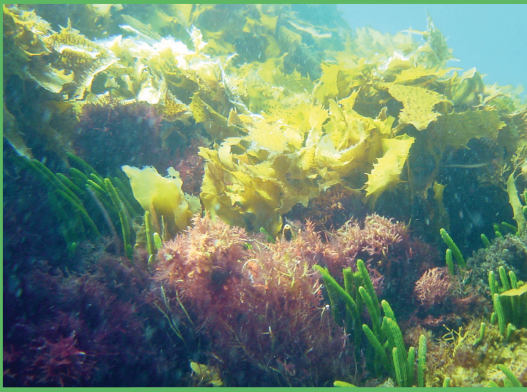
Marine Habitat within Selected areas of the South East NRM Region

Final Report to the South East Natural Resources Management Board for the program: Sustaining Marine Biological Health



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Government of South Australia

Department for Environment and Heritage

South East Natural Resources Management Board

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December 2009

Coast and Marine Conservation Branch

Department for Environment and Heritage

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1 Executive overview

Under the *Natural Resources Management* (NRM) *Act 2004*, NRM boundaries include all State waters. Therefore, NRM planning and programming must provide for the ecologically sustainable use of marine environments.

Measuring the effects of human activities in marine environments requires the establishment of baseline datasets, including habitat mapping, against which specific threats and condition targets can be measured and assessed. There is currently a paucity of this kind of information on benthic marine systems within the SE NRM region. Habitat mapping currently available is at a scale of 1:100,000, which does not provide adequately for the management needs of NRM Boards.

In 2006, the Department for Environment and Heritage (DEH) was engaged to undertake a program to address this knowledge gap. This included a broad scale marine habitat mapping program at a resolution more suited to local management needs and the collection of baseline biodiversity data for the South East (SE) NRM region.

The mapping and underlying GIS data outlined in this report are a valuable resource for managers in the SE NRM region. They provide a critical baseline against which future changes can be measured. This report also includes recommendations for future monitoring and research. Information collected as part of the baseline biodiversity survey is reported in a separate document (Rowling *et al* in prep).

Detailed spatial mapping of seafloor habitats was conducted across four areas within the SE NRM region. These included Lacepede Bay (Kingston), Guichen Bay (Robe), Rivoli Bay (Beachport and Southend) and the Nene/Piccaninnie Biounits (Carpenters Rocks/Port MacDonnell area). These areas each have high economic, social and environmental value to the South East region.

This summary document forms part of a set of information which also includes:

- A detailed map book.
- An interactive Arc Reader package (which will serve as a basis for identifying monitoring and management requirements as well as a driver of basic research and an educational tool).
- A separate report by SARDI Aquatic Sciences which includes a summary of baseline biodiversity information from the lower South East region (Rowling *et al* in prep).

The area mapped (~740km^2) represents approximately 30% of the total marine environment encompassed by the SE NRM region. It provides a more highly resolved baseline dataset than was previously available on important coast and marine habitats adjacent to areas of population where threats are most likely to arise.

Reef habitat dominates each of the surveyed areas, with the only large seagrass beds occurring in Lacepede Bay (Kingston). However, there is mounting evidence of a substantial loss of seagrasses in Rivoli Bay as well as other areas associated with large scale freshwater drainage (see Wear *et al.* 2006). Those remaining areas of seagrass are of critical importance to a coast that is otherwise dominated by reefs. A greater understanding of the spatial extent and magnitude of threats to marine systems should be developed, with particular reference to water quality.

Reef cover is substantial on the SE NRM coast, but there is a lack of data on the factors that structure reef systems in this region, with particular regard for nutrient-rich, cold-water upwellings.

2 Background

It is widely accepted that sustainable management of natural assets should be approached at a holistic systems-level rather than that of individual species. This approach recognises the interconnectivity within and between habitats such that factors that may directly affect one species will have flow on effects to the rest of the system (e.g. Fairweather 1999, GESAMP 2001, Allee *et al.* 2000, Flaherty and Sampson 2005). Management at broader ecosystem scale has a number of advantages (Fairweather 1999, GESAMP 2001, Flaherty and Sampson 2005) including (amongst others):

- Recognition that many environmental stress factors are non-specific.
- Broader understanding of the ecosystem effects that may result from exploitation of a resource, with concomitant realignment of what might constitute "sustainability".
- Management and monitoring strategies are more efficient.
- Ecosystems scale data will present the integrated impact of a number of anthropogenic and natural stress factors.
- A greater understanding of the natural dynamics and processes of systems, particularly at larger scales.
- Understanding that environmental threats are now recognised as operating at very large spatial scales including regional (i.e. urbanisation and habitat fragmentation), national (i.e. catchment degradation) and global levels (i.e. climate change).
- Local scale issues (e.g. fisheries, water pollution, etc) may be placed within a broader biogeographic context (see Connell and Irving 2008).
- Providing a more effective, cohesive and consistent basis for engagement with all stakeholders that have interests in the system(s) concerned.

Note that a systems level approach to environmental resource management does not preclude or discount the targeted strategies required for rare, threatened and endangered species, or indeed the specific approaches required for high priority pests.

Within the framework of large scale monitoring, there is a concomitant need to increase our understanding of the physical and biological factors that structure ecosystems and to identify areas of high biodiversity. Understanding spatiotemporal variability and biodiversity differences within systems across a range of scales leads to:

- An increased understanding of the ecosystem services provided by the resource, which may lead to improved engagement with stakeholders.
- A capacity to prioritise monitoring and management interventions on areas of high biodiversity.
- More efficient application of conservation/multiple use strategies.
- Identification of specific threats.
- The development of a notion of ecosystem "health" within the context of the broader habitat type (i.e. subtidal reef systems see Turner *et al.* 2007).

The Australian Government's Natural Heritage Trust (NHT) funded mapping of the upper Gulf St Vincent and Spencer Gulf areas in 2005, and the Adelaide Mount Lofty region between 2005 and 2008. Following this work funding was secured through the NHT strategic reserve to extend mapping and biodiversity work in the Yorke Peninsula Natural Resource Management (NRM) region and to begin mapping of the South East (SE) NRM region, through an existing partnership project with South Australia's Department for Environment and Heritage (DEH). In the SE NRM region this project was developed to produce a detailed spatial Geographic Information System (GIS) layer of seafloor habitats across four zones. These included large areas off the coast at Kingston (Lacepede Bay), Robe (Guichen Bay), Beachport (Rivoli Bay) and a large stretch of coastline in the Carpenter Rocks-Port Macdonnell area.

Work associated with this project included an update of previously available broad scale (southern Australia) marine benthic habitat maps produced by CSIRO, covering the inshore waters within these areas at a spatial scale relevant to regional management issues. The survey protocol and marine habitat definitions used in this project were aligned with those being developed elsewhere in Australia, with the aim of developing habitat maps that will fit within a broader national framework. In addition, as part of this funding an extensive biodiversity survey of the SE NRM area was carried out by SARDI Aquatic Sciences and will be reported in a separate document.

Effective large-scale marine management requires a capacity to obtain data on changes in systems at large spatial scales. Marine benthic habitat mapping offers a cost effective approach to obtaining data on shallow (< 20 m) nearshore systems. Further, the development of a hierarchical approach to habitat differentiation has resulted in a framework for mapping that is readily repeatable, consistent at the national scale and encompasses the capacity to incorporate additional data.

Within the SE NRM region, large-scale marine habitat assessment capability would greatly assist the development of State of the Region reporting as well as Monitoring, Evaluation and Reporting Frameworks (see AMLR NRM 2008). However, while there is a need for large-scale baselines, there is also a need to identify, monitor and manage smaller scale biodiversity and conservation "hotspots", understand spatiotemporal variability and identify the physical environmental drivers that structure marine systems across a range of spatial and temporal scales. This knowledge allows for ready identification of threats and appropriately targeted management responses.

Although the SE NRM region is included within the Flindersian Province it includes a number of unique transitional aspects as one moves east which, along with nutrient-rich cold-water upwellings, make a substantial contribution to marine productivity, nutrient cycling and habitat diversity within this zone (Edyvane 1999b). In addition, areas of the SE NRM coast, particularly the Canunda Biounit, are notable for persistent moderate to high wave energy (Short and Hesp 1984). The SE NRM coasts therefore present a number of unique aspects and challenges for marine benthic monitoring and management relative to other South Australian NRM regions.

This report describes a process of marine habitat mapping for the SE NRM region, including three main aspects:

- Marine management regions, broadscale marine observations and mapping in the SE NRM region, including what is understood with respect to risks to nearshore systems.
- A brief summary of the results of recent marine habitat mapping within four large areas within the region.
- Links between results of mapping relative to earlier benthic surveys as well as risks.

This document is analogous to similar reports related to marine habitat mapping developed for the Adelaide and Mount Lofty Ranges NRM Board (DEH 2009a), Northern and Yorke NRM Board (Miller *et al* 2009a) and the Eyre Peninsula NRM Board (Miller *et al* 2009b). The structure of these documents and portions of the text related to marine management areas and habitat mapping are therefore similar if not identical, as they deal with the same source material in many instances. While it is certainly feasible to reference this material to the companion documents in such instances, it was felt by the authors that every effort should be undertaken to ensure each report formed a "stand alone" entity.

2.1 Aims

The aims of this study were thus to:

- Establish baselines for coast, marine and estuarine biodiversity that will enable monitoring of changes in resource condition within the SE NRM region.
- Develop marine habitat mapping at scales relevant to management for four areas within the SE NRM region.
- Generate map books at a scale of 5 × 5 km and an interactive DVD of benthic habitat maps and other relevant GIS information layers.

This document summarises the management frameworks, approaches and history of habitat mapping for the purposes of natural resource management in the SE NRM region. The summary covers four areas related to marine environmental management including:

- Current and planned marine management regions within the SE NRM region.
- The history of habitat mapping within the region.
- Large scale habitat characterisation and comparison studies in reef, seagrass and soft bottom systems that might support habitat mapping.
- What is known regarding risks to coast, estuarine and marine systems within the SE NRM region.

From a mapping perspective this document includes:

- A brief summary of the mapping methodology, including ground truthing approaches.
- Some summary statistics of the results of the mapping, including areas that may be of further interest for marine managers.

3 Marine habitat mapping and broad scale surveys in the South East NRM region

Southern Australian nearshore marine systems are widely regarded for their high complexity, diversity and levels of endemism (e.g. Keough and Butler 1995, Edyvane 1999a, Connell 2007). Development of sustainable management strategies for these systems therefore presents a challenge (Turner *et al.* 2007), particularly in light of the broad range of potential or actual threats and given (Edyvane 1996, Baker 2004, FAO 2003, Flaherty and Sampson 2005, NY NRM 2008):

- A lack of historical/baseline data on marine systems in most instances.
- A diverse array of stakeholders competing for access to a range of overlapping resources.
- The physical difficulties and logistics of obtaining data in the marine environment at scales relevant to managers across a vast and often isolated coastline.

Broadscale habitat mapping has been a key feature of NRM in terrestrial systems, but has increasingly been applied to coast, estuarine and marine environments - although there is a concomitant need to develop a unified classification system (DEH 2007a, Mount *et al.* 2007). Baker (2004) describes a diverse group of marine benthic habitats from southern Australia:

- Estuaries.
- Freshwater outputs (overlaps with estuaries).
- Tidal flats.
- Beaches.
- Saltmarsh and samphire.
- Mangroves.
- Seagrass meadows.
- Reefs.
- Benthic sand habitats.
- Shallow and deep water sponge “gardens”.
- Benthic mud habitats.
- Island habitats.
- Mixed assemblages and gradients between broader habitat groups.

Most of the above are thought to occur within the SE NRM region, although differences in classification add a degree of confusion to interpreting the available information. For example, the Estuaries Information Package (DEH 2007a) for the SE NRM region describes floodplains, saltmarsh/samphire communities and intertidal mudflats whereas the Bryars (2003) inventory of fisheries habitats suggest that tidal creeks, tidal flats and saltmarsh do not occur. However, both reports state that mangroves do not occur within the SE NRM region. Lack of consistency in designation of habitat types may have serious implications for coastal management.

The SE NRM coast, like the rest of Southern Australia, is included within the Flindersian Province (Edyvane 1999a, b). However, the region includes the Maugean Subprovince that comprises the waters east of Robe that are noted for being slightly cooler and supporting a mildly different suite of species where cold-water, nutrient-rich upwellings (Lewis 1981) are thought to make a substantial contribution to marine productivity, nutrient cycling and habitat diversity (Edyvane 1999b). In addition, areas of the SE NRM coast, particularly the Canunda Biounit, are notable for persistent moderate to high wave energy with rare calm or low swell days (Short and Hesp 1984) relative to other South Australian Biounits (Edyvane 1999b). The resultant surge and limited visibility has severely inhibited marine research and monitoring (see Shepherd 1979). The SE NRM coast presents a number of unique aspects and challenges for marine benthic monitoring and management relative to other South Australian NRM regions.

3.1 Marine management regions

Marine habitat management regions within the SE NRM region comprise:

- IMCRA Bioregions.
- Edyvane (1999a, b) biounits.
- Marine Planning Areas.
- Marine Protected Areas.

It is worth noting that Australian NRM zones are largely based on terrestrial catchments, bioregions or State Government management boundaries (Australian Government, http://www.nrm.gov.au/nrm/region.html, Accessed April 2009, Planning South Australia, http://www.planning.sa.gov.au/go/SAGovernmentRegions, Accessed April 2009). The marine borders for NRM regions have no relationship to IMCRA bioregions and similar. For this reason, bioregions and biounits often overlap NRM marine boundaries.

3.1.1 Bioregions

The Integrated Marine and Coastal Regionalisation of Australia (IMCRA Version 4.0; Commonwealth of Australia 2006) classification places three coastal and two offshore provincial regions that occur to some extent within South Australia with the SE NRM region, including areas from the Spencer Gulf IMCRA Province and the Western Bass Strait IMCRA Transition (Commonwealth of Australia 2006). Mesoscale bioregions (that include the coastal regions defined under IMCRA Version 3.0) include eight coastal areas either wholly or partly within South Australia, two of which occur to some degree within the SE NRM region (Figure 1):

- Coorong – cool temperate, low grading to high energy coastline; and
- Otway – cool temperate, subject to nutrient rich upwellings with steep to moderate offshore gradients and generally high wave energy.

For full descriptions of these areas, including information on climate, oceanography, geology and geomorphology, biota and estuaries, see IMCRA Technical Group (1998).

Figure 1 - Map of the SE NRM region showing Bioregions, Biounits and the areas covered in the current benthic habitat mapping.

3.1.2 Biounits

Marine biounits, based on CSIRO habitat mapping (1:100,000 scale) and the work undertaken by Edyvane (1999a, b) comprise 35 areas along the South Australian coast to a depth of around 50 m. There are four Edyvane (1999a, b) biounits that occur wholly or partly within the SE NRM region (Figure 1).

Coorong

This large (1,290,715 ha) biounit is characterised by a gradient of decreasing wave energy from the Encounter Bay area in the west to the Lacepede Bay in the east (~ 190 km of coast; Edyvane 1999b). The Coorong estuary and Murray Mouth are included within this biounit, providing a significant diversity of wetland habitats (Haig *et al.* 2006). Intertidal habitats are dominated by sandy beaches, although there are some rocky outcrops at the southeast end. Subtidal habitats (totalling 170,935 ha) include sandy bottom (44.2%), reefs (41.2%) and seagrasses (14.7%) (Edyvane 1999b). More exposed reef communities see the first occurrence of bull kelp (*Macrocystis angustifolia*) and giant kelp (*Durvillea potatorum*) in South Australia (Edyvane 1999b) at Margaret Brock Reef (Cape Jaffa).

Canunda

The Canunda biounit (233,897 ha) is characterised by a range of wave energies (low to high) across its 140 km of coast (Edyvane 1999b). This biounit marks the beginning of significant nutrient-rich cold-water upwellings (see Lewis 1981) that make a significant contribution to local marine productivity (Edyvane 1999b). Intertidal habitats include rocky shores, bays and sandy beaches. Subtidal habitats (totalling 55,887 ha) include limestone reefs (90.5%), sandy bottom (9.5%) and a very small proportion (< 0.1%) of seagrass (Edyvane 1999b). However, it should be noted that Hart and Clarke (2002) found that much of the benthic community around Beachport that was identified as reef was actually seagrass. Nora Creina Bay to Stinky Bay has been recommended as an aquatic reserve (UEPG 1982).

Nene

The Nene biounit (32,543 ha) has roughly 36 km of highly convoluted and rugged coastline, including high energy low rise cliffs, limestone shore platforms and low energy shingle beaches (Edyvane 1999b). Intertidal habitats include rocky shores, sandy beaches and some estuarine areas. Subtidal habitats (10,215 ha) include limestone reefs (97.7%) and sandy bottom (2.3%), but virtually no seagrass (Edyvane 1999b).

Piccaninnie

The Piccaninnie biounit (44,923 ha) comprises around 24 km of coast that are largely comprised of sandy beaches and dune systems (Edyvane 1999b). Intertidal habitats include some limestone shore platforms, but mostly sandy bays and estuarine areas. Subtidal habitats (3,517 ha) include some reefs (19.2%) and seagrass (1.3%) but mostly comprise sandy bottom (79.6% Edyvane 1999b). Curiously the seagrass community within this region is reported to include *Posidonia coriacea* (as well as *P. australis* and *Amphibolis antarctica*; Edyvane 1999b), although Shepherd and

Robertson (1989) report that the eastern extent of this species is around Rivoli Bay (in the Canunda Biounit).

It must be noted that the above percentages relate to the total area mapped within each biounit rather than the area of the latter. For full descriptions of each biounit, see Edyvane (1999b), including information relative to (amongst others): biogeography, conservation values and status, fisheries, recreation and tourism, science, research and education as well as cultural and historical aspects.

IMCRA bioregions and/or Edyvane (1999a, b) biounits may be used as the first layer in defining areas/natural assets that may be of particular interest as well as the broader targeting of management activity (IMCRA Technical Group 1998, Baker 2004). Indeed, the IMCRA bioregions have played a role in the determination of Marine Protected Areas (DEH 2009b; see below). Similarly, biounits are employed as descriptive components of State of the Region reporting (e.g. AMLR NRM 2007, EP NRM 2008, NY NRM 2008). However, both regional classifications are based on integrated biogeographic data from a range of species groups as well as related geomorphological and physical environmental factors. These regions are therefore difficult to relate to specific areas/habitat types that may require targeted management intervention. Furthermore, most of the stress factors (or threats – see discussion) identified for marine systems relate to habitat destruction and water quality issues that are generally concentrated in the near shore fringe (Bryars 2003, AMLR NRM 2007) at smaller scales than either unit can readily resolve.

3.1.3 Marine protected areas

Marine Protected Areas (MPAs) are a major marine environmental management and conservation initiative within South Australia. Designation of MPA areas was based on 14 design principles that include biological, social and cultural aspects (DEH 2009b). The system of 19 MPAs spread across the South Australian coast will form a key mechanism for the protection and conservation of marine biodiversity as well as cultural and historical values within a framework that will allow for ecologically sustainable development of marine resources. The associated management and monitoring strategies thus have important implications for NRM throughout the state.

There are two MPAs that occur wholly within the SE NRM region (DEH 2009b):

- Park 18 Upper South East Marine Park.
- Park 19 Lower South East Marine Park.

Although MPA outer boundaries have been proclaimed, each requires further development in terms of internal multiple-use zoning, associated management plans and development of Performance Management Systems that will likely include some level of physical environmental and/or biological monitoring (NY NRM 2008, DEH 2009b). Zoning for Marine Parks in SA will include four types of internal zones plus provision for establishing special purpose areas (Marine Parks Act 2007; http://www.legislation.sa.gov.au/LZ/C/A/MARINE%20PARKS%20ACT%202007/CURRENT/2007.60.UN.PDF). These zones/areas are defined as follows:

- **General managed use zones** - zones established so that an area may be managed to provide protection for habitats and biodiversity within a marine park, while allowing ecologically sustainable development and use.

- **Habitat protection zones** – zones established so that an area may be managed to provide protection for habitats and biodiversity with a marine park, while allowing activities and uses that do not harm habitats or the functioning of ecosystems.
- **Sanctuary zones** - zones established so that an area may be managed to provide protection and conservation for habitats and biodiversity within a marine park, especially by prohibiting the removal or harm of plants, animals or marine products.
- **Restricted access zones** - zones established so that and area may be managed by limiting access to the area.
- **Special purpose areas** - areas within a marine park with boundaries defined by the management plan, in which specified activities, that would otherwise be prohibited or restricted as a consequence of the zoning of the area, will be permitted under the terms of the management plan.

3.2 Habitat mapping

Relative to elsewhere in South Australia, the SE NRM region has limited historical data on benthic habitats. As with the rest of the South Australian coast there is the CSIRO 1:100,000 benthic habitat maps that were used by Edyvane (1999a, b) to develop biounit designations (see above), but otherwise the available information is limited in terms of both mapping as well as potential ground truthing observations.

Haig *et al.* (2006) considered a range of acoustic mapping and ground truthing observations within the region between Goolwa and an area known as "The Granites" about 45 km north of Cape Jaffa. Some of the area considered therefore occurs within the adjacent SA Murray Darling Basin NRM region. Acoustic observations included both single beam, dual frequency as well as dual beam wide swath bathymetry transects perpendicular to the coast to a depth of 30 m or the limit of State waters (whichever came first). Ground truthing comprised a mixture of video and SCUBA observations as well as benthic sediment grabs. In addition to some wide ranging summaries of species occurring within the survey area, this investigation considered 10 broad habitat types;

- Low platform reef, densely vegetated.
- Low platform reef, sparsely vegetated.
- Complex reef, densely vegetated.
- Vegetated sand.
- Sand, fine to medium grain size.
- Sand, shell grit present.
- Sand, fine silted.
- Sand, unclassified texture.
- Seagrass and.
- Unclassified substrates.

Transitions between different habitat types were only reported within individual transects rather than extrapolated between observations (Haig *et al.* 2006), which suggests either a lack of resolution in terms of the number of observations (15 transects across ~ 100 km of coast) and/or an overly complicated suite of habitat types. Even within transects, differences between habitat types are somewhat difficult to interpret. The results of this survey may therefore be useful in terms of ground truthing other observations, but are not in themselves particularly comprehensive in terms of spatial coverage.

3.2.1 Fisheries habitat areas

An inventory of benthic habitats that are important for fisheries was undertaken by Bryars (2003) through an assessment of coastal near shore assets across South Australia (up to 20 m depth or 3 km offshore – whichever came first). This summary classified benthic communities relative to 13 basic habitat types (that included the associated overlying pelagic component):

- Reef.
- Surf beach.
- Seagrass meadow.
- Unvegetated soft bottom.
- Sheltered beach.
- Tidal flat.
- Tidal creek.
- Estuarine river.
- Coastal lagoon.
- Mangrove forest.
- Saltmarsh.
- Freshwater spring.
- Artificial habitats.

Habitat areas were only included if they were relatively large and/or significant to local fisheries. The depth/distance limit employed in this survey was based on a lack of data on deepwater systems as well as the view that shallow near shore areas were most threatened. The Bryars (2003) inventory was used to define 62 Fisheries Habitat Areas (FHAs) across the South Australian coast, including six within the SE NRM region that include many of the above habitat types except Tidal flat, Tidal creek, Mangrove forest, Saltmarsh and Artificial habitats (Appendix A).

Sustainable management of commercial and recreational fisheries is a critical element of marine NRM. However, the consideration of habitats in terms of their importance to fisheries may discount other values. For example, a large area of reef may support a number of fisheries relative to small, isolated outcrops, but the latter may be critically important in terms of biodiversity/conservation at local scales. In addition, the resolution of habitats within this assessment would appear to be too coarse to determine anything other than major changes through time. This issue may be compounded by the overlapping of some of the habitat types (Appendix A).

3.2.2 Other marine benthic habitat mapping

Alternative sources of information on benthic habitats might be obtained from environmental impact assessments and monitoring associated with current and proposed coastal developments including (among others):

- Marinas.
- Jetty and port facilities.
- Aquaculture zoning.
- Housing developments.
- Stormwater and wastewater outfalls (see Shepherd 1979).
- Desalination plants.
- Specific "one off" events (natural disasters, oil spills, etc).

There is a diverse array of "grey" literature associated with the above, the availability of which and relevance in support of benthic habitat mapping is variable.

3.2.3 Coastal vegetation mapping

The "Biological Survey of South Australia" database (DEH, http://www.environment.sa.gov.au/biodiversity/ecological-communities/biosurveys.html#surveys, Accessed April 2009) provides a nationally consistent approach to vegetation classification called the National Vegetation Information System (NVIS), with more than 9000 distinct habitat types based on the vegetation and physical environmental data (DEH 2006, DEWR 2007). Part of the South Australian biological survey includes a state-wide investigation into coastal, dune and cliff top vegetation that employed 22 broad vegetation types (Oppermann 1999). A similar survey of saltmarsh and mangrove habitats was completed by Canty and Hille (2002) and included 69 habitat codes based on a five-tiered classification system using landform, estuarine influence, degree of inundation, vegetation cover and integrity.

Extensive habitat mapping within the Coorong and Lower Lakes (Seaman 2003) includes detailed data on the distribution and status of wetland habitats within this Ramsar location. The resulting GIS database was developed with the aim of providing a planning tool for government, community and industry sectors.

Nine estuaries have been identified within the SE NRM region ranging from Salt Creek to the Glenelg River on the South Australia–Victoria border (DEH 2007b). Detailed descriptions of each estuary relative to physical environment (catchment area, flows, etc.), habitats, bird and fish species, protection arrangements, cultural assets, economic importance, activities and pressures are presented in the Estuaries Information Package for the SE NRM region (DEH 2007b).

3.2.4 Satellite imagery

Much of the following is based on a summary developed for Gulf St Vincent (see Petrusevics 2008) but should nonetheless be valid for most, if not all, of the South Australian coast.

Satellite remote sensing has provided almost daily data (cloud permitting) on oceanographic, meteorological and hydrodynamic data at a resolution of ~ 1 km^2 since the 1970s (Petrusevics 2008). A range of observational datasets is available from a succession of satellites, with varying degrees of emphasis on either sea surface temperature or visible light imagery including:

- Very High Resolution Radiometer (VHRR) – 1972 – 1978.
- Coastal Zone Color Scanner (CZCS) – late 1970s.
- Advanced Very High Resolution Radiometer (AVHRR) – 1978 – 1984.
- Sea-viewing Wide Field-of-view Sensor (SeaWiFS) – 1979 – 2004 .
- Moderate Resolution Imaging Spectrometer (MODIS) *Aqua* and *Terra* – from 2000.

3.2.5 Other potential data sources and GIS layers

Analysis and interpretation of GIS based habitat mapping would benefit from access to a range of additional information and/or layers related to a range of features including (among others):

- Infrastructure (shipping channels, jetties, breakwaters, etc).
- Coastal inputs (outfalls, rivers and stream).
- Tourist attractions (recreational beaches, boating/fishing or SCUBA diving areas, etc.).
- Aquatic and coastal reserves.
- Local and state government planning regions.
- Hydrodynamic modelling.

There are a variety of sources available for this type of information, generally at the state level, including :

- The extensive list of GIS layers summarised by Caton *et al.* (2007) as part of "Conservation Assessment of the Northern and Yorke Coast", many of which have relevance across the state.
- Atlas of South Australia (http://www.atlas.sa.gov.au/ - Coastal Management Area, accessed May 2008).
- South Australian Waters: an Atlas and Guide (Boating Industry Association of South Australia 2008).
- A number of management strategies developed by the Coastal Protection Board related to acid sulphate soils, coastal weeds, coastal erosion and beach monitoring (see http://www.environment.sa.gov.au/coasts/management.html, accessed March 2009).
- Fisheries stock assessments.
- Aquaculture monitoring (see below).
- Non-mapping environmental monitoring and research.

3.2.6 Aquaculture monitoring

All marine-based aquaculture in South Australia is required to maintain a level of environmental monitoring as part of licensing (Aquaculture Regulations 2005). This monitoring may form an information resource on benthic systems and water quality at the local scale, although there may be confidentiality/intellectual property issues. There are lease areas designated for Atlantic salmon sea cage farming in Lacepede Bay (http://outernode.pir.sa.gov.au/aquaculture/aquaculture_industry/marine_finfish, Accessed April 2009) but they may not be currently active.

There does not appear to be any SA Shellfish Quality Assurance Program monitoring regions within the SE NRM region, although there is one on the adjacent Murray Darling Basin NRM coast (http://www.pir.sa.gov.au/aquaculture/monitoring__and__assessment/sasqap, Accessed April 2009).

3.3 Reef systems

Reef systems in the SE NRM region are extensive, diverse and critically important to coastal productivity, particularly given the apparently low relative seagrass cover (Edyvane 1999b).

There is little doubt that the occurrence of cold, nutrient-enriched upwellings (Lewis 1981) and the occurrence of the large "kelps", *Durvillea pototorum* and *Macrocystic angustifolia*, within the SE NRM region play an important role in terms of both marine productivity and habitat diversity (Edyvane 1999b, Baker 2004). Indeed, the marine community from all waters east of Robe are considered as the Maugean Subprovince within the broader Flindersian Province that encompasses the entire southern Australian coast (Edyvane 1999b). However, benthic surveys, particularly on exposed rocky coasts, are problematic within much of the region, owing to high wave energy that results in substantial surge and/or very poor visibility (Shepherd 1979, Short and Hesp 1984, Edyvane 1999b

The spatial coverage of reef systems within the SE NRM region has been overstated by errors in earlier marine benthic habitat mapping (see Hart and Clarke 2002), but this does not mean that reefs are not extensive as well as biologically, economically and culturally important. The SE NRM region is thought to maintain reef and macroalgal communities that are amongst the richest in the world (Edyvane 1999b, Baker 2004). However, sea conditions along most of this coast are persistently rough (Shepherd 1979, Short and Hesp 1984), making SCUBA-oriented observations (along the lines of Turner *et al.* (2007) reef health or the Edgar and Barrett (1997, 1999) biodiversity surveys) highly problematic. There is thus a general lack of data on the composition and structure of these systems within the SE NRM region relative to reefs elsewhere in South Australia.

Surveys of Cape Northumberland reefs were conducted by Shepherd (1979) relative to the commissioning of a sewage outfall using towed diver observations and destructive harvests to determine the structure of reef systems relative to depth. Apart from shallow water bull kelp (*Durvillea pototorum*) to around 4 m (up to 12 m) depth on highly exposed areas and giant kelp (*Macrocystis angustifolia*) spanning a depth range from 13-25 (with scattered individuals up to 38 m) depth, this survey described three other macroalgal assemblages that Edyvane (1999b) suggested were probably typical of the lower south east coast:

- Red macroalgae with scattered larger brown species from 4-10 m depth.
- *Ecklonia radiata*/red macroalgal community from 10-15 m up to 30 m depth.
- Deep water sparse red macroalgae extending from 30-38 m up to ~ 60 m depth.

More detailed investigation of the composition and/or status of reef systems on the SE NRM coast are required to ascertain the composition of reef systems with respect to physical environmental gradients, or the status of reefs with respect to potential or actual threats. Unlike the AMLR NRM and NY NRM regions there have been no Reef Health surveys along the line of those summarised by Turner *et al.* (2007).

There are no observations for the SE NRM from the community monitoring group Reef Watch (http://www.reefwatch.asn.au/, Accessed March 2009).

3.4 Seagrasses

Mapping, site comparison or monitoring of seagrasses on the SE NRM coast is rather limited. The Shepherd and Robertson (1989) summary of seagrasses in South Australia suggests that much of the SE NRM coast, notably areas around Port MacDonnell, Rivoli Bay and Guichen Bay, is dominated by *Posidonia australis* with mixed assemblages around Lacepede Bay. Shepherd and Robertson (1989) also reported that a number of common seagrass species reach the limit of their eastern distribution within this stretch of coast, including:

- *Amphibolis griffithii* which occurs no further east than Encounter Bay
- *Posidonia sinuosa* which occurs no further east than Lacepede Bay
- *Posidonia coriaea* and *Posidonia denhartogii* which occur no further east than Rivoli Bay and
- *Posidonia angustifolia* which occurs no further east than Port MacDonnell.

The Coorong has been reported to support a number of seagrass/hallophilic species, including *Lepileana cylindricacea, Ruppia megacarpa* and *Zostera muelleri* (Shepherd and Robertson 1989), although the current salinity levels in the southern lagoon appear to have surpassed the tolerances of almost all macrofauna (Dittman *et al.* 2006).

Seagrass loss from the coastal waters off Beachport (Rivoli Bay) noted by Fotheringham (2000) was investigated by Hart and Clarke (2002) and then expanded by Seddon *et al.* (2003). The latter included video and SCUBA observations as well as acoustic mapping in conjunction with orthorectified aerial images from 1951 to 1997. Most of the seagrass loss from the area (~ 28.7 ha) would appear to be *Posidonia coriacea*, with the remaining population (~ 7.7 ha) comprising a mixture of *P. angustifolia, Heterozostera tasmanica* and *Amphibolis antarctica*. The decline would appear to be cyclical, related to the loss of adjacent seagrass exposing the remainder to high wave energy with an erosion scarp progressing landwards since the 1970s (Hart and Clarke 2002, Seddon *et al.* 2003). However, the primary cause was suggested as being the expansion of the "Drain M" system from the late 1940s through to the 1960s, resulting in turbid, nutrient rich freshwater being ejected into the vicinity (Seddon *et al.* 2003). However, the authors are quick to note that while there is substantial evidence for the role of nutrients and turbidity in seagrass loss (see Fox *et al.* 2007 for a summary of the causes for seagrass loss on the Adelaide metropolitan coast), there are no historical water quality data for Drain M in support of this inference. Seddon *et al.* (2003) mapped the benthic community in the area around the Beachport Jetty according to six habitat types:

- Raised *Posidonia* beds
- Fibre mat
- Mixed assemblages on fibre mat
- Sparsely populated sand
- Mixed assemblages on sand.
- Reef.

Most areas attributed to seagrass loss are now bare sand. It is worth noting that Seddon *et al.* (2003) suggested that seagrass loss around Beachport would continue.

The Hart and Clarke (2002) and Seddon *et al.* (2003) reports suggest that much of the seagrass in the Beachport area appears to have been misidentified as reef within the CSIRO 1:100,000 benthic maps that were used as a basis for designation of biounits. It would appear that as a consequence, Edyvane (1999b) identified very little seagrass within the mapped area of the Canunda Biounit (~ 2 ha). There also appears to have been more than 10 times this level of seagrass cover lost to the region over the past 50 years which would further emphasise the need for ground truthing of remotely sensed data.

Edyvane (1999b) also reports relatively little seagrass cover in the Coorong and Nene biounits, with modest cover (~ 44 ha) in Piccaninnie, although the area mapped within this biounit is rather small (~ 3,500 ha).

More general implications of the South East Drainage System in terms of seagrass health were investigated by Wear *et al.* (2006). This investigation considered four drain outlets (Blackford Drain, Maria Creek, Butchers Gap Drain in Lacepede Bay and Drain M in Rivoli Bay) relative to their potential impact on seagrass health and potential loss. Apart from seagrass health parameters (shoot length, shoot density, photosynthetic efficiency, etc), hydrodynamics and water quality observations, this study also mapped the benthic communities in the vicinity of the three Lacepede Bay drains. A series of irregularly spaced, 50 m long video transects were undertaken perpendicular to the coast in the nearshore area adjacent to each drain (Wear *et al.* 2006). Results of the survey indicated that water within the drains retained higher levels of nutrients, turbidity and chlorophyll *a* and may be responsible for declines in seagrass health and loss. In addition to the major losses of seagrass around Drain M (Seddon *et al.* 2003), there would appear to be declines in seagrass habitat associated with other drain outlets (Wear *et al.* 2006). Although estimates of areas of loss were not undertaken, Wear *et al.* (2006) reports that the inshore seagrass edge within Lacepede Bay has receded by 84 m over 20 years at Kingston and 40 m over five years at Butchers Gap.

Similar to the Haig *et al.* (2006) survey, this study also mapped habitat type transitions within transects. Given the somewhat confusing set of up to 25 habitat types employed (see Wear *et al.* 2006), interpolation of habitats between observations would have been problematic. The Wear *et al.* (2006) study may serve as an excellent tool for ground truthing habitat maps, but would be unlikely to directly contribute to benthic mapping.

3.5 Soft bottom habitats

Other than the observations reported within Haig *et al.* (2006), there is little by way of investigation into soft bottom systems within the SE NRM region. However, based on the CSIRO mapping, they are reported to be extensive except in the Nene Biounit (Edyvane 1999b).

3.6 Threats to marine systems in the SE NRM region

There is a diverse range of threats to coast, estuarine and marine systems in South Australia derived from an equally variable array of activities and stakeholders (Edyvane 1996).

In the absence of a State of the Region report for the SE NRM (one is due to be completed during 2009) and/or risk assessment, there is a lack of local assessment of the status of coast, estuarine and marine assets as well as pressures (threats) to which they are currently or potentially exposed. However, the NRM Ministerial Council Marine Biodiversity Decline Working Group, other South Australian NRM State of the Region reporting (AMLR NRM 2007, EP NRM 2008, NY NRM 2008) and risk assessments (Cheshire *et al.* 2007, Cheshire *et al.* 2008) have identified a broad range of threats to marine ecosystems. A general summary includes:

- Resource use.
- Climate change.
- Land-based impacts.
- Marine biosecurity.
- Marine pollution.

A common theme from most of the above relates to their respective impacts on water quality, including increased nutrients, sediment and turbidity loads. To determine to what degree these threats apply to the SE NRM region, identification of spatially relevant data on threats to marine systems should be a priority for future investigation, allowing appropriate targeting of investment, mitigation and monitoring strategies as a component of strategic planning and evaluation of NRM activity (see Monitoring Evaluation and Monitoring Frameworks, AMLR NRM 2008).

The Urban and Environmental Planning Group report for the South East region (UEPG 1982) noted a number of issues associated with dune stability and erosion associated with off-road vehicles and shacks. Drain outfalls, sewage outfalls and shack developments were also identified as issues with respect to marine systems.

4 Remote sensing and marine habitat mapping – development of a standardised approach

A key element to the development and implementation of resource condition targets for Natural Resource Management is to establish accurate baselines from which future changes in ecosystem structure (or health) can be compared.

Sustainable management of natural resources and the development of conservation strategies at ecosystems levels require a greater understanding of the distribution and status of the supporting habitats (DEH 2007a, Mount *et al.* 2007). Broad scale habitat mapping, coupled with geographic information system (GIS) capability is a powerful tool for large-scale environmental management (GESAMP 2001, Flaherty and Sampson 2005, Mount *et al.* 2007).

However, this approach is reliant upon a capacity to consistently differentiate and map habitat types and therefore presents a particular challenge when dealing with subtidal marine systems wherein traditional remote sensing techniques may be of restricted value (DEH 2007a, Mount *et al.* 2007). Current marine habitat mapping criteria are targeted at regional scales (Allee *et al.* 2000, Mount *et al.* 2007) and there is thus a need to develop standardised national criteria for marine habitat mapping (Allee *et al.* 2000, DEH 2007a, Mount *et al.* 2007).

National scale habitat mapping definitions have been established for terrestrial systems in Australia (see the National Vegetation Information System (NVIS) DEWR 2007), but marine systems are yet to be comprehensively unified (DEH 2007a, Mount *et al.* 2007). Allee *et al.* (2000) identified several requirements for a national marine habitat classification system including:

- Universal and consistent coverage that is spatiotemporally sensitive.
- An additive structure such that classification can be taken to finer scales that fit within broader classifications as data become available.
- Combines physical, geomorphic and biotic data.
- Compatibility with a GIS framework.
- Amenable to currently available data and technology.
- Identification of functional linkages wherein the observed patterns can be related to ecological processes.

The approach developed by Allee *et al.* (2000) for the USA employs a hierarchical system of 13 levels, most of which relate to broader scale geomorphic features. A hierarchical approach to habitat mapping has the advantage of flexibility in development of summaries as well as improving the resolution within more broadly classified regions as data become available (Allee *et al.* 2000, Mount *et al.* 2007).

Within Australia, one of the best examples of a large scale marine habitat mapping program is SEAMAP in Tasmania, which has been in operation since around 2001 (Barrett *et al.* 2001). More recently major mapping programs have been undertaken in other states (including those by Marine Parks in NSW, Dept for Primary Industry and Deakin University in Victoria, and the Marine Futures program in WA). In South Australia, there is also the recently completed benthic mapping of the upper Spencer

Gulf (DEH 2007c) as well as the entire AMLR NRM region (DEH 2009a). The methodologies employed by the SEAMAP and DEH (2007a, c, 2009a) mapping programs are based on that of Allee *et al.* (2000), although the hierarchy includes only four levels: geomorphic type, substratum/ecotype, substrate eco-type and a series of modifiers (see Benthic Mapping and ground truthing methods below).

Aerial and satellite imagery have frequently been employed in understanding shallow marine environments, although most historical aerial/satellite imagery was obtained with a view to terrestrial objectives (Mount *et al.* 2007) and the analysis of historical images from a marine habitat mapping perspective is frequently restricted (see Hart 1999). The limitations to detecting habitat differences in aquatic systems from aerial images include (Mount 2003, DEH 2007a, Mount *et al.* 2007):

- Water depth.
- Water clarity.
- Sun angle and reflection.
- Water surface state.

In spite of these restrictions, remote sensing has proven to be a useful tool in identifying habitat modification in shallow marine systems (Allee *et al.* 2000, Mount 2003, Mount *et al.* 2007). Even so, acoustic technologies and processing techniques are increasingly capable of covering large areas of substrate with substantial accuracy, largely independently of factors that limit more traditional approaches. However, it is important to realise that habitat mapping is never an exact science, with sacrifices being made relative to the competing needs for habitat type resolution versus spatial coverage. Furthermore, boundaries between habitat types are often broad transition zones rather than rigidly defined and these zones may shift according to seasonal fluctuations in vegetative cover (DEH 2007a).

Regardless of the broader habitat classification approach, finer scale investigation requires varying levels of ground truthing, generally in the form of video or SCUBA operations (DEH 2007a, Mount *et al.* 2007).

The following describes a program of marine habitat mapping in the SE NRM region, building on recent developments in subtidal mapping. The aim is to develop a system of reliable, repeatable and relevant habitat mapping capability for near shore environments that can be employed as a basis for natural resources monitoring and management.

5 Benthic habitat mapping in the SE NRM region

5.1 Overview

Mapping of nearshore marine habitats across the SE NRM region targeted areas close to the main coastal population centres. These areas included Lacepede, Guichen and Rivoli Bays and from Carpenters Rocks to east of Port MacDonnell. Mapping generally included the area from mean high water out to between 15 and 20 m depth (depending on quality and coverage of aerial imagery). This depth provided a balance of detection resolution while at the same time encompassing the major habitats likely to be impacted by shore-based activities, in particular reef and seagrass systems. Information on the distribution of benthic habitats was collected using a combination of techniques that compiled data across increasingly smaller scales, including:

- Aerial imagery to assess the spatial extent of habitats at the broadest level. Boundaries between habitats such as seagrass, bare substrate and reef are often evident on aerial images and have previously been used to map habitats out to 15 m depth in South Australia (DEH 2007a provides a simple overview of this process and habitat mapping in general).
- Acoustic data (side scan sonar) to further define the extent of habitats, particularly in deep water (where light penetration is limited) to provide confirmation of habitat extent in areas mapped from imagery.
- Habitat identification and verification carried out using towed underwater video.

All information collected was compiled as spatial layers within a Geographic Information System (GIS) and used to produce hardcopy map books and an interactive ARC reader DVD. The latter enables users to access spatial layers for habitat and video ground truthing as well as underwater images.

The following sections describe this process in detail.

5.2 Digitisation of aerial imagery

Orthorectified aerial imagery used for digitisation of habitat boundaries for the SE NRM region was collected by DEH in 2008 at a pixel resolution of 0.9 m.

Habitat boundaries were identified and digitised (digitally traced) based on varying patterns, tones and textures on the orthorectified aerial imagery (Figure 2) using GIS.

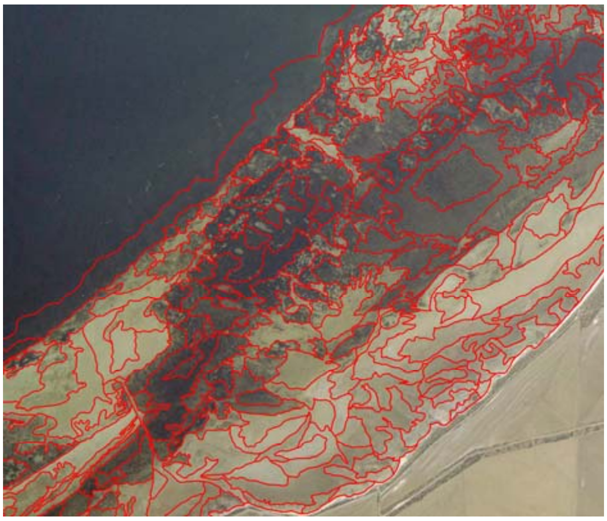

Figure 2 - Example of habitat delineation on an aerial image.

5.3 Field data

5.3.1 Acoustic survey

Interpretation of aerial imagery is subject to uncertainty due to the water clarity/light penetration and sun reflection on the sea surface and becomes less reliable with depth (Mount 2003, DEH 2007a, Mount *et al.* 2007). Transects spaced approximately 1 km apart were surveyed across the four survey areas using Sidescan sonar to increase the confidence of habitat delineation from aerial images and extend mapping beyond what is normally achievable from imagery in this region (i.e. 10 – 15 m depth).

Acoustic surveys were carried out in Guichen Bay and in the Port MacDonnell area using an Imagenex Yellowfin Sidescan sonar. In Rivoli and Lacepede Bays, Sidescan data was collected using a GeoAcoustics swath mapping system.

Sidescan is a hydroacoustic survey technique that provides an acoustic image of the seafloor by emitting fan shaped beams (formed as sound pulses known as pings) on either side of a towed (Yellowfin) or pole mounted (Geoswath) sonar head. Different features on the seafloor (e.g. reef habitats or sand habitats) reflect sound differently, thus acoustic returns (signals) from varied features can be georeferenced to provide textural/backscatter images that display the differences (Figure 3).

Figure 3 - An example of a processed sidescan track showing a patchs of reef and sand in Rivoli Bay (sand patches are light in colour).

The Yellowfin sidescan sonar survey was carried out using an operating frequency of 330 kHz, with a 100 m range setting (i.e. a swath width of 100 m either side of the vessel). Sidescan data was post processed using Sonarweb Pro software (Chesapeake Technology Inc.). Geoswath data was collected at 200 kHz with a total swath width of approximately 100m. Data from the Geoswath system was processed using Geotexture software. In both cases, georeferenced images were produced and imported into the ARC GIS environment for interpretation against other information (i.e. aerial imagery and video classifications).

5.3.2 Video ground truthing

Video footage was collected along the acoustic transects using one of two high-resolution, towed underwater video cameras (a Morphcam by Morphvision connected to a Sony GVD1000e digital video recording deck or a Scielex underwater video camera linked to a Archos portable digital hard drive recorder). Video drops were made along the acoustic survey transects at approximately 500 m intervals. GPS data was simultaneously encoded on the audio track of the videotape to provide position information relative to video footage.

Benthic habitat data was extracted from video footage using a purpose-built software program. The program allows the operator to view videotapes and assign habitat types, which are stored along with the corresponding GPS location from the audio channel. Data were then compiled in a database from which GIS spatial layers were produced. Around 900 video observations were collected and analysed across the Region.

5.3.3 Classification of habitats/production of maps

The approach used for classification of benthic habitats for marine habitat mapping in the Northern and Yorke NRM region and for the upper Spencer Gulf and Gulf St Vincent (see above; DEH 2007a) was modified to include new habitat types, comprising four levels (Figure 4) in line with approaches used elsewhere in Australia and internationally.

Digitised habitat polygons were assigned pre-determined benthic habitat classifications based upon information from all spatial layers (imagery, acoustic and video data). In addition, attributes such as density and percentage (%) cover were assigned to habitat categories using a visual aid, adapted from Kendall *et al.* (2001; Figure 5). Habitats were broken down into consolidated and unconsolidated groups and then classified based on whether or not they were dominated by 'Structural Macrobiota' such as habitat forming species (e.g. seagrasses; see Mount *et al.* 2007 for a full description; Figure 4).

Maps were produced using classifications across two levels. Consolidated habitats (reef) were classified at the level of substratum, since the dominant habitat structure is the reef. Unconsolidated habitats were classified at the level of biota since the structural complexity (at the macro scale) more often results from the biota itself (e.g. seagrasses, sponge gardens and *Pinna bicolor* beds).

An example of a benthic habitat map based on the above process is shown in Figure 6.

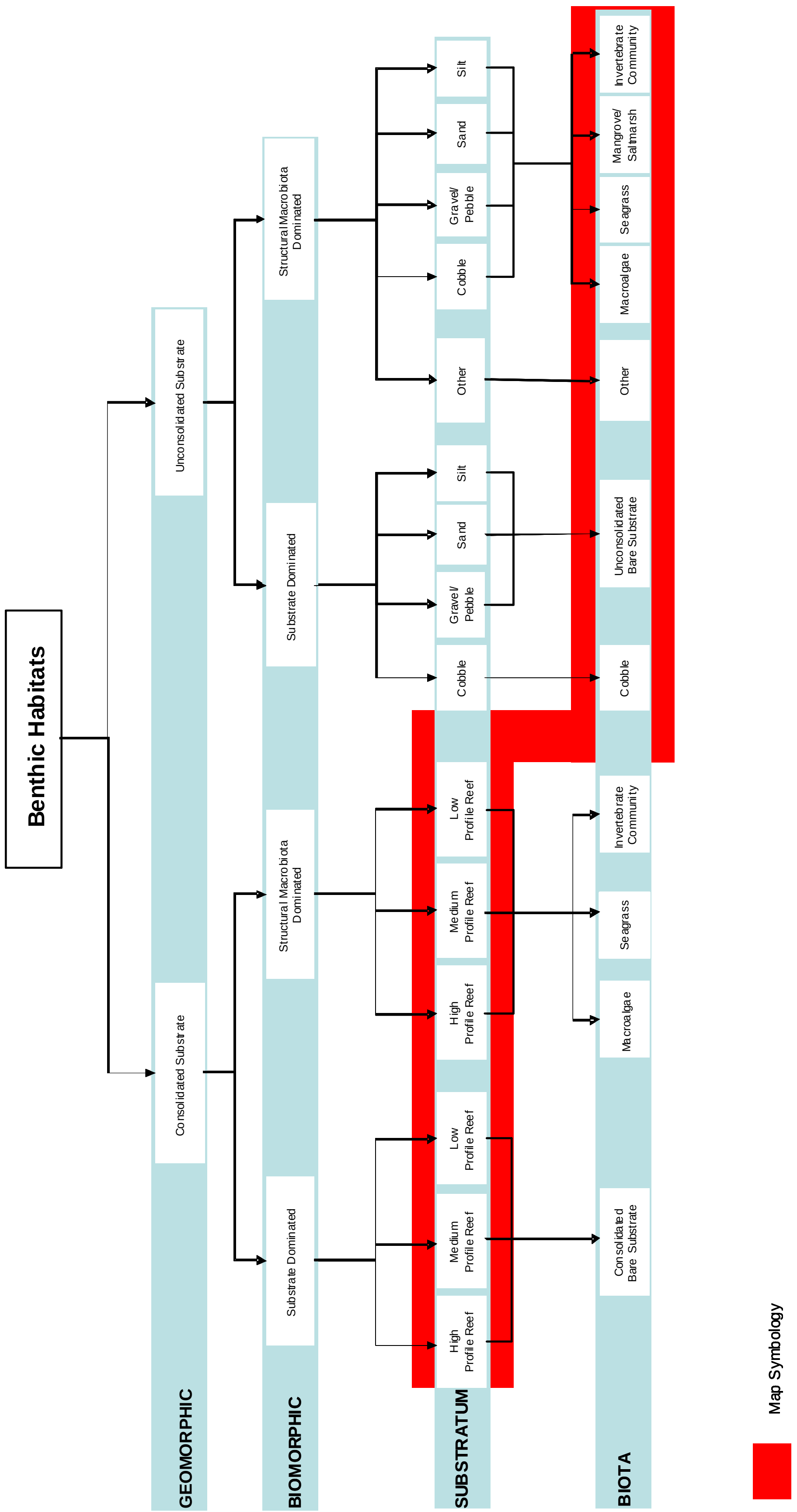

Figure 4 - Flow diagram of benthic habitat classifications. Map symbology is generated based on Substrate level classifications for consolidated benthos while video information (available in the associated ARC Reader DVD) is focussed more toward Biota level classifications.

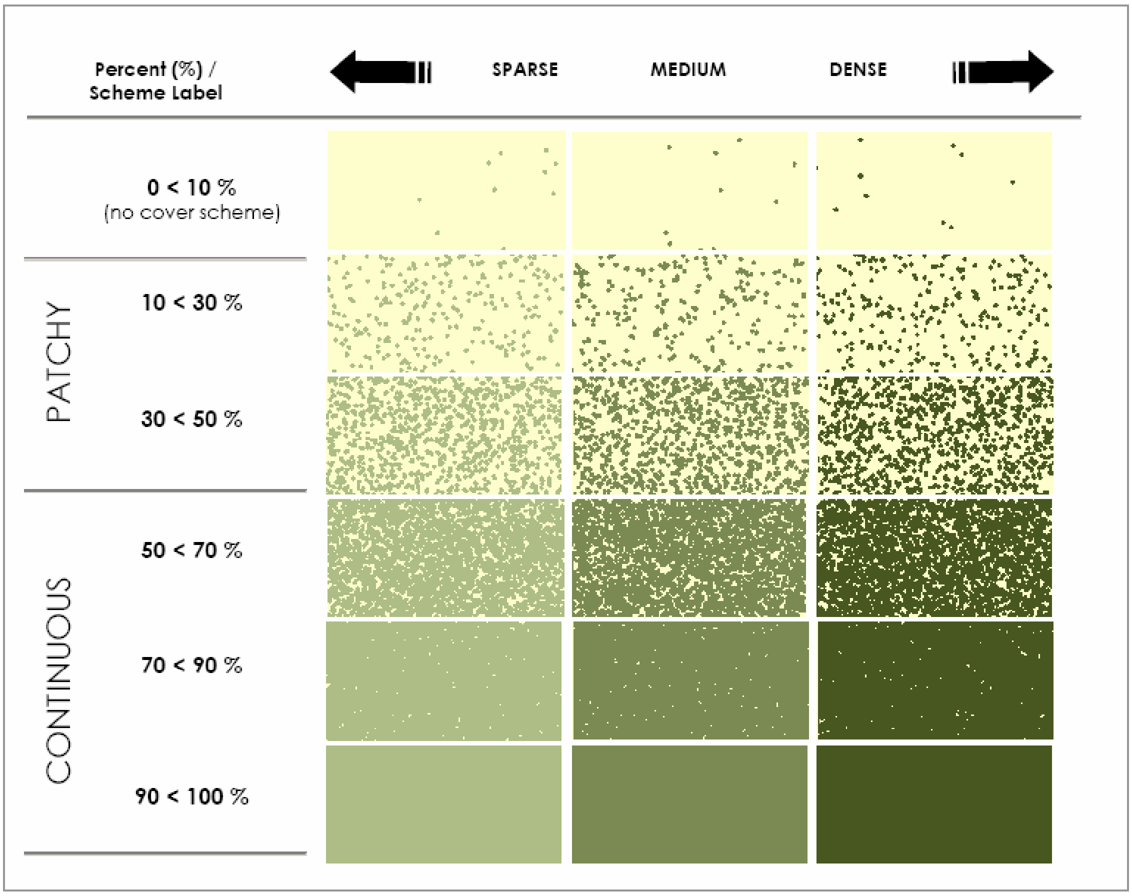

Figure 5 - Visual aid used for assigning percent cover and relative density (Kendall *et al.* 2001).

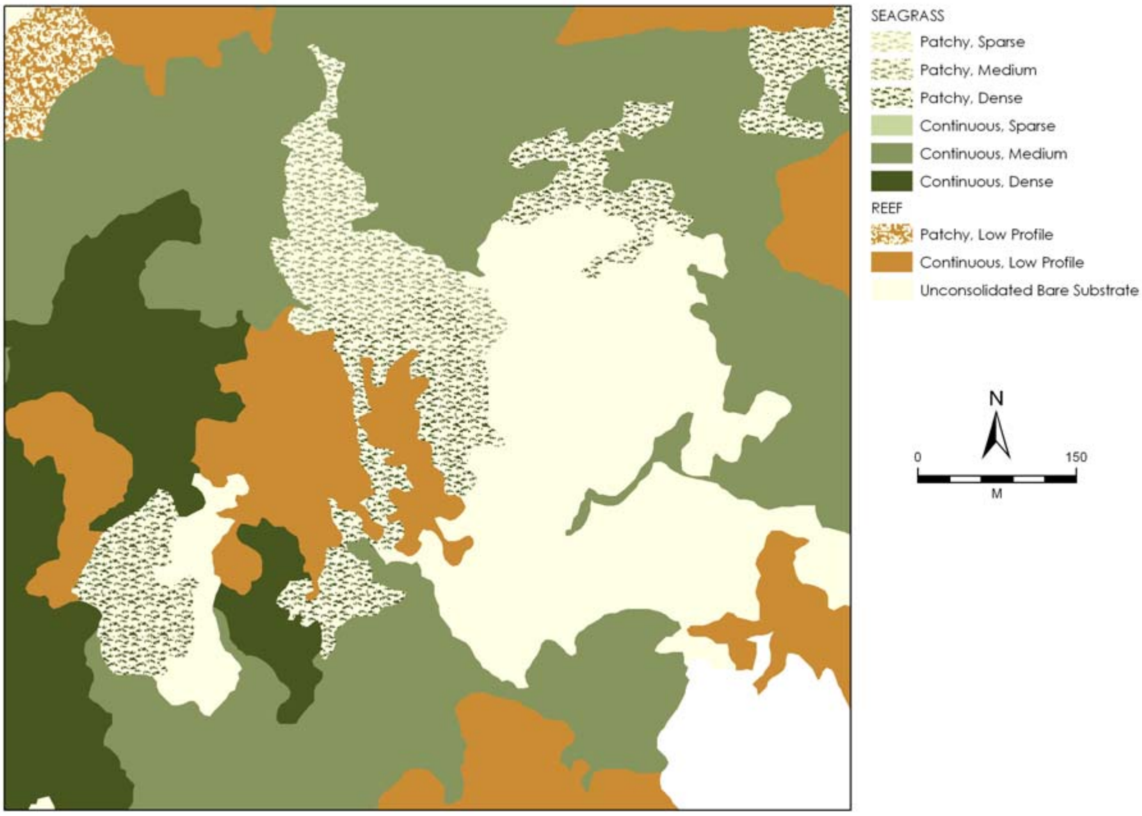

Figure 6 - Example of a benthic habitat map.

The interactive Arc Reader DVD component of this report includes a spatial layer showing video drop points and their respective habitat classifications based on the ”Biota” level interpretation. Information in the underlying database also includes a ”modifiers” level, which is derived from identification and description of the biota and substrate at the best taxonomic resolution possible based on the video images. Modifiers are therefore variable in terms of resolution, generally occurring at the genus or family level but ranges from species in some cases (e.g. *Posidonia coriacea,* or at least members of the *ostenfeldii* group of species, are easily identified from video relative to other *Posidonia* spp.) to broad “functional group” categories (e.g. foliaceous red macroalgae) in cases where even family differentiation is not possible.

5.3.4 Data and map limitations

Maps were based on digitisation of imagery at 90 cm pixel resolution. In areas where the use of imagery was limited, such as the deeper margins of the area mapped, acoustic information was used primarily to identify boundaries. Spatial accuracy of the acoustic information along the survey lines is limited to DGPS capability (1 m or better).

In natural systems the transitions from one habitat type to the next are frequently not discrete boundaries, but occur as a gradual change over some distance. These transitional areas or “ecotones” make detecting and defining boundaries for the purpose of habitat mapping difficult. For the purpose of this project, habitat boundaries that were apparent (e.g. from differences between video drops or acoustic transects), but whose exact locations were unclear due to their transitional nature or water depth and clarity, were marked as ”interpolated boundaries”.

The spatial accuracy of information in the video spatial layer is dependent on both the accuracy of the GPS itself and any layback error caused by the camera drifting behind the path of the GPS antenna. Testing of the least accurate GPS used in this study (Garmin GP60 with external aerial) suggested that 99% of the time position accuracy was within 3.2 m. Layback error is estimated at a maximum of ~15 m. Therefore it is estimated that spatial error associated with this layer can be defined as generally being ≤ 20 m.

The final maps were assessed separately for habitat accuracy by conducting independent ground truthing surveys. Habitat units or polygons within mapped areas were randomly selected and sampled with towed video drops. The resulting footage was processed in the same manner as outlined above and then overlayed on the existing classified habitat units. An accuracy value was then calculated based on the number of correct matches (between classifications and accuracy check points) as a percentage of the total number checked. Unfortunately, due to time and weather limitations, it was possible to collect only a relatively small number of samples within Guichen bay (15) plus several outside (3).

Alignment between habitat polygons and the video checkpoints confirmed the mapped habitat types in 94% of cases. Although the number is insufficient to definitively define accuracy for the region, it does provide some indication that for any randomly selected polygon the associated mapped habitat type may be considered reliable a large percentage of the time. Using the comparable checkpoints, previous mapping undertaken by CSIRO proved to be accurate 87 % of the time.

6 Benthic mapping observations

The major results of the mapping process are included within the accompanying map book and interactive DVD. The following comprises a brief summary of the benthic habitat mapping program for the SE NRM region, which is intended to cover broader observations for the major habitat groups as well as potential areas of interest or possible concern. This analysis is not intended to be comprehensive, and it should be understood that the underlying GIS data forms an important resource that can be summarised and interpreted in pursuit of a wide variety of agenda.

Rather than comprehensive coverage, benthic mapping has focussed on four important locations on the SE NRM coast, including a significant area of the Coorong biounit (Lacepede Bay), Guichen Bay and Rivoli Bay within the Canunda biounit and a long coastal strip that includes all the Nene and around half of the Piccaninnie biounits (Figure 7, Table 1). These locations tend to include larger regional population centres (Kinston, Robe, Beachport, Port MacDonnell, etc) and/or significant infrastructure and are therefore more likely to comprise areas of concern for nearshore systems, particularly in relation to human activities such as:

- Point source inputs (stormwater, wastewater, thermal and desalination outfalls).
- Coastal developments (construction, operation and maintenance).
- Shipping and boating related issues (e.g. marine pests, oil spills and marine litter).
- Access/tourism related activities (e.g. marine litter, illegal fishing and habitat disturbance).

Shallower and more sheltered bays on the SE NRM coast (specifically Lacepede Bay, Guichen Bay and Rivoli Bay) are also likely to include both sensitive (relative to the water energy) and ecologically important habitats, in particular seagrass systems. Seagrasses are critically important with respect to provision of a range of ecosystem services including (among others): productivity, sediment stabilisation and erosion protection, nursery habitat and potential for carbon sequestration (see Westphalen *et al.* 2004, EP NRM 2008). Observations of seagrass loss within Rivoli Bay since the 1950s (see Hart and Clarke 2002) have prompted investigations into seagrass decline relative to the outlet channels for freshwater drains along the SE NRM coast, notably those systems in Lacepede Bay and Rivoli Bay (see Seddon *et al.* 2003, Wear *et al.* 2006). As a result of these surveys, there is concern for water quality associated with drain outlets and the associated health and maintenance of adjacent benthic communities within the SE NRM region. Marine habitat mapping in the vicinity of the major drain inputs should therefore be a priority for future mapping, although ultimately the entire SE NRM coast should be mapped.

Marine waters in the SE NRM region encompass ~ 2,500 km^2 which includes only ~8% of the total area. CSIRO marine benthic mapping at a scale of 1:100,000 (see description in Edyvane 1999b) covered 1,674 km^2 of the SE NRM marine area (~ 68%). The total benthic area mapped within the SE NRM from this investigation was ~ 739 km^2 (~ 30% of the marine area), substantially less than the area covered by CSIRO. However, the resolution within the latest mapping is an order of magnitude higher, including 1,513 polygons, spread across 15 habitat types compared to 170 polygons using eight habitat types for CSIRO mapping (see Edyvane 1999b). The four mapped areas were spread over both the Coorong and Otway Bioregions that included patches within all four biounits and five of the six Bryars (2003) Fisheries Habitat Areas[1] that occur to some extent within SE NRM region (Table 1; Figure 7). However, the areas mapped varied substantially in size from 80.2 km^2 in the Piccaninnie biounit up to 338.8 km^2 in Kingston, although note that for the purposes of analysis the contiguous Nene and Piccaninnie areas have been combined (total area of 187.8 km^2).

Table 1 - Summary of benthic mapping within the SE NRM region. * Note that the continuous mapped areas from Nene and Piccaninnia Biounits were combined in analyses.

Region	Bioregion	Biounit	Fisheries Habitat Area	Area surveyed (km^2)	Depth range (m)
Kingston	Coorong	Coorong	Coorong	338.8	0 - 15
Robe	Otway	Canunda	Guichen Bay	116.6	0 - 15
Beachport	Otway	Canunda	Rivoli Bay	96.1	0 - 18
Nene/Piccaninnie*	Otway	Nene	Nene Valley	107.6	0 - 18
Nene/Piccaninnie*	Otway	Piccaninnie	Discovery Bay	80.2	0 - 18
Total				**739.3**	

Benthic habitat classes recognised within selected bays from the SE NRM region comprise four broad types, including:

- Seagrasses.
- Reefs (low, medium and high profile).
- Macroalgae occurring on unconsolidated substrate.
- Unconsolidated bare substrate comprising sand, shell debris and rubble.

The above classes have been further differentiated with respect to their structure in terms of continuity (Continuous or Patchy) and density (Sparse, Medium, Dense although not for reefs; Table 2), such that there were 16 different habitat class/structure type combinations identified across the SE NRM region.

Mangrove communities are not known to occur within the SE NRM region (Bryars 2003, DEH 2007a), but while Bryars (2003) Fisheries Habitat Areas do not appear to support any saltmarsh/samphire communities, the Estuaries Information Package reports areas of saltmarsh/samphire and mudflat around Salt Creek, Lake George and Maria Creek (DEH 2007b). Conversely, Bryars (2003) observations include

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[1] Note that there is a range of nomenclature relative to Fisheries Habitat Areas, biounits and bioregions. There are two bioregions, four biounits and six Bryars (2003) Fisheries Habitat Areas that occur within the SE NRM region (Appendix A). Fisheries Habitat Area 48 – The Coorong encompasses the entire coast from Middleton to Cape Jaffa, which is the same expanse of coast covered by the corresponding Coorong biounit and the Coorong bioregion. Fisheries Habitat Area 49 - Guichen Bay includes from Cape Jaffa to Cape Dombey (near Robe) rather than the actual bay. Similarly, Area 50 - Rivoli Bay covers from Cape Dombey to Cape Buffon (Southend). Area 51 – Canunda Beach is a section of the Canunda Biounit coast and the Nene Valley and Discovery Bay Fisheries Habitat Areas (Areas 52 and 53) appear to be analogous to the Nene and Piccaninnie biounit coasts. For this reason, the authors have differentiated current mapping by opting for labels based on adjacent coastal towns in most instances.

important coastal lagoon areas in the Coorong, Guichen Bay and Rivoli Bay Fisheries Habitat Areas.

Table 2 - List of habitat classes and subgroups employed in habitat maps (NA = Not Applicable).

Group	Habitat Class	Structure type	
		Continuity	Density
Reef	High Profile Reef	Cont.	NA
	High Profile Reef	Patchy	NA
	Low Profile Reef	Cont.	NA
	Low Profile Reef	Patchy	NA
	Medium Profile Reef	Cont.	NA
	Medium Profile Reef	Patchy	NA
Seagrass	Seagrass	Cont.	Dense
	Seagrass	Cont.	Medium
	Seagrass	Patchy	Dense
	Seagrass	Patchy	Medium
	Seagrass	Patchy	Sparse
Soft bottom	Macroalgae	Cont.	Dense
	Macroalgae	Cont.	Medium
	Macroalgae	Patchy	Medium
	Macroalgae	Patchy	Sparse
	Unconsolidated Bare Substrate	Cont.	NA

The Bryars (2003) Fisheries Habitat Areas nonetheless provide a useful basis for comparison with current mapping as they are based on a number of data sources, in particular the CSIRO 1:100,000 mapping (see Edyvane 1999a, b) that has been augmented with additional GIS layers and data sources. This approach was based on recognition of a range of errors in the CSIRO/Edyvane (1999a, b) and other mapping sources (see Hart and Clarke 2002, Bryars 2003). In addition, the Bryars (2003) observations provide a valuable resource with respect to identifying a range of factors related to each Fisheries Habitat Area including human usage, adjacent land use, local protection, adjacent catchments and threats (actual, perceived and potential).

6.1 Proportional cover of broader habitat groups

Benthic cover for each habitat class can be broadly allocated to one of reef, seagrass or soft bottom groups (Table 2). The area of each habitat is considered in terms of the percentage of the total area mapped within the host region (see Table 1, noting that the Nene and Piccaninnie data were combined). This approach allowed for some level of comparison between mapped areas without the confounding effect of differences in area covered. However, habitat types of particular interest, specifically seagrasses, were also considered in terms of their total area.

Mangrove, saltmarsh/samphire and coastal lagoon habitats were not observed in the current mapping. Given that the focus of this investigation is on subtidal systems, the lack of intertidal community types within the current mapping is of little surprise. The best resources for assessment of saltmarsh-like habitats within the SE NRM region include the coastal, dune and clifftop vegetation surveys by Oppermann (1999), saltmarsh and mangrove surveys completed by Canty and Hille (2002) as part of the NVIS program (see DEH 2006, DEWR 2007) and finally the Estuaries Information Package for the region (DEH 2007b).

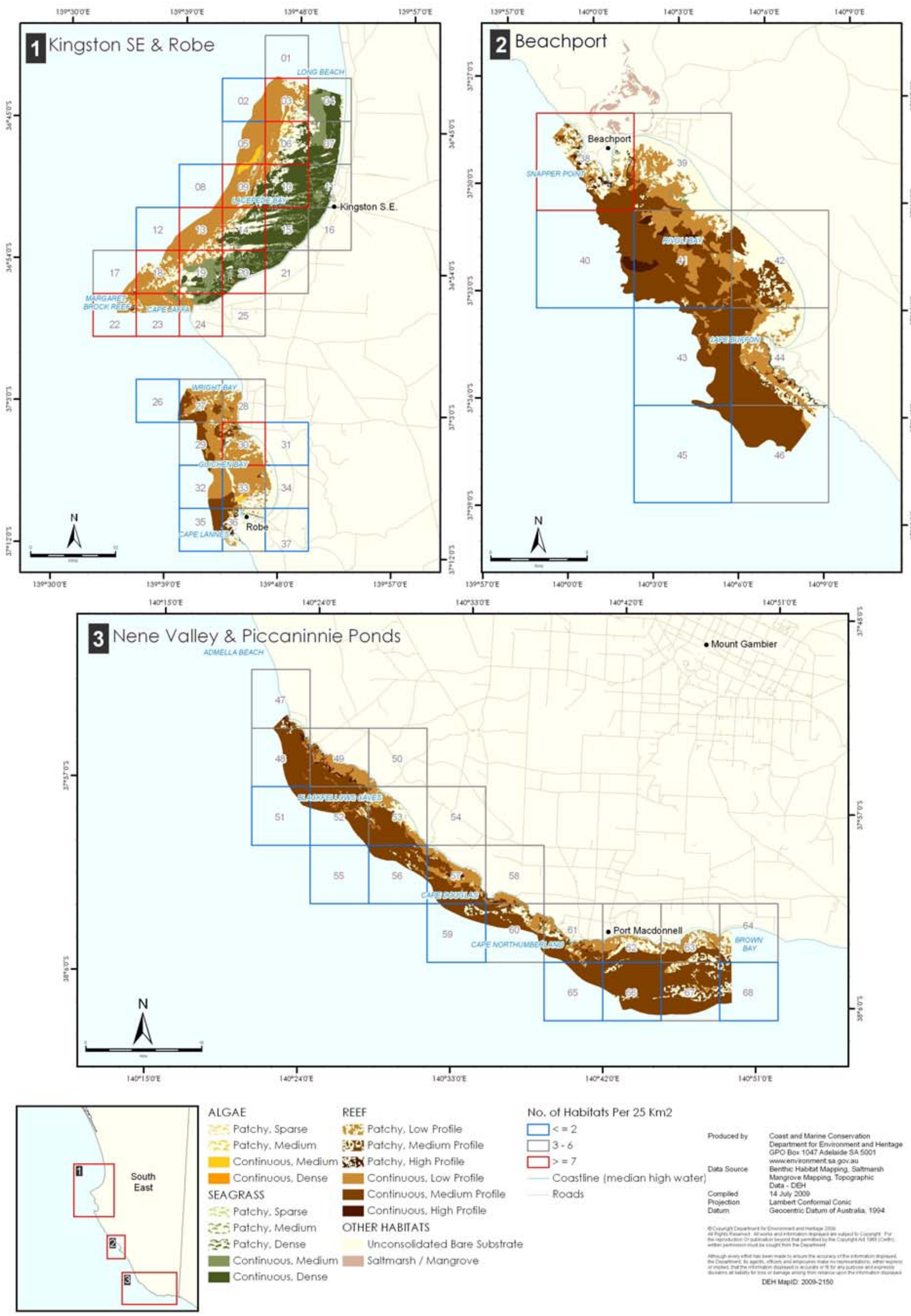

Figure 7 - Location of bays included within benthic habitat mapping for the SE NRM region, showing the position of 5 × 5 km grid squares relative to each of the habitats defined in Table 1. Red borders indicate mapped areas with a high number of habitat class/structure type combinations (≥ 7) blue borders indicate low numbers (≤ 2).

All of the Bryars (2003) Fisheries Habitat Areas and indeed the CSIRO/Edyvane (1999a, b) habitat mapping indicate that the South East coast from Cape Jaffa is overwhelmingly dominated by reef systems. Current mapping of Robe, Beachport and Nene/Piccaninnie supports this view, with continuous reef comprising 71-81% of the mapped areas and patchy reef encompassing a further 9-14% meaning that 80-95% of these areas were reef habitat (Figure 8). In absolute terms, areas of reef for Robe, Beachport and Nene/Piccaninnie cover 98 km^2, 78 km^2 and 179 km^2 respectively (Figure 9).

In spite of their extent, there is limited data on reef systems within the SE NRM region. Importantly, recent investigations into reef health (e.g. Turner *et al.* 2007) and biodiversity surveys using the Edgar and Barrett (1997, 1999) approach (e.g. DEH 2009a) that have occurred across other South Australian NRM regions have not thus far extended into the southeast coast. Given the difficulties of working in this region, particularly for SCUBA diving operations (see Shepherd 1979), investigations into reef systems (as well as other benthic habitats) in the South East may be reliant upon remote methods. There is no doubt that there is a need to learn more about reef biodiversity, structure, function and related environmental processed within the SE NRM region, particularly given the unique aspects of this coast relative to elsewhere in South Australia (notably cold water upwellings and the transitional nature of the Maugean Subprovince – see above).

The Kingston area within Lacepede Bay was starkly different to the other mapped areas, with less than half (40%) the mapped area covered by reef (either continuous or patchy; Figure 8). However, in absolute terms the area of reef in the Kingston area was second only to the Nene/Piccaninnie zone (137 km^2; Figure 9). The remainder of the Kingston site was dominated by continuous-dense and continuous-medium seagrass cover (32% and 11% respectively) as well as a mixture of continuous-sparse and patchy structure types (5% or less) for a total cover of ~ 50% (Figure 8). In terms of absolute area, seagrass cover in the Kingston area totalled ~ 174 km^2 (Figure 9).

Edyvane's (1999b) summary of CSIRO mapping reported some 250.6 km^2 of seagrass in the Coorong biounit which was ~ 14.7% of the area mapped from Encounter Bay to Lacepede Bay. Reef and bare sand were the dominant community types (703.7 km^2 - 41.2% and 755 km^2 – 44.2% respectively). The related mapping as well as the Bryars (2003) Coorong Fisheries Habitat Area, which used much the same data, shows substantial areas of seagrass meadow and seagrass intermixed with reef within the Lacepede Bay area where the current mapping occurred (Figure 7). While there appear to be substantial differences in the current mapping relative to Edyvane (1999b) and related Bryars (2003) mapping in terms of both the total areas and percentages, these can largely be attributed to big differences in the areas considered. Results of the current study therefore support earlier benthic mapping in showing substantial areas of seagrass within the Kingston area.

In contrast, the other mapped areas (Robe, Beachport and Nene/Piccaninnie) had combined seagrass cover across all structure types of less than 1% (Figure 8). These corresponded to absolute areas of 0.7 km^2, 0.41 km^2 for Robe and Beachport respectively, while no seagrass was observed in the Nene/Piccaninnie mapped area (Figure 9).

Edyvane (1999b) reported total areas of seagrass for the Canunda, Nene and Piccaninnie biounits at 0.02 km^2, 0.0 km^2 and 0.44 km^2 respectively (< 1 – 1.3% of the respective CSIRO mapped areas), which would appear to support the observations from the current survey (Figure 8; Figure 9). Lack of seagrass in the Nene biounit as reported by Edyvane (1999b) would appear to be supported by current mapping (Figure 8). However, the section of Piccaninnie included within the current mapping also had no seagrass and it remains to be seen as to whether seagrass cover reported by Edyvane (1999b) for this biounit (0.44 km^2) will be found in the as yet unmapped portion (Figure 7). It is worth noting that the Bryars (2003) observations defined small areas comprising a mixture of reef, seagrass and unvegetated soft bottom in all of the related Fisheries Habitat Areas (Guichen Bay, Rivoli Bay, Nene Valley and Discovery Bay) that would appear to be larger than previous mapping suggests.

Hart and Clarke (2002) undertook an investigation of the historical changes in seagrass cover within Rivoli Bay from 1951 to 1997, based on a series of aerial photographs. The estimated seagrass cover in the bay in 1951 was ~ 25.8 ha (0.26 km^2) but this declined over the ensuing 46 years to ~ 6 ha (0.06 km^2) by 1997. The observations of Hart and Clarke (2002) were refined by Seddon *et al.* (2003) who found the remaining area of seagrass within Rivoli Bay to be slightly larger (~ 0.08 km^2). While the loss of seagrass is undoubtedly a point of major concern, it is worth noting that the area of seagrass cover observed within Rivoli Bay in 1997 (Hart and Clarke 2002, Seddon *et al.* 2003) was actually three to four times larger than that reported for the entire Canunda Biounit by Edyvane (1999b). Although the areas mapped are entirely different, current mapping has found yet more seagrass in the Rivoli Bay area (Beachport ~ 0.41 km^2), which is 20 times more than that previously reported for the Canunda Biounit (Edyvane 1999b). It thus seems that, in spite of loss of substantial areas of seagrass, many patches appear to have been missed or excluded from previous mapping. However, there is no doubt that seagrasses are a minor component of the total mapped area.

Some of the difference between the previously mapped seagrass cover and more targeted monitoring relates to the likely misidentification of habitat types (see Hart and Clarke 2002, Bryars 2003). There are factors related to the prevailing sea conditions on the South East coast that are characterised by persistent heavy swell and high turbidity (Shepherd 1979, Short and Hesp 1984). Water depth and clarity are major determinants for identification of differences in habitat in aquatic systems from images (Mount 2003, DEH 2007a, Mount *et al.* 2007) and the highly energetic SE NRM region coast presents particular challenges to both remote observations and ground truthing.

There are also likely to be differences related to the scale at which the observations were undertaken. CSIRO mapping (Edyvane 1999a b) observations were undertaken at a scale of 1:100,000, while the images used in the Hart and Clarke (2002) study varied in scale from 1:14,600 to 1:81,000. However, four out of the five images considered were at 1:40,000 or less, corresponding to ground pixel sizes that ranged from 0.5 × 0.5 m – 2 × 2 m or a 16-fold difference in area that may be allocated to a particular habitat type. The current study maintains a minimum mapping unit of 1 ha between the scale of 1:5,000 and 1:10,000 using a pixel size of 0.9m. With greater resolving power and smaller mapping units, the finer scale observations are more likely to “see” small isolated patches of habitat that cannot be achieved at the courser scale.

The capacity to differentiate small patches of a particular habitat thus varies substantially but would appear to have been relatively low in the CSIRO mapping compared to the current study.

There would appear to be little doubt that there is rather more seagrass within the SE NRM region than previous mapping has identified. It would therefore seem likely that those seagrass areas that may occur within the nearshore SE NRM area will generally comprise small patches that may be relatively isolated from another.

Seagrass beds on the SE NRM nearshore comprise a broad suite of species, including “strap” or “tape” weeds (*Posidonia* spp.) as well as *Amphibolis antarctica* (“wire weed”) and *Heterozostera tasmanica* (“eelgrass”; Seddon *et al.* 2003). However, many species of *Posidonia* that are otherwise common elsewhere on South Australian nearshore areas (notably, Gulf waters), are reported to have their eastern limits along the SE NRM region coast. *Posidonia australis* is considered to be common on the SE coast, being the dominant species in Guichen Bay, Rivoli Bay and Port MacDonnell, but *Posidonia sinuosa* occurs no further east than Lacepede Bay (Shepherd and Robertson 1989). Similarly *Posidonia coriacea* and *Posidonia denhartogii* occur no further east than Rivoli Bay and *Posidonia angustifolia* no further than Port MacDonnell (Shepherd and Robertson 1989). The zones where particular seagrasses have reached their distributional limits are most likely to be the result of species having spread as far as their respective ecological tolerances will permit. It therefore follows that even small adverse environmental changes may have a pronounced effect on a population, particularly one that occurs in isolated patches. Global warming may have profound implications for seagrass communities on the SE NRM coast, although note that these impacts may not necessarily be negative. Many seagrass species, particularly *Posidonia* spp., are slow to establish and take a long time to recover from disturbance (Meehan and West 2004).

Seagrasses are critically important to coastal environments and processes (see review Westphalen *et al.* 2004), with losses linked to declines in water quality (notably stormwater, wastewater and industrial discharges as well as catchment decline; Westphalen *et al.* 2004, Fox *et al.* 2007). Sheltered bays would most likely form the preferred habitat for seagrasses on an otherwise highly energetic coast. Given that these areas are frequently the focus for regional population centres, industries and maritime transport, the relationship between threats, in particular those related to water quality relative to seagrass health, is worthy of specific attention.

Seddon *et al.* (2003) found that seagrass loss in Rivoli Bay was most likely to have begun as a result of the negative influence of the freshwater drainage for the South East. Increased nutrients and turbidity were probably the cause for loss of *Posidonia coriacea* in deeper water, which then exposed the shallower-living species (mostly *Posidonia angustifolia*) to highly erosive wave energy to produce an ongoing cycle of decline (where a loss event exposes the remainder to damage; see Larkum and West 1983, Seddon 2002). The remaining seagrasses in Rivoli Bay are still subject to erosion (Hart and Clarke 2002, Seddon *et al.* 2003) and there is evidence for other seagrass loss on the SE NRM coast related to freshwater drains (Wear *et al.* 2006).

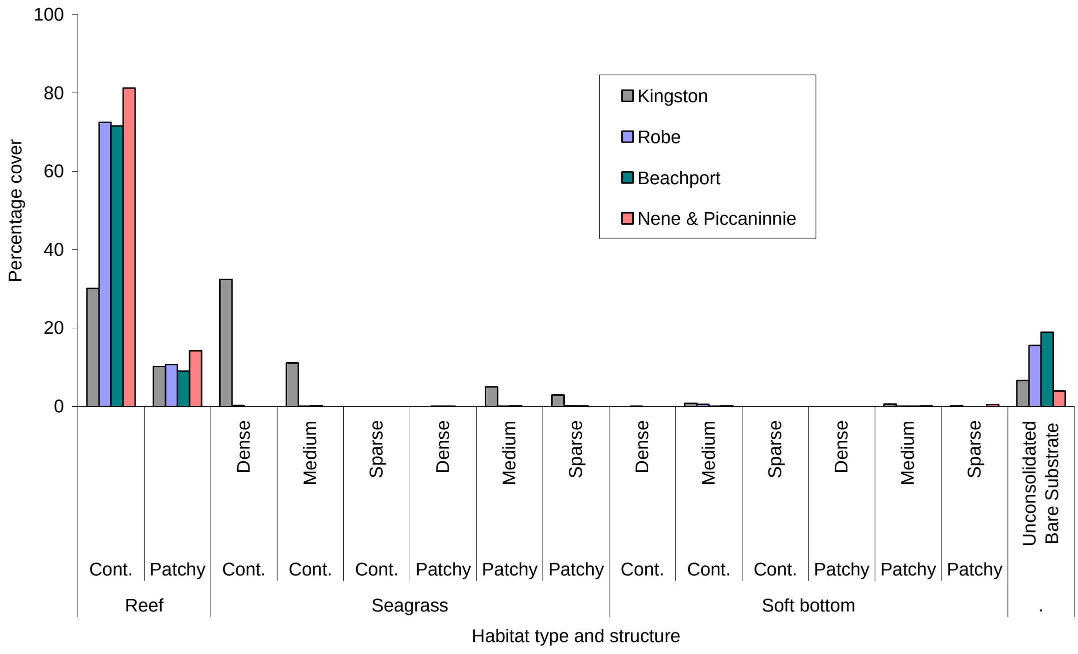

Figure 8 - Percentage cover of broader habitat types within each mapped area along the SE NRM coast.

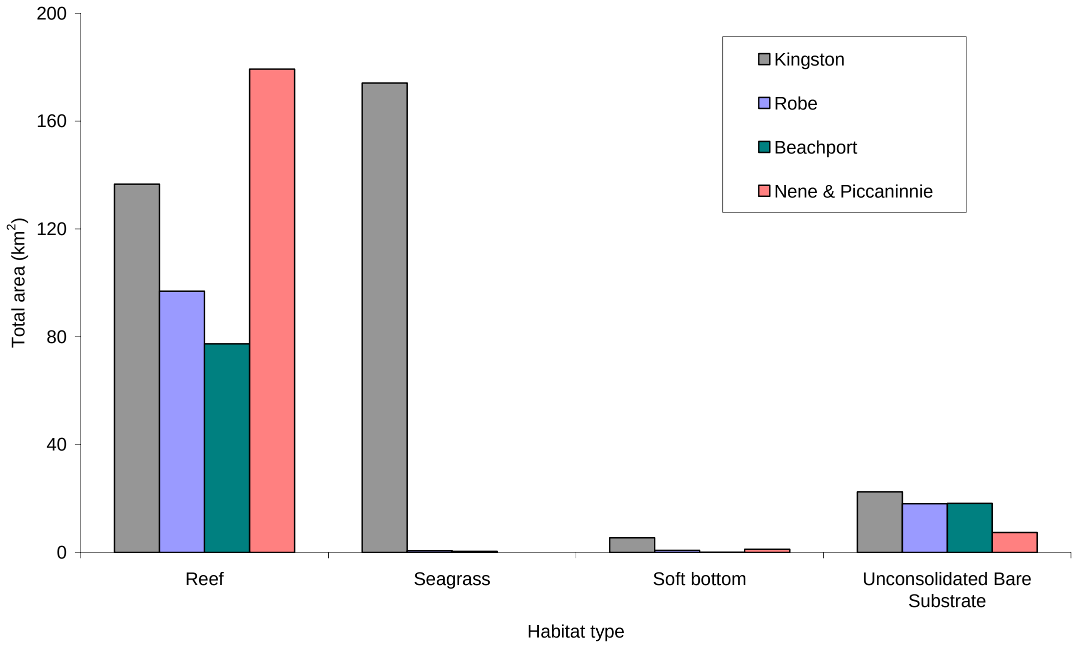

Figure 9 – Absolute area of seagrass, reef, soft bottom and unconsolidated bare substrate cover within each mapped area.

While CSIRO mapping that was employed within the Edyvane (1999a, b) biounit differentiation offers indications of the total area of broad habitat types (reefs, seagrasses and soft bottom), there is little information related to either the continuity or density of coverage, which is particularly important for seagrass assessment. In addition, discrepancies in CSIRO Mapping/Edyvane (1999b) highlight the need for a systematic framework for benthic habitat mapping that incorporates a significant investment in ground truthing. In using the CSIRO mapping/Edyvane (1999a, b) interpretations, Bryars (2003) employed a range of additional data sources in response to the need for caution when employing those data in isolation.

Greater understanding of the nature of seagrass systems (distribution patterns and environmental processes) along the SE NRM coast, including improved knowledge of compositional differences between beds relative to their spatial and physical environmental context (exposure, geomorphology, water quality, etc.), will help managers differentiate natural and anthropogenic drivers (see threats above) of seagrass community structure.

Bare sand habitats, including macroalgal community patches across structure types (continuity and density; Table 2), were < 1% of all mapped areas (Figure 8). When combined across structure types and including Unconsolidated bare substrate, the areas ranged from 4% at Nene/Piccaninnie to 19% at Beachport, although in absolute terms Kingston had the highest cover at 22.5 km^2 (Figure 8; Figure 9). With a depth of observation of < 20 m, deeper water systems as observed in the southern Gulf regions (Shepherd and Sprigg 1976) are unlikely to be encountered. However, given the diversity of substrates incorporated within the Unconsolidated bare substrate type (sand, shell debris and rubble), a detailed interpretation of levels of cover and their potential significance is considered unlikely to reveal an interpretation of any value. This habitat type is somewhat loosely defined in that it includes a diverse array of substrates that do not fit within other categories.

Bare/unconsolidated sand communities have often been discounted as environmentally unimportant (and therefore expendable) relative to reef and seagrass habitats (Fairhead *et al.* 2002, Baker 2004). However, there is substantial data to suggest that these systems are diverse, complex and spatiotemporally dynamic (Cheshire *et al.* 1996). The maximum depth of mapping observations ranged from 15-18 m (Table 1), which is well within the reported depth tolerances of seagrass species in southern Australia (see summary Westphalen *et al.* 2004). Given the loss of seagrass from some areas, most of which was presumably replaced with bare sand or unconsolidated community types (although erosion may have exposed rock as well), the dynamics of seagrass relative to bare sand communities is worthy of closer investigation.

Small, isolated patches of a particular habitat may be of critical importance to local-scale biodiversity as well as facilitate species migrations by allowing ”island hopping” between patches of favourable substrate. These areas may be targeted as favourable fishing and/or diving locations (although probably less so on the South East coast) and may thus incur a disproportionately higher level of anthropogenic exposure relative to larger patches.

6.2 Areas of high habitat diversity

Mapping of each bay in the map book associated with this report is presented in terms of a series of 5 x 5 km areas (Projection = Lamberts Conformal Conic; Datum = Geocentric Datum of Australia, 1994; Figure 7). An examination of the number of different habitats (including differences in structure type) across the grid of 68 maps offers a rough indication of the broader distribution of substrate complexity within and between each mapped area. This information may be used to indicate areas of higher habitat diversity and therein zones of potential conservation significance.

The average number of habitat class/structure type combinations per map was 4.2 ± 2.4 (mean ± SD). Distribution of map areas with low and high numbers of habitats was determined through an examination of grid areas wherein the number of habitat types was outside one standard deviation of the mean (i.e. ≤ 2 or ≥ 7 habitat class/structure type combinations; see Table 2 for a summary).

Of the 68 map areas that encompass all benthic mapping in this survey, those with relatively few habitats (two or less) totalled 18 maps (~ 26%) and tended to be those at the fringes of mapping, or close inshore, and often retained large unmapped marine areas or a high proportion of terrestrial coverage (Figure 7; Figure 10). Around 80% of the maps had six or fewer habitat class/structure type combinations with three being the most common (22 grids; Figure 10).

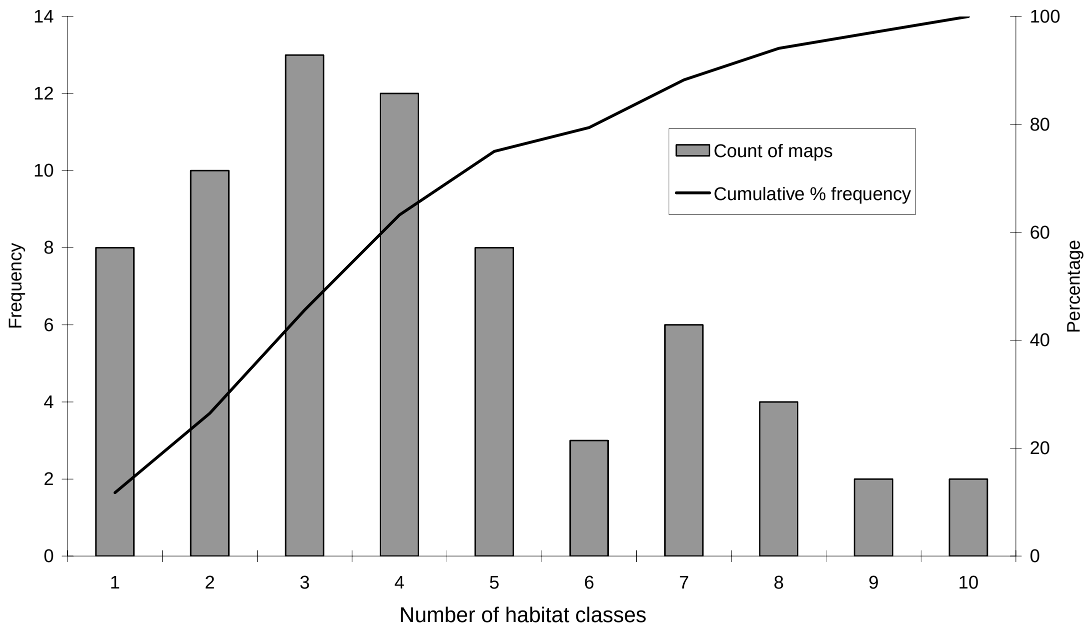

Figure 10 - Frequency distribution and cumulative percentage of the number of habitats within each 5 km × 5 km map (n = 68).

Map areas with seven or more habitat class/structure type combinations totalled 14 maps (Figure 7; Figure 10). Most areas were in the Kingston region within a strip parallel to the coast where substantial areas of seagrass abuts areas of reef and included: Maps 03, 06, 09, 10, 13, 14, 18, 19, 20, 22, 23 and 24 (Figure 7). Outside Kingston there were only two areas, Map 30 from Robe and Map 38 from Beachport, which incorporated a high diversity of habitat class/structure type combinations. Map 09 and Map 23 (both in Kingston) had the highest diversity, with 10 habitat class/structure type combinations each (Figure 7). However, given that reefs were ignored in terms of profile (low, medium or high) and density (patchy or sparse) in this analysis, and given the dominance of reef systems on most of the SE NRM coast, the overall lack of diversity in regions other than Kingston (where there is substantial seagrass) is therefore of little surprise. High diversity maps occur close to shore, where there is more interaction between seagrass and reef systems, but these areas are also where the greatest concentration of threats is likely to occur (Bryars 2003, AMLR NRM 2007). Shallower nearshore areas are also likely to allow greater habitat differentiation. However, while this approach might be used to identify areas of particular interest/concern, it is also apparent that the number of habitat types within a map grid is to some extent determined by the positioning of the grid.

It needs to be noted that this approach makes no allowance for the areas of each habitat class/structure type involved and map areas with 3-6 representatives should not be discounted as unimportant or even "typical". Apart from grid positioning, diversity measures at this scale are strongly influenced by differences in structure type (i.e. changes in continuity and density within a habitat class). Many map areas with relatively low diversity may be dominated by a particular habitat class. In particular, this includes seagrass areas at Kingston (Maps 04, 07, 11 and 15; Figure 7), but there are also large areas of reef, including Kingston (Map 05), Robe (Maps 27, 29 and 33), Beachport (Maps 41, 42, 44 and 46) and a strip of a dozen or so maps along the coast within the Nene/Piccaninnie biounit area (Figure 7) which is not surprising for the South East.

Areas with a large number of habitat class/structure type combinations should warrant closer attention relative the ecophysical factors that drive this diversity, including possible or actual threats and whether these zones also correlate to high species biodiversity. Conversely, areas with large expanses of a particular habitat class, in particular seagrasses, should also be considered relative to their respective threat exposure (see above).

6.3 Conclusions and recommendations

There is an overall paucity of information on benthic marine systems within the SE NRM region, owing mostly to the difficulties of operating on a high energy coastline with very turbid water (Shepherd 1979, Short and Hesp 1984). This lack is reflected to some extent with the discrepancies in the CSIRO habitat mapping (see Hart and Clarke 2002, Bryars 2003). While this mapping highlighted the preponderance of reefs within this region (Edyvane 1999b), other systems, in particular seagrasses, were to some extent discounted.

Current, more highly resolved mapping, although not comprehensive across the region, offers a substantial opportunity to redefine the nature of benthic systems on the SE NRM coast, confirming the abundance and broader complexity of reef systems, but also highlighting areas of seagrass and bare substrate. The results of current mapping therefore form an invaluable resource for marine managers within the SE NRM region serving as a critical baseline against which future changes can be measured. The resulting map books and related interactive DVD will serve as a basis for identifying monitoring and management requirements as well as a driver of basic research and an educational tool. It needs to be recognised that the underlying GIS data that supports current mapping can be summarised in pursuit of a wide variety of management, monitoring and research agendas over and above this brief summary.

Targeted areas for future monitoring may include:

- Areas of high habitat diversity near Kingston and Robe should be considered more closely to see if habitat diversity translates to biodiversity "hotspots" as well as to identify any potential threats.

- Areas of reported seagrass decline, notably within Rivoli Bay but including areas around Guichen Bay and Lacepede Bay where there are large freshwater inputs to the nearshore (see Wear *et al.* 2006).
- Reef systems within proximity to areas of seagrass loss might be assessed for their health status as water quality decline effects on seagrasses may be also manifest on reef systems, particularly with regard to increased sedimentation (see Turner *et al.* 2007).

Information from current mapping and an acknowledgment of knowledge gaps has resulted in a range of recommendations including:

- Targeted monitoring related to specific areas of interest (see above), such as:
    - More highly resolved mapping.
    - Spatially referenced data related to threats to marine benthic systems on the SE NRM coast is required to enable any observed changes to be appropriately assessed. Given that the mapped areas are frequently the focus for regional population centres, industries and maritime transport, the relationship between threats, in particular those related to water quality, relative to seagrass health is worthy of specific attention.
    - Engagement with stakeholders at the local scale.
- Greater understanding of the nature of seagrass systems (distribution patterns and environmental processes) along the SE NRM coast, including improved knowledge of compositional differences between beds relative to their spatial and physical environmental context (exposure, geomorphology, water quality, etc.), will help managers differentiate natural and anthropogenic drivers of seagrass community structure.
- Recognition that the highly energetic SE NRM region coast presents particular challenges to both remote observations and ground truthing.
- Expansion of current mapping to encompass the entire SE NRM coast, including drawing together mapping from alternative sources.
- Development of a greater understanding of physical environmental/ geomorphological factors that account for differences in composition between reef, seagrass and soft bottom systems in different locations, particularly given the unique aspects of this coast relative to elsewhere in South Australia (notably cold water upwellings and the transitional nature of the Maugean Subprovince).
- Understanding the role of natural drivers for compositional change between different areas will better inform managers as to the impact of threats relative to:
    - More spatially and temporally resolved data on water quality.
    - Improved spatial understanding of the range of stakeholders with interests in coastal environments.
- Reconsideration of the current mapped areas needs to be undertaken at a temporal scale relevant to NRM program scales (3-5 years).

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8 Appendix A – Bryars (2003) Fisheries Habitat Areas within the SE NRM region

FHA	Name	Benthic habitats
48	The Coorong	- Reef and Seagrass Meadow and Unvegetated Soft Bottom - Surf Beach - Seagrass Meadow and Unvegetated Soft Bottom - Sheltered Beach - Estuarine River - Coastal Lagoon
49	Guichen Bay	- Reef and Seagrass Meadow and Unvegetated Soft Bottom - Reef and Unvegetated Soft Bottom - Surf Beach - Sheltered Beach - Coastal Lagoon
50	Rivoli Bay	- Reef and Seagrass Meadow and Unvegetated Soft Bottom - Reef and Unvegetated Soft Bottom - Surf Beach - Sheltered Beach - Coastal Lagoon
51	Canunda Beach	- Reef and Seagrass Meadow and Unvegetated Soft Bottom - Sheltered beach - Surf Beach
52	Nene Valley	- Reef and Seagrass Meadow and Unvegetated Soft Bottom - Reef and Unvegetated Soft Bottom - Surf Beach - Sheltered Beach
53	Discovery Bay	- Reef and Seagrass Meadow and Unvegetated Soft Bottom - Reef and Unvegetated Soft Bottom - Surf Beach - Sheltered Beach - Freshwater spring

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