Bringing Back the Bay
Marine Habitats and Water Quality in Georges Bay

R. Mount, C. Crawford, C. Veal and C. White
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The Tasmanian Aquaculture and Fisheries Institute and Break O’Day Council have attempted to ensure the information in this report is accurate at the time of the survey. Habitat distributions, particularly seagrass, can vary seasonally and between years, and readers should not rely solely on these maps for decisions on current distributions.

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1. Project Summary

- **Background**

Georges Bay is an excellent example of a wave-dominated estuary with classic features including the barway, a long entrance channel, a well-developed flood tide delta, a deep main basin and large active riverine deltas. The bay is used for a variety of activities including marine farming, recreation, tourism and marine industries. It is also valued for its vibrant ecology and beautiful scenery. While the ecology of the bay is regarded as moderately degraded by human use pressures in terms of its conservation significance (Edgar et al., 1999), maintenance of good water quality and continuing ecological health and productivity is essential to preserving the excellent natural assets of Georges Bay and the sustainability of the Bay community.

The Northern Tasmania Natural Resource Management Strategy (2005) identifies the collection of baseline and monitoring data on coastal and estuarine habitats and water quality as a high priority Management Action (MAM8). The identification of appropriate indicators for sustainable management purposes is also highlighted.

This report presents detailed results from field surveys over the past year that have mapped the benthic habitats of the bay including the seagrass and unvegetated habitats. The report synthesises information relating to water circulation, sediments and water quality and makes recommendations regarding suitable monitoring programs. There are also sections that provide a background on the geological and human history of the region including the land uses within the bay’s catchment.

- **Physical and Human Setting**

Human pressures on the bay are also addressed and a summary of the legislation that relates to the bay is included. A separate report by Crawford and White (2005) details the water quality information available for the bay and recommends a water quality monitoring framework.

Georges Bay is an extensive waterway at the mouth of the George River that provides a sheltered location for a small port and numerous marine activities. The catchment of the bay is 557 km$^2$, which is small to medium sized in a Tasmanian context. Land use in the catchment is dominated by forestry and agricultural activities, with more intensive residential and industrial uses clustering around the estuary itself (Fig. 1.1).

The surface area of the bay is about 17.9km$^2$, of which 4.4 km$^2$ is Moulting Bay. During this study any reference to Georges Bay will include Moulting Bay unless otherwise specified. There is an oceanic (Tasman Sea) influence on the bay, which is mostly dominated by the East Australian Current (EAC), though the long entrance channel restricts the flow of water.

The recreational activities in the bay include boating, swimming, fishing and sailing, and the bay also provides a base for tourism based fishing and diving operations with launching and servicing facilities. Georges Bay is a major port on the east coast for commercial fishing and, within the bay, shellfish farming is a significant commercial activity. The bay also receives sewage and various forms of catchment and stormwater runoff (Fig.s 1.2 and 5.1).
Fig. 1.1. Conceptual diagram of Georges Bay showing major features in the Bay and catchment.
Fig. 1.2. Conceptual diagram of Georges Bay showing major features of the ecology of the Bay and catchment activities.
Circulation

The fresh and marine waters of the estuary are generally well mixed, although Moulting Bay at the mouth of the George River and the inner harbour near Medeas Cove often have a freshwater layer near the surface. During large floods, the bay is subject to higher freshwater influence, to which significant impacts on aquaculture have been linked. These impacts are partly explained by the relatively small amount of water exchanged during each tidal cycle. Winds, including the sea breezes, can also influence the movement of freshwater within the bay. For example, freshwater from the George River may be driven into the Moulting Bay by a south easterly.

Current speeds and direction are complex and can vary considerably throughout the bay. There is a clear flow back and forth along the main entrance channel, with flow rates between 31 and 23 centimetres/second (cm s\(^{-1}\)). Average current flows within the bay as a whole are about 8 cm s\(^{-1}\), while the current speeds in Moulting Bay are low at about 1 cm s\(^{-1}\).

The water circulation patterns of Georges Bay have important influences on the structure and ecological functioning of the bay, including on the water column, the benthic habitats and sediments. Further work would support an improved understanding of the way the bay is behaving, especially around sewage and stormwater outfalls and the river mouths.

Nutrients and Water Quality

Ensuring good water quality is a critical factor to maintaining the health of estuarine ecosystems. The nutrients and turbidity that affect water quality are mostly generated from point and diffuse sources, such as stormwater outfalls, sewage treatment plants, surface runoff from the catchment and direct industrial discharges.

Nutrients have not been routinely sampled in Georges Bay. Monthly sampling for 11 months in 1993/94 and more recent periodic sampling in 2004/05 in the bay has shown that nitrate plus nitrite values are variable, with higher concentrations generally in winter months and at the mouth of the bay. However, higher concentrations were recorded at the Bridge in St Helens on most sampling occasions in 2004/05. Ammonium levels were mostly at or below the minimum detection limit of the analysing equipment, although high peaks were occasionally recorded. Phosphate levels were generally highest at the marine station. Overall, nutrient levels were low, except for occasional high peaks. However, very little sampling has been conducted after heavy rains and flood events, which is when major influxes of nutrients into the bay are expected.

To enable the development of appropriate water quality guidelines and objectives, water quality indicators consistent with those collected throughout the state are required. Monitoring of these indicators should begin as soon as practicable.

Seagrass

There are two species of seagrass known from Georges Bay; *Zostera tasmanica* and *Zostera muelleri*, which look very similar to the naked eye. However, generally only *Zostera muelleri* is found in the intertidal zone.
The seagrass in Georges Bay is very abundant at present (688 Ha) and has been consistently so for the past 3 to 5 years. When compared to previous mapping done for circa 1950 and circa 1990 (Rees, 1993), there is substantially more seagrass present in the bay, notably in the very shallow nearshore areas. The level of epiphyte abundance was also found to be generally low, though the deeper fringes of the seagrass beds often had higher loadings, as did the seagrass on the basin face of the flood tide delta.

Seagrasses only grow to depths where they can obtain sufficient sunlight for photosynthesis. As the amount of light reaching the sea floor is largely controlled by the water clarity, the depth to which seagrass grow is an approximate indicator of the average water clarity conditions in the immediate area. The seagrass grows to a maximum depth of about 6.25 m along the southern shores of the bay and at McDonalds Point. The shallowest maximum depths are found in the inner harbour (about 2.7 m) area and Moulting Bay (about 3.4 m) (see Fig. 7.7).

Seagrass extent is the highest ever recorded. The reasons for the fluctuating abundance of seagrass are not clear. Threatening processes for seagrass are increased nutrient and sediment loadings, as well as reduced water clarity and direct disturbance. A monitoring program is critical to increase understanding of the causes of seagrass expansion and contraction. Now is an ideal time to begin such a program.

- Sediments

The rate of sedimentation in Georges Bay is not yet quantified, though it a critical aspect of ecological health in the bay. Estuaries are areas where sediments tend to be deposited. The rate of sediment delivery varies with both natural and human influenced processes. In drier times, the sediment loads are generally greater as plant growth is reduced and more sediment is available for transport. Most sediment is moved during storms and floods.

In the Georges Bay catchment, one of the most significant factors affecting sediment loads into the bay is the very large “slugs” of material produced by the historic tin mining activities in both the George River and Constable Creek/Golden Fleece Rivulet catchments. This material is likely to continue to arrive at the estuary for many decades.

Further research into both the effects of the sediments and how to minimise the detrimental effects is required to determine suitable management actions.

- Unvegetated Habitats

Unvegetated habitats such as mud and sand constitute about 60% of Georges Bay’s benthic habitats. Unconsolidated sand and siltym sand bottoms make up about 30 % of the area, while mud (silt and clay) make up the remaining portion apart from about 3% consisting of shelly banks or hard packed sand and shell. Typically, the sediment becomes siltier with increasing depth, while the areas subject to water carrying higher energy levels (waves and currents) tend to consist of larger particles. These areas include the main entrance channel, the flood tide delta, the river deltas and the beaches along the southern shores.
A great many species make use of the unvegetated habitats and recent research shows that many of the preferred recreational and commercial fish species utilise these areas for reproduction and feeding. There are very large numbers of native oysters inhabiting the silty sand areas in a zone just below the deep edge of the seagrass beds throughout the bay. The other species living in these areas also contribute to the overall health of the bay by forming an important part of the food chain and recycling nutrients. The condition of the unvegetated habitats is not adequately understood. Further work is recommended to investigate the extent and condition of the habitat.

- Ecological Health: Monitoring and Management

The activities of people as they go about their daily business do affect the ecological functioning of the bay, directly and indirectly. The report outlines some of the ways that these impacts occur and provides directions for improving the information feedback on the critical issues via monitoring. The associated report, *Establishment of an Integrated Water Quality Monitoring Framework for George Bay* (Crawford and White, 2005), sets out a detailed action plan for the monitoring water quality.

- Management Issues

There are a large number of government policies and legislation that cover Georges Bay and its management, including Australian, State and Local government. The new Natural Resource Management Framework and Strategy seeks to provide a mechanism for coordinating and integrating priorities and management action, while at the same time not adding a further layer of governance. An understanding of the regulations and jurisdictional issues is valuable when addressing management issues. Many of the relevant government controls are detailed in this report to assist this process.

- Environmental Issues of Concern

The key issues of concern identified for Georges Bay are as follows:

- The delay in upgrading the St Helens Sewage Treatment works.
- A lack of a standard water quality monitoring framework.
- The Protected Environmental Values (PEVs) are not yet established and the associated setting of Water Quality Objectives (WQOs) is yet to occur.
- Stormwater impacts are unquantified.
- Sedimentation rates are unknown.
- Some septic tank effluent on the southern shores of the bay.
- Information resources relevant to the monitoring of ecological health are dispersed and patchy.
- There is a lack of resources regarding the development of programs that foster education and participation, particularly in relation to the health of the bay.
- The impact of incremental planning decisions on the ecological functioning of the bay is not well understood. It is an issue of concern that while each decision is assessed on its merits, the accumulated impacts are not. Analysis of the combined results of these planning decisions could assist in informing future land use decisions.
2. Georges Bay Study

2.1 Current Study

2.1.1 Background

This study was commissioned because of a perceived need by the Georges Bay community to better understand the physical and biological conditions of the Bay. The study was also needed to assist the establishment of long term monitoring stations at specific locations around Georges Bay to facilitate a long-term community program investigating the health of the Bay. Georges Bay has a range of uses and values, such as shellfish farming, marine industries, recreational activities and tourism, and its continued ecological health and productivity is essential for the long-term viability of these activities.

A consortium of Break O’ Day Council and local aquaculture operators identified the need to map and monitor seagrass beds and their adjacent habitats in Georges Bay. The need for consistent and comparable information about water quality conditions in the Bay was also noted, recognising that this could further assist environmental management planning.

The environmental quality of the waterway was identified as a key factor contributing to the quality of life for the Georges Bay community. A range of contentious land and marine planning issues has surfaced over recent years with significant economic and ecological implications.

Comprehensive habitat and water quality information can provide an improved basis for environmentally sustainable resource management in the region. It is essential that Break O’Day Council and State Government Departments responsible for assessing development proposals that may impact on the ecological health of the Bay have access to current information on its ecology and develop indicators and targets to assess ongoing management practices.

Seagrass and water quality are recognised nationally as key indicators of estuarine health (Ward et al. 1998). The waters of Georges Bay are potentially effected by natural events, such as flooding of the George River, and anthropogenic inputs from the township of St Helens. There are concerns about the seagrasses in the bay, some of which were triggered by the apparent loss of seagrass beds between 1950 and 1990 reported by Rees (1993), and some also expressed about the perceived increase in seagrass abundance in recent times. The previous seagrass mapping in the bay was conducted in the early 1990s, and it was limited in spatial coverage and mapping accuracy (Rees, 1993). As such, there is some uncertainty over the extent of loss previously identified and a need existed to assess its current distribution with improved mapping technologies and techniques. Given that increased nutrient levels and turbidity have been shown to play a prominent role in the decline of seagrass beds, an assessment of the water quality conditions in Georges Bay was also identified as an important component of the study.

2.1.2 Study objectives

The objectives of the study were to:

- map existing areas of seagrass, macroalgae and unvegetated habitats
- assess water quality conditions
• identify and establish representative long-term monitoring sites
• publish a community oriented information booklet on the ecology of the Bay
• incorporate habitat information within the Strategic Management Plan
• compile a spatial database (GIS) for all seagrass and adjacent habitat types and publish maps on the Break O Day Council internet site and Australian Coastal Atlas
• communicate findings to stakeholders and the community
• identify and establish monitoring sites and protocols that would encourage community participation in future ongoing data collection
• provide information to the Break O’ Day Council to assist in land use decision making and revision of the Break O’ Day Planning Scheme.

This report details the results of field surveys of water column nutrients, sediments and benthic habitats (seagrass, reef and unvegetated) in Georges Bay. It provides information on the geological and human history of the region as well as current uses and significant ecological features and values of the bay. Also included is information on monitoring the ecological health of the bay as well as managing and reducing human-induced environmental pressures. Recent changes to components of legislation relating to planning and management issues in coastal waters such as Georges Bay and its catchment are also detailed. The range of ongoing studies occurring in the Georges Bay region and requirements for monitoring and management recommendations are outlined.

2.2 Previous Studies
A number of research and planning studies have been undertaken on the marine environment of the Georges Bay. These have examined specific issues relating to hydrology, environmental conditions at marine farming sites and management and planning issues. Many of these have identified a considerable lack of information on ecological aspects of Georges Bay, including habitats, nutrients, sediment condition and marine pests.

This section summarises earlier research and management reports relevant to this study, to provide background information and identify reports that may provide further information.

2.2.2 A Classification of Tasmanian Estuaries and Assessment of their Conservation Significance using Ecological and Physical Attributes, Population and Land Use (Edgar et al. 1999)

This study investigated 111 estuaries around Tasmania collating data on their physical and biological characteristics and level of anthropogenic disturbance using human population density data to determine their conservation significance. The report focused its data collection on: salinity, rainfall, geology, geomorphology, tidal range, aquatic plants, aquatic invertebrates, aquatic vertebrates, introduced species, biodiversity and productivity. The data was examined at a community level and took into account the affect of human influence and density on the catchment. The collated data was then used to grade estuary health based on each estuary’s significance as a biologically pristine and sensitive waterway. Due to the high level of human presence in the Georges Bay catchment it was classed as a degraded estuary, Class D conservation significance. The report highlighted the presence of the introduced bivalve *Theora*
lubrica, but also found a high species richness of Georges Bay.

### 2.2.3 Physical and Chemical Parameters of Several Oyster Growing Areas in Tasmania (Crawford & Mitchell 1999)

This study investigated the physical and chemical parameters of several areas in Tasmania, including Georges Bay in an effort to determine the carrying capacity for oyster farming. Valuable environmental data was collected, including information on hydrodynamic regimes, temperature, salinity, nutrients and chlorophyll a. Georges Bay is relatively productive compared to other estuaries, particularly considering the low flushing rate of Moulting Bay. The input of nutrients from the George River and the sewage treatment plant were cited as possible reasons for this productivity.

### 2.2.4 North Eastern Rivers Environmental Review (Koehnken, 2001)

This report provides a review of a large number of variables for many of the rivers in the north-east, including the George River. Information on the natural environment, land and water use, and anthropogenic inputs in the catchment was collated and summarised. Potential water quality issues in the George River catchment were identified, including uncontrolled stock access, septic tanks too close to the river, dairy effluent entering waterways, weeds in the riparian zone and past mining activities at the Anchor mine site.

### 2.2.5 Oyster Health in Georges Bay (Percival et al. 2004)

This report was compiled in response to concerns by oyster farmers regarding an increase in oyster health problems. It includes a comprehensive collation and analysis of historical data, including water quality information. The report suggested that there was no apparent single cause of oyster health problems in Georges Bay. Instead, the report cited numerous factors that may have the potential to contribute to oyster health problems, such as:-

- Extended periods of low salinity
- High turbidity impacting on phytoplankton abundance, speciation and oyster feeding rates
- Toxic phytoplankton
- Contamination of water by forestry, industrial, urban and/or agricultural chemicals
- Contamination of sewage

The report also made recommendations for future investigations such as:-

- The development of a structured, cooperative and coordinated approach to future investigation, including as many stakeholders as possible
- Linkage with the Natural Resource Management (NRM) project being coordinated by the Georges Bay Water Quality Committee
- Targeted investigation program comprising of an initial broad scale pilot program including an audit of chemical usage in the George River catchment, followed by a more focused ongoing project
- Preparation for timely structured investigation of flooding events
- Collection of appropriate and uniform production data by oyster farmers
- Research trial investigating the effects of salinity, temperature and suspended solids on oyster health
• Investigation by farmers of ways to minimise stress at handling and during flood events
• Seek to remedy any unacceptable inputs into Georges Bay and the catchment area

2.2.6 Environmental Problems, Georges Bay, Tasmania (Scammell et al 2004)

This study investigated the $1.6 million mass mortality of commercial oysters in Georges Bay following the February 2004 flood event. A 100 year record rainfall of 234 mm of rain was recorded at St Helens Post Office and 284 mm at Pyengana between the 27th to the 30th of January 2004. The report presents arguments that this amount of rainfall alone could not be responsible for such recorded mortality of not only oysters, but other intertidal and sub tidal species. The report details the crash of a forestry aerial spraying helicopter in the Georges Bay catchment prior to the flooding event. The helicopter was carrying a 29kg payload of alpha cypermethrin, a biocide that is toxic to aquatic ecosystems at 4 µg/L. The report investigates the link between the two events and the reasons behind such findings.

2.2.7 DPIWE response to the Scammell report (DPIWE, 2004).

A strong case was presented that challenged many of the assumptions and findings of the Scammell report, including the unlikelihood of the biocides entering the waterways that deliver into Georges Bay as they exhibit strong adsorption to clay particles. Further arguments and studies were presented against the view that alpha cypermethrin would remain only on the water surface and not mix into the water column.

2.2.8 Management Plan for the Moultine Bay Growing Areas (DHHS, 2003)

This report prepared by the Tasmanian Shellfish Quality Assurance Program (TSQAP) outlines the management strategy for each of the five shellfish lease zones in Georges Bay. All oyster leases in Georges Bay are classed as Approved Conditional, meaning that they can be subjected to intermittent, yet predictable pollution events, and have appropriate management programs in place to eliminate the risk to the consumer. The Georges River has been identified as the most significant source of faecal contamination in the growing area. Closure of farms can occur when critical values of rainfall or salinity are met or exceeded, or when biotoxins (toxic algae) and sewage treatment malfunctions are detected. Reopening only occurs when TSQAP confirms conditions are suitable.

2.2.9 DPIWE toxicology reports on water samples from the George River catchment. (Analytical Services, 2005)

Water sampling completed by DPIWE in February 2005 at six sites in the Georges River catchment were submitted to analytical services for chemical and toxicological examination. The samples collected included a four samples from the surface film/layer of the George River. No pesticides were detected in any of these samples, although naturally occurring compounds, including terpenes and fatty acids, were recorded. These compounds have the potential to be toxic to the cladoceran Daphnia magna. Levels of dissolved aluminium (Al) and less often, iron (Fe), were also observed in high concentrations.
3. Physical and Human Setting

3.1 Location

Georges Bay is a relatively deep estuary located on the northeast coast of Tasmania at 41°19’S, 148°14’E, approximately 93 km east of Launceston and 190 km northeast of Hobart. The bay is open to the sea through a long narrow channel and bar way. The bay has a surface area of 17.9 km², of which 4.4 km² is the shallow Moulting Bay embayment (see Figure 3.1). The township of St Helens is located at the head of the bay, with Medeas Cove to the south west of the township. St Helens sits at an elevation of 5 metres above sea levels and is bordered to the north by the George River, which is the primary freshwater input into the bay.

Fig. 3.1. Locality map of the study area: Georges Bay, Tasmania
3.2 Ocean Influences

Georges Bay is very sheltered from oceanic influence due to the 5.0 km long, shallow channel that has formed at the mouth of the bay. The large sand spit (including the Peron Dunes), formed as a result of water and air
driven deposition of sediments on a sub surface granitic ridge (Sloane 1974). The movement of sediments by wind and tidal action in the area is also responsible for the bar way deposition at the mouth of the bay.

3.3 Geology

The Georges Bay catchment region is composed predominantly of granitic rocks of Devonian age (Bird, 2000). The granitic rock within the catchment tends to be dark grey in colour, with the main deposits bearing tin found in the upper Groom-Ransom River system. There are several patches of quartzose sandstone, known as Mathinna beds, situated to the north east of St Helens. There are also scattered occurrences of younger basalt, mainly on hill tops (Bird, 2000).

Large volumes of Tertiary conglomerates, mainly mixed sands and clays, can be up to 80 metres thick around the St Helens region. These sediments are derived from the infilling of former river valleys and have a series of topographical surfaces relating to Tertiary sea level at the time of deposition (McClenaghan and Williams, 1982). A summary of the geological history of the Georges Bay catchment region is given in Table 3.1

Quaternary depositional features in Georges Bay are primarily related to outwash sediments from the various creeks and rivers that supply fresh water to the bay. The largest river flowing into the bay is the George River. The George River is a lobate braided delta system that is heavily sedimented with sands and gravel. Two secondary deltas to the south discharge fine sediments in periods of flood. Recent tin mining, deforestation and agriculture up
Physical and Human Setting

Stream have added to the sediment load in the George River resulting in more destructive flooding events with heavy rain. The delta is over 1.0 km wide, with multiple active braided stream systems. The Golden Fleece Rivulet, which drains into Medeas Cove, has also been subject to heavy sedimentation from upstream tin mining operations. Consequently, the lower reaches of the Golden Fleece Rivulet have been modified, with tailings almost filling the marine embayment of Medeas Cove.

<table>
<thead>
<tr>
<th>Age (millions of years ago)</th>
<th>Time Period</th>
<th>Geological Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>410-354</td>
<td>Lower Devonian</td>
<td>Deposition of the Mathinna Beds, consisting of un-metamorphosed sandstones or quartz-wacke and course grained siltstones. Deposition likely to have occurred in high turbidity currents.</td>
</tr>
<tr>
<td>410-354</td>
<td>Upper Devonian</td>
<td>Intrusion of the St Helens Pluton, which originated from the Blue Tier Batholith comprising: granodiorites, adamellites &amp; diorites. The bulk of granitic rocks from this event are generally dark grey in colouration and porphyritic in texture.</td>
</tr>
<tr>
<td>141-1.8</td>
<td>Tertiary</td>
<td>Deposition of sediments resulting from infilling of former river valleys, which were transporting large volumes of Granitic and Mathinna Bed source material. Composed of conglomerates gravels and sands.</td>
</tr>
<tr>
<td>1.8-recent</td>
<td>Quaternary</td>
<td>Quaternary deposits preserve a coastal record of the last interglacial period. Fluvial, aeolian, and marine processes formed these sedimentary rocks.</td>
</tr>
</tbody>
</table>

Table 3.1. Summary of the geological history of Georges Bay from the Carboniferous period to present day from Sloane (1974).

The deposition of aeolian and marine sediments during the Quaternary in the St Helens Conservation Area has partially concealed the remnant shape of a drowned coastline. Since the last glaciation 6000 years ago, the sea level has risen about 150 metres resulting in the deposition of sediments on the large granitic ridge near Akaroa. The sediment accumulation gave rise to a tombolo spit between St Helens Point and Akaroa. The accumulation of sediments on this ridge also generated the Peron Dunes, a large transgressive dune system with elevations in excess of 50 metres above sea level (Sloane 1974).
3.4 Climate

Georges Bay experiences a temperate maritime climate with air temperatures varying from a mean of 11.9°C (min) to 23.0°C (max) in February to 2.5°C (min) to 13.8°C (max) in July.

Rainfall patterns are generally consistent throughout the year, although on average the annual maximums tend to occur in winter and spring and minimums in summer and autumn. The average rainfall in St Helens is 779 mm, though higher rainfall is experienced inland.

The east coast is occasionally subject to very high rainfall events when low-pressure systems are held stationary in the Tasman Sea (Figure 3.4). These systems deliver large volumes of rain-producing moist air over the east coast of Tasmania. In the past five years, two such events have occurred, the most serious of which was in January 2004 when 237 mm of rain fell in one 24-hour period at Gray (a weather station just south of the...
Georges Bay catchment). This led to the flooding of St Helens township and contributed to the $1.6 million loss of oysters in Georges Bay. See Section 4.4 for more details.

Figure 3.3. Climatic means from the weather station at the St Helens Post Office (BOM, 2005).

Fig. 3.4. Synoptic situation on the 29th of January 2004 during the flood at St Helens showing a large low pressure system of the east coast that is delivering moist air to the northern part of the east coast.
Fig. 3.5. St Helens average seasonal wind roses collected from 1957 to present. These graphs summarise over 3000 wind direction records (BOM, 2005).
While Georges Bay is a relatively calm location, the winds display a clear seasonal pattern. The synoptic (large scale) weather patterns mostly generate northwesterly and, to a lesser degree, westerly winds throughout the seasons. However, in summer, and to some extent in autumn and spring, the pattern is influenced by sea breezes, which may arrive from the southeast, east or northeast. The breezes require significant land surface heating to drive their flow from the cooler sea to the land, and the wide flat open river flats of the George River provide the ideal land surfaces. The lightest winds are experienced in the winter months with north westerly and westerly the only two directions that produce any significant wind speeds. The westerly wind systems correspond with the regular movement of cold fronts over the state during the winter months, bringing with it cooler air temperatures and stronger winds. Spring has the strongest seasonally averaged winds, which also have a high degree of variability in direction and strength. This corresponds to the variable synoptic air pressure systems experienced during these transitional months as well as the increasing occurrence of sea breezes.

3.5 Catchment

The catchment of Georges Bay can be divided into the estuarine drainage area (EDA), where water drains directly off the land into the bay itself, and the river (fluvial) drainage area (FDA), where the land drains into the river and then the river empties into the bay. The total catchment area as calculated by GIS is 557 km$^2$ and the EDA is 34 km$^2$ (see Figure 3.6).

![Georges Bay: Catchment](image)
The fluvial drainage area is dominated by the George River, although the Constable Creek and Golden Fleece Rivulet catchments cover approximately 87 km$^2$. In Tasmanian terms, the George is a small to medium sized catchment as the Little Swanport, Prosser and North Esk are all about 1.5 times larger and the combined Swan/Apsley catchment about twice the size.

3.6 Land Use

The majority of the land in the Georges Bay catchment is either private property or state forest. Consequently, land use in the catchment is dominated by forestry and agricultural activities (Figure 3.7). The agricultural areas and associated land cultivation practices are spread along the flats of the Georges River and its tributaries, while the forestry areas are mainly in the surrounding hills and mountains.

Farming activities include cropping, grazing and dairies, with crops including potatoes, peas and onions. These activities are often dependent upon direct water withdrawal from rivers and irrigation schemes (Koehnken, 2001). In some areas where
agriculture is extensive there has been high levels of disturbance to the native riparian vegetation of the George River system (Sprod, 2003). Native riparian vegetation is important in maintaining important ecosystem processes. Consequently, these areas are prioritised for rehabilitation by Landcare groups.

Residential developments in the Georges Bay catchment are clustered around Georges Bay in the St Helens and Akaroa areas.

3.7 Regional Oceanography
The East Australian Current (EAC), which is characterised by warm water, stratification and low nutrient levels, dominates the oceanography of the northern part of the east coast (Harris et al. 1987). The EAC creates consistent temperature patterns (approximately 17°C) with little recycling or movement of nutrients on the shelf.

3.8 Human History
Prior to European settlement the Georges Bay area was home to bands of the North East Tribe of indigenous Tasmanian who hunted and fished on the banks of Georges Bay. Evidence of such activities and diet structure of this tribe have been drawn from various midden sites around the bay and surrounding catchment, some of which are archeologically and culturally significant. Food sources for the band in Georges Bay included shellfish, kangaroos, possums and a mixture of marine and terrestrial vegetables. The area where the St Helens township is now located was once an open dry sclerophyll forest on the edge of a tea tree swamp. The river delta and surrounding plains was a fertile region for band members, with an abundant supply of fresh water and food, which is reflected in the sedentary nature of this band of indigenous Australian.

The first evidence of white men in the area was around 1520 when a Portuguese navigator mapped a small section of the east coast from Cape Portland to Bicheno. It was not confirmed whether the sailors came ashore.

In 1828 the first settlers moved to Georges Bay occupying the land from the George River to the sea. Following this settlement greater numbers began arriving on the east coast due to the prosperous whaling and sealing in the area. In 1868, 20 groups of settlers established farming properties around the base of the Blue Tier, with forestry operations within the area commencing not long after.

Around the same time, the discovery of tin at the base of the Blue Tier heralded the birth of the east coast mining industry. The Anchor Mine, on the headwaters of the Groom River near Lottah, was the most productive, operating almost continuously between 1885 and 1945. Between the mid 1880’s and 1929 when stricter controls for the disposal of tailing were introduced, Bird (2000) estimates that approximately 1.2 million m³ of sediment was deposited on the Goshen floodplain, with smaller amounts at Priory and the George River delta. These floodplains were choked with sediments, elevating bed level and causing increased over-bank flooding and deposition (Sprod, 2003). A degrading of the available waterways drove the decline of the tin industry in the Blue Tier. The water was required in the mineral refinement stage for sorting the ore. The reduction in water velocities made this process much slower and less effective.
The fishing industry began with five metre sail-driven vessels taking very large risks to get their catch and come home over the St Helens Barway. Even though the fish price was low, fish were still loaded into Douglas DC aircraft and flown to the Melbourne Fish Markets for sale the next day. Boom and bust fisheries like scallops were discovered off St Helens in 1974, however these were fished out quickly so the fishery moved further north to the Bass Strait scallop beds. Orange Roughy were fished for some time off the shelf until stocks crashed due to over fishing. Abalone and rock lobster are still fished from these ports today. The tourism market is opening up new opportunities for fishermen, and St Helens is now marketed as the state’s Premier Game Fishing region (Brooks et al., 2001).

SOURCE: The History of St Helens.

3.9 Social Demographics

The township of St Helens and the immediate Georges Bay area has a total population of 383 (Census 2001). The population is comprised of 50.6% females and 49.6% males. The area has a small population that identifies as indigenous (2.4%). English is spoken by 93.6% of the population at their place of residence and 91.5% of the population hold Australian Citizenship. People of 65 years or older comprise 11.2% of the population, with 18.0% of people nearing retirement aged between 50 to 64 years of age. Nearly a quarter of the community (24.8%) is under the age of 15. Of those in St Helens classed as being in the workforce, 93.2% are employed in: primary production (agriculture, fisheries, and forestry), transport, tourism, retail, health and education.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>St Helens</td>
<td>817</td>
<td>1,005</td>
<td>1,149</td>
<td>1,145</td>
<td>1,776</td>
<td>1,800</td>
<td>45%</td>
</tr>
</tbody>
</table>


3.10 Current Uses of Georges Bay

Georges Bay is used for a variety of purposes, including recreational boating, fishing, swimming, aquaculture and commercial fishing operations (both resource and tourist based). It is also a popular tourist destination, with the regions summer time population expanding to over 10,000 people.

Industrially, Georges Bay is used for boat construction and slipping, commercial fleet harbour, as well as acting to assimilate sewage (Fig. 3.12), processing waste and various forms of runoff.

Fig. 3.12. Settlement ponds at the St Helens sewage treatment plant.
3.11 Significant Areas of the Georges Bay Region

- **St Helens Point Conservation Area, St Helens Point.**

The St Helens Point Conservation Area is comprised of 1066 hectares of land containing coastal heath communities and the Peron Dunes. The Peron Dunes are a series of tall sand dunes up to 50 metres high (Sloane 1974), which in the past have been severely degraded by vehicular and foot traffic. The introduction of marram grass (*Ammophila arenaria*), and the gradual return of native grasses to the area is assisting in binding the sand in the dune system, enabling more complex plant communities to establish.

- **Jocks Lagoon Ramsar Conservation Wetlands, Stieglitz.**

Jocks Lagoon is a small shallow fresh water lagoon that is located on the southern side of Georges Bay and listed on the Ramsar Convention on Wetlands. The lagoon forms part of the larger Chain of Lagoons swamp and wetland reserve. The lagoon is 20 metres above sea level and is of significant scientific and social importance, as this type of geomorphic structure is poorly reserved around the state and contains species of high conservation significance. The lagoon is acidic with a pH of 5.5 and is the only identified fresh water site of the dinoflagellate *Prorocentrum playfairi*. The site has two rare floral species, *Baumea articulata*, and *Villarsia exaltata* and also plays host to a range of small sedge land and coastal heath communities. The site is accessible by two wheel drive vehicles or by walking. The land is primarily privately owned with a small area covered under the St Helens Point Conservation Area.

- **Humbug Point Nature Recreation Area, Humbug Point.**

The Humbug Point Nature Recreation Area covers 1,620 hectares of land set aside for bushwalking and bird watching. The coastal heath attracts many heathland and coastal bird species. In the spring the heath blossoms in a spectacular montage of colours, with the yellow flowers of the *Banksia marginata* a common sight.

- **St Columba Falls State Reserve.**

St Columba Falls State Reserve covers 295 hectares of land in the South George River valley. The 4,000 hectare catchment of Mt Victoria above the falls facilitates a continuous flow of water over the 90 metre cliff face providing year long photographic opportunities. The falls also supply water to both the George River catchment, and the now disused water race which once delivered continuous water to the tin mining operations in the area. Situated at the base of the falls in pristine wet sclerophyll forest is a viewing platform only a short walk from the car park.

- **Medeas Cove Wildlife Sanctuary.**

The Medeas Cove Wildlife Sanctuary contains mudflats that support a large range of diversity and life stages of many estuarine species. It is particularly valued for its array of bird life. Silt and clay from mining operations up the catchment largely filled the natural embayment that existed in the early 1900s resulting in the extensive vegetated mud flats that exist today. An infestation of rice grass was discovered in 1997. This was treated rapidly after discovery and at this stage appears to have been successfully eradicated from the area. There is an ongoing monitoring conducted by DPIWE, stakeholders and community groups in the Georges Bay area.
4. Circulation

4.1 Introduction

The physics of an estuary or bay is a primary factor influencing both the biotic and abiotic structure as well as the time-scale in which the system operates. There are many factors that determine the physical make-up of an estuary, including:

- bathymetry (depth)
- geomorphology (shape)
- tidal variations
- rainfall
- freshwater input
- wind stress
- coastal input
- vertical and horizontal temperature and salinity structure.

These attributes all contribute to the horizontal and vertical transport of water within an estuary and ultimately determine the time these parameters remain in the system.

Managing the water and sediment quality in Georges Bay requires an understanding of the relative influence and interaction between these physical parameters. This chapter describes the basic physical parameters of Georges Bay.

4.2 Bathymetry (Depth)

Georges Bay is a relatively deep estuary, generally aligned south west to north east, with a long narrow entrance channel at the northeastern end. Moulting Bay forms a large shallow lobe or arm to the north of the main basin. The maximum depth is about 25 m in the middle of the main estuarine basin near O’Connors Beach, with the rest of the main basin averaging about 20 m (Fig. 4.1).

There are extensive shallow subtidal and intertidal flats in many sections of the bay including the along the edges of the entrance channel and in the Stockyard Flats area. There are further extensive flats around the main river deltas on the northern side of the main basin, as well as Moulting Bay, including Steels Spit. The very large river delta created by the George River (including Hodgman’s Spit and the Colchis Creek and Mosquito Creek deltas), also has a very large area of tidal flats. There is a particularly steep drop off at the mouth of the George River formed by the loosely packed gravels and coarse sands of the river delta.

The south side of the main basin has a mix of gently shelving beaches, including Stieglitz and O’Connors Beaches, and a more pronounced drop off along the Parnella/Dogger Bank shoreline. The very western end of the bay including the inner harbour and Meades Cove is characterised by a series of shallow (less than about 8 m) silty bays with narrow entrances that eventually open into the larger main basin. There are a series of three narrows at the southwest end of the bay. The first set of narrows is Jason’s Gates, followed by Lawry’s Point and the nameless spit on the opposite side of the bay. There is a further narrowing of the main basin another kilometre eastwards, between a protrusion from O’Connors Beach on the south side and, on the northern side, an unusual subtidal mound and the delta near Granny’s Gut. These narrowings reduce the circulation of waters into these inner harbour areas.

The bathymetric map of the bay (Figure 4.1) was generated by TAFI using over 200,000 individual soundings collected during a
series of field visits between 2001 and 2005 using an ES60 single beam sounder. The datum adopted was mean high water (MHW) and the volumes of the bay and the tide (see Section 4.3) were calculated with the digital elevation model (DEM) created from the soundings. Note, however, that soundings could not be obtained over the very shallow areas and the accuracy of the DEM is reduced in those areas.

Fig. 4.1  Depth and shape map of Georges Bay with depth displayed in 1 m interval. Depth is shown in metres below mean high water mark. The line A:A shows the boundary between of Moulting Bay used for volume calculations in this report. Source: TAFI soundings 2001-2005.

4.3 Geomorphology (Shape)
Georges Bay is classified as a wave-dominated estuary, which means that the wave energy is higher than the tidal energy at the mouth (Heap et al., 2001) (see Figure 4.2). This has resulted in the creation of a sand bar at the mouth of the estuary and the flood and ebb tide deltas. This also means that total energy is high at the mouth as the
Bringing Back the Bay

energy from both the waves and the tide are additive.

The OzEstuaries Project facies (substrate component) maps show the various sediments and bottom types and their relationship to the processes that formed them (Heap et al., 2001)(see Figure 4.3). This form of mapping enables estuaries to be compared to each other and to an ideal or pristine estuary. Georges Bay has all of the expected facies for this type of wave-dominated estuary.

![Figure 4.2](image1.png)

**Figure 4.2** A conceptual diagram of a wave dominated estuary (Heap et al., 2001)

![Figure 4.3](image2.png)

**Figure 4.3** Facies map showing the main sedimentary and substrate components of the Georges Bay estuary (Heap et al. 2001).
### 4.4 Tidal Variations

Primary variations in water level are caused by the tides, which in comparison to many other coastal regions of Australia have a small range in Georges Bay. The tides are semi-diurnal (two tidal cycles each day) with a maximum range of about 1 m and an average of about 0.5 m. The size of the bay and the narrow long entrance are likely to cause variation in the tidal influence in different parts of the bay. Small variations in tidal height do occur due to the effect of wind and variations in atmospheric pressure. For example, low-pressure systems will tend to raise the sea level in the Bay.

The total high water volume of Georges Bay is approximately 127.3 million m$^3$, while the low-water volume is approximately 111.6 million m$^3$ (see Table 4.1). During each tidal cycle, about 15.7 million m$^3$ (i.e. the “tidal prism”) moves into the bay and then out again, which represents about 12.3% of the total volume. The flushing rate of the bay is about 8.1 tidal cycles (100% divided by 12.3%), though clearly, the same water may move in and out repeatedly, which means the complete turnover of the water in the bay is probably more likely to occur every 2 to 3 weeks. The exchange rate of 12.3% and the flushing rate of 8.1 tidal cycles are about 10% less than other large east coast Tasmanian estuaries such as Pitt Water, Little Swanport and Pipeclay Lagoon. This is largely the result of the long narrow entrance and the large volume of the bay.

The volumes calculated from the digital elevation model (DEM) (see Section 4.2) are similar to those produced manually by Crawford and Mitchell (1994).

<table>
<thead>
<tr>
<th>(Units)</th>
<th>Georges Bay (whole)</th>
<th>Moulting Bay</th>
<th>Georges Bay (excluding Moulting Bay)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Water (km$^2$)</td>
<td>17.9</td>
<td>3.3</td>
<td>14.6</td>
</tr>
<tr>
<td>Low Water (km$^2$)</td>
<td>13.9</td>
<td>2.2</td>
<td>11.7</td>
</tr>
<tr>
<td>Volume</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Water (1000 m$^3$)</td>
<td>127,264</td>
<td>10,836</td>
<td>116,427</td>
</tr>
<tr>
<td>Low Water (1000 m$^3$)</td>
<td>111,571</td>
<td>8,097</td>
<td>103,474</td>
</tr>
<tr>
<td>Tidal Prism (1000 m$^3$)</td>
<td>15,692</td>
<td>2,739</td>
<td>12,953</td>
</tr>
<tr>
<td>Rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exchange Rate (%)</td>
<td>12.3</td>
<td>25.3</td>
<td>11.1</td>
</tr>
<tr>
<td>Flushing Rate (tidal cycles)</td>
<td>8.1</td>
<td>4.0</td>
<td>9.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Freshwater Input (per half tidal cycle)</th>
<th>Georges Bay Average (1000 m$^3$)</th>
<th>Moulting Bay (% tidal prism)</th>
<th>Georges Bay Average (1000 m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood (1987)</td>
<td>1,617</td>
<td>(10.3)</td>
<td>1,617</td>
</tr>
<tr>
<td>（% tidal prism）</td>
<td>(59.0)</td>
<td>（10.3）</td>
<td>(59.0)</td>
</tr>
<tr>
<td>（% tidal prism）</td>
<td>(100.7)</td>
<td>(576.6)</td>
<td>(100.7)</td>
</tr>
</tbody>
</table>
4.5 Rainfall and Freshwater Input

The total estuarine catchment area is 557 km², with about 35 km² draining directly into the bay and the balance (522 km²) into the rivers that then drain into the bay. The freshwater inflow is relatively small compared to the total volume of Georges Bay. The average flow of the George River (measured at Priory between 1969 and 1990) for the time period of the tidal prism’s movement (i.e. half a tidal cycle) is about 141.9 million m³. This is about 0.9% of the tidal prism and about 0.1% of the volume of the whole bay.

However, during flood events, fresh water inflow may be two orders of magnitude greater than normal flows. A couple of extreme examples illustrate the effect; the floods of January 1987 and Jan/Feb 2004 (see Table 4.1). For the 1987 flood, the flow rate at the George River Gauging Station was about 69.1 cumecs (or cubic metres per second). Estimating the total volume of water that this would produce over the same period as a half tidal cycle (~6.5 hours) enables a comparison with the volume of water in the bay’s tidal prism (i.e. the volume of water that moves in or out of the bay during half a tidal cycle). The flooding freshwater input in this case amounts to about 10% of the tidal prism, which is 2 orders of magnitude greater than the average freshwater inputs. The extremely large flood of 2004 was an order of magnitude larger again, and, with an estimated flow of 675 cumecs, produced 100% of the tidal prism per 6.5 hours. Anecdotal evidence from reliable sources suggests that the George River plume is directed into Moulting Bay during flooding. During ebb tides, significant quantities of the floodwaters will move more into the main entrance channel and out to sea. However, on a flood (incoming) tide, the water will back up throughout the bay and may result in additional flooding of low-lying areas. This mechanism could lead to mobilisation of substances that are normally static including pollutants and sediments.

4.6 Wind Stress

Georges Bay is a relatively low wind speed location, and experiences calm morning conditions up to 25% of the time in all seasons except spring (See Fig. 3.5). The winds are dominated by northwesterly flows, though some steady westerlies are also evident. In spring and summer, the general wind pattern is broken by the onset of the sea breezes from the ocean, primarily from the southeast and the northeast. The influence of wind speed is important in generating water flow around the Bay and this is likely to have an influence on the movement of freshwater inputs after they enter the bay, as they are more buoyant and remain on the surface for considerable lengths of time. For example, a strong southeasterly sea breeze is capable of driving freshwater from the mouth of the George River into Moulting Bay, though a northwester could drive the freshwater out along the delta edge past Hodgmans Spit and into the main basin.

4.7 Coastal Inputs

There is little information on the significance of coastal inputs in influencing water flow speed and direction in Georges Bay. However, the temperature and salinity signatures are broadly similar throughout the Bay, though Moulting Bay shows some reduced salinities, probably due to the input
of fresh water from the George River. These similarities generally indicate a well-mixed water body, probably as a result of tidal flows and wind. There is some evidence from satellite imagery that the clear oceanic water carried on the incoming tide, penetrates furthest into the bay along the southeastern side of the bay along past Stieglitz Beach, O’Connors Beach to Possum Tom, though mostly fails to enter the inner harbour due to the series of narrowings in the bay (see Figure 4.1). This is consistent with the physics governing the movement of large bodies of water, in particular the Coriolis Effect, which results in a tendency for the water body to deflect to the left of its direction of travel.

4.8 Temperature and Salinity

Water temperatures show a distinct seasonal trend, with an average maximum of 19° C, in February and an average minimum of 10.5° C in July. However, this varies between years due to the changing influence of the dominant warm East Australian Current. There are also greater extremes of temperature at the surface, particularly in the shallow depths, due to solar warming and cooling.

Freshwater inputs from the rivers clearly influence the salinity regime in the bay, but this appears to be significant only during and after periods of heavy rain (see Section 4.4). Note that as freshwater tends to remain on the surface, warmer conditions can cause loss of fresh water by evaporation.

On a single site visit (March 2005) temperature and salinity were measured at intervals through the water column at six sites throughout Georges Bay (Fig. 4.2). The results support the findings of Crawford and Mitchell (1999) (Fig. 4.3) and the trends evident in the TSQAP data; that the water body is generally well mixed though with reduced salinities in the parts of the bay subject to freshwater inputs, including the inner harbour area and the mouth of the George River and Moulting Bay. In March 2005, the salinity was high (~34 ppt) at all sites with little evidence of stratification, reflecting the low rainfall (<25 mm) during the previous month.

Overall, salinity conditions in Georges Bay are characteristic of adjacent coastal waters, with lower surface salinities only evident after periods of heavy rain. At these times a small amount of stratification occurs, which is likely to break down rapidly after freshwater inputs decrease and wind and tidal mixing of the water column occurs. This pattern is in distinct contrast to, for example, the Huon and Derwent estuaries, which are highly stratified, with out flowing freshwater on the surface and high salinity seawater flowing in along the bottom (CSIRO Huon Estuary Study Team 2000, Coughanowr 1997).

4.9 Current Speed and Direction

The speed and direction of water currents in Georges Bay is a highly complex subject and beyond the scope of this project to examine in detail. The available information suggests that within the main body of Georges Bay there are low tidal current flows with an average of 8.5 centimetres/second (cm s⁻¹). Starting with low speeds in the southwestern end of the main basin (inner harbour), the flows slowly increase to around the Stockyard Flats area at the flood tide delta near the start of the main entrance channel. The main channel experiences the peak flows of the whole bay at around 31 cm s⁻¹
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(Crawford & Mitchell, 1999) close to the training wall at the barway, while the narrow channel at Lords Point also has high flow rates of about 23 cm s\(^{-1}\). Moulting Bay has low flow rates with an average of about 1 cm s\(^{-1}\). Some streamline work has been done on the circulation patterns within Moulting Bay during tidal movements (Crawford and Mitchell, 1999), with the evidence suggesting that, on an outgoing tide, the water moves around the head of the bay in a counter clockwise direction and generally moves out of the bay along the southwestern shore. On the incoming tide the water tends to flood in across the whole bay. Along the Humbug Point shore the water streams out of the bay on both tides.

Hydromorphological features of interest are the long linear shell beds evident along the edges of many of the tidal flats, in particular those along the main channel at Stockyard Flats on the flood tide delta and along the large deltaic flats on the northern side of the main basin near Grannys Gut. The features indicate high current speeds at the margins of the tidal flats (Fig. 7.3).

Figure 4.2. Water column profiles of SALINITY and TEMPERATURE taken at 11 sites in Georges Bay.

Georges Bay Salinity/Temperature Sampling Locations

Figure 4.2. Water column profiles of SALINITY and TEMPERATURE taken at 11 sites in Georges Bay.
Figure 4.3. Water column profiles of SALINITY and TEMPERATURE taken at four sites in Georges Bay and one just outside the entrance from April 1993 to February 1994 from Crawford & Mitchell (1999) (see Fig. 4.3 for station positions).
5. Nutrients and Water Quality

5.1 Introduction

Maintaining good water quality in estuaries and coastal waters is a key factor in protecting the ‘health’ of these ecosystems. The quality of water can be described by a range of physical, chemical and biological parameters including:

- temperature and salinity
- turbidity
- nutrients
- dissolved oxygen
- chlorophyll $a$
- heavy metals
- suspended solids
- pH
- biochemical oxygen demand
- dissolved and total organic carbon
- bacterial concentration and composition
- ecological criteria such as faunal composition or seagrass beds.

Although several of these parameters are routinely measured to determine the condition of an estuary, they may also vary depending on the environmental values assigned to the estuary (e.g. ecosystems, recreation, industry, aquaculture). These are generally used collectively to describe and assess the health of the estuary.

The concentration and distribution of many of these parameters is determined by a combination of the load delivered from the catchment, direct inputs from groundwater and a range of point and diffuse sources. In many cases the major point sources are sewage treatment plants and stormwater outfalls, although leachates from tip sites or direct discharge from agricultural or industrial operations may also be important.

Diffuse sources occur through run-off from land cleared for farming, forestry or housing development, road building and maintenance, irrigation and other river flow modifications. While sediment flow through the catchment to the coast is a normal part of the process of erosion and deposition, the degree to which human development increases the load and/or adds new inputs is a key issue for assessing and managing this source. The extent of the added human impact on coastal waters depends on a range of factors including:

- size of catchment relative to the receiving coastal waters
- geomorphology of the catchment
- population size and distribution and land use in the catchment
- levels and seasonality of point source inputs
- water exchange and residence time
- light conditions
- extent and type of benthic habitats.

While there are large uncertainties in determining relative nutrient inputs into Georges Bay, primary inputs are likely to be from the Georges River and sewage.

The fate of most substances in estuaries and coastal embayments is either sediment deposition, biological uptake, transport to coastal waters, or in the case of molecular nitrogen and nitrous oxide, they can be lost to the atmosphere as dissolved gases.

The primary focus of this chapter is on nutrients (nitrogen and phosphorous), but it also assesses turbidity conditions. A general discussion on nutrient processes and biological responses to increased nutrient levels is included.
5.2 Turbidity

Turbidity is a measure of the water clarity. Water with very low turbidity appears clear or translucent and water with a high turbidity appears cloudy or opaque. Turbidity is influenced by many factors including phytoplankton and suspended material such as silts and clays. Each of these components tend to absorb or reflect different components of the white light that penetrates the water column resulting in water of different colours. For example, light absorption in marine waters is dominated by phytoplankton and appears green (due to the absorption of red and blue light) while estuarine waters are dominated by suspended solids that makes the water appear brown.

In turbid waters light does not penetrate as far into the water, thus photosynthesis by green plants is restricted to those closer to the water surface. However, turbidity is not related to water colour, such as the dark stained, tannin rich waters which have flowed over peat areas. This water, although dark brown in colour, generally contains very little suspended matter and is low in turbidity.

Turbidity in estuaries generally increases after rainfall as loose soil and associated organic matter is flushed into estuaries from higher in the catchment. Much of this material settles out in estuaries when the fresh water meets saline waters and when the flow is reduced in large sand/mud flat areas. Fine sediments can accumulate in these areas changing the habitat and for example, smothering sea grass or benthic algae which are important to the productivity of estuaries. This fine sediment is also easily resuspended in shallow bays during strong winds.

The delivery of suspended solids from the catchment during flooding also results in an influx of nutrients with areas of high turbidity generally linked to high nutrient levels.

Turbidity is often measured using a turbidity meter. This instrument shines light through a sample of water and detects how much light is scattered from particulates in the water. This type of scattered light measurement is called nephelometric and the unit of measurement is a Nephelometric Turbidity Unit (NTU). A simpler device called a Secchi disc is also commonly used to give estimates of turbidity in deeper water sampling from a boat. This consists of a 20 cm diameter black and white disc which is slowly lowered into water until it disappears from view. This depth at which it disappears is recorded; in turbid waters it is less than in clear water.

There have been few surveys addressing turbidity in Georges Bay. Anecdotal evidence suggests that turbidity levels can be high. For instance, video footage taken by Crawford et al. (2001) was too poor to survey features of the seabed due to a high concentrations of suspended solids. Similar conditions were reported by Aquenal Pty Ltd in 1999 when doing baseline video surveys on proposed marine farm development sites for DPIWE (2004).

However, when Crawford et al. (2001) measured turbidity in Moulting Bay, values ranged from 1-2 NTU. These values are classified as “low” using the draft indicator levels set by Murphy et al. (2003). Turbidity was also measured by K. Saunders (unpub. data) as part of a PhD project with the University of Tasmania. Values ranged from...
5 to 8, which is still only a “medium” classification by Murphy et al. (2003).

These two studies are the only occasions in which turbidity has been measured directly in Georges Bay and results are contradictory to observatory and anecdotal evidence. As high turbidity was tagged as a potential concern for the Bay by Percival (2004), this suggests a need for more consistent monitoring.

5.3 Nutrients

Nutrients are an essential component of all ecosystems as they are the building blocks of all living organisms. Key nutrients include nitrogen (N), phosphorous (P), carbon (C) and silica (Si). However, too little or too much of these nutrients can have major detrimental effects on living systems. In the marine environment nitrogen is commonly the limiting nutrient. Insufficient nitrogen will decrease the productivity of the estuarine and marine environment.

Conversely, greatly increased concentrations of nitrogen, which can occur as a result of land-based activities, such as fertilizer run-off from agricultural activities, effluent from dairy farms, sewage etc, can result in markedly increased productivity. In extreme cases this leads to eutrophication of estuaries whereby major algal blooms and/or production of macroalgae occurs, and the breakdown of this excess material by bacteria utilises all the available oxygen. This depletion of oxygen impacts on animals living in this system, leading to fish kills.

Because estuaries are commonly nitrogen limited, they are generally most sensitive and reactive to increased levels of nitrogen into the system. Conversely, freshwater ecosystems, are commonly phosphorous, rather than nitrogen, limited.

There are various forms of nitrogen and phosphorous in the water column that can be in dissolved organic, dissolved inorganic or particulate form. Dissolved organic nitrogen (DON), such as urea (active) and humic substances (non-active) and particulate nitrogen (PN) generally make up the largest pools of nitrogen in the water column. The dissolved inorganic (DIN) forms of nitrogen – ammonium NH$_4$, nitrate NO$_3$ and nitrite NO$_2$ and dissolved inorganic phosphorous - phosphate PO$_4$, although generally in lower concentrations, are most important to estuarine health as they are the biologically available forms of these nutrients, i.e. are most readily utilised by plants and animals.

Nutrients are also found in sediments in various forms, either dissolved in the sediment porewater, as an adsorbed layer on the surface of particles in the sediment or fixed within the matrix structure of the sediment grains. The process of nitrogen cycling in estuary and coastal waters and the role of sediments to the process is discussed in section 5.6.

5.3.1 Nitrates

Nutrients have not been routinely sampled in Georges Bay. Data are available from two studies: Crawford et al (1999) sampled nitrate + nitrite (commonly referred to as NO$_X$), phosphate (PO$_4$) and towards the end of their study silicate (SiO$_4$) at 4 sites throughout the estuary and one marine site over a 11 month period in 1993/94 (Fig 4.2). Sinclair Knight Mertz as part of a consultancy to the Break O’Day Council on upgrading the St Helens sewage system sampled 3 sites in the upper estuary and 1
site at the Compass Bridge (Fig 4.2) periodically from November 2004 to June 2005. Two sites were similar to those sampled by Crawford et al (1999).

Results from Crawford et al (1999) showed variation in NOx values over the sampling period (Fig. 5.2a). Highest concentrations were recorded over winter, reaching a peak of over 60 µg/l in July; highest concentration of chlorophyll a was also recorded at this time in the upper estuary. NOx values were consistently highest at the marine site, averaging 22.9 µg/l over the 11 month sampling period, indicating oceanic influxes of nitrogen. Lowest values were recorded at Mast and Lords Point sites over the sampling period, averaging 6.9 and 5.85 µg/l, respectively. However, much higher values of NOx have been recorded in the plume of freshwater entering Georges Bay from the Georges River after heavy rainfall (Crawford et al 1999).

The concentration of NOx in 2004-05 at the two sites, Mast and Lords Point, which were also sampled in 1993-94, showed little change except for a relatively high value at Lords Point in April 2005 (Fig. 5.2b). The Compass site also had low concentrations of NOx, whereas the Bridge site had much higher concentrations on most sampling occasions. For the three sampling sites in the estuary, two thirds of the measurements were at or below the minimum detection limit of 10 µg/l.

5.3.2 Ammonia

The ammonia concentration at the Mast sampling site was extremely high in November 2004. It was also slightly
Bringing Back the Bay

Elevated at the Bridge and Compass sites at this time. Otherwise, ammonium concentrations were generally relatively low, except for an increase at Lords Point in April 2005. 79% of all ammonia measurements were at or below the minimum detection limit of the analysing equipment.

5.3.3 Phosphate

No distinct seasonal trends in phosphate concentrations were observed and they generally ranged between 5 and 15 µg l⁻¹, with the Marine station having the highest levels in most months. Silicate concentrations were only measured in the last four months of sampling. They averaged 192 µg l⁻¹ and were clearly lowest at the marine site.

Fig. 5.3 Sampling of nutrients in Georges Bay a) Ammonia from SKM sampling b) PO₄ from TAFI sampling. NOTE: Different scale bars

5.3.4 Total N and Total P

TN and TP are indicators of catchment input of nutrients into the bay. Peak values of total N tended to show similar patterns to the peak NOₓ and ammonia concentrations, with maximum values at the Mast site in November 2004, at the Lords Point site in April 2005 and at the Bridge site in November 04 and June 05. The Compass site off the sewage outfall generally had low nitrogen values and did not show any major peaks during the sampling period.

Total P was relatively low for most of the sampling period except for May and June 2005 when peak values were recorded at the three sites in the estuary.
Nutrients and Water Quality

Figure 5.4 Sampling of nutrients in Georges Bay a) Total N from SKM sampling b) Total P from SKM sampling

5.4 Comparison with other estuaries and ANZECC guidelines

Because of the limited consistent monitoring of nutrients in estuaries in Tasmania in general, and in Georges Bay in particular, it is difficult to assess the health of Georges Bay with respect to nutrient concentrations with any level of certainty. However, a preliminary comparison can be made with results from Murphy et al (1999) from a survey of the water quality of 22 estuaries around Tasmania. From these data they developed a draft set of indicator levels for four water quality parameters (Table 5.1). Nutrients -NOx values in Georges Bay in 1993/94 were low for the majority of the months sampled, medium in 2 months and high in one month, especially in the lower estuary. In 2004/05 NOx values were again mostly low at sites in the estuary, except for one very high reading at Lords Point in April 2005. The Compass Bridge site regularly recorded very high concentrations. Phosphate concentrations were in the low – medium category.

Table 5.1 Draft indicator levels for estuaries in Tasmania from Murphy et al (1999)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>low</th>
<th>med</th>
<th>high</th>
<th>v high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbidity NTU</td>
<td>&lt;4</td>
<td>4-10</td>
<td>10-20</td>
<td>&gt;20</td>
</tr>
<tr>
<td>Chlorophyll a µg L⁻¹</td>
<td>&lt;2</td>
<td>2-5</td>
<td>5-10</td>
<td>&gt;10</td>
</tr>
<tr>
<td>NOx µg L⁻¹</td>
<td>&lt;21</td>
<td>21-50</td>
<td>51-100</td>
<td>&gt;100</td>
</tr>
<tr>
<td>PO₄ µg L⁻¹</td>
<td>&lt;6</td>
<td>6-15</td>
<td>16-30</td>
<td>&gt;30</td>
</tr>
</tbody>
</table>
Default trigger values for nutrients have been developed for south-eastern Australia for slightly disturbed ecosystems in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000) (Table 5.2). These guidelines are intended to provide a set of tools and framework to enable the assessment and management of ambient water quality according to the designated environmental values.

However, it is important to note that no data from Tasmanian estuaries or marine waters were used in the development of these values and it is recommended that a precautionary approach be used when applying these values in this region.

<table>
<thead>
<tr>
<th>Ecosystem Type</th>
<th>Estuarine</th>
<th>Marine</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>PO₄ (FRP)</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>TN</td>
<td>300</td>
<td>120</td>
</tr>
<tr>
<td>NOₓ</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>NH₄⁺</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 5.2. ANZECC guidelines (mg L⁻¹)

NOₓ values at Georges Bay in 1993/94 were above the ANZEEC recommended estuarine concentration on 3 out of 11 months of sampling and phosphates in every month sampled. Almost half the NOₓ and one quarter of NH₄⁺ concentrations recorded in 2004/05 were above the ANZEEC guidelines for estuaries. It is noted that NOₓ values at the marine site just outside the Bay were higher than ANZEEC guideline values on several occasions, indicating oceanic input of nutrients and that ANZEEC guidelines are not always applicable to Tasmanian conditions.

5.5 Nutrient Processes

The cycling of nitrogen in estuarine systems is complex and involves a series of biological, chemical and physical processes. Nitrogen may enter the system from various sources and in various forms. An important process in many shallow coastal environments, particularly seagrass beds, is nitrogen fixation, which is the conversion of N₂ gas to organic N by specialist bacteria and cyanobacteria. The subsequent conversion of organic N back to N₂ gas occurs through a series of steps defined as ammonification (release of NH₄⁺ from organic matter), nitrification (oxidation of NH₄⁺ to NO₃⁻) and denitrification (reduction of NO₃⁻ to N₂).

The biological and physical processes involve the biotic uptake of dissolved nutrients, conversion to particulate form through growth of algae and seagrass and sedimentation of dead plant and animal material. In the sediments, nutrients may be lost through burial, resuspended, or lost to the atmosphere as nitrogen gas as a result of denitrification.

The addition of nitrogen through point and diffuse sources can result at times in a significant increase in phytoplankton and benthic algal production. This is primarily driven by increases in the concentration of dissolved inorganic nitrogen. The specific levels of DON into an estuary compared to DIN is heavily influenced by the type of land use in the catchment. Areas dominated by urban development and land clearing tend to export much higher levels of inorganic nitrogen (nitrate and ammonia) than forested catchments (Harris 1999).

In general, water quality in estuarine and coastal waters is maintained by efficient
denitrification of the nitrogen load, with the amount of nitrogen lost through this process related to the time it remains in the waterway (i.e. residence time). In addition, oceanic sources of inorganic nitrogen that enters Tasmanian coastal waters may be exported before becoming biologically available.

For example, in winter the Huon Estuary is largely biogeochemically inactive, with large fluxes of dissolved inorganic nitrogen of marine origin not used but circulated through the estuary due to a combination of high flushing rates, high light attenuation and low temperatures (CSIRO Huon Estuary Study Team 2000). In spring, however, the high nitrogen levels result in algal blooms that are regarded as ‘natural’.

In general, the cycling of nutrients between the water column and sediment and from particulate to dissolved forms is not well understood in coastal and estuarine waters and is essential to understanding the impact of nutrient inputs in regions such as Georges Bay.

Excessive nutrient inputs into estuaries have led to widespread loss of seagrasses at many locations in Australia and overseas (Shepherd et al. 1989). A significant cause of the decline of seagrass is reduced light availability due to increased concentrations of phytoplankton (Abal and Dennison 1996, Dennison 1987) and algal epiphytes. The production of benthic algae can also result in decreased denitrification efficiency by creating a physical barrier between the water column and the sediments and creating an anoxic layer under the algal mat. This results in an increase in the flux of ammonium into the water column that may drive further algal blooms.

It is often difficult to definitively assess the impacts of increased nutrients on seagrass and algal habitats due to the relatively frequent natural variations of these habitats, the lack of historical monitoring data, the lack of suitable controls for comparison; and a poor understanding of the fate and fluxes of nutrients in the system.

Baseline information on the distribution and abundance of seagrass and associated algae in Georges Bay is presented in Chapter 7.
6. Seagrass

6.1 Introduction

Seagrasses are aquatic flowering plants found in mainly subtidal and intertidal bays and estuaries. Most species are associated with soft sediments, and many form extensive monospecific beds. Seagrasses consist of a rhizome (a root like structure), which anchors the plant to the substrate, and numerous vascular leaves, which are responsible for the absorption of nutrients from the water column and the photosynthesis of sun light. Seagrasses reproduce by flowering and disperse by seeds. These plants play an important role in maintaining the sediment stability, as the rhizomes act to stabilise the underlying sediment. Seagrasses are also important in maintaining water quality by using nutrients and limiting the resuspension of sediments.

Seagrass beds are important contributors to coastal productivity through the primary productivity of the seagrass and associated algae, including epiphytic algae. Seagrass beds form an important component of the food chain in adjacent waters. Much of the seagrass and algae produced within the beds are transported to adjacent habitats, where it supports a range of fish and invertebrate species. The relationship between seagrass bed productivity and that of adjacent coastal waters is yet to be fully investigated.

Five species of seagrass are commonly found within Tasmania:

- eelgrasses (*Zostera tasmanica*, formerly *Heterozostera tasmanica* (Les et al. 2002) and *Zostera muelleri*)
- strapweed (*Posidonia australis*)
- paddleweed (*Halophila australis*)
- *Amphibolis antarctica*.

Broad scale mapping has revealed that *Z. tasmanica* is the most commonly found species in the coastal bays and estuaries of south and east of Tasmania (Rees 1993, Barrett et al. 2001). In the north of the state, *P. australis* and *A. antarctica* are the dominant species; however *Z. tasmanica* is still present in some areas along the north coast.

A range of factors including depth, temperature, exposure to wave action, the ability to withstand desiccation and most importantly, the availability of light, limits the distribution of seagrass beds. The inner margins of seagrass beds are generally determined by either wave exposure or the ability of that species to withstand desiccation (being out of the water) for short periods of time. For example *Z. tasmanica* only occurs subtidally, while the closely related *Z. muelleri* can withstand short periods of desiccation, so is commonly found in the intertidal zone.

The outer margin of seagrass beds is generally limited by the light availability, which is determined by the depth and the clarity of the water. *Zostera tasmanica* is generally restricted to depths <10 m in areas of sheltered water, although sparse beds down to around 18 m have recently identified in some of the coastal bays of south east Tasmania (Barrett et al. 2001).

Seagrass is a key physical habitat for many species of fish and invertebrate. Seagrass beds provide more complex habitat compared to adjacent unvegetated habitats, with many species using them for shelter, food and breeding. Seagrass beds contain a significantly higher diversity and abundance...
of fish compared to unvegetated areas and are an important habitat for both juvenile and adult stages of commercial and recreational species such as sea garfish and sand flathead (Jordan et al. 1998). The fish communities within seagrass beds are distinct from fish communities in other habitats.

In Tasmania, fish communities in Zostera tasmanica (Fig. 6.1) beds are more similar within a bay than between bays, with each bay having some ‘unique’ community (Jordan et al. 1998). For example, the fish community of the seagrass beds in Georges Bay are considerably different from those in Prosser Bay and Norfolk Bay, with several species of fish present in one bay but not the other.

Fig. 6.1 Zostera tasmanica.

The growth in Zostera tasmanica is known to vary seasonally (Bulthuis and Woelkerling 1983), with longer-term changes in distribution and biomass also known to occur. There has been little work done to document these longer-term changes in seagrass distribution and biomass, which means it is difficult to attribute loss or gain in seagrass to human impact or natural variation. Often changes in seagrass beds are a combination of these two factors.

The major cause in the decline of seagrasses is a reduction in the availability of light reaching the plants (Walker and McComb 1992). As seagrasses generally have a higher minimum light requirement compared to other marine plants, they are more susceptible to changes in light availability (Dennison et al. 1993).

In Tasmania much of the seagrass is associated with the sheltered bays and estuaries, which are generally areas of highest human impact. Urban and industrial discharges and catchment usage cause increased nutrient levels and turbidity, which in turn are the key causes of light reduction and the subsequent decline of seagrass habitats. High levels of nutrients often result in increased epiphytic algal growth that can smother and shade seagrass blades causing beds to become patchy and fragmented. High turbidity and high plankton densities, as a result of increased nutrients, reduce the amount of light reaching the beds, which generally leads to a decline in the deeper margins of the bed.

Human impact on seagrass beds can also be through direct physical damage. Swing-mooring chains, boat propellers, and retrieval of anchors can all cause the loss of seagrass. The construction of jetties and pontoons can also affect seagrass through shading and altered flow regimes.
The reversal of any of these factors can also lead to an increase in seagrass extent, as the seagrass recovers or colonises areas that meet its growth requirements. Consequently, seagrass can be used as an approximate measure of the condition of an estuary (Dennison and Abal, 1999).

This chapter assesses the distribution and biomass of seagrass beds and associated algae in Georges Bay and examines some of the key factors influencing the ‘health’ of the beds.

6.2 Seagrasses of Georges Bay

The distribution of seagrass in Georges Bay was mapped using a combination of field based mapping and remote sensing. The field mapping used vessel mounted echo sounders, grab sampling and video surveys to determine the presence/absence of seagrass. This information was combined with positional and depth information and imported into computer mapping software known as a geographical information system (GIS).

Remote sensing data from rectified aerial photographs and high-resolution satellite imagery (Fig. 6.2 and 6.3) was also imported into the GIS. Optical remote sensing is most commonly used because water only transmits the visible wavelengths readily. Imagery types include digital and film aerial photography, multispectral and hyperspectral airborne scanners and the visible bands of satellites such as Landsat, SPOT and IKONOS (Lillesand and Kiefer, 2000). From this combination of the field and remote sensing data the seagrass distribution maps were generated.

Seagrasses form an important part of the Georges Bay ecosystem. The most common type of seagrass in the bay is *Zostera tasmanica*, which creates extensive fringing beds below the low water mark around much of the shoreline. *Zostera muelleri* is present in the intertidal areas of the bay, and probably the subtidal areas as well, though, because it is indistinguishable from *Z. tasmanica* without a microscope, the interspecies distribution is very difficult to ascertain. However, the two species play a similar role in the ecosystem where their ranges overlap. No other seagrasses were observed during the field trips, which is consistent with the records made by Rees (1993)

6.2.1 Seagrass distribution

Seagrasses in Georges Bay are found on relatively sheltered sandy or silty substrates in intertidal and shallow subtidal areas, typically, in less than 6 m of water (Fig. 6.4). The distribution map shows the total area of *Zostera tasmanica* and *Zostera muelleri* in Georges Bay (688 Ha) and shows the varying patchiness and biomass of the beds. There are large variations in the structure of the beds throughout Georges Bay, generally due to variations in water movement, nutrient availability, disturbance and light availability.
Fig. 6.2 Satellite imagery in the visible (top) and infrared (bottom) parts of the spectrum is used to assist mapping the extent of the seagrass in the subtidal and intertidal areas respectively (see next page, Figure 6.3).
Fig. 6.3 Satellite imagery in the visible and infrared parts of the spectrum is used to assist mapping the extent of the seagrass in the intertidal and subtidal areas. Other evidence is also used to create the maps such as benthic video surveys and acoustic soundings.

In the main channel the seagrass is mixed in its distribution patterns showing large tracts of patchy and sparse seagrass on the shallow banks along the sides of the channel and denser seagrass in and around the shallow channels (guts) that branch off the main channel. There are many areas where molluscs share the substrate with the seagrass, especially where the channel narrows around Lords Point and Stockyards Flat. As there are very high rates of tidal flow near the entrance, the opportunities for seagrass to find a stable substrate are reduced.

On the main flood tide delta near Stockyards Flat, the seagrass is generally patchy, again probably due to the high flow rates here, though the sides of the delta facing towards the main basin have denser seagrass, as do the shores along Doggys Bay and Humbug Point. In both the main channel and on the flood tide delta, the intertidal seagrass is *Zostera muelleri*.

Moultling Bay has the largest continuous area of dense seagrass with beds running from the intertidal zone to about 3.5 m depth on average. The seagrass becomes sparser in the deeper water and is patchy on the tip of Steels Spit, where more turbulent water flows are indicated by the coarser sediments. The active area of the George River delta is bare of seagrass, including the steep front
Seagrass

The more stable parts of the delta that stretch around to St Helens have a mixture of sparse and dense seagrass, in both continuous and patchy bed formations. The denser seagrass is generally found below the low water mark and young *Zostera muelleri* were found on the edges of the tidal flats, apparently actively colonising areas previously inhabited by feral oysters.

![Georges Bay Subtidal Habitats](image)

**Legend**
- Vegetation
- Land
- Low profile reef
- Hard sand
- Shelly sand
- Sand
- Silty sand
- Silt
- Seagrass
- Patchy seagrass
- Sparse seagrass
- Sparse patchy seagrass
- Unknown

Fig. 6.3. Distribution of subtidal seagrass beds in Georges Bay.

The inner harbour has dense seagrass along the shores and patchy seagrass under the active area of boat traffic. Medeas Cove has similar formations. The seagrass only grows to depths of about 2.7 m, indicating lower water clarity conditions (Fig. 6.4).

While the south side of Georges Bay is much more limited in the area of substrate suitable for seagrass, the available sandy and silty areas all exhibit dense seagrass beds down to about 4.7 m. These are the greatest depths to which seagrass grows in Georges Bay, indicating that the clearest waters circulating
6.4  Highly turbid light coloured water is evident in this Quickbird satellite image (2/5/2002) in the inner harbour area. The clearer waters show as darker blue. The light colour of the water indicates a light coloured geological origin of the suspended sediments.

6.2.2  Seagrass growth limiting factors

Generally, the seagrass beds of Georges Bay show evidence of limiting factors to their growth, as the inner (shallower) and outer (deeper) edges of are typically patchier than the middle sections of the beds. This is particularly true for areas including Moulting Bay, O’Connors and Stieglitz Beaches and the edges of the main river delta.

A study was conducted on the maximum depth limit (MDL - see Fig. 6.6) of seagrass in many parts of the Georges Bay. The results show a marked contrast in the MDL for different parts of the bay. The average MDL was calculated by obtaining over 700 sample points of the seagrass deep edge position and depth throughout the bay from benthic video and maps, and then averaging the depths for the locations shown in Fig. 6.7.

This study found that the deeper edge of the seagrass occurs to an average 4.7 m all along the southern shore and on the eastern face of the George River delta near McDonalds Point and Hodgmans Spit. These indicate consistently clearer water conditions, probably because of the influence of the clear oceanic waters flushing into the bay on the incoming tide. The apparently anomalous shallow MDL on the flood tide delta of 2.4 m can be explained by high levels of turbulence creating a shifting, mobile substrate of sand that makes it very difficult for the seagrass to establish apart from some optimal locations in the lee of the banks.

within the bay occur along this southern shore.

Boat moorings can cause considerable damage to seagrass beds through the scouring action of the mooring chain. Fortunately, there does not appear to be mooring scour damage in Georges Bay. In Moulting Bay, the vessels tend to moor in water deeper than the outer edge of the seagrass. Similarly, the moorings in the inner harbour, Kirwans Beach and Possum Tom all appear to be beyond the outer edge of the seagrass. However, some propeller damage is evident in the approaches to the Stieglitz Beach boat ramp (see Fig. 6.9).
The northern shore of the main basin at Granny’s Gut has an MDL of 4.1 m, indicating slightly less clear waters in this area. Moulting Bay has an average MDL of 3.4 m, which is significantly lower than the other locations reported above. The water clarity here is strongly influenced by the George River and possibly a lower input of clear incoming tidal waters. The inner harbour exhibits seagrass growing to only 2.7 m, which is indicative of more turbid conditions than that found in other parts of the bay. The probable causes include turbid river water inflows from Medeas Cove and possibly from resuspension of fine flocculated sediments by boat traffic or winds (see Fig. 6.4).

The absolute maximum depth limit (i.e. NOT the average maximum depth limit) to which seagrass was found in the whole bay was consistently about 6.25 m all along the southern shore of the bay and at McDonalds Point.
6.7 Average maximum depth limits (MDLs) of seagrass in Georges Bay in metres.

6.2.3 Seagrass monitoring

The mapping of the seagrass provides a basis for future comparison of the spatial distribution of the beds, their structuring in terms of patchiness and density, and their maximum depth limits (MDLs). It is of note that the Quickbird satellite image (captured on 2nd May 2002) was used as the source of imagery-based evidence for much of the mapping. The comparison between the boat-based field observations (using video, sounder and direct observation) collected in
March 2005 and the satellite imagery of May 2002 is of even more interest as those dates straddle the extreme flood event of January/February 2004. Given that the flood event delivered a massive pulse of sediments and nutrients into the bay, the potential for large scale damage was considerable. For example, Hervey Bay, Queensland, experienced major losses of seagrass from an extreme flood event (Preen et al., 1995). While the short term impacts of the 2004 flood on the seagrass are undocumented, there is almost no difference between the areas visible in the satellite image prior to the flood and those mapped with a large number of field observations in March 2005. In exception is the southerly end of Stieglitz Beach, with an apparent loss of a 50 m strip of seagrass about 500 m long along the deep edge (Fig. 6.8). The reasons for this particular loss are not clear.

The method involved wading (rather than snorkelling or scuba) at a number of sites around the bay. In the dense central part of the fringing seagrass bed, blade length, percent cover, shoot density and epiphytic loading were measured in randomly located quadrats at each site.

Average blade length, percentage cover and shoot density of seagrass (i.e. Zostera tasmanica and/or Zostera muelleri) was measured within four 0.25 m by 0.25 m quadrats in a square pattern (giving a 1 m by 1 m quadrat) at five random locations within the central dense part of each bed. The first quadrit of each set of four quadrats was randomly selected by throwing the quadrat frame without looking. The observations were made through a bathyscope (viewing bucket) (Fig. 6.10).
As blade length, percentage cover and shoot density broadly correspond to seagrass biomass they are discussed together in terms of biomass in this chapter.

The results of the fine scale survey show that the seagrass in most parts of the bay are very similar, with the exceptions being the inner harbour (IHBR), Stockyard Flats (SYFT) and...
the main channel (MNCH). Apart from the exceptions, the mean blade length was between 315 and 365 mm. The inner harbour site had a much shorter average blade length of 78 mm. Stockyard Flats average blade length was 141 mm.

The percent canopy cover results reflected the overall high density cover of the selected sample sites, with all sites except the inner harbour averaging between 94% and 100% canopy cover. The inner harbour is significantly different to the other sites and averaged 79%, with patches clearly present at the quadrat scale. Average shoot density was also consistent across most sites, with the exception being the main channel site, which had a higher average shoot density of 73%. The other sites averaged between 48% and 57%.

The results show that the inner harbour site contains seagrass in poorer condition both in terms of reduced blade length and reduced percent cover. While both *Zostera tasmanica* and *Zostera muelleri* are known for the variability of their growth habit, these results suggest that the area is subject to high sedimentation rates or more intense grazing pressure from, for example swans. It could also indicate recovery after a disturbance event, such as feral oyster harvesting.

The Stockyard Flats site had a reduced blade length (144 mm) and the highest variability in shoot density. This site is subject to the highest hydrodynamic flow rates of all the sites sampled. Seagrass growing in high flow areas often display variable growth habits. Of interest, that whilst this site showed the highest variability in shoot density, the percent canopy cover was very consistent in every quadrat. This means that there was, mostly, an unbroken canopy, but mixed levels of shoots per square metre.

Of note was the significant quantities of fine sediments covering the seagrass in Moulting Bay and along the southern shores of the main basin. This indicates a recent influx of sediments to these areas.

Further details on seagrass distribution and biomass is presented in the fine-scale maps in Fig. 6.3 and video footage in Appendix 1 on the accompanying CD-ROM.
6.2.4 Associated Macroalgae

Filamentous algae, either loosely associated (drift algae) or growing directly on the seagrass (epiphyte), are a natural and commonly occurring component of most seagrass beds (Kendrick and Lavery, 2001). The algae contribute substantially to ecosystem functioning via primary and secondary production, biogeochemical processes and nutrient cycling including nitrogen fixing (Vanderklift and Lavery, 2000; Irlandi et al., 2004).

They can also have adverse effects on seagrass where nutrient levels are elevated, as increased epiphyte growth can lead to increased seagrass shading (Silberstein et al., 1986; Fitzpatrick and Kirkman, 1995; Hauxwell et al., 2003). Excessive nutrient inputs into estuaries have led to widespread loss of seagrasses via this mechanism at many locations in Australia and overseas (Shepherd et al., 1989).

While most of the biomass of epiphytic and drift algae is usually made up of a few species, such as *Polysiphonia* spp. and *Enteromorpha* spp., there are often large numbers of species present.

At the six seagrass sampling site the amount (abundance) of epiphytic algae was assessed on a scale that ranked no epiphyte as 0 and complete coverage of the seagrass by a thick mat of epiphyte as 5. Generally, levels of epiphyte were low with a grand mean of 2.

The sample sites can be divided into three groups with the first group of the inner harbour (IHBR), Moulting Bay (MBAY) and the main channel (MNCH) all with low levels of epiphyte abundance around 1 and 1.5. Stieglitz Beach (SBCH) and O’Connors Beach (OBCH) have significantly more epiphyte, though it is still low in absolute terms; around 2 to 2.5. The Stockyards Flat (SYFT) site had a much higher level of epiphyte at around 4, perhaps as a result of both the higher flow rates over this area. The results of this study should not be interpreted without caution. It is important to collect information from a series of surveys to begin to understand the variation in the measured factors. For example, nutrient levels will vary seasonally and the epiphytic growth on the seagrass is likely to reflect respond to this variation. Other factors influencing epiphyte growth temporally are light availability, salinity, temperature and the reproductive cycles of the algae.

6.2.5 Historical seagrass changes

Historical changes in the extent of seagrass was assessed by Rees (1993) through the interpretation of aerial photography from circa 1950 and circa 1990. While there is useful information in the maps produced by his study, there are a number of limitations that should be noted. There were difficulties in interpreting some of the older photos due to deterioration with age and the interpretations “ground truths”. Further, imagery was unavailable for the Moulting Bay area around 1990. Following detailed analysis, it appears
that these maps tend to underestimate the extent of seagrass on the intertidal flats (a problem that was overcome in the current study through the use of infrared satellite imagery (Figs. 6.2 and 6.3)) and overestimate the depths to which seagrass occurs in other areas such as the main channel and along the southern shores (c. 1950).

However, in spite of the problems, there are some interesting comparisons that can be made with the maps produced by this study (see Figs. 6.15, 6.16, and 6.16). In Moulting Bay, there is agreement between the 2005 and c1950 boundaries at the inner (shallow) edge of the seagrass. However, the deep edge of the seagrass is not reliably depicted in the c1950 data apart from the deep edges of Steels Spit.

Another comparison based on more reliable components of the analysis, is the very close similarity of the boundaries along the southern shores between 2005 and c1990 (Fig. 6.16). There is a close match of the deep edge boundary, while the c1990 inner boundary is more patchy revealing that there were small, though significant areas of bare sand up to 50 m wide along the edges of the beaches which are now covered in seagrass. These observations hold for both Stieglitz Beach and O’Connors Beach. The c1950 maps for this area are not regarded as reliable, particularly along O’Connors Beach to Kirwan’s Beach as it is unlikely that the species present in the bay would have grown to the depths depicted.

In the main entrance channel and on the flood tide delta at Stockyards Flat, the early mapping (Fig. 6.17) appears to be more reliable and it generally shows an increase in seagrass extent with persistent beds of seagrass in the Middle Gut and the bay between Pelican Point and Lords Point. There does appear to be a large reduction in seagrass biomass between 1950 and c1990 to the present day on the bank along the western shore of the main channel by the Oak Gut.

Due to the general unreliability of the early maps, direct comparison of areal extents was not conducted.
Fig. 6.15. Historic changes in seagrass beds in Moulting Bay. Circa 1950 data from Rees, 1993. Note that there is no circa 1990 data available for this area.
Fig. 6.16. Historic changes in seagrass beds in upper Georges Bay. Circa 1950 and circa 1990 data from Rees, 1993.
Fig. 6.17. Historic changes in seagrass beds in lower Georges Bay – main channel, flood tide delta and Stieglitz Beach. Circa 1950 and circa 1990 data from Rees, 1993.
6.3 Seagrass Associated Fauna

6.3.1 Fishes

Seagrasses generally contribute to the overall biodiversity of an estuary (Edgar et al., 1999) and they act as important sources of primary and secondary food production in the nearshore food web. For example, much of the leaf material produced by seagrass is transported to nearby areas when it dies and it supports a large number of detritivores, which in turn, support other animals higher up the food chain. Seagrass is also a vital nursery area for some recreational fish species such as sand flathead, southern sea garfish and southern calamary. However, it is of note that the fish fauna is usually dominated by fish such as pipefish and small leatherjackets, which do not usually constitute target species for fishers (Jordan et al. 1998). Compared to the other regions in temperate Australia, there are relatively few larger fish species utilising the seagrass as nursery habitat.

A study by Jordan et al (1998) found that the seagrass of Georges Bay supports a large variety of fish species in high numbers. For example, the very high numbers of wide-bodied pipefish (Stigmatopora nigra) in Moulting Bay is unusual.

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Common name</th>
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<td>Red cod</td>
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<td>Vanacampus poeciliaemus</td>
<td>Long-snouted pipefish</td>
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Table 6.2. Fish species commonly found in seagrass beds in the Georges Bay region from Jordan et al (1998).

Fig. 6.17. Hairy pipefish (*Urocampus carinistrosis*). Source: R.H. Kuiter.
6.3.2 Invertebrates

Many invertebrate species inhabit seagrass beds. The dominant species in southern Australia within *Heterozostera tasmanica* beds are *Barantolla* sp., *Terebellides* sp., *Diala suturalis*, *Pseudoliotia micans*, *Nephtys australiensis* and Palaemonid shrimps (Edgar *et al.* 1994). A study by (Moverley and Jordan 1996) found high densities of oligochaete worms, *Leptochella dabia*, *Paradexumine churinga*, ragworms (Family Nereididae), blood worms (Family Capitellidae) and low densities of Phoronid worms.
7. Sediments and Unvegetated Habitats

7.1 Introduction

Unvegetated habitats are generally the dominant habitat type within estuaries and coastal embayments and range from intertidal flats to deep basins. They are a particularly important habitat for fish, sharks and rays in Tasmania (Jordan et al. 1998, Edgar et al. 1999) and contain many species of invertebrates, such as Ostrea angasi (Edgar and Barrett 2000).

The distribution of subtidal unvegetated habitats in Georges Bay was assessed through the analysis of sediment cores taken as part of a sediment study. The intertidal areas were mapped by a combination of rectified aerial photography and Quickbird satellite imagery, supported by topographic map layers (1:250 000) from the LIST (DPIWE). The unvegetated areas were categorised into three habitat types, based on a combination of their tidal position, hydrodynamics and distribution of sediment particle size:

- sand
- silty-sand
- silt.

7.2 Sediments

Estuaries and coastal embayments are generally importers of sediment that is delivered primarily through direct riverine input and diffuse run-off from adjacent land. The natural pattern of input and potential loss to the ocean is generally unique to each estuary and reflects catchment size and geomorphology, rainfall patterns and the significance of wind and tide.

While sediment delivery is a normal part of catchment processes, a large number of human activities increase the load. An increased sediment load within Georges Bay can impact upon marine and estuarine habitats, aquaculture, and recreational activities such as fishing and boating.

This section details the present distribution of sediment types in Georges Bay to provide a better understanding of their depositional patterns.

7.2.1 Sediment Sources

The George River and other associated waterways, such as Constable Creek and Golden Fleece Rivulet, are the main sources of sediments entering Georges Bay. Sediments are typically derived from land-use practices that remove vegetation and result in an increased runoff, which transports materials down through the catchment to be deposited as silt in the Bay.

Another source of sedimentation is the natural process of flocculation, where sediments suspended in freshwater aggregate into larger (though still fine) particles when they mix with saltwater (Woodroffe, 2003). This occurs in the mixing zone near where the freshwater comes into the bay, such as around the river deltas in the head of the bay. The inner harbour near St Helens and the body of water immediately adjacent to the George River delta are sites where flocculation is taking place. Flocculated particles are subject to easy resuspension through wind or boat traffic, which leads to reduced water clarity.

There are many activities associated with the silt load delivered into Georges Bay, including road building, forestry activities, land clearing for residential development,
Bringing Back the Bay

river works using heavy mechanical equipment and other river flow modifications. The primary source of sediments into Georges Bay is the mobile sediment produced by the mining activities within the catchment. Between the 1880s and 1929, up to 1.2 million m$^3$ of sandy sediment was deposited into the river system as tailings by tin mining operations within the catchment, including vegetation removal and sluicing (Bird, 2000). Much of this is moving down the system as a large “slug” that is impacting on the river flow regimes and has implications for flooding by raising the level of the river channels. Inspection of Brooker’s 1862 bathymetric chart clearly indicates very large quantities of new material arriving at the George River delta (Spred, 2003) and up to an extra 5 m of new material deposited into Medeas Cove. Sloane (1974) reports high sediment load to discharge ratios for the rivers emptying into Georges Bay and lobate delta formations associated with “extensively braided channel system at its mouth where deposition of sand and gravel is occurring.”

The effects of the deposition of these large quantities of sediment on Georges Bay are considerable. If the sediment supply is maintained or increases over time, there are likely to be continuing ecological consequences. For example, filter-feeding fauna such as native oysters are likely to be displaced by detritus feeders such as worms (Edgar and Barrett, 2000). This may be partly through the direct mechanism of smothering, though many filter feeders also do not thrive in high sediment loads. Very large losses of filter feeding mollusc species have been associated with increased sedimentation rates in estuaries in south eastern Tasmania (Edgar and Samson, 2004) and clear evidence of a change from filter feeding environments to detritus feeding environments caused by sedimentation is provided by Jordan et al. (2003) in the Derwent estuary.

7.3 Sediment Distribution

As part of this study, sediments were surveyed at a total of 33 sites throughout Georges Bay (Fig. 7.2). At each site up to three sediment samples were taken with a corer that samples the top 5 cm. Each sample was analysed for particle size distribution in the laboratory. An important measure of particle size from a biological perspective is that of the proportion between the very fine particles (silt and clay) and the coarser particles (fine to coarse sand and granules) (Edgar and Shaw, 1995). These proportions were calculated for each of the sediment samples and the results are presented in Fig. 7.2.

Large portions of Georges Bay are covered in mud, that is, silt and clay consisting of particles less than 63 thousandths of a millimetre (<63 µm). The particles are particularly fine in central basin (Crawford et al., 2001) and, generally, become progressively more coarse in the shallow waters. This progression is illustrated by the three sediment samples taken in a nearshore transect running into Stieglitz Beach, where there is a clear increase in the proportion of courser particles closer to shore.

The correlation between depth and particle size is a reflection of the hydrodynamics of the bay, where the finer particles are only deposited when the water turbulence (e.g. waves and current speed) is low enough for these very small particles to settle out. Moulting Bay also exhibits extensive
Sediments and Unvegetated Habitats

Deposits of fine particles apart from Steels Spit, where higher turbulence has allowed only coarser sands to remain. The larger (sandier) particles found in the nearshore areas indicate a higher energy environment. For example, the edges of the main George River Delta and O'Connors Beach are influenced by the wave action of the harbour chop. Higher sand proportions are also evident in the main channel and on the flood tide delta near Stockyards Flat. Here, the main influence is the higher tidal current flows through the channel.

The largest particles were found on the active section of the George River delta, where there are large fluvial (river) deposits of granules and fine gravel. The steepness of the front of the delta is also indicative of coarse sediment deposition (Woodroffe, 2002).

Fig. 7.2. Sediment particle size sampled in Georges Bay showing the proportion of sand to silt, a significant biological factor that strongly influences the flora and fauna communities.
Georges Bay has some unusual emergent coarse shell bank deposits in two locations, along the margins of the small sand bars on the main channel side of the flood tide delta and along the south eastern margin of the main riverine deltas in the bay (Fig. 7.3). These formations are likely to be formed by moderate energy water transport from adjacent areas that have mollusc beds, including those bed occurring within nearby seagrass (Prager and Halley, 1999). These authors also showed that dense seagrass along the margins of banks can reduce water velocities at the substrate on the bank by up to 80%.

7.4 Unvegetated Habitat Distribution
The unconsolidated sediment habitats are 60% of the total area of the bay below the high water mark (Fig. 7.4). Sand dominated habitats (not including hard and shelly sand) constitute about 15% (286 Ha) of the bay’s area, while silty sand (i.e. sand with a silt content of more than 20% and less than 80%) makes up a further 15% (274 Ha). The balance of the unvegetated area is largely silty (i.e. mud) at 27% (500 Ha), while hard sand and shelly sand habitats are about 3% (51 Ha) of the bay’s area.
The silty habitats generally occur below about 10 metres depth, though parts of the bay, such as the inner harbour area and Moulting Bay, have silty habitats in shallower waters, reflecting the lower hydrodynamic energy of these areas. Conversely, on the face of the flood tide delta adjacent to the main basin, the silty habitats are found in deeper water. This indicates that the tidal stream associated with the flood tide is carrying sandy sediments of marine origin into the main basin. The overlay of sand found at the toe of the flood tide delta is consistent with active growth of the delta due to the deposition of sandy marine sediments overlying silty sediment likely to be of fluvial origin (Fig. 7.5).

The entrance channel is a complex area with the bottom of the main channel consisting of hard packed coarse sand, often with high shell content. The video observations revealed macroalgae colonising these sediments in places, indicating a relatively stable and hard substrate. Towards the entrance, the sands are actively reworked by the increased wave energy and consist of...
moderately well sorted medium sized sand grains.

There were two main distribution patterns of the native oysters. Firstly, they consistently occurred in the zone of silty sand habitats below the deep edges of the seagrass beds. These oyster beds consisted mostly of mature animals and were scattered across the bottom at densities of up to 40 or 50 \( \text{m}^{-2} \). The second distribution pattern consisted of the very dense beds found in the vicinity of the flood tide delta, around Humbug Point and Lords Point. The oysters create a unique habitat by providing shelter and anchor points for many other plant and animal species, including algae and small fish.

7.4.1 Native Flat Oyster distribution

The native oyster (\textit{Ostrea angasi}) population of Georges Bay was surveyed in 1987 (Wilson, 1991) to assess the viability for commercial exploitation. Over 24 million native flat oysters were estimated to be present in a series of beds covering about 33 Ha throughout the bay. The highest quality oysters were found in and around the flood tide delta between Humbug Point and Lords Point, where a maximum density of 344 oysters \( \text{m}^{-2} \) with an average length of 85mm was found (Fig. 7.6).

The current study has not repeated that survey and, as per the SEAMAP mapping protocols, the oysters are included in both the unvegetated sediments categories and in seagrass categories. While the extent of oysters were not precisely mapped, positions were logged whenever oysters were observed in the field with the benthic video (See Fig. 7.5 and 7.6; Appendix 1 on the CD ROM for video footage of the oyster habitats).
Figure 7.7. The upper two maps show the location of native oyster beds in 1987 (Wilson, 1991). The map on the left shows the shallow beds and the one on the right shows the deeper beds. The lower map consists of a Quickbird satellite image (May 2002) which shows the locations where oysters were observed via the benthic video (purple spots) in March 2005. Most of the 1987 oyster beds are readily identifiable in the satellite image and are consistent with the video observations. The blue arrows indicate some examples. The orange arrow indicates an apparent loss of oyster habitat.
7.5 Unvegetated Associated Fauna

7.5.1 Fishes

Georges Bay has high fish species biodiversity, with 39 species recorded in a statewide survey by Last (1983) and Edgar et al. (1999). This is comparable to the Tamar (41), Great Swanport (37), the Derwent (37) and the North East Estuary (Flinders Island)(40). The result is consistent with the finding that estuaries with seagrass have greater biodiversity (Edgar et al., 1999). However, many fish species make use of unvegetated habitats, and there are different species that make use of sand and silt substrates. Typical species found in these areas include leatherjackets, hardyheads, flounders, eastern Australian salmon and mullets (Jordan et al. 1998). As both juvenile and adult species are found, these areas act as both nursery and adult habitat. Typical fish assemblages on deeper (>10 m) unvegetated (soft) bottom include leatherjackets, stingarees and gurnards (Jordan, 1997).

While this study did not conduct any fish surveys, the species presented in Table 7.1 are compiled from a series of studies including Last (1983), Edgar et al. (1999) and Jordan et al. (1998).

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### Sediments and Unvegetated Habitats

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<td>unveg</td>
</tr>
<tr>
<td><em>Platycephalus bassensis</em></td>
<td>Sand flathead</td>
<td>veg, unveg</td>
</tr>
<tr>
<td><em>Pseudocaranx dentex</em></td>
<td>Silver trevally</td>
<td>open water, unveg</td>
</tr>
<tr>
<td><em>Pseudogobius olorum</em></td>
<td>Bluespot goby</td>
<td>unveg</td>
</tr>
<tr>
<td><em>Pseudophritis urvillii</em></td>
<td>Freshwater flathead</td>
<td>veg, unveg</td>
</tr>
<tr>
<td><em>Pseudophycis bachus</em></td>
<td>Red cod</td>
<td>veg, unveg</td>
</tr>
<tr>
<td><em>Pomatomus saltatrix</em></td>
<td>Tailor</td>
<td>open water</td>
</tr>
<tr>
<td><em>Rhombosolea taprina</em></td>
<td>Greenback flounder</td>
<td>unveg</td>
</tr>
<tr>
<td><em>Stigmatopora argus</em></td>
<td>Spotted pipefish</td>
<td>veg</td>
</tr>
<tr>
<td><em>Stigmatopora nigra</em></td>
<td>Wide-bodied pipe fish</td>
<td>veg</td>
</tr>
<tr>
<td><em>Tetractenos glaber</em></td>
<td>Smooth toadfish</td>
<td>veg, unveg</td>
</tr>
<tr>
<td><em>Trachurus declivis</em></td>
<td>Jack mackerel</td>
<td>open water</td>
</tr>
<tr>
<td><em>Urocampus carinirostris</em></td>
<td>Hairy pipefish</td>
<td>veg</td>
</tr>
<tr>
<td><em>Urolophus crucatus</em></td>
<td>Banded stingaree</td>
<td>unveg</td>
</tr>
<tr>
<td><em>Vanacampus phillipi</em></td>
<td>Port Phillip pipefish</td>
<td>veg</td>
</tr>
<tr>
<td><em>Vanacampus poecililaemus</em></td>
<td>Longsnout pipefish</td>
<td>veg</td>
</tr>
<tr>
<td><em>Vincentia conspersa</em></td>
<td>Southern cardinalfish</td>
<td>veg</td>
</tr>
</tbody>
</table>

Table 7.1. Fish and ray species recorded in Georges Bay (Last, 1983; Edgar et al., 1999; Jordan et al., 1998). The primary habitat is indicative only. The code “veg” includes vegetated habitats such as reef and seagrass, while “unveg” includes sand, silty sand and mud and “Open water” refers to the water column.

### 7.5.2 Macroinvertebrates

The unvegetated habitats of Georges Bay are host to a wide variety of macroinvertebrates species (Edgar et al. 1999; Table 7.2). The dominant species include *Actaeia bipleura* and dog whelk, (*Nassarius nigellus*; Fig. 7.5). More comprehensive surveys conducted in other parts of the state in similar habitats showed 25 to 30 taxa is the average number of invertebrates found (Moverley and Jordan, 1996). Macroinvertebrate species in deeper muddy habitats typically include *Theora fragilis* (Fig. 7.6), *Lumbrineris* spp. and *Nephtys* sp., while the sandier habitats are dominated by amphipods and worms, such as Phoronids, Opheliidae polychaetes and the less common Capitelliidae (Fig. 7.7). Edgar (1997) provides further detailed information about these species.

Crawford et al. (2001) and Aquenal Pty Ltd (2004) have also sampled macroinvertebrate communities in Georges Bay. In Moulting Bay, Crawford et al. (2001) found that
polychaete worms were the most common faunal group, comprising of 39% of species recorded, with Nemertean worms also important (19%). Overall, the benthic infauna was low in species richness and individuals per site. This was confirmed by surveys conducted by Aquenal Pty Ltd (1999) in Moulting Bay.

Conversely, sampling around the sewage outfall pipe by Aquenal Pty Ltd (2004) revealed a relatively diverse macrofaunal assemblage, with polychaete worms, amphipods and mollusc fauna all represented. The most common species were the capitellid polychaete, *Capitella* sp. (Fig 7.10) and the spionid polychaete *Malacoceros tripartitus*. Previous studies in Tasmania have recorded these species in areas with increased organic loading (e.g. McCleod et al., 2002). These species appear to be absent from Moulting Bay, so it is possible that organic enrichment from the sewage pipe outfall is having an impact on the benthic invertebrate communities at this site.

**Macroinvertebrate Species**

<table>
<thead>
<tr>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actaeia bipleura</td>
</tr>
<tr>
<td>Euzonus sp.</td>
</tr>
<tr>
<td>Exoeideroides ?maculosus</td>
</tr>
<tr>
<td>Heteromastus sp.</td>
</tr>
<tr>
<td>Magelona sp.</td>
</tr>
<tr>
<td>Mysella donaciformis</td>
</tr>
<tr>
<td>Nassarius nigellus</td>
</tr>
<tr>
<td>Nassarius pauperatus</td>
</tr>
<tr>
<td>Nephtys australiensis</td>
</tr>
<tr>
<td>Notospisula trigonella</td>
</tr>
<tr>
<td>Perinereis vallata</td>
</tr>
<tr>
<td>Tellina deltoidalis</td>
</tr>
</tbody>
</table>

Table 7.2. Twelve most common macroinvertebrate species in unvegetated habitats in Georges Bay (from Edger et al. 1999).
8. Ecological Health: Monitoring and Management

8.1 Introduction

The management of human activities that affect the environmental, ecological and aesthetic values of Georges Bay is a key concern, as the estuary often receives the cumulative impacts of recreation, industry, urbanisation and land degradation within the catchment. Many of these activities and impacts are also of direct and indirect concern for human health. For example, poor quality sewage treatment can lead to disease in humans while nutrient overloading can place stresses on plants and animals in the bay, which may lead to long term shifts in community structure.

This chapter outlines the existing human impacts on the bay (see Fig. 8.1) and identifies the monitoring and management approaches that seek to respond to these impacts. The final section outlines monitoring options for both habitats and water quality.

8.2 Sewage Discharges

8.2.1 Council sewage treatment plants

Break O’Day Council runs one major sewage treatment plant with an outfall into Georges Bay. The St Helens wastewater treatment plant is located off Binalong Bay Road on the eastern bank of Colchis Creek. Sewage is collected by a gravity sewerage system and through a series of pump stations situated throughout the main township of St Helens, and is piped into a lagoon system. The St Helens wastewater treatment plant currently consists of primary and secondary treatment lagoons, licensed to cater for an average dry weather flow of 690 kL/day. These lagoons provide biochemical treatment and settling of sewage, and discharges treated wastes directly into Georges Bay via a concrete ocean outfall pipe. This system services a permanent population of around 1500, although during the summer holiday period this figure can increase to around 4,000.

Whilst the current system is functional, the effluent discharge quality is of minimum standards. Emissions are frequently over draft guideline values set by DPIWE (2001). As a result of the expansion of the aquaculture industry in the Bay and concerns regarding water quality, Break O’Day Council is proposing to upgrade the current lagoon system to Membrane Bio-reactor technology. This technology allows for the production of high quality effluent, which requires no primary or secondary settlement stages and will be supplemented by UV treatment (SKM, 2005). The existing lagoons will be maintained and used as emergency storage.

Another small sewage treatment plant exists at Stieglitz (See Fig. 8.1). This services the Stieglitz and Akaroa region to the west of O’Connors Beach. The Stieglitz plant consists of a primary and secondary lagoon, with a re-use scheme in operation to deal with the discharge. Wastewater from the secondary lagoon is currently used to irrigate the St Helens aerodrome. Consequently there is no direct discharge from the Stieglitz plant into Georges Bay.

The only other sewage lagoon system in Georges Bay services the four aquaculture businesses near the mouth of the George River. This is comprised of one oxidation lagoon, in which evaporation tends to exceed...
output. Consequently, it is of little concern in regard to the water quality of Georges Bay.

8.2.2 Domestic on-site systems

In the past, a key impact on water quality in Georges Bay was effluent discharge from under-performing septic tank systems. Prior to the mid 1900s, domestic waste water in St Helens was handled by septic tank systems with disposal via absorption drains in the ground. Around the mid 1900s the first waste disposal system was developed that accepted septic tank waste, as well as stormwater and sullage and then piped it directly into the Bay. This system remained until the early 1980’s, when the existing sewage lagoons were built and wastes intercepted and pumped to the lagoons.

Figure 8.1. Position of key point and diffuse pollution sites in Georges Bay.

Ongoing work has seen a gradual shift from septic tanks into the current waste disposal system, although there remain small pockets of urban areas still using septic tanks. Break O’Day Council have an ongoing program to service all properties accessible to the sewer in St Helens and Stieglitz, including Akaroa.

Currently, there is very little remaining land available for development around Georges Bay that would not be required to connect to the sewerage system. When subdivisions are proposed in unsewered locations, the planning process requires an assessment of the capacity of the soils to cope with the wastewater load. If any development poses a potential threat to the bay or contributing
waterways, the council requires an aerated wastewater treatment system (AWTS) to be installed rather than a septic tank. Some landowners are also actively choosing to install or upgrade to AWTS systems to ensure they handle their wastewater on site.

Fig. 8.1. Primary and secondary treatment ponds at the Stieglitz sewage treatment plant. The wastewater is finally reused on the St Helens aerodrome surrounds

8.3 Industrial Discharges

Direct pollution from industrial discharge is minimal in Georges Bay. There is a small industrial estate in St Helens located off the Tasman Hwy near the St Helens sporting complex. This industrial estate contains a saw mill and panel beater. The saw mill has been integrated into the St Helens wastewater system, with no direct wastewater discharge into the marine environment.

The other potential site for industrial waste discharge is the oyster processing plant near the mouth of the George River. However, the four aquaculture businesses maintain an oxidation lagoon system to service industrial waste from this site, thus avoiding direct industrial discharge into the Bay.
8.3.1 Level 1 activities
Under the provisions of the *Environmental Management and Pollution Control Act* (1994) the council is responsible for controlling wastes from small-scale industries. There are a range of activities that could cause environmental harm, and though many of them are relatively innocuous, cumulatively they may produce unwanted effects.

Typically, the council will respond to these situations as they arise via complaints. An exception is the approach taken to ensure sewage is either delivered into the sewerage system or, if on-site systems are required, that they perform adequately. While any one poorly performing septic tank does not create much environmental damage, a large number does. An audit of Level 1 activities is one way to proceed to a more structured approach to these small, but never-the-less, important components of sustainable management.

8.3.2 Level 2 activities
DPIWE holds responsibility for controlling potentially hazardous activities under the *Environmental Management and Pollution Control Act* (1994). It does this through the use of licences and permits, some of which can require monitoring. Level 2 activities are defined by taking into account the following criteria:

- the potential for serious or material environmental harm (including nature of impact);
- the level of ongoing regulation required;
- consistency of regulatory provisions (either across planning schemes or between jurisdictions);
- the impact on an industry of inclusion on Schedule 2; and
- public interest in an activity.

Apart from the St Helens Timber Mill, the council is the holder of all the permits for Level 2 activities in the St Helens district. These include the two sewage treatment plants (STPs), the St Helens Inert Waste Depot and the Nephele Creek Pit quarry.

Conditions may be set on the licences. For example, while the Inert Waste Depot, which has a long history of the deposition of putrescibles, has now ceased, the Level 2 licence still requires the council to conduct monitoring of two nearby groundwater bores and the major drain outfall for a range of water quality parameters, including nutrients.

8.4 Stormwater Discharges
Stormwater contamination and urban runoff are potentially key sources of pollution including litter, pathogens (bacteria), oils, heavy metals and nutrients into urbanised coastal regions. For example in 1998 it was estimated that urban runoff delivered approximately 70% of the total faecal coliform load to the Derwent Estuary and 40% of the suspended solids load (Coughanowr and Green 2003).

No similar estimates are available for Georges Bay, but contaminated stormwater has considerable potential to effect water quality in the Bay. In the St Helens area stormwater is likely to be contaminated with typical urban pollutants such as litter, silt, bacteria from dog faeces and nutrients. Testing of stormwater by the St Helens District High School in October 2004 for faecal coliform and heavy metals showed relatively high levels of faecal coliform during heavy rain. Aluminium, iron and chromium were also detected in the...
stormwater (Fig. 8.2). The mobilisation of aluminium from soils of granitic origin is not unusual, which may explain the high aluminium value reported from this study. This is particularly true for soils on granitic bedrock that may have been broken down either naturally, or through historical tin mining activity. Recent DPIWE testing has indicated that the background values of dissolved aluminium in the George River catchment may be slightly higher than ANZECC Guidelines (Analytical Services Tasmania, Report 24444, 2005).

![Figure 8.2. Results of stormwater testing by St Helens District High School, October 2004. These values are for total metals including the dissolved (more biologically active) and particulate (less biologically active) components.](image)

In rural areas, particular those around the George River and catchment, diffuse stormwater runoff is likely to be contaminated with silt (from land and unsealed roads) and bacteria and nutrients (from stock and septic tanks).

Stormwater monitoring is an important component of managing the impacts. The Derwent Estuary Program has created a Stormwater Working Group to provide guidance and initiatives and its outcomes are potentially useful for Georges Bay.

### 8.5 Solid Waste Disposal

Solid waste from the Georges Bay region is currently disposed of at the landfill in Scamander. Inert solid waste, such as cardboard, is buried at the Break O’Day Council Depot located on Medeas Cove Esplanade, beside Medeas Cove. This has been protocol for the last five years. Prior to this, all solid waste was disposed of in landfill at the Depot.

The potential discharge of leachate from this site and subsequent groundwater contamination is of concern. However, as this site is no longer fully operational, the problem is not escalating and expected to slowly self-remediate over time. The site is monitored for a range of leachates on a regular basis as part of its licence conditions and the results reported to DPIWE.

### 8.6 Boating Wastes

Boating activities can affect water quality. A number of these activities are identified below.

#### 8.6.1 Sewage

Untreated sewage and sullage may be discharged from commercial and recreational boats in Georges Bay. Existing acts and regulations disapprove of such actions, but do not prohibit it. In response to the risk of untreated sewage discharge from a large number of vessels, Break O’Day Council has installed a marine waste pump out facility on the commercial wharf at St Helens.

This facility has enabled boats to pump out their toilet waste at any time and has allowed
waterfront businesses to be connected to the main sewage reticulation system.

8.6.2 Bilgewater

The liquid that finds its way into the bottom of boats through spills and leaks is called bilgewater. Bilgewater often contains oil, diesel, detergents and other contaminants. High level controls operate on the discharge of bilgewater from large vessels, though there are no large vessels using the port of St Helens. Regulations on smaller vessels are at a much lower level and, without further study, it is not clear whether bilgewater is impacting on the bay.

8.6.3 Oil spills

The State Marine Pollution Control Committee holds responsibility for responding to oil spills in Tasmania when they are greater than 10 tonnes and they operate in cooperation with Commonwealth Government (Australian Maritime Safety Authority), State Government (DPIWE and Marine and Safety Tasmania), Port Authorities and oil/shipping industries. For spills less than 10 tonnes the port Authorities are required to respond. Georges Bay was covered by the Hobart Port Authority until corporatisation in 1997. Since then some efforts have been made to stockpile spill response materials in Georges Bay.

8.6.4 Ballast water

Ballast water is likely to be a source of introduced pests in Georges Bay. Controls are in place for ballast water discharges from international ships, but not for domestic shipping or smaller vessels.

Marine introduced pests such as the toxic dinoflagellate *Gymnodinium catenatum*, the macroalga *Undaria pinnatifida* and mussel *Musculista senhousia* are believed to have all been introduced to Georges Bay through ballast water discharge (TAFI, 2002; DPIWE, 2003). For instance, the population of *Musculista senhousia* in Georges Bay is the only confirmed report of this species on the east coast. The nearest known population is the Tamar estuary on the north coast, so it is probable that a fishing or recreational vessel(s) has acted as a vector for the translocation of this species (DPIWE, 2003). A similar mechanism is likely for *U. pinnatifida*, which only has a limited capacity for natural dispersal.

8.6.5 Slipway wastes

Slipways have the potential to deliver toxic substances to the surrounding marine environment as they are the site of activities such as cleaning and painting boats. The toxic paint chips and residues can mix with other contaminants such as heavy metals and acids and find their way into the waterways, where they can damage components of the natural environment through poisoning and genetic damage.

There are several small slipways and one major slipway at Georges Bay Marine Pty Ltd. Part of the slipway’s workload is the repair and maintenance of small boats, including the local fishing fleet. The Georges Bay Marine slipway has recently upgraded the liquid and solid waste collection system to lessen its impact on Georges Bay. The slipway containing boat cradles also has a concrete kerb on the downslope end to contain and prevent the discharge of wastes into the sea. Liquids and solids drain into concrete pits, with the oil intercepted prior to wastewater discharge.
8.6.6 Antifouling paints / Tributyltin (TBT)

The impact of some antifouling paints traditionally used on vessel hulls is of concern worldwide. TBT based antifouling paints have been banned for sale or use in Tasmania since 31st March 2003.

There has been some concern regarding TBT contamination in Georges Bay, particularly in relation to oyster deformities. Testing for TBT was conducted in July 2001 to November 2002. DPIWE tested for the presence of TBT in oyster meat and sediments at sites around Georges Bay. The highest concentrations of TBT occurred around slipways and wharf areas. All oysters with high TBT values in meat were also associated with slipways and wharf areas. TBT concentrations in sediment around oyster leases were low to non-detectable. On rare occasions that TBT was detected in oyster meat from leases, the concentration was at least an order of magnitude lower than that associated with effects on adult oyster populations. Additionally, results indicate that there was no sustained source of TBT in the vicinity of the oyster leases.

8.7 Recreational Water Quality

The beaches of Georges Bay are regularly monitored by council in summer and the results show that the water quality complies with the standards set for recreational use, apart from some minor problems after heavy rainfall near stormwater outfalls.

8.8 Environmental flows

The Georges River is a key to the water quality of Georges Bay. Although the health of the George River and its tributaries is generally good, the catchment is still recovering from extensive tin mining that occurred in the late 1800’s which resulted in large quantities of sediment being mobilised. The impact of this sediment loading on the flow of the George River and the deposition in Georges Bay is difficult to gauge.

The Goshen and Priory floodplains and George River delta have thick deposits of sediment and there is evidence that the George River mouth is still receiving large quantities of fine sediment from residual in-stream deposits. Although high levels of suspended solids in estuarine waters often lead to deterioration in the condition of seagrass beds, this does not appear to be the case for Georges Bay. However, Moulting Bay, which has very high levels of silts and clays compared with sediments in many other estuaries in Tasmania, has seagrass beds that are more patchy and less dense than in other areas of the bay, even though these beds have expanded in recent years.

The importance of freshwater flows into estuaries on estuarine ecosystem health is poorly understood in Tasmania, and no studies have been conducted in Georges Bay on changes in plant and animal communities with different levels of freshwater flow into the bay. As mentioned previously, the water quality of the bay has been measured almost entirely during normal conditions and there is minimal information on the impact of different levels of flooding.
8.9 Introduced Marine Pests

There have been several surveys conducted in Georges Bay that have looked at the distribution and density of pest species. DPIWE commissioned Aquenal Pty Ltd to conduct an exotic marine pest survey on Tasmanian small ports, including St Helens, between May and November 2003. Exotic species identified fell into one of three categories – target introduced pests, introduced species and cryptogenic species (origin uncertain). Target marine pests were those most likely to have large scale effects once introduced into an ecosystem. St Helens was found to have 17 exotic species, six of which were target introduced pests (see Table 3).

<table>
<thead>
<tr>
<th>Species</th>
<th>Common name /description</th>
<th>Status</th>
<th>L</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crassostrea gigas</td>
<td>Pacific oyster</td>
<td>Target Introduced Pest</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Gymnodinium catenatum</td>
<td>Naked dinoflagellate</td>
<td>Target Introduced Pest</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Carcinus maenas</td>
<td>Green crab</td>
<td>Target Introduced Pest</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Corbula gibba</td>
<td>European clam</td>
<td>Target Introduced Pest</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Undaria pinnatifida</td>
<td>Wakame, Asian kelp</td>
<td>Target Introduced Pest</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Musculista senhousia</td>
<td>East Asian bag mussel</td>
<td>Target Introduced Pest</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Watersipora subtorquata</td>
<td>Bryozoan</td>
<td>Introduced</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Halicarcinus innominatus</td>
<td>Pill box crab</td>
<td>Introduced</td>
<td>X</td>
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<tr>
<td>Petrolisthes elongatus</td>
<td>Porcelain crab</td>
<td>Introduced</td>
<td>X</td>
<td></td>
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<tr>
<td>Maoricolpus roseus</td>
<td>New Zealand screwshell</td>
<td>Introduced</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Raeta pulchella</td>
<td>Bivalve mollusc</td>
<td>Introduced</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Theora lubrica</td>
<td>East Asian bivalve</td>
<td>Introduced</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Venerupis largillierti</td>
<td>Baby clam</td>
<td>Introduced</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Membranipora membranacea</td>
<td>Bryozoan</td>
<td>Cryptogenic</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Corophium sextonae</td>
<td>Gammarid amphipod</td>
<td>Cryptogenic</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Corophium acherusicum</td>
<td>Gammarid amphipod</td>
<td>Cryptogenic</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Myxicola infundibulum</td>
<td>Tube worm</td>
<td>Cryptogenic</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Table 8.1. Introduced species recorded in St Helens by Aquenal Pty Ltd May to Nov 2003.
L – Identified through literature review, F – Identified through field survey.

This survey was the first time *Musculista senhousia* had been documented on the east coast of Tasmania. It is likely to have been introduced through ballast water or hull fouling on recreational or fishing vessels (DPIWE, 2003). *Gymnodinium catenatum* and *Undaria pinnatifida* are also likely to have been introduced into Georges Bay in this manner.

A survey of the distribution and density of *Undaria pinnatifida* was undertaken by TAFI in August 2002. The survey indicated that *Undaria* was confined to the area of the navigation channel between Humbug Point and Lords Point at that point in time. *Undaria* was also observed at the reef edges of the points either side of Akaroa near where boats were launched from the beach. Dispersion of *Undaria* out of the channel and into Moulting Bay appear restricted. Sediment tends to be fine silts with little or no vegetation cover and a moderate density of suspended particulate matter, considerably reducing light penetration. Hence, the establishment of new populations of *Undaria* in these areas is unlikely in current conditions.
The distribution of feral Pacific oysters in Georges Bay was undertaken by Mitchell et al. (2000) in the spring/summer of 1999/2000. Feral oysters were sighted all around the Bay, but were ranked as “abundant” in the main wharf and Medeas cove area. Over the past seven years the oyster farmers have endeavoured to clean up the feral Pacific oysters in Georges Bay. The first harvest began in 1998 and six months later the oysters were processed in Sydney for the Asian market (J. Harris, TECMO, pers. comm). For the first two years, an average of approximately 30,000 dozen feral oysters were removed, along with approximately 20 tonnes of waste shell to eliminate settlement substrate. Currently, 4,000 dozen feral Pacific oysters are harvested annually from Georges Bay (J. Harris, TECMO, pers. comm.).

*Centrostephanus rodgersii* has also been observed in Georges Bay, in the region of Akaroa (TAFI, 2002). *Centrostephanus* has undergone a southerly range extension over the past 40 years, and therefore is not classified as an introduced pest. However, there has been considerable concern regarding the changes in distribution of *Centrostephanus*, given its potential to cause urchin barrens and drive ecosystem changes.

### 8.10 Seafood Safety

#### 8.10.2 Wild shellfish

Wild shellfish in Georges Bay may be affected by faecal contamination from the George River and other inputs around the Bay. There are prohibited zones for a 500m radius around the mouth of the George River and the sewage treatment plant outfall. Where these zones exist it is inadvisable to harvest shellfish for consumption.

There are two wild harvest zones in Georges Bay, both of which are monitored by TSQAP for the bacteria *Escherichia coli*. The first zone covers the area encompassing Grannys Gut and O’Connors Beach stretching to Humbug Point and Yellow Bluff, including Moulting Bay. The second zone extends from Humbug Point and Yellow Bluff to the Georges Bay entrance. The TSQAP sanitary report for 2004 recommended that these zones be closed when salinities reach <31 for zone 1 and <30 for zone 2. Rainfall to prompt salinity checks is >40mm in 7 days at Pyengana.

The main area of St Helens is excluded from the wild harvest zones. There is a strong potential for heavy metal contamination around major slipways and wharf areas. For instance, DPIWE recorded the presence of TBT in oysters around the Georges Bay Marine Services Wharf. There is also potential for contamination by other heavy metals in areas that are subject to frequent marine traffic. For instance, copper is often the active component of anti-fouling in place of TBT, and is likely to be present in elevated concentrations around wharf and slipway areas. Furthermore, the St Helens area carries the highest population density of Georges Bay, and subsequently there is likely to be a pollutant component in stormwater discharge into the Bay. As such,
the harvest of wild shellfish for consumption in this area of Georges Bay would be inadvisable.

8.11 Monitoring: Seagrass

Seagrass is a key component of the Georges bay ecosystem and is known to fluctuate in its abundance on decadal time scales. There are a very large number of ways in which seagrass can be monitored, however, the monitoring program should reflect both objectives for monitoring and the resources available. St Helens is a regional rural centre and does not have the human and financial resources to conduct detailed ongoing monitoring. The volunteer community groups are also significantly stretched in their capacity. In the light of the limited resources, two options are put forward.

The first option is to conduct another mapping exercise in 5 to 10 years time, of similar (or improved) scope and precision to the one completed for this report. Given the accuracy of the current maps, this would enable an assessment of the distribution and density of the seagrass and associated epiphytic algae throughout the bay at the time, as well as allow quantifiable comparisons with the results of the current study.

The second option is to initiate a targeted community based monitoring program based on international best practise, which would produce results useful to management of the bay. There are excellent programs that are already developed, documented and implemented within Australia. They are documented with detailed support guides for any group that wished to proceed with a seagrass monitoring program. The recently prepared Parks Victoria Technical Guide (See Appendix 2 on the CD-ROM) not only deals with precisely the same species present in Tasmania, it also enables participation in Seagrass-Watch which is the largest community-based seagrass monitoring program in the world with over 150 monitoring sites in the Western Pacific to date – mostly in tropical waters (http://www.seagrasswatch.org/).

8.11.1 Seagrass monitoring recommendation

That if the Georges Bay community choose to initiate a seagrass monitoring program they consider the following options:

1. Every 5 to 10 years conduct a mapping exercise using boats with subsurface detection equipment, such as video and sounders, in combination with expertly selected and interpreted remote sensing.

2. Conduct a community seagrass monitoring program based on the Seagrass Watch protocols as presented by Parks Victoria each 3 to 12 months.

8.12 Water Quality Monitoring

9. Management Issues

9.1 Introduction

There are a large number of activities that can potentially affect the ecological health and functioning of Georges Bay, either positively or negatively. The management of many of those activities is shared between many agencies, groups and individuals and it is useful to understand the basis of management actions, including the potential stakeholders, legislation and jurisdictions. The active participants in natural resource management rely on each other and, with a clearer understanding of the interrelationships and networks, improved management options will become more likely.

This chapter outlines a number of the management issues pertinent to Georges Bay.

9.2 General Community

As more people with more resources at their disposal continue to expand their lifestyle choices in both the immediate vicinity of Georges Bay and its catchment, potential impacts must be identified and considered for management action. Some of the impacts could include further land clearing with consequent vegetation and soil losses, increased loads on infrastructure and amenities, increased competition for natural resources such as fish, and increased contaminated runoff into the bay.

There is broad community agreement about the need for development that is ecologically sustainable, as most people acknowledge that securing a healthy environment is an essential component for future growth and prosperity. The participation of the wider community in making positive choices for their collective future wellbeing through consultation, inclusion and education is crucial to a successful management strategy for Georges Bay.

9.3 Community Groups

Community groups play a key role in the management of environmental assets. Around Georges Bay there are a number of groups that have identified themselves as having a strong interest in one or more aspects of the bay and their community and environmental service contributions are highly valued. This report is designed to support these groups or people with sufficient information to inform their goals and activities.

There are few community groups with a direct interest in the bay. They include the St Helens Area Landcare and Coastcare Group and the North East Bioregional Network.

9.4 Industry

9.4.1 Marine farming

Marine aquaculturalists are strongly involved with the ecological functioning of Georges Bay, as their livelihood depends on good water quality and sustainable use of the environmental services provided by the bay. There are some conflicts about the use of the bay including noise and visual impacts, occupation and obstruction of the waterway and concerns about nutrient enrichment of the sea floor under the farms. On the other hand, marine farmers are concerned that their livestock are vulnerable to damage by detrimental land management practices within the catchment.
Oyster farmers are very active scientifically and undertake research projects into issues facing their industry at the local scale. Part of this effort is underpinned by monitoring programs, which are overseen by the Tasmanian Shellfish Quality Assurance Program (TasQAP). The program reports are publicly available on request.

The industry is closely involved in the shaping of the future management actions within the bay and, given their key role in the bay, it is vital that they remain engaged.

9.4.2 Shore-based activities

There is a small boat building and maintenance industry in Georges Bay, mostly servicing the commercial fishing fleet. Continuing vigilance is required to ensure the potential environmental impacts are kept to a minimum. These potential impacts include water pollution, noise and visual aspects, conflicts with the public regarding foreshore access and infrastructure demands. All of these industries are too small to require monitoring by DPIWE.

Given the likely impacts from these industries is critical that they become more involved with the ongoing management issues around the bay. Clearly, this sector is able to play an important role in information sharing about the sustainable use of the bay and it is preferable they are invited to participate in future management activities.

9.5 Government

Break O’Day Council is the main operator of the major infrastructure surrounding Georges Bay including two sewage treatment plants, current and past waste disposal sites, roads and other infrastructure. It is also directly responsible for planning and (human) environmental health.

These activities have a critical influence on the ecological outcomes in the bay and are a core component of any management scenario.

While the local council is an important actor, the other two levels of government often have overriding responsibilities for policy development and implementation. As such, it is imperative that there is a concerted effort to harmonise the legislative and jurisdictional frameworks with the resources and efforts of the local actors. Doing so will increase the effectiveness of strategic resource management.

9.6 Jurisdiction

The three tiers of government have joint responsibilities for the management of Georges Bay. Local Government has jurisdiction over land use and development above the low water mark and up into the catchment. The council has a very large number of other responsibilities including land management, road building and maintenance, water supply, waste disposal, recreational facilities, traffic management and sewerage.

The State government has control over development in the immediate coastal zone, especially if the development is on coastal reserve or crown land. The State also has jurisdiction over the “State Coastal Waters”, which are defined to include the sea and the land under the sea (the sea floor) out to 3 nautical miles from the high water mark. Georges Bay forms part of the “Internal Waters” (a subset of the State Coastal
Waters) due to the short distance across the entrance compared to the length of the bay.

9.7 Legislation and Policies

There are a large number of statutory Acts, Regulations and policies relating to natural resource management at all levels of government that may impact on activities in and around Georges Bay.

Generally, Commonwealth legislation provides the overarching principles for natural resource management, while State legislation provides the specific controls and principles applicable to Tasmanian needs. The Break O’Day Planning Scheme provides local-level controls on land use management.

9.7.1 State controls

The following State controls apply to the environmental management of North West Bay:

- **Resource Management Planning System (RMPS)**
  
  This is the overarching land management legislation in Tasmania and most land management legislation refers to its core principles of sustainable management.

- **State Policy on Water Quality Management (1997)**

  The *State Policies and Projects Act* (1993) provides the legal basis for a number of State Policies including Water Quality. The Policy is designed to maintain and enhance the quality of surface waters in Tasmania, while still allowing responsible development in accord with the RMPS. It is consistent with the national Policy model and enables Protected Environmental Values (PEVs) to be identified and set. This is a process completed in consultation with each local government in Tasmania and is overseen by the Environmental Management and Pollution Control Board. After PEVs are established, Water Quality Objectives (WQOs) can also be created to ensure the PEVs are reached and maintained.

  - **Protected Environmental Values (PEV)**

    Break O’Day is the last council in Tasmania to finalise the PEVs. The process stalled at the Public Discussion Paper stage, with the paper released for discussion in June 2000, though recent progress should see the PEVs finally signed off in the near future. The likely PEVs for Georges Bay are:

    Protection of Aquatic Ecosystems - modified (not pristine) ecosystems from which edible fish, crustacea and shellfish are harvested.

    Recreational Water Quality & Aesthetics - defined as primary and secondary contact water quality and aesthetic water quality.

    PEVs default to the highest level of protection for any one water body and provide protection to the bay itself and the people and industries that use the bay. A recent review of the PEVs conducted for the State Water policy may include a new Primary Industry PEV that, among other purposes, is designed to protect marine aquaculture.

  - **Water Quality Objectives (WQOs)**

    WQOs are designed to enable PEVs to be achieved, as well as provide targets for emissions and can operate as performance indicators. However, they are not usually
incorporated into planning schemes and do not carry legislative or regulatory power.

None the less, they are valuable components of the management framework for achieving and maintaining good water quality. In the absence of WQOs, the current proposed upgrade for the St Helens Sewage Treatment Plant used a modified set of Water Quality Targets set by DPIWE and based on the ANZECC Guidelines (See 9.7.2 below).

- **State Coastal Policy**

  The State Coastal Policy forms a part of the overall RMPS and was generated under the State Policies and Projects Act 1993. It seeks to provide strategic policy guidelines for action in the coastal zone including the onshore and nearshore regions.

  The Policy is currently under review, with significant changes drafted in response to identified problems and it is about to be put out for public comment. The mooted changes are designed to create a shorter policy and provide councils with a set of Guidelines to assist with implementation as well as offer a set of model standards for inclusion into Planning Schemes. Until the new policy comes into effect (possibly in 2006), the existing policy remains in force.

- **Environmental Management and Pollution Control Act (1994)**

  This Act is the primary environment protection legislation in Tasmania and aims to prevent, reduce and remediate environmental harm. The Act is designed to preventing environmental damage from pollution and wastes.

- **Tasmanian Natural Resource Management (NRM) Framework and Act**

  The Tasmanian NRM Framework has been developed to provide the State with a systematic way of integrating natural resource management, to ensure consistency, efficiency and improve natural resource outcomes. The enabling legislation for the Framework is the **Natural Resource Management Act 2002**.

  The Northern Tasmania Natural Resource Management Strategy (March 2005) is now in place following a community consultation process. The NRM committee guides the priorities for investment in natural resource management in the north and north east.

- **Tasmania Together**

  A Community Leaders Group has developed a long-term plan for the State through the Tasmania Togetherness process. The relevant natural resource management goals in the plan aim to value, protect and conserve our natural and cultural heritage and diversity, ensure balance exists between environment protection and economic and social development and to long-term sustainable management of natural resources.

  **9.7.2 Commonwealth controls**

  - **National Water Quality Policy (NWQP)**

    This policy was initiated in 1992 and aims to achieve sustainable use of the nation’s water resources.

  - **Environment Protection and Biodiversity Conservation Act (1999)**

    The Commonwealth Minister is empowered by this act to approve development proposals in States and Territories where matters of national environmental significance may be substantially impacted.
Management Issues

- National Action Plan on Salinity and Water Quality
  
  This is based on the concept of integrated regional and/or catchment planning and management of natural resources. It requires agreements between the Commonwealth and States.

  The Inter-Governmental Agreement on Salinity and Water Quality includes agreement to an accreditation process for regional natural resource management plans and to national standards and targets for salinity, water quality, biodiversity and other natural resources matters.

- ANZECC Water Quality Guidelines
  
  The Australian and New Zealand Environment and Conservation Council (ANZECC) guidelines form a central plank of the water quality management at all levels of management in Australia and New Zealand. They consist of authoritative recommendations based on detailed and thoroughly reviewed science. The primary objective of the guidelines is to ‘achieve sustainable use of the nations water resources by protecting and enhancing their qualities while maintaining economic and social development’.

  Where WQOs are not set in Tasmania, the ANZECC guidelines usually act as default levels for minimum standards of water quality.

9.7.3 Local controls

  
  The Break O’Day Planning Scheme was one of the first schemes in Tasmania to implement the new performance based planning standards and the scheme has just undergone a comprehensive review and amendment process. The following are extracts from the objectives of the scheme that are relevant to the management of the bay:

  b) To ensure that approvals are given for use and development so that the total quality of life is maintained, both now and in the future, and the ecological processes on which life depends are improved.

  c) To ensure that decision making processes effectively integrate long and short term economic, environmental, social and equity considerations and recognises the global dimension of environmental impacts.

  j) To ensure that where there are threats of serious or irreversible environmental damage, lack of full scientific certainty is not used as a reason for allowing environmental degradation and the precautionary principle is applied.

  k) To ensure that important terrestrial and marine habitats are protected from use and development that would adversely affect their role as habitats.

  l) To protect and maintain the conservation values of native forests, critical habitats for native fauna, natural bushland, grasslands, alpine areas, wetlands, heathlands and waterways.

  Specific Environmental Objectives are:

  2.2.3 Environmental Protection

  a) Management of water resources is to focus on the achievement of water quality objectives which will maintain or enhance
water quality for both surface and groundwaters.

b) Diffuse and point sources of pollution are not to prejudice the achievement of water quality objectives and pollutants discharged to waterways are to be reduced by the use of best practice environmental management.

c) Integrated catchment management is to be promoted through the achievement of the above objectives and commitment to the Natural Resource Management Objectives and Strategy for the region.

d) Development in National Parks, formal conservation reserves and near the coast is to be controlled and managed to ensure that the values of those areas are not diminished.

f) Design and siting of developments is to be managed to ensure that important visual landscapes are protected from inappropriate development.

9.8 Marine Farming Controls


This Act specifies responsibility to the Government to manage the State’s living marine resources in a sustainable manner. The objectives of this act provide for native fish and their habitat to be managed in a sustainable manner for both recreational and professional users of the resource.

Licences for marine farming activities are issued under this Act (including activities such as fish processing). These licences, along with management controls associated with the marine farming development plans, are the main controls for marine farming activities.

In terms of fishing restrictions, Georges Bay is designated as: no netting west of a line between Grants Pt and St Helens Pt (see below). However, bait nets may be used.

It is also a shark refuge, which means that:

- No shark of any kind may be taken in Shark Refuges.
- If caught in nets or on a rod and line they must be returned to the water as soon as possible with a minimum of damage.
- The use of set lines, which are unattended lines of up to 5 hooks, is prohibited in Shark Refuges.
- The use longlines and droplines is prohibited in Shark Refuges.
Management Issues

- Other restrictions apply, particularly for netting


The Act outlines the systems that assist in the planning and regulation of marine farming industry. The Act allows the creation of regional marine farming development plans that sets the conditions over specific marine farm zones within the each region.

This act forms part of the RMPS and has adopted the objectives of the system. The current Marine Farm Development Plan for Georges Bay was approved in 1998. There are currently six zones in Georges bay and the Plan places controls on marine farms operational issues such as environmental impact, carrying capacity, visual impacts, waste, disease. It also places a requirement for monitoring on the farmers. The zones in Georges Bay are:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Locations</th>
<th>Species</th>
<th>Area (Ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hodgmans Spit</td>
<td>Shellfish, seaweed</td>
<td>31.00</td>
</tr>
<tr>
<td>2</td>
<td>East McDonalds Pt</td>
<td>Shellfish, seaweed</td>
<td>24.49</td>
</tr>
<tr>
<td>4</td>
<td>Moulting Bay West</td>
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</tr>
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<td>5</td>
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<td>6A</td>
<td>South West Pelican Point</td>
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<td>Total</td>
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10. Environmental Issues of Concern

10.1 Introduction

During this current project a number of key environmental issues in Georges Bay have been identified for which environmental objectives and strategies could be developed.

In recent years, there has been considerable public awareness of the linkages between catchment activities and ecological impacts on Georges Bay. Additionally, the population of St Helens township and areas around the bay has grown rapidly in the last couple of years placing increased pressures on the bay through the associated intensification of development. This chapter discusses issues of concern within Georges Bay that have been identified during the preparation of this report.

10.2 Issues of Concern

One of the key ecosystem-based management responses that is of concern is the delay in upgrading the St Helens Sewage Treatment works. There is also a residual area where some ecological impacts may be occurring from septic tank effluent on the southern shores of the bay.

Another related issue of concern is that there is no standard water quality monitoring framework for Georges Bay. Information on water quality is very limited and there are no data on the effect of flood events on the condition of the bay. The Protected Environmental Values (PEVs) are not yet established and the associated setting of Water Quality Objectives (WQOs) is yet to occur. The research undertaken as part of this project could progress the setting of WQOs and an establishment of and integrated water quality framework, including a baseline assessment program. Please see the associated report: Establishment of an Integrated Water Quality Monitoring Framework for George Bay (Crawford and White, 2005) for details.

Stormwater management is another concerning issue affecting the bay – partly because not enough is currently known about the impacts from this source and partly based on experience in other catchments. The last set of monitoring was completed in 2001. It is important to quantify and understand the impacts on the bay from the nutrients, sediments, bacteria and contaminants delivered from stormwater outlets, especially given the significant development in the Estuarine Drainage Area since 2001.

Similarly, the knowledge about the impacts from sedimentation arriving down the river systems is not adequately understood. It would be useful to quantify the sedimentation rates and also assess the quantity of material likely to erode in the short and medium terms.

One of the issues identified during this research was the dispersed and patchy information available about the ecological health of the bay. This lack of information affects the management of Georges Bay as critical environmental data are not readily available to the stakeholders, including the wider community. An associated issue of concern is the lack of ongoing resources and support to develop programs that foster education and participation, particularly in relation to the health of the bay. The community, local and state government need to work together to obtain the necessary resources to support information collection and access.
Planning decisions made incrementally have generated a pattern of development around the bay that affects the ecological functioning of the bay. It is an issue of concern that while each decision is assessed on its merits, the accumulated impacts are not. Analysis of the combined results of these planning decisions could assist in informing future land use decisions.
Acknowledgements

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Bringing Back the Bay


