (Strachan et al., 1999).

4.5.2.13.5 Physical factors

Environmental factors such as air and sediment temperature did not seem to affect the results of this study. However, there were variations in density within sites across time. The lowest overall densities were observed during December which also was a period of heavy storms. This result could be due to crabs remaining in their burrows which may have been plugged closed (Hughes, 1966). Also, heavy rain, hail and strong winds can obscure burrow openings. These environmental conditions may explain the overall low densities observed during December 2007 compared to other months.

4.5.3.14 Conclusion

Assessing Ghost crab abundance by counting their burrows was found to be an effective method to assess dune health. The results of this study suggest that Ghost crabs are vulnerable to human activities on beaches. Dune width seems to be the most obvious factor that influences abundance. However, results suggest that even though it is crucial to maintain a wide dune system, these areas need to be managed in order to increase plant biodiversity and keep exotic species under control. Human trampling and mechanical beach cleaning are also having a detrimental effect on...
ghost crab density. Mechanical cleaning of beaches provides a beach free of rubbish and natural debris. This has the aim of improving safety and aesthetic appeal for people. Currently, Gold Coast City Council has three mechanical beach cleaning machines in operation. The machines operate on all Gold Coast beaches. Further research is needed to determine the impact of mechanical beach cleaning on ghost crabs and other intertidal organisms.

With the continuously increasing human population of the Gold Coast the ecological health of beaches is at great risk. A common coastal management response to population growth is to update and create new beach facilities such as parklands, showers, toilet blocks and access paths. Unfortunately, this study found that beaches which exhibit a higher number of beach facilities are the ones with the lowest number of ghost crabs and worst dune health.

This study suggests that in order to prevent further environmental degradation detailed planning which considers the ecological value of beaches should be undertaken, followed by the implementation of a zoning scheme, where some areas are given a higher ecological value and are managed accordingly. Management decisions such as widening dune areas (as opposed to creating parkland or turfing of areas), installation of interpretative signage, minimising the use of mechanical beach cleaning and restricting the number of beach access paths are likely to have a positive effect on the ecology of some areas. This approach could also allow some of the ecological attributes of beaches to be maintained and possibly improved and could also give locals and tourists the option of experiencing different types of beach environments. Thus locals might be able to experience a beach environment that resembles beaches located in more pristine areas without having to travel outside the local government area.

4.5.3  Shorebird disturbance at Gold Coast beaches

4.5.3.1 Introduction

There is a lack of information on the environmental impact of the increasing anthropogenic demands placed on Australia’s sandy beaches. Despite their importance as a major coastal habitat, sandy beach ecology is not fully understood. On the Gold Coast, rapid population growth has been accompanied by extensive development which is concentrated along the narrow coastal strip. This development has resulted in extensive loss of shorebird habitat such as sand dunes, estuaries and mud flats. The ecological impacts of human development on sandy beaches are visible but have not been appropriately studied or quantified.

In addition to the loss of habitat due to coastal development, human disturbance of roosting and feeding grounds is a major factor in the long-term decline of shorebird populations (De Long, 2002). Disturbance can lead to less access to resources such as food and resting sites, resulting in lower reproduction and survival rates (Lafferty, 2001). Locally, there is only anecdotal information in regards to the amount of disturbance caused by recreational activities. Human activities that cause disturbance to shorebirds need to be identified and quantified. This information could aid management decisions and hopefully achieve better local conservation outcomes.

4.5.3.2 Aims

This study aims to quantify the amount of shorebird disturbance at four sites along the coast; identify behavioural differences between shorebirds exposed to little or no
disturbance and those exposed to high levels of disturbance; and to determine which recreational activities cause the most impact. To date, there has been no attempt to quantify human caused disturbance of shorebirds on the Gold Coast open shores.

4.5.3.3. Study Area

Over the past 50 years the Gold Coast has experienced extensive coastal development. Private properties and public infrastructure have been constructed on land previously occupied by sand dunes. More recently there have been efforts to protect small sections of incipient dune vegetation through the construction of fences and beach access paths, which restrict access to dune areas. With the prediction of more frequent storm events related to climate change and private and public infrastructure being built on or adjacent to sand dunes, sandy beaches and sand dunes are being squeezed between the ocean and the land.

On the Gold Coast, shorebird species use sandy beaches for roosting and/or feeding (e.g. Pelicans, Cormorants, Terns, Stints, Plovers) and nesting (e.g. Little Terns, Pied Oystercatchers). Monitoring of roosting and feeding sites has been limited and there is almost no information in regards to breeding success. Consequently, relatively little information exists on past and present shorebird use of exposed sandy intertidal shores.
Figure 90: Map of shorebird study sites on the Gold Coast area.

Four study sites: South Stradbroke Island (SSI) (Figure 91), Broadwater (Figure 92), Currumbin Creek (Figure 93) and Kirra (Figure 94) were identified as suitable for this study.

The SSI study site consists of two adjacent areas that are used by shorebirds for feeding, roosting and breeding. Some species commonly found at the site are Crested Tern, Little Tern, Caspian Tern, Red-necked Stint, Red-capped Plover, Eastern Curlew, Bar-tailed Godwit, Pied Oystercatcher and Whimbrel. Human disturbance in the area is believed to be caused mainly on weekends from people walking from the nearby camping site, people that arrive by boat and from 4WD vehicles. There are a limited number of 4WD vehicle permits on the island. Visitors are not allowed to bring their 4WD vehicles.
Figure 91: South Stradbroke Island study site

Figure 92: Broadwater study site
The second study site, Broadwater, is located within the Gold Coast Seaway. The site is a sand bank used for roosting and feeding. Species present at South Stradbroke Island area also present at this site. Disturbance comes from boats and jet skis.
The third site, Currumbin Creek, is an estuary located at the southern end of the Gold Coast. The site is mainly used by roosting Crested Terns, which are the most abundant bird species present. The site is also a highly popular recreational area and disturbance of shorebirds is believed to arise from a variety of sources such as people, dogs and boats.

The last site, Kirra, has been subject to beach nourishment from the Tweed River Entrance Sand Bypassing Project in recent years. This has resulted in unusually very wide beach (approximately 400 m). There is a small creek that opens into the ocean and provides a roosting and grooming site for Crested Terns which are the most abundant bird species on the site. Like at Currumbin Creek, disturbance of shorebirds is believed to be caused mainly from people walking and running on the beach.

4.5.3.4 Methods

This study focused on Crested terns (Sterna bergii) which are commonly present at various locations along the coast. Observations were conducted at all four sites between November 2007 and June 2008. Each site was visited 6 times, 3 times during busy periods e.g. weekends or school holidays and 3 times during non or low activity periods e.g. during the week. Each observation period lasted a minimum 2.5 hours. All observations were conducted during daylight hours under many kinds of weather conditions but never while it was raining. Shorebirds were observed from a stationary position that was close enough to observe birds through the spotting scope and video camera, yet far enough to enable shorebirds to behave as if the observer was not present.

Bird behaviour was observed through a 20x-60x 60mm spotting scope and recorded using a video camera. Birds were counted using a hand tally counter. Video recordings helped confirm and refine field observations.

4.5.3.4.1 Observations

The following information was recorded:

- Each potential disturbance agent that either came within 200m of the roost, walked between the roost or else. Events were noted whether they disturbed shorebirds or not.
- Shorebird activity prior to disturbance e.g. roosting, feeding.
- Type of disturber e.g. dog, boat, car, people walking.
- Speed of disturber e.g. walking, running.
- Species reaction to disturbance e.g. stopped feeding looked alert, walked or ran a few meters away, flew a short distance etc.
- Flight distance - distance between an animal or approaching human at which point the birds escaped from the visitor. Flight distance has been used as a measure of bird tolerance and to determine minimum approaching distances (Fernandez-Juricic et al., 2001; Fox & Madsen, 1997).
- Flight distance relatively to species richness.
- Flight distance relatively to species abundance.
- Duration of disturbances at different sites.
4.5.3.4.2 Physical beach attributes

Beach profiles were taken at Kirra, Currumbin and South Stradbroke Island. No beach profiles were taken at the Broadwater site which is a flat tidal island. In addition, weather conditions and wave height were recorded at the start and finish of the observations periods. Wind speed was obtained from the Australian Bureau of Meteorology. Sediment samples were taken from each site. Three sediment cores (3mm x 20cm) were excavated at each beach and later used to determine granulometry. In the laboratory, the sediment was dried to constant weight (65°C for 48hrs). Sediment was then sieved through a nested series of sieves with mesh sizes of 4000μm, 2000μm, 1000μm, 500μm, 250μm, 125μm and 63μm. Sediment statistics (mean grain size, sorting, skewness and kurtosis) was calculated using the GRADISTAT software, according to the Folk and Ward method (Blott & Pye, 2001).

4.5.3.4.3 Statistics

A two factor analysis of variance (ANOVA) was used to compare the mean grain size of all beaches over time. Comparisons among means were using the Games-Howell test. Non parametric Kruskal-Wallis test was used to compare relatively abundance among sites. Post hoc comparisons between sites were made with a series of Mann-Whitney tests.

4.5.3.5 Results

4.5.3.5.1 Physical processes

Mean grain size ranged from 278 μm at Kirra to 301 μm at Currumbin (83, Table 49). There is a significant difference between the mean grain size of all sites, ANOVA F(4,10)=11.662, p<0.001. Post Hoc tests show the mean grain size was only significantly different between Kirra and Currumbin (Games-Howell p <0.05).

![Figure 95: Mean sand grain size of all sites](image)
Table 49. Mean grain size (µm), standard deviation between brackets.

<table>
<thead>
<tr>
<th></th>
<th>SSI</th>
<th>Broadwater</th>
<th>Currumbin</th>
<th>Kirra</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>287.33 (4.7)</td>
<td>286.00 (2.6)</td>
<td>300.33 (2.1)</td>
<td>280.00 (2.0)</td>
</tr>
</tbody>
</table>

Table 50. Site morphology

<table>
<thead>
<tr>
<th>Site</th>
<th>Beach slope (°)</th>
<th>Average wave height (cm)</th>
<th>Average wave period (s)</th>
<th>Mean beach width (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSI</td>
<td>1.50</td>
<td>15</td>
<td>5.5</td>
<td>420</td>
</tr>
<tr>
<td>Broadwater</td>
<td>Na</td>
<td>0</td>
<td>na</td>
<td>52</td>
</tr>
<tr>
<td>Currumbin</td>
<td>2.07</td>
<td>70</td>
<td>6</td>
<td>21</td>
</tr>
<tr>
<td>Kirra</td>
<td>0.97</td>
<td>70</td>
<td>5.5</td>
<td>302</td>
</tr>
</tbody>
</table>

na = not available

All sites surveyed are morphologically considerably different. Broadwater is a sand bank which is totally submerged during high tide and it is not exposed to the open ocean. Kirra and SSI are wide beaches with mild slopes and plenty of roosting area (Table 50). The site at Currumbin has a narrow beach and a steeper slope. The average wave height was higher at Currumbin and Kirra, which are more exposed to south east swells. On the other hand Broadwater and SSI recorded lower wave heights.

4.5.3.5.2 Frequency of disturbance and time spent on air due to disturbance

4.5.3.5.2.1 South Stradbroke Island

At SSI no disturbance was recorded during week days. However, there was a relatively high amount of disturbance on weekends and long weekends. Disturbance was caused by people walking along the beach and by dogs on and off leash (Figure 96). Results showed that crested terns spent approximately 6% of each hour of observation in the air due to human caused disturbance (Figure 97).

![Figure 96: Disturbance frequency at SSI on high disturbance days](image-url)
4.5.3.5.2.2 Broadwater

On weekends there was a relatively high amount of disturbance caused by speed boats and by people (who had arrived by boat or jet ski) walking or bait collecting (Figure 98). During these days birds spent approximately 1% of each hour of observation in the air due to human caused disturbance (Figure 99). Lesser disturbance was recorded during week days. During this time birds spent less than 0.5% in the air due to disturbance. Disturbance was mainly caused by people collecting bait and jet skis.
4.5.3.5.2.3 Currumbin

At Currumbin there was a relatively high amount of disturbance on weekends caused mainly by two or more people walking on the beach (Figure 100). During weekdays
disturbance is mainly caused by individuals walking along the creek (Figure 100). Results showed that birds spent approximately 4-5% of each hour of observation on air due to human caused disturbance (Figure 101). The percentage of time that birds spent on air due to human caused disturbance is less on week days compared to weekends (Figure 101).

Figure 100: Disturbance frequency at Currumbin on low and high disturbance days
4.5.3.5.2.4 Kirra

At Kirra, disturbance occurred during the week and on weekends but there was relatively more disturbance on weekends. However, the amount of time birds spent in the air due to disturbance was similar between week days and weekends (91). On weekends disturbance was mainly caused by one or two people walking along the beach and the lifesavers vehicle (Figure 102). On weekdays disturbance was caused mainly by individuals (Figure 102).
Figure 102: Disturbance frequency at Kirra on low and high disturbance days

Figure 103: Mean percentage of time spent on air due to disturbance at Kirra
4.5.3.5.3 Summary of disturbance at all sites

On low disturbance days, no disturbance events were observed at SSI, whereasCurrumbin, Kirra and the Broadwater site experienced similar amounts ofdisturbance, ranging from 3 to 10 disturbance events per hour. On high disturbance
days the Broadwater, SSI and Kirra experienced relatively similar levels of
disturbance among them, ranging from 8 to 17 disturbance events per hour.
Currumbin showed the highest amount of disturbance among all sites on high
disturbance days.

<table>
<thead>
<tr>
<th>Site</th>
<th>Low disturbance days</th>
<th>High disturbance days</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSI</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Broadwater</td>
<td>10</td>
<td>17</td>
</tr>
<tr>
<td>Currumbin</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>Kirra</td>
<td>12</td>
<td>14</td>
</tr>
</tbody>
</table>

Table 51. Summary of all disturbances on high and low disturbance days.

4.5.3.5.4 Time between disturbances

During high disturbance days, the average time between disturbances ranged from3.40min at Currumbin to 12min at SSI (Table 52 and Figure 104).

<table>
<thead>
<tr>
<th>Kirra</th>
<th>SSI</th>
<th>Currumbin</th>
<th>Broadwater</th>
</tr>
</thead>
<tbody>
<tr>
<td>4:50</td>
<td>12:05</td>
<td>3:40</td>
<td>9:00</td>
</tr>
</tbody>
</table>

Table 52. Average time between disturbance events recorded on weekends (min)
4.5.3.5.5 Abundance and species richness

Abundance of Crested Terns significantly differed among sites (Table 53 and Figure 105). The only not significant difference in abundance was found between Broadwater and Kirra (Mann-Whitney p > .05, Table 54). Species richness was significantly different between all sites (Kruskal Wallis p <.05, Table 53). Post hoc tests found a non significant difference between Currumbin and Kirra (Mann-Whitney p = .336, Table 54). All other sites significantly differ among each other.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Chi square</th>
<th>df</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abundance between all sites</td>
<td>15.205</td>
<td>2</td>
<td>.000</td>
</tr>
<tr>
<td>Species richness between all sites</td>
<td>18.341</td>
<td>3</td>
<td>.000</td>
</tr>
</tbody>
</table>
## Table 54. Mann-Whitney tests results of abundance between sites

<table>
<thead>
<tr>
<th>Variable</th>
<th>Site</th>
<th>Site</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abundance</td>
<td>SSI</td>
<td>Broadwater</td>
<td>.004</td>
</tr>
<tr>
<td>Abundance</td>
<td>SSI</td>
<td>Kirra</td>
<td>.004</td>
</tr>
<tr>
<td>Abundance</td>
<td>SSI</td>
<td>Currumbin</td>
<td>.004</td>
</tr>
<tr>
<td>Abundance</td>
<td>Broadwater</td>
<td>Currumbin</td>
<td>.004</td>
</tr>
<tr>
<td>Abundance</td>
<td>Broadwater</td>
<td>Kirra</td>
<td>.225</td>
</tr>
<tr>
<td>Abundance</td>
<td>Currumbin</td>
<td>Kirra</td>
<td>.020</td>
</tr>
<tr>
<td>Species richness</td>
<td>SSI</td>
<td>Broadwater</td>
<td>.004</td>
</tr>
<tr>
<td>Species richness</td>
<td>SSI</td>
<td>Currumbin</td>
<td>.003</td>
</tr>
<tr>
<td>Species richness</td>
<td>SSI</td>
<td>Kirra</td>
<td>.003</td>
</tr>
<tr>
<td>Species richness</td>
<td>Broadwater</td>
<td>Currumbin</td>
<td>.018</td>
</tr>
<tr>
<td>Species richness</td>
<td>Broadwater</td>
<td>Kirra</td>
<td>.011</td>
</tr>
<tr>
<td>Species richness</td>
<td>Currumbin</td>
<td>Kirra</td>
<td>.336</td>
</tr>
</tbody>
</table>

![Abundance (mean ± SEM)](image)

**Figure 105**: Mean abundance to Crested Terns at all sites during low and high disturbance days.
Figure 106: Mean species richness at all sites during low and high disturbance days.

4.5.3.5.6 Flight distances at all sites

Flight distance at SSI was considerably higher when compared to all other sites (Figure 107 and Table 55). The Broadwater site had a mean flight distance of 11m, followed by Kirra and Currumbin.

Figure 107: Mean flight distance (m) at all sites during low and high disturbance days.
Table 55. Mean flight distance during weekends (m)

<table>
<thead>
<tr>
<th></th>
<th>Kirra</th>
<th>SSI</th>
<th>Currumbin</th>
<th>Broadwater</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.2</td>
<td>72.5</td>
<td>10.5</td>
<td>11</td>
<td></td>
</tr>
</tbody>
</table>

4.5.3.6 Correlations

A significant and positive correlation ($p < .001$) was found between species richness and abundance of Crested Terns (Figure 108 (a) and Table 56). A moderate and significant ($p < .05$) correlation was found between crested tern abundance and flight distance (Figure 108 (b) and Table 56). A weak negative correlation was found between Crested Tern abundance and disturbance amount, however, the relationship is not significant (Table 56).

![Graphs showing correlation between Crested Terns and species richness and flight distance at all sites.]

Table 56. Correlation values between crested tern abundance, species richness and flight distance at all sites.

<table>
<thead>
<tr>
<th>Variable (Crested Tern abundance)</th>
<th>Spearman value</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species richness</td>
<td>0.819</td>
<td>0.000</td>
</tr>
<tr>
<td>Flight distance (m)</td>
<td>0.469</td>
<td>0.002</td>
</tr>
<tr>
<td>Disturbances per hour</td>
<td>-0.285</td>
<td>0.178</td>
</tr>
</tbody>
</table>

4.5.3.7 Discussion

Shorebirds require specific habitat conditions for migration and for breeding (EPA., 2005b). Migratory shorebirds must have space, food and protection from predators and disturbances in order to recuperate from long flights and to prepare for the next stage of their journey (EPA., 2005b). Resident shorebirds also need similar habitats including safe areas for roosting and breeding (EPA., 2005b). On the Gold Coast, disturbance has become a mayor threat to shorebird survival due the growing number of people recreating in areas frequented by shorebirds.

4.5.3.7.1 Shorebird abundance and disturbance

The most frequent disturbance encountered by shorebirds on the Gold Coast is people walking along the shore. On low and high disturbance days Currumbin experiences the highest amount of disturbance, followed by Kirra. Currumbin also presents the lowest abundance of birds. At Currumbin, the area that is available for birds to roost is limited especially at high tide. At low tide sand islands in the middle
of the creek are exposed offering more roosting space. However, the beach area at the northern side of the creek is an off-leash dog area and at low tide it is possible for people and their dogs to disturb birds roosting on sand islands. Kirra presents higher bird abundance when compared with Currumbin. This could be explained by the width of the beach (approximately 400m), which provides more space for birds to move to when disturbed. Of all the sites observed, South Stradbroke Island presents the highest abundance of birds and the highest species richness. Even though the site experiences high levels of disturbance during weekends, the amount of disturbance during the rest of the week is extremely low. During this study no disturbance was recorded at SSI on low disturbance days. The area is only accessible by boat thus it is mainly a weekend destination. Currently there are a small number of residents with 4WD licenses on the island. If the number is increased this could result in heavier disturbance. On high disturbance days the Broadwater presents the lowest disturbance level. Similarly to SSI the area is only accessible by boat. Even though the area is relatively quiet during weekdays and provides habitat suitable for roosting, the site area is greatly reduced during high tide.

4.5.3.7.2 Behavioural changes due to human disturbance

The average flight distance resulting from human disturbance at SSI was 72.5 m while at Currumbin and Kirra it varied between 10.5m to 12.2m respectively. It appears that birds roosting at Kirra and Currumbin have become ‘desensitised’ to disturbance. These results contradict a study by Lafferty (2001) who found that the reaction distance of birds was greater the more often they were disturbed indicating that they may become ‘hyper-sensitised’. However, these results were based on plovers, suggesting that different species cope differently with repeated disturbances. Gill et al., (2001) suggests that some species may seem to better cope with disturbance not as a choice but simply because they have no other sites to move to whereas other species may be able to avoid disturbance because they have other sites to go to. Overall, the decision of whether or not to move away from disturbed areas has been attributed to factors such as the quality of the site currently being occupied, the distance to and quality of other sites and the relative risk of predation or density of competitors (Gill et al., 2001). On the Gold Coast, the study sites chosen for this study (with the exception of the Broadwater) and the south-eastern side of SSI are the only open shore sites were concentrations of 10 or more shorebirds occur. With the exception of seagulls, the rest of the open shore beaches are generally devoid of bird life. Disturbance is suspected of having a detrimental effect on the availability of roosting sites, however other factors such as availability of food and the worldwide decline of breeding grounds are also suspected of having detrimental impacts.

Another factor to consider is the positive correlation between flight distance and bird abundance. Results from this study found birds to have a ‘hyper-sensitive’ response to disturbance when in groups. However, this result is mainly driven by flight responses recorded at SSI where bird abundance is consistently high and disturbance events are generally low. As a result the positive correlation could be attributed to the birds not being used to disturbance or to different behavioural reactions to disturbance when in groups.

4.5.3.7.3 Further research

Uncertainty remains in relation to how recreational activities affect other species such as Red-capped Plovers, Red-necked Stints, Oystercatchers and Little Terns. In addition, further research needs to be conducted to establish correlations between
flight distance and time of the day, tide level and prey availability.

As well as flight distance, alert distance should also be considered in order to obtain a more conservative estimate of tolerance (Fernandez-Junricic et al., 2001). Alert distance is the distance between an animal and an approaching human/threat at which point the animal begins to exhibit alert behaviours to the human/threat (Fernandez-Junricic et al., 2001). In order to efficiently determine alert behaviour and flight distance some variables such as number of disturbers, speed of approach, number of birds on ground, time of day and tide need to be standardised. It would be useful to conduct experiments as opposed to relying on field observations of disturbance.

Further studies need to address how behavioural changes in response to disturbance affect demographic parameters such as survival and reproductive success. Priority should be given to the Little Tern which, roosts and nests at SSI and whose population decline is well documented. Little Terns nest on the island during the summer months when recreational activity at the island is at its peak. To date no research on reproduction success and chick survival rates has been conducted in the area.

4.5.3.7.4 Management considerations

To date, the approach to shorebird conservation in Australia has been to identify ‘Areas of International and National Importance’ based on criteria contained in the Ramsar Convention (Watkins, 1993). The numbers of shorebirds observed at all Gold Coast sites would be insufficient to be regarded as an ‘Area of International or National Importance’. However, a large number of shorebirds still nest and roost along the coast with higher numbers present at SSI. Considering the history of coastal environmental degradation that the Gold Coast has experienced, areas that hold special ecological significance at a local government level should be prioritised, protected and preserved.

There are a range of management options available to trial. In the case of SSI we recommend the following;

- Increase the awareness of people as to their impact on shorebirds via signs, brochures and media
- On-ground habitat management trials eg. seasonal/part beach closures, walkways/interpretive trails, zoning.
- Education eg. talks, guided walks
- Information on the adverse impacts of shorebird disturbance should be provided to tourist operators. Both day and overnight visitors to the island should be made aware of the ecological significance of shorebirds. Minimum approach distances should be established and operators advised.

For sites such as Kirra, Currumbin and the Broadwater we recommend strategies to increase awareness via signs, brochures, posters and the media.

4.5.3.8 Conclusion

Overall, the Gold Coast region supports low numbers of shorebirds. The sites chosen for this study represent the main Crested Tern roosting areas. It is not clear why Crested Terns and other shorebirds are absent along the rest of the open coastline,
however, human disturbance and extensive development of the area are the most likely factors responsible for low numbers.

A lack of community understanding and education of shorebird related conservation issues results in high levels of disturbance, which is a significant threat to shorebird survival (EPA., 2005b). Results from this study suggest that human disturbance has a negative impact on shorebirds numbers. Given the challenges associated with coastal development on the Gold Coast, including climate change, rapid population growth and high levels of tourism, this study recommends a number of management actions that we believe will help to protect roosting sites for resident and migratory species. These recommendations should promote greater awareness of the importance of resident and migratory shorebirds in this region and should aim at reducing unnecessary disturbance as well as improving community and visitor knowledge about the local environment. While the species numbers at the Gold Coast study sites are not nationally significant they are important at the local level. The study also recommends further research to improve the current knowledge on resident and migratory shorebirds that are sighted in the area.
5. CHAPTER 5 - ECONOMIC VALUE OF GOLD COAST BEACHES

5.1 Introduction

Coastal areas contain some of the world’s most diverse and productive resources (Underwood & Chapman, 1995). People all over the world have concentrated on the coastal margins of continents for a variety of reasons, some of which have changed over time:

- The seas provide a source of food;
- Rainfall is generally greater and more reliable on the coast than inland;
- Coastal lands are usually suitable for a wide range of uses;
- The coastal climate is milder than the extremes found in the interior of continents;
- Transport was initially easier by water than across land or in the skies and later improved road transport has allowed easier access to the coast;
- The demand for coastal real estate and ocean views has grown significantly in recent years; and
- Increased leisure time, resulting from greater affluence has changed working conditions and holidays by the sea have become attainable (Government of New South Wales, 1989; Lazarow, 2007; OECD, 1991)

5.2 Valuing the coast

The State Coastal Management Plan (currently under review) recognises that the natural and cultural resources along the Queensland coast have associated ecological, economic and social values. These include:

- Beach and dune systems;
- Coastal wetlands;
- Headlands;
- Rocky foreshores;
- Soft-bottom (benthic) systems;
- Mid-water (pelagic) systems;
- Coastal and estuarine waters;
- Freshwater flows;
- Indigenous Traditional Owner cultural resources;
- Cultural sites;
- Mainland;
- Islands; and

The interconnectedness of the coast means that many of the values we associate with the coast are common across resources – and include scenic amenity; recreational amenity; freshwater flows; coastal protection; habitat and biological
productivity; sediment sink and source; Indigenous values; spiritual significance; cultural heritage; and nursery habitat. Similarly, many of the pressures are common across resources. Major coastal pressures include: coastal development; land clearing and reclamation; invasive pests and weeds; loss of habitat; overfishing; storms and floods; catchment runoff; water pollution; sand mining; invasive weeds; water extraction; access; recreation / tourism activities; and climate change and sea level rise (see Government of Queensland, 2001, pp. 3-7).

The coastal economy, defined as the portion of economic activity that takes place on or near the coast (Colgan, 2003) contains ocean and non-ocean related economic activities. Traditionally, the coastal economy has been viewed in terms of market values, however, non-market values (i.e. goods and services traditionally not traded through the market such as the value of habitats) also play a significant role in determining the health of the coast and affect the people who use the coast for work and play (Pendleton et al., 2006). Some uses of the coast are viewed in market terms, even though the market may only partially capture their total economic value. Similarly, some goods and services do not have a market value or have a value to society that cannot be adequately expressed in market terms. Some of these are crucial to the maintenance of a healthy society and its economy. On the Gold Coast, the beach is a good example of this.

Costanza et al. (1997) use the concept of Total Economic Value (TEV) to provide a framework for understanding the value of both market and non-market assets on our coast (see Lazarow et al., 2007a for a useful model). For example, non-market values can include: ecosystem services such as carbon cycling in estuaries; recreational activities such as enjoying a walk on the beach, swimming in clean water, and being able to catch a fish or watching a beautiful sunset over the ocean; as well as the value of conservation initiatives to current and future generations (Lazarow et al., 2008).

For example, even where an individual does not go to the beach, they may see the benefits to others and to future generations and society from doing so. These values may be termed non-use values and include option, bequest, existence and vicarious values. In this way, much of the value of the beach may be expressed outside of the market.

Pendleton and Kildow (2006) state that while the market expenditures by beach goers in California could substantially exceed $US3 billion each year, the value that day users place on access to the beach beyond what they pay in terms of travel costs, parking fees and tolls is substantial and is estimated to range from $US2.25 - $US7.5 billion dollars annually. Similar estimates in Australia for beach recreation values at Mooloolaba beach in Queensland have been estimated at between $153 million and $862 million annually (Blackwell, 2007). The non-use, non-market values are yet to be estimated for beaches in Australia.

While scholars in the United States have made significant progress in determining the market and non-market value of the coastal economy through the National Ocean Economics Program (National Ocean Economics Program, 2007) and at a more local level, the Southern California Beach Valuation Project (National Oceanic and Atmospheric Service, 2006), formal knowledge of the non-use values of beaches is generally poorly understood and considerably lacking in Australia and is seldom used in the decision-making process.
5.3 Previous studies

5.3.1 An economic appraisal of Gold Coast Beaches (1972)

In 1972, the State Government and Gold Coast City Council commissioned Philip Shrapnel and Co. P/L to undertake an economic appraisal of the capital works required to restore Gold Coast beaches that were damaged as a result of cyclone and storm damage (Maitra & Walker, 1972). The findings from the report were as follows:

1. Cyclones approach the Gold Coast at irregular intervals. After a gap of nearly 15 years, three cyclones in 1967 caused significant damage to the coast. Despite some accretion in the intervening period, the beaches were significantly vulnerable and in early 1972, cyclones virtually destroyed many of the Gold Coast’s beaches.

2. Using two ‘benchmark’ surveys as baselines, researchers estimated that tourist visitation grew from 320,000 in 1961 to 1,103,800 in 1971 with an average trend rate of growth of 12.2%. These figures excluded day-visitors, who were estimated to have made an additional 1 million visits in 1971.

3. The average length of stay for visitors was recorded as 6.9 nights. In 1970, visitors were estimated to spend $6.80 per night.

4. Beaches occupy a prime position in the Gold Coast tourism industry. To the extent that the loss of sand slowed the growth of tourist income, the proprietors of accommodation houses and caravan parks were believed to be exposed to considerable financial strain.

5. While the number of tourists continued to grow, it was been suggested that fewer family groups were being attracted to the Gold Coast, possibly because of a deterioration of the beaches. Close to 20% of the total workforce in the City was estimated to be directly employed in the accommodation industry and a further 35 - 40% were engaged in tourist-orientated occupations such as building and commerce. It was argued that the pace of expansion in tourism would largely determine the rate of growth in employment and incomes on the Gold Coast.

6. As a result of the cyclones and associated beach damage, the Gold Coast received an amount of negative publicity in the media, which was vigorously countered by the tourist industry and GCCC. The report’s authors projected that visitation in 1981 - 82 would be approximately 3.1 million, compared to almost 4.7 million if the beaches were restored. The loss due to a reduction in visitor spending from 1972 - 73 to 1981 - 82 was estimated to be approximately $574 million (in 1972 prices).

7. The engineering works required to restore Gold Coast beaches were provided by the Delft Hydraulics Laboratory in a 1970 report and included beach nourishment as well as a program of capital works (Delft Hydraulics Laboratory, 1970). The beach nourishment works were estimated to cost close to $12 million ($108 million in 2007).

8. Using discount rates of 6% (then long-term rate on government bonds) and 10%, it was estimated that the net benefit of undertaking the beach restoration program amounted to $276 million at 6% and $217.4 million at 10%. ($2.5 billion and $1.95 billion respectively in 2007).

9. The report’s authors argued that the case for State and Federal Government assistance in the event of natural disasters was well-precedented, especially when economic assets were destroyed as a result of disasters. The report argued...
for a 20/40/40 split for Gold Coast City Council, the State Government and the Federal Government, which amounted to a request for $4.8 million in aid from the Commonwealth. It was suggested that without Commonwealth aid, local rates would rise by over 25% between 1975/6 and 1992/93.

10. The study concluded that it was in the interests of the Commonwealth to assist in the restoration of the Gold Coast’s beaches in order to enable the region to compete with overseas resorts, which were ‘vigorously’ marketing overseas packaged tours at the time.

No funds were received from the Federal Government for beach protection works. This is still the case today. The various capital works program and projects that were progressed as a result of the Delft Report recommendations and subsequently, were funded by either the State Government or Gold Coast City Council or both. This is with the exception of the Tweed River Entrance Sand Bypassing Project, 50% of which was funded by the NSW Government, 25% by GCCC and 25% by the State Government. 

Figure 109: Artificial Reef at Narrowneck, Gold Coast

5.3.2 ‘Northern Gold Coast Beach Protection Strategy benefit cost analysis’ (1998) and ‘Cost-benefit study of protection of the northern beaches of Australia’s Gold Coast’ (1999)

In 1998 Gold Coast City Council commissioned a benefit-cost analysis report as part of the Northern Gold Coast Beach Protection Strategy (NGCBPS) (Raybould & Mules, 1998). The following year the results of the study were also published in the journal Tourism Economics (Raybould & Mules, 1999). This section draws on both of these documents to provide a summary of the findings of this investigation. The investigation estimated the benefit-costs associated with:

- Beach nourishment works between Northcliffe and Main Beach, which were intended to widen the beach by 30-50m; and the
- Construction of an artificial surf reef at Narrowneck.
The findings from the report were as follows:

- The major benefits of the project would be the protection of tourism values and publicly owned assets.
- The average annual ongoing cost of the project was expected to be approximately $275,000 (sand replenishment and maintenance of artificial reef).
- The project was expected to yield benefit-cost ratios of 60 to 1 at an 8% discount rate (1991 Department of Finance recommendation).
- The Net Present Value of the project at an 8% discount rate was estimated to be $457 million in 1996. This indicated that the project would be expected to make a large positive economic contribution to the region.
- The direct tourism revenue benefits of the project were estimated to generate over $1.6 million in indirect taxation revenue each year for State and Federal Governments.
- Beach erosion associated with a ‘1-in-5’ year cyclone, similar to that which occurred in June 1996, cost the Gold Coast approximately 2% of annual tourism receipts, or $47 million in 1996 ($62 million in 2007).
- Beach erosion associated with a ‘1-in-10’ year cyclone, similar to that which occurred in June 1996, cost the Gold Coast approximately 5.5% of annual tourism receipts, or $129 million in 1996 ($170 million in 2007).
- Researchers estimated that the actual impact of the 1967 cyclones caused losses in tourism revenues of 26% in the first 12 months and a further 18% the following year. They stated that the effects of the 1967 erosion lasted for 2½ years because there was no effort to repair the beaches. With a more diverse tourism product that is not as heavily influenced by beach condition; social and political pressure to undertake large scale beach replenishment work; and tourism marketing campaigns to counter the effects of negative media coverage, the authors suggest that the economic effects of a major cyclone or storm could be limited to one year.
- Beach erosion associated with a ‘1-in-25’ year cyclone, similar to that which occurred in June 1967, cost the Gold Coast approximately 13% of annual tourism receipts, or $305 million in 1996 ($402 million in 2007).
- Beach erosion associated with a ‘1-in-50’ year cyclone, similar to that which occurred in June 1967, cost the Gold Coast approximately 20 – 25% of annual tourism receipts, or $470 million in 1996 ($620 million in 2007).
- By undertaking a sensitivity analysis, researchers found that even if the project only achieved 50% of the anticipated benefits and costs were underestimated by 25%, the project would still yield a benefit-cost ratio of 25 to 1 at an 8% discount rate and had a Net Present Value of over $200 million.

The study did not quantify:

- The expected recreation benefits to local residents;
- The existence values of well maintained beaches;
- The enhanced property values resulting from beach protection; or
- The negative long-term effects of tourists coming to the Gold Coast and finding that beaches did not meet their expectations in the absence of the NGCBPS.
The study recommended further investigation into:

- The use and value of the beach as a non-market recreation facility and whether, as the beneficiaries of beach nourishment and enhancement programs, local residents would be willing to support such initiatives;
- How tourists use and value the beach;
- The effect that the existence of the beach and beach quality have on property values in the region; and
- The benefit from the taxes and licence fees paid directly or indirectly by tourists to all three levels of government.

Table 57 and 58 summarise the costs and benefits that were expected to accrue from the project and identify what data was used to quantify them.

**Table 57. The assessment framework for estimating benefit-cost of the Northern Gold Coast Beach Protection Strategy (costs)**

<table>
<thead>
<tr>
<th>Costs</th>
<th>Data needs and treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Research, design and development for beach nourishment works.</td>
<td>Estimated costs</td>
</tr>
<tr>
<td>2. Initial capital expenditure on sand pumping / beach nourishment projects.</td>
<td>Estimated costs (1997 values) and years in which capital expenditure is expected to occur.</td>
</tr>
<tr>
<td>3. Maintenance costs over the life of the project for sand pumping / beach nourishment.</td>
<td>Estimated costs (1997 values) for each year.</td>
</tr>
<tr>
<td>6. Maintenance costs of artificial surf reef over its expected life.</td>
<td>Estimated costs (1997 values) for each year.</td>
</tr>
<tr>
<td>8. Maintenance costs of ancillary facilities associated with artificial surf reef.</td>
<td>Estimated costs (1997 values) for each year.</td>
</tr>
<tr>
<td>9. Harmful effects of overcrowding, traffic movements caused by visitors to artificial surf reef.</td>
<td>Qualitative data from Social Impact Study of local residents and businesses.</td>
</tr>
</tbody>
</table>

Table 58. The assessment framework for estimating benefit-cost of the Northern Gold Coast Beach Protection Strategy (benefits)

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Data needs and treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Avoided costs of damage to public assets.</td>
<td>Analysis of asset values and expected losses based on previous erosion events.</td>
</tr>
<tr>
<td>2. Avoided loss of tourism revenues.</td>
<td>Analysis of tourism impacts of previous beach erosion events.</td>
</tr>
<tr>
<td>3. Additional event tourism receipts related to the artificial surf reef.</td>
<td>Estimates based on economic impact study of the Billabong Pro surf event.</td>
</tr>
<tr>
<td>4. Avoided loss in recreation benefits to local residents.</td>
<td>Not possible to quantify within the time frame constraints of the project.</td>
</tr>
<tr>
<td>5. Avoided loss in ‘existence value’ benefit to local residents.</td>
<td>Not possible to quantify within the time frame constraints of the project.</td>
</tr>
<tr>
<td>6. Enhanced recreation values resulting from construction of artificial surf reef.</td>
<td>Not possible to quantify within the time frame constraints of the project.</td>
</tr>
<tr>
<td>7. Enhanced property values.</td>
<td>Not possible to quantify within the time frame constraints of the project.</td>
</tr>
</tbody>
</table>


5.3.2.1 Effects of beach erosion on tourism

In the report Raybould and Mules (1998) investigate the impact that beach erosion and negative media coverage of erosion events can have on visitation to the region. By reviewing the impact of various storm and cyclone events (1967, 1990, 1996) on the Gold Coast, the authors attempted to estimate the tourism losses that would occur as a result of an event of a particular scale with and without the NGCBPS proceeding. The authors argued that although the NGCBPS would provide protection to only a small section of the Gold Coast coastline, it was in an area (Surfers Paradise area) that contained almost 50% of guest rooms on the Gold Coast (ABS, in Raybould and Mules 1998, p. 24). In the event of a cyclone the NGCBPS was expected to reduce tourism losses by approximately 50% (see Table 59).

Table 59. Summary of estimated tourism losses and project benefits from the NGCBPS

<table>
<thead>
<tr>
<th>Frequency of erosion event</th>
<th>Estimated % of annual tourism lost</th>
<th>Approximate gross loss (1996 / $m)</th>
<th>Estimated loss ‘with project’ (1996 / $m)</th>
<th>Project benefit (1996 / $m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 in 5</td>
<td>2%</td>
<td>47</td>
<td>23.5</td>
<td>23.5</td>
</tr>
<tr>
<td>1 in 10</td>
<td>5.5%</td>
<td>129</td>
<td>64.5</td>
<td>64.5</td>
</tr>
<tr>
<td>1 in 25</td>
<td>13%</td>
<td>305</td>
<td>152.5</td>
<td>152.5</td>
</tr>
<tr>
<td>1 in 50</td>
<td>20%</td>
<td>470</td>
<td>235</td>
<td>235</td>
</tr>
</tbody>
</table>

Source: (Raybould & Mules, 1998, 1999)

5.3.2.2 Effects of beach erosion on public assets

In conjunction with GCCC, erosion zones, at risk assets, asset value and repair and replacement costs were also estimated in the area from the Seaway to Burleigh Heads.

Table 60 describes the damage to public assets that could be expected along this stretch of coastline in the event of a particular size storm without the project proceeding as well as the expected benefits that were likely to be delivered as a result of the NGCBPS.

The report’s authors note the highly unpredictable nature of cyclones and associated beach erosion. Based on the economic argument that a dollar today is worth more than a dollar in the future, they argued that the benefits of the project were closely linked to the occurrence of cyclone activity. That is, the project would be valued more
highly if several large cyclones were experienced early on in the life of the project – assuming the structure actually performed as it was intended. As Table 60 demonstrates, expected project benefits were anticipated to be greater in the event of bigger storms.

Table 60: Summary of public asset damage estimates and project benefits from the NGCBPS

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 in 5</td>
<td>446,721</td>
<td>371,803</td>
<td>74,918</td>
<td>98,775</td>
</tr>
<tr>
<td>1 in 10</td>
<td>4,190,963</td>
<td>3,074,080</td>
<td>1,116,884</td>
<td>1,472,553</td>
</tr>
<tr>
<td>1 in 25</td>
<td>21,757,077</td>
<td>16,287,979</td>
<td>5,469,098</td>
<td>7,210,718</td>
</tr>
<tr>
<td>1 in 50</td>
<td>26,583,730</td>
<td>19,993,754</td>
<td>6,589,976</td>
<td>8,688,536</td>
</tr>
</tbody>
</table>


5.3.2.3 Event tourism benefits

As well as its primary coastal protection function the artificial reef at Narrowneck, which was a feature of the NGCBPS, was intended to improve beach amenity by creating a more reliable and regular surfbreak. Raybould and Mules (1998, p.26) state that the surfbreak was most likely to transfer surfing activity from other locations on the Gold Coast to Narrowneck and there was unlikely to be any net benefit to the region. They did argue, however, that the increased ‘reliability’ of the surfbreak meant that it might be more desirable for competitive surfing events. While no estimates were provided, the authors indicated that a study by Wills and Allen Leisure Consultants for Gold Coast City Council found that the 1997 Billabong Pro event generated an estimated net economic benefit to the region of $2,259,800 ($2,971,958 in 2007) (Raybould & Mules, 1998, p. 26). The economic benefits of surfing events were clearly identified as an important coastal economic activity.

It is worth noting that in the 2007 review of Narrowneck Reef, Jackson et al. (2007) make a number of important points about the performance of the reef with respect to surf quality. They state that:

- Media hype prior to construction of the reef was unrealistic resulting in a negative public perception of its success;
- Despite not being well-quantified, the wave provides improved surf conditions for a wide range of surf craft;
- The reef has not gained a reputation as a great surf spot, partly because it is surrounded by world-class surfbreaks and partly because the take-off point is located some distance offshore, which may be less attractive to some surfers; and
- Further improvements to improve surf quality are not considered warranted (L. A. Jackson et al., 2007, p. 67).

5.3.3 Attitudes and willingness-to-pay for beach protection on the Gold Coast (2005)

This study, a PhD thesis titled ‘Attitudes and information effects in contingent valuation of natural resources’ was completed in 2005 (Raybould, 2005). The thesis used a combination of photographs and text information to describe different beach conditions (e.g. eroded state, accreted state) and through a survey, tested
respondents’ (Gold Coast residents) attitudes and willingness-to-pay for a proposed (hypothetical) beach protection scheme in an erosion prone area of the Gold Coast.

The study tested the general hypothesis that respondents would indicate a positive relationship between images of beach erosion, attitudes towards beach protection and a willingness-to-pay for the protection of beaches that were severely eroded.

Raybould found that ‘while respondent’s attitude toward beach protection was affected by the information treatments, their willingness-to-pay for the proposed beach protection program was insensitive to information (photos and text)’ (Raybould, 2005, p. i). In particular, research showed that high levels of previous knowledge in a large proportion of the sample had a moderating effect on attitude change. The research concluded that respondent’s willingness-to-pay in a contingent valuation experiment was quite insensitive to photographic treatments when previous knowledge was high and that costly and time consuming testing procedures, recommended by authorities, may not be necessary under these conditions (Raybould, 2005, pp. i-ii).

5.3.4 Valuing Burleigh Beach, Gold Coast (2005)

In 2005 a position paper was prepared by GCCM intern Marc Lebreton (2005). Burleigh Beach is highly vulnerable and under even relatively calm conditions, the beach faces a constant risk of erosion. Active management is currently required in order to provide a beach at Burleigh. A large investment in time and effort by GCCC has resulted in a natural looking beach complemented by a well-used park and foreshore area. The purpose of the study was to assess the value of the beach and whether users would be willing-to-pay for beach protection measures. This information would then contribute to a management strategy for the beach. Although the study was not completed, it identified an effective methodology for valuation.

It is worth noting that a large amount of the information required for the first part of the Burleigh project was ultimately collected as part of the CRC for Sustainable Tourism study (described below) in 2007 – 08. Part 1 of the CRC study used a survey instrument to collect information on beach and foreshore use and value for all Gold Coast ocean beaches. The study found that Burleigh Heads was the most popular beach for Gold Coast residents (Raybould & Lazarow, 2008).

5.3.5 CRC Tourism study on resident and visitor use of Gold Coast beaches (2007)

In 2007 the Cooperative Research Centre for Sustainable Tourism funded a study to investigate the economic and social values of beach recreation on the Gold Coast (Raybould & Lazarow, 2008). The study was completed in 2008 and comprised of two sub-projects that were conducted concurrently. The major sub-project involved a survey of residents’ use and attitudes toward Gold Coast ocean beaches and foreshore areas. The second sub-project, a desk-top study based on available secondary data, investigated tourist use and values of Gold Coast beaches.

**Results of the survey of residents use and attitudes toward Gold Coast ocean beaches and foreshore areas**

- This study considered the value of Gold Coast beaches to local residents only.
- Surveys were distributed by mail to 8000 local residents and 1,862 responses were received - a return rate of approximately 23.5% after allowing for surveys returned as non-deliverable.
Over 80% of respondents indicated that the beach, parks and foreshore were important or very important to them.

On average residents visited 10 beaches per month during summer and 6 per month during winter – but visitation was strongly influenced by the distance people lived from the beach.

The report estimated that Gold Coast residents made a total of just over 40 million beach visits in 2007.

Using a crude travel cost model it was estimated that average travel costs per adult beach visit were between $0.50 and $2.30.

The report estimated that Gold Coast residents spent somewhere between $21.5 million and $91 million in total (between $64 per adult and $270 per adult) accessing the beach in 2007.

The costs incurred in accessing the amenity provide some guidance to the use-values that residents place on the beach and foreshore area; however they provide no indication of the non-use values (e.g. existence or bequest values) that people may hold for the amenity (Raybould & Lazarow, 2008).

Results of the investigation of tourist use and values of Gold Coast beaches

This study considered the value of Gold Coast beaches to tourists only.

The results were based on analysis of available secondary data and a number of assumptions about tourist behaviour and value functions. As with any analysis of this type the estimates are sensitive to the assumptions made.

Approximately 4.9 million day visitors and 4.4 million overnight tourists aged 15 and over visited the Gold Coast in 2006.

Domestic and international overnight visitors were responsible for approximately 23 million visitor nights in commercial and non-commercial (e.g. visiting friends and relatives) accommodation.

Approximately 30% of day visitors, 49.5% of domestic overnight visitors, and 82.3% of international overnight visitors use the beach at some point during their stay (Tourism Research Australia, 2004, 2006a, 2006b).

The report estimated that tourists made just over 7 million visits to Gold Coast beaches in 2006.

Analysis of relevant published research, actual travel costs incurred by day visitors, and market prices for relevant recreation goods, suggest a value for a beach visit of between $15 and $45 for a visitor to the Gold Coast.

Based on the information available the researchers estimated of the gross value of Gold Coast beaches to tourists alone was between $106 million and $319 million in 2006.

The report recommended that surveys of visitors to the Gold Coast should be conducted in the future to check some of the assumptions about beach use and value functions made in this analysis in order to provide greater confidence in the estimates.

5.3.6 A socio-economic study of recreational surfing on the Gold Coast (2008)

Between 2006 and 2008, researchers from the Australian National University and Griffith University undertook a socio-economic study of recreational surfers on the
Gold Coast Shoreline Management Plan
Volume 1

Gold Coast (Lazarow, 2008). As part of this research program a report was prepared for GCCC as part of the GCSMP. A full copy of this report is provided in Volume 4 of the GCSMP.

The study reported on Part 1 of GCCC Minute No CD05.0808.006 – ‘That the Chief Executive officer report to Council on the recreational value of the multiple point surfing breaks on the southern Gold Coast’. The other components of the request were progressed through another report, the Kirra Wave Study. The report is discussed in some detail in Chapter 3 and a full copy of this report is provided in Volume 4 of the GCSMP. A survey was designed and online and face-to-face surveys were conducted within Gold Coast City Council boundaries as well as Duranbah Beach, which is in Tweed Shire. The recreational value of Gold Coast surfbreaks was estimated by collecting and analysing data on gross market expenditure, frequency of surfing activity and respondents’ preferred locations for surfing within the study area. The following is a summary of the economic findings from the report:

- A total of 471 surfers were interviewed as part of this study. The study also relied on the use of available secondary data where primary data sources were not available.

- Three techniques were used to estimate the number of recreational surfers on the Gold Coast. A conservative estimate of the number of recreational surfers on the Gold Coast is 65,000, made up of 41,000 resident surfers and 24,000 visiting surfers. The upper estimate is approximately 120,000 surfers.

- It was estimated that there are between 6 - 15 million person visits or individual surf sessions per year on the Gold Coast.

- The total reported annual expenditure by recreational surfers on the Gold Coast was estimated to range from $256 - $474 million. A more conservative approach filtered the data in order to account for expenditure that was likely to take place outside of the Gold Coast. Using this method the total reported annual expenditure by recreational surfers on the Gold Coast in 2007 was estimated to range from $126 – $233 million. These figures treat visitation and expenditure by local residents and visitors (day, short-stay, long-stay and semi-permanent) in the same manner, do not account for the value of surf schools, airline travel to the Gold Coast, accommodation taken up by visitors who surf or surf industry related values such as rent and the wages of those involved in the surf industry. Each of these factors may substantially increase the total worth of surfing to the region.

- Expenditure per session for recreational surfing was estimated to range from $18.67 - $30.36, with a mid-point of approximately $24.50. This relatively low range smooths out significant differences in expenditure between surfers, especially between locals and visitors. For example, other than vehicle running costs, some surfers spend only a small amount on items such as wax and sunscreen each year whereas other surfers may purchase a number of boards and a new wetsuit each year.

- When compared with similar studies, the estimations presented in this report appear to be at the lower end of reported market expenditure for the cost of a surf session. This is further emphasised when one considers that this study also includes the cost of equipment, which is generally not accounted for in other studies.

- The report did not consider indirect and non-use values such as the social and community benefits or costs associated with surfing such as fitness, joy,
mentoring, sharing, community spirit or the risk of injury or multipliers, which may substantially add to these amounts. Further investigation into these values was recommended.

- On a managed coastline like the Gold Coast, coastal planning and management programs such as dredging, sand pumping and beach nourishment must consider their impact on surf quality and how these programs might be better able to concurrently provide coastal protection services as well as maintain or improve surf quality. A key element in this regard is the need to determine a standard for measuring surf quality at surfbreaks that have been and continue to be affected by coastal protection programs. Where coastal security can be maintained, progress towards improving surf quality should be made.

- The report concluded that based on the high expenditure and increasing participation in recreational surfing, it was worth considering the value to the City of constructing a number of purpose built offshore artificial surfing reefs as stand alone structures or and continuing to incorporate surfing elements into the design of multipurpose offshore submerged coastal protection structures, as was done at Narrowneck.

- The study recommended that further investigation into the total economic value and importance of surfing and the surf industry to the region be undertaken. Two specific projects were recommended:
  
  a) Little is known of the total value of the surfing industry (retail, distribution, education, surf schools, manufacturing etc). A project could be developed in conjunction with partners such as the Cooperative Research Centre for Sustainable Tourism (Tourism CRC), GCCC, Gold Coast Tourism, industry and others as required to prepare a report on the market and non-market value of the surf industry on the Gold Coast. Areas of investigation include, but are not limited to foreign students, industry (manufacture, distribution, sales), surf schools, travel, accommodation, gross market expenditure and the value of major surfing events.

  b) An opportunity exists to develop a project in conjunction with partners such as the Tourism CRC, GCCC, Gold Coast Tourism, Gold Coast and Brisbane Airports, industry and others as required to more accurately report on the number of surf related visits to the Gold Coast and the associated expenditure and importance of this market sector.

5.3.6.1 The value of individual surfbreaks on the Gold Coast

By dividing gross expenditure against the percentage of use for surfing activity at each surfbreak, the study estimated the reported value (in gross expenditure) of surfing at each of the Gold Coast's surfbreaks (Table 61).
Table 61. Estimated expenditure value of recreational surfing at various Gold Coast locations per year

<table>
<thead>
<tr>
<th>Location</th>
<th>Percentage of total effort</th>
<th>Expenditure value (to the nearest million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duranbah</td>
<td>10</td>
<td>$13 – 23</td>
</tr>
<tr>
<td>Snapper / Rainbow Bay / Greenmount / Coolangatta / Kirra</td>
<td>20</td>
<td>$26 – 46</td>
</tr>
<tr>
<td>Bilinga / Tugun / Flat Rock</td>
<td>2</td>
<td>$2.5 – 5</td>
</tr>
<tr>
<td>Currumbin / Currumbin Alley</td>
<td>12</td>
<td>$15 – 28</td>
</tr>
<tr>
<td>Palm Beach (Lacey’s Lane to Tallebudgera Creek)</td>
<td>6</td>
<td>$8 – 14</td>
</tr>
<tr>
<td>Burleigh Heads and Burleigh Beach</td>
<td>14</td>
<td>$17 – 33</td>
</tr>
<tr>
<td>Miami / Nobby / Mermaid</td>
<td>7</td>
<td>$9 – 16</td>
</tr>
<tr>
<td>Broadbeach / Surfers Paradise</td>
<td>2</td>
<td>$3 – 6</td>
</tr>
<tr>
<td>Narrowneck</td>
<td>3</td>
<td>$3.5 – 7</td>
</tr>
<tr>
<td>Main Beach / Southport</td>
<td>3</td>
<td>$3.5 – 7</td>
</tr>
<tr>
<td>Spit</td>
<td>6.5</td>
<td>$7.5 – 15</td>
</tr>
<tr>
<td>South Stradbroke Island</td>
<td>14.5</td>
<td>$18 – 33</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>$126 – 233 million</strong></td>
</tr>
</tbody>
</table>

Source: (Lazarow, 2008).

5.3.7 **Ocean Beaches and Foreshore Economic Impact Assessment**

In May 2008 GCCC appointed a consultant to undertake the ‘Ocean Beaches and Foreshores Economic Impact Assessment’. The project brief states:

The aim of the Ocean Beaches and Foreshore Economic Impact Assessment (OBFEIA) is to develop an economic impact model that will provide a detailed picture of the impact of the ocean beaches and foreshore on the Gold Coast economy. The assessment will provide the framework for a current analysis of the economic contribution of the ocean beaches and foreshore to the Gold Coast economy. The final report will provide an option for a stand alone and updateable assessment will can be updated annually to ensure currency of data and to track and measure the flow on effects to other industries of the ocean beaches and foreshores.

The assessment will provide the basis for the development of a strategy and implementation plan that will collectively manage and plan for the future of Gold Coast City’s ocean beaches and foreshore and provide key data for Gold Coast City Council (GCC) to integrate their activities across key directorates to identify infrastructure and resources for Gold Coast City’s ocean beaches and foreshore.

At the time of writing, this important project had not been completed. It is recommended that the GCSMMP be read in conjunction with this report once it has been finalised.

5.4 **Discussion**

A reading of the studies described in this chapter indicates the importance of the beach to the Gold Coast. This is seen most obviously through the multiple roles that
beaches perform: coastal property protection; environmental services; use for residents and visitors; economic benefits; as well as the cultural and spiritual significance of the coast to many people. The interconnectedness of the coast means that many of the values we associate with the beach are common across uses and user groups – and this makes the coast a highly prized and a highly competitive environment.

With the exception of South Stradbroke Island, the majority of the Gold Coast’s beaches are squeezed between a high-energy ocean and fixed property boundaries along much of the coastline. The interruption of natural processes caused by development within the active coastal system, including coastal protection measures, means that beach systems do not have the flexibility to ‘wobble’ (naturally erode and accrete) under changing conditions over time. If Gold Coast beaches aren’t actively managed then we can expect the quality of our public coastal assets (beaches) to decline. This degradation will be exacerbated through the impacts of climate change, storms and cyclones and this will have socio-economic and environmental consequences for the community, the city and the region.

The studies by Maitra and Walker (1972) and Raybould and Mules (1998, 1999) underscore the economic importance of the Gold Coast beaches to the tourist economy. Since the early 1980s, the Gold Coast has diversified its tourism product and while the beaches are still important to the tourist industry, they are not the sole lifeblood that they once were. In the past 35 years, however, the Gold Coast population has increased from approximately 60,000 to over 500,000. In 2006 - 07 the Gold Coast had the largest growth of all LGA’s in Australia (Australian Bureau of Statistics, 2008b) and forecasts are for the city to remain one of the fastest growing regions in Australia over the next 20 years. While the value of the beach to local residents was acknowledged in these studies, until recently we knew very little about this important issue.

The 2008 studies (Lazarow, 2008; Raybould & Lazarow, 2008) made a significant contribution towards improving our understanding of both resident and visitor use of Gold Coast beaches as well as expenditure related to accessing the beach and specific recreational activities such as surfing. Raybould and Lazarow (2008) estimated that in 2007 Gold Coast residents were estimated to have made approximately 40 million trips to the beach and foreshore, possibly spending as much as $91 million in accessing the beach and foreshore. In 2006 tourists were estimated to have made a further 7 million visits to the beach and foreshore and may have spent as much as $319 million in accessing Gold Coast beaches, or between $15 - $45 per visit. As an individual user group, surfers were estimated to have participated in between 6 and 15 million surfing sessions in 2007. The report into the socio-economic impact of recreational surfing on the Gold Coast found recreational surfing to be of immense value. A conservative estimate of the annual gross market expenditure related to recreational surfing on the Gold Coast is $126 - $233 million. According to the study, the total value of the surfing industry to the Gold Coast is likely to be much greater. Activities such as recreational fishing, diving and boating further add to the value of outdoor coastal-based recreational activities in this area. There can be no doubt that market expenditure by beach goers on the Gold Coast is significant, however, as in California, the non-market value of our beaches could be substantially higher.

In an interesting study that attempted to estimate the loss to both the State and US economies should beaches cease to exist in California King and Symes (2004) argued that with no beaches, California, with a population of approximately 36 million, would lose $US5.5 billion in Gross State Product annually, while the U.S
economy would lose $US2.4 billion in Gross National Product annually. The authors suggest that while there would be some substitution amongst users of other beaches within the USA, there would still be significant losses to both the Californian and national economy as ‘beach lovers’ seek out ‘beach’ experiences in other regions and countries. The direct losses in annual tax revenue to California are reported by King and Symes to be $US509 million compared to an estimate of $US12 - $US18 million per year for shore protection works. The concept of substitution in this form, however, has been challenged by Buckley (pers. comm. 2007), who suggests that over time a different type of recreational user is likely to replace the ‘lost’ beach user resulting in much lower levels of substitution and economic losses (Lazarow et al., 2007b). It is worth noting that shore protection works may have a negative effect on some users and on environmental quality. Further, given some uncertainty relating to natural processes and climate change, the high ongoing maintenance costs of many projects may even provide a false sense of security about the medium-to-long-term health of beaches within urbanised areas. This poses an interesting set of challenges for GCCC, which, along with most other coastal LGA’s,

“faces the challenge of accommodating rapid urbanisation and balancing demands associated with economic development, social well-being of the community and maintenance of a healthy and sustainable environment.”
(Government of Queensland, 2001, p. 7).

5.4.1 Setting priorities for coastal management on the Gold Coast

Understanding and clearly articulating the total economic value of the coast can help drive the vision for coastal planning and management and provide a rational basis for government decision-making. The Delft Report (1970) recommended a program of works that included both capital infrastructure and beach nourishment for Gold Coast ocean beaches. The primary purpose of the infrastructure (mainly groynes) was to hold sand on beaches. Sand was intended to serve as a coastal protection buffer as well as providing the venue for recreation for residents and visitors.

“Ocean beaches are a valuable recreation asset for local residents and are an important part of the tourism product for many resort destinations. Loss or damage to them, whether caused by human disasters such as oil spills, or natural disasters such as cyclones, results in diminished utility for users” (Raybould & Mules, 1999, p. 121).

The study by Raybould in 2005 demonstrated that residents are deeply concerned about the issue of beach erosion on the Gold Coast yet, for a number of reasons, were unwilling to pay for beach protection measures. In order for a respondent to be willing-to-pay for a beach protection measure, they needed to: value the resource; believe the proposed solution would be effective; be able to pay; and they needed to accept the decision-making mechanism and the political process (Raybould, 2005). This suggests that ongoing community consultation and mechanisms to incorporate local knowledge into decision-making must be vital components of the Gold Coast’s coastal management program. Community consultative committees at Palm Beach and Currumbin are examples of where this approach.

While many residents and visitors take the existence of our beaches for granted, the cost of a 1 in 50 year storm to the Gold Coast is likely to be hundreds of millions of dollars and the repair bill for Gold Coast beaches will be many millions of dollars. It is conceivable that with high costs and limited options (i.e. coastal retreat is not really an option), residents and industry alike should be prepared to debate the type of quality they expect from their beaches. For example, if adequate public funding is not
available, should some beaches be left to natural processes while other ‘pockets’ are protected? If so, on what grounds should we make such decisions? Beach concessions on Gold Coast beaches for many decades suggest that there is a precedent for business to be involved in the use of the beach and they could have a role in the management of the city’s beaches. There are also legal requirements for landowner’s along the coast to ensure that their property is protected by a seawall. In other parts of the world, industry has stepped in where government has not been willing or able to pay for beach protection works. If this happens on the Gold Coast, what will this mean for public ownership and access rights to beaches?

5.4.2 A mandate for beach management

GCCC’s approach to beach management over the past 35 years has been to manage the beaches in a fashion that is as close to natural processes as possible. When viewed in concert, the reports that supplement the GCSMP suggest that with few exceptions there is indicative support for GCCC’s coastal management program. That is, there is broad support for a soft (sand nourishment) approach to coastal protection.

The challenge of incorporating predictions for climate change and variability brings with it of course a discussion on how we should manage our coastal resources into the future. Predictions are that we are moving into a period of greater storm activity (Helman and Tomlinson, 2008), similar to that of the late 1960’s and early 1970’s. These natural events may be compounded by the impacts of anthropogenic driven climate change, including sea level rise and frequent and more severe storms. Without the flexibility to ‘wobble’, Gold Coast beaches will continue to require active management or they will degrade and disappear. It is often argued that the number one priority for the Gold Coast is to make sure that there are beaches. Then, and only then, is it possible to have a debate about what type of recreational or environmental services beaches provide.

However, community concern about coastal management programs at Narrowneck (perceptions of a failed surfing reef); Palm Beach (threat to Palm Beach Reef and surf quality); Currumbin (loss of amenity); The Spit (loss of public space, access and amenity); and Coolangatta Bay (loss of Kirra Reef, loss of amenity) suggest that we need a better understanding of the competing and potentially conflicting uses and how best to manage the beaches for the public good. In other words, we need to be paying closer attention to how the beach is managed. The results of the Beach Health Report suggest that a management approach that trades off coastal protection benefits against environmental and recreational benefits is not wholly acceptable to the community and should be revisited. This may well have financial benefits for the coastal management program. For example, in the Shrapnel Report (Maitra & Walker, 1972), GCCC made an unsuccessful attempt to secure funding from the Federal Government for beach protection and repair, which was caused by the 1967 cyclones (1 in 50 year event). The business case was based on the importance of the beaches to the tourism sector. An improved understanding of the socio-economic value of the city’s beaches to residents, visitors, the economy and the environment may provide a more compelling case for public funding from the Federal Government, should it be required in the future. The current level interest and investment by the Federal Department for Climate Change on the impacts of climate change on coastal cities suggests that such an approach is likely to be more successful than an approach that focuses exclusively on coastal protection.

The Shoreline Management Plan recommends a forward program of capital works and that where possible, the city adapt for expected changes in sea level rise and
predicted increases in the frequency and intensity of storms and cyclones. The 10-year capital works program to support the management of Gold Coast beaches so that they protect our coastline as well as continue provide recreational amenity and environmental services is costly and there remain significant uncertainties in dealing with a system that while actively managed, is still dominated by natural processes along a high energy coastline. This chapter provides evidence of the benefits to the community, the city and the region from having well-managed beaches. These benefits are believed to significantly outweigh the costs of funding an adaptive coastal management program.

5.5 Chapter summary

The chapter commenced with an outline of coastal resources and assets and a description of how we traditionally value the coast. This was followed by an overview of what is known about the economic value of the Gold Coast’s beaches. Our formal knowledge has been gained through a number of investigations as well as the practical experience of actively managing Gold Coast beaches for over 40 years.

Traditionally we’ve viewed the coastal economy in term of market values, however, incorporating non-market values, which may have a value substantially greater than market values, can assist us in capturing much of the total economic value of coastal resources.

Beaches perform a number of important functions on the Gold Coast: coastal protection of public and private property; environmental services; use for residents and visitors; economic benefits; as well as the cultural and spiritual significance of the coast to many people. The interconnectedness of the coast means that many of the values we associate with the beach are common across uses and user groups – and this makes the coast a highly prized and a highly competitive environment.

Cyclones and large storms can have a significant economic impact on the coastal economy – the cost to the economy as a result of major events is estimated to be hundreds of millions of dollars. Coastal protection projects are likely to be valued more highly if several events are experienced in the early years after the project has been completed.

To date, the financial responsibility for managing Gold Coast beaches has been split between the State and Local Government (with the exception of the TRESBP, which is 50% funded by the NSW Government) on a project basis.

Until recently, large gaps in our knowledge of beach use and value has meant that advocating for increased funds for coastal management and protection of the Gold Coast beaches has sometimes been difficult, even at the local government level. A better understanding and a clear articulation of the value of the coast can help drive the vision for coastal planning and management and provide a rational basis for government decision-making.

Note:

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# Appendix A

## Gold Coast City Council
### Beaches and Waterways

Dune Maintenance Program
Dune Assessment Form

## General

<table>
<thead>
<tr>
<th>Date:</th>
<th>Time:</th>
<th>Name of Assessor:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Beach:</th>
<th>Northern End:</th>
<th>Southern End:</th>
<th>Area (m²):</th>
</tr>
</thead>
</table>

## Management Unit

<table>
<thead>
<tr>
<th>Major Public</th>
<th>Minor Public</th>
<th>Urban</th>
<th>Non-Urban</th>
</tr>
</thead>
</table>

## Erosion Risk

<table>
<thead>
<tr>
<th>Is natural rock present?</th>
<th>Yes / No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is a boulder wall present?</td>
<td>Yes / No</td>
</tr>
<tr>
<td>Is the boulder wall exposed?</td>
<td>Yes / No</td>
</tr>
<tr>
<td>Is there a hind dune area present?</td>
<td>Yes / No</td>
</tr>
<tr>
<td>Is there headland or offshore protection present?</td>
<td>Yes / No</td>
</tr>
<tr>
<td>Does a canopy exist to break the wind and drop sediments?</td>
<td>Yes / No</td>
</tr>
</tbody>
</table>

Estimate dune height compared to the road level?  
(eg +1 is 1 m above road level, -2 is 2m below road level)

Estimate distance from landward end of beach access to seaward edge of vegetation. (m)

Estimate distance from seaward edge of vegetation to beach berm. (m)
Estimate distance from seaward edge of vegetation to waterline. (m)

Total number of beach access ways.
Number of official access ways.
Accessways per metre of beach.

What type of fencing is in place?  
Fully fenced | Side fencing | Rear fencing | Front fencing
Condition of present fencing:  Good  •  Minor repairs needed  •  Needs replacing

| Erosion Risk Factor: | Very high | High | Medium | Low |

**Environmental Value**

Do the dunes link up with any other vegetated corridors?
If so, which ones?

Is there any pollution or debris at the site? (i.e., grass clippings, rubbish, etc.)

**Plants**

Is there any dead vegetation spotted? (give approximate positioning)

Is a monoculture present?
What is the dominant species?

What dunal zones are present?
Pioneer  Woodland/Scrub  Forest/Heath

Percentage coverage of weeds:
What weeds are present?

**Animals**

Were any animals sighted?
If yes, what were they?

What potential habitats are present?

What food sources for native fauna are available?
Environmental Value Factor:

Very high  High  Medium  Low

Community Issues

Do the dunes abut private or public land?

Dunes abutting public land have priority for Council funded maintenance.

Private landholder may get permission from Council to do maintenance works.

What division is this area within?

Do the dunes appear neglected?

General dune appearance and visual quality:

Very appealing  -  Appealing  -  Moderate appeal  -  Poor appeal

Are filtered views available at ground level?

What are the local community's views on dunal vegetation?

Have there been complaints about the dunes at this beach?
If so, please describe the issues.

How many people using beach?

How many towers within the area?

How many large buildings back onto the area?

Is there a main road leading to the access?
Community Issues Factor:
(Desire for maintenance)

<table>
<thead>
<tr>
<th>Very high</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
</tr>
</thead>
</table>

Sketch the beach and dunal area in question

Plan View

Profiles
Gold Coast City Council
Beaches and Waterways
Dune Maintenance Program
Assessment Method

Officer: Greg Stuart

The state of the dunes need to be assessed to determine the priority areas for maintenance.

There are a number of issues to consider when making such an assessment. The dunes are to be judged on the following criteria:

<table>
<thead>
<tr>
<th>Erosion Risk (R)</th>
<th>Environmental Value (E)</th>
<th>Community Issues (C)</th>
</tr>
</thead>
</table>

The associated Dune Assessment Form elaborates on these criteria with the types of questions that should be asked. This section will show how to combine the answers to these questions as factors for each criteria that will be combined to create a ranking for each dunal area.

Criteria for assessment

Erosion risk
A yes answer to all the yes/no questions will lead towards a low erosion risk. The higher and wider the dunes and beach are, the less risk there will be from erosion. Too many uncontrolled access paths will lead to a greater risk of erosion. The higher the erosion risk, the higher the priority for maintenance.

Environmental value
Vegetated links from the dunes to other natural areas reduces the environmental risk. Any pollutants or debri dumped at site may adversely effect dunal vegetation. Dead vegetation may need to be extracted or replaced as it may cause harm to humans and animals. A range of native species and dunal zones reduces the environmental risk. Low weed coverage reduces the environmental risk. The presence of animals, animal habitats and food sources reduces the environmental risk. The higher the environmental risk, the higher the priority for maintenance.

Community Issues
Dunes abutting public land have priority for Council funded maintenance. Private landholder may get permission from Council to do maintenance works. If filtered views are not present it is likely that the public will provide there own. If the dunes are full of weeds or look messy and un cared for the public will not value them. The public and Councillor views on the look and existence of dunal vegetation are critical.
A very high rating means that the public desire maintenance to be done on their dunes now. A low rating means that the public are happy with the dunes as they are.

Overall Dune Maintenance Rating

To determine the overall rating you need to combine the factors on the Dune Assessment Form. Each factor has an equal weighting.

<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>E</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>High</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Medium</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Low</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Overall Rating = (R + E + C)/3

Example:
After an inspection of the dunes between Tallebudgera Ck and 23rd Ave, Palm Beach the following factors were derived.

R 1
E 2
C 2

Therefore the overall rating is \((1+2+2)/3 = 1.67\)

All the beaches that have been assessed should then be ranked and added to the Dune Maintenance Program

A high value for the overall rating means that the dunes are in a good condition.

Example:
Palm Beach with a rating of 3.5, would be a lower priority on the list than Broadbeach with a rating of 1.5

The criteria for assessment is in tune with information taken from the following journal article, referenced as: