SHOREBASE: SPATIAL ASSESSMENT AND REPORTING TOOL FOR FORESHORE VALUES, CONDITION AND PRESSURE

REPORT TO THE DEPARTMENT OF SUSTAINABILITY, ENVIRONMENT, WATER, POPULATION AND COMMUNITIES

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Executive Summary

This report describes a project partially funded by Aquenal Pty Ltd and the Australian Government’s Caring for our Country (CfoC) initiative. The project meets CfoC national priorities by delivering detailed information on the state of the coastal foreshore environment in the North and Cradle Coast Natural Resource Management (NRM) Regions of Tasmania.

Foreshores are unique and diverse environments, often of high ecological, economic and/or social value. They require particular management attention because they are potentially impacted by activities occurring in both the terrestrial and marine environments. However a lack of integrated information, including monitoring data, often limits the capacity to develop suitable management strategies. A feature of the approach adopted here is that it can provide useful information even where data are limited.

Activities within this project include the development and application of an assessment framework which depicts foreshore condition and risk with regard to a series of environmental stressors. These include aquatic sediments, bacteria and pathogens, biota removal and disturbance, habitat removal, hydrodynamics, introduced species, litter, nutrients, pH and toxicants. Natural values relating to ecology and geomorphology are also identified, as well as human use values such as recreation and tourism use, commercial activity, amenities and heritage significance. The assessment framework compiles existing data and information relating to coastal ecosystems and human uses into readily understood GIS maps and report cards.

For the purposes of this project, the coastal foreshore is defined as the area between the highest and lowest astronomical tides, wherever tidal influence exists. A line map of the mean high water mark has been used to represent the foreshore. The entire coastline of the North and Cradle Coast NRM Regions, including national parks and islands (over 4,600 km), has been divided into 100 m spatial units. Considerable amounts of data have been compiled to support the assessment, and the framework has been applied to classify each spatial unit reflecting varying levels of risk, condition and value.

Results of this ShoreBase assessment show that the environmental stressors considered are generally presenting little risk to coastlines in the study area with the majority of foreshore segments classified as being at negligible risk. The stressor presenting extreme risk to the greatest proportion of foreshore segments is pH (16.5%) which may reach damaging levels in the coastal environment as a result of disturbance to acid sulphate soils. Habitat removal presents a high risk to over 20% of foreshore segments, which can be partly attributed to the widespread distribution of beach weeds, and the use of off-road vehicles on many Tasmanian beaches. Approximately 13% of segments are at high risk from the removal and disturbance of biota which may be related to the easy accessibility of much of the shoreline. The same proportion is at high risk from altered hydrodynamics, more specifically from the hydrodynamic effects of climate change.

As expected, the foreshores in and around the major population centres such as those in the Tamar and Mersey estuaries are generally at greater risk from all stressors compared to less populated coastlines. The remote southwest and offshore islands are largely at negligible risk. Despite the considerable amount of data computed, in many cases there remains insufficient data available to adequately support an assessment of condition. This is largely due to the lack of monitoring data being collected in the study area and the difficulty in obtaining current and consistent data across a broad geographic area.
The assessment of values indicates that a large proportion of foreshores within the study area are of very high natural value due to the significant communities and habitats present, the naturalness of the surrounding area and unspoiled geomorphic features. Human use values such as recreation and tourism, amenity use, commercial use and heritage significance are considered, however much of the study area is classified as having “unknown” value with regard to these indicators, reflecting the lack of comprehensive data.

ShoreBase output is designed for use by managers, land users and community groups. The integrated approach used can help improve our understanding of the interactions between humans and the coastal environment, whilst providing a basis for ecologically sensitive coastal planning and management. Assessment results also provide a baseline against which change can be monitored over time and can be applied on a number of geographic scales and management levels, including in the form of report cards.
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1 Introduction

1.1 Background
Caring for Our Country (CfoC) is an Australian Commonwealth Government funding scheme which aims to achieve an environment that is healthy, better protected, well-managed, resilient and provides essential ecosystem services in a changing climate (see the Australian Government website for more information http://www.nrm.gov.au/).

CfoC is investing in six national priority areas, including Coastal Environments and Critical Aquatic Habitats. Community Coastcare is part of the package of activities contributing to this priority outcome. Projects that fall under this package will contribute by:

- protecting and rehabilitating coastal environments and critical aquatic habitats, and
- enhancing community skills, knowledge and engagement with Indigenous Australians, volunteers and coastal communities.

This report describes a project partially funded through Community Coastcare. The project is designed to meet the national priorities by delivering an easy-to-use tool for land users, managers and community groups that provides detailed information on the coastal foreshore environment in the North and Cradle Coast Natural Resource Management (NRM) Regions of Tasmania.

The tool consists of an assessment framework which reports on foreshore condition, pressures, vulnerability, risk and values. The framework compiles existing data and information relating to coastal ecosystems and human uses into readily understood maps and report cards. The integrated approach can help improve our understanding of the interactions between humans and the coastal environment, whilst providing a basis for ecologically sensitive planning and management. Assessment results also provide a baseline against which change can be monitored over time and can be applied on a number of geographic scales and management levels.

This project is the extension of a similar assessment completed in 2008 for Tasmania’s Southern NRM Region (commissioned by NRM South) (Migus 2008). Outputs from the southern project included an assessment framework and a series of publicly available GIS maps. The current project has seen further development of the assessment framework and associated methods, as well as the production of report cards and GIS maps specific to the remainder of the Tasmanian coastline.

This report is presented in two distinct sections. The first outlines the general development and workings of the framework used to assess coastal foreshores. The second details more specifically the application of the framework to the North and Cradle Coast NRM Regions of Tasmania, and the outputs produced.

1.2 The Coastal Foreshore Environment
For the purposes of this project, the coastal foreshore is defined as the area between the highest and lowest astronomical tides, wherever tidal influence exists. Essentially the focus of this project is on the intertidal zone, but as adjoining zones can have a significant influence, additional information relating to these areas is also included where relevant.
Coastal foreshores are unique and diverse environments, comprising highly varied habitats. Foreshores are easily observed, and for this reason can provide an early indication of ecosystem change within the intertidal zone itself, or in the greater coastal area.

Foreshores are at the margins of traditional management zones and can therefore be overlooked in decision making, or not considered in their own right. However they require particular management attention because they are potentially impacted by activities occurring in both terrestrial and marine environments. Tasmania’s coastal area, as defined by the State Coastal Policy, refers to the immediate nearshore area including the intertidal zone and adjacent dry land. This area is managed on a number of levels, with local, state and federal governments involved in decision making and planning.

Tasmanian foreshores are high value areas. There is significant stakeholder interest in this part of the coast, ranging from commercial and tourist operations to community conservation and recreation activities. It is important to consider the range of uses when managing this area, and balance stakeholder needs with the maintenance of ecological condition and function. In order to do this successfully, it is important to understand the natural functioning of the system and the potential impact of anthropogenic activities.

ShoreBase is designed to help understand the effect of anthropogenic activities on the foreshore by defining links between cause and effect, and identifying values that may be at risk.

1.3 Objectives

This project supports the previously mentioned Community Coastcare national priorities by achieving the following objectives:

- To develop a transparent and comprehensive framework for assessing the condition, pressure, vulnerability, risk and value of coastal foreshores, and apply it to the North and Cradle Coast NRM Regions of Tasmania.

- To establish a baseline in the study region, against which changes in state (condition) can be monitored over time.

- To develop associated systems (including software and databases) with the capacity to store and analyse large amounts of supporting data, that are both updatable and easily maintained.

- To highlight areas that could be prioritised for management, including for conservation or rehabilitation, through interpretation of assessment results.

The current project aims to extend the mapping and assessment of the Southern NRM Region to include the remaining Tasmanian coastline, and therefore provide complete coverage of the state’s foreshores. This project is the logical extension of the southern assessment and is an important step to increase the current level of knowledge of coastal foreshores. The focus of this project is not to re-map intertidal habitats, but rather to provide interpreted information that is directly applicable to management decisions.
1.4 Applications
Results of the previous assessment of the Southern NRM Region have been used in a variety of ways, supporting environmental impact assessments, coastal management strategies and frameworks, conservation action plans, development applications and State of the Environment reporting. Data have also been used by community groups and students.

It is expected that the results of the current assessment will have similar applications. With the additional capacity for updating the dataset and producing report cards, it can also be used as a monitoring tool to generate a baseline of condition and report on changes over time.

1.5 Caveat
This tool is for managers, planners and other stakeholders interested in coastal foreshores of the North and Cradle Coast NRM Regions of Tasmania. The results presented here are indicative and should not be considered a definitive representation of the intertidal zone. The study incorporates a large number of existing datasets and users should be aware that more current data will subsequently become available and should be referred to where possible. Due to inaccuracies in some project data and a lack of extensive ground-truthing, discrepancies in the mapped and actual states of foreshores are inevitable. These mapping layers should therefore be supported by more detailed assessment of areas of interest wherever possible to ensure the most current and case-specific information is considered.

The identification of data contributors in no way implies either that they have had any further input into this mapping project other than making their data available, or that they agree with the manner in which their data have been interpreted or displayed.

At the request of the Tasmanian Aboriginal community, Aboriginal values have not been mapped as part of this project. A statement from the Aboriginal community is included below. Investment in the further participation of the Aboriginal community in management and research of Aboriginal values in coastal areas would be beneficial. For advice and services regarding protection of the range of Aboriginal values associated with coastal areas, contact the Tasmanian Aboriginal Land and Sea Council (TALSC) and/or Aboriginal Heritage Tasmania (AHT).

Aboriginal Aspirations for Natural Resource Management
Aboriginal people have lived on the islands that make up Tasmania for many thousands of years (upwards of 40,000 years), living interdependently with the land throughout that time.

Many of the values Aboriginal people hold as important exist within and across the wider landscape, and respect, management and protection of those values is seen as a broad Tasmanian community responsibility.

The whole landscape is part of the story. All Aboriginal sites are important in that each one is an integral part of the country.

In recent times the Tasmanian Aboriginal community has progressed from being dispossessed of land a little over 200 years ago to having a small amount of that land returned (in 1995). Other areas of land have been purchased by the Aboriginal community. With the return of land,
a number of land management problems, resulting from historical and contemporary European land management practices, have been inherited by the Aboriginal community.

Aboriginal land management knowledge and practices have been increasingly acknowledged by sections of the wider community. Aboriginal people have strong physical and spiritual links with country. Land management expertise of the old people has survived. Today’s Aboriginal community is also developing knowledge and skills of contemporary land management practices.

The aim of this statement is to promote the views, needs and aspirations of Tasmanian Aborigines in relation to sustainable natural resource and land management that ensure protection and enhancement of Aboriginal culture and heritage values throughout Tasmania.

This statement was prepared and endorsed by the Tasmanian Aboriginal Land Council, Tasmanian Aboriginal Centre and the Aboriginal Land Council of Tasmania at Risdon Cove, 25 June 2004.

1.6 Acknowledgements

Aquenal gratefully acknowledges the contributions of the School of Geography and Environmental Studies at the University of Tasmania, NRM North, Cradle Coast NRM and the Queensland Government (Environment and Resource Sciences Division) to help achieve project objectives. A large number of organisations and individuals have also contributed to this project through data supply, technical advice, expert opinion and review.

The involvement of the following is greatly appreciated:

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2 Development of Assessment Framework

When developing a comprehensive and widely applicable method of foreshore assessment, a number of features were considered essential. Key considerations included transparency and easy maintenance, and the capacity to assess large numbers of spatial units, store all supporting data, and link to GIS. The framework also had to assess condition and risk, and importantly, foreshore values.

Prior to finalising an approach, a review of existing assessment methods was conducted to identify any with potential applications to the foreshore environment. No current methods were deemed to meet all project objectives. As such, methods used in the previous assessment of the Southern NRM Region were further developed and combined with an approach originally designed to assess estuarine health in Queensland. This is known as the VPSIRR approach (Vulnerability, Pressure, State, Impact, Risk, Response) which uses indicators to report on the status of a system and monitor change over time. Further detail on VPSIRR is included in Section 2.1.

The final merged assessment framework applied to the study area contains all the desired features, and is unique in that it is specific to the foreshore environment. It is not based on what data are available, but rather on information that is considered key to environmental monitoring. It allows a wide range of information on the foreshore to be presented in a user-friendly format. It can highlight areas for which there is very little data, and in doing so can identify important environmental aspects that should be further investigated to support effective ongoing monitoring. It also provides useful information in the absence of comprehensive monitoring data.

2.1 The Use of VPSIRR in Foreshore Assessment

A valuable component of the ShoreBase assessment framework is the Vulnerability Pressure State Impact Risk Response (VPSIRR) approach. The VPSIRR model was originally developed in 2005 by David Rissik, Andrew Moss and David Scheltinga through a collaborative joint venture partnership between the CRC for Coastal Zone, Estuary and Waterway Management, Queensland Environmental Protection Agency, NSW Department of Infrastructure, Planning and Natural Resources, and the Victorian Environmental Protection Agency. It has been used to assess estuarine and wetland health in Queensland and the potential for its wider application has been identified in the National Land and Water Resources Audit Estuarine, Coastal and Marine National Condition Assessment Scoping Report (Mount 2008). VPSIRR also uses a similar computational engine as that applied in the AquaBAMM (Aquatic Biodiversity Assessment and Mapping Method) decision support tool which is designed to assess wetland conservation values and has been applied in Queensland (Clayton et al 2006).

The VPSIRR model allows links to be established between environmental and human induced pressures, system vulnerability and resultant condition. It has the capability to detect changes in foreshore condition, and to attribute that change to a particular set of variables. The power of this method is that it helps identify what action can be taken to manage threats posed to the system. As the model is largely automated, it is also possible to perform repeat assessments over time.

VPSIRR uses a stressor-based approach. A stressor can be defined as a *component of the environment that when changed, has an impact on that environment* (Scheltinga and Moss.
Stressors can be natural components of the foreshore environment (such as sediments or nutrients) and it is only when changed, by anthropogenic activity for example, that they present a risk. Human activities can result in direct pressure on the foreshore system, which can in turn lead to a change in biological or physical-chemical condition. This process is summarised below, using dredging activities as an example:

A number of adaptations were made to the original VPSIRR software to suit the aims of the foreshore assessment. These include additional capacity to assess large numbers of spatial units, links to a purpose-built database to store all input and output data, and links to a GIS so that results may be presented spatially and in conjunction with existing managerial data. VPSIRR had not previously been used to assess values, so further adaptations were required to make this possible.

For further information on the VPSIRR approach and its current use in assessing the health of wetlands in Queensland, see the Department of Environment and Resource Management report: *A framework for assessing the health of, and risk to, Queensland’s lacustrine (lake) and palustrine (swamp) wetlands. Component A: the framework* (Scheltinga et al. 2010).

### 2.2 Determining Stressors, Values and Indicators

Background research and expert consultation was conducted to select stressors most relevant to the foreshore system i.e. components of the environment with the potential to place stress on the intertidal zone. Stressors identified in the framework used to assess the health of coastal waters (Scheltinga and Moss 2007) formed the basis for this study. However the unique and highly dynamic nature of the foreshore area means that stressors relevant to other parts of the coast, such as entire estuaries, are not necessarily meaningful in the intertidal habitat. Stressors were therefore adapted to ensure their relevance in this study, with ten foreshore stressors selected:

- Aquatic Sediments
- Bacteria/pathogens
- Biota Removal / Disturbance
- Habitat Removal
- Hydrodynamics
- Introduced Species
- Litter
- Nutrients
- pH
- Toxicants
In addition to stressors, the assessment framework also identifies natural and human use values of the foreshore. Identification of values can increase awareness of how the foreshore area is used, and what is actually at risk from a changing environment. Values were identified through research and consultation and were divided into two broad categories:

- Natural Values (ecological and geomorphic)
- Human Use Values (recreation and tourism, commercial, amenities and heritage).

For each stressor and value, a series of indicators was identified. These are measures that have been selected with the aim of best reflecting the state of the foreshore environment with regard to each stressor/value. There were 74 indicators developed for this assessment, which fall into four different categories:

**Pressure**: Includes actions and processes that pose a current pressure to the foreshore system and may alter stressor level and condition.

**Vulnerability**: Factors of the foreshore system that may mediate the impact of a changing stressor. This indicator, in combination with the pressure indicators can be used to determine risk. This is explained in further detail in Section 2.5.

**Condition**: The actual change observed as a response to the changing stressor. Indicators fall under two categories – physical-chemical, and biological.

**Value**: Natural components or human uses of the foreshore environment considered valuable.

Indicators can be monitored over time to show environmental trends including diminished condition, increased vulnerability or shifts in values and uses.

## 2.3 Background to Stressors and Associated Indicators

As the intertidal zone is the boundary between land and sea, its health is heavily influenced by management practices in adjoining zones (Hardiman and Burgin 2010). A conceptual model was developed for each stressor to help identify processes and mechanisms in the greater coastal area which can alter stressor levels in the intertidal zone (Appendix 5-1). Clear links were established between cause and effect and with this information, the following could be identified:

- Potential causes of change to stressor levels in the foreshore environment.
- Direct pressures on the foreshore system i.e. the factor directly related to the changing stressor.
- Mediating factors i.e. factors that may result in the shore being more or less vulnerable to the impacts of a changing stressor.
- Condition responses which include the changes in actual condition in response to a changing stressor.
- Indicators of pressure and condition.

Tables containing detailed background information for each stressor are included below in sections 2.3.1 to 2.3.10. It is important to note that the potential causes of change listed in the tables may not be included as final indicators in the foreshore assessment due to their impractical or immeasurable nature. For the same reasons, mediating factors and condition indicators may not be listed for all stressors. More specific information on each indicator and its relevance to the Tasmanian coastal environment can be found in section 3.3.
2.3.1 Aquatic Sediments

Aquatic sediments are an important component of intertidal systems. However, anthropogenic alteration of sediment loads can have a considerable impact on biota and water quality. Changes in sediment loads in the foreshore can be the result of activities in both terrestrial and marine environments. Erosion of catchments and shorelines is a significant contributor of sediments to the coastal zone and is one of the main processes leading to increased sediment load in Australian coastal areas (OzCoasts 2010a). Erosion can result from land clearing, agriculture, boating activity, stormwater runoff, unsealed roads and off-road vehicle use. Other sediment sources include dredging, mining and industrial discharge. Sediments can be transported to the intertidal zone via a number of mechanisms including runoff, input from streams/rivers, pipelines, and resuspension and deposition.

An increase in fine sediment loads can have a numerous impacts on the physical-chemical condition of the foreshore, which can in turn affect biological condition. Physical-chemical impacts include reduced water clarity, increased concentration of suspended sediments, increased deposition and a change in grainsize distribution. These can lead to modified predator/prey interactions and a reduction in primary productivity and abundance of sensitive species which may in turn result in changes to species abundance, diversity and habitat.

The dilution rate, or rate at which water is moved out of the intertidal zone, may mitigate the impacts of a change in aquatic sediment loads. Increased sediment loads in exposed shores with high wave energy, tidal range and rate of marine exchange will naturally be transported quickly. However areas with relatively poor dilution rates and restricted marine exchange (i.e. closed embayments with low tidal ranges) are likely to retain additional loads for longer, and the resulting impact can be greater.

Changes in actual foreshore condition as a result of anthropogenic change to aquatic sediments can be measured by monitoring turbidity, changes in sediment particle size distribution, and changes in the extent of seagrass (where present) over time.

Potential causes of anthropogenic change to aquatic sediments, the direct pressure on the foreshore system, mediating factors, response and indicators of condition and pressure are listed in Table 2.1.
Table 2.1 Description of the pressure, condition and system responses for the Aquatic Sediment stressor.

<table>
<thead>
<tr>
<th>Potential Causes of Change to Aquatic Sediments in the Foreshore</th>
<th>Physical - Chemical</th>
<th>Biological</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjacent land use</td>
<td>Reduced water clarity</td>
<td>Reduced visibility leading to modified predator/prey interactions</td>
</tr>
<tr>
<td>Catchment and shoreline erosion</td>
<td>Increased concentrations of suspended sediments</td>
<td>Reduced light penetration, photosynthesis, primary productivity, plant biomass, and condition/abundance of herbivores.</td>
</tr>
<tr>
<td>Unsealed roads</td>
<td>Increased sediment deposition</td>
<td>Reduced abundance of filter feeders and sensitive species</td>
</tr>
<tr>
<td>Dredging</td>
<td>Change in sediment particle size distribution</td>
<td>Reduced abundance of susceptible biota</td>
</tr>
<tr>
<td>Historic spoil dump</td>
<td></td>
<td>Change in habitat</td>
</tr>
<tr>
<td>Industrial discharge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boating activity (boat wash, resuspension)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extraction (mining) activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stormwater discharge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary treated STP discharge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximity to stream/river input and level of catchment clearing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flooding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slumping</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storm surge events</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Direct Pressure on the System</th>
<th>Increase in the amount of suspended sediment entering the intertidal zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mediating Factor</td>
<td>Dilution rate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Condition Response</th>
<th>Physical / Chemical</th>
<th>Biological</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced water clarity</td>
<td></td>
<td>Reduced visibility leading to modified predator/prey interactions</td>
</tr>
<tr>
<td>Increased concentrations of suspended sediments</td>
<td></td>
<td>Reduced light penetration, photosynthesis, primary productivity, plant biomass, and condition/abundance of herbivores.</td>
</tr>
<tr>
<td>Increased sediment deposition</td>
<td></td>
<td>Reduced abundance of filter feeders and sensitive species</td>
</tr>
<tr>
<td>Change in sediment particle size distribution</td>
<td></td>
<td>Reduced abundance of susceptible biota</td>
</tr>
<tr>
<td>Change in particle size</td>
<td></td>
<td>Change in habitat</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pressure Indicators</th>
<th>Stressor Sources</th>
<th>Direct Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nearby dredging</td>
<td></td>
<td>Fine sediment load entering the intertidal area</td>
</tr>
<tr>
<td>% of adjacent land cleared</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximity to point sources and discharge treatment level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boating activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of unsealed roads within 100 m of shoreline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensive agriculture on adjacent land</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extraction (mining) activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximity to input from streams/rivers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Off-road vehicle use</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Condition Indicators</th>
<th>Physical / Chemical</th>
<th>Biological</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbidity</td>
<td></td>
<td>Change in seagrass extent and in abundance of susceptible species</td>
</tr>
<tr>
<td>Change in particle size</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.3.2 Bacteria / Pathogens

A pathogen is any disease-causing biological agent, including bacteria, viruses, fungi and protozoans. Increased loads of pathogens in the foreshore environment can lead to biological impacts such as human health problems, increased disease in biota and increased susceptibility to other environmental stressors.

Potential sources of increased bacterial/pathogen loads are aquaculture operations, agriculture, septic tanks, sewage treatment plants, stormwater, runoff and vessel discharge. The potential impact of these sources may be mediated by the rate at which water is moved away from the foreshore. Reduced residence times present less opportunity for biota to come into contact with pathogens.

Foreshore condition can change as a result of increased bacterial loads. The direct physical-chemical response is an increase in the actual occurrence or concentration of bacteria/pathogens. Biological condition may be altered through increased mortality events and increased incidence of disease in humans that come into contact with the impacted area.

Potential causes of anthropogenic change to bacteria/pathogen levels, the direct pressure on the foreshore system, mediating factors, response and indicators of condition and pressure are listed in Table 2.2.
### Table 2.2 Description of the pressure, condition and system responses for the Bacteria/Pathogen stressor.

<table>
<thead>
<tr>
<th>POTENTIAL CAUSES OF CHANGE TO BACTERIA/PATHOGENS IN THE FORESHORE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Aquaculture (marine and land based operations)</td>
<td></td>
</tr>
<tr>
<td>• Intensive agriculture on adjacent land (animal production)</td>
<td></td>
</tr>
<tr>
<td>• Sewage treatment plant discharge</td>
<td></td>
</tr>
<tr>
<td>• Stormwater discharge</td>
<td></td>
</tr>
<tr>
<td>• Sewage discharge from vessels</td>
<td></td>
</tr>
<tr>
<td>• Septic tanks</td>
<td></td>
</tr>
<tr>
<td>• Industrial discharge</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DIRECT PRESSURE ON THE SYSTEM</th>
<th>Increase in the amount of bacteria/pathogen in the intertidal zone</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>MEDIATING FACTOR</th>
<th>Dilution rate</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>CONDITION RESPONSE</th>
<th>PHYSICAL-CHEMICAL</th>
<th>BIOLOGICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Increased bacteria/pathogen concentrations</td>
<td>• Human health problems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Increased disease in biota</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Increased susceptibility to other stressors</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PRESSURE INDICATORS</th>
<th>STRESSOR SOURCES</th>
<th>DIRECT PRESSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level of treatment of STP wastewater</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Occurrence of STP overflow events</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intensive agriculture (animal production) in adjacent land</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of septic tanks near shoreline</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Proximity to stormwater outflow</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Proximity to aquaculture operations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Proximity to boat moorings, marinas, anchorages etc.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONDITION INDICATORS</th>
<th>PHYSICAL-CHEMICAL</th>
<th>BIOLOGICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Increase in concentrations of bacteria/pathogens</td>
<td>• Number of mortality events caused by bacteria/pathogens</td>
</tr>
</tbody>
</table>
2.3.3 Biota Removal and Disturbance

Coastal foreshores are often highly accessible environments with numerous recreational, tourism and commercial uses. Infrastructure such as roads, car parks, buildings and general activities associated with populated coastal areas means foreshore disturbance is often proportional to the size of the local human population (Ward et al. 1998). Artificial light, noise, movement, shading from foreshore structures, boat wash, fire and trampling all constitute disturbance.

This stressor is concerned with the direct removal, loss or disturbance of foreshore biota of a particular species, rather than with the removal of large areas of habitat. Where a single species is targeted in a relatively restricted habitat such as in the intertidal zone, impacts on local populations can be significant (Airoldi et al. 2005; Hardiman and Burgin 2010). Biota may be removed through bait collection, commercial or recreational harvest, aquarium collection or dredging. Disturbance may be caused by recreational and tourist activities, trampling and grazing by stock, backshore development and fire.

Continued removal and disturbance can lead to a reduction in species abundance, diversity and distribution and to the mortality of protected shorebird and seabird species. Disturbance also provides opportunity for introduced species to become established and can lead to increased competition for resources amongst foreshore biota.

The biological response to biota removal and disturbance is a reduction in the abundance, distribution and/or size class distribution of targeted biota and a general loss of biodiversity.

There are some factors that may potentially reduce the impact of an increase in biota removal/disturbance, such as the size and structure of directly affected populations. However given the difficulty in quantifying this in the foreshore environment, no vulnerability indicator is listed.

Potential causes of biota removal and disturbance, the direct pressure on the foreshore system, mediating factors, response and indicators of condition and pressure are listed in Table 2.3.
**Table 2.3** Description of the pressure, condition and system responses for the Biota Removal and Disturbance stressor.

<table>
<thead>
<tr>
<th>POTENTIAL CAUSES OF CHANGE TO BIOTA REMOVAL / DISTURBANCE IN THE FORESHORE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Biota collection (recreational and commercial)</td>
<td></td>
</tr>
<tr>
<td>• Boating/jet skiing</td>
<td></td>
</tr>
<tr>
<td>• Recreation and tourism</td>
<td></td>
</tr>
<tr>
<td>• Shading structures</td>
<td></td>
</tr>
<tr>
<td>• Dredging</td>
<td></td>
</tr>
<tr>
<td>• Stock trampling/grazing</td>
<td></td>
</tr>
<tr>
<td>• Fire management</td>
<td></td>
</tr>
<tr>
<td>• Backshore development</td>
<td></td>
</tr>
<tr>
<td>• Access</td>
<td></td>
</tr>
</tbody>
</table>

| DIRECT PRESSURE ON THE SYSTEM | Removal, loss or disturbance of individual plants or animals of a particular species (not areas of habitat). |

| MEDIATING FACTOR | None |

<table>
<thead>
<tr>
<th>CONDITION RESPONSE</th>
<th>PHYSICAL-CHEMICAL</th>
<th>BIOLOGICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Seabird/shorebird mortality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Reduction in abundance/distribution/size distribution of targeted biota</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Increased competition by introduced species</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PRESSURE INDICATORS</th>
<th>STRESSOR SOURCES</th>
<th>DIRECT PRESSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Biota collection activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Boating/jet ski activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Recreational use (frequency and volume)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Tourist use (frequency and volume)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Dredging</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Presence of foreshore shading structures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Population size in adjacent coastal area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Access of stock to beach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Occurrence of fires in adjacent backshore</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Percentage of development in immediate backshore area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Accessibility of shore</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONDITION INDICATORS</th>
<th>PHYSICAL-CHEMICAL</th>
<th>BIOLOGICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Reduction in abundance/distribution/size distribution of targeted biota</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Establishment of introduced species</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.3.4 Habitat Removal

Foreshore habitats are diverse. They include beaches, rock platforms, mud flats, cliffs, saltmarsh, seagrass beds and more. Some anthropogenic activities can impact large areas of natural habitats through direct removal, damage and/or disturbance. Certain foreshore habitats, such as saltmarsh and other wetlands, are highly valuable environments because they play vital roles in coastal ecosystems and provide important habitat for marine and terrestrial organisms (OzCoasts 2010b).

Habitat may be removed or disturbed through boating, construction, reclamation (land claim), sedimentation, off-road vehicle use, sea level rise, storm surge events, dredging, mining, collection, beach grooming, thermal effluent and the establishment of weeds.

The detectible physical response to habitat removal is a reduction in the extent or percentage cover of habitats. Biological responses to habitat loss may be altered community structures and an increased opportunity for the establishment of non-native species.

There are some factors that may potentially minimise the impact of foreshore habitat removal, such as the size of similar habitat still remaining. However given the diversity of intertidal habitats and the difficulty in identifying all potential environmental characteristics, no vulnerability indicator is listed.

Potential causes of habitat removal, the direct pressure on the foreshore system, mediating factors, response and indicators of condition and pressure are listed in Table 2.4.
Table 2.4 Description of the pressure, condition and system responses for the Habitat Removal stressor.

| POTENTIAL CAUSES OF HABITAT REMOVAL IN THE FORESHORE | • Boating (erosion from boat wash)  
| • Foreshore construction  
| • Artificial shores/reclamation  
| • Sedimentation  
| • Uncontrolled foreshore access (especially off-road vehicles)  
| • Climate change (erosion and inundation due to sea-level rise, temperature change and storm surge events)  
| • Drainage of wetlands and marshes  
| • Extraction activities  
| • Dredging  
| • Thermal effluent  
| • Collection of wrack, rock or sand  
| • Beach grooming  
| • Beach weeds  
| • Rice grass  
| • Freshwater input |

| DIRECT PRESSURE ON THE SYSTEM | Removal, loss or disturbance of large areas of habitat |

| MEDIATING FACTOR | None |

| CONDITION RESPONSE | PHYSICAL-CHEMICAL | BIOLOGICAL |
| • Reduced habitat (extent, % cover) | • Altered community structure  
| • Increased opportunity for establishment of introduced species |

| PRESSURE INDICATORS | STRESSOR SOURCES | DIRECT PRESSURE |
| • Boating activity (frequency of visits)  
| • Reclaimed or artificial shore  
| • Off-road vehicle use  
| • Beach grooming activity  
| • Dredging and extraction activities  
| • Collection  
| • Presence of rice grass and beach weeds  
| • Drainage of wetlands/marshes | • % of intertidal habitat modified |

| CONDITION INDICATORS | PHYSICAL-CHEMICAL | BIOLOGICAL |
| | | • Change in habitat extent |
2.3.5 Hydrodynamics

This stressor is focused on the movement of water in and around the intertidal zone. When natural patterns of water movement are altered through anthropogenic influence, changes in sediment transport, water chemistry, local wave patterns, currents and tidal exchange can occur (OzCoasts 2010c).

Hydrodynamics can be affected on a local level by artificial structures and physical changes to the seabed (through dredging or reclamation for example), or on a larger scale by the effects of climate change i.e. sea level rise and storm surge events. The presence of any structure within, or in proximity to, the intertidal zone also has the potential to influence the movement of water as does rice grass invasion, regulated river output, groundwater, drought and flooding.

The physical-chemical response to altered hydrodynamics may be a change in erosion and/or deposition processes. Associated biological responses can include increased growth of plants or algae leading to possible eutrophication. The altered conditions may also result in habitat loss and a change in species composition. Shore type may mediate such impacts in that hard, stable shores are less vulnerable to changes in hydrodynamics than soft sediment shores.

The measurement of shoreline movement may provide a useful indication of a change in foreshore condition in response to altered hydrodynamics.

Potential causes of anthropogenic change to hydrodynamics, the direct pressure on the foreshore system, mediating factors, response and indicators of condition and pressure are listed in Table 2.5.
Table 2.5 Description of the pressure, condition and system responses for the Hydrodynamics stressor.

| POTENTIAL CAUSES OF CHANGE TO HYDRODYNAMICS IN THE FOreshore | • Aquaculture structures  
• Climate change  
• Foreshore structures  
• Dredging  
• Foreshore reclamation  
• Regulated stream/river output  
• Groundwater input  
• Weeds  
• Drought  
• Flooding and scouring |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DIRECT PRESSURE ON THE SYSTEM</td>
<td>Changes to local patterns of waves, currents or tidal exchange</td>
</tr>
<tr>
<td>MEDIATING FACTOR</td>
<td>Vulnerability to shoreline movement</td>
</tr>
<tr>
<td>CONDITION RESPONSE</td>
<td>PHYSICAL-CHEMICAL</td>
</tr>
</tbody>
</table>
| • Changed current and wave pattern leading to change in erosion/deposition processes | • Increased growth of aquatic plants or algae leading to increased algal blooms and possible eutrophication  
• Habitat loss, change in species composition |
| PRESSURE INDICATORS | STRESSOR SOURCES | DIRECT PRESSURE |
| • Occurrence of dredging  
• Presence of foreshore structures  
• Presence of aquaculture structures  
• Reclamation of foreshore  
• Proximity to regulated stream/river output  
• Presence of weeds in intertidal zone  
• Effects of climate change | | |
| CONDITION INDICATORS | PHYSICAL-CHEMICAL | BIOLOGICAL |
| • Shoreline movement | | |
2.3.6 Introduced Species

Introduced or non-native species are those that have been transported outside their natural range by human-mediated dispersal (Williamson et al. 2002). New introductions can occur through factors associated with boating activity such as fouling, ballast water, equipment and infrastructure. Aquaculture operations can provide opportunity for escape and translocation of non-native species, whilst accidental release through aquarium operations is also a risk.

Introduced species can significantly alter the ecology of an area and threaten natural and human use values. Non-native species pose risks of predation of native species, competition for resources, alteration and degradation of habitat structure, monoculture, disease, and nuisance fouling on foreshore structures (Williamson et al. 2002; Hardiman and Burgin 2010). Once established, introduced species can disperse to other locations and potentially impact large geographic areas (Hardiman and Burgin 2010).

A factor of the natural environment that may reduce the vulnerability of a shore to invasion by non-native species is the availability of suitable habitat. The type of habitat that can be considered “suitable” is highly variable given the wide range of niches available for species invasion in the foreshore environment, and the diversity of invasive biota. The naturalness of the shore may provide a more general indication of vulnerability to invasion, as disturbed habitats are thought to be more susceptible to establishment of non-native species.

The actual occurrence of introduced species in the foreshore environment is indicative of condition with regard to this stressor.

Potential causes of anthropogenic change to the presence and extent of introduced species, the direct pressure on the foreshore system, mediating factors, response and indicators of condition and pressure are listed in Table 2.6.
Table 2.6 Description of the pressure, condition and system responses for the Introduced Species stressor.

<table>
<thead>
<tr>
<th>POTENTIAL CAUSES OF INTRODUCED SPECIES IN THE FORESHORE</th>
<th>PHYSICAL-CHEMICAL</th>
<th>BIOLOGICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Aquaculture operations (escapees/translocation)</td>
<td>• Changes to natural conditions e.g. sediment accumulation and changed hydrodynamics with rice grass</td>
<td>• Dominance of introduced species</td>
</tr>
<tr>
<td>• Boating activity</td>
<td></td>
<td>• Increased predation/competition</td>
</tr>
<tr>
<td>• Aquarium release</td>
<td></td>
<td>• Increase in disease/pathogens</td>
</tr>
<tr>
<td>• Hull cleaning facilities</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DIRECT PRESSURE ON THE SYSTEM</th>
<th>PHYSICAL-CHEMICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction of non-native species</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MEDIATING FACTORS</th>
<th>PHYSICAL-CHEMICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Availability of suitable habitat</td>
<td></td>
</tr>
<tr>
<td>• Naturalness of shore</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONDITION RESPONSE</th>
<th>PHYSICAL-CHEMICAL</th>
<th>BIOLOGICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRESSURE INDICATORS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Presence of introduced species in adjoining segments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Frequency of boat visits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Presence of aquaculture operations</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONDITION INDICATORS</th>
<th>PHYSICAL-CHEMICAL</th>
<th>BIOLOGICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRESSOR SOURCES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Occurrence of introduced species</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.3.7 Litter

Coastlines are subject to litter from both domestic and offshore sources. In 2009, approximately 9,000 pieces of rubbish equalling 1.4 tonnes were collected from the remote west coast of Tasmania, with much derived from foreign sources (Grant 2000).

The presence of litter in the intertidal zone reduces the amenity and aesthetic appeal of the coast. Litter can injure or entangle foreshore species and can be ingested by foragers such as shorebirds, ultimately resulting in death. There are no factors identified that mediate the impact of litter on the foreshore.

Sources of litter include rubbish dumping, recreation and tourist use (especially fishing and boating), terrestrial runoff, marine debris and shipping.

Potential causes of anthropogenic change to litter levels, the direct pressure on the foreshore system, mediating factors, response and indicators of condition and pressure are listed in Table 2.7.

Table 2.7 Description of the pressure, condition and system responses for the Litter stressor.

| POTENTIAL CAUSES OF CHANGE TO LITTER IN THE FORESHORE | • Recreation and tourist use (especially fishing and boating)  
| • Rubbish dumping  
| • Terrestrial sources  
| • Shipping |
| DIRECT PRESSURE ON THE SYSTEM | Rubbish/debris entering the system |
| MEDIATING FACTOR | None |
| CONDITION RESPONSE | PHYSICAL-CHEMICAL | BIOLOGICAL |
| | • Presence of litter | • Ingestion or entanglement |
| PRESSURE INDICATORS | STRESSOR SOURCES | DIRECT PRESSURE |
| | • Boating activity  
| | • Recreation and tourist use  
| | • Population size in adjoining coastal area  
| | • Presence of stormwater outflows |
| CONDITION INDICATORS | PHYSICAL-CHEMICAL | BIOLOGICAL |
| | • Presence of litter |
2.3.8 Nutrients

Nutrients such as nitrogen and phosphorus have an important function in coastal systems, and are essential for plant and animal growth. However, increased nutrient loads can have detrimental effects in the foreshore environment and impact the system in a number of ways. Eutrophication (high nutrient concentrations) can result in growth of nuisance algae, algal blooms, changes in community structure and reduced oxygen levels (OzCoasts 2010d).

Nutrient loads can increase as the result of anthropogenic activities such as agriculture, aquaculture operations, sewage treatment plant discharge and overflow, stormwater, industrial discharge, boating activity, general runoff and seepage from septic tanks.

As with other water-borne stressors, the impact of increased nutrients in the intertidal system may be mediated by the rate of dilution i.e. the rate at which water is moved into and out of the intertidal zone.

Increases in individual nutrient levels (compared to suitable baseline and trigger levels) indicate a change in foreshore condition. Biological indicators such as Chlorophyll-a can indicate algal blooms, possible eutrophication of waterways and a reduction in oxygen concentrations (Crawford 2006). Some intertidal macroalgae species are known to flourish in nutrient enriched waters and can act as additional indicators of increased nutrients. These “nuisance” blooms, predominantly of green algae, can include a number of species from the genera *Ulva*, *Cladophora*, *Chaetomorpha* and *Enteromorpha* (Valiela et al. 1997; Oh 2009).

Potential causes of anthropogenic change to nutrient levels, the direct pressure on the foreshore system, mediating factors, response and indicators of condition and pressure are listed in Table 2.8.
Table 2.8 Description of the pressure, condition and system responses for the Nutrients stressor.

<table>
<thead>
<tr>
<th>POTENTIAL CAUSES OF CHANGE TO NUTRIENTS IN THE FORESHORE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Catchment runoff (rural and urban)</td>
<td></td>
</tr>
<tr>
<td>• Industrial discharge</td>
<td></td>
</tr>
<tr>
<td>• Agriculture</td>
<td></td>
</tr>
<tr>
<td>• Aquaculture operations</td>
<td></td>
</tr>
<tr>
<td>• STP discharge and overflow</td>
<td></td>
</tr>
<tr>
<td>• Sewage discharge from vessels</td>
<td></td>
</tr>
<tr>
<td>• Stormwater</td>
<td></td>
</tr>
<tr>
<td>• Septic tanks</td>
<td></td>
</tr>
<tr>
<td>• Seabird colonies</td>
<td></td>
</tr>
<tr>
<td>• Boating activity</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DIRECT PRESSURE ON THE SYSTEM</th>
<th>Change in the amount of nutrients entering the intertidal system</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>MEDIATING FACTORS</th>
<th>Dilution rate</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>CONDITION RESPONSE</th>
<th>PHYSICAL-CHEMICAL</th>
<th>BIOLOGICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Increased nutrient concentrations</td>
<td>• Increase in nuisance growth of algae</td>
<td></td>
</tr>
<tr>
<td>• Change in community structure</td>
<td>• Change in community structure</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PRESSURE INDICATORS</th>
<th>STRESSOR SOURCES</th>
<th>DIRECT PRESSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Agriculture in backshore</td>
<td>• Total nitrogen load</td>
<td></td>
</tr>
<tr>
<td>• Aquaculture operations</td>
<td>• Total phosphorus load</td>
<td></td>
</tr>
<tr>
<td>• Occurrence of sewage overflow events</td>
<td>• Presence of port/harbours/marinas etc.</td>
<td></td>
</tr>
<tr>
<td>• Proximity to industrial discharge point</td>
<td>• Proximity to STP discharge point</td>
<td></td>
</tr>
<tr>
<td>• Proximity to STP discharge point</td>
<td>• Presence of septic tanks</td>
<td></td>
</tr>
<tr>
<td>• Proximity to stormwater outflow</td>
<td>• Proximity to stormwater outflow</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONDITION INDICATORS</th>
<th>PHYSICAL-CHEMICAL</th>
<th>BIOLOGICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Filterable Reactive Phosphate (FRP) levels in water</td>
<td>• Increase in abundance of “nuisance” intertidal macroalgae species</td>
<td></td>
</tr>
<tr>
<td>• Oxidised Nitrogen levels in water</td>
<td>• Chlorophyll-a in water</td>
<td></td>
</tr>
<tr>
<td>• Total phosphorous levels in water</td>
<td>• Total nitrogen levels in water</td>
<td></td>
</tr>
<tr>
<td>• Total nitrogen levels in water</td>
<td>• Ammonia levels in water</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STRESSOR SOURCES</th>
<th>DIRECT PRESSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Agriculture in backshore</td>
<td>• Total nitrogen load</td>
</tr>
<tr>
<td>• Aquaculture operations</td>
<td>• Total phosphorus load</td>
</tr>
<tr>
<td>• Occurrence of sewage overflow events</td>
<td>• Presence of port/harbours/marinas etc.</td>
</tr>
<tr>
<td>• Proximity to industrial discharge point</td>
<td>• Proximity to STP discharge point</td>
</tr>
<tr>
<td>• Proximity to STP discharge point</td>
<td>• Presence of septic tanks</td>
</tr>
<tr>
<td>• Proximity to stormwater outflow</td>
<td>• Proximity to stormwater outflow</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONDITION INDICATORS</th>
<th>PHYSICAL-CHEMICAL</th>
<th>BIOLOGICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Filterable Reactive Phosphate (FRP) levels in water</td>
<td>• Increase in abundance of “nuisance” intertidal macroalgae species</td>
<td></td>
</tr>
<tr>
<td>• Oxidised Nitrogen levels in water</td>
<td>• Chlorophyll-a in water</td>
<td></td>
</tr>
<tr>
<td>• Total phosphorous levels in water</td>
<td>• Total nitrogen levels in water</td>
<td></td>
</tr>
<tr>
<td>• Total nitrogen levels in water</td>
<td>• Ammonia levels in water</td>
<td></td>
</tr>
</tbody>
</table>
2.3.9 pH

Acid sulphate soils (ASS) are naturally occurring soils that contain iron sulphides in microscopic form (DPIPWE 2009a). If ASS are disturbed in coastal areas and the sulphides present are exposed to air, the process of oxidisation will produce sulphuric acid and heavy metals. These substances can move into coastal waterways, degrading coastal systems and having significant environmental and economic impacts (Hardiman and Burgin 2010; OzCoasts 2010e).

The potential impacts of disturbing ASS include reduced pH, damage to foreshore structures, poor water quality, disease and mortality of susceptible species, as well as reduced shell strength and increased gill damage in invertebrates which can both affect aquaculture stocks.

The rate at which water is exchanged (or diluted) in the affected area can mediate the impact of ASS. High tidal ranges and marine exchange rates reduce residence times so that water of a damaging pH level is moved away from the coastline more quickly.

Indications that ASS may be affecting the condition of an area include sustained low pH values after an inflow event such as heavy rainfall, and associated mortality of coastal biota.

Potential causes of anthropogenic change to pH levels, the direct pressure on the foreshore system, mediating factors, response and indicators of condition and pressure are listed in Table 2.9.

**Table 2.9** Description of the pressure, condition and system responses for the pH stressor.

<table>
<thead>
<tr>
<th>POTENTIAL CAUSES OF CHANGE TO pH IN THE FORESHORE</th>
<th>DIRECT PRESSURE ON THE SYSTEM</th>
<th>MEDIATING FACTORS</th>
<th>CONDITION RESPONSE</th>
<th>PRESSURE INDICATORS</th>
<th>CONDITION INDICATORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Disturbance of potential or actual Acid Sulphate Soils (ASS)</td>
<td>Acid sulphate run-off entering the system</td>
<td>Dilution rate</td>
<td>• Reduced pH</td>
<td>• Areal extent of adjoining disturbed acid sulphate soils</td>
<td>• Minimum sustained pH after inflow event</td>
</tr>
<tr>
<td>• Drainage of coastal wetlands and marshes</td>
<td></td>
<td></td>
<td>• Damage to foreshore structures</td>
<td></td>
<td>• Number of mortality events caused by low pH</td>
</tr>
<tr>
<td>• Clearing of adjoining vegetation</td>
<td></td>
<td></td>
<td>• Increased mortality and disease in susceptible species</td>
<td></td>
<td>• Number of mortality events caused by low pH</td>
</tr>
</tbody>
</table>
2.3.10 Toxicants

A toxicant is any substance that causes adverse effects in a living organism, including chemical compounds and heavy metals. Some chemical elements are essential for biological processes, but are considered toxic in higher concentrations. Other compounds, such as herbicides and pesticides can be toxic to biota at very low concentrations.

Toxicants can increase disease and mortality in foreshore biota, change physiology, and lead to imposex in intertidal molluscs (the development of male sexual characteristics in female organisms). These effects can result in a general reduction in biodiversity and altered community structure.

The rate at which water is moved into and out of the intertidal zone can mitigate the impact of toxicants. Reduced residence times present less opportunity for uptake of toxicants by intertidal biota.

A change in the physical-chemical state of the foreshore due to increased toxicant levels can be measured by increases in toxicants in intertidal sediments, water and biota. A biological measure of condition in regard to toxicants is the number of mortality events caused by toxicants in the intertidal zone.

Potential causes of anthropogenic change to toxicant levels, the direct pressure on the foreshore system, mediating factors, response and indicators of condition and pressure are listed in Table 2.10.
Table 2.10 Description of the pressure, condition and system responses for the Toxicant stressor.

| POTENTIAL CAUSES OF CHANGE TO TOXICANTS IN THE FORESHORE | • Boating activity (maintenance and emissions)  
| • Runoff from adjacent land (urban and rural)  
| • Industrial discharge  
| • Intensive agriculture  
| • Stormwater outfalls  
| • STP discharge  
| • Shipping accidents  
| • Toxicant spills  
| • Harmful algal blooms  
| • Aquaculture operations  
| • Dredging of contaminated sediments  
| • Infrastructure maintenance  
| • Extraction activities (mining) |

| DIRECT PRESSURE ON THE SYSTEM | Increase in the amount of toxicants entering the system |

| MEDIATING FACTORS | Dilution rate |

| CONDITION RESPONSE | PHYSICAL-CHEMICAL  
| BIOLOGICAL  
| • Increase toxicant concentrations  
| • Increased biota mortality  
| • Increased disease in biota  
| • Changes in physiology  
| • Increased imposex |

| PRESSURE INDICATORS | STRESSOR SOURCES  
| DIRECT PRESSURE  
| • Proximity to point sources  
| • Boating maintenance  
| • Boating activity  
| • Intensive agriculture in adjacent land  
| • Proximity to aquaculture operations  
| • Occurrence of dredging of contaminated sediment  
| • Occurrence of sewage overflow events  
| • Proximity to STP discharge point  
| • Proximity to extraction activities  
| • Fish condition advisories (i.e. government-issued warnings about eating fish/shellfish from certain areas) |

| CONDITION INDICATORS | PHYSICAL-CHEMICAL  
| BIOLOGICAL  
| • Toxicants in water column  
| • Toxicants in sediments  
| • Toxicants in biota  
| • Number of mortality events caused by toxicants |
2.4 Background to Values and Associated Indicators

Assessing foreshore condition, pressures and vulnerability is important in establishing health and the potential risks that may impact on the environment. However, it is equally important to identify any existing values that may help improve understanding of the social and ecological importance of an area, and any values that may be threatened by environmental change.

Foreshore values are assessed separately to condition, pressures and vulnerability because although related, they are not dependent on the calculation of these factors. However, once identified, values can be compared against risk to identify areas with recognised value that are potentially at risk from changing stressors.

In this assessment, foreshore values have been divided into two distinct categories – Natural Values and Human Use Values. Each category is further divided into sub-categories which better define the components considered when assessing value.

2.4.1 Natural Values

The natural value of the foreshore has been divided into sub-categories of ecology and geomorphology. Definitions of each sub-category and indicators of value are presented in Table 2.11.

<table>
<thead>
<tr>
<th>SUB-CATEGORY</th>
<th>DEFINITION</th>
<th>INDICATORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECOLOGY</td>
<td>The value of the foreshore with regard to the presence of significant species, features of conservation significance and/or representation of naturalness</td>
<td>• Presence of habitat of listed or otherwise significant species</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Presence of significant communities or habitats</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Area within or directly adjacent to a protected natural area</td>
</tr>
<tr>
<td>GEOMORPHOLOGY</td>
<td>The value of the foreshore with regard to rare or threatened geomorphic features or processes</td>
<td>• Geomorphic Value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Sensitivity of the geomorphic feature</td>
</tr>
</tbody>
</table>

2.4.2 Human Use Values

Human use values assessed in this study have been divided into the sub-categories of recreation and tourism, amenity, commercial and European heritage. Definitions of each sub-category and indicators of value are presented in Table 2.12.

<table>
<thead>
<tr>
<th>SUB-CATEGORY</th>
<th>DEFINITION</th>
<th>INDICATORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>RECREATION AND TOURISM</td>
<td>Value of the foreshore for recreation/tourism purposes with regard to the listed activities only</td>
<td>• Recreation activity and frequency of use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Tourist activity and frequency of use</td>
</tr>
<tr>
<td>AMENITY</td>
<td>Amenity value of the foreshore</td>
<td>• Presence of foreshore amenity and frequency of use</td>
</tr>
<tr>
<td>COMMERCIAL</td>
<td>Commercial value of the foreshore</td>
<td>• Presence of commercial activity</td>
</tr>
<tr>
<td>HERITAGE</td>
<td>European heritage value of foreshore</td>
<td>• Sites listed as having European heritage significance according to government listings</td>
</tr>
</tbody>
</table>
2.5 Defining and Scoring Spatial Units

A line map of the mean high water mark (MHWM) (1:25,000 scale) is used to represent the intertidal zone and forms the spatial basis of this assessment. This baseline is divided into 100 m segments along its entire length. Each line segment is assigned a unique identifying number which is retained in all associated data tables and can be used to link project data throughout the assessment process.

The segmentation of the shoreline into uniform lengths of 100 m allows information to be presented on a fine scale, and is unbiased in that division is not based on a single factor such as shore type that may not be relevant to all indicators. This is important in a broad assessment such as this, where a diverse range of environmental and social factors are considered.

Using geoprocessing techniques, each foreshore segment is attributed with spatial data to support the assessment of indicators of each stressor (pressure, vulnerability and condition) or value (natural or human use). The attributed data are transformed into quantifiable scores using decision matrices which define the range of possible outcomes for an indicator and assign a score to each. The VPSIRR software, adapted for foreshore assessment, automates this process and assigns a score of 1 to 5 to each foreshore segment for each indicator (see Table 2.15 for interpretation of scoring categories).

Once all indicators have been scored, the VPSIRR software calculates several additional outputs which are useful in assessing the state of the foreshore and providing further information about the supporting data. These are:

**Risk:** Risk considers the likelihood and consequence of a pressure impacting the foreshore. It is an assessment of the relationship between pressures acting on the system and the vulnerability of the shore to that pressure. Risk scores are therefore calculated for each pressure indicator (Table 2.13), but not as part of the values assessment. A risk score is also calculated for each stressor by averaging the individual indicator risk scores and applying a “boosted” category to emphasise the influence of extreme risk scores. A ‘boosted’ category score increases the influence of the maximum indicator value for a particular stressor.

<table>
<thead>
<tr>
<th>VULNERABILITY</th>
<th>PRESSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>High</td>
<td>Extreme</td>
</tr>
<tr>
<td>Extreme</td>
<td></td>
</tr>
</tbody>
</table>

Source: Scheltinga et al. 2010.

**Overall risk score:** This is essentially the average of the risk scores for all stressors. Overall risk scores range from A+ to F.

**Overall health score:** This is essentially the average of the condition indicator scores for all stressors. Overall health scores range from A+ to F.
**Overall assessment score (risk and health):** The overall assessment score for the risk and health component is derived from combining the overall risk rating and overall health rating. Overall assessment scores range from A+ to F.

**Overall natural values score:** This is essentially the average of the value scores for all indicators within the natural values category.

**Overall human use values score:** This is the essentially average of the value scores for all indicators within the human use values category.

**Overall value score:** The overall assessment score for the values component is derived from combining the overall natural values rating and overall human use values rating. Overall assessment scores range from A+ to F.

**Dependability:** This provides some indication as to the dependability of the final "rolled-up" overall assessment score. The dependability value specifies what percentage of indicators used in the assessment have data attributed to them and have actually been scored. This is an important value as limited data availability is a significant limitation of the assessment.

**Confidence:** A confidence category can be assigned to each indicator score so the quality of the supporting data is apparent. Confidence categories are defined in Table 2.14.

### Table 2.14 Confidence categories for data used in assessment

<table>
<thead>
<tr>
<th>CONFIDENCE CATEGORY</th>
<th>SCORE</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High</td>
<td>1</td>
<td>High quality data collected according to international, national or state recommended protocols, good temporal and spatial replication. Strict quality assurance and control measures in place. Data are current.</td>
</tr>
<tr>
<td>High</td>
<td>2</td>
<td>Good quality data collected according to recognised protocols but poor temporal and spatial replication. Quality assurance and control measures in place.</td>
</tr>
<tr>
<td>Moderate</td>
<td>3</td>
<td>Data quality and replication questionable. Little quality assurance or control.</td>
</tr>
<tr>
<td>Low</td>
<td>4</td>
<td>One-off data used (no replication) or data of dubious quality. Low accuracy equipment used. Poor methods used with no quality assurance or control. Data are not current.</td>
</tr>
</tbody>
</table>


Further detail on the calculation of overall risk, health and other VPSIRR processes is presented in Appendix 5-2. Detail on the methods used to calculate VPSIRR outputs can also be found in Scheltinga et al. (2010).

The process of defining spatial units and assigning indicator and overall assessment scores is summarised in Figure 2.5-1.
Define spatial units

- Use a 1:25,000 line map of the MHWM to represent the foreshore
- Divide MHWM into 100 m line segments
- Assign a unique identifier to each line segment

Attribute data

- Attribute data to line segments to support assessment of each indicator

Analyse

- Using VPSIRR software, decision matrices assign indicator scores to each line segment
- VPSIRR calculates risk, health, value and overall assessment scores

Figure 2.5-1 Summary of scoring process

Once all indicator and overall assessment scores are assigned, data can be displayed in a GIS for easier interpretation. Foreshore segments are colour-coded based on their scores. A simple 5-level colour coded system is used whereby a score of 1 is presented as bright green and indicates the segment is subject to the lowest risk, or is in excellent condition, or of very high value (depending on which layer is viewed). At the opposite extreme, a segment with a score of 5 is presented in red and indicates extreme risk, poorest condition or least value. Where scores are presented in a range from A+ to F, as for the overall assessment, the same principle is applied whereby A is green, and the poorest assessment of F is red. Interpretation of the colour-coded system used in segment scoring for each indicator category is outlined in Table 2.15.

Not all foreshore segments are attributed with data. A category of “Not applicable” is necessary where an indicator is not relevant to a segment. For example, measuring seagrass extent is irrelevant to areas of foreshore where seagrass has never been present. In other cases, no data are assigned where there is not enough information to reasonably support a classification.
Table 2.15 Interpretation of scoring categories and corresponding colours used in the assessment.

<table>
<thead>
<tr>
<th>SCORE</th>
<th>LEVEL OF PRESSURE ON THE FORESHORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Negligible</td>
</tr>
<tr>
<td>2</td>
<td>Low</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>4</td>
<td>High</td>
</tr>
<tr>
<td>5</td>
<td>Extreme</td>
</tr>
<tr>
<td></td>
<td>Unknown / Not applicable</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SCORE</th>
<th>CONDITION OF THE FORESHORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Excellent</td>
</tr>
<tr>
<td>2</td>
<td>Good</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>4</td>
<td>Poor</td>
</tr>
<tr>
<td>5</td>
<td>Very poor</td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SCORE</th>
<th>VULNERABILITY OF THE FORESHORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Negligible</td>
</tr>
<tr>
<td>2</td>
<td>Low</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>4</td>
<td>High</td>
</tr>
<tr>
<td>5</td>
<td>Extreme</td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SCORE</th>
<th>VALUE OF THE FORESHORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Very high</td>
</tr>
<tr>
<td>2</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>4</td>
<td>Low</td>
</tr>
<tr>
<td>5</td>
<td>Very low</td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
</tr>
</tbody>
</table>
2.6 Mapping and Reporting

As described in Section 1.1, ShoreBase aims to assess the state of the foreshore, and report on it using GIS maps and report cards. Mapping is used both as a means to prepare data for the adapted VPSIRR assessment software, and to present the final results. GIS maps present the final results in a useable format that can be interrogated and used in conjunction with other existing spatial data. The large amount of information that supports an assessment score can be accessed, allowing the user a good understanding of the decision making processes.

Assessment results can also be viewed in report cards which are produced by the VPSIRR software in HTML and .csv format. The report cards present results in a simplified manner and are useful for quick reference as the important final scores can be easily understood and compared.

Report cards include the overall assessment score for the segment, as well as the overall risk and health scores. The associated confidence and dependability scores are also listed. A break-down of risk scores for each stressor is presented in a summary table so that risk, condition, confidence and dependability scores can be viewed simultaneously. Further information is then provided on each stressor, including all pressure and condition indicators and their associated scores. Vulnerability indicators and risk calculations are also included.

Report cards are not generated for the values assessment, however all pertinent information can be viewed in the final dataset. All scores and ratings are colour coded according to the 5-level system outlined in Table 2.15.

2.7 Database Development

Considerable amounts of input data are required to support the scoring of stressors and values, and equivalent volumes are output as results. In order to successfully and efficiently assess and manage this data, a suitable system was required.

A database has been developed using Microsoft Access with the capacity to store all input and output data related to the assessment. It links numerous programs and acts as an interface that allows users to direct the assessment process from within one application. In conjunction with the VPSIRR software, the database automates the assessment of very large numbers of spatial units in a relatively short time period. The database can generate file formats required for VPSIRR software, run the VPSIRR software and compile outputs into a useable format that can be opened in a GIS application and viewed spatially. These features can be used to update results simply where more current information is available. A built-in map window is also included which allows the user to view foreshore line segments within Microsoft Access.
3 Application of Framework to the North and Cradle Coast NRM Regions

3.1 Study Area

Tasmania is divided into three Natural Resource Management (NRM) Regions – South, North and Cradle Coast. This project focused on the foreshores of the North and Cradle Coast Regions and included all national parks and islands, assessing over 4,600 km of coastline against the framework (see Figure 3.1-1).

Figure 3.1-1 Map of study area
The economies of the North and Cradle Coast regions rely heavily on estuarine, coastal and marine resources, as well as agriculture, tourism, manufacturing, forestry and mining. A large proportion of the regions’ population is concentrated around the major centres of Launceston, Burnie and Devonport, and in the numerous towns and cities present along the coast (Cradle Coast NRM 2010). Aside from the regions’ significant economic and amenity value, there are also a number of ecologically important areas present. These range from internationally significant wetlands to pristine wilderness. The numerous uses, sensitive habitat, diverse environments and large coastal extent pose a challenge for sustainable management of this area. Table 3.1 summarises the main features of each NRM region.

Table 3.1 Overview of the North and Cradle Coast NRM Regions.

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>NORTH REGION</th>
<th>CRADLE COAST REGION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total area</td>
<td>25,200 km²</td>
<td>22,492 km²</td>
</tr>
<tr>
<td>Total length of coastline*</td>
<td>~ 2077 km</td>
<td>~ 2573 km</td>
</tr>
<tr>
<td>% of total Tasmanian population</td>
<td>~ 28</td>
<td>~ 22</td>
</tr>
<tr>
<td>Number of local councils</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Major centres</td>
<td>Launceston</td>
<td>Burnie and Devonport</td>
</tr>
<tr>
<td>Basis of economy</td>
<td>• Estuarine, coastal and marine resources</td>
<td>• Agriculture</td>
</tr>
<tr>
<td></td>
<td>• Tourism</td>
<td>• Forestry</td>
</tr>
<tr>
<td></td>
<td>• Agriculture</td>
<td>• Manufacturing</td>
</tr>
<tr>
<td></td>
<td>• Viticulture</td>
<td>• Mining</td>
</tr>
<tr>
<td></td>
<td>• Forest industries</td>
<td>• Retail</td>
</tr>
<tr>
<td></td>
<td>• Fishing</td>
<td>• Tourism</td>
</tr>
<tr>
<td></td>
<td>• Aquaculture</td>
<td></td>
</tr>
<tr>
<td>Significant natural areas</td>
<td>• Logan Lagoon</td>
<td>• Arthur–Pieman Conservation Area</td>
</tr>
<tr>
<td></td>
<td>• Flyover Lagoon</td>
<td>• Narawntapu National Park</td>
</tr>
<tr>
<td></td>
<td>• Jock’s Lagoon</td>
<td>• Rocky Cape National Park</td>
</tr>
<tr>
<td></td>
<td>• Little Waterhouse Lake</td>
<td>• Franklin and Gordon Rivers</td>
</tr>
<tr>
<td></td>
<td>• Chimneys Lagoon</td>
<td>• World Heritage Areas</td>
</tr>
<tr>
<td></td>
<td>• Douglas-Apsley National Park</td>
<td>• Southwest National Park</td>
</tr>
<tr>
<td></td>
<td>• Mt William National Park</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Strzelecki National Park</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Kent Group National Park</td>
<td></td>
</tr>
</tbody>
</table>

Source: Natural Resource Management Tasmania 2010 and *ILS Hydline GIS layer

3.2 Data Sources

The extent of the project area and level of detail in this study meant that much of the assessment was supported by existing data. As such, it was important to identify all potentially relevant datasets held by government, universities, consultants, community groups and non-government organisations. The extent of existing information was ascertained through consultation with various experts and levels of government, and through searches of literature and data libraries.

In cases where suitable data did not exist, some new datasets were generated. This was done through interpretation of aerial imagery and through compilation of various scientific
studies and local knowledge. Given the resources needed to generate new data over such a large area, it was not feasible to fill all data gaps. The generation of new datasets was prioritised based on the estimated time taken to produce the dataset, its accuracy and overall applicability to the assessment.

A Reference Group was assembled in the initial stages of the project to help identify and discuss data sources, data access, assessment methods, community consultation processes, mapping formats and delivery mechanisms. The group included coastal managers, GIS specialists, local government representatives, and other specific interest groups.

This project also included a community consultation process which aimed to compile local knowledge on the study area. A questionnaire was distributed which focused on the values, condition, uses and pressures on foreshore habitats, as well as uses and perceived threats. Community groups conducting activities deemed to be particularly relevant to the study area were targeted to obtain feedback on their main concerns and priorities. General awareness of the project was also raised through articles in local publications, with an open invitation to the community to contribute data and other relevant information.

An extensive list of data sources and contributors is included in Appendix 5-3.

3.3 Scoring of Indicators

The sections below (3.3.1 to 3.3.12) present a breakdown of each stressor and value and associated indicators. Detailed information is provided on the relevance of each indicator to the stressor or value, and the rationale for inclusion in the assessment of the Tasmanian coastline. This builds on the general background information provided earlier in the report on stressors and associated indicators (section 2.3). Decision matrices used to determine scores for each indicator have been developed specifically for the study region and are also included below. Scoring categories defined in the decision matrices were derived from expert consultation, review of other studies and/or government regulations such as trigger levels, where available and relevant. A grey field indicates that the scoring category is unused.

In some cases indicators are included in more than one stressor. This is because a single pressure can act on the shore in different ways and potentially lead to change in a number of environmental stressors. For example, boating activity can result in boat wash, resuspension of aquatic sediments and emission of toxic substances. Stressors are also considered independently and therefore all pressure, vulnerability and condition indicators need to be part of their assessment.

The “immediate backshore” is a spatial area included in many of the below indicators. It is defined as the area from the mean high water mark to 100 m inland from each foreshore segment. The immediate backshore is considered to be the area most relevant to various indicators as it is assumed that the activities within 100 m of the intertidal zone will have the greatest and most immediate impact.

3.3.1 Aquatic Sediments

Scoring categories used to assign scores for indicators in the Aquatic Sediments stressor are included in Table 3.2. Specific information on each pressure, condition and vulnerability
Occurrence of Dredging (Pressure)

Dredging can increase the suspended sediment load in the water column and increase levels of fine sediments in intertidal systems. Dredging is carried out in ports, marinas and shipping channels throughout the study area for maintenance purposes. General dredging activities in Tasmania are managed by several bodies including government, port authorities and other agencies and permits are not always required. Information on spoil dump and dredging volumes is therefore not readily available. Given the lack of available data, broad categories have been used to define dredging operations with values taken from the definitions of dredging programs outlined in the National Assessment Guidelines for Dredging (DSEWPC 2009). A precautionary approach has been adopted in areas where dredging is likely to occur but no records can be found, and a score of 4 (high pressure) has been applied.

Boating Activity (Pressure)

This indicator relates to erosion and resuspension of aquatic sediment resulting from boating activity. When boat wash strikes the foreshore, it can cause rapid and severe erosion, and lead to an increase in suspended sediments. Many Tasmanian waterways are comprised of soft sediment and are therefore vulnerable to damage from boat wake and propeller wash (DPIWE 2008). Shores with high levels of nearby boating activity and low wave energy are at particular risk and include areas such as estuaries and sheltered bays. The frequency of boat visits to a particular area is therefore the focus of this indicator as increased boating activity increases the potential for sediment disturbance from vessel wake.

Boating activity has been inferred from the presence of foreshore structures and local knowledge. An “impact zone” of 1 km has been used in this indicator as it is thought the impact of boating on aquatic sediments will be direct and most significant when a vessel is within 1 km of the foreshore.

Agriculture within Immediate Backshore Area (Pressure)

Agriculture is an important activity in Tasmania and a major land use in the northwest of the state (Green 2001). Agricultural activities can lead to soil erosion and have been linked to increased sediment loads in coastal waters, particularly on steep slopes (OzCoasts 2010f). This indicator determines levels of pressure based on the proportion of the immediate backshore area used for agricultural activity. In any case where more than half of the area is used for agriculture, a high to very high pressure score is assigned.

Clearing in Immediate Backshore Area (Pressure)

This indicator reports on the increase in sediment loads in the foreshore environment that could result from land clearing in the adjacent backshore area and the associated increases in erosion. The percentage of backshore area cleared is used to determine the different levels of pressure, with rates greater than 75% considered a very high pressure.
Proximity to Sediment Point Source Discharge (Pressure)

This indicator focuses specifically on industrial discharge into a coastal receiving environment. Within Tasmania, industrial discharge can be classed as either a Level 1 or Level 2 activity. According to the Department of Primary Industries, Parks, Water and the Environment, Level 1 activities are those that may cause environmental harm and require a permit from Councils under the Land Use Planning and Approvals Act 1993. Level 1 activities are generally smaller industrial-type activities. They are assessed, approved and regulated by councils. There are also a range of other activities which are NOT classed as level 1, because they do not require permits from council. They remain the responsibility of councils to regulate. Level 2 activities are those activities included in Schedule 2 of EMPCA. These are generally larger industries or mining activities, or activities which have a greater potential to cause significant environmental harm. Level 2 activities are assessed, approved and regulated by the Environmental Protection Authority.

A category of “unknown” has been included in the scoring table to account for those activities not covered by Level 1 or Level 2 classification. This identifies areas for which no information is available, but where point source discharge is likely. Unlisted activities are considered a significant risk and have been scored accordingly.

Proximity to Stormwater Outflow (Pressure)

Stormwater comprises all forms of runoff from urban and suburban areas. It includes water discharged through pipelines and established infrastructure as well as runoff entering the foreshore area through rivulets and other natural watercourses. Stormwater is an important contributor to aquatic sediments as it can both erode sediments, and transport them to the coastline.

This indicator considers stormwater outflow in permanently populated areas only as this is likely to have a much greater impact with regard to anthropogenic increases in aquatic sediments than undisturbed, remote locations.

Proximity to Stream/River Input and % of Catchment Cleared (Pressure)

The catchment clearing included in this indicator is different to that considered in the clearing of the immediate backshore. Clearing relates to the catchments of streams and rivers that are not included in the immediate study area (i.e. beyond 100 m from the foreshore). This indicator is designed to consider the sediment load entering a marine waterway via stream/river output.

Density of Unsealed Roads in Immediate Backshore Area (km per km²) (Pressure)

Unsealed roads are common in the more remote and sparsely populated areas of Tasmania. Unsealed roads are likely to contribute greater sediment loads to the coastal area than sealed roads through increased erosion and ongoing maintenance activities. The density of unsealed roads in the backshore area is used as an indicator of potential pressure in this indicator, and it is assumed a density of greater than 8 km per km² presents a high to very high pressure.
Use of Foreshore and Immediate Backshore by Off-Road Vehicles (Pressure)

Four-wheel driving is a popular activity in the coastal areas of the North and Cradle Coast regions. However, the use of off-road vehicles can lead to reduced soil stability, alteration to drainage patterns, damage to vegetation and deterioration of water quality (Recreational Vehicle Working Group 2005). Studies have shown that 4WD tracks can destroy dune fronts, accelerate erosion and damage or remove vegetation (Thompson and Schlacher 2008).

There is very little information collected on off-road vehicle use in the coastal zone in Tasmania. As such, a general use scale was developed which considered access to the shore and estimated frequency of use. Shore type was also considered as off-road activity is likely to focus on sandy shores, rather than rocky, muddy or cliffed areas.

Change in Seagrass Extent (Condition)

Degradation of water quality resulting from increased sediment run-off in human altered watersheds can have a damaging impact on seagrass (Waycott et al. 2009). This indicator focuses specifically on the seagrass species found in Tasmanian intertidal seagrass beds (Zostera muelleri and Heterozostera nigricaulis) and considers the change in extent per year within 100 m of the MHWM. Zostera muelleri is the only fully intertidal seagrass species in Tasmania (G. Edgar, pers. comm. 2009) and is found on intertidal flats. Heterozostera nigricaulis is typically found in the subtidal zone or shallow intertidal pools (Ball and Blake 2007).

Accurate assessment of this indicator requires historic records and monitoring data. It is also important to note that this indicator is extremely species dependent i.e. some seagrass species show seasonal patchiness and change in extent, others are dense and not seasonal. It is important assessors understand the natural variation of density and condition for each species so that decline over time can be accurately assessed.

Large areas of coastline may not be assigned a classification for this indicator as it is not applicable where seagrass is not, and has never been present.

Change in Particle Size (Condition)

A change in particle size distribution in the intertidal zone, from sand to mud for example, indicates sedimentation or erosion is occurring, which could be the result of anthropogenic influence.

The timescale of this indicator is “since last assessment”. This means any previous study can be used as a “baseline” for monitoring provided the geographic coverage is sufficient over the study area, and consistent methods and timeframes are considered.

Turbidity (Condition)

A change in turbidity in intertidal water could indicate a change in levels of suspended aquatic sediments due to anthropogenic activity.

There are no regulatory turbidity guidelines or trigger levels available specific to Tasmanian waters. Guidelines from the Australia and New Zealand Environment Conservation Council (ANZECC 2000) are currently in use, however this is potentially problematic as no Tasmanian
data were included in their development and many sites in the state are naturally above trigger levels. Guidelines specific to Tasmanian waters should be used where possible, such as those outlined in *Indicators for Monitoring the Condition of Estuaries and Coastal Waters* (Crawford 2006).

**Dilution Rate (Vulnerability)**

This is a general indicator of dilution based on exposure and marine influence. "High", "moderate" and "poor" dilution rates have been used as relative descriptions due to the difficulty in defining exact rates. A relatively high dilution rate is that of an open coast with high tidal range and high rate of marine exchange. Relatively poor dilution rates would be characteristic of closed embayments or sheltered shores with low tidal range and restricted marine exchange.

It is important to include dilution rate as a vulnerability factor as an exposed shore with a high dilution rate subject to an unnatural sediment load will be less impacted than a sheltered shore subject to the same load.
Table 3.2 Criteria used to assign scores for indicators within the Aquatic Sediments stressor.

<table>
<thead>
<tr>
<th>STRESSOR</th>
<th>INDICATOR TYPE</th>
<th>INDICATOR NAME</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Occurrence of dredging (within 1 km of foreshore segment)</td>
<td>No dredging activity within last year (assumed or known)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Boating activity (within 1 km of foreshore segment)</td>
<td>Very limited, or no boating activity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>% of immediate backshore area used for agriculture</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>% clearing in immediate backshore area</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proximity of foreshore segment to sediment point source discharge</td>
<td>No point sources (or likely point sources) within 1 km</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proximity of foreshore segment to stormwater outflow</td>
<td>Stormwater outflows (or likely outflow) absent from within 1 km</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proximity of foreshore segment to stream/river input and % of catchment cleared</td>
<td>Segment within an estuary or within 1 km of mouth of estuary with 0% catchment cleared OR segment is beyond 1 km of estuary mouth</td>
</tr>
</tbody>
</table>
### ShoreBase: A Coastal Management Tool

<table>
<thead>
<tr>
<th>STRESSOR</th>
<th>INDICATOR TYPE</th>
<th>INDICATOR NAME</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pressure</td>
<td>Density of unsealed roads in immediate backshore (km²)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;0 and &lt;=2.5</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;2.5 and &lt;=8</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;8 and &lt;=15</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;15</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Use of foreshore and immediate backshore by off-road vehicles</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Very rarely used (inaccessible, prohibited, remote)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sometimes used (average of &lt;10 vehicles per week)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Regularly used (average of 10 or more vehicles per week)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Habitat no longer present (previously was)</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Aquatic Sediments</td>
<td>Change in seagrass extent</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Condition</td>
<td>Increase or no change in extent</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Minor declining trend in extent (&lt;5% decrease per year)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moderate declining trend in extent (5 to 40% decrease per year)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Major declining trend in extent (&gt;40% decrease per year) OR no data in areas where seagrass is known or has been known to be present</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Habitat no longer present (previously was)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Change in particle size</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No change</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moderate change from previous distribution</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Significant change from previous distribution</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Evidence within 1 km of foreshore segment of EITHER no change from natural regime OR no exceedance of guidelines within last year</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Turbidity</td>
<td>Evidence within 1 km of foreshore segment of EITHER turbidity occasionally altering from natural regime OR occasionally exceeding guideline levels within last year</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Evidence within 1 km of foreshore segment of EITHER complete change from natural regime, OR turbidity regularly exceeding guideline levels within last year</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Vulnerability</td>
<td>Dilution rate</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively high</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively moderate</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively poor</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively poor</td>
<td>5</td>
</tr>
</tbody>
</table>

*Aquenal Pty Ltd*
3.3.2 Bacteria and Pathogens

Scoring categories used to assign scores for indicators in the Bacteria and Pathogens stressor are included in Table 3.3. Specific information on each pressure, condition and vulnerability indicator is included below with indicator type defined in brackets after each heading. See section 2.3.2 for a full description of this stressor.

**Presence of Septic Tanks (Pressure)**

Septic tanks are a potential source of bacteria and pathogens, particularly when poorly maintained. The use of septic tanks is widespread in the study area due to the remote nature of many coastal populations.

This indicator uses a conservative approach and assumes that where present, septic tanks are a potential source of pressure with regard to bacteria/pathogen seepage. Some systems will be of no concern, but a number will seep and in the absence of any further information, all are treated alike.

It is thought an estimated density of four septic tanks per Ha of adjacent backshore is enough to be of significant concern (i.e. receive a pressure score of 5) with regard to increases in bacteria and pathogens. A score of 4 is applied in cases where residences are present but where no sewage infrastructure exists, and it is unknown if septics are present. This includes areas where sewage infrastructure has recently been introduced, as some dwellings may still use septics, and old systems with the potential for seepage may remain in the ground unempted. A score of 2 is applied where only one septic is present, as potential pressure still exists (albeit minor), and a score of 1 (i.e. no pressure) has only been applied where septic tanks are absent.

**Proximity to Stormwater Outflow (Pressure)**

Stormwater comprises all forms of runoff from urban and suburban areas and can contribute significant amounts of faecal bacteria and other pathogens to coastal waterways. It includes water discharged through pipelines and established infrastructure as well as runoff entering the foreshore area through rivulets and other natural watercourses. This indicator considers stormwater outflow in permanently populated areas only as this is likely to have a greater impact with regard to bacteria and pathogen loads than unpopulated, remote locations.

In built-up areas where data on stormwater infrastructure are not available, a conservative score of 4 is applied to foreshore segments within the 1 km area around any point where an outflow is suspected.

**Proximity to Aquaculture Operations (Pressure)**

This indicator focuses on aquaculture operations involving both finfish and shellfish. High stocking densities of any aquaculture species and the associated increased stress levels can result in outbreaks of disease which can be transferred to wild populations. Solid waste including faeces can also be concentrated around aquaculture operations leading to increased activity of microorganisms (National Oceans Office 2001). Shore-based operations can also result in bacterial output through other discharge and waste products and have therefore been included in this indicator.
Occurrence of Sewage Treatment Plant Overflow Events (Pressure)

Effluent from sewage treatment plants into the coastal environment can increase levels of pathogenic micro-organisms with potentially harmful impacts (DPIWE 2001). In Tasmania, there are problems with cross connections between sewage and stormwater systems with stormwater infrastructure completely absent in some parts of the state. Cross-connection leads to increased volumes of water in the sewage system and can cause plant malfunction and consequent overflow events (Green 2001). Reports have indicated that in Tasmania there are 23 communities on permanent boil water alerts and 90% of waste treatment plants do not comply with permit notice discharge limits (Department of Premier and Cabinet 2010).

Based on rates of overflow events published by the Tasmanian Government (i.e. over 200 per year, and 100 in two months alone), it could be assumed that all plants are having at least one overflow event per year. It is assumed that even one event within 500 m of a foreshore segment is going to have a notable impact.

Proximity to Wastewater Treatment Plant Discharge (Pressure)

Discharge from wastewater treatment plants can increase the level of bacteria/pathogens in the receiving environment. The scale of impact can vary significantly depending on the level of treatment. As such, both the level of treatment and the proximity of the wastewater discharge point to the foreshore are considered. The three treatment levels included in this indicator can be defined as follows:

- **Primary**: involves screening the solids from the water and allowing a proportion of the suspended solids and organic matter to settle from the wastewater.

- **Secondary**: takes primary treated effluent and with the aid of biological processes breaks down a further proportion of the dissolved or suspended organic matter to a form that reduces its environmental impact if discharged. Disinfection by means of chlorination, ozonisation or UV radiation is also often considered to be part of the secondary treatment process step. Secondary treatment is usually sufficient for effluent discharged by way of an ocean outfall, where nutrients are dispersed rapidly. Effluent reuse also usually requires treatment to secondary level, provided that the specified disinfection limits can reliably be achieved.

- **Tertiary**: secondary treated effluent is further processed using various techniques including flocculation, coagulation, clarification and filtration. The main aim is to remove nutrients such as nitrogen and phosphorus and further reduce the small amount of organic material and any remaining harmful micro-organisms in the secondary treated effluent. Tertiary treatment is becoming a standard requirement for effluent discharged to waterways which are sensitive to nutrient enrichment, such as small inland watercourses or poorly flushed bays (EPA Division 2010).

Boat Moorings (Pressure)

There is an increased likelihood of bacterial or pathogenic discharge from vessels where they are moored for long periods and/or in high densities. In Tasmania there is no legislation for sewage discharge from small recreational and commercial vessels (unless acting under the Navigation Act). A voluntary code of practice exists which describes best practice environmental management in relation to the disposal of raw sewage and other wastes from
boats. However as the code is voluntary, it can be assumed that some waste will be discharged from vessels in coastal areas where boating activity occurs.

**Proximity to Bacteria/Pathogen Point Source Discharge (Pressure)**

Some industries in Tasmania discharge waste to the marine environment that contains high levels of bacteria/pathogens. These can be classed as Level 2 activities which, according to the *Environmental Management and Pollution Control Act 1994* (EMPCA), are generally larger industries or mining activities, or activities which have a greater potential to cause significant environmental harm. Level 2 output related to potential bacterial/pathogenic industrial activities is included in this indicator. Point source discharges considered are those where waste is discharged from a specific site such as a pipe or drain directly to the coast. It does not include general stormwater runoff which is considered in a separate indicator.

**Occurrence / Concentration of Enterococci (CFU/100mL) (Condition)**

According to the ANZECC Microbiological Guidelines, the guidelines for primary contact with water state:

*The median bacterial content in samples of fresh or marine waters taken over the bathing season should not exceed 35 enterococci organisms/100 mL (maximum number in any one sample: 60–100 organisms/100 mL).*

Guidelines for Secondary Contact state:

*The median bacterial content in fresh and marine waters should not exceed 230 enterococci organisms/100 mL (maximum number in any one sample 450–700 organisms/100 mL) (DPIPWE 2010).*

Primary contact guidelines have been used in this indicator as these are the most conservative, and also because most information that is likely to be available to support this indicator will be from monitoring programs for recreational waters and shellfish farms. In these cases, exceedance of primary contact guidelines would be a significant event.

**Occurrence / Concentration of Faecal Coliforms (CFU/100mL) (Condition)**

According to the ANZECC Microbiological Guidelines, the guidelines for primary contact with water state:

*The median bacterial content in samples of fresh or marine waters taken over the bathing season should not exceed 150 faecal coliform organisms/100 mL (minimum of five samples taken at regular intervals not exceeding one month, with four out of five samples containing less than 600 organisms/100 mL).*

Guidelines for Secondary Contact state:

*The median bacterial content in fresh and marine waters should not exceed: 1000 faecal coliform organisms/100 mL (minimum of five samples taken at regular intervals not exceeding one month, with four out of five samples containing less than 4000 organisms/100 mL) (DPIPWE 2010).*
Primary contact guidelines have been used in this indicator as these are the most conservative and, as for Enterococci, most information that is likely to be available to support this indicator will be from monitoring programs for recreational waters and shellfish farms. In these cases, exceedance of primary contact guidelines would be a significant event.

**Dilution Rate (Vulnerability)**

This is a general indicator of dilution based on exposure and marine influence. "High", "moderate" and "poor" dilution rates have been used as relative descriptions due to the difficulty in defining exact rates. A relatively high dilution rate is that of an open coast with high tidal range and high rate of marine exchange. Relatively poor dilution rates would be characteristic of closed embayments or sheltered shores with low tidal range and restricted marine exchange.

It is important to include dilution rate as a vulnerability factor as an exposed shore with a high dilution rate subject to a bacteria/pathogen load will be less impacted than a sheltered shore subject to the same load.
Table 3.3 Criteria used to assign scores for indicators within the Bacteria / Pathogens stressor.

<table>
<thead>
<tr>
<th>STRESSOR</th>
<th>INDICATOR TYPE</th>
<th>INDICATOR NAME</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Presence of septic tanks within the 1 Ha backshore area adjacent to the foreshore segment</td>
<td>Septics absent</td>
<td>1 septic present</td>
</tr>
<tr>
<td></td>
<td>Proximity of foreshore segment to stormwater outflow</td>
<td>Outflows (or likely outflow) absent from within 1 km</td>
<td>Outflow present within 500 m to 1 km</td>
</tr>
<tr>
<td></td>
<td>Occurrence of STP overflow events and proximity to foreshore segment</td>
<td>No STP infrastructure present within 1 km to allow overflow events</td>
<td>No overflow events in past year within 1 km (but STP infrastructure present within 1 km)</td>
</tr>
<tr>
<td></td>
<td>Boat moorings within 1 km of foreshore segment</td>
<td>No mooring or anchorage sites / facilities of any kind identified</td>
<td>Mooring or anchorage sites identified (no permanent mooring)</td>
</tr>
<tr>
<td></td>
<td>Proximity of foreshore segment to finfish and shellfish aquaculture operations</td>
<td>Aquaculture operations absent from within 1 km</td>
<td>Aquaculture operations present within 500 m to 1 km</td>
</tr>
<tr>
<td></td>
<td>Proximity of foreshore segment to WWTP discharge and treatment level</td>
<td>No discharge within 1 km</td>
<td>Tertiary Level discharge within 500 m to 1 km</td>
</tr>
<tr>
<td>STRESSOR</td>
<td>INDICATOR TYPE</td>
<td>INDICATOR NAME</td>
<td>SCORE</td>
</tr>
<tr>
<td>----------</td>
<td>----------------</td>
<td>---------------</td>
<td>-------</td>
</tr>
<tr>
<td><strong>PRESSURE</strong></td>
<td>Proximity of foreshore segment to bacteria / pathogen point source discharge</td>
<td>No point sources (or likely point sources) within 1 km</td>
<td>1</td>
</tr>
<tr>
<td><strong>BACTERIA / PATHOGENS</strong></td>
<td>Occurrence / concentration of Enterococci (CFU/100mL) and proximity to foreshore segment</td>
<td>No sites within 5 km exceeded ANZECC guidelines for Primary Contact within last year</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Occurrence / concentration of faecal Coliforms (CFU/100mL) and proximity to foreshore segment</td>
<td>No sites within 5 km exceeded guidelines for Primary Contact within last year</td>
<td>1</td>
</tr>
<tr>
<td><strong>VULNERABILITY</strong></td>
<td>Dilution rate</td>
<td>Relatively high</td>
<td>1</td>
</tr>
</tbody>
</table>
3.3.3 Biota Removal and Disturbance

Scoring categories used to assign scores for indicators in the Biota Removal and Disturbance stressor are included in Table 3.4. Specific information on each pressure indicator is included below. See section 2.3.3 for a full description of this stressor.

Recreation and Tourist Use (Pressure)

Recreation and tourist activities can lead to disturbance of foreshore biota and removal of targeted species. In order to score this indicator, an index was developed that considered recreational and tourist activities with the potential to result in biota removal and/or disturbance. Tourist accommodation, tour operations and hire activities, and the frequency and type of recreation use were considered.

Popular recreation activities in the Tasmanian coastal environment that may result in removal or disturbance of biota include swimming, walking, surfing, picnics and barbeques, kayaking and canoeing, horse riding, fishing, dog exercise, off-road driving and camping. Recreation activities such as dog walking and the use of off-road vehicles in foreshore areas can cause significant disturbance to some foreshore biota. Shorebirds are particularly sensitive to disturbance and have been known to abandon nests if sufficiently disturbed (State of Queensland Environmental Protection Agency 2007). Algae in intertidal habitats may suffer reduced abundance and cover as a result of trampling and can be slow to recover (Hardiman and Burgin 2010).

The frequency of recreation use and associated pressure with regard to the disturbance and removal of biota is calculated in a separate table (Frequency of Recreation Use Calculation) and weights different uses based on their association with this stressor. For example, dog walking, off-road vehicles and camping activities are likely to cause greater disturbance to
foreshore biota than swimming. For each segment, a score is assigned based on the frequency of occurrence of each recreational activity.

**Frequency of Recreation Use Calculation Table**

<table>
<thead>
<tr>
<th>RECREATIONAL USE</th>
<th>FREQUENCY OF USE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NONE</td>
</tr>
<tr>
<td>Swimming</td>
<td>1</td>
</tr>
<tr>
<td>Walking</td>
<td>1</td>
</tr>
<tr>
<td>Surfing</td>
<td>1</td>
</tr>
<tr>
<td>Picnic/BBQ</td>
<td>1</td>
</tr>
<tr>
<td>Kayaking/canoeing</td>
<td>1</td>
</tr>
<tr>
<td>Horse riding</td>
<td>1</td>
</tr>
<tr>
<td>Fishing</td>
<td>1</td>
</tr>
<tr>
<td>Dog exercise</td>
<td>1</td>
</tr>
<tr>
<td>Off-road vehicles</td>
<td>1</td>
</tr>
<tr>
<td>Camping</td>
<td>1</td>
</tr>
</tbody>
</table>

The total of all the scores for each segment is then calculated and based on the following ranges (which have been derived from the distribution of scores) an overall category is assigned that represents the frequency of recreation use:

<table>
<thead>
<tr>
<th>Frequency of recreation use category</th>
<th>Total of frequency of use scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>10</td>
</tr>
<tr>
<td>Low</td>
<td>11</td>
</tr>
<tr>
<td>Moderate</td>
<td>12 to 14</td>
</tr>
<tr>
<td>High</td>
<td>15 to 19</td>
</tr>
<tr>
<td>Very high</td>
<td>20 +</td>
</tr>
</tbody>
</table>

**Boating Activity (Pressure)**

This indicator is intended to reflect the disturbance to foreshore biota caused by recreational and commercial boating activities. The noise, movement and vibration associated with boating may contribute to disturbance.

The frequency of boat visits, as inferred from boating infrastructure and local knowledge is the basis of category scoring as the level of boating activity is likely to be proportional to disturbance. An “impact zone” of 1 km has been used in this indicator as it is thought the impact of boating with regard to disturbance is going to be direct and most significant when a vessel is within 1 km of the foreshore.

**Adjacent Population Density (Pressure)**

The level of disturbance to foreshore biota is related to the density of the adjacent population. Development and general anthropogenic activity can result in light, noise, trampling and runoff, all of which can lead to disturbance. This indicator considers the density of the population in the adjacent areas, and assigns the highest pressure score where densities are greater than 1000 people per km². Populations of less than 10 people per km² are unlikely to pose a significant pressure.
Access to Shore (Pressure)
Although access to the shore in itself is not necessarily indicative of disturbance, accessible shores are much more likely to be subject to disturbance from noise, trampling, litter, movement, light etc. Such impacts are limited on inaccessible shores.

This indicator is based on direct access to the shore. It is a simple measure of how easy it is to get to the shore, not how many people actually visit the shore. It is assumed that foreshores in highly protected, cliffed and very remote areas are going to be accessed rarely. In the case of beaches, it is assumed that where a single access point is present, the entire beach is likely to be accessed. Where there is more than one foreshore access point, the score associated with the highest impacting point is used.

Access of Stock to Foreshore (Pressure)
In Tasmania, direct access of stock to foreshore areas is a relatively common occurrence (Koehnken 2001). Allowing livestock to access foreshore areas can lead to the grazing and trampling of foreshore biota. This indicator assumes that wherever stock are accessing the foreshore, disturbance is occurring. In order to highlight an important potential pressure, a score of 4 has been assigned to areas where grazing occurs in the directly adjacent land, but it is unknown if stock access the shore.

Occurrence of Fires in Immediate Backshore (Pressure)
Fire in the area immediately adjacent to the foreshore can lead to disturbance through heat, smoke and loss of backshore habitat and vegetation. Although fire is a natural occurrence along much of the Tasmania coastline, the frequency of fires (managed or wild) is the critical factor in determining disturbance. Fires occurring more than 20 years apart may be positive regeneration factors to which the ecology of the area is well adapted. Fires occurring more frequently than every 10 years may be considered a disturbance with negative impacts. A frequency of between 10 and 20 years may be a transitional period where the impacts become increasingly negative (J. Marsden-Smedley, pers. comm. Dec 2009).

Presence of Shading Structures (Pressure)
Shading of foreshore biota has been shown to decrease growth rates of some intertidal biota (Blockley 2007) and influence patterns of recruitment (Blockley and Chapman 2006), thereby altering community structure. In this indicator, the extent of shading from structures in the intertidal zone is estimated using a “segment shading score”. An approximate estimate of size is assigned to each foreshore structure using broad, relative categories of small, medium and large. These act as a proxy for shading capacity in both the alongshore and inshore areas. Approximate size is then converted into a numeric score where “small” = 1, “medium” = 5 and “large” = 10. Where more than one structure is present in a foreshore segment, all scores are added together.
Biota Collection (Pressure)
This indicator considers biota collection for recreational and commercial purposes, including targetted collection of bait and commercial invertebrate species within the foreshore area. Species collected for commercial and recreational purposes in the study area include *Venerupis largillerti* (Venerupis clam) and *Katelysia scarlarina* (cockle). The Pacific oyster *Crassostrea gigas* is also included, as although introduced, collection is likely to disturb other species present, especially due to the vigorous way in which they are sometimes removed (e.g. "oyster smashing").

There is a notable lack of data regarding the collection of biota on Tasmania shores. It is therefore important to include an “unknown” category to highlight areas where shores are easily accessed and collection is likely to be occurring. Where a shore is inaccessible or very rarely accessed, it is assumed biota collection activity would be negligible.

Development in Immediate Backshore Area (Pressure)
This indicator is included because of the general disturbance associated with existing backshore development and infrastructure such as noise, light, vibration and movement. Development is considered to be any building or structure and their associated infrastructure such as car parks. The percentage of development in the immediate backshore is used to assess potential disturbance, with the highest level of pressure assigned where more than 75% of the backshore is developed.

Occurrence of Dredging (Pressure)
Regular dredging activities occur in ports, marinas and shipping channels throughout the study area. The noise, vibration, movement and light, as well as the potential for increased turbidity associated with dredging are likely to disturb foreshore biota.

In Tasmania, dredging activities are managed by several bodies including government, port authorities and other agencies and permits are not always required. Permits are not issued for dredging itself and numerous small scale dredging operations may not be recorded or reported. Information on volumes of sediment dredged is therefore not readily available. Given the lack of available data, broad categories have been used to define dredging operations with values taken from the definitions of dredging programs outlined in the National Assessment Guidelines for Dredging (DSEWPC 2009). A score of 4 (high pressure) is applied where dredging is likely to occur, but no records can be found.
**Table 3.4** Criteria used to assign scores for indicators within the Biota Removal and Disturbance stressor.

<table>
<thead>
<tr>
<th>STRESSOR</th>
<th>INDICATOR TYPE</th>
<th>INDICATOR NAME</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biota Removal and Disturbance</td>
<td>Recreation and tourist use index score</td>
<td>3</td>
<td>4</td>
<td>5 to 6</td>
<td>7 to 10</td>
<td>11 to 15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Boating activity within 1 km of foreshore segment</td>
<td>Very limited, or no boating activity</td>
<td>Recreational vessel activity only</td>
<td>Commercial and recreational vessel activity</td>
<td>Marina facilities present</td>
<td>International / domestic port facilities present</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Population density adjacent to foreshore segment</td>
<td>No coastal population present</td>
<td>Up to 10 people/km²</td>
<td>&gt;10 to 100 people/km²</td>
<td>&gt;100 to 1000 people/km²</td>
<td>&gt;1000 people/km²</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Access to shore</td>
<td>Inaccessible or very rarely accessed - no foreshore access</td>
<td>Accessible via walking tracks or horse trails only (i.e. no direct access or roads within 1 km) OR accessible via private road only</td>
<td>Directly/publicly accessible, BUT there are no arterial roads or highways present within 1 km</td>
<td>Directly/publicly accessible AND there are arterial roads or highways present within 1 km</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Access of stock to foreshore</td>
<td>Stock never access foreshore (not accessible, no adjacent grazing)</td>
<td></td>
<td>Grazing occurs in adjacent area, but unknown if stock access foreshore</td>
<td>Stock regularly access foreshore</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frequency of fires in adjacent immediate backshore area</td>
<td>Very infrequent (no fire on record OR no fires within last 20 years)</td>
<td>Infrequent (10 - 20 years between fires, or only 1 fire on record within last 20 years)</td>
<td></td>
<td>Frequent (less than 10 years between fires (occurring within the last 20 years))</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Presence of shading structures (segment shading score)</td>
<td>None present within foreshore segment</td>
<td>Segment shading score of 1 to 4</td>
<td>Segment shading score of 5 to 10</td>
<td>Segment shading score of &gt;10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Biota collection within foreshore segment</td>
<td>No known collection</td>
<td>Moderate (average of 1-5 people collecting biota per week)</td>
<td>Unknown in a foreshore segment with an access score of &gt;3 where collection is likely to occur</td>
<td>Extensive (average of &gt;5 people collecting per week), OR any commercial collection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STRESSOR</td>
<td>INDICATOR TYPE</td>
<td>INDICATOR NAME</td>
<td>SCORE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>----------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOTA REMOVAL AND DISTURBANCE</td>
<td>PRESSURE</td>
<td>% development in immediate backshore area</td>
<td>0%</td>
<td>&gt;0 to 25%</td>
<td>&gt;25 to 50%</td>
<td>&gt;50 to 75%</td>
<td>&gt;75 to 100%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Occurrence of dredging (within 1 km of foreshore segment)</td>
<td>No dredging activity within last year (assumed or known)</td>
<td>Occasional or one off dredging programs of &quot;very small&quot; scale (i.e. &lt;15,000 m³)</td>
<td>Occasional or one off dredging programs of &quot;small&quot; scale (i.e. 15,000 to &lt;50,000 m³) OR no data within 1 km of areas where dredging is likely to occur</td>
<td>Any &quot;medium&quot; (50,000 - 500,000 m³) or &quot;large&quot; (&gt;500,000 m³) scale dredging within last year OR any regular maintenance dredging of any volume</td>
<td></td>
</tr>
</tbody>
</table>

| CONDITION                      | NONE           |                                                                                   |                                                                      |
| VULNERABILITY                  | NONE           |                                                                                   |                                                                      |
3.3.4 Habitat Removal

Scoring categories used to assign scores for indicators in the Habitat Removal stressor are included in Table 3.5. Specific information on each pressure and condition indicator is included below with indicator type defined in brackets after each heading. There is no vulnerability indicator listed for this stressor. See section 2.3.4 for a full description of this stressor.

Foreshore Modification (Pressure)

Foreshore modifications are structures or reclamation (land claim) that alter the natural state of the foreshore. Foreshore structures can cause fragmentation and loss of habitat (Bulleri and Chapman 2010), whilst construction phases and ongoing maintenance can also result in removal or burial of habitat.

Structures considered in this indicator include jetties, slipways, marinas, boat ramps, moorings, breakwaters, boat sheds, pontoons, boardwalks and wharves.

Use of Foreshore and Immediate Backshore by Off-Road Vehicles (Pressure)

The use of off-road vehicles can lead to reduced soil stability, alteration to drainage patterns, damage to vegetation, introduction of weeds, introduction of rubbish and an increased fire risk (Recreational Vehicle Working Group, 2005). Studies have shown that 4WD tracks can lead to the removal of habitat through destruction of dune fronts, acceleration of erosion and damage or removal of vegetation (Thompson and Schlacher 2008).

There is very little information collected on off-road vehicle use in the coastal zone in Tasmania. As such, a general use scale was developed which considered access to the shore and estimated frequency of use. Shore type was also considered as off-road activity is likely to focus more on sandy shores, rather than rocky, muddy or cliffed areas.

Beach Grooming (Pressure)

The aim of beach grooming is to remove litter and marine debris to improve amenity, however it can lead to the direct removal of strandline habitat and beach vegetation (Dugan and Hubbard 2010) which serves an important function for shorebirds and intertidal invertebrates.

Due to the difficulty in collecting detailed information on beach grooming activities in Tasmania, broad categories have been applied in this indicator. "Regular" grooming activity is defined as any scheduled or ongoing grooming activity. "Occasional" is defined as one-off or irregular activities - i.e. no planning for regular intervals. In areas where beach grooming is likely, but for which no data exists, a conservative score of 4 is applied.

Removal of Wrack, Rock or Sand (Pressure)

The removal of important habitats in the intertidal zone can occur through collection of wrack (i.e. debris washed ashore, including seaweed, shells etc), rock and sand. These components can be collected through fossicking and collection of cast weed for home and commercial use, or can be removed by large scale operations such as sand mining.
This indicator uses broad classifications to assess the potential pressure from habitat removal through collection of wrack, rock or sand. Occasional removal (i.e. irregular collection) is considered to have a moderate impact within a foreshore segment, whilst ongoing or frequent collection is considered to have the greatest impact and has been known anecdotally to alter habitat through continued targeted collection of certain rock types.

**Presence of Foreshore Weeds (Pressure)**

The establishment of weeds in the intertidal zone can dramatically alter habitat and have a significant impact on foreshore communities (Kriwoken and Hedge 2000). This indicator considers rice grass (*Spartina anglica*) and the beach weeds marram grass (*Ammophila arenaria*), beach daisy (*Arctotheca populifolia*), sea spurge (*Euphorbia paralias*), pyp grass (*Ehrharta villosa*) and sea wheatgrass (*Thinopyrum junceiforme*).

Scoring categories within this indicator consider only presence or absence as the occurrence of any beach weed in the foreshore segment is assumed to be removing/altering the natural habitat.

**Disturbance of Tidal Wetlands / Saltmarshes (Pressure)**

Saltmarshes and wetlands in Tasmania are important habitat for several rare and threatened species and additionally serve to stabilise the coastline. Tidal wetlands and saltmarshes may be drained and/or filled so land can be used for other purposes such as agriculture (DPIPWE 2009b).

The disturbance of wetlands/saltmarsh within or directly adjacent to the foreshore segment is considered in this indicator. The highest pressure score has been assigned where any disturbance is occurring.

**Occurrence of Dredging and/or Extraction Activities in the Intertidal Zone (Pressure)**

Dredging or extraction activities within the intertidal zone result in the direct removal of intertidal habitat. It is assumed where dredging activity is occurring within the foreshore segment, habitat is being removed and is posing a significant pressure. A score of 5 has therefore been applied. A score of 4 is assigned to areas where dredging is likely to occur, but for which no data are available.

**Boating Activity (Pressure)**

This indicator is intended to reflect the removal of intertidal habitat through boat wash resulting from recreational and commercial boating activities. When boat wash strikes the foreshore, it can cause rapid and severe erosion. Many Tasmanian waterways are comprised of soft sediment and are therefore vulnerable to damage from boat wake and propeller wash. (DPIWE 2008). Shores with high nearby boating activity and low wave energy are at particular risk and include areas such as estuaries and sheltered bays.

Boating activity has been inferred from the presence of foreshore structures and local knowledge. An “impact zone” of 1 km has been used in this indicator as it is thought the impact of boating on habitat will be direct and most significant when a vessel is within 1 km of the foreshore.
Change in Saltmarsh Extent (Condition)

This indicator records observations of actual removal of saltmarsh habitat and considers the change in extent per year within 100 m of the MHWM. Not all foreshore habitats are suitable indicators of condition in the short-term due to the difficulty in assessing change over a single year. This indicator will not be relevant to all parts of the foreshore and as such, areas where saltmarsh has never been known to occur are not assigned a score.

It was beyond the scope of this study to gather information to support this indicator. For any successful assessment of condition, an initial wide-scale assessment of saltmarsh extent is needed to establish “baseline” information on the proportion of each segment that is of a particular habitat type. Once established, ongoing assessment is required to identify any change over time. Historic data on habitat extent could also be used.

Change in Seagrass Extent (Condition)

This indicator records observations of actual removal of seagrass habitat and considers the change in extent per year within 100 m of the MHWM. As with saltmarsh extent, this indicator will not be relevant to all parts of the foreshore and areas where seagrass habitat has never been known to occur are not assigned a score.

An initial wide-scale assessment of seagrass extent is needed to establish “baseline” information on the proportion of each segment that is of a particular habitat type. Once established, ongoing assessment is required to identify any change over time. Historic data on habitat extent could also be used.

It is important to note that this indicator is extremely species dependent i.e. some seagrass species show seasonal patchiness and change in extent, others are dense with no seasonality. It is important the natural variation of density/condition for each species is understood so that decline over time can be accurately assessed.
### Table 3.5 Criteria used to assign scores for indicators within the Habitat Removal stressor.

<table>
<thead>
<tr>
<th>STRESSOR</th>
<th>INDICATOR TYPE</th>
<th>INDICATOR NAME</th>
<th>PRESSURE</th>
<th>HABITAT REMOVAL</th>
<th>CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% foreshore segment modified</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Use of foreshore and immediate backshore by off-road vehicles</td>
<td>Very rarely used (inaccessible, prohibited, remote)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Beach grooming within foreshore segment</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Removal of wrack, rock or sand within foreshore segment</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Presence of foreshore weeds within segment (specified weeds only)</td>
<td>All foreshore weeds absent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Disturbance of tidal wetlands / saltmarsh (including drainage or filling)</td>
<td>No disturbance within or directly adjacent to foreshore segment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Occurrence of intertidal dredging and/or extraction (mining) activities in the foreshore segment</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Boating activity within 1 km of foreshore segment</td>
<td>Very limited, or none</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Change in saltmarsh extent within 100 m of MHWM within last year</td>
<td>Increase or no change</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
</tbody>
</table>

- **10% or greater decrease in saltmarsh extent or saltmarsh habitat no longer present (previously was)**
<table>
<thead>
<tr>
<th>STRESSOR</th>
<th>INDICATOR TYPE</th>
<th>INDICATOR NAME</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Habitat Removal</strong></td>
<td><strong>Condition</strong></td>
<td>Change in seagrass extent within 100 m of MHWM within last year</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increase or no change</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Minor declining trend (&lt;5% decrease per year)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moderate declining trend (5 to 40% decrease per year)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Major declining trend (&gt;40% decrease per year) OR no data in areas where seagrass is known or has been known to be present</td>
<td>5</td>
</tr>
<tr>
<td><strong>Vulnerability</strong></td>
<td>NONE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.3.5 Hydrodynamics

Scoring categories used to assign scores for indicators in the Hydrodynamics stressor are included in Table 3.6. Specific information on each pressure, condition and vulnerability indicator is included below with indicator type defined in brackets after each heading. See section 2.3.5 for a full description of this stressor.

Proportion of Segment Occupied by Foreshore Structures / Reclamation (Pressure)

Reclamation (land claim) and foreshore structures can alter the natural movement of water in the foreshore area. This indicator considers the proportion of each segment that is occupied by foreshore structures/reclamation, as well as structures in adjoining segments. Changes to hydrodynamics will be proportionate to the size of a structure and its relative dominance within a foreshore segment.

Foreshore structures may include jetties, slipways, marinas, boat ramps, moorings, breakwaters, boat sheds, pontoons, boardwalks and wharves. Aquaculture structures are not included as they are covered in the below indicator.

Presence of Inshore Aquaculture Structures (Pressure)

Inshore aquaculture structures such as racks, lines and pens associated with shellfish and finfish culture may alter the natural movement of water in the foreshore area. Aquaculture structures present within 100 m of the foreshore are considered in this study to have the greatest potential for altering hydrodynamics within a segment, while structures beyond 500 m from the foreshore are assumed to have no impact.

Presence of Rice Grass (Pressure)

Rice grass (*Spartina anglica*) inhabits the upper intertidal zone in a number of estuarine locations around Tasmania. Infestations can dramatically alter hydrodynamics, affecting the volume and movement of water in coastal areas (DPIWE 1998).

This indicator is based on simple presence/absence as it is assumed that wherever rice grass is present, it will be posing a potential pressure. A cautionary score of 3 has been assigned to areas near a known infestation where suitable habitat exists and the status of rice grass cannot be reliably identified.

Hydrodynamic Effects of Climate Change (Pressure)

The hydrodynamic effects of climate change in the intertidal environment include sea level rise, changing wave energy and storm surge events. Currently the only major area of coastline in the study region which has been assessed in terms of the hydrodynamic effects of climate change is Boullanger Bay in northwest Tasmania (R. Mount, pers. comm. June 2010). Given the significant consequences of not knowing the effects of climate change in the foreshore environment, areas that have not yet been assessed are assigned a precautionary score of 4.
The timescale of this indicator (i.e. “since last assessment”) is intended to identify any effects of climate change since the last assessment or sampling event. Any previous study can therefore be used as a "baseline" for monitoring provided the geographic coverage is sufficient over the study area, and consistent methods and timeframes are considered.

**Occurrence of Dredging (Pressure)**

Dredging can change the depth and contours of the seabed and thereby alter currents, tidal ranges and general water movement. Dredging is carried out in ports, marinas and shipping channels throughout the study area for maintenance purposes. General dredging activities in Tasmania are managed by several bodies including government, port authorities and other agencies and permits are not always required. Information on spoil dump and dredging volumes is therefore not readily available. Given the lack of available information, broad categories have been used to define dredging operations with values taken from the definitions of dredging programs outlined in the National Assessment Guidelines for Dredging (DSEWPC 2009). A precautionary approach has been adopted where dredging is likely to occur, but no records can be found, and a score of 4 (high pressure) has been applied.

**Shoreline Movement (Condition)**

Due to the difficulty in measuring direct changes in waves, currents and storm activity across the study area, shoreline movement is used as a surrogate for these factors. Shoreline movement is likely to be the result of changed hydrodynamics.

No scores could be assigned for this indicator due to limited or non-existent supporting studies. However, movement of the shoreline is an important indicator of condition with regard to hydrodynamics, and should be monitored where possible. Establishing shoreline movement will require comparison against a previous position. The timeframe of “since last assessment” means any previous study can be used as a "baseline" for monitoring (provided the geographic coverage is sufficient over the study area, and consistent methods and timeframes are considered). When further information becomes available to support this indicator, definitions of “moderate” and “significant” movement can be established based on the range of observed rates.

**Vulnerability to Shoreline Movement (Vulnerability)**

The vulnerability of the shoreline to movement through erosion will mediate the impact of a change in hydrodynamics. In the case of this indicator, there are only two possible outcomes with the shore considered either vulnerable to movement, or not. As a number of shore types may be present within a single 100 m shoreline segment, the proportion of each segment classified as vulnerable is considered. The classification assigned to the majority of the segment is applied.
Table 3.6 Criteria used to assign scores for indicators within the Hydrodynamics stressor.

<table>
<thead>
<tr>
<th>STRESSOR</th>
<th>INDICATOR TYPE</th>
<th>INDICATOR NAME</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>HYDRODYNAMICS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRESSURE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Proportion of foreshore segment occupied by foreshore structures / reclamation</td>
<td>Structures absent AND absent within directly adjoining segments</td>
<td>Structures absent but present in directly adjoining segment(s)</td>
</tr>
<tr>
<td></td>
<td>Presence of inshore aquaculture structures in adjacent seaward area</td>
<td>Aquaculture structures absent from within 500 m</td>
<td>Aquaculture structures present within 100 - 500 m</td>
</tr>
<tr>
<td></td>
<td>Presence of rice grass within foreshore segment</td>
<td>Rice grass absent</td>
<td>Unknown if rice grass is present</td>
</tr>
<tr>
<td></td>
<td>Hydrodynamic effects of climate change</td>
<td>None</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>Occurrence of dredging (within 1 km of foreshore segment)</td>
<td>No dredging activity within last year (assumed or known)</td>
<td>Occasional or one off dredging programs of &quot;very small&quot; scale (i.e. &lt;15,000 m³)</td>
</tr>
<tr>
<td>CONDITION</td>
<td>Shoreline movement (since last assessment)</td>
<td>None</td>
<td>Moderate</td>
</tr>
<tr>
<td>VULNERABILITY</td>
<td>Vulnerability to shoreline movement</td>
<td>Not vulnerable</td>
<td></td>
</tr>
</tbody>
</table>
3.3.6 Introduced Species

Scoring categories used to assign scores for indicators in the Introduced Species stressor are included in Table 3.8. Specific information on each pressure, condition and vulnerability indicator is included below with indicator type defined in brackets after each heading. See section 2.3.6 for a full description of this stressor.

The term “specified pest” is used in a number of indicators within this stressor. This relates to the selection of non-native species that have been identified as most relevant to the foreshore environment within the study area. These are the only introduced species considered where “specified pests” are referred to in this study and were selected on the basis of listing by the State and Federal Governments and other agencies. Specified pests and their relevant listings are included in Table 3.7.

Table 3.7 Specified pest species.

<table>
<thead>
<tr>
<th>SPECIES NAME</th>
<th>Recognised Marine Pest (DPIPWE)</th>
<th>Marine Pests (SoE Unit 2009*)</th>
<th>Trigger List (CCIMPE**)</th>
<th>Significant Weeds (DPIPWE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcinus maenas (green crab)</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Spartina anglica (rice grass)</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crassostrea gigas (Pacific oyster)</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undaria pinnatifida (Japanese kelp)</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Musculista senhousia (Asian bag mussel)</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Ammophila arenaria (marram grass)</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Arctotheca populifolia (beach daisy)</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Euphorbia paralias (sea spurge)</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Ehrharta villosa (pyp grass)</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Thinopyrum junceiforme (sea wheatgrass)</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

* Tasmanian Planning Commission (2009)
** Trigger List was generated by the Consultative Committee on Introduced Marine Pest Emergencies and comprises species that are likely to have significant impact if introduced.

Frequency of Boat Visits (Pressure)

Vessels are able to translocate and introduce non-native marine species to an area through fouling and discharges. A high frequency of boat visits through recreational or commercial activities increases the chance of new introductions. Frequency of boat visits can be inferred from the presence of boating infrastructure such as ports, harbours, marinas, slipways, moorings, jetties, wharves and boat ramps. Where more than one structure is present in a
foreshore segment, the score associated with the structure posing the highest pressure is assigned.

**Proximity of Specified Pest to Uninfested Segments (Pressure)**

This indicator is designed to assess the proximity of a known pest infestation to uninfested areas, and hence report on the pressure posed by the natural range expansion of existing populations into previously unaffected suitable habitats.

Due to the variations in natural dispersal rates of the specified pests, a conservative proximity of between 5 and 10 km has been used to highlight segments that are at most risk from range expansion. This is based on estimated rates of spread. Although non-native species can be transported by other mechanisms such as boating or oceanic currents, it is difficult to assess the associated pressure on the system accurately without detailed modelling. A simple proximity measure is therefore used in this indicative assessment.

Where more than one pest species is in proximity to a suitable uninfested foreshore segment, the highest pressure score is assigned.

**Proximity to Aquaculture Operations (Pressure)**

Aquaculture operations within the study area focus mainly on the production of non-native species including the Pacific oyster (*Crassostrea gigas*), and Atlantic salmon (*Salmo salar*). Exotic oysters may become established in foreshore habitats when individuals escape or are accidentally released. Aquaculture operations of any kind may also translocate other non-native species from an infested area to a non-infested area as fouling on boats and other equipment.

Proximity measures of 500 m are used as the basis for assigning the highest pressure to a foreshore segment in this indicator as the area immediately surrounding aquaculture operations is considered most at risk. Segments more than 20 km away from operations are considered to be under no pressure.

**Occurrence of Any Specified Pest Species (Condition)**

Simple presence/absence is used as an indicator of condition as it is assumed that where a specified pest species (Table 3.7) is present, it will have some level of impact. Although it is possible other non-native species are impacting on condition, the small amount of information available on their distribution and abundance would not be beneficial in establishing foreshore condition using these assessment methods.

Ten species are considered in this indicator, each with different habitat requirements. The poorest condition score has been assigned to foreshore segments where one or more of these species is present. The number of species present in a segment cannot be used to assess different levels of condition, as this is a function of habitat type and may not reflect true condition. For example, a segment may be suitable habitat for only one specified pest, but that species could have a significant impact.
Estimated Level of Disturbance within Foreshore Segment (Vulnerability)

The level of disturbance is derived from averaging the estimated segment condition as calculated for all other stressors. In the absence of sufficient condition data, the overall risk score can reflect the estimated condition of each segment. Risk scores for all other stressors are considered as any disturbance, be it sediment or nutrient increase or habitat removal, can potentially destabilise a system and lead to a change in species distribution, abundance and community composition. This shift from natural state can provide opportunity for the establishment of non-native species.
Table 3.8 Criteria used to assign scores for indicators within the Introduced Species stressor.

<table>
<thead>
<tr>
<th>STRESSOR</th>
<th>INDICATOR TYPE</th>
<th>INDICATOR NAME</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCED SPECIES</td>
<td>PRESSURE</td>
<td>Frequency of boat visits</td>
<td>SCORE</td>
</tr>
<tr>
<td></td>
<td>Boats almost never visit the foreshore segment (no boating infrastructure present within 5 km)</td>
<td>Segment is within 1 to 5 km of boating infrastructure</td>
<td>Segment is within 1 km of boating infrastructure OR within 1 to 5 km of a marina or high use commercial slipway OR within 1 to 5 km of a port or shipping facility</td>
</tr>
<tr>
<td></td>
<td>Proximity of specified pest to uninfested foreshore segments</td>
<td>No pest species present within segment, or within 10 km.</td>
<td>Pest present within 5 to 10 km of a segment where suitable habitat exists and the species is otherwise absent</td>
</tr>
<tr>
<td></td>
<td>Proximity to aquaculture operations</td>
<td>Aquaculture operations absent within 20 km of foreshore segment</td>
<td>Aquaculture operations present within 5 - 20 km of foreshore segment</td>
</tr>
<tr>
<td>CONDITION</td>
<td>Occurrence of any specified pest species within foreshore segment</td>
<td>No specified species known to be present</td>
<td>One or more specified species present</td>
</tr>
<tr>
<td>VULNERABILITY</td>
<td>Estimated level of disturbance within foreshore segment</td>
<td>Average range 1.0 to 1.8</td>
<td>Average range 1.9 to 2.6</td>
</tr>
</tbody>
</table>
3.3.7 Litter

Scoring categories used to assign scores for indicators in the Litter stressor are included in Table 3.9. Specific information on each pressure and condition indicator is included below with indicator type defined in brackets after each heading. No vulnerability indicator is listed for litter. See section 2.3.7 for a full description of this stressor.

**Boat Moorings (Pressure)**

There is an increased likelihood of litter being released from vessels where they are moored for long periods and/or in high densities. The volume of boating traffic and length of stay has been estimated from the presence of boating infrastructure such as moorings, anchorages, marinas and ports. The presence of such structures within 1 km of the foreshore is assumed to be a risk with regard to litter.

**Adjacent Population Density (Pressure)**

The presence of coastal populations is likely to be indicative of the amount of litter reaching the foreshore from terrestrial sources. Where the adjacent population is relatively dense, it is assumed the amount of litter generated will be greater than in a more sparsely populated area.

**Recreation and Tourist Use (Pressure)**

Recreation and tourist activities can result in the littering of foreshore areas. In order to score this indicator, an index was developed that considers recreational and tourist activities likely to result in litter reaching the intertidal zone. Tourist accommodation, tour operations and hire activities and the frequency and type of recreation use are included.

Popular recreation activities in the Tasmanian coastal environment that may be associated with littering include fishing, dog exercise, off-road driving and camping, picnics and barbeques and other general shore activities.

The index used to generate scores for this indicator is described in the tables below (Recreation and Tourist Use Scoring, Frequency and Recreation Use Calculation). For each segment a score is assigned for each recreational or tourist use. All scores are then summed and based on the ranges identified in the recreation indicator in Table 3.9, an indicator score is assigned.

**Recreation and Tourist Use Scoring Table**

<table>
<thead>
<tr>
<th>USE</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3</td>
</tr>
<tr>
<td>Tourist accommodation and use within 100 m of foreshore segment</td>
<td>None present</td>
</tr>
<tr>
<td>Tour operators / hire activities and use within 100 m of foreshore segment</td>
<td>None present</td>
</tr>
<tr>
<td>Frequency of recreation use**</td>
<td>None Low Moderate High Very high</td>
</tr>
</tbody>
</table>
The frequency of recreation use and associated pressure with regard to litter is calculated in a separate table (Frequency of Recreation Use Calculation) and weights different uses based on their association with litter generation. For example, picnic/BBQ, fishing and camping activities are likely to generate more litter than walking. For each segment, a score is assigned based on the frequency of occurrence of each recreational activity.

**Frequency of Recreation Use Calculation Table**

<table>
<thead>
<tr>
<th>RECREATIONAL USE</th>
<th>FREQUENCY OF USE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NONE</td>
</tr>
<tr>
<td>Swimming</td>
<td>1</td>
</tr>
<tr>
<td>Walking</td>
<td>1</td>
</tr>
<tr>
<td>Surfing</td>
<td>1</td>
</tr>
<tr>
<td>Picnic/BBQ</td>
<td>1</td>
</tr>
<tr>
<td>Kayaking/canoeing</td>
<td>1</td>
</tr>
<tr>
<td>Horse riding</td>
<td>1</td>
</tr>
<tr>
<td>Fishing</td>
<td>1</td>
</tr>
<tr>
<td>Dog exercise</td>
<td>1</td>
</tr>
<tr>
<td>Off-road vehicles</td>
<td>1</td>
</tr>
<tr>
<td>Camping</td>
<td>1</td>
</tr>
</tbody>
</table>

The total of all the scores for each segment is then calculated and based on the following ranges (which have been derived from the distribution of scores) an overall category is assigned that represents the frequency of recreation use:

<table>
<thead>
<tr>
<th>Frequency of recreation use category</th>
<th>Total of frequency of use scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>10</td>
</tr>
<tr>
<td>Low</td>
<td>11</td>
</tr>
<tr>
<td>Moderate</td>
<td>12 to 14</td>
</tr>
<tr>
<td>High</td>
<td>15 to 19</td>
</tr>
<tr>
<td>Very high</td>
<td>20 +</td>
</tr>
</tbody>
</table>

**Proximity to Stormwater Outflow (Pressure)**

Stormwater comprises all forms of runoff from urban and suburban areas and can contribute significant amounts of litter to coastal waterways. It includes water discharged through pipelines and established infrastructure as well as runoff entering the foreshore area through rivulets and other natural watercourses. This indicator considers stormwater outflow in permanently populated areas only as this is likely to have a greater impact with regard to terrestrial-derived litter than unpopulated, remote locations.

In built-up areas where data on stormwater infrastructure is not available, a conservative score of 4 is applied to foreshore segments within the 1 km area around any point where an outflow is suspected.

**Presence of Litter (Condition)**

Studies conducted by the Tasmanian Parks and Wildlife Service indicate there are 300 pieces of rubbish, mostly plastic, per one kilometre of Tasmanian coastline (Pryor 1998). Despite this estimate, very little quantitative information regarding litter is available within the study area. General categories have therefore been used in this indicator to provide a broad indication of the presence of litter within foreshore segments.
### Table 3.9 Criteria used to assign scores for indicators within the Litter stressor.

<table>
<thead>
<tr>
<th>STRESSOR</th>
<th>INDICATOR TYPE</th>
<th>INDICATOR NAME</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>LITTER</td>
<td>PRESSURE</td>
<td>Boat moorings within 1 km of foreshore segment</td>
<td>No mooring or anchorage sites/facilities of any kind identified</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Population density adjacent to foreshore segment</td>
<td>No coastal population present</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recreation and tourist use index score</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proximity to stormwater outflow</td>
<td>Outflows absent from within 1 km of foreshore segment</td>
</tr>
<tr>
<td>CONDITION</td>
<td>Presence of litter within foreshore segment within last year</td>
<td>Very little or no litter present</td>
<td>Litter sometimes present</td>
</tr>
<tr>
<td>VULNERABILITY</td>
<td>NONE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ShoreBase: A Coastal Management Tool
3.3.8 Nutrients

Scoring categories used to assign scores for indicators in the Nutrients stressor are included in Table 3.10. Specific information on each pressure, condition and vulnerability indicator is included below with indicator type defined in brackets after each heading. See section 2.3.8 for a full description of this stressor.

Agriculture within Immediate Backshore Area (Pressure)

Elevated nutrient loads have been documented during and after rainfall events in parts of the study area, and are most pronounced in agricultural areas where riparian vegetation has been damaged or lost and stock has direct access to waterways (Koehnken 2001). Increased nutrients can result in eutrophication of coastal waters, with associated problems such as algal blooms and oxygen depletion (OzCoasts 2010g).

The percentage of backshore area used for agriculture functions as a proxy for the potential pressure placed on the system from this activity.

Proximity to Finfish Aquaculture Operations (Pressure)

This indicator focuses on aquaculture operations involving finfish only. Although the farming of shellfish is widespread in the study region, it is considered to cause less environmental damage with regard to nutrient enrichment and can actually result in a net removal of nutrients from the water column (National Oceans Office 2001). In contrast, finfish farming results in the release of a number of wastes into the coastal system which can lead to nutrient enrichment of the water column and accumulation of organic matter in the sediments. Impacts of nutrient enrichment include phytoplankton blooms, epiphytic algal growth and altered sediment chemistry which can alter species composition, increase mortalities and result in smothering and contamination (National Oceans Office 2001). Shore-based operations can also result in nutrient output through other discharge, waste products and runoff and have therefore been included in this indicator.

Occurrence of Sewage Treatment Plant Overflow Events (Pressure)

Effluent from sewage treatment plants containing high nutrient loads can have potentially harmful impacts in the coastal environment (DPIWE, Emission Limit Guidelines for STPs 2001). In Tasmania, there are problems with cross connections between sewage and stormwater systems with stormwater infrastructure completely absent in some parts of the state. Cross-connection leads to increased volumes of water in the sewage system and can cause plant malfunction, and consequently, overflow events (Green 2001).

Based on rates of overflow events published by the Tasmanian Government (i.e. over 200 per year, and 100 in two months alone), it could be assumed that all plants are having at least one overflow event per year. It is assumed that even one event within 500 m of a foreshore segment is going to have a notable impact.
Proximity to Wastewater Treatment Plant Discharge (Pressure)
Discharge from wastewater treatment plants can increase the level of nutrients in the receiving environment, and the resulting impact can vary significantly depending on the level of treatment. As such, both the treatment level and the proximity of the wastewater discharge point to the foreshore are considered in this indicator. Definitions of the three treatment levels included in the scoring categories (primary, secondary and tertiary) are listed under the indicator of the same name in the Bacteria and Pathogens stressor.

Proximity to Stormwater Outflow (Pressure)
Stormwater comprises all forms of runoff from urban and suburban areas and can contribute significant amounts of nutrients to coastal waterways. It includes water discharged through pipelines and established infrastructure as well as runoff entering the foreshore area through rivulets and other natural watercourses. Nutrients in stormwater can be sourced from fertilisers, detergents, eroding soils, decomposing lawn clippings and pet faeces (OzCoasts 2010h).

This indicator considers stormwater outflow in permanently populated areas only as this is likely to have a greater impact with regard to nutrient input than unpopulated, remote locations. In built-up areas where data on stormwater infrastructure are not available, a conservative score of 4 is applied to foreshore segments within the 1 km area around any point where an outflow is suspected.

Proximity to Nutrient Point Source Discharge (Pressure)
This indicator reports on nutrients from industrial sources that are discharged through a specific site such as a pipe or drain. This comprises output from animal-related production including dairy sheds or processing plants.

The proximity of foreshore segments to a nutrient point source is considered, with any segment within 500 m of a source considered to be subject to significant pressure.

Presence of Septic Tanks (Pressure)
Septic tanks are a potential source of increased nutrients to the coastal environment, particularly when poorly maintained. The use of septic tanks is widespread in the study area due to the remote nature of many coastal populations.

This indicator uses a conservative approach and assumes that where present, septic tanks are a potential source of pressure with regard to seepage and increased nutrients. Some systems will be of no concern, but a number will seep and in the absence of any further information, all are treated alike.

It is thought an estimated density of 4 septic tanks per Ha of adjacent backshore is enough to be of significant concern (i.e. receive a pressure score of 5) regarding increased nutrient levels. A score of 4 is applied in cases where residences are present but where no sewage infrastructure exists and it is unknown if septics are present. This includes areas where sewage infrastructure has recently been introduced as some dwellings may still use septic systems. A score of 2 is applied where only one septic is present, as potential pressure still
exists (albeit minor), and a score of 1 (i.e. no pressure) is applied where septic tanks are absent.

**Boat Moorings (Pressure)**
The likelihood of nutrient release through the dumping of wastewater from vessels is increased where they are moored for long periods and/or in high densities. In Tasmania there is no legislation for wastewater discharge from small recreational and commercial vessels (unless acting under the Navigation Act). A voluntary code of practice exists which describes best practice environmental management in relation to the disposal of raw sewage and other wastes from boats. However as the code is voluntary, it can be assumed that some waste will be discharged from vessels in coastal areas where boating activity occurs.

**Ammonia in Water (Condition)**
Ammonia is an important source of nitrogen, but can be directly toxic to biota (ANZECC 2000). The guidelines in this indicator refer to those listed in the Aquatic Ecosystems section of the ANZECC (2000) guidelines for Fresh and Marine Water Quality. According to the guidelines, the term "Trigger value" means the concentration (or load) of the key performance indicators measured for the ecosystem, below which there exists a low risk that adverse biological (ecological) effects will occur. They indicate a risk of impact if exceeded and should 'trigger' some action, either further ecosystem specific investigations or implementation of management/remedial actions. Within the guidelines, Table 3.4.1 lists non-metallic inorganics and associated trigger values for marine waters. Levels of protection for slightly to moderately disturbed ecosystems should be applied, and 95% or 99% protection levels for biota as recommended. ANZECC (2000) guidelines are referred to as they are a nationally accepted and developed standard and are most suitable in the absence of trigger levels specific to Tasmania. See section 3.4 Water Quality Guidelines for Toxicants within the ANZECC document for further detail on ammonia in water.

**Chlorophyll-a in Water (Condition)**
Chlorophyll a is a useful indicator of condition with regard to nutrients as elevated concentrations can reflect an increase in nutrient loads and indicate eutrophication (OzCoasts 2010i). The guidelines for this indicator refer to those listed in the Aquatic Ecosystems section of the ANZECC (2000) guidelines for Fresh and Marine Water Quality. Within the guidelines, Table 3.3.2 lists default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems. Trigger values are included which assess the risk of adverse effects due to nutrients, biodegradable organic matter and pH in estuarine and marine ecosystems. Levels for Chlorophyll-a are listed as 4 μg L^{-1} for estuaries, and 1 μg L^{-1} for marine waters.

ANZECC (2000) guidelines are referred to as they are a nationally accepted and developed standard and are most suitable in the absence of trigger levels specific to Tasmania. See section 3.3 Physical and Chemical Stressors within the guidelines for further detail on nutrients in water.
Total Nitrogen (TN) in Water (Condition)

Total nitrogen is the sum of organic and reduced nitrogen, ammonia and nitrate-nitrite. Although essential, elevated concentrations can lead to reduced levels of dissolved oxygen in water and impacts on coastal biota. Emissions from industry, sewage treatment plants and agriculture can lead to increased nitrogen levels (National Pollution Inventory 2010a).

The guidelines for this indicator refer to those listed in the Aquatic Ecosystems section of the ANZECC (2000) guidelines for Fresh and Marine Water Quality. Within the guidelines, Table 3.3.2 lists default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems. Trigger values are included which assess the risk of adverse effects due to nutrients, biodegradable organic matter and pH in estuarine and marine ecosystems. Levels for TN are listed as 300 $\mu$g NL$^{-1}$ for estuaries, and 120 $\mu$g NL$^{-1}$ for marine waters.

ANZECC (2000) guidelines are referred to as they are a nationally accepted and developed standard and are most suitable in the absence of trigger levels specific to Tasmania. See section 3.3 Physical and Chemical Stressors within the guidelines for further detail on nutrients in water.

Total Phosphorus (TP) in Water (Condition)

Total phosphorus is the sum of all phosphorus present in a waterway. High levels of phosphorus sourced from industry, agriculture or wastewater can lead to algal blooms and eutrophication (National Pollution Inventory 2010b).

The guidelines for this indicator refer to those listed in the Aquatic Ecosystems section of the ANZECC (2000) guidelines for Fresh and Marine Water Quality. Within the guidelines, Table 3.3.2 lists default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems. Trigger values are included which assess the risk of adverse effects due to nutrients, biodegradable organic matter and pH in estuarine and marine ecosystems. Levels for TP are listed as 30 $\mu$g PL$^{-1}$ for estuaries, and 25 $\mu$g PL$^{-1}$ for marine waters.

ANZECC (2000) guidelines are referred to as they are a nationally accepted and developed standard and are most suitable in the absence of trigger levels specific to Tasmania. See section 3.3 Physical and Chemical Stressors within the guidelines for further detail on nutrients in water.

Oxidised Nitrogen (NO$_x$) Level in Water (Condition)

The fraction of nitrogen in the water that is soluble (nitrate and nitrite) is called oxidised nitrogen (South Australian EPA 2010). The guidelines used to assess condition with regard to oxidised nitrogen in this indicator refer to those listed in the Aquatic Ecosystems section of the ANZECC (2000) guidelines for Fresh and Marine Water Quality. Within the guidelines, Table 3.3.2 lists default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems. Trigger values are included which assess the risk of adverse effects due to nutrients, biodegradable organic matter and pH in estuarine and marine ecosystems. Levels for NO$_x$ are listed as 15 $\mu$g NL$^{-1}$ for estuaries, and 5 $\mu$g NL$^{-1}$ for marine waters.
ANZECC (2000) guidelines are referred to as they are a nationally accepted and developed standard and are most suitable in the absence of trigger levels specific to Tasmania. See section 3.3 Physical and Chemical Stressors within the guidelines for further detail on nutrients in water.

**Filterable Reactive Phosphate (FRP) in Water (Condition)**

Filterable reactive phosphate is a measure of the amount of dissolved phosphorus present in a waterway (which is readily available for uptake by plants) (Scheltinga and Moss 2007). The guidelines in this indicator refer to those listed in the Aquatic Ecosystems section of the ANZECC (2000) guidelines for Fresh and Marine Water Quality. Within the guidelines, Table 3.3.2 lists default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems. Trigger values are included which assess the risk of adverse effects due to nutrients, biodegradable organic matter and pH in estuarine and marine ecosystems. Levels for FRP are listed as $5 \mu g PL^{-1}$ for estuaries, and $10 \mu g PL^{-1}$ for marine waters).

ANZECC guidelines are referred to as they are a nationally accepted and developed standard and are most suitable in the absence of trigger levels specific to Tasmania. See section 3.3 Physical and Chemical Stressors within the guidelines for further detail on nutrients in water.

**Dilution Rate (Vulnerability)**

This is a general indicator of dilution based on exposure and marine influence. "High", "moderate" and "poor" dilution rates have been used as relative descriptions due to the difficulty in defining exact rates. A relatively high dilution rate is that of an open coast with high tidal range and high rate of marine exchange. Relatively poor dilution rates would be characteristic of closed embayments or sheltered shores with low tidal range and restricted marine exchange.

It is important to include dilution rate as a vulnerability factor as an exposed shore with a high dilution rate subject to a high nutrient load is likely to be less impacted than a sheltered shore subject to the same load.
Table 3.10 Criteria used to assign scores for indicators within the Nutrients stressor.

<table>
<thead>
<tr>
<th>STRESSOR</th>
<th>INDICATOR TYPE</th>
<th>INDICATOR NAME</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% of immediate backshore area used for agriculture</td>
<td>% of immediate backshore area used for agriculture</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Proximity of foreshore segment to finfish aquaculture operations</td>
<td>Aquaculture operations absent from within 1 km</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Occurrence of STP overflow events and proximity to foreshore segment</td>
<td>No sewerage infrastructure present within 1 km to allow overflow events</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Proximity of foreshore segment to nutrient point source discharge</td>
<td>No point sources (or likely point sources) within 1 km</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Presence of septic tanks within the 1 Ha backshore area adjacent to foreshore segment</td>
<td>Septics absent</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Proximity of foreshore segment to stormwater outflow</td>
<td>Outflows (or likely outflow) absent from within 1 km</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Proximity of foreshore segment to WWTP discharge and treatment level</td>
<td>No discharge within 1 km</td>
<td>7</td>
</tr>
</tbody>
</table>

ShoreBase: A Coastal Management Tool
## ShoreBase: A Coastal Management Tool

<table>
<thead>
<tr>
<th>STRESSOR</th>
<th>INDICATOR TYPE</th>
<th>INDICATOR NAME</th>
<th>CONDITION</th>
<th>PRESSURE</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pressure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Boat moorings within 1 km of foreshore segment</td>
<td>No mooring or anchorage sites/facilities of any kind present</td>
<td>Mooring or anchorage sites present (no permanent mooring)</td>
<td>Domestic and/or international port facilities present</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ammonia in water</td>
<td>No sites within 5 km of foreshore segment exceeded guidelines within last year</td>
<td>One or more sites within 1 -5 km of foreshore segment exceeded guidelines within last year</td>
<td>One or more sites within 1 km of foreshore segment exceeded guidelines within last year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chlorophyll-a in water</td>
<td>No sites within 5 km of foreshore segment exceeded guidelines within last year</td>
<td>One or more sites within 1 -5 km of foreshore segment exceeded guidelines within last year</td>
<td>One or more sites within 1 km of foreshore segment exceeded guidelines within last year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total nitrogen in water</td>
<td>No sites within 5 km of foreshore segment exceeded guidelines within last year</td>
<td>One or more sites within 1 -5 km of foreshore segment exceeded guidelines within last year</td>
<td>One or more sites within 1 km of foreshore segment exceeded guidelines within last year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total phosphorus in water</td>
<td>No sites within 5 km of foreshore segment exceeded guidelines within last year</td>
<td>One or more sites within 1 -5 km of foreshore segment exceeded guidelines within last year</td>
<td>One or more sites within 1 km of foreshore segment exceeded guidelines within last year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oxidised nitrogen in water</td>
<td>No sites within 5 km of foreshore segment exceeded guidelines within last year</td>
<td>One or more sites within 1 -5 km of foreshore segment exceeded guidelines within last year</td>
<td>One or more sites within 1 km of foreshore segment exceeded guidelines within last year</td>
</tr>
<tr>
<td>STRESSOR</td>
<td>INDICATOR TYPE</td>
<td>INDICATOR NAME</td>
<td>SCORE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>----------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NUTRIENTS</td>
<td>CONDITION</td>
<td>Filterable Reactive Phosphate in water</td>
<td>1: No sites within 5 km of foreshore segment exceeded guidelines within last year</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2: One or more sites within 1 -5 km of foreshore segment exceeded guidelines within last year</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3: One or more sites within 1 km of foreshore segment exceeded guidelines within last year</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>VULNERABILITY</td>
<td>Dilution rate</td>
<td>4: Relatively high</td>
<td>5: Relatively poor</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2: Relatively moderate</td>
<td>3: Relatively poor</td>
<td></td>
</tr>
</tbody>
</table>

**SCORE**

1: No sites within 5 km of foreshore segment exceeded guidelines within last year
2: One or more sites within 1 -5 km of foreshore segment exceeded guidelines within last year
3: One or more sites within 1 km of foreshore segment exceeded guidelines within last year
4: Relatively high
5: Relatively poor
3.3.9 pH

Scoring categories used to assign scores for indicators in the pH stressor are included in Table 3.11. Specific information on each pressure, condition and vulnerability indicator is included below with indicator type defined in brackets after each heading. See section 2.3.9 for a full description of this stressor.

Presence of Acid Sulphate Soils and Level of Disturbance (Pressure)

The presence of acid sulphate soil (ASS) in itself does not necessarily present a threat to the coastal environment. However, the consideration of ASS presence in conjunction with likely disturbance and drainage points provides a suitable indicator of potential pressure from changes in pH. In order to assess this pressure, an index was developed which weighed the probability of occurrence of ASS (as calculated by the Tasmanian State Government) against disturbance factors such as agriculture or urban development, and the presence of drainage points including rivers, stormwater discharge and natural watercourses.

<table>
<thead>
<tr>
<th>Probability of occurrence of ASS within 1 km of foreshore segment</th>
<th>DISTURBANCE AND DRAINAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No disturbance</td>
</tr>
<tr>
<td>HIGH</td>
<td>3</td>
</tr>
<tr>
<td>LOW</td>
<td>2</td>
</tr>
<tr>
<td>EXTREMELY LOW</td>
<td>1</td>
</tr>
<tr>
<td>NONE</td>
<td>1</td>
</tr>
</tbody>
</table>

Minimum Sustained pH Values (Condition)

The pH values used to score this indicator relate to those measured in the foreshore area following an inflow event (e.g. rainfall). On the log scale of pH measurement, 7 is neutral, 0 is extremely acidic and 14 is extremely alkaline. The pH of marine waters is approximately 8.2, however drainage from ASS can range from just over 4 to as low as 2 which can have adverse impacts on biological processes and result in physical damage to foreshore biota (OzCoasts 2010j). Areas with a sustained pH of less than 4 are therefore considered to be in the poorest of condition with regard to minimum sustained pH.

Dilution Rate (Vulnerability)

This is a general indicator of dilution based on exposure and marine influence. "High", "moderate" and "poor" dilution rates have been used as relative descriptions due to the difficulty in defining exact rates. A relatively high dilution rate is that of an open coast with high tidal range and high rate of marine exchange. Relatively poor dilution rates would be characteristic of closed embayments or sheltered shores with low tidal range and restricted marine exchange.

It is important to include dilution rate as a vulnerability factor as an exposed shore with a high dilution rate subject to low pH levels is likely to be less impacted than a sheltered shore subject to the same levels.
Table 3.11 Criteria used to assign scores for indicators within the pH stressor.

<table>
<thead>
<tr>
<th>STRESSOR</th>
<th>INDICATOR TYPE</th>
<th>INDICATOR NAME</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>PRESSURE</td>
<td>Presence of acid sulphate soils and level of disturbance (INDEX)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>CONDITION</td>
<td>Minimum sustained pH values</td>
<td>&gt;7.0</td>
</tr>
<tr>
<td></td>
<td>VULNERABILITY</td>
<td>Dilution rate</td>
<td>Relatively high</td>
</tr>
</tbody>
</table>
3.3.10 Toxicants
Scoring categories used to assign scores for indicators in the Toxicants stressor are included in Table 3.12. Specific information on each pressure, condition and vulnerability indicator is included below with indicator type defined in brackets after each heading. See section 2.3.10 for a full description of this stressor.

Boating Maintenance (Pressure)
The maintenance of vessels can result in the release of toxic substances to the coastal environment, particularly through paint and antifouling materials that may be washed off during slipping. Commercial slipways have been used to identify areas subject to pressure from boating maintenance with regard to the release of toxicants. It is assumed commercial slipways are used regularly for maintenance, repair and construction and would therefore be associated with greater releases of toxicants compared to private slipways whose primary function is to move small privately owned boats in and out of the water.

A distance buffer ranging from 500 m to 1 km has been used around each commercial slipway as toxicants are likely to be transported along the coast through water movement. Foreshore segments in closest proximity to the source are likely to be most affected.

Boating Activity (Pressure)
This indicator relates to emissions resulting from boating activity and the toxicants associated with running a vessel such as fuel, oil, antifoulant and other chemicals. The frequency of boat visits to a particular area is considered as increased boating activity increases the potential for the release of toxicants.

Boating activity has been inferred from the presence of foreshore structures and local knowledge. An “impact zone” of 1 km has been used as it is thought the potential affect of toxicants is going to be most significant when a vessel is within 1 km of the foreshore.

Proximity to Toxicant Point Source Discharge (Pressure)
This indicator reports on toxicants from industrial sources that are discharged through a specific site such as a pipe or drain. This may include output from mines, chemical plants, timber production and manufacturing.

The proximity of foreshore segments to a toxicant point source is considered, with any segment within 500 m of a source considered to be subject to significant pressure.

Proximity to Wastewater Treatment Plant Discharge (Pressure)
Common toxicants disposed of through sewage systems can be released to the coastal environment through wastewater treatment plant discharge. The resulting impact can vary significantly depending on the level of treatment. As such, both the treatment level and the proximity of the wastewater discharge point to the foreshore are considered in this indicator. Definitions of the three treatment levels included in the scoring categories (primary, secondary and tertiary) are listed under the indicator of the same name in the Bacteria and Pathogens stressor.
Proximity to Stormwater Outflow (Pressure)
Stormwater comprises all forms of runoff from urban and suburban areas and can contribute significant amounts of toxicants to coastal waterways. It includes water discharged through pipelines and established infrastructure as well as runoff entering the foreshore area through rivulets and other natural watercourses. This indicator considers stormwater outflow in permanently populated areas only as this is likely to have a greater impact with regard to toxicants than unpopulated, remote locations.

In built-up areas where data on stormwater infrastructure are not available, a conservative score of 4 is applied to foreshore segments within the 1 km area around any point where an outflow is suspected.

Proximity to Aquaculture Operations (Pressure)
Toxicants can be released into the marine environment as the result of a variety of activities in both finfish and shellfish aquaculture operations. These include antifouling, disinfection, management of stock health and water quality, and through equipment emissions. Shore-based operations can also result in toxicant output through other discharge, waste products and runoff and have therefore been included in this indicator.

The potential pressure posed by aquaculture activities with regard to toxicant release is considered greatest in the foreshore segments within 500 m of operations.

Proximity to Extraction Activities (Pressure)
This indicator relates primarily to current mining activities in the study area. Mining and associated extraction and processing activities can result in the release of heavy metals and toxic chemicals into the coastal system.

A general scale of proximity has been used to assign scores for this indicator. Foreshore segments more than 5 km away from extraction activities are not considered to be at any risk from operations, and segments within 1 km are considered to be subject to most pressure.

Occurrence of Dredging of Contaminated Sediment (Pressure)
Within the study area, information on dredging activity and the constituents of dredged material was difficult to obtain. As such, “suspected” contaminated sediment has been included in this indicator.

The lowest pressure score (i.e. 1) is only applied to foreshore segments where dredging activity is known to be absent within a 5 km radius. The highest pressure score (i.e. 5) is assigned where contaminated sediment, or suspected contaminated sediment is being dredged within 1 km of the foreshore. A classification of “no data” has been assigned to segments that are within 1 to 5 km of suspected dredging activity to highlight areas where further investigation is required.
Aqu наличествуют широко в сельском хозяйстве для контроля растительных и животных вредителей и поддержания здоровья скота. Пестициды и гербициды, используемые в сельскохозяйственном производстве, могут быть транспортированы с водой и попадать в прибрежные среды, где они накапливаются в осадках и могут влиять на биоту (Аussome State of the Environment Committee 2001). Как значительные части исследуемой территории используются для сельского хозяйства, этот индикатор важен для идентификации областей, которые могут быть под угрозой.

Процент использования береговой зоны для сельского хозяйства может служить показателем потенциальной нагрузки, с которой система сталкивается в результате этой активности.

**Токсиканты в биоте (условие)**

Для учета большого количества токсикантов, которые могли бы быть рассмотрены в этом стрессоре, создан общий условный индикатор, который может включать в себя любые потенциальные токсиканты, измеренные в фошорной биоте в пределах исследуемой территории. Этот индикатор предельно вершиль, что позволяет целенаправленно отслеживать специфические токсиканты, связанные с определенными видами деятельности, такими как сельское хозяйство или добыча месторождений, например. При рассмотрении видов, которые могут быть лучшими индикаторами для уровня токсикантов, склонные к седиментации виды, такие как устрицы или моллюски, будут наиболее подходящими. Мотильные виды не обязательно являются индикаторами состояния, так как контакт с токсикантами мог произойти в других местах. Присутствие токсикантов в биоте — человека вопрос здоровья. Поэтому руководящие принципы должны быть учтены в соответствии с нормами Форум по стандартам Пищи и Здоровья Австралии и Новой Зеландии (FSANZ), см. Стандарт 1.4.1 Contaminants and Natural Toxins, устанавливающий максимальные уровни специфических металлических и неметаллических токсикантов и природных токсикантов в номинированных продуктах, включая раковинных, рыб, моллюсков и водорослей.

**Токсиканты в осадках (условие)**

Некоторые заливы в Тасмании сильно загрязнены и превышают национальные стандарты по токсикантам на несколько порядков. Основной источник загрязнения — это добыча и/или промышленные производственные процесса в бассейн водах (Tasmanian Indicator Compendium Working Group 2006).

Для учета большого количества токсикантов, которые могли бы быть рассмотрены в этом стрессоре, создан общий условный индикатор, который может включать в себя любые потенциальные токсиканты, измеренные в осадках. Этот индикатор предельно вершиль, что позволяет целенаправленно отслеживать специфические токсиканты, связанные с определенными видами деятельности, такими как сельское хозяйство или добыча месторождений, например.

Предлагаемые в этом индикаторе руководства относятся к темам в разделе Aquatic Ecosystems стандартам по водным экосистемам ANZECC (2000) для свежих и морских вод. Согласно этим стандартам, термин "Trigger value" означает концентрацию (или нагрузку) ключевых показателей состояния экосистемы, ниже которой существует низкий риск неблагоприятных биологических (экологических) последствий. Это указывает на необходимость принятия мер, включая дополнительные экосистемно-специфические исследования или реализацию управленческих/ремонтировальных мероприятий. В этих стандартах, таблица 3.5.1 содержит рекомендуемые значения для осадков по металлу, металлоиду, органометаллу и органикам. Примените значения, указанные в разделе ISQC-Low как значения спуска. ANZECC руководства при необходимости отсылаются к ним, как они являются основанием...
nationally accepted and developed standard and are most suitable in the absence of trigger levels specific to Tasmania. See section 3.5 Sediment Quality Guidelines within the ANZECC document for further detail on toxicants in sediment.

**Toxicants in Water Column (Condition)**

Due to the very large numbers of toxicants that could be considered in this stressor, a general condition indicator has been created that can include any potential toxicant measured in coastal waters. This indicator is deliberately broad so that monitoring can be targeted to detect specific toxicants associated with selected activities such as agriculture or mining for example.

The guidelines in this indicator refer to those listed in the Aquatic Ecosystems section of the ANZECC (2000) guidelines for Fresh and Marine Water Quality. Within the guidelines, Table 3.4.1 lists toxicants and associated trigger values for marine waters. Levels of protection for slightly to moderately disturbed ecosystems should be applied, and 95% or 99% protection levels for biota as recommended. ANZECC guidelines are referred to as they are a nationally accepted and developed standard and are most suitable in the absence of trigger levels specific to Tasmania. See section 3.4 Water Quality Guidelines for Toxicants within the ANZECC document for further detail on toxicants in water.

**Dilution Rate (Vulnerability)**

This is a general indicator of dilution based on exposure and marine influence. "High", "moderate" and "poor" dilution rates have been used as relative descriptions due to the difficulty in defining exact rates. A relatively high dilution is that of an open coast with high tidal range and high rate of marine exchange. Relatively poor dilution rates would be characteristic of closed embayments or sheltered shores with low tidal range and restricted marine exchange.

It is important to include dilution rate as a vulnerability factor as an exposed shore with a high dilution rate subject to increased toxicant loads is likely to be less impacted than a sheltered shore subject to the same load.
### Table 3.12 Criteria used to assign scores for indicators within the Toxicant stressor.

<table>
<thead>
<tr>
<th>STRESSOR</th>
<th>INDICATOR TYPE</th>
<th>INDICATOR NAME</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boating maintenance and proximity to foreshore segment</td>
<td>No commercial slipways present within 1 km</td>
<td>Commerical slipway present within 500 m to 1 km</td>
<td>Commercial slipway present within 500 m</td>
</tr>
<tr>
<td>Boating activity within 1 km of foreshore segment</td>
<td>Very limited, or none</td>
<td>Recreational vessel activity only</td>
<td>Commercial and recreational vessel activity</td>
</tr>
<tr>
<td>Proximity of foreshore segment to toxicant point source discharge</td>
<td>No point sources (or likely point sources) within 1 km</td>
<td>One point source within 500 m to 1 km</td>
<td>&gt;1 point source within 500 m to 1 km OR Unknown within 1 km of area where point source is likely</td>
</tr>
<tr>
<td>Proximity of foreshore segment to stormwater outflow</td>
<td>Outflows (or likely outflow) absent from within 1 km</td>
<td>Outflow present within 500 m - 1 km</td>
<td>No data within 1 km of area where outflow is likely</td>
</tr>
<tr>
<td>% of immediate backshore area used for agriculture</td>
<td>0%</td>
<td>&gt;0 to 25%</td>
<td>&gt;25 to 50%</td>
</tr>
<tr>
<td>Proximity of foreshore segment to finfish and shellfish aquaculture operations</td>
<td>Aquaculture operations absent from within 1 km</td>
<td>Aquaculture operations present within 500 m to 1 km</td>
<td>Aquaculture operations present within 500 m</td>
</tr>
<tr>
<td>Proximity of foreshore segment to extraction activities</td>
<td>No extraction activities within 5 km</td>
<td>Extraction activities within 1 to 5 km</td>
<td>Extraction activities within 1 to 5 km</td>
</tr>
<tr>
<td>Proximity of foreshore segment to WWTP discharge and treatment level</td>
<td>No WWTP discharge within 1 km</td>
<td>Tertiary Level discharge within 500 m to 1 km</td>
<td>Tertiary Level discharge within 500 m OR Secondary Level discharge within 500 m to 1 km</td>
</tr>
</tbody>
</table>
## ShoreBase: A Coastal Management Tool

### Table: Indicator Scores

<table>
<thead>
<tr>
<th>STRESSOR</th>
<th>INDICATOR TYPE</th>
<th>INDICATOR NAME</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PRESSURE</td>
<td>Occurrence of dredging of contaminated sediment and proximity to foreshore segment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No dredging activity within 5 km</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dredging of any volume of known or suspected contaminated sediment within 1 to 5 km</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dredging of any volume of known or suspected contaminated sediment within 1 km</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>TOXICANTS</td>
<td>Toxicants in biota within foreshore segment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No samples taken from biota within last year exceeded guidelines</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 sample taken from biota within the last year exceeded guidelines</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;1 sample taken from biota within the last year exceeded guidelines</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>CONDITION</td>
<td>Toxicants in sediment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No sites within 5 km of foreshore segment exceeded guidelines within last year</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>One or more sites within 1 to 5 km of foreshore segment exceeded guidelines within last year</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>One or more sites within 1 km of foreshore segment exceeded guidelines within last year</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>VULNERABILITY</td>
<td>Dilution rate</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively high</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively moderate</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively poor</td>
<td>3</td>
</tr>
</tbody>
</table>

---

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3.3.11 Natural Values

The aim of these indicators is to highlight areas of natural value. They are not designed to identify areas which have little or no natural value. As such, foreshore segments with no listed values in relation to the prescribed indicators are not assigned a score. For indicators where low value scores (4 and 5) are assigned, areas have been specifically assessed as having little value. For example a geovalue score of 4 is given to artificial shores, which have no natural value.

Scoring categories used to assign scores for indicators of Natural Value are included in Table 3.13. Specific information on each value indicator is included below. The sub-category under which the indicator falls is defined in brackets after each indicator heading.

Habitat of Listed or Significant Species (Ecology)

This indicator includes foreshores that are considered habitat for listed or otherwise significant species based on reliable records of presence. Listed species are those classed as rare, threatened or endangered through government legislation and international conventions.

A number of significant invertebrate species are found in shallow coastal habitats in Tasmania such as the seastars *Parvulastra vivipara* (previously known as *Patiriella vivipara*), *Smilasterias tasmaniae* and *Marginaster littorialis*, however these are restricted to the south-east of the state. As such, this indicator includes only shorebird and seabird species that utilise the foreshore for foraging and nesting habitat. No other listed intertidal species have been identified.

Presence of Significant Communities or Habitats (Ecology)

This indicator is designed to identify foreshores of significant ecological value based on habitat or communities present. Sites are selected specifically for their ecological value regardless of adjacent land use.

Species richness, endemic species, species with biogeographical significance, representative communities (e.g. Ramsar wetlands), rare habitat (e.g. saltmarsh), and areas listed as having a very high conservation value in existing studies are considered here.

Area Within or Directly Adjacent to a Protected Natural Area (Ecology)

Foreshores within or directly adjacent to protected natural areas are assumed to have a higher degree of naturalness compared to those adjacent to developed areas. This indicator aims to identify foreshores that are part of wider natural functioning systems, rather than focussing on individual ecological elements. High value protected areas are selected based on reservation status and the associated restrictions on activities.

Foreshores assigned the highest value score (i.e. a score of 1) under this indicator are those within or directly adjacent to a dedicated formal reserve equivalent to IUCN (International Union for Conservation of Nature) protected area management categories i, ii, iii, iv, or vi (see IUCN Guidelines for Applying Protected Area Management Categories (Dudley 2008) for
further detail). Formal reserves include National Parks, State Reserves, Game Reserves, Nature Reserves, Historic sites, Forest Reserves, Conservation areas, and areas with a Conservation Covenant. High value foreshores (i.e. those assigned a score of 2) are those within or directly adjacent to areas not listed under IUCN equivalents but included in other Informal Reserves, and State or Forestry Managed Land.

**Geomorphic Value (Geomorphology)**

Geomorphic value is derived from a calculation of geoconservation priority (Geovalue) and the sensitivity category applied to sites of geoconservation significance by the Tasmanian Geoconservation Database (TGD). Geovalue values (Sharples and Mowling 2006) are designed to highlight coastal segments which are most likely to warrant management attention regarding the maintenance of geoconservation value. A Geovalue of 1 indicates high geoconservation priority, with coastal segments having either the highest sensitivity to disturbance, and/or the most natural condition. A score of 4 indicates lowest geoconservation priority where coastal segments are of low sensitivity to disturbance, yet are significantly disturbed. This mainly refers to hard rock shores that have been extensively modified. Scores of 2 or 3 indicate moderate and moderate to low geoconservation priority respectively. See Sharples and Mowling (2006) for further information on calculation of Geovalue.
Table 3.13 Criteria used to assign scores for indicators of Natural Value.

<table>
<thead>
<tr>
<th>VALUE</th>
<th>SUB-CATEGORY</th>
<th>INDICATOR NAME</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECOLOGY</td>
<td>Habitat of listed or significant species</td>
<td>Actual habitat for listed or significant species</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Presence of any significant communities or habitats</td>
<td>Significant community or habitat present</td>
<td>Areas identified by CFEV as having medium integrated conservation values</td>
</tr>
<tr>
<td></td>
<td>Area within or directly adjacent to a protected natural area</td>
<td>Foreshores within or directly adjacent to a dedicated formal reserve that is an IUCN protected area equivalent OR otherwise listed National Park, Conservation area, Conservation Covenant or Nature Reserve</td>
<td>Foreshores within or directly adjacent to protected natural areas not listed under IUCN equivalents</td>
</tr>
<tr>
<td>GEOMORPHOLOGY</td>
<td>Geomorphic value</td>
<td>Geovalue of 1 AND TGD sensitivity category 1 to 5</td>
<td>Geovalue of 1 (TGD sensitivity category may be 6-10)</td>
</tr>
</tbody>
</table>
3.3.12 Human Use Values

As with Natural Values, the aim of these indicators is to highlight areas of known human use value. Areas with no recorded value are not considered to be of “no value”, but are simply assigned no score in the absence of a full and thorough investigation into foreshore uses.

Scoring categories used to assign scores for indicators of Human Use Value are included in Table 3.14. Specific information on each value indicator is included below.

Recreation and Tourist Use

This indicator score is derived from an index of recreational and tourist activities relevant to the foreshore, frequency of use, tourist accommodation, tour operations and hire activities. Popular recreation activities in the Tasmanian coastal environment include swimming, walking, surfing, picnics and barbeques, kayaking/canoeing, horse riding, fishing, dog exercise, off-road driving, camping and boating.

The index used to generate scores for this indicator is described in the below tables (Recreation and Tourist Use Scoring, Frequency and Recreation Use Calculation). For each segment a score is assigned for each recreational or tourist use. All scores are then summed and based on the ranges identified in the recreation indicator in Table 3.14, an indicator score is assigned.

Recreation and Tourist Use Scoring Table

<table>
<thead>
<tr>
<th>USE</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Tourist accommodation and use within 100 m of foreshore segment</td>
<td>High frequency use</td>
</tr>
<tr>
<td>Tour operators / hire activities and use within 100 m of foreshore segment</td>
<td>High frequency use</td>
</tr>
<tr>
<td>Frequency of recreation use**</td>
<td>Very high</td>
</tr>
</tbody>
</table>

The frequency of recreation use as a human use value is calculated in a separate table (Frequency of Recreation Use Calculation Table). All activities are considered equally valuable. For each segment, a score is assigned based on the frequency of occurrence of each recreational activity.
**Frequency of Recreation Use Calculation Table**

<table>
<thead>
<tr>
<th>RECREATIONAL USE</th>
<th>FREQUENCY OF USE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NONE</td>
</tr>
<tr>
<td>Swimming</td>
<td>4</td>
</tr>
<tr>
<td>Walking</td>
<td>4</td>
</tr>
<tr>
<td>Surfing</td>
<td>4</td>
</tr>
<tr>
<td>Picnic/BBQ</td>
<td>4</td>
</tr>
<tr>
<td>Kayaking/canoeing</td>
<td>4</td>
</tr>
<tr>
<td>Horse riding</td>
<td>4</td>
</tr>
<tr>
<td>Fishing</td>
<td>4</td>
</tr>
<tr>
<td>Dog exercise</td>
<td>4</td>
</tr>
<tr>
<td>Off-road vehicles</td>
<td>4</td>
</tr>
<tr>
<td>Camping</td>
<td>4</td>
</tr>
<tr>
<td>Boating</td>
<td>4</td>
</tr>
</tbody>
</table>

The total of all the scores for each segment is then calculated and based on the following ranges (which have been derived from the distribution of scores), an overall category is assigned that represents the frequency of recreation use:

<table>
<thead>
<tr>
<th>Frequency of recreation use category</th>
<th>Total of frequency of use scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High</td>
<td>27 to 33</td>
</tr>
<tr>
<td>High</td>
<td>34 to 38</td>
</tr>
<tr>
<td>Moderate</td>
<td>39 to 42</td>
</tr>
<tr>
<td>Low</td>
<td>43</td>
</tr>
<tr>
<td>None</td>
<td>44</td>
</tr>
</tbody>
</table>

**Commercial Use**
This indicator is best used to identify foreshore areas of high commercial use, including aquaculture operations, seafood processing plants (involving shoreline activities), sand mining, seaweed/wrack collection, ship building, working ports, water transport (e.g. ferry terminal) and commercial slipways.

**Amenity Use**
An amenity is a feature that improves the use of an area. In this study, amenities specific to the foreshore are considered to be marinas, boat ramps, moorings, jetties, slipways, boardwalks and wharves. They do not include areas used for commercial purposes (e.g. ports and commercial slips).

According to the definitions used in this study, large portions of the coastal foreshore will have no assigned amenity value. This indicator is therefore best used to identify areas of high amenity value based on frequency of use.

**Heritage Significance**
Sites included in this assessment are those listed on special zoning plans or by the Australian Heritage Database, Register of the National Estate, Parks and Wildlife Tasmania or any other management listing as having European heritage significance. This does not include sites listed as having geohertage, natural or indigenous significance since geohertage and natural heritage sites are included in a separate indicator, and all indigenous sites are excluded from the assessment at the request of the Aboriginal community.
Table 3.14 Criteria used to assign scores for indicators of Human Use Value.

<table>
<thead>
<tr>
<th>VALUE</th>
<th>SUB-CATEGORY</th>
<th>INDICATOR NAME</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Recreation and Tourism</td>
<td>Recreation and tourist use index</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Commercial</td>
<td>High frequency use of the foreshore segment for commercial purposes (i.e. used &gt; once per week)</td>
<td>3 to 10 (OR where any sub value = 1)</td>
</tr>
<tr>
<td></td>
<td>Commercial</td>
<td>Moderate frequency use of the foreshore segment for commercial purposes (i.e. used once weekly)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Commercial</td>
<td>Low frequency use of the foreshore segment for commercial purposes (i.e. used monthly or less)</td>
<td></td>
</tr>
<tr>
<td>Human Use</td>
<td>Amenity use</td>
<td>High frequency use of amenities present within foreshore segment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Amenity use</td>
<td>Moderate frequency use of amenities present within foreshore segment (raise score by 1 if more than one amenity use is present and 2 is the highest score)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heritage</td>
<td>European heritage significance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>European heritage significance</td>
<td>Listed site of European heritage significance</td>
<td></td>
</tr>
</tbody>
</table>
3.4 Assessment Results

Results of this assessment are indicative of the general state of coastal foreshores within the study area, potential risk factors that may trigger management action and the values present. It is important to note that the results presented in this report aim only to provide a general overview of the area. For further detail, including assessment results for individual 100 m foreshore segments, the complete dataset should be viewed using GIS software.

The output from this project is available in two formats – report cards and GIS maps and associated datasets. Simplified GIS maps showing overall risk, classifications for individual stressors, and natural and human use values are publicly available on the Land Information System Tasmania (LIST) website (http://www.thelist.tas.gov.au/). More detailed GIS files and report cards are available from the Tasmanian State Government NRM Data Library.

3.4.1 Stressor Risk

The percentage of foreshore segments assigned to each risk category for individual stressors is presented in Table 3.15. The pressure and vulnerability indicator scores that support the risk assessment (as described in section 3.3) are available in the final dataset and can be viewed and interrogated in a GIS.

The environmental stressors considered in this assessment are generally presenting little risk to coastlines in the study area with the majority of foreshore segments considered to be at negligible risk. A very small proportion of the study area is assessed as being at extreme risk from any one stressor, with less than 3% of segments assigned to this category for nine of the ten stressors.

The stressor presenting extreme risk to the greatest proportion of foreshore segments (16.58%) is pH which may reach damaging levels in the coastal environment as a result of disturbance to acid sulphate soils. Habitat removal presents a high risk to over 20% of foreshore segments, which can be partly attributed to the widespread distribution of beach weeds, and the use of off-road vehicles on many Tasmanian beaches. Approximately 13% of segments are at high risk from the removal and disturbance of biota, partly because of the easy accessibility of much of the shoreline. The same proportion is at high risk from altered hydrodynamics, which is largely due to the effects of climate change.

Table 3.15 Percentage of foreshore segments assigned to each risk category for each stressor.

<table>
<thead>
<tr>
<th>STRESSOR</th>
<th>Negligible</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Extreme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquatic Sediments</td>
<td>69.06</td>
<td>13.59</td>
<td>9.71</td>
<td>7.59</td>
<td>0.04</td>
</tr>
<tr>
<td>Bacteria / Pathogens</td>
<td>81.42</td>
<td>4.65</td>
<td>10.83</td>
<td>3.04</td>
<td>0.06</td>
</tr>
<tr>
<td>Biota Removal/Disturbance</td>
<td>32.53</td>
<td>24.22</td>
<td>29.29</td>
<td>13.24</td>
<td>0.72</td>
</tr>
<tr>
<td>Habitat Removal</td>
<td>52.77</td>
<td>10.45</td>
<td>15.95</td>
<td>20.71</td>
<td>0.12</td>
</tr>
<tr>
<td>Hydrodynamics</td>
<td>61.71</td>
<td>4.07</td>
<td>20.27</td>
<td>13.78</td>
<td>0.70</td>
</tr>
<tr>
<td>Introduced Species</td>
<td>51.69</td>
<td>35.15</td>
<td>7.26</td>
<td>3.13</td>
<td>2.78</td>
</tr>
<tr>
<td>Litter</td>
<td>55.19</td>
<td>20.81</td>
<td>14.04</td>
<td>8.52</td>
<td>1.43</td>
</tr>
<tr>
<td>Nutrients</td>
<td>77.89</td>
<td>7.71</td>
<td>10.05</td>
<td>4.33</td>
<td>0.01</td>
</tr>
<tr>
<td>pH</td>
<td>61.04</td>
<td>6.92</td>
<td>8.46</td>
<td>7.00</td>
<td>16.58</td>
</tr>
<tr>
<td>Toxicants</td>
<td>73.66</td>
<td>10.15</td>
<td>10.22</td>
<td>5.97</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Risk assessment results for individual stressors are presented spatially in Figure 3.4-1 to Figure 3.4-10. As expected, the foreshores in and around the major population centres of the study area such as those in the Tamar and Mersey Estuaries are generally at greater risk from all stressors compared to less populated coastlines. The remote southwest and offshore islands are largely at negligible risk.

Not all stressors are related to coastal population and the associated pressures. Altered hydrodynamics, the impact of which is mitigated by the vulnerability of the shoreline to movement, presents a high risk to the sparsely populated Macquarie Harbour and moderate risk to the east coasts of Flinders and King Islands. Changes in pH from the disturbance of acid sulphate soils present an extreme risk to foreshores in parts of the Tamar River, Mersey River, Port Sorell but also to small portions of the less populous Macquarie Harbour. Larger areas of Macquarie Harbour have additionally been assessed as being at high risk from this stressor.

The new introduction of non-native species to some remote coastlines is also a risk. It is important to note that the results from the introduced species risk assessment (Figure 3.4-6) show a large proportion of the coast is at negligible risk from introduced species. This risk level is related to new introductions through translocation and range expansion and does not reflect the pressure from the specified introduced species that are already present within a segment. Further examination of the individual indicators that comprise this stressor would provide a better understanding of the overall risk calculation. The condition assessment results for this stressor show the actual condition of the foreshore with regard to the presence of specified introduced species and should also be referred to for present distributions (Figure 3.4-14).
**Figure 3.4-2** Risk to foreshores from Bacteria / Pathogens.

**Figure 3.4-3** Risk to foreshores from Biota Removal / Disturbance.
Figure 3.4-4 Risk to foreshores from Habitat Removal.

Figure 3.4-5 Risk to foreshores from altered Hydrodynamics.
Figure 3.4-6 Risk to foreshores from Introduced Species.

Figure 3.4-7 Risk to foreshores from Litter.
Figure 3.4-8 Risk to foreshores from Nutrients

Figure 3.4-9 Risk to foreshores from pH.
3.4.2 Overall Risk

The overall risk assessment (calculated by averaging the risk scores for each stressor) reflects the combined risk from all stressors and rates the majority of foreshore segments as either A+, A or A- (59.1%). Only 17% of segments are rated at or below a C level (Figure 3.4-11), with less than 1% receiving the lowest rating of F. Overall risk to foreshores tends to be greatest (and hence assigned poorest ratings) in the more populated and developed parts of the study area (Figure 3.4-12).
3.4.3 Condition and Overall Health

In many cases, there are insufficient data available to adequately support an assessment of condition. Of the 20 condition indicators included in this assessment, data have only been assigned for three supporting the Bacteria and Pathogens, Introduced Species and Litter stressors. This is largely due to the lack of monitoring data being collected in the study area and the difficulty in obtaining current and consistent data across a broad geographic area.

Some information was available for condition indicators within the Bacteria and Pathogens and Litter stressors, however these were restricted to very small areas. The condition of much of the coastline is therefore still classified as “unknown” for these stressors (Figure 3.4-13 and Figure 3.4-15). Where only small amounts of data are available, the inclusion of any results may be misleading. For this reason, the “unknown” classification is very important to identify areas where monitoring is not occurring and current condition is unknown.

Sufficient data were available to support the single condition indicator within the Introduced Species stressor - Occurrence of specified pest species. The condition of foreshores with regard to introduced species is very poor across much the study area, with widespread distribution of specified pest species (Figure 3.4-14).

Despite the lack of condition data, the indicators and associated calculations have been retained within the framework as it is an important function of the assessment process and can help identify areas where collection of monitoring data would be most beneficial.

**Figure 3.4-12** Overall risk to foreshores.
Due to the lack of extensive condition data, the overall health score (calculated by averaging the condition scores for each stressor) will be misrepresentative and lack meaning in many cases. Overall health classifications can also be particularly misleading where the only condition information that is available returns poor results for the study area, as is the case for Introduced Species in this assessment. For these reasons, the overall health results are not presented in this report.

Figure 3.4-13 Condition of foreshores with regard to Bacteria / Pathogens.
Figure 3.4-14 Condition of foreshores with regard to Introduced Species.

Figure 3.4-15 Condition of foreshores with regard to Litter.
3.4.4 Overall Assessment

The overall assessment score, which is a combination of the overall health and overall risk scores, rates 48% of foreshore segments at an A level. However, nearly 49% of segments are rated at or below a C level, with 5% of segments receiving the lowest rating of F (Figure 3.4-16). These seemingly poor ratings are the result of poor overall health scores (as described in chapter 3.4.3) diminishing the overall assessment score. It is therefore important to note that due to the lack of sufficient condition information, the overall assessment scores calculated for each segment may be misleading. With this in mind, the results are presented spatially Figure 3.4-17.

![Overall Assessment Classifications](image)

**Figure 3.4-16** Percentage of foreshore segments within the study area assigned to each overall assessment category.

![Overall Assessment Classification](image)

**Figure 3.4-17** Overall assessment classification.
3.4.5 Report Cards

Report cards have been produced for each foreshore segment and present a summary of the output for the risk and health (condition) assessment. In the example of the risk and health report card presented in Table 3.16, the foreshore segment is part of a sandy shoreline in a moderately populated area. The segment number is identified at the top of the report (27.301), along with the overall assessment score of C+. The overall summary presents the overall risk and health rating of B- and C respectively, as well as the associated confidence and dependability scores. The inclusion of confidence and dependability scores in the final report card is a valuable feature. The confidence score provides users with an indication of the quality of the data used to support the assessment, whilst the dependability score reveals what proportion of indicators within a stressor have been addressed.

The stressor summary provides a break-down of the risk and condition scores for each stressor. This particular segment is at high risk from aquatic sediments, biota removal and disturbance and changes in pH. It is in very poor condition with regards to introduced species. There is moderate level of confidence in the data supporting this decision, and the 100% dependability score specifies that data were supplied for all condition indicators in this stressor. The segment is in excellent condition with regards to bacteria and pathogens, with 50% of condition indicators within this stressor addressed and a high confidence in the supporting data.

The report includes further detail for individual stressors, listing the scores for each pressure, vulnerability and condition indicator (where applied), as well as risk and confidence levels. Management indicators are built into the VPSIRR software and can be applied to vary the likelihood of a particular pressure changing stressor levels. Management indicators have not been included in this assessment as none were identified as suitable for the selected stressors within the study region. However the capacity to include these has still been retained and is available if required.

Table 3.16 Risk and health assessment.

<table>
<thead>
<tr>
<th>Overall Summary</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rating</td>
<td>Confidence</td>
</tr>
<tr>
<td>Risk</td>
<td>B-</td>
<td>moderate</td>
</tr>
<tr>
<td>Health</td>
<td>C</td>
<td>high</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stressor Summary</th>
<th>Stressor</th>
<th>Risk</th>
<th>Confidence</th>
<th>Condition</th>
<th>Dependability</th>
<th>Score</th>
<th>Confidence</th>
<th>Dependability</th>
<th>Dependability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aquatic Sediments</td>
<td>high</td>
<td>moderate</td>
<td>90%</td>
<td>unknown</td>
<td>unknown</td>
<td>0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bacteria / Pathogens</td>
<td>moderate</td>
<td>moderate</td>
<td>100%</td>
<td>excellent</td>
<td>high</td>
<td>50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Biota removal / Disturbance</td>
<td>high</td>
<td>high</td>
<td>70%</td>
<td>unknown</td>
<td>unknown</td>
<td>0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Habitat Removal</td>
<td>negligible</td>
<td>low</td>
<td>75%</td>
<td>unknown</td>
<td>unknown</td>
<td>0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hydrodynamics</td>
<td>negligible</td>
<td>high</td>
<td>83%</td>
<td>unknown</td>
<td>unknown</td>
<td>0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Introduced Species</td>
<td>moderate</td>
<td>moderate</td>
<td>75%</td>
<td>very poor</td>
<td>moderate</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Litter</td>
<td>negligible</td>
<td>moderate</td>
<td>100%</td>
<td>unknown</td>
<td>unknown</td>
<td>0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nutrients</td>
<td>negligible</td>
<td>moderate</td>
<td>100%</td>
<td>unknown</td>
<td>unknown</td>
<td>0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>pH</td>
<td>high</td>
<td>high</td>
<td>100%</td>
<td>unknown</td>
<td>unknown</td>
<td>0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Toxicants</td>
<td>moderate</td>
<td>moderate</td>
<td>90%</td>
<td>unknown</td>
<td>unknown</td>
<td>0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Aquatic Sediments

### Pressure indicator scores and risk calculations

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Pressure</th>
<th>Management</th>
<th>Vulnerability</th>
<th>Risk</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boating activity</td>
<td>1</td>
<td>*</td>
<td>5</td>
<td>1</td>
<td>low</td>
</tr>
<tr>
<td>Clearing in backshore</td>
<td>1</td>
<td>*</td>
<td>5</td>
<td>1</td>
<td>moderate</td>
</tr>
<tr>
<td>Proximity to sediment point source discharge</td>
<td>1</td>
<td>*</td>
<td>5</td>
<td>1</td>
<td>high</td>
</tr>
<tr>
<td>Density of unsealed roads in backshore</td>
<td>4</td>
<td>*</td>
<td>5</td>
<td>5</td>
<td>high</td>
</tr>
<tr>
<td>Intensive agriculture in backshore</td>
<td>1</td>
<td>*</td>
<td>5</td>
<td>1</td>
<td>high</td>
</tr>
<tr>
<td>Occurrence of dredging</td>
<td>*</td>
<td>*</td>
<td>5</td>
<td>*</td>
<td>unknown</td>
</tr>
<tr>
<td>Proximity to stream/river input and % of catchment cleared</td>
<td>3</td>
<td>*</td>
<td>5</td>
<td>4</td>
<td>high</td>
</tr>
<tr>
<td>Use of foreshore and backshore by off-road vehicles</td>
<td>1</td>
<td>*</td>
<td>5</td>
<td>1</td>
<td>low</td>
</tr>
<tr>
<td>Proximity to stormwater outflow</td>
<td>1</td>
<td>*</td>
<td>5</td>
<td>1</td>
<td>low</td>
</tr>
</tbody>
</table>

### Condition indicator scores

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Condition</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbidity</td>
<td>*</td>
<td>unknown</td>
</tr>
<tr>
<td>Change in seagrass extent</td>
<td>*</td>
<td>unknown</td>
</tr>
<tr>
<td>Change in particle size</td>
<td>*</td>
<td>unknown</td>
</tr>
</tbody>
</table>

## Bacteria / Pathogens

### Pressure indicator scores and risk calculations

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Pressure</th>
<th>Management</th>
<th>Vulnerability</th>
<th>Risk</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximity to stormwater outflow</td>
<td>1</td>
<td>*</td>
<td>5</td>
<td>1</td>
<td>low</td>
</tr>
<tr>
<td>Proximity to aquaculture operations</td>
<td>3</td>
<td>*</td>
<td>5</td>
<td>4</td>
<td>high</td>
</tr>
<tr>
<td>Boat moorings</td>
<td>1</td>
<td>*</td>
<td>5</td>
<td>1</td>
<td>low</td>
</tr>
<tr>
<td>Presence of septic tanks</td>
<td>1</td>
<td>*</td>
<td>5</td>
<td>1</td>
<td>low</td>
</tr>
<tr>
<td>Occurrence of STP overflow events</td>
<td>1</td>
<td>*</td>
<td>5</td>
<td>1</td>
<td>low</td>
</tr>
<tr>
<td>Proximity to bacteria/pathogen point source discharge</td>
<td>1</td>
<td>*</td>
<td>5</td>
<td>1</td>
<td>high</td>
</tr>
<tr>
<td>Proximity to WWTP discharge</td>
<td>1</td>
<td>*</td>
<td>5</td>
<td>1</td>
<td>high</td>
</tr>
</tbody>
</table>

### Condition indicator scores

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Condition</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occurrence / concentration of Enterococci</td>
<td></td>
<td>unknown</td>
</tr>
<tr>
<td>Occurrence / concentration of faecal coliforms</td>
<td>1</td>
<td>high</td>
</tr>
</tbody>
</table>
## Biota Removal / Disturbance

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Pressure</th>
<th>Management</th>
<th>Vulnerability</th>
<th>Risk</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recreation and tourist use</td>
<td>3</td>
<td></td>
<td></td>
<td>1</td>
<td>low</td>
</tr>
<tr>
<td>Boating activity</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td>low</td>
</tr>
<tr>
<td>Adjacent population density</td>
<td>2</td>
<td></td>
<td></td>
<td>2</td>
<td>very high</td>
</tr>
<tr>
<td>Access to shore</td>
<td>3</td>
<td></td>
<td></td>
<td>3</td>
<td>high</td>
</tr>
<tr>
<td>Access of stock to foreshore</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td>high</td>
</tr>
<tr>
<td>Occurrence of fires in backshore</td>
<td>5</td>
<td></td>
<td></td>
<td>5</td>
<td>moderate</td>
</tr>
<tr>
<td>Presence of shading foreshore structures</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td>high</td>
</tr>
<tr>
<td>Biota collection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>unknown</td>
</tr>
<tr>
<td>Development in backshore</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td>high</td>
</tr>
<tr>
<td>Occurrence of dredging</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>unknown</td>
</tr>
</tbody>
</table>

## Habitat Removal

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Pressure</th>
<th>Management</th>
<th>Vulnerability</th>
<th>Risk</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreshore modification</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td>high</td>
</tr>
<tr>
<td>Use of foreshore and backshore by off-road vehicles</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td>low</td>
</tr>
<tr>
<td>Beach grooming</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td>low</td>
</tr>
<tr>
<td>Boating activity</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td>low</td>
</tr>
<tr>
<td>Removal of wrack, rock or sand</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td>low</td>
</tr>
<tr>
<td>Presence of foreshore weeds</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td>high</td>
</tr>
<tr>
<td>Disturbance of tidal wetlands/saltmarsh</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td>unknown</td>
</tr>
<tr>
<td>Occurrence of dredging and/or extraction activities in the intertidal zone</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td>unknown</td>
</tr>
</tbody>
</table>

## Condition indicator scores

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Condition</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in seagrass extent</td>
<td>*</td>
<td>unknown</td>
</tr>
<tr>
<td>Change in saltmarsh extent</td>
<td>*</td>
<td>unknown</td>
</tr>
</tbody>
</table>

## Hydrodynamics

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Pressure</th>
<th>Management</th>
<th>Vulnerability</th>
<th>Risk</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of segment occupied by foreshore structures or reclamation</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td>high</td>
</tr>
</tbody>
</table>
### ShoreBase: A Coastal Management Tool

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Condition</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence of inshore aquaculture structures</td>
<td>1</td>
<td>*</td>
</tr>
<tr>
<td>Occurrence of dredging</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Hydrodynamic effects of climate change</td>
<td>4</td>
<td>*</td>
</tr>
<tr>
<td>Presence of rice grass</td>
<td>1</td>
<td>*</td>
</tr>
</tbody>
</table>

#### Condition indicator scores

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Condition</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoreline movement</td>
<td></td>
<td>unknown</td>
</tr>
</tbody>
</table>

#### Introduced Species

### Pressure indicator scores and risk calculations

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Pressure</th>
<th>Management</th>
<th>Vulnerability</th>
<th>Risk</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximity to aquaculture operations</td>
<td>4</td>
<td>*</td>
<td>2</td>
<td>3</td>
<td>moderate</td>
</tr>
<tr>
<td>Proximity of specified pest to uninfested segment</td>
<td>*</td>
<td>*</td>
<td>2</td>
<td>*</td>
<td>unknown</td>
</tr>
<tr>
<td>Frequency of boat visits</td>
<td>3</td>
<td>*</td>
<td>2</td>
<td>2</td>
<td>moderate</td>
</tr>
</tbody>
</table>

| Condition indicator scores
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Occurrence of specified listed pest species</td>
<td></td>
<td>moderate</td>
</tr>
</tbody>
</table>

#### Litter

### Pressure indicator scores and risk calculations

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Pressure</th>
<th>Management</th>
<th>Vulnerability</th>
<th>Risk</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boat moorings</td>
<td>1</td>
<td>*</td>
<td>*</td>
<td>1</td>
<td>low</td>
</tr>
<tr>
<td>Adjacent population density</td>
<td>2</td>
<td>*</td>
<td>*</td>
<td>2</td>
<td>very high</td>
</tr>
<tr>
<td>Recreation and tourist use</td>
<td>3</td>
<td>*</td>
<td>*</td>
<td>1</td>
<td>low</td>
</tr>
<tr>
<td>Proximity to stormwater outflow</td>
<td>1</td>
<td>*</td>
<td>*</td>
<td>1</td>
<td>low</td>
</tr>
</tbody>
</table>

| Condition indicator scores
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence of litter</td>
<td></td>
<td>unknown</td>
</tr>
</tbody>
</table>

#### Nutrients

### Pressure indicator scores and risk calculations

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Pressure</th>
<th>Management</th>
<th>Vulnerability</th>
<th>Risk</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensive agriculture in backshore</td>
<td>1</td>
<td>*</td>
<td>5</td>
<td>1</td>
<td>high</td>
</tr>
<tr>
<td>Proximity to aquaculture operations</td>
<td>1</td>
<td>*</td>
<td>5</td>
<td>1</td>
<td>high</td>
</tr>
<tr>
<td>Proximity to nutrient point source discharge</td>
<td>1</td>
<td>*</td>
<td>5</td>
<td>1</td>
<td>high</td>
</tr>
</tbody>
</table>
### ShoreBase: A Coastal Management Tool

**Condition indicator scores**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Condition</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia in water</td>
<td>*</td>
<td>unknown</td>
</tr>
<tr>
<td>Chlorophyll-a in water</td>
<td>*</td>
<td>unknown</td>
</tr>
<tr>
<td>Oxidised nitrogen level in water</td>
<td>*</td>
<td>unknown</td>
</tr>
<tr>
<td>Filterable Reactive Phosphate in water</td>
<td>*</td>
<td>unknown</td>
</tr>
<tr>
<td>Total nitrogen in water</td>
<td>*</td>
<td>unknown</td>
</tr>
<tr>
<td>Total phosphorus in water</td>
<td>*</td>
<td>unknown</td>
</tr>
</tbody>
</table>

**Pressure indicator scores and risk calculations**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Pressure</th>
<th>Management</th>
<th>Vulnerability</th>
<th>Risk</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence of ASS and level of disturbance</td>
<td>3</td>
<td>*</td>
<td>5</td>
<td>4</td>
<td>high</td>
</tr>
</tbody>
</table>

**Toxicants**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Pressure</th>
<th>Management</th>
<th>Vulnerability</th>
<th>Risk</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boating maintenance</td>
<td>1</td>
<td>*</td>
<td>5</td>
<td>1</td>
<td>moderate</td>
</tr>
<tr>
<td>Intensive agriculture in backshore</td>
<td>1</td>
<td>*</td>
<td>5</td>
<td>1</td>
<td>high</td>
</tr>
<tr>
<td>Proximity to aquaculture operations</td>
<td>3</td>
<td>*</td>
<td>5</td>
<td>4</td>
<td>high</td>
</tr>
<tr>
<td>Proximity to toxicant point source discharge</td>
<td>1</td>
<td>*</td>
<td>5</td>
<td>1</td>
<td>high</td>
</tr>
<tr>
<td>Boating activity</td>
<td>1</td>
<td>*</td>
<td>5</td>
<td>1</td>
<td>low</td>
</tr>
<tr>
<td>Proximity to extraction activities</td>
<td>3</td>
<td>*</td>
<td>5</td>
<td>4</td>
<td>high</td>
</tr>
<tr>
<td>Occurrence of dredging of contaminated sediment</td>
<td>*</td>
<td>*</td>
<td>5</td>
<td>*</td>
<td>unknown</td>
</tr>
<tr>
<td>Proximity to WWTP discharge</td>
<td>1</td>
<td>*</td>
<td>5</td>
<td>1</td>
<td>high</td>
</tr>
<tr>
<td>Proximity to stormwater outflow</td>
<td>1</td>
<td>*</td>
<td>5</td>
<td>1</td>
<td>low</td>
</tr>
</tbody>
</table>
## Condition indicator scores

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Condition</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toxicants in biota</td>
<td>*</td>
<td>unknown</td>
</tr>
<tr>
<td>Toxicants in sediment</td>
<td>*</td>
<td>unknown</td>
</tr>
<tr>
<td>Toxicants in water column</td>
<td>*</td>
<td>unknown</td>
</tr>
</tbody>
</table>

VPSIRR version: [16-12-2010] v 2.2

**Scoring guide:**

![Scoring scale with Best and Worst categories]

* = data out of range, invalid, not applicable, or absent
3.4.6 Natural Values

The assessment of values is somewhat separate from the overall risk and health assessment as they are not associated with the calculation of pressure, vulnerability or condition. Foreshore values can be considered in addition to risk and health, or act as a stand alone management tool.

The percentage of foreshore segments assigned to each natural value category is presented in Table 3.17. The individual indicator scores and the associated detail that support the values assessment (as described in section 3.3) are available for each 100 m segment in the final dataset and can be viewed and interrogated within a GIS.

Results of the assessment show that large proportions of foreshore segments within the study area are of very high natural value with regard to the indicators considered. Over 70% of foreshore segments have significant communities or habitats present, which include saltmarsh and other wetlands, areas of high value conservation as listed by the Conservation of Freshwater Ecosystem Values (CFEV) assessment, and sites listed by the Register of the National Estate. Over 50% of foreshore segments are within or adjacent to a protected natural area. This is reflective of the large expanses of the study area that are in proximity to National Parks and other reservations. A notable proportion of the study area (30.19%) is considered suitable foraging or nesting habitat for listed and significant shorebird and seabird species, and over 40% of segments are of high or very high geomorphic value. The classifications of "low" and "very low" apply only to the geomorphic value indicator and account for less than 1% of segments. The classification of "unknown" indicates segments for which no value has been identified, and does not necessarily indicate that no values are present. Further investigation of the coastline is needed before these segments can be fully assessed.

### Table 3.17 Percentage of foreshore segments assigned to each natural value category.

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>INDICATOR</th>
<th>Very high</th>
<th>High</th>
<th>Moderate</th>
<th>Low</th>
<th>Very low</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecology</td>
<td>Habitat of listed or significant species</td>
<td>30.19</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>69.81</td>
</tr>
<tr>
<td></td>
<td>Presence of significant communities or habitats</td>
<td>73.93</td>
<td>0.06</td>
<td>0.07</td>
<td>N/A</td>
<td>N/A</td>
<td>25.95</td>
</tr>
<tr>
<td></td>
<td>Area within or directly adjacent to a protected natural area</td>
<td>52.86</td>
<td>14.89</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>32.25</td>
</tr>
<tr>
<td>Geomorphology</td>
<td>Geomorphic value</td>
<td>10.31</td>
<td>30.34</td>
<td>4.27</td>
<td>0.79</td>
<td>0.05</td>
<td>54.25</td>
</tr>
</tbody>
</table>

Values assessment results for individual categories are presented spatially in Figure 3.4-18 to Figure 3.4-21. Areas of significant natural value are distributed throughout the study area, including in those areas most heavily developed and subject to the greatest risk from the environmental stressors considered in this study. The overall natural value of the study area (a combination of all natural values indicators) is presented in Figure 3.4-22. The majority of coastline is shown to be of high or very high natural value. This is reflective of the aims of this assessment which are to identify areas of value, not to identify areas of little or no natural value.
ShoreBase: A Coastal Management Tool

Figure 3.4-18 Habitat of listed or significant species.

Figure 3.4-19 Presence of significant communities or habitats.
Figure 3.4-20 Areas within or directly adjacent to a protected natural area.

Figure 3.4-21 Geomorphic value.
3.4.7 Human Use Values

The percentage of foreshore segments assigned to each human use value category is presented in Table 3.18. The classifications of “low” and “very low” are not applicable to indicators of human use value, and are therefore not included in the table. Large proportions of the study area are classed as having unknown human use value. This does not indicate areas of no value, but rather the difficulty in obtaining comprehensive data on foreshore uses. Over 47% of foreshore segments have moderate recreation and tourist use value, representing at least one recreation and/or tourist use in the area. Approximately 6.5% of segments are classed as very high value for this indicator reflecting high frequency recreation/tourist use. Approximately 3.5% of segments have very high European heritage significance.

Table 3.18 Percentage of foreshore segments assigned to each human use value category.

<table>
<thead>
<tr>
<th>INDICATOR</th>
<th>Very High</th>
<th>High</th>
<th>Moderate</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recreation and tourist use</td>
<td>6.49</td>
<td>0.15</td>
<td>47.17</td>
<td>46.19</td>
</tr>
<tr>
<td>Commercial use</td>
<td>0.87</td>
<td>2.71</td>
<td>0.88</td>
<td>95.54</td>
</tr>
<tr>
<td>Amenity use</td>
<td>0.24</td>
<td>0.24</td>
<td>0.30</td>
<td>99.22</td>
</tr>
<tr>
<td>Heritage significance</td>
<td>3.56</td>
<td>N/A</td>
<td>N/A</td>
<td>96.44</td>
</tr>
</tbody>
</table>

The assessment results for individual categories of human use value are presented spatially in Figure 3.4-23 to Figure 3.4-26. The overall human use value (a combination of all human use values indicators) is presented in Figure 3.4-27. For a number of indicators and for overall human use value, very large proportions of the study area are classified as unknown and hence much of the information contained in the dataset is lost at the scale presented in this report. The assessment may provide useful information for stakeholders when the dataset is viewed on a smaller scale to examine specific areas of interest within a GIS.
**Figure 3.4-23** Recreation and tourist use.

**Figure 3.4-24** Commercial use.

**Values Classifications**
- Very high
- High
- Moderate
- Low
- Very low
- Unknown
- Not assessed
Figure 3.4-25 Amenity use.

Figure 3.4-26 Heritage significance.
3.4.8  Overall Value

The overall values assessment is a combination of the overall natural value and overall human use value scores and rates approximately 92% of segments at an A or B level. Less than 5% of segments rate at or below a C level and approximately 2% are classed as unknown (Figure 3.4-28). However, as for the results provided above for individual values, the significant proportion of foreshore segments considered to be of high value reflects the general non-inclusion of low or poor scores to areas of little or no value.

It is important to consider the methods used in calculating the overall value when viewing the results of the assessment. If only one of the possible two value scores is assigned to a segment (i.e. overall natural value or overall human use value), then the overall value score will be based only on the value for which data exists. As much of the coastline has “unknown” human use value, many overall value classifications will reflect natural value only. For these reasons, users should consider the individual indicator scores contained within the dataset and the dependability score associated with overall values. Noting this, overall value of the study area is presented spatially in Figure 3.4-29.
Figure 3.4-28 Percentage of foreshore segments within the study area assigned to each overall value category.

Figure 3.4-29 Overall value.
3.5 Applications
The GIS outputs and report cards produced in this study are designed to assist coastal managers and stakeholders in decision making. The information they provide can support strategic planning, natural resource management and sustainable development within the North and Cradle Coast NRM Regions as required by the Tasmanian State Coastal Policy and other legislation. This integrated approach to foreshore assessment can operate as a stand-alone interpretive tool to support decision making processes, or can complement existing detailed mapping studies to gain a more comprehensive understanding of the greater coastal area.

3.5.1 Using the Assessment Output
Output from the ShoreBase assessment can be used to prioritise areas for management, particularly with regard to maintaining values, managing multiple uses, as well as implementing conservation and rehabilitation programs. Examination of individual components of the assessment, and the relationship between them can provide valuable guidance. Although there is no process for assessing the impact of changing stressors on values within the assessment framework, this can done by users on a case-by-case basis by examining risk levels for specific habitats or areas of value.

A key advantage of the incorporation of the VPSIRR approach in foreshore assessment is the identification of risk in the absence of sufficient condition data. Where condition data are lacking, the risk score (a combination of vulnerability and pressure) can identify areas of concern and prioritise assessments. For example, areas at extreme risk at the stressor or overall level may benefit from more detailed collection of condition data to establish the current state of the area, and observe trends over time.

The values assessment, in combination with the overall condition or risk score can be used to identify areas of highest priority for conservation and rehabilitation. Areas with the highest natural or human use value (i.e. score of 1) can be considered high priority if a new development is proposed and a site investigation may be triggered to assess the systems in place to maintain such values. A high natural value classification may also prompt further investigation where development or other modifications with the potential to threaten values are proposed.

Where the condition of the foreshore is poor to very poor (i.e. score of 4 or 5), or where assumed risk is high or extreme (i.e. 4 or 5), management action may aim to minimise further disturbance or to investigate further the reasons behind such classification. These scores can also identify areas that may benefit from the establishment of ongoing monitoring and/or rehabilitation programs.

Where areas are at moderate levels of condition or risk, management attention may focus on preventing degradation to a poor or very poor level, or on improving health and reducing risk so that a better overall assessment classification is reached.

Table 3.19 identifies different combinations of segment classifications that may result in management issues. Potential management actions are also described. Although the most extreme scores for each classification are generally presented (i.e. the greatest risk, the highest value etc.), management issues may be similar for areas where classifications are less extreme.
### Table 3.19 Identifying priority areas for management.

<table>
<thead>
<tr>
<th>Classification #1</th>
<th>Classification #2</th>
<th>Management Issue</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very high natural value</strong></td>
<td>Extreme risk</td>
<td>Area of high natural value at extreme risk</td>
<td>Identify source of risk, investigate further and implement management strategy to minimise impact on values.</td>
</tr>
<tr>
<td><strong>Very high natural value</strong></td>
<td><strong>Very high human use value</strong></td>
<td>Overlap of uses may compromise natural value</td>
<td>Assess impact (if any) of human uses on natural values. Manage for multiple uses.</td>
</tr>
<tr>
<td><strong>Excellent (A) overall health</strong></td>
<td>Extreme risk</td>
<td>Area in good condition, although at risk and may be impacted without intervention.</td>
<td>Assess consequences of change/impact and mitigate if unacceptable</td>
</tr>
<tr>
<td><strong>Very high natural value</strong></td>
<td></td>
<td>Area of very high natural value, for ecological or geomorphological reasons</td>
<td>Consider conservation/reserve status if not already applied</td>
</tr>
<tr>
<td><strong>Low value</strong></td>
<td>Poor condition</td>
<td>Degraded shoreline with minimal values</td>
<td>Assess suitability for rehabilitation</td>
</tr>
<tr>
<td><strong>Moderate risk or condition</strong></td>
<td></td>
<td>Shoreline is at moderate level of risk or condition and could degrade or improve depending on management</td>
<td>Prevent degradation, aim to improve foreshore state</td>
</tr>
</tbody>
</table>

The overall assessment, risk and health scores provide a general overview of the state of the foreshore. The more detailed information that is assigned for each stressor and supporting indicator is not presented at this level. As such, it is important to view the overall scores as well as the stressor and indicator scores to identify where information may be lacking and to better understand the underlying reasons for the segment’s classification. This is particularly true for areas considered to be at the extreme limits of the scoring range, as such areas are likely to warrant prioritised management attention and reasons for their classification should be thoroughly understood.

### 3.5.2 State Coastal Policy

The Tasmanian State Coastal Policy is a statutory document with the central objective of sustainable development. It applies to all coastal areas of Tasmania, including islands, and addresses the use, development and protection of natural and physical resources. Further detail on the policy can be accessed through the Tasmanian Department of Primary Industries, Parks, Water and Environment.

The outputs from this assessment can help decision makers assess activities against the objectives and principles of the State Coastal Policy. As information is contained in this assessment that is related to both the intertidal zone and the adjacent areas, results are relevant to the coastal zone as defined in the policy i.e. *State waters and all land to a distance of one kilometre inland from the high-water mark*.

The stressors, values and individual indicators most relevant to the specific principles, objectives and outcomes of the Coastal Policy are listed in Table 3.20. This information is not exhaustive, and other applications of ShoreBase may also exist with regard to the policy.
Table 3.20 Foreshore assessment output as it relates to outcomes of the revised *Tasmanian State Coastal Policy 1996.*

<table>
<thead>
<tr>
<th>OUTCOME</th>
<th>ITEM</th>
<th>RELEVANT STRESSOR / VALUE</th>
<th>RELEVANT INDICATOR/S</th>
<th>RELEVANCE OF OUTPUT TO POLICY</th>
</tr>
</thead>
<tbody>
<tr>
<td>The coastal zone will be managed to protect ecological, geomorphological and geological coastal features and aquatic environments of conservation value.</td>
<td>1.1.2</td>
<td>Natural Value</td>
<td>All</td>
<td>Identifies areas of ecological and geomorphological value, including those in areas at risk from environmental stressors</td>
</tr>
<tr>
<td>The coastal zone will be managed to conserve the diversity of all native flora and fauna and their habitats, including seagrass and seaweed beds, spawning and breeding areas. Appropriate conservation measures will be adopted for the protection of migratory species and the protection and recovery of rare, vulnerable and endangered species in accordance with this Policy and other relevant Acts and policies.</td>
<td>1.1.3</td>
<td>Natural Value</td>
<td>Habitat of listed or significant species</td>
<td>Identifies habitat of listed species, particularly shorebirds and seabirds</td>
</tr>
<tr>
<td>Exotic weeds within the coastal zone will be managed and controlled, where possible, and the use of native flora encouraged.</td>
<td>1.1.4</td>
<td>Introduced Species</td>
<td>Occurrence of specified pest species</td>
<td>Identifies presence of beach weeds and rice grass</td>
</tr>
<tr>
<td>Water quality in the coastal zone will be improved, protected and enhanced to maintain coastal and marine ecosystems, and to support other values and uses, such as contact recreation, fishing and aquaculture in designated areas.</td>
<td>1.1.5</td>
<td>Aquatic Sediments Nutrients Toxicants Bacteria/pathogens Human Use Value</td>
<td>Turbidity Nutrients in water Toxicants in water Bacteria/pathogens in water Recreation and tourist use</td>
<td>Provides framework for monitoring water quality in conjunction with other indicators of foreshore condition, and identifies areas where recreation and aquaculture activities occur</td>
</tr>
<tr>
<td>Appropriate monitoring programs and environmental studies will be conducted to improve knowledge, ensure guidelines and standards are met, deal with contaminants or introduced species and generally ensure sustainability of coastal ecosystems and processes and ensure that human health is not threatened.</td>
<td>1.1.6</td>
<td>Introduced Species Nutrients Toxicants Bacteria/pathogens pH</td>
<td>All</td>
<td>Identifies areas where introduced marine species are present and potential sources of contaminants such as toxicants, pathogens and/or acid sulphate soils. Provides framework for monitoring condition to track status with regard to these aims.</td>
</tr>
<tr>
<td>Representative ecosystems and areas of special conservation value or special aesthetic quality will be identified and protected as appropriate.</td>
<td>1.1.7</td>
<td>Natural Value</td>
<td>All</td>
<td>Identifies areas of conservation value significance</td>
</tr>
<tr>
<td>OUTCOME</td>
<td>ITEM</td>
<td>RELEVANT STRESSOR / VALUE</td>
<td>RELEVANT INDICATOR/S</td>
<td>RELEVANCE OF OUTPUT TO POLICY</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------</td>
<td>-------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Important coastal wetlands will be identified, protected, repaired and managed so that their full potential for nature conservation and public benefit is realised. Some wetlands will be managed for multiple use, such as recreation and aquaculture, provided conservation values are not compromised.</td>
<td>1.1.9</td>
<td>Natural Value</td>
<td>- Presence of significant communities or habitats - Recreation and tourism - Commercial use - Amenity use</td>
<td>Identifies important coastal wetlands and can be used to establish which areas have multiple uses, including recreation and aquaculture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Human Use Value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Places and items of cultural heritage will be identified, legally protected, managed and conserved where appropriate.</td>
<td>1.3.1</td>
<td>Human Use Value</td>
<td>- Heritage significance</td>
<td>Identifies areas of European cultural heritage significance</td>
</tr>
<tr>
<td>Areas subject to significant risk from natural coastal processes and hazards such as flooding, storms, erosion, landslip, littoral drift, dune mobility and sea-level rise will be identified and managed to minimise the need for engineering or remediation works to protect land, property and human life.</td>
<td>1.4.1</td>
<td>Hydrodynamics</td>
<td>- Vulnerability to shoreline movement - Hydrodynamic effects of climate change - Shoreline movement</td>
<td>Identifies risk from the hydrodynamic effects of climate change, and assesses vulnerability</td>
</tr>
<tr>
<td>Recreational use of the coastal zone will be encouraged where activities can be conducted in a safe and environmentally responsible manner.</td>
<td>2.8.1</td>
<td>Human Use Value</td>
<td>- Recreation and tourist use</td>
<td>Identifies areas where recreational activities occur</td>
</tr>
</tbody>
</table>
3.6 Limitations

Users of this data should be aware that the levels of value, condition and risk assigned in this study are specific to the intertidal zone and are based on a framework designed for the North and Cradle Coast NRM Regions. This means an area assigned the poorest condition level for example, is considered such within the region, and not on a broader state-, country- or worldwide scale.

This study incorporated a number of datasets that are not regularly maintained. Some data used in the assessment are many years old and/or have limited geographic coverage within the study area. However, inclusion of such data was considered important in the absence of more current information.

Due to a significant lack of current and region-wide data for a number of indicators, supporting data have been obtained from a variety of sources including inference from aerial imagery and local knowledge. It is important that users are aware of instances where data are missing or “unknown” and consider this when interpreting segment classifications. For example, there are few data available on the volume and frequency of tourist visits to foreshore sites, as well as recreational use information. Frequency and use data are important when assessing impact, particularly in the study regions where some areas of tourist and recreational value are also of high geomorphic, cultural and/or conservation value. Site specific information on recreation uses and tourism value may be held by councils, stakeholders and members of the community. This local knowledge should be referred to in order to complement the existing inferred information included in this project.

Detailed region-wide monitoring studies are also lacking. Collection of monitoring data is expensive and often not a priority for coastal managers. For these reasons, there is a noticeable lack of monitoring data used to establish actual condition of the foreshore in this study.

In cases where data are lacking and/or inference has been used to support assessment, confidence scores associated with each classification provide an indication of data quality. Further, the risk assessments based on pressure and vulnerability in the absence of condition data provide valuable, management oriented information.

3.7 Monitoring

The benefits and applications of ShoreBase will be enhanced if regular monitoring of foreshore state is adopted. Monitoring can detect change in foreshore systems, and if incorporated into the framework described here, can help to identify possible reasons for change and potential sources of pressure.

Monitoring programs can be targeted to a specific stressor or indicator, or can be generalised to detect broad scale changes in overall condition. Ongoing and thorough monitoring of all condition indicators is likely to be expensive and time consuming. Managers may choose to monitor only those factors most relevant to activities occurring in their area of interest, such as those related to agriculture in areas of intense farming, or indicators relating to high density populations in regional centres. It is suggested that collection of data to support monitoring of foreshores in the study area using this framework should be collected according to current guidelines.
For further key information on indicators, including monitoring methods and reporting see *Users Guide to Estuarine, Coastal and Marine Indicators for Regional NRM Monitoring* (Scheltinga et al. 2004). The *Tasmanian Indicator Compendium* (Mount 2006) and the report *Indicators for Monitoring the Condition of Estuaries and Coastal Waters* (Crawford 2006) should also be referred to as they provide information on indicators and preferred monitoring methods specific to Tasmania.

Over large areas, a suitable monitoring alternative may be to adopt a simplistic, general method that can show large scale changes in physical and biological components of the foreshore. This can be achieved through the selection and ongoing monitoring of representative reference sites.

### 3.7.1 Reference Sites

A monitoring method is described below to provide an easily applied technique for recording the general state of selected reference sites in the intertidal zone, and for detecting major changes at these sites through the qualitative interpretation of repeated high resolution digital photography. This method can provide an early indication of change and can prompt the collection of more detailed monitoring data. If possible, the incidental collection of information on pressures and values (such as the presence of introduced or threatened species) or more detailed monitoring data at reference sites would be beneficial in supporting the indicators included in this assessment and hence establishing and quantifying current condition or value.

Reference sites can be selected based on their representation of a particular level of value, condition or risk and their importance to the community. Sites should have characteristics with the potential to show broad scale change over time using this method. Transects consisting only of sand (for example) are unlikely to be useful in detecting change. Favourable site characteristics may include proximity to known pressure sources (such as outfalls for example) where change is likely; pristine areas where change is not expected, but important to detect; or the presence of diverse or otherwise significant ecological features.

The recommended methods for assessing sites are straightforward and are suitable for adoption by community groups or other relevant stakeholders. Local councils and other agencies may choose to select monitoring sites relevant to their particular management priorities and apply the methods described here.

Suggested methods for assessing general monitoring sites:

- Visit sites at low tide (preferably on a spring tide).
- Run a transect from the lowest point in the intertidal zone to the high water mark. Two transects should be laid 10 m apart and photographed as outlined below. The process should then be repeated 100 m away in similar habitat so that a total of four transects are photographed at each site.
- Mark the start and end points of each transect with a GPS. Record waypoints, total transect length and time and date of survey.
• Place 0.5 x 0.5 m quadrat on either side of the transect line at five levels along the shore i.e. low water, low mid-water, mid-water, high mid-water and high water.

• Take paired high-resolution photographs at each level (one on each side of the transect), totalling ten at each site. Do not take paired photographs immediately adjacent to one another. Instead move the quadrat along the transect, approximately 1 m where transect length allows, to gain better coverage of the shore.

• Ensure the quadrat fills the camera frame or that the photo covers 0.5 m x 0.5 m and is high resolution (i.e. 10 mega pixels or greater) (see example in Figure 3.7-1).

![Example of quadrat photograph](image)

**Figure 3.7-1** Example of quadrat photograph

• Take additional photographs of the entire transect and the alongshore view to provide a general overview of the area and serve as reference points for repeated visits (see example in Figure 3.7-2).
3.7.2 Example photograph of an entire transect

- Photograph in finer detail any additional factors of relevance to the indicators within this assessment such as listed species, introduced species, algae associated with nutrient input, litter, point sources etc.

- Once the field component is complete, all high resolution photographs should be stored on a secure electronic data storage device with backup copies kept separately. Photographs should be clearly labelled with details of site, transect number, position on the shore (low water, mid water etc) and a number indicating the order of the photograph within the pair (e.g. The 1st quadrat photographed at the low water mark on transect 1 at Site X = Site X_T1_LW1). Records should then be archived in order to monitor change by comparison with future assessments.

3.8 Recommendations

This assessment provides an indication of the current risks to coastal foreshores within the study region. In order to maintain its relevance, it is important that the data supporting ShoreBase are updated regularly, and the assessment repeated to detect change and report on trends in the foreshore environment. Furthermore, the establishment of a central repository for storage of all relevant data would reduce the resources required to maintain and update the dataset, and simplify repeat assessments.

Stakeholders are encouraged to implement the selection and ongoing monitoring of reference sites using the methods described in this report. Monitoring sites of particular relevance to stakeholders, or those in areas of high value subject to significant pressure may help identify potential risks to the environment and minimise future impact.
Further investigation of indicators suitable for assessing the state of foreshores would help identify those most effective at detecting change. The costs of ongoing monitoring can be minimised if the amount of information required to detect significant change is reduced.

Collection of condition data on any scale will be beneficial in improving confidence in the assessment results. Long-term monitoring programs, gap-filling and repeat assessments are all important to further develop the foundation provided by this assessment, and fully utilise the functionality within this framework. As ShoreBase is founded on 100 m segments of coastline, repeat assessments can include the entire study area, or smaller areas of interest.

ShoreBase is developed for use by state and local governments, NRM regional bodies, interested stakeholders and the wider community. The development of a communication plan specific to each of these groups would be beneficial in raising awareness of the potential applications of the dataset and ensuring its effective and ongoing use.
4 References


Natural Resource Management Tasmania (2010). Accessed November 2010 from:
http://www.nrmtas.org/regions


OzCoasts (2010a). *Coastal indicators, fine sediment loads.* Accessed November 2010 from:
http://www.ozcoasts.org.au/indicators/fine_sediment_loads.jsp


Waycott, M., Duarte, C.M., Carruthers, T.J.B., Orth, R.J., Dennison, W.C., Olyarnik, S., Calladine, A., Fourquean, J.W., Heck, K.J., Hughes, A.R., Kendrick, G.A., Kenworthy, W.J.,


5 Appendices

Appendix 5-1: Conceptual Models

The aim of these conceptual models is to identify anthropogenic activities and natural processes that may potentially impact the foreshore environment. Although the focus is on any increase in a particular stressor due to anthropogenic activity, this assessment does not imply that natural processes are without impact.

- Grey text boxes indicate stressor sources.
- White text boxes indicate the mechanism by which the stressor is delivered or arrives at the intertidal zone.
- Blue text boxes indicate those sources that are not directly related to anthropogenic activity and may be natural processes, but are nonetheless potential sources of change to the stressor. They are not included as condition or pressure indicators, but may be used to identify vulnerability in some cases.

- **HAT** = Highest Astronomical Tide: The highest level of water which can be predicted to occur under any combination of astronomical conditions
- **LAT** = Lowest Astronomical Tide: The lowest tide level which can be predicted to occur under average meteorological conditions and under any combination of astronomical conditions. (Australian Hydrographic Service Website [http://www.hydro.gov.au/index.htm](http://www.hydro.gov.au/index.htm)).

AQUATIC SEDIMENTS
ShoreBase: A Coastal Management Tool

BACTERIA/PATHOGENS

INDUSTRIAL DISCHARGE
CATCHMENT RUN-OFF
INTENSIVE AGRICULTURE
STORMWATER DISCHARGE
SEPTIC TANKS
STP DISCHARGE
INTRODUCED SPECIES
MIGRATORY SPECIES
NEW BACTERIA/PATHOGENS
AQUACULTURE
SHIPPING (SEWAGE)

BACTERIA/PATHOGENS

BACTERIA/PATHOGENS

BIOTA REMOVAL / DISTURBANCE

FIRE MANAGEMENT
(e.g. grass/leaf burning by farmers)

STOCK GRAZING

BACKSHORE DEVELOPMENT
(vacation/industrial/recreational)

SMOKE ASH, HEAT
TRAMPING BY STOCK ON BEACH
NOISE, LIGHTS, VIBRATION, VISUAL DISTURBANCE
FORESHORE STRUCTURES
(including aquaculture)

BIOTA COLLECTION
PHYSICAL REMOVAL
TARGETING SPECIES

COMMERCIAL FISHING

RECREATION/TOURISM
(NOISE, LIGHTS, VIBRATION, PHYSICAL DISTURBANCE)

FORESHORE STRUCTURES
(INCLUDING AQUACULTURE)

DISTURBANCE, NOISE, VIBRATION

DREDGING

BOATING AND JET SKIING

BACKSHORE DEVELOPMENT
(VACATION/INDUSTRIAL/RECREATIONAL)

SMOKE ASH, HEAT
TRAMPING BY STOCK ON BEACH
NOISE, LIGHTS, VIBRATION, VISUAL DISTURBANCE
FORESHORE STRUCTURES
(INCLUDING AQUACULTURE)

BIOTA COLLECTION
PHYSICAL REMOVAL
TARGETING SPECIES

COMMERCIAL FISHING

RECREATION/TOURISM
(NOISE, LIGHTS, VIBRATION, PHYSICAL DISTURBANCE)

FORESHORE STRUCTURES
(INCLUDING AQUACULTURE)

DISTURBANCE, NOISE, VIBRATION

DREDGING

BOATING AND JET SKIING
Appendix 5-2: Assessment and Scoring Analysis

The below text describes in more detail the VPSIRR calculation processes. It is adapted from Scheltinga and Moss 2007 who acknowledge that much of the information, both intellectual and written, provided in their report comes from work done through the Aquatic Biodiversity Assessment and Mapping Method (AquaBAMM) project (Clayton et al, 2006).

Conversion of indicator scores into an overall pressure, risk and condition score for each stressor

Indicator weighting
As the framework looks at a large range of indicators there will be some that are more important in terms of the ‘effect’ they have on a stressor than others, similarly there is a general assumption that some stressors are more important to overall risk or health than others. Applying weights to indicators and ranking to stressors will therefore have an effect on the assessment and scoring of a spatial unit.

Expert opinion can be used to weight each indicator according to its importance to the respective stressor category (pressure, risk or condition). This is done by applying a weighting between 1 and 10 to each indicator. In the case of the foreshore assessment, the same weighting has been applied to all indicators, and equal ranking to all stressors. This conservative approach was applied due to the hugely varied intertidal habitats included in this assessment and the uncertainty surrounding the significance of each indicator in varied environments.

Preliminary stressor category (pressure, risk and condition) score
A ‘preliminary’ stressor category score is calculated with the use of ‘indicator weighting’. In this way, any variability in the contribution of each indicator is reflected prior to the finalisation of the stressor score.

For each stressor category in turn, the preliminary score is calculated as:

\[
\frac{\sum (\text{Indicator score} \times \text{Weight})}{\sum \text{Weights}}
\]

The preliminary stressor score therefore has values from 1 to 5.

Stressor score (with a boost)
The unadjusted weighted score calculated above is similar to most other ‘measures of central tendency’ statistics (e.g. average) in that outlying values are deemphasised. This is not necessarily desirable because extreme values can be very important regardless of the distribution of other values. For example, if five indicators for a stressor’s pressure category are assigned negligible, negligible, low, low and very high, respectively, it is arguable that the presence of data indicating a ‘very high’ pressure value in the last indicator should be recognised beyond its influence in an ‘average’ statistic, which would have the final stressor pressure score marginally above a ‘low’ pressure.

There are a number of arithmetic methods for addressing this issue (Turpie et al., 2002 – cited in Clayton et al., 2006). Importantly for this assessment, the interest is in reducing the likelihood of scores that underestimate pressure or risk and overestimate condition rather
than the opposite. This is the ‘precautionary principle’ in practice and infers the need for a one-tailed correction or adjustment mechanism.

This assessment thus uses a ‘boosted’ stressor category score to increase the influence of the maximum indicator value for the particular stressor category. The maximum value is simply re-combined with the preliminary score before calculation of the final score and this parallels the method of Turpie et al. 2002 (cited in Clayton et al., 2006). To demonstrate this, a worked example is shown below for pressure indicators of the stressor ‘biota removal/disturbance’ used in an estuarine assessment. The final indicator score (boosted) has values from 1 to 5.

Indicators with ‘no data’ are ignored in these calculations.

**Stressor (biota removal/disturbance) pressure score.**

<table>
<thead>
<tr>
<th>Indicator name</th>
<th>Score</th>
<th>Weight</th>
<th>Score x Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recreational bait collector usage of an estuary</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Boat moorings</td>
<td>5</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Boating activity within the estuary</td>
<td>4</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>Coastal population size</td>
<td>2</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Total commercial fisher catch from an estuary and adjoining coastal waters</td>
<td>3</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>Commercial licensed collector usage of an estuary and adjoining coastal waters</td>
<td>3</td>
<td>8</td>
<td>24</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td><strong>38</strong></td>
<td><strong>115</strong></td>
<td><strong>115</strong></td>
</tr>
</tbody>
</table>

preliminary Stressor Pressure Score (pSPS) = \( \frac{\sum (\text{Indicator score} \times \text{Weight})}{\sum \text{Weights}} \)

\[ \frac{11}{38} = 3.03 \]

Stressor Pressure Score (boosted) = \( \frac{2}{(3.03 + 5)} \)

\[ \frac{2}{8} = 0.25 \]

\[ 4.01 \text{ (i.e. high pressure)} \]

Preliminary and boosted ‘Stressor Condition Scores’ are calculated in the same manner.

**Calculation of stressor risk score**

A preliminary and boosted stressor risk score is calculated in a similar manner but with a slight difference. Risk is a combination of the pressure on a system and the vulnerability of that system to that particular pressure. Therefore, the initial ‘risk’ value is calculated by comparing the pressure indicator score against the relevant vulnerability indicator score. This risk value is then used to determine the stressor’s overall risk score using the method...
described above for boosted stressor scores and using the same weighting as used for the relevant pressure indicators for which the initial risk value was calculated.

For example, the risk score for the stressor biota removal/disturbance with a vulnerability score of 2, is as shown in the below Table.

Stressor (biota removal/disturbance) risk score.

<table>
<thead>
<tr>
<th>Indicator number</th>
<th>Indicator name</th>
<th>Pressure Score</th>
<th>Risk Score</th>
<th>Weight</th>
<th>Score x Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>P17</td>
<td>Recreational bait collector usage of an estuary</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>P19</td>
<td>Boat moorings</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>P5</td>
<td>Boating activity within the estuary</td>
<td>4</td>
<td>3</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>P21</td>
<td>Coastal population size</td>
<td>2</td>
<td>1</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>P27</td>
<td>Total commercial fisher catch from an estuary and adjoining coastal waters</td>
<td>3</td>
<td>2</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>P28</td>
<td>Commercial licensed collector usage of an estuary and adjoining coastal waters</td>
<td>3</td>
<td>2</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Sum</td>
<td>38</td>
<td>80</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In this example the ‘Stressor Risk Score (boosted)’ would be = 3.05 (i.e. moderate risk).

If no vulnerability indicators have been identified for a particular stressor then the pressure score is used as a surrogate of risk.

**Final scoring**

Each stressor category score will thus have a value from 1 to 5. A final ‘score’ for each stressor category is then calculated by comparing the boosted score to the values provided in the below table which uses the 20th percentile divisions of this 1 to 5 data range.

Boosted stressor category scoring thresholds.

<table>
<thead>
<tr>
<th>Boosted score</th>
<th>Pressure (score) rating</th>
<th>Risk rating (score)</th>
<th>Condition (health) rating (score)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤1.8</td>
<td>Negligible (1)</td>
<td>Negligible (1)</td>
<td>Excellent (1)</td>
</tr>
<tr>
<td>&gt;1.8 to ≤2.6</td>
<td>Low (2)</td>
<td>Low (2)</td>
<td>Good (2)</td>
</tr>
<tr>
<td>&gt;2.6 to ≤3.4</td>
<td>Moderate (3)</td>
<td>Moderate (3)</td>
<td>Fair (3)</td>
</tr>
<tr>
<td>&gt;3.4 to ≤4.2</td>
<td>High (4)</td>
<td>High (4)</td>
<td>Poor (4)</td>
</tr>
<tr>
<td>&gt;4.2</td>
<td>Extreme (5)</td>
<td>Extreme (5)</td>
<td>Very poor (5)</td>
</tr>
</tbody>
</table>

Confidence scoring would be calculated in the same manner (i.e. replace the pressure score in the Stressor Pressure Score table with the appropriate confidence score). However, as the confidence scoring only uses four categories then the final ‘boosted stressor ‘confidence’ scoring’ threshold table would use 25th percentile divisions of a 1 to 4 data range (see below Table).
Boosted stressor category scoring thresholds.

<table>
<thead>
<tr>
<th>Boosted score</th>
<th>Confidence rating (score)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤1.75</td>
<td>Very High (1)</td>
</tr>
<tr>
<td>&gt;1.75 to ≤2.5</td>
<td>High (2)</td>
</tr>
<tr>
<td>&gt;2.5 to ≤3.25</td>
<td>Moderate (3)</td>
</tr>
<tr>
<td>&gt;3.25</td>
<td>Low (4)</td>
</tr>
</tbody>
</table>

Conversion of stressor scores into an overall risk and health rating

Stressor ranking
As discussed above (see indicator weighting), some stressors are more important to the overall risk or health level than others. Applying a ranking to the stressors will therefore have an effect on the final overall assessment and scoring of spatial unit.

Expert opinion can be used to rank each stressor according to its importance with respective to the overall risk or health. This can be done by ranking each stressor by its relative importance with 1 being the highest rank. As discussed above, all stressors have been weighted equally for the foreshore assessment.

Overall risk and health scores
For each spatial unit, a preliminary risk or health score is first calculated by taking the average of the risk or condition scores for each stressor. However, in a similar way to that described for the preliminary stressor score calculation, an average value poorly represents the spread of values with respect to the objectives of the assessment. Also, it does not reflect, when necessary, any between-stressor difference in their respective contribution/importance to the overall risk or health. Accordingly, a mechanism is required to adjust the overall risk or health scores.

The assessment uses an ‘adjusted’ score method to increase the influence of the stressors that are considered to be the most important contributors. Values from stressors ranked as 1 are simply recombed with the preliminary risk or health scores before calculation of the final score. Unlike the almost identical calculation to boost the stressor score, adjustment of the overall risk or health score is two-tailed and can result in a score increasing or decreasing from its preliminary value. To demonstrate this, a worked example is shown below. The final overall risk or health score (adjusted) has values from 1 to 5.

Stressor ranking and scoring

<table>
<thead>
<tr>
<th>Stressor</th>
<th>Stressor ranking</th>
<th>Stressor risk score</th>
<th>Stressor condition score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquatic sediments</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Bacteria/pathogens</td>
<td>4</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Biota removal/disturbance</td>
<td>3</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>pH</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Habitat removal/disturbance</td>
<td>2</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Hydrodynamics</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>3.3</strong></td>
<td><strong>3.25</strong></td>
<td></td>
</tr>
</tbody>
</table>
preliminary Overall Risk Score (pORS) = average risk score = 3.3 (i.e. moderate risk)

Overall Risk Score (adjusted) = \( \frac{(pORS + \text{rank 1(risk score)})}{1 + \text{count(rank 1(risk score))}} \)

\[ \frac{(3.3 + 3 + 2)}{3} \]

= 2.77 (i.e. moderate risk)

**Final scoring**
The final overall risk or health score (adjusted) are converted to an overall risk or health rating based on the 20\(^{th}\) percentile thresholds in Table 3.5. (Or Table 3.6 for the overall confidence score).

The assessment and calculation steps used in this assessment are presented in the figure below.
**Step 1**
- Raw data

**Step 2**
- Pressure indicator 1 score
- Pressure indicator 2 score
- Vulnerability indicator 1 score

**Step 3**
- Stressor 1 Pressure score
- Stressor 1 Risk score
- Stressor 2 Risk score
- Stressor 1 Condition score
- Stressor 2 Condition score

**Step 4**
- Overall risk score
- Overall health score
### Appendix 5-3: Data Usage and Data Contributors

<table>
<thead>
<tr>
<th>STRESSOR</th>
<th>INDICATOR TYPE</th>
<th>INDICATOR NAME</th>
<th>SUPPORTING DATA</th>
<th>SOURCE AND DATE OF SUPPLY</th>
</tr>
</thead>
</table>
| AQUATIC SEDIMENTS | Pressure | Occurrence of dredging | − Dredging activities  
− Dredging activities  
− Inferred from local knowledge, literature search and personal communications  | − MAST, July 2009  
− TasPorts, August 2009  
− Including C. Rees pers. comm., July 2009 |
| Boating activity | | | − Marine structures assessment project  
− Assets (marine infrastructure)  
− Managed marine facilities  
− Planning Special Areas  
− Tasmanian Anchorage Guide  
− Inferred from local knowledge and inspection of aerial imagery  | − DPIPWE, September 2009  
− Tasmania Parks and Wildlife Service, December 2009  
− MAST, September 2009  
− DPIPWE, September 2009  
− Royal Yacht Club of Tasmania, 2007  
− Imagery supplied by NRM North, September 2009. Additional imagery from Google Earth. |
| Agriculture within immediate backshore area | | | − TASVEG 2.0  | − DPIPWE, May 2009 |
| Clearing in immediate backshore area | | | − TASVEG 2.0  | − DPIPWE, May 2009 |
| Proximity to sediment point source discharge | | | − Industrial discharge  | − DPIPWE, December 2009 |
| Proximity to stormwater outflow | | | − Hydrological data (Hydstra)  
− Stormwater outflows  | − DPIPWE, September 2010  
− Waratah Wynyard Council, December 2009 |
| Proximity to stream/river input and % of catchment cleared | | | − TASVEG_2_0  
− Catchments  
− Oz_coasts_estuaries (NLWRA, 1998)  | − DPIPWE, May 2009  
− LIST, 2006  
− NLWRA, 1998 |
| Density of unsealed roads in immediate backshore area | | | − RoadsNE_PWS  
− RoadsNW_PWS  
− thelist_transportsegments  | − Tasmania Parks and Wildlife Service, December 2009  
− Tasmania Parks and Wildlife Service, December 2009  
− DPIPWE, November 2009 |
<table>
<thead>
<tr>
<th>STRESSOR</th>
<th>INDICATOR TYPE</th>
<th>INDICATOR NAME</th>
<th>SUPPORTING DATA</th>
<th>SOURCE AND DATE OF SUPPLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>AQUATIC SEDIMENTS</td>
<td>Pressure</td>
<td>Use of foreshore and immediate backshore by off-road vehicles</td>
<td>thelist_transportsegments</td>
<td>DPIPWE, December 2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Shore type</td>
<td>C. Sharples (TascoastgeoV6), September 2010</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>N and NW Coast Assets</td>
<td>Tasmania Parks and Wildlife Service, December 2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Inference from local knowledge and research</td>
<td>Including A. Davey, pers. comm., September 2010</td>
</tr>
<tr>
<td></td>
<td>Condition</td>
<td>Change in seagrass extent</td>
<td>Not supported</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Change in particle size</td>
<td>Not supported</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Turbidity</td>
<td>Not supported</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vulnerability</td>
<td>Dilution rate</td>
<td>Tidal range (1 km resolution)</td>
<td>M. Lacey (Blue Wren Group) from National Tidal Centre data, July 2010</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Australian Coastal Smartline</td>
<td>Geoscience Australia, October 2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tasmanian estuaries</td>
<td>theLIST, 2006</td>
</tr>
<tr>
<td>BACTERIA/PATHOGENS</td>
<td>Pressure</td>
<td>Presence of septic tanks</td>
<td>WWTP locations and discharge</td>
<td>DPIPWE, September 2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Facility Emissions Data</td>
<td>National Pollution Inventory, September 2010</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hydrological data (Hydstra)</td>
<td>DPIPWE, September 2010</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Land use</td>
<td>Australian Land Use and Management (ACLUMP), October 2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tasmanian Parks and Wildlife Service, December 2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>DPIPWE, September 2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>DPIPWE, September 2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proximity to stormwater outflow</td>
<td>Hydrological data (Hydstra)</td>
<td>DPIPWE, September 2010</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stormwater outflows</td>
<td>Waratah Wynyard Council, December 2009</td>
</tr>
<tr>
<td>STRESSOR</td>
<td>INDICATOR TYPE</td>
<td>INDICATOR NAME</td>
<td>SUPPORTING DATA</td>
<td>SOURCE AND DATE OF SUPPLY</td>
</tr>
<tr>
<td>-----------------------</td>
<td>----------------</td>
<td>----------------------------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>BACTERIA/PATHOGENS</td>
<td>Pressure</td>
<td>Proximity to finfish and shellfish aquaculture operations</td>
<td>– Marine Leases&lt;br&gt;– Land use&lt;br&gt;– Marine Structures Assessment Project</td>
<td>– DPIPWE, December 2009&lt;br&gt;– Australian Land Use and Management (ACLUMP), October 2009&lt;br&gt;– DPIPWE, September 2009</td>
</tr>
<tr>
<td>STRESSOR</td>
<td>INDICATOR TYPE</td>
<td>INDICATOR NAME</td>
<td>SUPPORTING DATA</td>
<td>SOURCE AND DATE OF SUPPLY</td>
</tr>
<tr>
<td>--------------------------</td>
<td>----------------</td>
<td>----------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| BACTERIA/PATHOGENS       | Pressure       | Proximity to bacteria/pathogen point source discharge | – Facility Emissions Data  
– Level 2 output | – National Pollution Inventory, September 2010  
– DPIPWE, September 2009 |
|                          | Condition      | Occurrence / concentration of Enterococci    | – Water quality data  
– Water quality data | – Tasmanian Shellfish Quality Assurance Program (TSQAP), July 2010  
– Waratah Wynyard Council, July 2010 |
|                          |                | Occurrence / concentration of faecal Coliforms | – Water quality data  
– Water quality data | – Tasmanian Shellfish Quality Assurance Program (TSQAP), July 2010  
– Waratah Wynyard Council, July 2010 |
|                          | Vulnerability  | Dilution rate                                | – Tidal range (1 km resolution)  
– Australian Coastal Smartline  
– Tasmanian estuaries | – M. Lacey (Blue Wren Group) from National Tidal Centre data, July 2010  
– Geoscience Australia, October 2009  
– theLIST, 2006 |
| INTRODUCED SPECIES       | Pressure       | Frequency of boat visits                     | – Marine structures assessment project  
– Assets (marine infrastructure)  
– Managed marine facilities  
– Planning Special Areas  
– Tasmanian Anchorage Guide  
– Inferred from local knowledge and inspection of aerial imagery | – DPIPWE, September 2009  
– MAST, September 2009  
– DPIPWE, September 2009  
– Royal Yacht Club of Tasmania, 2007  
– Imagery supplied by NRM North, September 2009. Additional imagery from Google Earth |
<table>
<thead>
<tr>
<th>STRESSOR</th>
<th>INDICATOR TYPE</th>
<th>INDICATOR NAME</th>
<th>SUPPORTING DATA</th>
<th>SOURCE AND DATE OF SUPPLY</th>
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</thead>
</table>
| INTRODUCED SPECIES| Pressure       | Proximity of specified pest to uninfested segments                              | - *Carcinus maenas* catches  
- Beach weed distribution  
- Pest species distribution  
- Natural Values Atlas  
- Distribution data  
- Coastal Values Mapping  
- *Crassostrea gigas* distribution  
- Rice grass and sea spurge distribution  
- Australian Coastal Smartline (shore type) | - CSIRO, January 2009  
- SPRATS, December 2009  
- State of the Environment Reporting, Department of Justice, August 2009  
- DPIPWE, July 2009  
- Various projects, Aquenal, 2009, 2010  
- North Barker Ecosystem Services, April 2010  
- Mitchell et al. 2000  
- Campbell-Ellis 2009  
- Geoscience Australia, October 2009 |
|                   |                | Proximity to aquaculture operations                                              | - Marine Leases  
- Land use  
- Marine Structures Assessment Project | - DPIPWE, December 2009  
- Australian Land Use and Management (ACLUMP), October 2009  
- DPIPWE, September 2009 |
| Condition         | Occurrence of any specified listed pest species | - *Carcinus maenas* catches  
- Beach weed distribution  
- Pest species distribution  
- Natural Values Atlas  
- Distribution data  
- Coastal Values Mapping  
- *Crassostrea gigas* distribution  
- Rice grass and sea spurge distribution | - CSIRO, January 2009  
- SPRATS, December 2009  
- State of the Environment Reporting, Department of Justice, August 2009  
- DPIPWE, July 2009  
- Various projects, Aquenal, 2009, 2010  
- North Barker Ecosystem Services, April 2010  
- Mitchell et al. 2000  
- Campbell-Ellis 2009 |
| Vulnerability     | Estimated level of disturbance within foreshore segment                        | - Derived from risk scores in current assessment                                | - Aquenal, April 2011 |

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</table>
| HYDRODYNAMICS | Pressure  | Proportion of segment occupied by foreshore structures / reclamation | − Marine Structures Assessment Project  
− Marine infrastructure  
− Managed marine facilities  
− Planning Special Areas  
− Australian Coastal Smartline (shore type)  
− Inferred from local knowledge and inspection of aerial imagery | − DPIPWE, September 2009  
− Tasmania Parks and Wildlife Service, December 2009  
− MAST, September 2009  
− DPIPWE, September 2009  
− Geoscience Australia, October 2009  
− Imagery supplied by NRM North, September 2009. Additional imagery from Google Earth. |
|          |                | Presence of inshore aquaculture structures         | − Marine Leases  
− Land use  
− Marine Structures Assessment Project | − DPIPWE, December 2009  
− Australian Land Use and Management (ACLUMP), October 2009  
− DPIPWE, September 2009 |
|          |                | Presence of rice grass                             | − Rice grass distribution  
− Natural Values Atlas  
− Coastal Values Mapping  
− Rice grass distribution | − State of the Environment Reporting, Department of Justice, August 2009  
− DPIPWE, July 2009  
− North Barker Ecosystem Services, April 2010  
− Campbell-Ellis 2009 |
|          |                | Hydrodynamic effects of climate change             | − Sea level rise vulnerability assessment | − Mount et al. 2010 |
|          |                | Occurrence of dredging                             | − Dredging activities  
− Dredging activities  
− Inferred from local knowledge, literature search and personal communications | − MAST, July 2009  
− TasPorts, August 2009  
− Including C. Rees pers. comm., July 2009 |
| Condition | Shoreline movement | Not supported                                          |                                                                                                  |                                                                 |
| Vulnerability | Vulnerability to shoreline movement | Australian Coastal Smartline                     |                                                                                                  | Geoscience Australia, October 2009 |

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<td>Recreation and tourist use index</td>
<td>– Land use</td>
<td>Australian Land Use and Management (ACLUMP), October 2009</td>
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<td>– thelist_transportsegments</td>
<td>DPIPWE, December 2009</td>
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<td></td>
<td></td>
<td>– Australian Coastal Smartline (shore type)</td>
<td>Geoscience Australia, October 2009</td>
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<td></td>
<td>– Foreshore structures</td>
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<td>– N and NW Coast Assets</td>
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<td>– Inference from local knowledge and research</td>
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<td>– Australian Land Use and Management (ACLUMP), October 2009</td>
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<td>– DPIPWE, September 2009</td>
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<td>– Geoscience Australia, October 2009</td>
<td>DPIPWE, September 2009</td>
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<td></td>
<td>Boating activity</td>
<td></td>
<td>– Marine structures assessment project</td>
<td>DPIPWE, September 2009</td>
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<td>– Managed marine facilities</td>
<td>MAST, September 2009</td>
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<td>– Planning Special Areas</td>
<td>DPIPWE, September 2009</td>
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<td>– Tasmanian Anchorage Guide</td>
<td>Royal Yacht Club of Tasmania, 2007</td>
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<td>– Inferred from local knowledge and inspection of aerial imagery</td>
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<td>Population by census collecting district</td>
<td>– Australian Bureau of Statistics, September 2009</td>
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<td>Access to shore</td>
<td></td>
<td>– Transport segments</td>
<td>DPIPWE, November 2009</td>
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<td>– Aerial imagery</td>
<td>Supplied by NRM North, September 2009</td>
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<td>Additional imagery from Google Earth.</td>
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<td>Access of stock to foreshore</td>
<td>Conservation of Freshwater Ecosystem Values (CFEV)</td>
<td>– DPIPWE, September 2010</td>
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<td>SUPPORTING DATA</td>
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<td>Pressure</td>
<td>Occurrence of fires in adjacent immediate backshore</td>
<td>Fire management data</td>
<td>Tasmanian Parks and Wildlife Service, December 2009</td>
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<td>Biota collection</td>
<td>Collection information, <em>Crassostrea gigas</em> distribution, Literature search and inference from local knowledge</td>
<td>King Island Council, November 2009, Mitchell et al. 2000</td>
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<td>Occurrence of dredging</td>
<td>Dredging activities, Inferred from local knowledge, literature search and personal communications</td>
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</table>
| HABITAT REMOVAL | Pressure       | Foreshore modification | - Australian Coastal Smartline (shore type)  
- Marine Structures Assessment Project  
- Marine infrastructure  
- Managed marine facilities  
- Planning Special Areas  
- Inferred from local knowledge and inspection of aerial imagery | - Geoscience Australia, October 2009  
- DPIPWE, September 2009  
- Tasmania Parks and Wildlife Service, December 2009  
- MAST, September 2009  
- DPIPWE, September 2009  
- Imagery supplied by NRM North, September 2009. Additional imagery from Google Earth. |
|                 |                | Use of foreshore and immediate backshore by off-road vehicles | - thelist_transportsegments  
- Shore type  
- N and NW Coast Assets  
- Inference from local knowledge and research | - DPIPWE, December 2009  
- C. Sharples (TascoastgeoV6), September 2010  
- Tasmania Parks and Wildlife Service, December 2009  
- Including A. Davey, pers. comm., September 2010 |
|                 |                | Beach grooming | - Grooming activities  
- Australian Coastal Smartline (shore type)  
- Literature search | - King Island Council, November 2009  
- Geoscience Australia, October 2009 |
|                 |                | Removal of wrack, rock or sand | - Collection information  
- Mining leases  
- Literature search | - King Island Council, November 2009  
- Mineral Resources Tasmania, November 2009 |
|                 |                | Presence of foreshore weeds | - Beach weed distribution  
- Beach weed distribution  
- Natural Values Atlas  
- Coastal Values Mapping  
- Sea spurge distribution | - SPRATS, December 2009  
- State of the Environment Reporting, Department of Justice, August 2009  
- DPIPWE, July 2009  
- North Barker Ecosystem Services, April 2010  
- Campbell-Ellis, 2009 |
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<td>HABITAT REMOVAL</td>
<td>Pressure</td>
<td>Disturbance of tidal wetlands / saltmarshes</td>
<td>− TASVEG 2.0&lt;br&gt;− Conservation of Freshwater Ecosystem Values (CFEV)</td>
<td>− DPIPWE, May 2009&lt;br&gt;− DPIPWE, September 2010</td>
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<td>Occurrence of dredging and/or extraction activities in the intertidal zone</td>
<td>− Mining leases&lt;br&gt;− Dredging activities&lt;br&gt;− Dredging activities&lt;br&gt;− Inferred from local knowledge, literature search and personal communications</td>
<td>− Mineral Resources Tasmania, November 2009&lt;br&gt;− MAST, July 2009&lt;br&gt;− TasPorts, August 2009&lt;br&gt;− Including C. Rees pers. comm., July 2009</td>
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<td>Change in seagrass extent</td>
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<td>LITTER</td>
<td>Pressure</td>
<td>Boat moorings</td>
<td>− Marine structures assessment project&lt;br&gt;− Managed marine facilities&lt;br&gt;− Planning Special Areas&lt;br&gt;− Inferred from literature searches, local knowledge and inspection of aerial imagery</td>
<td>− DPIPWE, September 2009&lt;br&gt;− MAST, September 2009&lt;br&gt;− DPIPWE, September 2009&lt;br&gt;− Imagery supplied by NRM North, September 2009. Additional imagery from Google Earth.</td>
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<td>− Population by census collecting district</td>
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<td>Pressure</td>
<td>Recreation and tourist use</td>
<td>− Land use</td>
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<td>− C. Sharples (TascoastgeoV6), September 2010</td>
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<td>− Foreshore structures</td>
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<td>− Community Facilities</td>
<td>− DPIPWE, September 2009</td>
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<td>− Building_Points</td>
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<td>− Building_Polys</td>
<td>− DPIPWE, September 2009</td>
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<td>− Planning zones</td>
<td>− DPIPWE, September 2009</td>
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<td>− Inference from local knowledge and research</td>
<td>− Including A. Davey, pers. comm., September 2010</td>
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<td></td>
<td>Pressure</td>
<td>Proximity to stormwater outflow</td>
<td>− Hydrological data (Hydstra)</td>
<td>− DPIPWE, September 2010</td>
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<tr>
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<td></td>
<td>− Stormwater outflows</td>
<td>− Waratah Wynyard Council, December 2009</td>
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<td>Condition</td>
<td>Presence of litter</td>
<td>− Southwest Tasmania Marine Debris Cleanup data</td>
<td>− Surfrider Tasmania, May 2010</td>
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<td>− Literature search</td>
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<td><strong>NUTRIENTS</strong></td>
<td>Pressure</td>
<td>Agriculture within immediate backshore area</td>
<td>− TASVEG 2.0</td>
<td>− DPIPWE, May 2009</td>
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<td>Proximity to finfish aquaculture operations</td>
<td>− Marine Leases</td>
<td>− DPIPWE, December 2009</td>
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<td>− Land use</td>
<td>− Australian Land Use and Management (ACLUMP), October 2009</td>
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<td>− Marine Structures Assessment Project</td>
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</table>
| NUTRIENTS        | Pressure       | Occurrence of STP overflow events           | - WWTP locations  
<pre><code>              |                             |                                                                             | - National Pollution Inventory, September 2010                 |
</code></pre>
<p>|                  |                |                                             | - Facility Emissions Data                                                        | - DPIPWE, September 2009                                      |
|                  |                |                                             | - Hydrological data (Hydstra)                                                    | - Australian Land Use and Management (ACLUMP), October 2009    |
|                  |                |                                             | - Assets (sewage)                                                               |                                                                  |
|                  |                |                                             | - Literature search                                                             |                                                                  |
|                  |                | Proximity to WWTP discharge                | - WWTP locations and discharge                                                  | - DPIPWE, September 2009                                      |
|                  |                |                                             | - Facility Emissions Data                                                       | - National Pollution Inventory, September 2010                 |
|                  |                |                                             | - Hydrological data (Hydstra)                                                    | - DPIPWE, September 2010                                      |
|                  |                |                                             | - Land use                                                                      | - Australian Land Use and Management (ACLUMP), October 2009    |
|                  |                |                                             | - Assets (sewage)                                                               | - Tasmanian Parks and Wildlife Service, December 2009         |
|                  |                | Proximity to stormwater outflow            | - Hydrological data (Hydstra)                                                    | - DPIPWE, September 2010                                      |
|                  |                |                                             | - Stormwater outflows                                                           | - Waratah Wynyard Council, December 2009                      |
|                  |                | Proximity to nutrient point source discharge| - Facility Emissions Data                                                        | - National Pollution Inventory, September 2010                 |
|                  |                |                                             | - Level 2 output                                                                | - DPIPWE, September 2009                                      |</p>
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| NUTRIENTS| Pressure       | Presence of septic tanks                  | − WWTP locations and discharge  
− Facility Emissions Data  
− Hydrological data (Hydstra)  
− Land use  
− Assets (sewage)  
− Community Facilities  
− Building_Points  
− Building_Polys  
− Literature search | − DPIPWE, September 2009  
− National Pollution Inventory, September 2010  
− DPIPWE, September 2010  
− Australian Land Use and Management (ACLUMP), October 2009  
− Tasmanian Parks and Wildlife Service, December 2009  
− DPIPWE, September 2009  
− DPIPWE, September 2009  
− DPIPWE, September 2009 |
|          |                | Boat moorings                             | − Marine structures assessment project  
− Managed marine facilities  
− Planning Special Areas  
− Inferred from literature searches, local knowledge and inspection of aerial imagery | − DPIPWE, September 2009  
− MAST, September 2009  
− DPIPWE, September 2009  
− Imagery supplied by NRM North, September 2009. Additional imagery from Google Earth. |
| Condition| Ammonia in water| Not supported                             |                                                                                   |                          |
|          | Chlorophyll-a in water| Not supported                             |                                                                                   |                          |
|          | Organic nitrogen in water| Not supported                             |                                                                                   |                          |
|          | Total nitrogen in water| Not supported                             |                                                                                   |                          |
|          | Total phosphorus in water| Not supported                             |                                                                                   |                          |
|          | Oxidised nitrogen (NOx) level in water| Not supported                             |                                                                                   |                          |
|          | Filterable Reactive Phosphate in water (FRP)| Not supported                             |                                                                                   |                          |
| Vulnerability| Dilution rate| Tidal range (1 km resolution)  
− Australian Coastal Smartline (exposure)  
− Tasmanian estuaries | − M. Lacey (Blue Wren Group) from National Tidal Centre data, July 2010  
− Geoscience Australia, October 2009  
− theLIST, 2006 |
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<td>pH</td>
<td>Pressure</td>
<td>Presence of acid sulphate soils and level of disturbance</td>
<td>− ASS Atlas</td>
<td>− DPIPWE, May 2010</td>
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<td>− LIST_Hydroline</td>
<td>− DPIPWE, May 2009</td>
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<td>− TASVEG 2.0</td>
<td>− DPIPWE, May 2009</td>
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<td>Condition</td>
<td>Minimum sustained pH values</td>
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<td>Vulnerability</td>
<td>Dilution rate</td>
<td></td>
<td>− Tidal range (1 km resolution)</td>
<td>− M. Lacey (Blue Wren Group) from National Tidal Centre data, July 2010</td>
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<td>− Australian Coastal Smartline (exposure)</td>
<td>− Geoscience Australia, October 2009</td>
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<td>− Tasmanian estuaries</td>
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<td>TOXICANTS</td>
<td>Pressure</td>
<td>Boating maintenance</td>
<td>− Marine structures assessment project</td>
<td>− DPIPWE, September 2009</td>
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<td>− Managed marine facilities</td>
<td>− MAST, September 2009</td>
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<td>− Planning Special Areas</td>
<td>− DPIPWE, September 2009</td>
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<td>− Assets (marine infrastructure)</td>
<td>− MAST, September 2009</td>
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<td>− Managed marine facilities</td>
<td>− DPIPWE, September 2009</td>
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<td>− Planning Special Areas</td>
<td>− Royal Yacht Club of Tasmania, 2007</td>
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<td>− Imagery supplied by NRM North, September 2009. Additional imagery from Google Earth.</td>
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<td>Proximity to toxicant point source discharge</td>
<td>Facility Emissions Data</td>
<td>− Level 2 output</td>
<td>− National Pollution Inventory, September 2010</td>
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<td>− M. Lacey (Blue Wren Group) from National Tidal Centre data, July 2010&lt;br&gt;− Geoscience Australia, October 2009&lt;br&gt;− theLIST, 2006</td>
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