Marine invertebrates of potential conservation concern in the Adelaide and Mount Lofty Ranges Natural Resources Management Board region - A review

A report prepared by Janine L. Baker
for the Adelaide and Mount Lofty Ranges Natural Resources Management Board

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Government of South Australia
Adelaide and Mount Lofty Ranges
Natural Resources Management Board

MARINE INVERTEBRATES OF POTENTIAL CONSERVATION CONCERN IN THE ADELAIDE & MT LOFTY RANGES NRM REGION - A REVIEW

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Dedication

This report is dedicated to the memory of Peter Clarkson, whose ecological understanding and appreciation of marine specimen shells was unique and unparalleled within southern Australia. Peter's passion for the sea started in early childhood, and continued unabated until his tragic and untimely death by white shark on 17th February, 2011.

Acknowledgments

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MARINE INVERTEBRATES OF POTENTIAL CONSERVATION CONCERN IN THE ADELAIDE & MT LOFTY RANGES NATURAL RESOURCES MANAGEMENT REGION -

A REVIEW

SUMMARY

Marine strategies within South Australian Government state the need to consider the conservation of threatened marine species, including invertebrates, as part of this State's long-term commitment to biodiversity protection. Evaluating which species may qualify as threatened is a key step in the process. This review provides species-specific information from one NRM region in SA (Adelaide and Mt Lofty Ranges NRM), which can assist threatened species evaluation processes at a larger, State-wide scale in future. The review is based on a detailed search for information over 4 years (July 2007 to March 2011), regarding the current taxonomy, distribution, habitat, depth range, relative abundance and apparent conservation status (according to IUCN criteria) of marine invertebrates from 17 major taxonomic groups. The information search was undertaken as part of a larger scale project managed by Dr Graham Edgar, on potentially threatened marine species across southern Australia. The current report, supported by the AMLR NRM Board, forms one of the smaller, regional level components of that southern Australian review. Members of 16 of the taxonomic groups have representatives in South Australia that may be considered of conservation concern, based on multiple criteria outlined in this report. This report describes the apparently rare species and endemic species, and other marine invertebrates of conservation concern in the AMLR NRM region, and outlines their currently known distribution in the region. The species are also tabled according to any of 35 characteristics that determine vulnerability of marine species to decline. A potential category of threat is proposed, at a State level, following IUCN criteria where possible. Potential threatening processes are also discussed, and recommendations for conservation of habitats, species and populations over the long term are made.

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1. Introduction

South Australia's *No Species Loss* nature conservation strategy (Government of South Australia 2007) and the *Living Coast Strategy* (Government of South Australia 2004) both state the South Australian government's commitment to providing protection for threatened marine species, including evaluation processes, and the development of recovery plans. To date, no formal evaluation of potentially threatened marine invertebrates in this State has occurred. This report is one contribution towards evaluating the rare, endemic and other potentially threatened marine invertebrates in South Australia, by documenting the existence of such species within the Adelaide and Mt Lofty Ranges (AMLR) NRM region. It is hoped that such information can eventually form part of a more co-ordinated Statewide assessment of South Australia's rare, endemic and other potentially threatened marine invertebrates.

At a national scale, Ponder (Senior Fellow at Australian Museum), Hutchings and Chapman produced an overview of the conservation of marine invertebrates in Australia, in 2002. That report discussed the state of knowledge of Australia's marine invertebrate fauna, impediments to improved knowledge, threatening processes, an overview of State legislation and policies for marine species and habitat protection, and recommendations for conservation, policy, research, management, education and community involvement. The Ponder et al. report included a detailed overview of the characteristics that can be used to determine whether a species is potentially vulnerable, and many of these are discussed in later sections of this report. The Ponder et al. report did not include an assessment or listings of potentially threatened marine invertebrate species at a national level, nor for each State, but provided one or a few examples for nine phyla.

Prior to the 2002 national overview, Ponder and Grayson produced a report in 1998 on the commercial marine molluscs of potential conservation concern, based on their distribution, commonness or rarity and value for trade, and a number of species discussed in that report are also relevant here, due to their occurrence in the AMLR NRM region, as discussed below. The Ponder and Grayson report used a rating system of "A" (most threatened) to "E" (least threatened) for shells in the commercial trade, based on a summation of scores from 1 to 5, for the following criteria:

- *Distribution*: ranging from "very restricted" = found only in a small area within a State or Territory and not elsewhere unless near a border, and the species has a very restricted distribution on the other side of the border, to "spread" = widespread in the State or territory);

- *Development*: ranging from "direct" (benthic eggs, often incubated, and benthic juveniles) to "planktotrophic" (larval stage that feeds on plankton);

- *Accessibility*: ranging from "intertidal" (very readily accessible) to "very deep water" (very difficult to access, other than by deep sea trawling);

- *Market value*: ranging from "more than $1000" per specimen to "less than $20" per specimen.

Additional criteria used in the Ponder and Grayson (1998) assessment that were not ranked from 1 to 5 included fecundity (listed as low, medium or high, where known); relative abundance / size of local populations (where known). The final categories that were assigned following summation of criteria were "A" (scores of less than 8); "B" (> 8, to 9.5); "C" (> 9.5 to 11.5); "D" (> 11.5 to 13.5) and "E" (> 13.5).

At a State level, a number of threatened species assessments for marine invertebrates have been undertaken in south-eastern Australia, and the work from Victoria and Tasmania is of particular note. O'Hara and Barmby (2000) and O'Hara (2002) reported on the molluscs, echinoderms and decapod crustaceans of conservation concern in Victoria, particularly species known from very few locations, even after extensive searches.

Norman and Sant (1995) also discussed conservation issues for a number of marine invertebrates in Victorian waters. In Tasmania, Edgar and Samson (2004) and Edgar et al. (2005) reported on the apparent decline in the species diversity of marine molluscs in that State over the 20th century. They studied mollusc fragments in sediment cores from across a 100km region. The cores ranged in age from the start of the 20th century, to the 1990s, and the study recorded a significant decline in mollusc species richness and diversity over that period, concomitant with a rise in the abundance of few introduced taxa.

There have been few targetted studies of marine invertebrates in South Australia, to determine the distribution and abundance of rare and endemic species. Some examples of studies undertaken for other purposes, such as assessment of species composition and relative abundance of marine invertebrates at various sites around South Australia, include:

- Studies of specific marine invertebrate groups from various islands in South Australia, arising from expeditions sponsored by the Royal Society of South Australia, in conjunction with South Australian government agencies. Examples include, from the Pearson Island 1969 expedition: Burn (1973) on opisthobranchs, Seed (1973) on isopods, and Watson (1973) on hydroids. From the St Francis Isles 2002 expedition: Hirst (2003) on peracarid crustaceans; Gershwin and Zeidler (2003) on jellyfishes and related fauna (medusae, siphonophores and ctenophores), and Watson (2003) on hydroids. From the Althorpe Islands 2004 expedition: Staples (2005) on Pycnogonida (sea spiders), and Benkendorff (2005) on intertidal molluscs and echinoderms. From the Investigator Group 2006 expedition: Staples (2008) on Pycnogonida, and Sorokin et al. (2008) on sponges.
- Studies to characterise and map the benthic environment of upper Spencer Gulf (Shepherd 1974; Shepherd and Branden 1974; Shepherd 1983a, 1983b) and Gulf St Vincent (Shepherd and Sprigg 1976; Tanner 2005; DEH 2008). All of the Spencer Gulf and Gulf St Vincent studies recorded a number of sessile invertebrate-dominated communities.
- The intertidal reef studies of Benkendorff and colleagues. These studies recorded the species richness and relative abundance of intertidal reef fauna, particularly molluscs and other macro-invertebrates, at Port Stanvac and other locations along the Fleurieu Peninsula in the AMLR NRM region, and at sites around Kangaroo Island (Benkendorff and Thomas 2007; Benkendorff et al. 2007; Dutton and Benkendorff 2008). Earlier studies of rock platform invertebrates include the work of Edmonds, who studied the invertebrate fauna (sponges, corals, worms, crustaceans, molluscs, ascidians and echinoderms), their relative abundance and zonation, at Pennington Bay on Kangaroo Island, between 1944 and 1947 (Edmonds 1948).
- Biodiversity studies undertaken by SARDI, around Yorke Peninsula (Rowling et al. 2009a), and the South East (Rowling et al. 2009b), which documented the infauna extracted from benthic Smith-McIntyre grab samples; the epibiota from benthic sled tows; and the mobile macro-invertebrates from beam trawl samples. A large proportion of the taxa in these surveys was not identified to species level.
- Surveys undertaken as part of the community-based Reef Watch program, which have documented approximately 30-35 of the common invertebrate species associated with shallow subtidal reefs at various South Australian locations, especially in eastern Gulf St Vincent and at sites around southern Yorke Peninsula (e.g. Turner et al. 2007; Westphalen 2009, 2010).
- A study of the sponge fauna of Spencer Gulf, based on the results of a survey in 2007 to quantify the relative abundance and distribution of marine fauna in Spence Gulf (Sorokin and Currie 2009).
- Surveys of the sessile invertebrate fauna (particularly ascidians, molluscs, bryozoans and sponges) of reefs and caves at selected sites along the north coast of Kangaroo Island, from 1999 to the mid 2000s (by K. Gowlett-Holmes, T. Laperousaz from SA Museum, J. Thistelton, and D. Muirhead);
- Studies of the invertebrate fauna on jetty piles at selected sites around South Australia (by K. Gowlett-Holmes on Kangaroo Island, and by A. Butler and other former researchers at University of Adelaide, at sites along Fleurieu Peninsula and Yorke Peninsula (e.g. studies of recruitment and other aspects of invertebrate population dynamics by Butler 1986, 1991; Butler and Connolly 1995, 1999). Detailed studies of the invertebrate epifauna on *Pinna* razorfish shells have also been undertaken (e.g. Keough 1983, 1984a, 1984b, Kay and Keough 1981).

- A community-based, government-sponsored project to document the marine flora and fauna (including benthic invertebrates) at sites along the Dudley Peninsula on Kangaroo Island (KI-AMCS 2000);
- A detailed study in the eastern Great Australian Bight (GAB), documenting the epifauna inside and outside of the benthic protection zone of the GAB Marine Park (e.g. Sorokin et al. 2005; Ward et al. 2006; Currie et al. 2007, 2008).
- Documentation of marine invertebrates during surveys to record distribution of invasive species. For example, at least 250 marine invertebrate species were recorded during surveys around Eyre Peninsula in spring of 2009 (Dittman et al. 2010).
- Numerous studies undertaken for environmental impact assessment of various coastal and marine developments. Examples over several decades include: studies of the potential environmental effects of a petro-chemical complex at Redcliff in northern Spencer Gulf (DEC 1974; Redcliff Petrochemical Company 1974; Dow Chemical Australia 1980), which included characterisation of the marine invertebrate fauna in the area; studies of the effect of power station development on intertidal invertebrates in the Port River estuary (Thomas et al. 1986) and northern Spencer Gulf (Ainslie et al. 1989); studies of the effects of trace metals from a lead smelter at Port Pirie, on epibenthic invertebrates and infauna (Ward and Young, 1982, 1984; Ward and Hutchings 1996; Hutchings et al. 1993); study of the macro-invertebrate epifauna of seagrasses in Holdfast Bay (a site affected by sewage treatment effluent) (Sergeev et al. 1988); effects of wastewater treatment on invertebrate infauna off Christies Beach (Loo 2001), and marine benthic characterisation studies (including invertebrates) in relation to dredging projects at Port Stanvac (e.g. Cheshire and Miller 1996, 1999), Outer Harbour (Cheshire et al. 2002; Fairhead et al. 2002a) and Port Giles (Fairhead et al. 2002b), and the development of a seawater desalination plant in Gulf St Vincent during the late 2000s (Loo et al. 2008; Theil and Tanner 2008a,b,c).

2. Threatened Species Legislation and Definitions

Threatened species legislation is designed to prevent the decline (and eventual extinction) of rare or endangered species, by preventing over-exploitation, and/or by protecting critical habitats. Recovery programs are often formulated for listed threatened species. Threatened species listings in each state of Australia mainly include marine mammals and birds. A small number of marine invertebrates are listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*) as threatened species, and these include the Derwent River Seastar *Marginaster littoralis* from Tasmania (listed as *Critically Endangered*), and the Tasmanian Live-bearing Seastar *Patiriella* (= *Parvulastra*) *vivipara* (listed as *Vulnerable*). Under the provisions of the *EPBC Act*, conservation advice and recovery plans are developed for listed species (and for listed ecological communities). Key threatening processes are also recognised, and threat abatement plans are developed to try to reduce the impacts of threatening processes. The two listed marine invertebrates will not be discussed here because they do not occur in South Australia. A very similar live-bearing seastar, *Parvulastra parvivipara* occurs along the western side of Eyre Peninsula / eastern Great Australian Bight, and is discussed briefly in the section below on Asteroidea (Sea Stars).

Most States in Australia have specific legislation under which marine invertebrate species can be listed as threatened (**Table 1**). However, in New South Wales and South Australia, marine invertebrates can be listed as threatened under existing fisheries legislation.

Table 1: Species listed under threatened species Acts or other relevant legislation in southern Australian States. Categories for listing are as follows (alphabetical order): CEn = Critically Endangered; E = Endangered; PEx = Presumed Extinct; R = Rare; T = Threatened Vu = Vulnerable.

State	Marine Threatened or Protected Species Legislation	Marine Invertebrates Listed	% of all Marine Species and Species Population Listings that are Invertebrates
NSW	*Threatened Species Conservation Act 1995* *Fisheries Management Act 1994* *Fisheries Management (General) Regulation 2002*	*Metaprotella haswelliana* Haswells caprellid (PEx) *Smeagol hilaris* a marine slug (CEn) *Branchinella buchananensis* Buchanans fairy shrimp (Vu)	9% (= 3 of 34 species and species populations)
Victoria	*Wildlife Act 1975* *Flora and Fauna Guarantee Act 1988*	*Amphiura triscacantha* a brittle star (T) *Apsolidium densum* a sea-cucumber (T) *Apsolidium handrecki* a sea-cucumber (T) *Athanopsis australis* Southern Hooded Shrimp (T) *Bassethullia glypta* a chiton (T) *Eucalliax tooradin* a ghost shrimp (T) *Michelea microphylla* a ghost shrimp (T) *Ophiocomina australis* a brittle star (T) *Pentocnus bursatus* a sea-cucumber (T) *Platydoris galbana* a marine opisthobranch (T) *Ralpharia coccinea* a stalked hydroid (T) *Rhodope* sp. a marine opisthobranch (T) *Thyone nigra* a sea-cucumber (T) *Trochodota shepherdi* a sea-cucumber (T)	35% (14 of 40 species, including marine birds)
Tasmania	*Threatened Species Protection Act 1995*	*Patiriella vivipara* Live-Bearing Seastar (En) *Marginaster littoralis* a seastar (En) *Gazameda gunnii* Gunn's Screw Shell (En) *Smilasterias tasmaniae* a seastar (R)	14% (= 4 of 29 species, including marine birds)
South Australia	*National Parks and Wildlife Act 1972* *Fisheries Management Act 2007*	(no marine invertebrates listed under threatened species legislation)	
Western Australia	*Wildlife Conservation (Specially Protected Fauna) Notice 2010*, under the *Wildlife Conservation Act 1950*		0% (0 of 36 species, excluding *Schedule 3 - Migratory birds protected under an international agreement*)

In Victoria, species listed under the *Flora and Fauna Guarantee Act 1988* as *threatened*, have Action Statements prepared. These statements detail the species description, distribution, habitat, life history, ecology, and conservation status at national and Victorian scales. Threats are also listed, with past management actions and future management objectives to ameliorate threats. In Victoria, in addition to the current listings under the *Flora and Fauna Guarantee Act 1988* (**Table 1**), there is also an Advisory List (DSE 2009) with further recommendations for formal listing under the Act. Current marine invertebrate examples include the sea cucumber *Apsolidium falconeri* sea-cucumber and the Brackish Jellyfish *Australomedusa baylii* (both recommended for listing as *vulnerable*).

In South Australia, although there is provision for listing threatened species under schedules of the *National Parks and Wildlife Act 1972*, invertebrates have not been listed under this Act as "protected animals", because "animals" are defined as comprising mammals, birds and reptiles. However, invertebrates and their habitats can be legally protected in Aquatic Reserves (declared under the *Fisheries Act 1982*, now known as the *Fisheries Management Act 2007*) and marine parks. The fisheries legislation (section 42 of the former *Fisheries Act 1982*) enables various categories of "fish" (including invertebrates) to be declared as "protected", with collection prohibited. Some commercially important species are subject to special management arrangements, such as closed seasons and areas, quotas and/or and bag and boat limits. Examples include abalone (*Haliotis* spp.), the Blue Swimmer Crab (*Portunus pelagicus*), the Southern Rock Lobster (*Jasus edwardsii*) and Southern Calamari (*Sepioteuthis australis*). Acts in South Australia which can benefit marine invertebrate conservation indirectly include the *Coast Protection Act 1972*; the *Environment Protection (Marine) Policy 1994*, the *Marine Parks Act 2007*.

The *National Parks and Wildlife Act* in South Australia has a schedule for listing species as "rare", but marine invertebrates are not included, as indicated in the previous paragraph. The category of rare may relate to either: a reduced area of occupancy and/or extent of occurrence, a sharp decline in abundance, small population sizes, and/or restricted extent of occurrence or area of occupancy, with specific criteria for each of those categories.

At a global scale, the categories of the IUCN's Red List of Threatened Species (IUCN, 2001) no longer includes a category of "rare", but some species which may qualify as rare due to very small or restricted population (with evidence of fluctuation or decline), or very restricted geographic range, may instead be listed as *critically endangered*, *endangered* or *vulnerable*, depending on specific numeric criteria.

For example, according to IUCN criteria, if a species is known from 5 or fewer locations, it may satisfy criteria for listing as *vulnerable*. Many other criteria, including those relating to extent of occurrence and area of occupancy are also used to assess status, as shown in **Table 2** below.

Although not included as an IUCN category, a species may be considered "rare" according to geographic range (often narrow, in the case of rare species); narrow habitat range / specificity, and small local population size (Davey 1993). Species which satisfy all three criteria are intrinsically vulnerable to decline (Ponder et al. 2002). Many species are naturally "rare", due to low population numbers (local abundances) at any one location across the range, but may not be considered threatened due to their broad geographical distribution and relatively high overall abundance (Jones and Kaly 1995). The concept of "rare" differs according to the application, and can loosely refer to species that are not commonly recorded in surveys, but may not be truly rare in the biogeographic sense. For example, many of the species reported by Dutton and Benkendorff (2008) to be rare species, according to intertidal surveys in the AMLR NRM region, actually have a broad distribution across southern or south-eastern Australia, and are prolific in some areas. Others are more common in the shallow subtidal (e.g. several meters deep), and therefore are unlikely to be recorded in intertidal surveys, even if present in the area. As another example, a species considered in the report by Dutton and Benkendorff (2008) to be rare because it has been recorded only at Port Stanvac, and in no other intertidal survey in SA, is known mainly from tropical Australia, including port areas, and is thus likely to have been imported into South Australia, through shipping.

Table 2: Summary of the IUCN Red List Categories and Criteria (from IUCN Shark Specialist Group 2007).

Summary of the five criteria (A-E) used to evaluate if a species belongs in a category of threat (Critically Endangered, Endangered or Vulnerable).

Use any of the criteria A-E	Critically Endangered	Endangered	Vulnerable
A. Population reduction	Declines measured over the longer of 10 years or 3 generations		
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3 & A4	≥ 80%	≥ 50%	≥ 30%
A1. Population reduction observed, estimated, inferred, or suspected in the past where the causes of the reduction are clearly reversible **AND** understood **AND** have ceased, based on and specifying any of the following: **(a)** direct observation **(b)** an index of abundance appropriate to the taxon **(c)** a decline in AOO, EOO and/or habitat quality **(d)** actual or potential levels of exploitation **(e)** effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.			
A2. Population reduction observed, estimated, inferred, or suspected in the past where the causes of reduction may not have ceased **OR** may not be understood **OR** may not be reversible, based on (a) to (e) under A1			
A3. Population reduction projected or suspected to be met in the future (up to a maximum of 100 years) based on (b) to (e) under A1.			
A4. An observed, estimated, inferred, projected or suspected population reduction (up to a maximum of 100 years) where the time period must include both the past and the future, and where the causes of reduction may not have ceased **OR** may not be understood **OR** may not be reversible, based on (a) to (e) under A1.			
B. Geographic range in the form of either B1 (extent or occurrence) AND/OR B2 (area or occupancy)			
B1. Extent of occurrence	< 100 km²	< 5,000 km²	< 20,000 km²
B2. Area of occupancy	< 10 km²	< 500 km²	< 2,000 km²
AND at least 2 of the following:			
(a) Severely fragmented, **OR** Number of locations	= 1	≤ 5	≤ 10
(b) Continuing decline in any of: **(i)** extent of occurrence; **(ii)** area of occupancy; **(iii)** area, extent and/or quality of habitat; **(iv)** number of locations or subpopulations; **(v)** number of mature individuals			
(c) Extreme fluctuations in any of: **(i)** extent of occurrence; **(ii)** area of occupancy; **(iii)** number of locations or subpopulations; **(iv)** number of mature individuals			
C. Small population size and decline			
Number of mature individuals	< 250	< 2,500	< 10,000
AND either C1 or C2:			
C1. An estimated continuing decline of at least: (up to a max. of 100 years in future)	25% in 3 years or 1 generation	20% in 5 years or 2 generations	10% in 10 years or 3 generations
C2. A continuing decline **AND** (a) and/or (b):			
(a) (i) # mature individuals in each subpopulation:	< 50	< 250	< 1,000
(a) (ii) or % individuals in one sub-population at least	90%	95%	100%
(b) extreme fluctuations in the number of mature individuals			
D. Very small or restricted population			
Either: Number of mature individuals	≤ 50	≤ 250	**D1.** ≤ 1,000 **AND/OR**
Restricted area of occupancy			**D2.** AOO < 20 km² or # locations ≤ 5
E. Quantitative Analysis			
Indicating the probability of extinction in the wild to be:	≥ 50% in 10 years or 3 generations (100 years max)	≥ 20% in 20 years or 5 generations (100 years max)	≥ 10% in 100 years

Ideally, species assessments using the criteria listed in **Table 2** above should only be undertaken using all known data on range, and number of records. Also, even if a species qualifies for listing using any of the categories or criteria listed in **Table 2**, the accuracy of the assessment is time-specific, and may be revised in future as better information becomes available regarding distribution and relative abundance. This is particularly true for many marine invertebrate species, which are known from very few, opportunistically collected records, and the true distribution may be much broader (and abundance may be considerably higher), than is considered from the currently available records. For most of the apparently uncommon marine invertebrate species in SA, targetted searches of records have not been undertaken, and for many of these species, the few examples known were incidental, recorded during general dredging studies (particularly early 1900s), beam trawl surveys, dive trips to popular locations, or surveys undertaken for some other purpose.

One of the most important metrics to estimate rarity (and threatened status) refers to the area of occupancy. In the marine environment, however, area of occupancy and extent of occurrence can be difficult to apply in terms of square kilometres, due to the three dimensional nature of the sea. In this case, depth range should also be considered rather than a linear distance along a coast (hence volume instead of area is often the preferred spatial unit). However, the choice of spatial scale can vary according to which species is under study, and the nature of the benthos (e.g. with or without extreme changes in depth such as sand plains versus canyons). Also, some invertebrate species have microscopic life stages which spend weeks or months at sea, and others have adult stages which are so small and cryptic that their distribution would be impossible to determine without unfeasibly large survey efforts. Consequently, many species which may not genuinely be uncommon or rare, are known from very few records.

Moreover, a number of species which may qualify as rare may not necessarily be vulnerable (if there are no threatening processes occurring) and a number of species may not qualify for listing as rare, but could be considered threatened if threatening processes are widespread and continuous.

Other than for commercial species, there is a distinct lack of baseline population data for marine species, particularly invertebrates, and this hinders attempts to propose species for listing under State threatened species legislation. In Tasmania, Edgar and Sampson (2004) provided a telling example of this problem, in which only one mollusc species (*Gazameda gunnii*) has been listed as threatened in Tasmania, despite the majority of the more than 1000 Tasmanian mollusc species (May and Macpherson 1958) not having been sighted or collected alive during the past two decades.

3. Characteristics that Determine Vulnerability of Marine Species

There are numerous recognised life history and population characteristics that can render marine invertebrates (and other species) vulnerable to decline, and eventually to extinction. **Table 3** below lists many of these characteristics.

Table 3: Characteristics that render marine invertebrates vulnerable to population decline and eventual extinction (adapted from Jones and Kaly 1995; Roberts and Hawkins 1999 and Ponder et al. 2002, with additions)

Characteristic	Features shared by potentially vulnerable species
Population turnover	1. Long life span 2. Slow growth rate 3. Low natural mortality 4. Low production biomass
Reproduction	5. Low reproductive effort 6. Low fecundity 7. Highly variable reproductive output / prolonged periods of recruitment failure 8. Semelparous reproduction (i.e. reproduces once in a lifetime) 9. Large size at maturity and/or old age at maturity (i.e. long time to maturity) 10. Large difference in size between sexes 11. Sex change (particularly protandry: male stage followed by a female stage) 12. Forms spawning aggregations at predictable locations 13. Live bearing / direct development of young (compared with egg-bearing) 14. Strong Allee effects at reproduction (i.e. when a reduction in population density has significant impacts on the ability of the organism to reproduce) 15. Brooding of young 16. Poorly dispersed benthic larvae (compared with widely dispersed planktonic larvae)
Capacity for Recovery	17. Regeneration from fragments does not occur 18. Short distance dispersal / limited dispersal ability 19. Poor competitive ability 20. Poor colonizing ability 21. Low adult mobility 22. Irregular recruitment by larval settlement and/or low level of larval settlement 23. Strong Allee effects at settlement
Range & Distribution (related to Rarity)	24. Horizontal distribution restricted to nearshore area (compared with offshore) 25. Narrow depth range (= narrow vertical distribution) 26. Small geographic range / restricted distribution 27. High patchiness / fragmentation of population within range (i.e. composed of few small, highly fragmented populations) 28. High habitat specificity / specialisation 29. High vulnerability to habitat destruction by people
Trophic Level	30. High trophic level
Other Ecological Factors	31. Close association with threatened habitat, or threatened taxa (as parasites or commensals, food source etc.)
Commercial & Social Value	32. Value as food (promotes exploitation by commercial &/or recreational fishing / collecting) 33. Value in trade for collections / ornaments etc (promotes exploitation).
Miscellaneous	34: High visibility (due to large size, bright colour / patterning, and/or presence in intertidal habitats 35: Adults live in aggregations, or form feeding aggregations 36: Subject to large scale mass mortality events

In addition to the characteristics detailed above in **Table 3**, other factors that can increase the vulnerability of marine invertebrate species to decline (particularly from over-exploitation) include a readily accessible habitat (e.g. if collected for food or trade); high visibility (i.e. large size and/or bright colours and patterns, as are some shells), and high value (especially specimen shells, or highly valued food species) (Ponder et al. 2002).

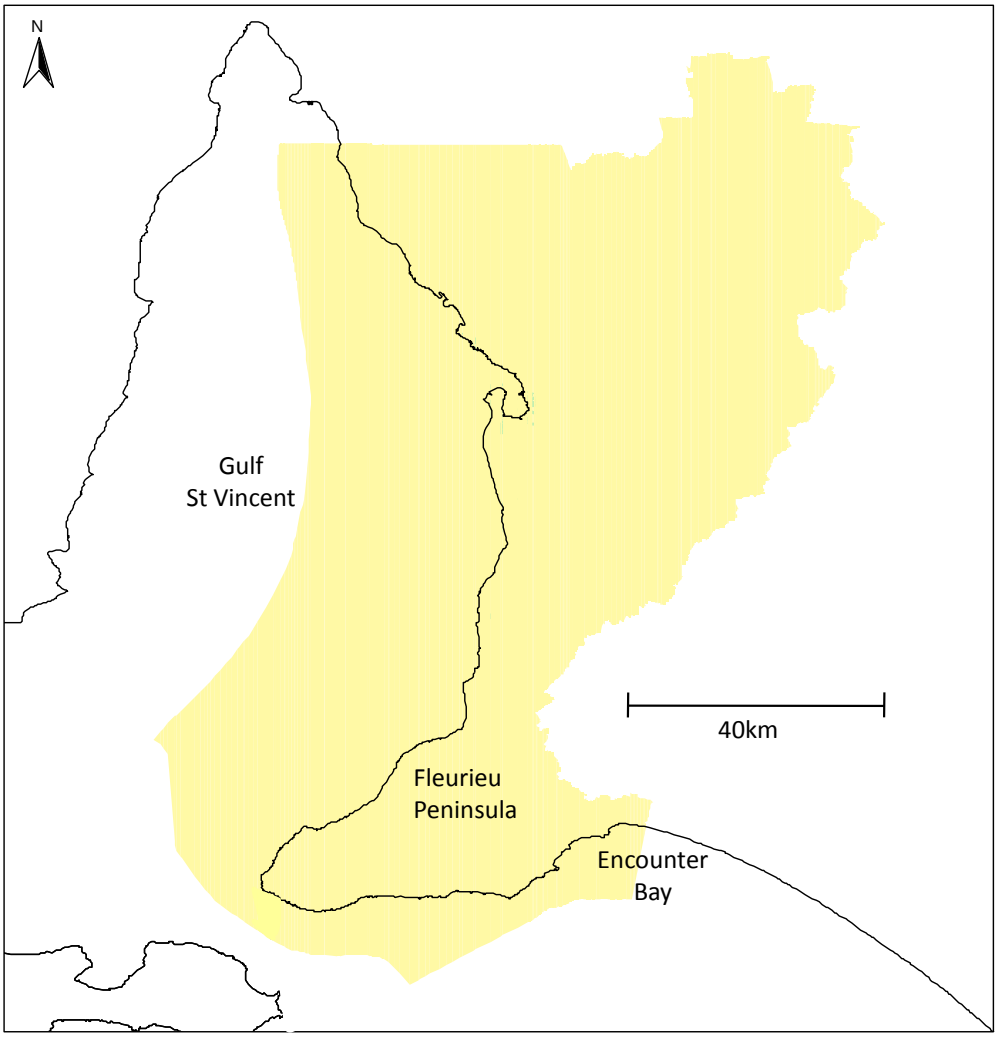
Many marine species may qualify as potentially vulnerable due to restricted range (particularly apparent endemism within South Australia), apparent rarity (known from very few records), and small populations. Other characteristics, especially those associated with reproduction (mode, fecundity, frequency of spawning, total reproductive output, and survivorship of larvae and juveniles) are not known for the majority of these marine invertebrates. Inferences can be made from similar taxa (e.g. within the same family, or the same genus) that exhibit vulnerable population characteristics. For example, some groups of Apodid sea cucumbers exhibit brooding of young, and hermaphroditism (protandric – male stage followed by a female stage). Similarly for some gastropod molluscs in temperate waters, brooding of young or otherwise production of young via direct development (rather than having widely dispersed planktonic larvae), is often also associated with low fecundity and narrow geographic range of specific breeding populations (or sub-populations), and these characteristics renders such molluscs at greater risk of extinction. However, for species with unknown modes of reproduction, whilst inferences can be made by comparison with what is known of closely related taxa, such inference can be not always be reliable, because some taxa show considerable variation, even within genera or within a species (Ponder et al., 2002).

4. Methods

A detailed search for information on South Australian marine invertebrates from 17 major taxonomic groups was undertaken over a three year period between March 2008 and March 2011. In alphabetical order, these groups are:

- Anthozoa (corals and anemones)
- Aplacophora (chaetoderms and neomenioids)
- Ascidiacea (sea squirts)
- Asteroidea (sea stars)
- Bivalvia (bivalve shells)
- Brachiopoda (lamp shells)
- Cephalopoda (squids, cuttlefishes, octopus)
- Crinoidea (feather stars)
- Decapoda (shrimps, prawns, crabs)
- Echinoida (sea urchins and sand dollars)
- Holothuroidea (sea cucumbers)
- Ophiuroidea (brittlestars)
- Opisthobranchs / Heterobranchia (sea slugs)
- Polyplacophora (chitons)
- Prosobranchs (sea snails, gastropod shells)
- Pycnogonida (sea spiders)
- Stomatopoda (mantis shrimps)

For members of these groups that occur in South Australia, information regarding the current taxonomy, distribution, habitat, depth range, relative abundance and apparent conservation status (using IUCN criteria) was collated. Members of 16 of the groups (with the apparent exception of Aplacophora) have representatives in the Adelaide and Mt Lofty Ranges NRM region (**Map 1**) that may be considered of conservation concern, based on criteria outlined below.



Map 1: Adelaide and Mt Lofty Ranges NRM Region

Information collated during the literature review phase of this project included:

- Taxonomy: current nomenclature checked against the most reliable taxonomic sources for each major group
- Common Name
- Distribution: currently known geographic range, including number of States, and distribution within State(s)
- Maximum Size
- Type Locality
- Example Locations (other than Type Locality)
- Habitat
- Known Depth Range
- Other Information (e.g. existing conservation status listings; trade information; discrepancies in nomenclature)
- Major References

References included museum records and databases, taxonomic and other related databases, taxonomic monographs, field survey reports, scientific papers, fisheries and trade data, amongst other references. Based on the results of the literature searches, an IUCN category of threat was proposed, using the criteria outlined in section **3**, and considering known distribution (including apparent endemism), number of records, depth range (e.g. narrowness); mode of reproduction (e.g. benthic larvae and brooding of young are both characteristics which can increase vulnerability); apparent degree of threat (e.g. habitat degradation, or indications of over-exploitation, in the case of commercially and/or recreationally harvested species).

5. Results - Species Accounts

The following sections discuss marine invertebrate species of conservation concern in the AMLR NRM region, from each of the 16 major groups studied. Results are presented in alphabetical order of major group.

Anthozoa (Anemones and Corals)

The class Anthozoa includes the sea anemones and stinging sea anemones, tube anemones, jewel anemones, zoanthid anemones, soft corals, gorgonian corals, hard corals, and sea pens. Members of the Class Anthozoa occur as polyps or colonies of polyps, most of which can reproduce either sexually (by releasing sperm and eggs into the water, which fuse to become a mobile larva which disperses), or asexually, by budding off tiny new individuals from the body wall (Edgar 2008; Gowlett-Holmes 2008).

The taxonomic status of anthozoans (particularly anemones) in southern Australia is very poorly known, with various undescribed species, and several named species that may require taxonomic revision. For example, previous identification work was based largely on museum specimens, which bear little resemblance to live specimens. A number of named species may really be the same species, and conversely, a single named species may contain several species that have not yet been correctly identified. Field guides have been known to depict the same species under different names, or use the same name for different species. In some cases, species attributed to a particular genus (e.g. *Epiactis*) might actually not belong to a single genus, but have been assigned to it because they seem to belong nowhere else (D. Fautin, Professor of Ecology and Evolutionary Biology, and Curator of Natural History Museum and Biodiversity Research Centre, University of Kansas, pers. comm. 2009). Establishing a southern Australian species inventory, and also determining species' distributions, and the relationship (and overlap) between species of anemone in Australia, New Zealand and other regions, would involve measuring nematocysts of animals from these regions, and comparing morphology and histology. Despite recent studies, much remains to be done, and the taxonomy of anemones is still poorly known (D. Fautin, University of Kansas, pers. comm. 2009). A revision of the Actiniaria (anemones) is currently being undertaken by D. Fautin and C. Wallace and associates, and recently, work is also being undertaken by a taxonomist in Victoria (M. Mitchell) on the southern Australian anthozoan fauna.

Some species known from one locality are likely to occur much more widely, but records are scant, because collecting efforts have been opportunistic over the decades, and not systematic. The existence of cryptic species further complicates determination of distribution.

Table 4: Anthozoan species of potential conservation concern found to date in South Australia, which either occur in AMLR NRM, or are likely to occur there, based on known presence in the SA gulfs region. Species that may be known to date only from AMLR NRM are highlighted in grey. GAB = Great Australian Bight; GSV = Gulf St Vincent; KI = Kangaroo Island; VIC = Victoria.

Family	Genus and Species	Authority	Known Records (to 2011)
Actiniidae	Actiniid sp. 3	(in Edgar 2008)	Various in SA gulfs region, including Port Lincoln
Corallimorphidae	*Corynactis* sp.	(in Gowlett-Holmes, 2008)	SA gulfs, KI, south-east SA, western VIC
Edwardsiidae	*Edwardsia vivipara*	Carlgren 1950	GSV & Spencer Gulf in SA Port Phillip Bay in VIC
Isophelliidae	*Thelmactis* sp.	(in Gowlett-Holmes 2008)	SA gulfs & KI
Cerianthidae	Unknown	(in Gowlett-Holmes 2008)	SA gulfs & KI
Edwardsiidae	Unknown	(in Gowlett-Holmes 2008)	SA gulfs & KI
Edwardsiidae	Unknown	(in Gowlett-Holmes 2008)	GSV
Aliciidae	Unknown	(in Gowlett-Holmes 2008)	SA gulfs, Kangaroo I. & GAB
Aliciidae	Unknown	(in Gowlett-Holmes 2008)	SA gulfs & Kangaroo I. (e.g. Boxing Bay)
Edwardsiidae	Unknown	(in Gowlett-Holmes, 2008)	SA and VIC
Unknown	Unknown	(in Gowlett-Holmes, 2008)	western SA, possibly Eyre Peninsula and KI (unspecified)

The undescribed White-striped Anemone (Actiniid sp. 3 in Edgar 2008) is known from the South Australian gulfs, and although it is not often seen, is reported to be locally abundant where present. This small species (to 2cm high) occurs on moderately exposed reef; under rock overhangs in areas with tidal currents (Edgar 2008). Currently known records for this species range from 8m to 15m deep.

Edwardsia vivipara Carlgren 1950 is a live-bearing anemone known from both SA (including AMLR NRM) and Victoria (Thomas and Shepherd 1982; McKinnon et al. 2003). Examples in GSV include Outer Harbour (Lund University Museum of Zoology record, in Fautin 2010). It grows to about 6cm, and is found in sand (and muddy shores), out in the open, mainly on sheltered coasts, between 1m and 10m (Gowlett-Holmes 2008). *Edwardsia vivipara* has a brown or black column, and white star-shaped tentacles which protrude from the sand and are quickly withdrawn upon disturbance (Thomas and Shepherd 1982). This species may contain symbiotic zooxanthellae algae (Gowlett-Holmes 2008). The status of this species in SA is not known due to lack of information about full distribution in this State, and relative abundance.

There are 7 other anemones known to date only from South Australia; these are likely to occur in the AMLR NRM region, and all are undescribed (**Table 4**). Four of the 7 species known from the SA gulfs are sea anemones, two are stinging anemones in the Aliciidae family and one is a tube anemone in the Cerianthidae. Two of the sea anemones are known to be members of the Edwardsiidae (burrowing anemones), but genus and species names have not yet been assigned. One is known from Gulf St Vincent, between 3m and 20m, and the other from both gulfs in SA, and Kangaroo Island, between 1m and 12m (Gowlett-Holmes 2008). Both occur in sandy habitats. A third unnamed species in the Edwardsiidae has been recorded in both South Australia and Victoria, in clean, well sorted sand, in areas of moderate to strong current. **Figure 1** shows an example of a species in Edwardsiidae, photographed in American River on northern Kangaroo Island. Another unnamed species in South Australia, not currently known from any other State, is *Thelmactis* sp., an anemone with a pink column, purple oral disc, and pink and white tentacles. It is found in sand, attached to a pebble / stone. This species has been recorded in the SA gulfs and northern Kangaroo Island, between 1m and 10m (Gowlett-Holmes 2008).

There is also an unnamed white anemone with radiating red lines, found in western South Australia (and possibly also the gulfs region and/or Kangaroo Island), but it has not yet been assigned to a family, genus or species. The unnamed white anemone, which has short tentacles, is found buried in sand or attached to a pebble or piece of dead shell, on moderately sheltered to open coasts, between 0m and 15m (Gowlett-Holmes 2008).

The two unnamed stinging anemones (in Aliciidae) have both been recorded in the SA gulfs and at locations off Kangaroo Island, in macroalgae and seagrass from about 1m to 8m deep. Both are possibly tropical species, found in warmer months, and they adhere to plants but will let go and float if disturbed (Gowlett-Holmes 2008). **Figure 2** shows two examples of one of these stinging anemones, from Boxing Bay on northern Kangaroo Island, and Carrickalinga on the Fleurieu Peninsula, respectively. This stinging anemone has also been recorded at other locations, such as Normanville Beach in GSV, at 2m deep (photograph by D. Muirhead, pers. comm. 2011). Neither the genus nor the species has been formally described. This species is known from the gulfs region in SA (see map in Gowlett-Holmes 2008), and from Kangaroo Island (**Figure 2a**).

The unnamed tube anemone (Cerianthidae) known to date from South Australia (Gowlett-Holmes 2008) has been found in the SA gulfs and northern Kangaroo Island, in sand on sheltered to moderately exposed coasts, between 2m and 15m deep. The tentacles, which are red-brown with pale spots, are longer than those on sea anemones.

Figure 1: An anemone species in Edwardsiidae. Photo (c): K. Smith

Figure 2A: A locally common unnamed anemone species in Aliciidae. Photo: (c) C. Hall, MLSSA

Figure 2B: A locally common unnamed anemone species in Aliciidae. Photo: (c) J. Brook

The soft corals is another group of anthozoans which contains members known to date only in South Australia, but which might be more widespread. Two members of the Nephtheidae have been recorded at Wedge Island in SA (Verseveldt 1977; Verseveldt 1982, in Shepherd and Thomas, 1982), but it is not yet known if they are also found in the AMLR NRM region. These species *Capnella shepherdi* Verseveldt 1977 and *Chromonephthea cornuta* (Verseveldt 1977) have been recorded at 12m and 12m – 15m respectively, the latter on a vertical reef face under a cliff. The holotype specimen of *C. cornuta* is 24cm long and 11cm wide, and is red with white polyps. No recent information appears to be available, and knowledge to date appears to be limited to the original descriptions by Verseveldt; the taxonomic update by Verseveldt in Shepherd and Thomas (1982), and a discussion of the taxonomy of *C. cornuta* (using the type specimen) by van Ofwegen (2005). The full distribution of these two species is not known, due to the lack of targetted searches in the cryptic habitats in which these species reside.

The zoanthid anemones are not discussed here due to the uncertain nature of current taxonomy. Few of the known southern Australian species appear to have limited geographic ranges. There is an unnamed white species in *Epizoanthus* which is known from sponges in caves, on moderately exposed to open coasts in the gulfs region and GAB of South Australia (Gowlett-Holmes 2008), but this poorly known zoanthid may have a wider distribution that cannot yet be ascertained due to the lack of vouchered specimens and comparative material across southern Australia and New Zealand (K. Gowlett-Holmes, pers. comm. 2009). There is at least one unnamed species of white zoanthid in southern Australia. The taxonomy and distribution of zoanthids is complicated by the fact the visually similar specimens may be sympatric species rather than a single species (as indicated in recent work on the golden zoanthids, by Philipp and Fautin 2009).

The jewel anemones (Corallimorpharia), which are colonial and have knobs on the ends of the tentacles, include an undescribed member (*Corynactis* sp.) which has a more limited distribution than the common south-eastern Australian species *Corynactis australis*. *Corynactis* sp. is known from the gulfs region and south-eastern SA, and extends to Victoria (Gowlett-Holmes 2008). To date, it has been found on rocks, rubble and dead shells, in silty sand and seagrass between 1m and 8m, mainly on sheltered coasts (Gowlett-Holmes 2008). This species may contain symbiotic zooxanthellae algae.

A number of unusual anthozoans are known from northern Spencer Gulf, such as the sea pen *Scytalium* sp. (in Utinomi and Shepherd 1982) and the gorgonian corals *Echinogorgia* sp. and *Euplexaura* sp. (in Grasshoff 1982 and Shepherd 1983), but these will not be discussed in detail here because there are no records to date from the AMLR NRM region. *Euplexaura* sp. has also been found in the Great Australian Bight (Ward et al. 2003), as has the gorgonian coral *Oparinisis viking* (Alderslade 1998). Another *Oparinisis* species (*O. parkeri*) is known from a single 40cm long specimen, collected by S. Shepherd in 1975 at 62m deep, at a reef site 12km off Cape Northumberland in south-eastern SA. The full distribution and depth range are not known.

There are several hard corals that have either been recorded in the AMLR NRM region, or are likely to occur there, due to their broad southern Australian coastal waters distribution. Examples include:

- *Culicia australiensis* Hoffmeister 1904 and *Culicia hoffmeisteri* Squires 1966, colonial species which resemble jewel anemones, and occurs in caves, and on shaded reefs and jetty piles. C. *australiensis* has a broad depth range (to about 240m);
- *Culicia tenella tenella* Dana 1846, a small coral found across southern Australia, and common on cave walls and other shaded reef surfaces;
- *Scolymia australis* (Milne Edwards and Haime 1849), a mainly solitary coral, found on reefs in tropical and temperate Australia from 0m to about 20m deep. It is bright green, and contains symbiotic zooxanthellae algae, from which it derives nutrition, but also feeds on plankton by extending it polyps at night;
- *Coscinaraea mcneilli* Well 1962, a colonial coral that ranges across the southern half of Australia. It forms plates on rock walls and reefs on moderately exposed to open coasts, from 1m to about 30m.
- *Plesiastrea versipora* (Lamarck 1816), a colonial coral that forms plates and “bommie” shapes in temperate waters, but is also widespread in the tropical to warm temperate Indo-Pacific, where is can form reefs. Like *Scolymia*, it contains symbiotic zooxanthellae algae, from which it derives nutrition, but also feeds on plankton.

These corals are widespread and not uncommon, and are not considered to be currently threatened on a global scale (e.g. DeVantier et al. 2008; Sheppard et al. 2008; Turak et al. 2008). However, there may be localised threats for particular populations, particularly of shallow water species, such as sedimentation of nearshore reefs, and nutrient enrichment of coastal waters (e.g. from dredging, coastal developments or discharges). Furthermore, such corals may face future threats during this century that are less easily rectifiable. Of primary concern is the influence of global warming, including sea level rise, increased UV exposure, increased susceptibility to disease, increased severity of El Nino – Southern Oscillation events and storms, and increasing ocean acidification (Wilkinson 2004; Carpenter et al. 2008; DeVantier et al. 2008, in IUCN 2010).

Ascidiacea (Sea Squirts)

The Ascidiacea is a large class of sessile invertebrates commonly known as sea squirts. Ascidians can be solitary or colonial, and are usually attached by adhesive secretions of their body, to reef surfaces, rubble / stones, macroalgae or shell particles. Characteristic features include a muscular, incurrent siphon which opens into a cavity where food (such as bacteria, phytoplankton and organic detritus) and oxygen are extracted from the water, which then exits from an excurrent siphon. Ascidians are very efficient at filtering water. All ascidians are hermaphrodites and contain both male and female gonads, but the gonads usually mature at different times to avoid self-fertilisation (Kott 1997; Gowlett-Holmes 2008). Colonial ascidians can reproduce both sexually and asexually. Also, some colonial species are broadcast spawners, with long range dispersal of larvae, and others are philopatric, with brooded larvae settle close to the parent colony.

Table 5 lists the uncommon and little known species of ascidians that occur in AMLR NRM, or are likely to occur there, based on known presence in the SA gulfs region. Most of these are considered to be endemic within South Australia, and are thus of potential conservation concern. **Table 6** also lists potentially endemic and rarely recorded ascidian species, some of which may occur in AMLR NRM, but have not yet been recorded there. Information in **Tables 5** and **6** was compiled mainly using the taxonomic references of Kott (1972, 1975, 1985, 1990, 1992, 1997, 2001, 2003, 2004, 2005a, 2005c in ABRS 2009, 2006), supplemented by other references as specified below. Recent name changes to the species described by Kott in earlier monographs (e.g. 1970s to 1990s) have been included. Some of the species are widespread across SA, but known from few records. Examples include *Aplidium gastrolineatum* (previously recorded as the widespread species *A. flavolineatum*), for which Waldegrave Island in the eastern GAB is the type locality, but for which records from reefs in the SA gulfs region are also known.

Of the 61 species of ascidians that are currently of limited known distribution in South Australia (**Tables 5** and **6**), the depths of records have been recorded for 38 species, and the majority of these are known from between 1m and 20m. The depth distribution in most cases relates to the diving depths at which specimens were collected. For example, a number of species are known from between 10m and 14m, which is the depth of dives at several sites between Snug Cove and Western River Cove on Kangaroo Island, where various type specimens were collected by K. Gowlett-Holmes and colleagues, rather than reflecting the overall depth range, which is not known for all of these uncommonly recorded ascidian species. One of the few species for which records below 20m exist is *Leptoclinides volvus* Kott 1975 from the Great Australian Bight, recorded to date to 42m (Kott 1975, 2001; Kott 2005c, in ABRS 2010).

Habitat details have been documented for around 36 of the 61 uncommonly recorded ascidian species in South Australia. Most of these species have been found on reefs, including rock walls, caves, crevices, and under ledges / overhangs. A number also occur on rubble reefs as well as more solid reef wall surfaces (e.g. *Polysyncraton pedunculatum* Kott 2001); several on jetty piles (e.g. *Aplidium formosum* Kott 2006, *Diplosoma fecundum* Kott 2004 and *Leptoclinides variegatus* Kott 2001), and several on *Posidonia* seagrass (*Eudistoma aureum* Kott 1990, for which West Beach in GSV is the type locality, and *Tridemnum spumosum* Kott 2001 from Edithburgh, which also occurs on macroalgae). *Cnemidocarpa amphora* Kott 1992 and *Didemnum minisculum* Kott 2001 are also known from seagrass beds, and sand and rubble habitats. *Euherdmania translucida* has been recorded on sand and in root mats of *Posidonia*. Also of interest is the soft encrusting ascidian *Lissoclinum laneum* (**Figure 3**), closely related to the widespread southern Australian species *L. tasmanense*, but known to date only from two records in South Australia. Kott (2004) described the species, and reported it as being known only from the type locality of Port Victoria in Spencer Gulf, where K. Gowlett-Holmes collected the type specimen. Gowlett-Holmes (2008) showed the distribution as being only in Spencer Gulf, and the Australian Faunal Directory (for which the ascidian listings were last modified in 2008) also reported this species as being known only from the type locality. During a field trip in 2009, to document uncommon fish fauna of the AMLR NRM region, we recorded from Encounter Bay a specimen of *L. laneum* (identity supported by K. Gowlett-Holmes, per. comm. 2009), which expands the known range, since the record is out of the gulfs region and further south-east.

Figure 3: *Lissoclinum laneum*, photographed in Encounter Bay. Photo (c): H. Crawford

Aplidium formosum, one of the species in **Table 5**, for which only the type locality (Port Adelaide) is recorded, may be an import. The holotype was a wedge-shaped gelatinous colony to 2 cm high, found on jetty piles at 3m deep (Kott 2006a). No other published information could be found on that species.

Table 5: Ascidian species of potential conservation concern found to date in South Australia, which either occur in AMLR NRM, or are likely to occur there, based on known presence in the SA gulfs region. Species apparently known to date only from AMLR NRM are highlighted in grey. GAB = Great Australian Bight; GVS = Gulf St Vincent; KI = Kangaroo Island. * = may be an import. Compiled from Kott (1972, 1975, 1985, 1990, 1992, 1997, 2001, 2003, 2004a, 2004b, 2005a, Kott 2005c in ABRS 2009, 2006a, 2006b), Museum of Victoria data (1972); Gowlett-Holmes (2008); and an *in situ* photograph by H. Crawford (2009).

Family	Genus	Species	Authority	Known Records (to 2011)
Polyclinidae	*Aplidium*	*gastrolineatum*	Kott, 1992	Anxious Bay, 1 km NW of Waldegrave I.; also locations in SA gulfs region
Polyclinidae	*Aplidium*	*formosum* *	Kott, 2006a	Port Adelaide
Polyclinidae	*Aplidium*	*bacculum*	Kott, 1992	Edithburgh (Yorke Peninsula), Thorny Passage in Spencer Gulf, GAB
Polyclinidae	*Aplidium*	*acroporum*	Kott, 1992	The Gap (near Thistle I., Spencer Gulf), and KI
Polyclinidae	*Aplidium*	*petrosum*	Kott, 1992	Margaret Brock Lighthouse at Cape Jaffa; The Gap & Hopkins I. (Thorny Passage, Spencer Gulf, and eastern GAB
Pyuridae	*Claudenus* (prev. *Ctenicella*)	*antipodus* (*antipoda*)	(Kott, 1972)	Yankalilla Bay
Didemnidae	*Clitella* / *Clitellum*	*nutricula*	Kott, 2001	Edithburgh, and Marum I. (Sir Joseph Banks Group, Spencer Gulf)
Styelidae	*Cnemidocarpa*	*amphora*	Kott, 1992	Sir Joseph Banks group in Spencer Gulf. May also occur in eastern GAB.
Styelidae	*Cnemidocarpa*	*tribranchiata*	Kott, 1992	Seal Rocks, Encounter Bay
Didemnidae	*Didemnum*	*minisculum*	Kott, 2001	Stansbury Jetty, Yorke Peninsula
Didemnidae	*Didemnum*	*delectum*	Kott, 2001	GAB, Tourville Bay (near Ceduna, eastern GAB), Spencer Gulf; Yorke Peninsula; Gulf St Vincent; Investigator Strait; Kangaroo I.
Didemnidae	*Didemnum*	*effusium*	Kott, 2001	Kingston (South East SA); SA gulfs; Hobsons Bay, Victoria

Table 5 (cont.):

Family	Genus	Species	Authority	Known Records (to 2011)
Didemnidae	*Didemnum*	*microthoracicum*	Kott, 2001	Avoid Bay (southern Eyre Peninsula); ?Reevesby Island in Spencer Gulf; Kangaroo Island
Polycitoridae	*Eudistoma*	*aureum*	Kott, 1990	South Australian gulfs. West Beach in GSV is type locality.
Euherdmaniidae	*Euherdmania*	*translucida*	Kott, 1992	Marum I., Sir Joseph Banks Group; Flinders Island in Investigator Group (eastern GAB)
Didemnidae	*Leptoclinides*	*variegatus*	Kott, 2001	Topgallant I. (Investigator Group, eastern GAB); Spencer Gulf; Gulf St Vincent; Investigator Strait; Kangaroo I.
Didemnidae	*Lissoclinum*	*laneum*	Kott, 2004	Port Victoria in eastern Spencer Gulf, and Encounter Bay
Holozoidae	*Neodistoma*	*mammillatum*	Kott, 1990	Seacliff in Gulf St Vincent; Flinders I. & Ward I. in Investigator group (eastern GAB)
Styelidae	*Polyandrocarpa*	*simulans*	Kott, 1972	SA gulfs (based on records from Investigator Strait, south of Foul Bay); Elliston; St Francis I. in eastern GAB
Polycitoridae	*Polycitor*	*obeliscus / obeliscum*	Kott, 1972	Investigator Strait
Didemnidae	*Polysyncraton*	*pedunculatum*	Kott, 2001	Investigator Strait, Topgallant I. & Ward I. in Investigator Group; Franklin I.; Nuyts Archipelago (eastern GAB); Kangaroo I.
Didemnidae	*Polysyncraton*	*rica*	Kott, 2001	GSV; D'Estrées Bay, Kangaroo I.; Spencer Gulf; Topgallant I., Flinders I., Pearson I. & others in Investigator Group (eastern GAB).
Didemnidae	*Polysyncraton*	*tegetum*	Kott, 2001	Great Australian Bight (32°4'S, 133°30'E); Kangaroo Island; and reported from SA gulfs coast but specific published records lacking
Didemnidae	*Tridemnum*	*spumosum*	Kott, 2001	Edithburgh, Yorke Peninsula is the type locality. Occurs in SA gulfs, but published records from specific locations are lacking.

Table 6: Ascidian species of potential conservation concern found to date only in South Australia, some of which may occur in AMLR NRM, but have not yet been recorded there. GAB = Great Australian Bight; KI = Kangaroo Island. Compiled from Kott (1972, 1975, 1985, 1990, 1992, 1997, 2001, 2003, 2004a, 2004b, 2005a, Kott 2005c in ABRS 2009, 2006), Gowlett-Holmes (2008).

Family	Genus	Species	Authority	Known Records (to 2011)
Polyclinidae	*Aplidiopsis*	*sabulosa*	Kott, 1992	Price Island, Avoid Bay, Eyre Peninsula
Polyclinidae	*Aplidiopsis*	*mammillata*	Kott, 1992	Cathedral Rock, near Thistle I., Spencer Gulf
Polyclinidae	*Aplidium*	*elatum*	Kott, 1972	Elliston, eastern GAB
Didemnidae	*Atriolum*	*lilium*	Kott, 2001	Flinders, Topgallant, & Ward Is. in the Investigator Group, and Franklin I., eastern GAB
Styelidae	*Botrylloides*	*saccus*	Kott, 2003	Penneshaw, KI
Didemnidae	*Didemnum*	*monile*	Kott, 2001	West Island in Nuyts Archipelago, GAB
Didemnidae	*Didemnum*	*cilicium*	Kott, 2005	between Western River Cove & Snug Cove on KI
Didemnidae	*Didemnum*	*bicolor*	Kott, 2001	Topgallant I., eastern GAB

Table 6 (cont.):

Family	Genus	Species	Authority	Known Records (to 2011)
Didemnidae	*Diplosoma*	*fecundum*	Kott, 2004	Kingscote jetty, KI
Holozoidae	*Distaplia*	*tokiokai*	Kott, 1990	Price I., Avoid Bay, Eyre Peninsula
Didemnidae	*Leptoclinides*	*compactus*	Kott, 2001	Price I., Avoid Bay, Eyre Peninsula and other locations in eastern GAB
Didemnidae	*Leptoclinides*	*frustus*	Kott, 2005	between Snug Cove & Western River Cove, KI
Didemnidae	*Leptoclinides*	*volvus*	Kott, 1975	north Great Australian Bight (32º24'S 133º30'E)
Didemnidae	*Leptoclinides*	*decoratus*	Kott, 2004	between Snug Cove & Western River Cove, KI
Didemnidae	*Lissoclinum*	*clavatum*	Kott, 2005	E of Snug Cove, and site between Snug Cove & Western River Cove, KI
Molgulidae	*Molgula*	*ellistoni*	Kott, 1972	Elliston, eastern GAB
Polycitoridae	*Polycitor*	*nubilus*	Kott, 1990	Flinders I. in Investigator Group
Polycitoridae	*Polycitor*	*obeliscus*	Kott, 1972	Investigator Strait
Polycitoridae	*Polycitor*	*cerasus*	Kott, 1990	Breaking Reef, Franklin I. in Nuyts Archipelago
Didemnidae	*Polysyncraton*	*longitubis*	Kott, 2004	between Snug Cove & Western River Cove, KI
Didemnidae	*Polysyncraton*	*rubitapum*	Kott, 2001	Topgallant I. in Investigator Group
Didemnidae	*Polysyncraton*	*montanum*	Kott, 2004	W side of Western River Cove, KI
Styelidae	*Polyzoa*	*nodosa*	Kott, 1990	Price I., Avoid Bay, Eyre Peninsula
Holozoidae	*Protoholozoa*	*australiensis*	Kott, 1992	NE of Margaret Brock Reef off Cape Jaffa
Pseudodistomidae	*Pseudodistoma*	*pulvinum*	Kott, 1992	Waldegrave I., Ward I. and Flinders I. in Investigator Group
Pseudodistomidae	*Pseudodistoma*	*acuatum*	Kott, 1992	Ward I. in Investigator Group; Nora Creina in upper SE of SA; one unverified record from Victoria
Pycnoclavellidae	*Pycnoclavella*	*elongata*	Kott, 1990	N of West I., Nuyts Archipelago
Pycnoclavellidae	*Pycnoclavella*	*aurantia*	Kott, 1990	Franklin I., eastern GAB
Ritterellidae	*Ritterella*	*papillata*	Kott, 1992	Price I., Avoid Bay, Eyre Peninsula
Ritterellidae	*Ritterella*	*compacta*	Kott, 1992	Flinders I. in Investigator Group; Price I., Avoid Bay; southern Spencer Gulf
Ritterellidae	*Ritterella*	*cornuta*	Kott, 1992	Price I., Avoid Bay, Eyre Peninsula
Holozoidae	*Sigillina*	*exigua*	Kott, 2006a	between Western River Cove & Snug Cove, KI
Styelidae	*Stolonica*	*brevigastra*	Kott, 2003	Ward I. & Topgallant I. in Investigator Group
Stomozoidae	*Stomozoa*	*australiensis*	Kott, 1990	Topgallant I. in Investigator Group, and Kangaroo Island
Styelidae	*Symplegma*	*arenosa*	Kott, 1972	Waldegrave I.
Didemnidae	*Tridemnum*	*tectum*	Kott, 2001	Franklin Is., Nuyts Archipelago
Didemnidae	*Tridemnum*	*caelatum*	Kott, 2001	SW of Eucla, GAB

Many of the uncommonly recorded ascidian species listed above in **Tables 5** and **6** are poorly known, with few details about habitat, depth range or geographic range. The full range, as well as the distribution within SA is not known for many species. Detailed surveys of the ascidian fauna in South Australia have been undertaken at very few locations, most notably several islands in the eastern Great Australian Bight (particularly the Investigator Group); several jetties in the SA gulfs region, and sites along northern Kangaroo Island (collected by K. Gowlett-Holmes). A number of type specimens also came from islands at the bottom of Eyre Peninsula, collected during abalone surveys by personnel of the former Department of Fisheries.

Approximately half of the species known to date only from South Australia (and therefore assumed to be endemic until further collections prove otherwise) have been recorded only from the type locality, due to opportunistic and sporadic nature of collecting efforts over time. Many of the ascidians found on Kangaroo Island and at islands in the eastern GAB are known from caves and under ledges, and are unlikely to be recorded unless specific collections are made in these cryptic habitats, which rarely occurs. An additional issue which reduces knowledge of the true distribution of ascidian species is the fact that accurate identification is a difficult task requiring specialist expertise, and such taxonomic expertise in this group is limited to one prolific worker (P. Kott), who, since the 1950s, has described the majority of the southern Australian species, but is now retired.

Asteroidea (Sea Stars)

The asteroids, or sea stars, are echinoderms composed of calcium carbonate plates. Between the plates on the dorsal surface are thin-walled sacs called papulae, used for respiration. Asteroids have a central disc, with five or more radially-arranged arms. Along the underside of each arm, are tube feet in grooves, and these are used for locomotion, and to manipulate prey. The tube feet are pointed in species which burrow in sand, and suckered in species which inhabit rocky bottom. The mouth is on the underside of the central disc, and many sea stars are predators or scavengers. Some are herbivorous, and a few are detritivores. Although all sea stars can reproduce by spawning, some (e.g. *Allostichaster polyplax*) can also reproduce asexually, by splitting in two and regrowing the other half, or by dropping parts of arms, which grow into new sea stars (Zeidler and Shepherd 1982; Gowlett-Holmes 2008).

In southern Australian States, there are 28 asteroid species of potential conservation concern, based on limited known range, or small number of existing records (Baker and Edgar, in prep.). Of these, almost half (15) are found in Western Australia, and only 4 are known from South Australia. Within South Australia, *Uniophora nuda* (Perrier, 1875), definitely occurs within the AMLR NRM region, and the second species, a western Australian asteroid known as *Goniodiscaster seriatus* (Müller & Troschel 1843, and *Pentaceros granulosus* Gray 1847 is a junior synonym), might also occur in the gulfs region, based on unverified survey records from Spencer Gulf (**Table 7**). *Uniophora nuda* has been found between 0m and 60m, in seagrass beds and also sandy bottom. It was reported by Zeidler and Shepherd (1982) to be "relatively rare", but there are various records from numerous locations in the gulfs region. More recently, Clark and Mar (2001) reported it to be a *nomen nudum* (i.e. taxonomy not accepted yet because it was not published formally according to standards of the International Code of Zoological Nomenclature), and may be form of *U. granifera* (Gowlett-Holmes 2008). However, *Uniophora nuda* is still included as a species in the *World Asteroidea Database* (Mah 2010). In a conservation overview of threatened marine invertebrates in south-eastern Australia, O'Hara (2002) reported *Uniophora nuda* to be threatened due to its limited range and endemic nature within South Australia.

Table 7: Asteroid species of potential conservation concern found to date in South Australia, which either occur in AMLR NRM, or are likely to occur there, based on known presence in the SA gulfs region. GSV = Gulf St Vincent; SG = Spencer Gulf.

Family	Genus & Species	Authority	Type Locality	Other Known Records (to 2011)
Asteriidae	*Uniophora nuda*	(Perrier, 1875)	between Backstairs Passage & Pages Is. (as *Uniophora gymnonota*) Pt Lincoln (as *Asterias nuda*)	N coast of KI (e.g. Kingscote, Inner Spit, Outer Spit and Island Beach in Nepean Bay; Pelican Lagoon); Backstairs Passage; southern GSV; southern SG (e.g. Cape Donington; Spilsby I.)
Oreasteridae	*Goniodiscaster seriatus*	(Müller & Troschel, 1843)	south-west Australia, possibly Fremantle	Various locations between Cape Leeuwin and Houtman Abrolhos in WA. Also, unverified records from SG in SA, not identified by echinoderm expert (Currie et al. 2009; S. Sorokin, SARDI, pers. comm. 2010).

Two other asteroid species of conservation concern in South Australia have not yet been recorded in AMLR NRM region. One of these, *Parvulastra* (previously *Patiriella*) *parvivipara* Keough & Dartnell 1978, commonly known as "Little Patty", is well known in scientific and conservation media due to its very small size (~0.5 – 1cm, hence it is reputed to be one of the world's smallest sea stars), specific habitat requirements (low energy tide pools on granite platforms), hermaphroditic mode of reproduction, and very limited geographic range (known to date from locations along ~ 200km coastal strip of Eyre Peninsula coast in SA) (Thomas 1982; Byrne and Cerra 1996; Byrne et al. 1999; Roediger and Bolton 2008). The fourth species, the hermaphroditic *Aquilonastra* (previously *Asterina*) *scobinata* Livingstone 1933, is known mainly from shallow rocky reefs around Tasmania, but it also occurs in Victoria, and the distribution extends at least as far west as Port MacDonnell in south-eastern South Australia (Dartnall 1970; O'Hara 2002; O'Loughlin and Waters 2004).

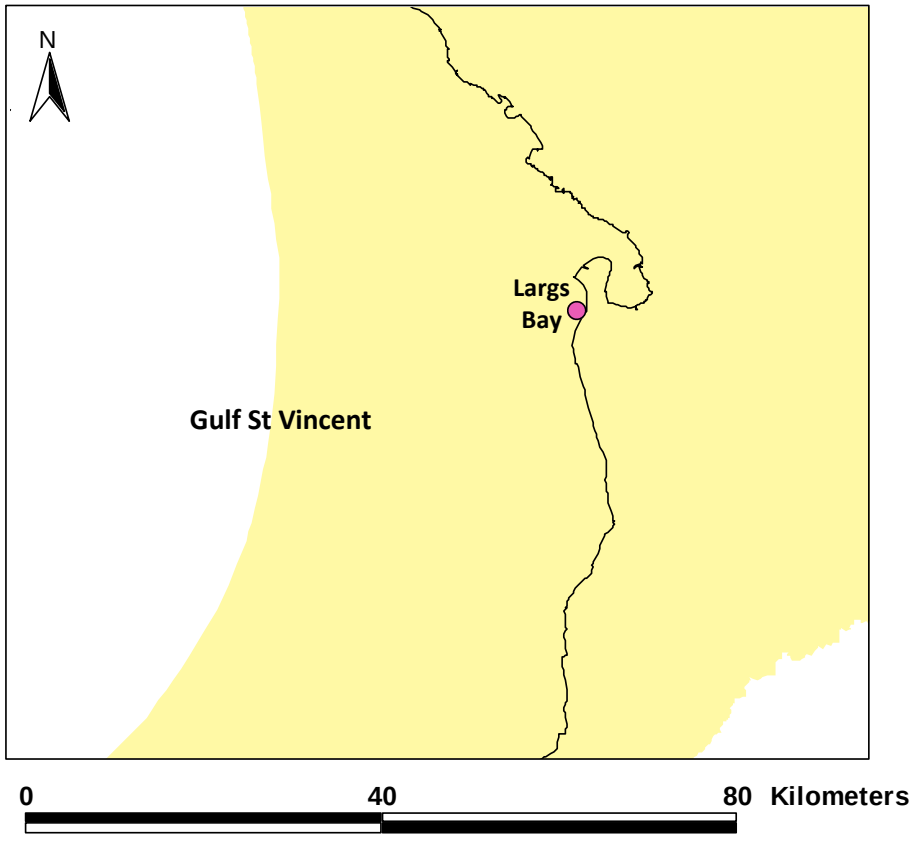
Bivalvia (Bivalve Shells)

Bivalvia is a large class of shells whose representatives have two valves joined at the margin, by an elastic hinge ligament and hinge teeth (Edgar 2008). The elasticity of the ligament opens the values, and they close by contraction of muscles that connect the two halves of the shell. Bivalves are filter feeders, and most are adapted for living in soft sediments. A few species attach to reefs, others bore into soft rocks, and some are free-swimming (aided by jet propulsion of water).

Table 8 details 12 species of bivalve shell known to date only from South Australia (one possibly also from New South Wales), which are likely to occur in the AMLR NRM region, based on existing records, or known presence in the SA gulfs. Most of these bivalves are small, and known from very few records. Of interest is the large (to 17cm) Watering Pot Shell *Brechites, Foegia* or *Kendrickiana veitchi* (Smith 1971) (**Figure 4**), a tube-building bivalve which has been recorded in coarse sand and seagrass habitat to 12m deep, off the Port Lincoln and Thorny Passage areas of southern Spencer Gulf (Lamprell and Healy 1998; Moreton 2004; Academy of Natural Sciences 2006). Very little is known about this species, and its full distribution and depth range have not been recorded. However, it is also known in fossil form from the Roe Plains (Eucla Basin) in WA. The previous genera to which *K. veitchi* belonged were called *Brechites* and *Foegia*; however Morton (2004) proposed the assignment of this species to a new genus, *Kendrickiana*, based on anatomical differences between *veitchi* and the type species in *Foegia*, *F. novaezelandiae*.

Figure 4: *Kendrickiana* (formerly *Foegia* or *Brechites*) *veitchi*.
Photo (c): Museum Victoria. Photographed by D. Staples

Half of the bivalves that are likely to occur in AMLR NRM region are known from very limited geographic range and few records, and were described by Tate during the late 19th century. Most are small cockles, clams, or mussels, and were recorded in dredged material from sandy habitats. There was a lack of targeted sampling for endemic bivalves during the 20th century (and also to date during the 21st century), hence little is known about most of the rarely recorded bivalves listed in **Table 8**. Another rarely known species is the bivalve *Thracia* (*Thracia*) *concentrica* recorded in Backstairs Passage by Joseph Verco and described in 1907. There is no knowledge of the full geographic distribution or depth range, but the holotype may have been collected at 46m deep. A more recently described species is Hall's Scallop *Semipallium* (previously *Notochlamys*) *hallae*, described by Cotton in 1960 from specimens at Larg's Bay (**Map 2**). This species has been recorded on reefs between 2m and 15m deep on sheltered and moderately exposed coasts. It is considered to be rare, and known to date only from the waters of Gulf St Vincent (Gowlett-Holmes 2008 and undated).



Map 2: Approximate type locality of *Semipallium hallae* Cotton 1960, an uncommon and possibly endemic scallop known to date from Gulf St Vincent.

The clam *Raeta* (*Raeta*) *meridionalis*, described by Tate in 1889 from a single valve found on the beach at Aldinga, may also be known from Chinaman's Beach in Middle Harbour (Sydney) in New South Wales (Hedley 1900; Iredale and McMichael 1962), and the identity of specimens from that area were confirmed by Tate. Some published distributions state South Australia only (Lamprell and Whitehead 1992; Academy of Natural Sciences 2006), but it is not known for this report if the specimens from New South Wales were ignored intentionally or unintentionally by the those authors. The full distribution of the species is not recorded, and it is not known if *Raeta* (*Raeta*) *meridionalis* has a disjunct distribution, or occurs continuously but uncommonly from NSW through to SA.

One of the more widely distributed and less rarely recorded species is *Montacuta meridionalis* Tate 1887, which is known from sandy and shelly sand habitats over a broad depth range (10m to 200+m). There are records ranging from metropolitan GSV through to the GAB in South Australia (**Table 8**; Lamprell and Healy 1998; Academy of Natural Sciences 2006; Currie et al. 2007), and a record from Western Port Bay in Victoria (NMV record F 170121).

Table 8: Bivalve species known from few records to date in South Australia, which either occur in AMLR NRM, or are likely to occur there, based on known presence in the SA gulfs region. GSV = Gulf St Vincent; GAB = Great Australian Bight; NSW = New South Wales. Compiled from Rombouts (1991), Lamprell & Whitehead (1992), Moreton (2004), Lamprell & Healy (1998), Academy of Natural Sciences (2006), Currie et al. (2007), OZCAM (2010), and shell sale web sites. Nomenclature has been updated to 2011, because a number of original binomials are now considered junior synonyms.

Family	Genus & Species	Authority	Type Locality	Other Known Records (to 2011)	Notes
Clavagellidae	*Brechites / Foegia / Kendrickiana veitchi*	(Smith, 1971)	Snapper Rock, off Cape Donington, near Port Lincoln	Thorny Passage	A large (to 168mm) Watering Pot Shell, found in coarse sand amongst *Posidonia* seagrass and shell debris. Morton (2004) proposed the assignment of this species to a new genus, *Kendrickiana*. Also known in fossil form from Roe Plains (Eucla Basin) in WA (Morton 2004), and from earliest Pleistocene beds on Yorke Peninsula (Yates 2011).
Carditidae	*Carditella (Carditella) subtrigona*	Tate, 1887	Streaky Bay	GSV; Investigator Strait; Backstairs Passage; Newland Head	Dredged alive from 17 to 24 fathoms (31 - 44m) (Verco 1908). No recent information.
Cyamiidae	*Eugaimardia perplexa*	(Cotton, 1931)	Port Lincoln area		A bivalve with a reported depth range of 0m – 16m (lower limit might be based on holotype only, which was collected at 9 fathoms).
Mytilidae	*Lithophaga* (*Lithophaga*) *cuneiformis*	(Tate, 1892)	Port Victoria	other locations in Spencer gulf; Kangaroo I.	The Southern Date Mussel, previously included in the Limopsidae family. Recorded from 0m – 16m, in habitat described as "consolidated shell ooze". Taxonomy uncertain: Huber (2010) reports that *Lithodomus cuneiformis*, which was the previous name for *Lithophaga cuneiformis*, is a junior synonym of *Botula tatei* Huber 2010. Kleeman (1990) reported this species as *Botula cuneiformis.*

Table 8 (cont.):

Family	Genus & Species	Authority	Type Locality	Other Known Records (to 2011)	Notes
Lucinidae	*Monitilora* (*Monilitora*) *paupera*	(Tate, 1892)	Hardwicke Bay	Possible record from Ocean Beach, Point Nepean in Victoria, as *Lucina paupera* (Pritchard and Gatliff 1903)	A small cockle (to 11mm) found to date in sand down to about 14m.
Galeommatidae	*Montacuta meridionalis*	Tate, 1887	Aldinga Bay	Marino in GSV; 100km off Corvisart Bay, eastern GAB; site at head of GAB (Currie et al. 2007) Western Port Bay (Museum Victoria record F 170121).	A small bivalve (to 10mm) found in sand and shelly sand, and reportedly also under rocks. Broad depth range (10m – 200+m). Has been recorded in shallows, and also in deeper waters of GAB. Occasionally sold in the shell market.
Mactridae	*Raeta (Raeta) meridionalis*	Tate, 1889	Aldinga (paratype)	possibly Chinaman's Beach, Middle Harbour, NSW (Hedley 1900)	A clam (to 45mm), found in intertidal sand.
Nuculidae	*Rumptunucula vincentiana*	(Cotton & Godfrey, 1938)	GSV; Macdonnell Bay (Port Macdonnell)	possibly NSW	A small (3cm) nut shell, recorded to date in sand down to 112m. Some confusion as the location where various South Australian specimens were collected (e.g. see Bergmans 1978). Lamprell and Healy (1998) included NSW in distribution; Academy of Natural Sciences (2006) did not. Also called *Pronucula vincentiana*.
Semelidae	*Semele ada*	Adams (A.) & Angas, 1863	"Port Adelaide creek" (North Arm area)		A small (to 8mm) bivalve found in rubble, sand and seagrass. No recent information.
Pectinidae	*Semipallium / Notochlamys hallae*	Cotton, 1960	Largs Bay	Unspecified locations in GSV	A scallop (to 47mm) found on sand and reef, between 2m and 15m deep.
Crassatellidae	*Talabrica / Crassatella carnea*	(Tate, 1891)	Yankalilla Bay		A cockle with a broad depth range (10m-364m). Holotype collected at 16 - 27m (9 - 15 fathoms).
Thraciidae	*Thracia* (*Thracia*) *concentrica*	Verco, 1907	Backstairs Passage		A bivalve that occurs to at least 46m (lower depth limit may be based on holotype only).

Table 9 lists bivalve species of known from few records to date in South Australia, some of which may occur in AMLR NRM, but site-specific information is lacking. Most of these are known from dredge work undertaken during the 1930s, including a site 40 miles south of Eyre Peninsula. A number of these species are known over a broad depth range, despite the paucity of records. All could be considered of unknown conservation status, despite their apparent endemic nature in South Australia. The full geographic distribution and depth range of these species is not known, and no systematic searches in suitable habitats have ever been undertaken.

Table 9: Bivalve species known from few records to date in South Australia, some of which may occur in AMLR NRM, but site-specific information is lacking. Compiled from Lamprell & Whitehead (1992), Lamprell & Healy (1998), Academy of Natural Sciences (2006), Currie et al. (2007), OZCAM (2010), and shell sale web sites. Nomenclature has been updated to 2011, because a number of the original binomials are now considered junior synonyms.

Family	Latin Name and Authority	Type Locality	Other Known Records (to 2011)	Notes
Mactromyidae	*Bathycorbis percostata* (Hedley, 1904)	40 miles S of Cape Wiles, southern Eyre Peninsula		Holotype dredged at 100 fathoms (182m). Little information on depth range.
Philobryidae	*Cosa* / *Philobrya tardiradiata* (Cotton, 1931)	Guichen Bay, near Robe, south-east SA	St Francis I., eastern GAB	A very small (2mm) bivalve found to date down to 19m.
Mactridae	*Diaphoromactra versicolor* (Tate, 1887)	Lake MacDonnell near Penong, in central GAB		The small (15mm) Varied-coloured Trough Shell, found in sand. Listed occasionally in the shell market (low value) and referred to as an "obscure species".
Donacidae	*Donax (Tentidonax) francisensis* Cotton & Godfrey, 1938	St Francis I., eastern GAB		A pipi recorded to date on sand down to 64m.
Veneridae	*Gouldia (Gouldiopa) francisensis* Cotton & Godfrey, 1938	St Francis I., eastern GAB		A bivalve recorded between 27m and 275m.
Nuculanidae	*Ledella / Nuculana remensa* (Iredale, 1929)	40 miles S of Cape Wiles, southern Eyre Peninsula	GAB, 120mls W of Eucla	Recorded down to 165m. Might also occur in south-western WA.
Limopsidae	*Limopsis* (*Pectunculina*) *idonea* (Iredale, 1929)	40 miles S of Cape Wiles, southern Eyre Peninsula		Bushy False Dog Cockle, a small shell (to 7mm), found down to 200m deep.
Mytilidae	*Musculus (Musculus) semiradiatus* (Verco, 1908)	Cape Jaffa		Full depth range not recorded. Holotype collected at 130 fathoms (238m). No recent information.
Galeommatidae or Erycinidae	*Myllita (Myllita) benthicola* Cotton & Godfrey, 1938	Cape Borda, Kangaroo I.		A small (3mm) bivalve found in shell sand on beaches, and also subtidally. Holotype collected from 55 fathoms. Depth range reported to be 0m – 100m.
Galeommatidae / Lasaeidae	*Mysella ovalis* Tate, 1892	Hardwicke Bay		A bivalve to 18mm, ranging in depth from the intertidal down to the outer continental shelf. Holotype from 10 fathoms

Table 9 (cont.):

Family	Latin Name and Authority	Type Locality	Other Known Records (to 2011)	Notes
Nucinellidae or Manzanellidae	*Nucinella hedleyi* (Cotton & Godfrey 1938)	40 miles S of Cape Wiles, southern Eyre Peninsula		A small bivalve (to 4mm), found down to 200m deep.
Nuculanidae	*Nuculana (Scaeoleda) comita* (Cotton & Godfrey, 1938)	Cape Jaffa		A beaked cockle, recorded to date down to 71m.
Crassatellidae	*Talabrica* / *Crassatella angustior* (Verco, 1907)	NW of Cape Borda, Kangaroo I.		A cockle, occurring to at least 100m deep.

Brachiopoda (Lamp Shells)

Brachiopoda, or lamp shells, are solitary, benthic marine animals that superficially resemble bivalve shells, but the body plan is different to that of bivalves (Middelfart and Reid 2001, in ABRS 2011). Some species are attached to the substrate by a stalk (pedicle) or are cemented there; a few species anchor their pedicle in sand or mud, and others lie freely on the surface. Most of the species in Australia are found on soft sediments of the continental shelf and can move freely in response to changes in levels of sediment (Richardson 1997). Brachiopods range in size from 1mm to almost 10cm, and members of the phylum collectively encompass a very broad depth range (from intertidal to the abyssal depths).

The phylum Brachiopoda is an ancient one, dating back at least 600 million years. Worldwide, there may be about 12,000 described fossil species, but only 335 described Recent species. Excluding brachiopods from Antarctica, there are around 43 named species in Australian waters, plus 6 others awaiting description (CSIRO 2010). The Australian brachiopod fauna is particularly diverse (Richardson 1997). Most of those that occur in South Australia are also found in other States. Examples include the common species *Megerlina lamarckiana,* found under limestone slabs on rocky bottoms between 2m and 200m, and *Magellania flavescens*, found in rubbly sand on reefs, and in seagrass beds across southern Australia (Richardson 1997). One globally widespread tropical species also occurs here (e.g. *Frenulina sanguinolenta* has been recorded at Fowlers Bay). One possibly endemic species in South Australia is notable: *Argyrotheca australis* (Blochmann 1910) is known from Kangaroo Island, and Cape Willoughby (at 40m) is the type locality (Cotton and Godfrey 1943; Richardson 1997; Middelfart and Reid 2001, in ABRS 2010; Emig 2010). The species was previously known as *Cistella australis* (in Blochmann, 1910), and it is noted that there are unverified records (by IFREMER) from Mozambique.

Cephalopoda (Squids, Cuttlefishes and Octopus)

The class Cephalopoda includes soft-bodied animals such as squid, cuttlefish and octopus, which have a head that is partly or fully fused with the foot, and 8 or 10 arms covered with suction discs. Cephalopods have complex sensory systems, enabling rapid movements and responses, sudden colour changes, visual acuity, and well developed behaviour patterns, including learning ability. Of the 10 uncommonly recorded and/or limited range cephalopods in southern Australia (Baker and Edgar, in prep.), three are of note in South Australia, and all of these occur in the gulfs region.

Octopus superciliosus Quoy and Gaimard 1832 (**Figure 5**), the Frilled Pygmy Octopus occurs in Bass Strait (across Victoria and northern edge of Tasmania) and South Australia. Most records to date are from Victoria (e.g. Port Welshpool; Western Port Bay; Stony Point; Portsea Hole; Popes Eye; Wilsons Promontory), but the species is also known in South Australia, from Gulf St Vincent (Steer et al. 2005), and St Francis Island in the eastern Great Australian Bight.

The Frilled Pygmy Octopus occurs on sand or mud substrates (e.g. Poore and Rainer 1974); in seagrass beds, macroalgae or sponge gardens, and is often cryptic in habit, deep amongst the blades and roots of seagrasses or macroalgae (Norman and Reid 2000, cited in DEWHA 2010). It is a small species, with an arm span of 10cm - 15cm. The depth range, estimated from museum specimens, may be about 0m to 70m. Most specimens known so far were collected from shallow water trawls, but one live animal was found camouflaged as piece of red algae, on back of a Wavy Volute shell (Robson 1929; Museum of Victoria records; DEWHA 2010; Lu, in ABRS 2011). In recent years, this species has also been photographed by divers (e.g. in Port Phillip Bay). This species is prey for calamari (*Sepioteuthis australis*) in South Australia (Steer et al. 2005) and also Australian fur seals (Gales et al. 1993). No specific threats are known, but it is noted that this benthic-living species has a strong site association, and females produce large, benthic eggs (Guzic 2004) that become bottom-living young, hence dispersal is limited.

Figure 5: *Octopus superciliosus*. Photo (c): A. Newton http://users.ncable.net.au/~anewton/

Another octopus of interest is the unusual, inkless Velvet Octopus *Grimpella thaumastocheir* Robson 1928, which is known from the South Australia gulfs and south-western Australia (Robson 1928, 1929; Norman and Reid 2000; Guzik 2004; DEWHA 2010), plus one record from Mallacoota in Victoria (Museum of Victoria, 1982). Port Lincoln is the type locality, and this species has also been recorded from several other locations in SA, such as Edithburgh, Port Victoria, and the Great Australian Bight. It occurs over rocky reef, rubble and sand, over a broad depth range (5m to several hundred metres deep: DEWHA 2010). Features that *Grimpella thaumastocheir* shares with deep-sea octopuses include the lack of an ink sac and simple colour patterns and skin sculpture (DEWHA 2010). Despite its unusualness and apparent uncommonness, this species is not considered here to be threatened in SA, due to its broad distribution and broad depth range, and lack of specific threatening processes over much of the habitat.

An unusual cephalopod known to date only from the SA gulfs is the Lace Bottletail Squid *Sepiadarium* sp. (in Norman and Reid 2000, and Gowlett-Holmes 2008). This is a small species, to 35mm, and examples of records include Edithburgh in GSV, and northern Spencer Gulf. It is possibly common in the South Australian gulfs. Lace Bottletail Squid (**Figure 6A,B**) resembles and is related to Southern Bottletail Squid *S. austrinum*, except that it does not have the white spots which are obvious on the latter species. Lace Bottletail Squid occurs on sand, sandy rubble and on reef, on sheltered to moderately exposed coasts, and the recorded depth range is 1m – 12m. This squid is a nocturnal feeder on crustaceans, and remains buried in sand during the day (Gowlett-Holmes 2008).

The full geographic range of the Lace Bottletail Squid is unrecorded, and it is not known if this unnamed species really is endemic within South Australia. It is noted that Kangas et al (2007) recorded an unnamed *Sepiadarium* sp. bottletail squid (not the widespread *S. austrinum*, which was also present) at Shark Bay in WA.

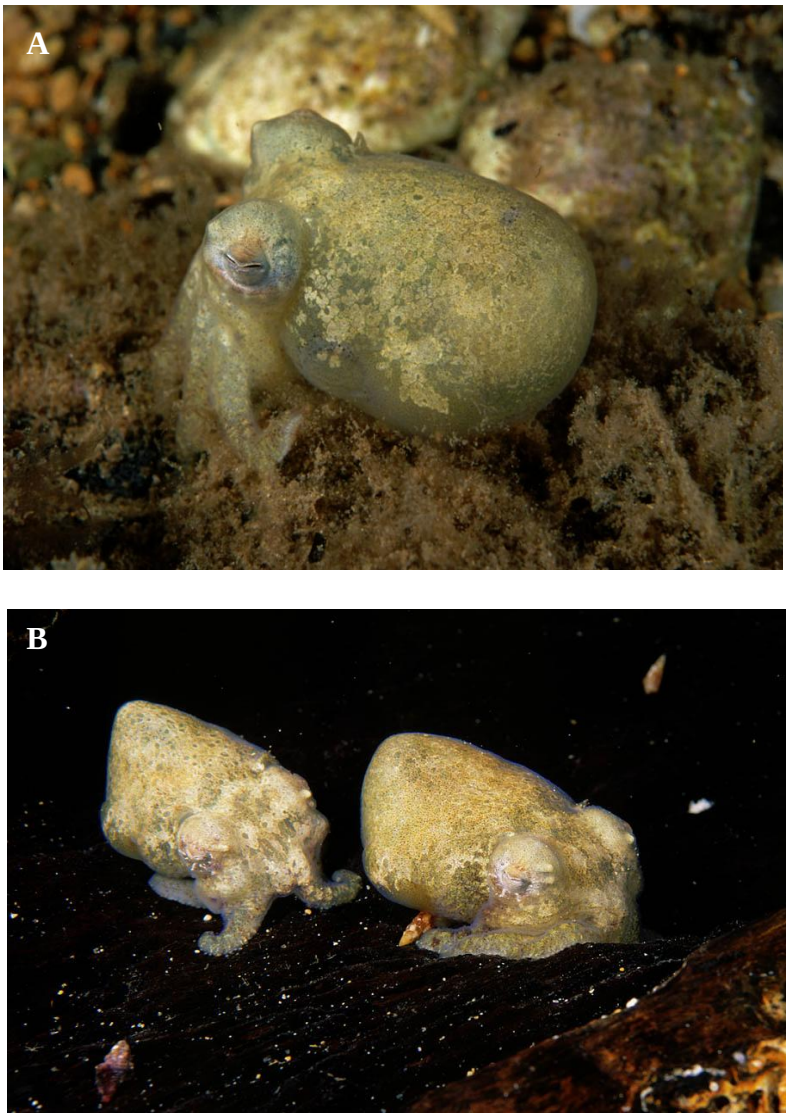


Figure 6A,B: *Sepiadarium* sp. Photo (c) J. Lewis

Crinoidea (Feather Stars)

Crinoidea is a small class of echinoderms which are characterised by having a small central disc, and feathered arms that are used to catch and transport drifting food particles down to the mouth in the disc. On the underside of the body are slender, jointed calcareous appendages called cirri, which assist in locomotion, and in anchoring the feather star to the substrate. Compared with the tropics, there are few species in temperate Australian waters. The largest and one of the most common species in southern Australia is *Cenolia trichoptera* (Müller 1846), the Orange Feather Star.

Within southern Australia, there are 8 species of crinoid that either occur over a relatively narrow geographic range, or are known from very few records, and one is known from a single specimen (Baker and Edgar, in prep.). Only one of these narrow-range species occurs in South Australia, the small (to 4cm) crinoid *Euantedon paucicirra* H.L. Clark 1928, which is known from few records in Bass Strait Victoria (with Wilsons Promontory being the published eastern limit), and in the South Australian gulfs (Clark and Clark 1967; T. O'Hara, pers. comm., cited by Rowe and Gates, in ABRS 2011). Marino in GSV is the type locality.

Across the range, *Euantedon paucicirra* has been recorded on reef between 0m and 10m. There is very little information known about this species, because it is uncommonly sighted, and known from few records.

Decapoda (Shrimps, Prawns, Crabs)

The Decapoda is a large order of crustaceans that includes the shrimps, prawns, lobsters, crabs and hermit crabs. Decapods have five pairs of rear limbs, used for walking, and three pairs of modified limbs that are used for feeding. They are also characterised by an exoskeleton, and the carapace part of this covers the cephalothorax (fused head and thorax), and is calcified to varying degrees according to major group. The carapace is particularly well developed in lobsters and crabs. Decapods have extensive branched gills, enabling them to grow to a large size compared with other crustaceans (Poore 2004; Edgar 2008). Many decapods in southern Australia are widespread and common. A small number of crabs and shrimps that are known to date only or mainly from South Australia and/or are uncommonly recorded, are detailed below in **Table 10**.

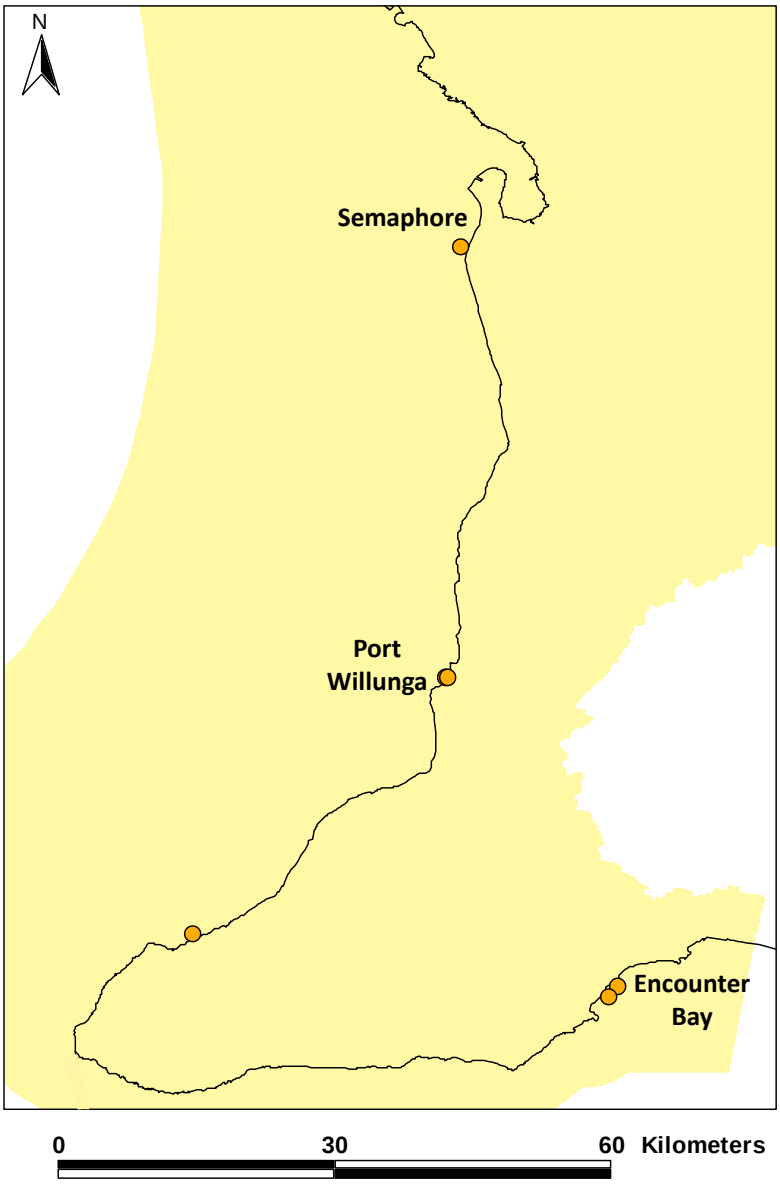
Table 10: Decapod species of potential conservation concern found to date in South Australia, which either occur in AMLR NRM, or are likely to occur there, based on known presence in the SA gulfs region. GSV = Gulf St Vincent. GAB = Great Australian Bight.

Family	Genus & Species	Authority	Type Locality	Other Known Records (to 2011)	Common Name
Leucosiidae	*Cryptocnemus vincentianus*	Hale, 1927	Semaphore	Northern Spencer Gulf. Record from survey in northern Spencer Gulf (Ainslie et al. 1989) not included in Poore's (2004) account. Single record from central west coast of WA (Babcock et al. 2006)	Tortoise-crab / tortoise crab
Goneplacidae	*Flindersoplax vincentiana*	(Rathbun, 1929)	Port Willunga		(a crab)
Dromiidae	*Haledromia bicavernosa*	(Zietz, 1888)	Hog Bay, Kangaroo I.	Encounter Bay; Gulf St Vincent; GAB	Eared Sponge Crab
Xanthidae	*Zalasius australis*	(Baker, 1906)	Port Willunga	northern Spencer Gulf	Long-haired Crab
Palaemonidae	*Periclimenes carinidactylus*	Bruce, 1969	Bottle and Glass Rocks, Port Jackson (NSW)	central and southern NSW coast; Stokes Bay, Kangaroo Island; ?gulfs region in SA	(a carid shrimp)
Hippolytidae	*Tozeuma elongatum* *T. kimberi*	(Baker, 1904)	Victor Harbor (*T. elongatum*) Pt Willunga (*T. kimberi*)	Flinders, Wilsons Promontory & Portland in Victoria; Encounter Bay & Flinders I. in SA	(a hump-backed shrimp)
Hippolytidae	*Tozeuma pavoninum*	(Bate, 1863)	GSV	QLD; unverified record from Shark Bay in WA	(a hump-backed shrimp)

The very small (to 7mm) tortoise-crab *Cryptocnemus vincentianus* is apparently known to date from a recent record along the central west coast of WA (Babcock et al. 2006), and previously from two locations in the South Australian gulfs, which includes the holotype dredged from Semaphore in GSV during the 1920s (**Map 3**), and a record from a survey in northern Spencer Gulf during the 1980s (Ainslie et al. 1989; Davie 2001, in ABRS 2011; O'Hara 2002; Poore 2004). It is noted that the survey record from Spencer Gulf was not included in Poore's (2004) account. This tortoise-crab occurs on soft sediments in the low intertidal and subtidal.

The full depth range of *Cryptocnemus vincentianus* is not known. Given the small size of this crab species, it might be more common than records indicate but would be easy to overlook unless specifically searched for in targetted surveys (e.g. using dredge).

Another crab, the 3cm *Flindersoplax vincentiana* is apparently known to date only from the type locality at Port Willunga in GSV (Davie 1989, 2001; Poore 2004) (**Map 3**). This crab from the shallow subtidal was originally called *Heteropanope vincentiana*, and the depth range is not known. The holotype has been searched for in the SA Museum on two occasions (by ex-curator W. Zeidler, on P. Davie's request during the late 20th century, and by invertebrate collection manager T. Laperousaz, on J. Baker's request in 2011) but was not found. The only record is the neotype deposited in the Smithsonian Institution. There are no other records in the South Australian Museum (T. Laperousaz, pers. comm. 2011), nor apparently in the literature, nor in published survey reports.



Map 3: Examples of locations in AMLR NRM region where 5 uncommon decapod crustacean species have been recorded. Collectively these include: the Tortoise-crab *Cryptocnemus vincentianus*, the Long-haired Crab *Zalasius australis*, the possibly endemic Eared Sponge Crab *Haledromia bicavernosa*, the small crab *Flindersoplax vincentiana* (apparently known to date only from type locality) and the hump-backed shrimp *Tozeuma elongatum* (Baker 1904).

A third species that is possibly endemic within South Australia is the Eared Sponge Crab *Haledromia bicavernosa*, known from the GAB, South Australian gulfs, Kangaroo I. and Encounter Bay, a distance of at least 750km between known location limits (Hale 1927; Davie 2001, in ABRS 2011; O'Hara 2002; Poore 2004; Gowlett-Holmes 2008). This is a medium sized species, to about 9 or 10cm, and occurs on low intertidal to subtidal reef (~2m – 40m deep), on moderately exposed to open coasts. Poore (2004) reported that this species may have direct development of young. Although the Eared Sponge Crab is the only member of its genus, this nocturnally-active crab is a common species (Poore 2004; Gowlett-Holmes 2008).

The small (18mm) Long-haired Crab *Zalasius australis* is known to date from the gulfs region in South Australia, and is rarely recorded (Hale 1927; Davie 2001, in ABRS 2011; Poore 2004; Saunders 2009). It was previously known as *Trichia australis* or *T. dromiaeformis australis*. Serène and Crosnier (1984) reported this species from Madagascar. Poore (2004) referenced Serène, but listed this species as occurring only in South Australia. The endemism of this species is questionable, based on the record of Serène and Crosnier (1984), and a discussion of the type in a previous French publication (Guinot 1976).

A very large crab species of conservation concern in South Australia is the Giant Crab (Tasmanian Giant Crab / King Crab / Queen Crab) *Pseudocarcinus gigas* (Lamarck, 1818). This species is not listed in **Table 10** above, because it mainly occurs in deeper waters (> 100m) south and west of the gulfs. *P. gigas* is a commercial species in southern Australian States, including South Australia (e.g. Currie and Ward 2009). Fishing is the main threat to populations of this species. Quotas, limited entry and seasonal closures are some of the main management measures in the SA fishery.

There are three possibly uncommon shrimp species in South Australia, and one of these is *Periclimenes carinidactylus* Bruce 1969, a carid shrimp known from a narrow depth range in central and lower coast of New South Wales, and from Kangaroo Island and possibly the SA gulfs (Bruce 1969, 1980, 1983; Davie 2001, in ABRS 2011; Poore 2004). It is a reef species, living commensally on the crinoid *Comanthus trichoptera*, and is known from few confirmed specimens. However, during a recent survey at Narabeen lagoon in New South Wales, a shrimp reported to be this species was recorded in abundance in shallow seagrass (The Ecology Lab 2008). So far, most known records of this species range from 6m to 9m, but the purported examples from Narabeen lagoon were recorded at 1m deep. It is not known for this report whether the Narabeen specimens were correctly identified, given the differences in habitat and depth compared with confirmed published examples. Two hump-backed shrimps in the genus *Tozeuma* have been recorded in South Australia, and both are uncommonly recorded. *Tozeuma pavoninum* (Bate 1863) has a disjunct distribution, being known mainly from Queensland, and the SA gulfs coast (Holthuis 1947; Chace 1997; Davie 2001, in ABRS 2011; Poore 2004). There is also an unverified record from Shark Bay in WA (Kangas et al. 2007). This shrimp, of about 6cm long, occurs in seagrass beds, and has been recorded to date over a narrow depth range (18-24m). There is no information on abundance over the range, but its apparent reliance on seagrass beds is a population characteristic that increases vulnerability. Similarly, the hump-backed shrimp *Tozeuma elongatum* (Baker 1904) is also found in seagrass beds, but has been recorded over a broader depth range (0m – 27m), and is known from few records in Victoria and SA, the latter including AMLR NRM region (e.g. **Map 3**) (Davie 2001, in ABRS 2011; Poore 2004; Museum of Victoria records). This may be the same species as *Tozeuma kimberi*, previously thought to be a South Australian endemic (Davie 2001, in ABRS 2011'; Poore 2004), but which has also been recorded in Victoria (Plummer et al. 2003). The taxonomic relation between *Tozeuma kimberi* and *T. elongatum* need to be ascertained. *Tozeuma elongatum* is considered to be uncommon (Edgar 2000, 2008). During a survey in Portland Harbour, this species was found in 1 (20%) of 5 sled samples, in low densities (Parry et al. 1997). In a report by O'Hara (2002), both *T. pavoninum* and *T. elongatum* were reported (presumably erroneously) as being endemic within South Australia.

In addition to the shrimps discussed above, the slow prawn *Neocallichirus angelikae* is another uncommon species, known to date only from South Australia, at Murat Bay in the eastern GAB (Sakai 2000; Davie 2001, in ABRS 2011; Poore 2004). This is a benthic, burrowing species from an intertidal stony flat, and it is not known where else the species occurs, east or west of the type locality. It is separated from the south-eastern Australian slow prawn *N. limosa* by minor characters (see Sakai 2000).

Echinoidea (Sea Urchins and Sand Dollars)

The Class Echinoidea is divided into two groups of urchins: *regular* (which have a spherical body covered with radiating spines, and the *irregular* (including heart urchins, and the flattened sand dollars). The body of sea urchins is known as the test, and is composed of interlocking calcareous plates. Echinoids move with the aid of tube feet, which extend through the test. They are active grazers, using five, sharp, beak-like teeth, and when urchins occur in large numbers on reefs, can cause significant damage to beds of macroalgae.

Of the numerous species of urchin found in South Australia, two uncommon sand dollars of uncertain distribution are known from the AMLR NRM region. One of these, *Ammotrophus cyclius* H.L. Clark 1928 is known to date from 20m – 45m at locations in Great Australian Bight, SA gulfs, Encounter Bay (possibly the type locality), and south-eastern SA. Other than Gulf St Vincent, locations in which it has been recorded include south of Goat I. (Nuyts Archipelago); Spencer Gulf; and Robe in south-eastern SA. *Ammotrophus cyclius* (**Figure 7**) might be synonymous with other species such as *A. platyterus* (see below) and *A. arachnoides*. There are 62 paratypes, and at least 14 of these come from Encounter Bay (Clark 1928, 1946; Baker, in Shepherd and Thomas 1982; O'Hara 2002; Rowe and Gates in ABRS 2011).

The second uncommon species in *Ammotrophus* known from AMLR NRM region is *A. platyterus* H.L. Clark, 1928, known to date only from Gulf St Vincent (Clark 1928, 1946; Mortensen 1948; O'Hara 2002; Rowe and Gates, in ABRS 2011). According to Mortensen (1948), this might not be a distinct species: it is known from a single, very distinctive specimen, but might be synonymous with other species such as *A. cyclius* (see above) and *A. arachnoides*.

Figure 7: *Ammotrophus cyclius*. Photo (c) B. van der Steld (2005) at http://www.echinoids.nl

There is one sea urchin species that may be endemic within South Australia (*Genocidaris incerta* H.L. Clark, 1928), and it is unlikely that this species occurs in the AMLR NRM, given the depth range to date from which is has been recorded (108-540m), and the locations (deeper waters off Beachport, through to Cape Borda, Kangaroo Island) (Clark 1928, 1946; Rowe and Gates, in ABRS 2011). The holotype and 13 paratypes are from Cape Jaffa or Beachport.

Holothuroidea (Sea Cucumbers)

Sea cucumbers, or holothurians, are slug-like echinoderms with microscopic, calcified spicules called ossicles in the body wall. The ossicles may be variously shaped (e.g. perforated plates, wheels, stars or anchor shapes). These animals range in size from a few millimetres to half a metre long. Holothurians have modified tube feet that form feeding tentacles which extend out through the mouth. The body wall is composed of a type of collagen which can be loosened and tightened at will (e.g. Yamada et al. 2010). For example, this enables sea cucumbers to squeeze their body into small spaces such as reef crevices, and then make the body firm again (by hooking up the collagen fibres).

There are several large-bodied, widely distributed species in southern Australia, such as the Southern Sea Cucumber *Australostichopus mollis*, but numerous other species are small and cryptic, living under rocks or in sand, with just the tentacles extended (Gowlett-Holmes 2008). There are 9 sea cucumber species of potential conservation concern in South Australia, 5 of these are likely to occur in the AMLR NRM region, and another might possibly be present but there is insufficient information on its distribution in SA (**Table 11**).

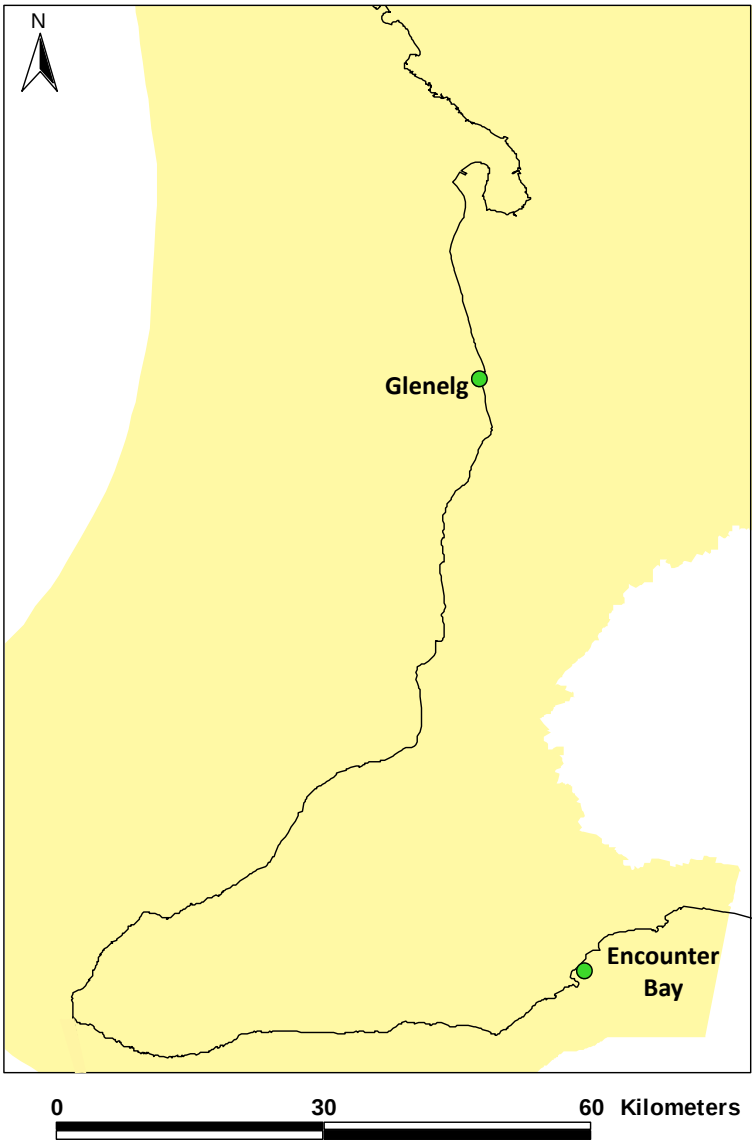
Apsolidium alvei O'Loughlin and O'Hara 1992 is known from Yorke Peninsula to Encounter Bay in SA (**Map 4**), and is thought to range in depth from 0m to about 10m (Rowe 1982; O'Loughlin and O'Hara 1992; Rowe and Gates 1995 and 2001 update by O'Hara, in ABRS 2011; O'Hara 2002). This species was known as "*Cucumaria*" *squamatoides* H.L. Clark, 1946, a *nomen nudum* in Rowe (1982). It was considered by O'Hara (2002) to be a short range endemic within South Australia.

A second possibly endemic species within SA is "*Staurothyone*" *vercoi* (Joshua & Creed 1915) known to date from Glenelg in GSV (**Map 4**), plus the unknown location of the holotype (approx. 33-37ºS, 132-140ºE) (Clark 1946; Rowe 1982; Rowe & Gates 1995, & 2001 update by O'Hara, in ABRS 2011; O'Hara 2002). The reported depth range is 0m – 10m. Rowe (1982; also Rowe and Gates 1995) queried placement of *S. vercoi*, which has 20 tentacles, not 10 as described; therefore, the species should be assigned to another (possibly new) genus. The species is considered rare (Rowe 1982) and appears to be a short-range endemic (O'Hara 2002).

Apsolidium handrecki O'Loughlin and O'Hara 1992, has been recorded from very few locations in Victoria, SA and WA. This small (to 20mm) sea cucumber occurs on shallow rocky platforms and on jetty piles, on plants of the green macroalga *Caulerpa*, presumably over a shallow depth range (listed as 0m-3m). This species is known in Victoria from only six specimens taken from Merrick, and no others have been found following 10 years of searches (O'Hara and Barmby 2000; DSE Victoria undated; Rowe and Gates 1995, in ABRS 2011). There is only one record from South Australia (Arno Bay), and *A. handrecki* is also known from two metropolitan coastal locations in Western Australia. *A. handrecki* is a listed threatened species in Victoria (*Flora and Fauna Guarantee Act 1988*). It may be an external brooder. Potential threats are considered to include reef trampling, coastal development and discharges, declining water quality, oil spills, and introduced species and pathogens (DSE Victoria undated).

Another small (15mm), brooding sea cucumber species that is listed as threatened in Victoria also occurs in SA: *Pentocnus bursatus* O'Loughlin & O'Hara 1992. Although the range is broad (Cape Paterson in Victoria to Rottnest Island in WA), it is known from very few locations in each State (Rowe and Vail 1982; O'Loughlin 1991; Marsh and Pawson 1993; O'Hara and Barmby 2000; DSE Victoria undated d; Rowe & Gates, in ABRS 2011). The only South Australian location known to date is Beachport, and there appear to be no published records from the SA gulfs (including AMLR NRM region), but it may occur here. In Victoria it has been found at Cape Paterson in Bunurong Marine National Park (records from 1980-88 and also 2008), but it is not known if there are other isolated populations in Victoria. The species occurs amongst algal tufts and sponge in intertidal and shallow subtidal (0m – 4m) rocky habitats, in moderately exposed, well flushed areas. A number of species in the family brood the young (e.g. O'Loughlin 2007). This species might be susceptible to localised habitat damage, marine pollution, marine pests, and future impacts from global warming.

Lipotrapeza ventripes (Joshua & Creed 1915) is an uncommon sea cucumber recorded from Bass Strait to the SA gulfs coast, and Kangaroo Island. There is very little information on this species, which is brown with whitish coloured tube feet (Rowe 1982). Another south-eastern species, *Psolidiella hickmani* O'Loughlin, 2000 is unlikely to occur in the AMLR NRM region, because the most westerly record is Robe in south-eastern SA. *P. hickmani* is not uncommon in Victoria and Tasmania, and probably also not uncommon in south-eastern SA, but may be of conservation concern due to its narrow depth range (reportedly 0m – 6m, mostly less than 1m) in rocky and silty bays and estuaries, and its reproductive mode (external brood-protecting). One example from southern Tasmania had approximately 40 brood embryos in pockets, and several have been recorded in Victorian specimens (Clark 1946; Rowe 1982; O'Loughlin 2000; Rowe and Gates 1995, in ABRS 2011).



Map 4: Examples of locations in AMLR NRM region where 2 uncommon and possibly endemic sea cucumbers have been recorded. These are *Apsolidium alvei* O'Loughlin and O'Hara 1992 and "*Staurothyone*" *vercoi* (Joshua & Creed 1915).

Thyone nigra Joshua & Creed 1915 (for which a taxonomic revision pending) is a widespread sea cucumber found on soft sediments in seagrass beds (*Zostera*, *Heterozostera*) and in mixed beds with filamentous algae, from 0m to 20m. It occurs in Victoria, Tasmania, South Australia and Western Australia (Rowe 1982; O'Hara 2002; Rowe and Gates 1995, in ABRS 2011). In SA this sea cucumber has been recorded from the gulfs region, and also the GAB. *Thyone nigra* is a listed threatened species in Victoria, under the *Flora and Fauna Guarantee Act 1988*. Specimens have recently been recorded at Phillip Island (DSE Victoria undated). This species is considered to be vulnerable to habitat degradation and pollution of seagrass-lined bays, marine pests and climate change (DSE Victoria, undated).

One of the largest sea cucumbers of conservation concern that occurs in South Australia is *Trochodota shepherdi* Rowe 1976, which grows to about 6cm. It is known from two locations in Victoria, and from the South Australian gulfs and Kangaroo Island (Rowe 1982; O'Hara et al. 2002; Ferns et al. 2003; O'Loughlin and Vandenspiegel 2007; Edmunds et al. 2007; Rowe and Gates 1995, in ABRS 2011). This species is known from sand and seagrass (*Posidonia* and *Heterozostera*) habitat, and from epiphytic macroalgae (e.g. the brown *Lobospira bicuspidata*) on seagrass. The published range is 0m–15m.

Information on reproduction in *Trochodota shepherdi* has apparently not been published, but it is noted that a number of species in the Chiridotidae brood the young (e.g. McEdward and Miner 2001). In Victoria, *T. shepherdi* is known from less than 5 records, in isolated populations, and it is a listed threatened species in that State. This species is considered threatened in Victoria, especially in areas of seagrass decline (O'Hara and Barmby 2000; O'Hara 2002), but its status in South Australia is unclear, because the full distribution within this State is unknown, and no population censuses have been undertaken.

Table 11: Holothurian species of potential conservation concern found to date in South Australia, which either occur in AMLR NRM, or are likely to occur there, based on known presence in the SA gulfs region. GSV = Gulf St Vincent. GAB = Great Australian Bight; VIC = Victoria

Family	Genus & Species	Authority	Type Locality	Other Known Records (to 2011)
Cucumariidae	*Apsolidium alvei*	O'Loughlin & O'Hara 1992	Marion Bay, Yorke Peninsula	Encounter Bay
Cucumariidae	*Apsolidium handrecki*	O'Loughlin & O'Hara 1992	N of Merricks, Western Port	VIC: Merricks SA: Arno Bay WA: Trigg I.; Mudurup Rocks at Cottesloe
Phyllophoridae	*Lipotrapeza ventripes*	(Joshua & Creed, 1915)	South Australia (possibly Gulf St Vincent)	Western Port and Somers Beach in VIC; Kangaroo I. in SA
Cucumariidae	"*Staurothyone*" *vercoi*	(Joshua & Creed, 1915)	off South Australia, location uncertain (33-37ºS, 132-140ºE)	off Glenelg, metropolitan GSV
Phyllophoridae	*Thyone nigra*	Joshua & Creed, 1915	Off SA (33-37ºS 132-140ºE)	TAS: Waterhouse Point VIC: Corio Bay and Phillip I. SA: Wool Bay; Elliston, Point Westall, Point Sinclair WA: King George Sound, Cockburn Sound
Chiridotidae	*Trochodota shepherdi*	Rowe, 1976	Proper Bay near Port Lincoln, Spencer Gulf	VIC: NE of Snake Island, Nooramunga & Corner Inlet; SA: GSV, North Spencer Gulf, Boston Bay (SW Spencer Gulf) and Kangaroo I.

Ophiuroidea (Brittlestars)

Brittlestars are echinoderms which have a central disc and five slender arms, which are usually long and sinuous. When the arms are branched, the animals are known as basket stars. Some brittlestars bury in mud or sand, but most live under rocks, or among macroalgae, or in association with sponges, hard corals and bryozoans (Baker 1982). Ophiuroids can readily regenerate lost arms or arm segments unless all arms are lost. A number of species brood developing young in the bursae (cilia-lined sacs used for gas exchange and excretion), but reproduction in the uncommon southern Australian species requires more research.

There are three uncommonly known brittlestars of potential conservation concern that might occur within AMLR NRM region. *Ophiocomina australis* Clark 1928 is a small (12mm) brittlestar is known from Bass Strait in Victoria (O'Hara, in ABRS, 2011), and from GSV, Spencer Gulf and Kangaroo Island in SA (Clark 1928 and 1946; Zeidler 1978; Thomas 1982; O'Hara et al. 2002; Rowe and Gates, in ABRS 2011). The type locality is a site between Troubridge Island and Backstairs Passage. Other South Australian records include north-east Kangaroo Island, Port Gawler, Outer Harbour and Semaphore in GSV, and a site in Investigator Strait. This small species is known from *Posidonia* and *Heterozostera* seagrass beds, and has been recorded between 1m and 20m deep.

In Victoria, *Ophiocomina australis* is known from Nooramunga and Corner Inlet, and is a protected species in that State, under the *Flora and Fauna Guarantee Act*. It is considered vulnerable in Victoria, due to reliance on embayments, and population vulnerability in areas of seagrass dieback (O'Hara and Barmby, 2000). However, *O. australis* has a relatively broad distribution in south-eastern Australia, and is not uncommon. Its status in SA in uncertain due to lack of knowledge of full distribution and population sizes in this State.

Another broadly distributed brittlestar known from seagrass beds is *Amphiura* (*Amphiura*) *trisacantha* H.L. Clark, 1928. There are confirmed records ranging from Spencer Gulf in South Australia through to Nooramunga in Victoria (including Tasmania), and 3 unconfirmed Museum of Victoria records from Nambucca Heads in New South Wales (Baker and Devaney 1981; O'Hara and Barmby 2000; Aquenal 2001; Rowe and Gates 1995, and update by T. O'Hara, in ABRS 2011; Museum Victoria data). Spencer Gulf or Gulf St Vincent is the type locality. Most of the South Australian records come from areas of Spencer Gulf, including Port Pirie. *Amphiura trisacantha* is known mostly from *Posidonia* and *Heterozostera* seagrass beds, between 0m and 10m. Like *Ophiocomina australis, A. trisacantha* is protected under legislation in Victoria, and considered vulnerable there, due to reliance on embayments, and population vulnerability in areas of seagrass dieback (O'Hara and Barmby 2000). The status of the broadly distributed species in SA in uncertain due to lack of knowledge of full distribution and population sizes in this State.

Ophiacantha shepherdi Baker and Devaney 1981 is another uncommon species that has been recorded from Victoria and South Australia (Baker and Devaney 1981; O'Hara 1990; Ferns and Hough 2000; Rowe and Gates, in ABRS 2011). Seal Rock, West I. near Encounter Bay is the type locality, and the species may also occur in GSV. *Ophiacantha shepherdi* has been recorded at various locations in Victoria, such as Port Campbell; Queenscliff (southern Port Phillip Bay); Shoreham; a site off Cape Woolamai; and 1km E of Harmers Haven. The depth range may be from 1m to at least 25m deep, according to records. A number of species in the genus *Ophiacantha* brood the young.

A fourth uncommon brittlestar that might occur in South Australia, is *Amphiura* (*Amphiura*) *perplexus* / *perplexa* (Stimpson, 1855), of uncertain distribution. It is possible but unlikely that this species occurs in the AMLR NRM region. Rowe and Gates (1995 in ABRS, 2011) reported (apparently erroneously) that this species is known only from the type locality in New South Wales. O'Hara and Barmby (2000) stated that *A. perplexa* occurs only from Bass Strait to Sydney, but there is a Museum Victoria record from 52m deep, from a location off the Murray Mouth (south of Encounter Bay) in South Australia, and the specimen was identified by O'Hara. Other known specimens include eastern Bass Strait (6 records) and central Bass Strait. *Amphiura perplexus* was listed in O'Hara and Barmby (2000) as a species of conservation concern, due to its presence in the East Shelf habitat off eastern Australia, which has been extensively trawled. Its status in South Australia is unknown.

Two other uncommon brittlestars known from SA are unlikely to occur in the AMLR NRM region. These are: *Macrophiothrix* or *Ophiothrix* (*Keystonea*) *hymenacantha* Clark, 1928 and *Macrophiothrix* or *Ophiothrix* (*Placophiothrix*) *albostriata* (H.L. Clark, 1928), both of uncertain distribution, and known from the Great Australian Bight, where the holotypes were collected (Clark 1928 and 1946; Baker and Devaney 1981; Rowe and Gates, in ABRS 2011). The depth range is not recorded. Stöhr (2009) reported that the senior name of the genus is *Macrophiothrix* for both of the 'forementioned species.

Opisthobranchs / Heterobranchia (Sea Slugs / Nudibranchs)

Opisthobranchs are sea slug gastropods with "rearward" gills. Most members of this large group lack a shell, or have a reduced internal shell. Some have a fragile external shell. The shell-less nudibranchs are often brightly coloured and patterned, and have evolved bizarre body shapes. In most sea slugs, the head bears two pairs of sensory tentacles: a pair of tactile oral tentacles, and a dorsal pair of rhinopores (chemo-sensory organs), which may be ornamented to increase their surface area (Burn 1989).

Opisthobranchs are hermaphrodites, and can function as male and female at the same time. Eggs are usually laid in a gelatinous mass. Most species have planktonic larvae, but some hatch as crawling miniatures which resemble the adults (Gowlett-Holmes 2008).

Many sea slugs have a specialised diet, and their distribution thus reflects the presence of their preferred food type. For example, the green *Oxynoe viridis* sea slug from the Indo-Pacific and around Australia, feeds on green *Caulerpa* macroalgae. Some of the larger sea slugs are predatory, feeding on polychaete worms, colonial ascidians, or even on other sea slugs. Some opisthobranchs are seasonal in occurrence, and others may be locally abundant in some years, and absent from the same area in other years.

There are 6 or 7 species of sea slug that appear to be known so far only from South Australia, and four of these are named to genus level only (**Table 12**).

Table 12: Opisthobranch species of found to date only in South Australia, which either occur in AMLR NRM, or are likely to occur there, based on known presence in the SA gulfs region. GSV = Gulf St Vincent. GAB = Great Australian Bight; VIC = Victoria

Family	Genus & Species	Authority	Type Locality	Other Known Records (to 2011)
Doridiidae	*Aphelodoris lawsae*	Burn, 1966	Christies Beach, GSV	3NM off metro coast in GSV; Rapid Bay in GSV; Point Turton & Sir Joseph Banks Group in southern Spencer Gulf; Stokes Bay at Kangaroo I.; Ceduna in eastern GAB NB Might also occur in SW WA, but there appear to be no published records
Doridiidae	*Discodoris* sp. *Rostanga* sp. 1	(in Coleman 2001) (in Rudman 2000)		Edithburgh, GSV
Doridiidae	*Doris* sp.	(in Coleman 2001)		Edithburgh, GSV
Doridiidae	*Taringa* (previously *Aporodoris) merria*	(Burn, 1973)	Pearson Isles in Investigator Gp, eastern GAB	possibly Spencer Gulf (Might also occur in Victoria, but published records are lacking)
Discodoridiidae	*Jorunna* sp.	(in Gowlett-Holmes 2008)		Kangaroo Island?
Aglajidae	*Philinopsis troubridgensis*	(Verco, 1909)		Edithburgh; Port Lincoln (e.g. Boston Bay and Kirton Point Wharf)

Aphelodoris lawsae Burn, 1966 (Law's Aphelodoris) is known so far from Ceduna in the eastern GAB through to Kangaroo Island and Gulf St Vincent (Burn 1966; Burn 1989; Rudman 2000; Gowlett-Holmes 2008). It may also occur in south-western WA, but there appear to be no published records. It grows to about 4.5cm (Debelius and Kuiter 2007) or 5cm long, and is found on reef and under stones, between 0m and 10m deep. This species eats sponges (Coleman 2001).

Two other sea slugs in Doridiidae known to date from South Australia are the Maze Discodoris *Discodoris* sp. and the Edithburgh Doris *Doris* sp., both mentioned in Coleman (2001) and McDonald (2006). *Discodoris* sp. grows to about 2cm, and Doris sp. to 4cm. Both have been recorded at Edithburgh in Gulf St Vincent.
One example of *Discodoris* sp. is known from 5m deep on sponge, and *Doris* sp. has been found to date on jetty piles in the shallow subtidal (e.g. 3m at Edithburgh). The Edithburgh Doris eats sponges, and forms mating groups (Coleman 2001).

The distribution may extend beyond South Australia but there are no published records. Taxonomic work is required on both of these sea slugs to determine their relationship with named species in *Doris* and *Discodoris*. Another species in the Doridiidae apparently known to date from South Australia and no other State is the red *Rostanga* sp. 1 (in Rudman 2000) (**Figure 8**), which may be the same species as the unnamed *Discodoris* discussed above. This 5cm sea slug is well camouflaged, and resembles the sponges on which it feeds. It has been recorded uncommonly at Edithburgh in Gulf St Vincent. A fifth South Australian species in Doridiidae, *Taringa* (previously *Aporodoris*) *merria* (Burn, 1973) might also occur in Victoria. The holotype was collected at 52m from Pearson Isles in Investigator Group, but the species is more often known from between 1m and 10m (Gowlett-Holmes 2008), on reef and jetty piles, mainly on sheltered coasts. This species feeds on brown encrusting *Clathria* (*Dendrocia*) sponge (Gowlett-Holmes 2008).

Figure 8: *Rostanga* sp. 1 (in Rudman 2000; also N. Coleman pers. comm. 2011), or *Discodoris* species (Coleman 2008; B. Burn, pers. comm. 2011). Photo (c) S. Hutchison http://www.stuarthutchison.com.au/

An unnamed species in the Discodorididae that has apparently been recorded so far only in South Australia is the pink or pinkish-brown *Jorunna* sp. (in Gowlett-Holmes 2008). This species grows to about 5cm, and has been recorded under rocks on reef, between 0m and 10m deep, on sheltered to moderately exposed coasts (Gowlett-Holmes 2008). The full distribution of this unnamed species is not known.

Figure 9: *Philinopsis troubridgensis*. Photo (c) J. Lewis

One of the larger South Australian sea slugs is *Philinopsis troubridgensis* (Verco, 1909) (**Figure 9**), which grows to about 10cm, and is found in sand, on or near reefs and seagrass beds (Burn 1989; Coleman 2001; Gowlett-Holmes 2008). There are records from both Gulf St Vincent and Spencer Gulf, between 0m and 15m deep. This species feeds on other sand-burrowing sea slugs (Gowlett-Holmes 2008). Debelius (1996) reported *P. troubridgensis* to also occur in Western Australia, but records have not been confirmed.

An intertidal survey in the Port Stanvac area of the AMLR NRM region (Dutton and Benkendorff 2008) reported the presence of rare nudibranch species, but a search of the distribution records of species listed from that survey indicated that all nudibranchs are widespread either in southern Australia or the Indo-Pacific, and most are also relatively common. The purported record of *Dendrodoris citrina* (apparently an endemic New Zealand species: Rudman 1998, Spurgeon 2007) from that survey, may have referred to the yellow form of *Doriopsilla carneola*, a widespread southern Australian species which resembles *Dendrodoris citrina* in shape, colour (although highly variable) and markings.

Although most sea slugs are brightly coloured and conspicuous, and therefore easily recorded, the full distribution of many species is still unknown, because the majority of records come from popular diving locations. In South Australia, this includes jetties at Port Noarlunga, Rapid Bay, Edithburgh, Port Hughes; a number of shipwrecks in Gulf St Vincent; and a few diving locations around southern Eyre Peninsula. Also, a number of sea slug species are small and cryptic, and well camouflaged on macroalgae. These are not easily seen or collected, unless destructive techniques are used. Many of these smaller, less colourful species are usually not seen or photographed, so distribution records are biased.

Polyplacophora (Chitons)

The chitons are a large group of marine molluscs which live on wave-exposed rock surfaces, or under rocks or in crevices. Chitons have eight overlapping shell valves (plates) with a tough flexible girdle on the top side; and a head, mouth, gills and large fleshy foot on the underside. This group is very well represented in Australia, which contains at least 150 (more than 20%) of the world's known species (Gowlett-Holmes 2008; CSIRO 2010). There are several species known to date only from South Australia (**Table 13**).

Table 13: Chiton species found to date only in South Australia, which either occur in AMLR NRM, or are likely to occur there, based on known presence in the SA gulfs region. GSV = Gulf St Vincent; GAB = Great Australian Bight; SG = Spencer Gulf.

Family	Genus & Species	Authority	Type Locality	Other Known Records (to 2011)
Acanthochitonidae	*Acanthochitona saundersi*	Gowlett-Holmes & Zeidler 1987	off NW point of East Franklin I., Nuyts Archipelago	Tiparra Reef in Spencer Gulf; Point Gilbert (Port Moorowie) on Yorke Peninsula
Ischnochitonidae	*Ischnochiton* (*Ischnochiton*) *pilsbryi*	Bednall, 1897	Sultana Point / Bay, Yorke Peninsula (neotype)	Cape Jervis, Hickey Point (S of Edithburgh), Giles Point / Wool Bay area in GSV; Corny Point in SG; St. Francis I. in Nuyts Archipelago
Chitonidae	*Onithochiton ashbyi*	Bednall & Matthews, 1906	Aldinga Bay	Marino Rocks and Port Willunga (neotype) in GSV; Corny Point in SG
Ischnochitonidae	*Stenochiton nubilus* (previously *Ischnochiton nubilus*)	(Cochran, 1993)	Gulf St Vincent	Brighton in GSV; Marum I. and Reevesby I., Sir Joseph Banks group; Cape Donington in SG; Point Sinclair (paratype) in eastern GAB
Acanthochitonidae	*Bassethullia porcina* (prev. *Acanthochiton porcina*)	(Ashby, 1919)	Gulf St Vincent	Christies Beach in GSV; Investigator Strait; Kangaroo I.; Robe in south-eastern SA

Of the few chiton species known only from South Australia, *Onithochiton ashbyi* Bednall and Matthews 1906 (**Figure 10**) has been reported to date only from the SA gulfs coast (**Map 5**), notably the metropolitan area and upper Fleurieu in GSV (Torr 1897; Ashby 1918, 1926; Zeidler and Gowlett 1986; Gowlett-Holmes 1999, in ABRS 2011; South Australian Museum record, in OZCAM 2011). This species has been found on encrusting calcareous red algae, on rocky reefs, including sheltered rock pools. The girdle and valves have been described as being a brilliant green and pink colour (Ashby 1918), enabling effective camouflage on the algae-covered rock surfaces on which it lives.

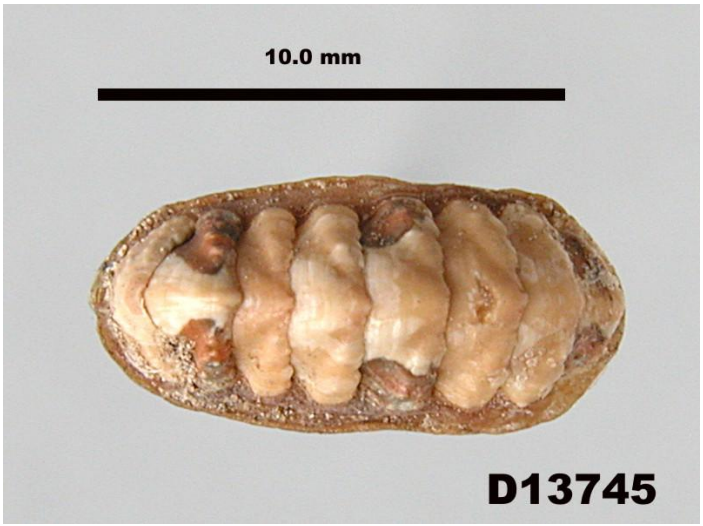


Figure 10: Dried specimen of *Onithochiton ashbyi*. Photo (C) South Australian Museum, in OZCAM (2011).

Acanthochitona saundersi Gowlett-Holmes and Zeidler 1987 (**Figure 11**) is a small chiton (1.5cm) that has been reported so far only from the gulfs region and the GAB in South Australia (Gowlett-Holmes and Zeidler 1987; Gowlett-Holmes 1999, in ABRS 2011; South Australian Museum record, in OZCAM 2011). This species is found under granite rocks, boulders and ledges in fine - medium sand; and rocks embedded in sand pockets on reefs, in areas of moderate swell. Specimens have been collected to date from 6m to 12m. *A. saundersi* is known from few specimens, taken by divers. The species was considered by Gowlett-Holmes and Zeidler (1987) to be relatively rare, since few have ever been found, despite extensive collecting of chitons in South Australia. However, the small size and cryptic habit is noted here, which would reduce the probability of finding specimens unless specific searches are made, on and under sand-embedded rocks in reef habitats.

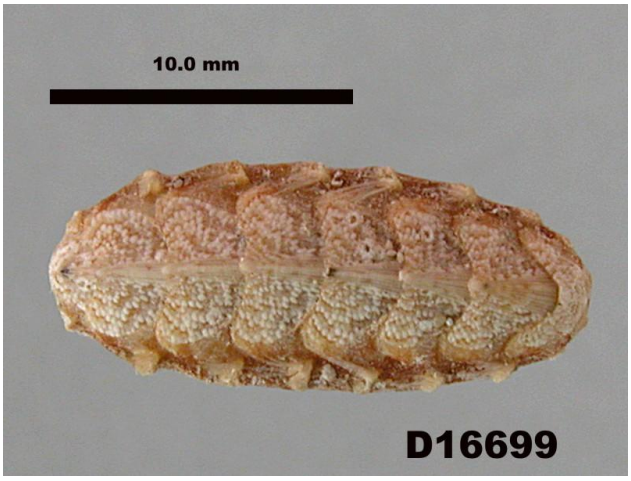
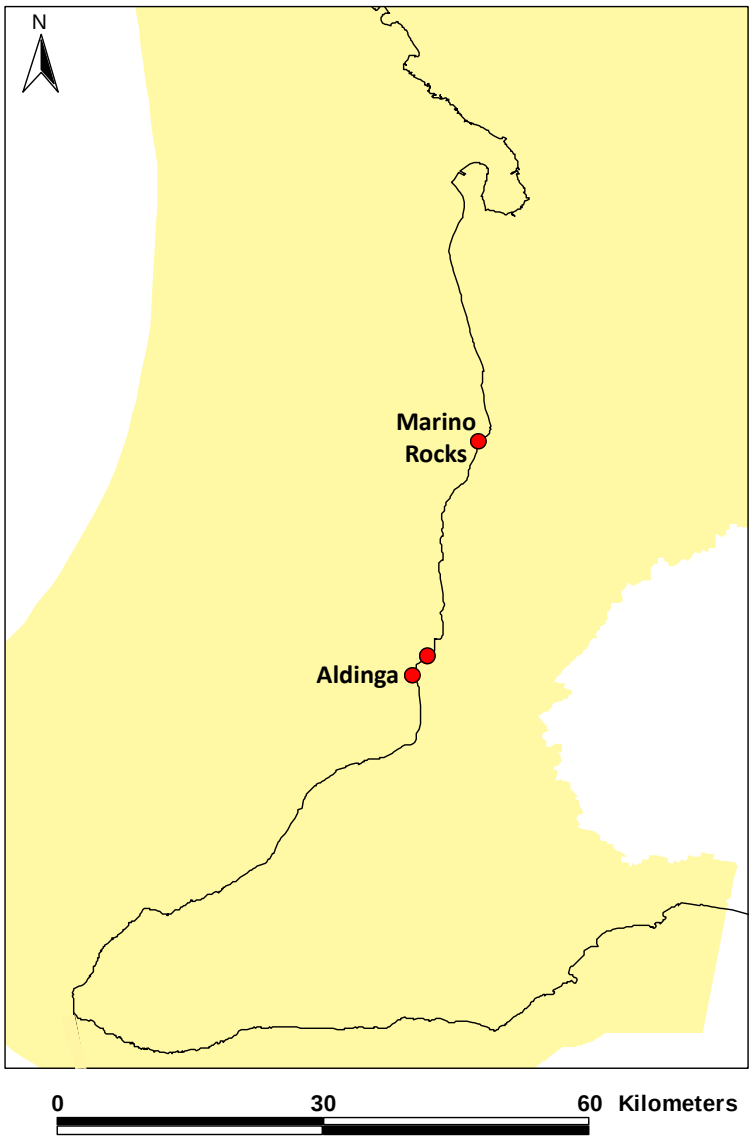


Figure 11: Dried specimen of *Acanthochitona saundersi*. Photo (C) S.A. Museum, in OZCAM (2011).

Another chiton species known from both the SA gulfs and the GAB is *Ischnochiton* (*Ischnochiton*) *pilsbryi* Bednall 1897 (Torr 1897; Ashby 1918; Kaas and Van Belle 1990; Gowlett-Holmes 1999, in ABRS 2011), which is an ochre-yellow colour, and grows to about 4cm. There are records from GSV (as far south as Cape Jervis) through to the eastern GAB, and it may not be uncommon in South Australia. This species has been found on rocks embedded in sand (Torr 1897). *I. pilsbryi* is considered to be a shallow water species (Kaas and Van Belle 1990).

A third species known from the SA gulfs and eastern GAB is *Stenochiton nubilus* (Cochran 1993), which occurs in pebbles, in sand and seagrass (Cochran 1993; Gowlett-Holmes and Zeidler 1995; Gowlett-Holmes 1999, in ABRS 2011; South Australian Museum record, in OZCAM 2011).

Bassethullia porcina (Ashby, 1919), previously known as *Acanthochiton* (*Notoplax*) *porcina*, is known from Robe to Investigator Strait, including Kangaroo I. (Cotton 1953; Gowlett-Holmes 1999, in ABRS 2011; South Australian Museum record, in OZCAM 2011). The holotype was dredged in Gulf St Vincent. This species is reported from smooth rocks under loose, clean fine to medium sand.



Map 5: Examples of locations in AMLR NRM region where the uncommon and possibly endemic chiton *Onithochiton ashbyi* Bednall and Matthews 1906 has been recorded.

Prosobranchs (Sea Snails, Gastropod Shells)

The Prosobranchia was for many decades considered one of three large subclasses of gastropod shells, along with Pulmonata and Opisthobranchia. A substantial revision of this classification (e.g. Ponder and Lindberg 1997, cited by Ponder et al. 2002; Bouchet et al. 2005) now recognises the following groups:

- Patellogastropoda (true limpets);
- Vetigastropoda (top shells, abalones, turban shells, keyhole limpets, slit shells etc.);
- Neritopsina or Neritimorpha (nerites);
- Caenogastropoda (many of the marine snails, including periwinkles, whelks, cowries, cones, moon snails, balers, etc.) and
- Heterobranchia or Euthyneura (land snails and slugs, sea slugs etc.).

Most prosobranchs have external shells that can completely contain and protect the soft animal within, but a few species have reduced internal shells. Another characteristic of prosobranchs is the presence of gills in a mantle cavity under the edge of the shell. There is often a horny or shelly operculum on the back of the foot, which is used to block the aperture of the shell when the animal retreats inside (Gowlett-Holmes 2008).

The prosobranch gastropod mollusc fauna in South Australia is rich and diverse, with hundreds of species occurring from the intertidal, shallow subtidal and upper shelf waters combined (e.g. Appendix 4 in Baker 2004). A number of species in the AMLR NRM region are discussed below, from groups whose members have potentially vulnerable population characteristics, such as direct development; narrow geographic distribution; narrow depth range, and/or high value for trade. One of the principle groups of interest is the cowries, many species of which have beautiful shells that are highly sought after by collectors. Southern Australian cowries are not closely related to the tropical counterparts, due to the fact that they brood eggs, which hatch as crawling snails, and therefore have no dispersive larval stage. Temperate cowries camouflage their ornamented shells with folds of the mantle cavity; are often nocturnal in habit, and eat sponges. **Table 14** below lists 7 species and several sub-species or varieties of cowries that are of conservation concern in South Australia, and are known to occur, or are likely to occur, in the AMLR NRM region.

Reeve's Cowrie *Austrocypraea reevei* (Sowerby 1832) ranges from South Australia to about Geraldton in WA (Wilson et al. 1993; Ponder and Middelfart 2005, in ABRS 2011; Academy of Natural Sciences 2006), with most examples coming from the southern coast of WA. There are also Pliocene fossil specimens from the Roe Plain in WA. Reeve's Cowrie is found on rocky reefs, under rocks or near sponges, macroalgae and/or bryozoans. It has also been found in caves, and under ledges, and on reef walls (Enzer Marine Environmental Consulting 2002). Reeve's Cowrie is of moderate value in the commercial shell market. In the Western Australian specimen shell fishery, 156 were recorded as being taken in 1999, and 16 in 2003. The range in annual recorded take was 85-205 shells during the 1990s, and 80-168 shells per annum between 2005 and 2008 (WA Department of Fisheries data). The annual catch of this species in South Australia is not publicly available. In an assessment of molluscs in the shell trade that are vulnerable to over-exploitation, Ponder and Grayson (1998) classified this species as category "B" in WA and SA.

Notocypraea angustata (Gmelin 1791), the Plump Cowrie (also known as the Southern Cowrie, Tight Cowrie or Brown Cowrie), ranges from Eden in NSW through to Eyre Peninsula in South Australia (Wilson et al. 1993; Ponder and Middelfart 2005; Academy of Natural Sciences 2006; Grove 2010). This small cowrie (to about 4cm), is commonly found under rocks and stones; also in crevices, or on sponges. It has a broad depth range across the continental shelf (from the intertidal to about 150m deep). This species is common in Tasmania, but there are some rare forms over the range. Plump Cowrie is of medium value in the shell trade. This species is reportedly over-exploited in shallow subtidal waters in Victoria (O'Hara and Barmby 2000). At a national level, it has been classified as moderately vulnerable to over-exploitation (category "C" in Ponder and Grayson 1998). The closely related Speckled Cowrie *Notocypraea declivis* (Sowerby, 1870) is not discussed here, because the south-east of South Australia is the western edge of the range, and thus the species is unlikely to occur in the AMLR NRM region.

Table 14: Cowrie shells of potential conservation concern found to date in South Australia, which either occur in AMLR NRM, or are likely to occur there, based on known presence in the SA gulfs region. GSV = Gulf St Vincent. GAB = Great Australian Bight; SE SA = south-eastern South Australia.

Genus & Species	Authority	Distribution	Type Locality	Other Known Records in SA (to 2011)
Austrocypraea reevei	(Sowerby, 1832)	WA, SA		Streaky Bay, Thorny Passage, southern Fleurieu; Backstairs Passage; Dudley Peninsula (including Penneshaw area) on KI
Notocypraea angustata	(Gmelin, 1791)	NSW, VIC, TAS, SA	Twofold Bay, NSW	Backstairs Passage & Port MacDonnell
Notocypraea piperita	(Gray, 1825)	NSW, VIC, TAS, SA, WA		Eucla & Streaky Bay area in GAB; Thorny Passage; SW GSV / SE Yorke Peninsula; southern Fleurieu in GSV; Backstairs Passage; Pt MacDonnell in SE SA
Notocypraea comptoni casta	(Schilder & Summers, 1963)	SA		Great Australian Bight Port MacDonnell in SA SA
Notocypraea comptoni comptoni	(Gray, 1847)	WA, SA		Pt Lincoln / Thorny Passage area; Tumby Bay area; southern Fleurieu in GSV; Backstairs Passage
Umbilia armeniaca	(Verco, 1912)	WA, SA	60 miles from shore, 80 miles W of Eucla, GAB	Investigator Strait / N. Kangaroo I. ; Thorny Passage / Pt Lincoln area; Cape Nuyts; Head of Bight (Yalata); Eucla
Zoila friendii thersites	(Gaskoin, 1849)			Cape Jaffa; Dudley Peninsula and other locations around Kangaroo Island; Backstairs Passage; south-western GSV / SE Yorke Peninsula; Thorny Passage; Sir Joseph Banks group; northern Spencer Gulf; Ceduna area; Nuyts Archipelago
Zoila marginata orientalis	Raybaudi 1985	SA	Ceduna	Head of Bight; Nuyts Archipelago; Port Lincoln / Thorny Passage area; Yorke Peninsula; Backstairs Passage / Cape Jervis area; Encounter Bay; Dudley Peninsula (including Penneshaw area) and other parts of Kangaroo Island.
Z. marginata marginata	(Gaskoin 1849)	WA (possibly also SA)	possibly King George Sound (*as Z. marginata marginata*); Garden I. (as *Z. marginata consueta*)	Ceduna; Port Lincoln area; Kangaroo Island

Another small species in *Notocypraea* is *N. piperita* (Gray 1825) the Peppered Cowrie, widely distributed across southern Australia, from southern NSW to Cape Naturaliste in Western Australia (Wilson et al. 1993; Academy of Natural Sciences 2006; Ponder and Middelfart 2005, in ABRS 2011). Like *N. angustata*, this species is found under rocks and stones, and on sponges, ranging from the intertidal to about 200m deep. There are various named forms over range, such as *N. piperita bicolor* in WA, and *N. piperita piperita* in south-eastern Australia. Peppered Cowrie is common in south-eastern Australia, except albino forms. This species is of low to moderate value in the shell trade and, like *N. angustata*, has been classified as moderately vulnerable to over-exploitation (category "C" in Ponder and Grayson 1998).

Two more small cowries (2.5cm) are *Notocypraea comptoni casta* (Schilder & Summers 1963), and *Notocypraea comptoni comptoni* (Gray, 1847), the southern and western forms respectively of Compton's Cowrie (**Figure 12**). *N. comptoni casta* is found in South Australia, including the Great Australian Bight, and *N. comptoni comptoni* occurs along the lower west and south west coast of Western Australia, and in South Australia (Wilson et al. 1993; Ponder and Middelfart 2005, in ABRS 2011; Academy of Natural Sciences 2006). These are both recognised as subspecies, by Ponder and Middelfart (2005). Compton's Cowrie is found under rocks and rubble. The southern form has a published depth range of 5m to 150m, and the western form 0m to 100m deep.

Figure 12: *Notocypraea comptoni.* Photo (c) P. Mercurio

There are two cowries in the genus *Umbilia* in South Australia, and one is amongst the most highly valued cowries in the world, but is now less rarely found than in previous decades, due to trawling, which has uncovered previously unknown populations. *Umbilia armeniaca* (Verco 1912), the Apricot-coloured Cowrie or Armenian Cowrie, ranges from the north coast of Kangaroo Island in SA through to Rottnest I. in WA (Wilson et al. 1993; Darragh 2002; Wilson and Clarkson 2004; Academy of Natural Sciences 2006). It is a large species (to about 12.4cm), and occurs on low profile sandy and rubbly reef, particularly in areas rich in sponges (and dense macroalgae, in shallower part of range). It has a broad depth range, from about 25m deep through to 320m. The Apricot Cowrie occurs as small sub-populations confined in highly localised areas, and is apparently absent throughout much of the total range (Edgar 2008). It is highly valued in the international shell market, and is taken by divers; also trawled on the outer shelf (e.g. in south-western WA). *U. armeniaca* is found occasionally in lobster pots, scallop trawls and fish stomachs. The species has been classified as being highly vulnerable to overexploitation in SA and WA, and therefore nationally (category "A" in Ponder and Grayson 1998).

The other species in *Umbilia*, Undecided Cowrie or Wonder Cowrie *U. hesitata* (Iredale 1916) occurs in south-eastern Australia, from Fraser I. in Queensland to Cape Jaffa in SA (Darragh 2002; Wilson and Clarkson 2004; Academy of Natural Sciences 2006; Grove 2010), and there are two forms over the range. This species is not discussed in detail here, because the AMLM NRM region is out of the recorded range.

Several species, subspecies and forms in *Zoila* are known from South Australia and some of these occur in the AMLR NRM region. The best known is the Black Cowrie *Zoila friendii thersites* (Gaskoin 1849) (**Figure 13**), which ranges from approximately Apollo Bay in western Victoria through to Point Fowler in western South Australia (Wilson et al. 1993; Wilson and Clarkson 2004; Ponder and Middelfart 2005, in ABRS 2011). "*Zoila thersites*" (with 2 subspecies or forms) was recognised as a species by Lorenz (2001) and Academy of Natural Sciences (2006) but not by Wilson and Clarkson (2004). This cowrie grows to about 11 or 12cm, but is rarely seen at that large size. *Z. friendii thersites* is one of a group of closely related subspecies or forms, some of which occur only in WA. There are records of Z. *friendii thersites* from across South Australia (**Table 14**). It occurs on limestone, granite and other reefs with sponges. There are also records from sandy reefs with *Pinna* razorfish and sponges, and silty substrates with sponges. *Zoila friendii thersites* ranges in depth from about 2m to more than 50m deep. A form known as "*contraria*" may range from 100m to 300m (Academy of Natural Sciences 2006). Black Cowrie is hand-collected by divers (e.g. 20-45m+), and also trawled, and sold in the shell trade. Some rare forms were collected by diving in deep sponge beds off Kangaroo Island during 1970s. A population in one area of north-eastern Kangaroo Island area is reported to still be abundant, possibly increasing (P. Clarkson, pers. comm. 2011). However, some larger Kangaroo Island and Port Lincoln forms are reported by other divers to have been over-collected. Divers have also reported this *Zoila* as being over-collected off the Stansbury and Edithburgh area in Gulf St Vincent, with habitat damage to sponges in that area.

In South Australia, there is a recreational bag limit of 1 per day for *Zoila friendii thersites* (PIRSA web site, 2011). Black Cowrie has previously been classified as being of moderate vulnerability to over-exploitation (category "C" in Ponder and Grayson 1998). In Victoria, O'Hara and Barmby (2000) classified it as being vulnerability category "B" in that State, using Ponder and Grayson's criteria.

Figure 13: *Zoila friendii thersites* Photo (c) P. Macdonald http://www.paulmacdonaldphoto.com

Another subspecies or form in *Zoila* that occurs in SA is *Z. marginata orientalis* Raybaudi 1985, part of the species *Z. marginata*, which is found in WA and SA. *Zoila marginata orientalis* (**Figure 14**) is known to date only from South Australia, between Encounter Bay and the head of the GAB (Laws 1965; Wilson and Clarkson 2004; Academy of Natural Sciences 2006), and thus appears to have a limited geographic distribution (central to western SA coast). This cowrie, which grows to a little over 7cm, occurs on exposed reef (including in crevices) with the host sponge *Trachycladus laevispirulifer*, and also on reefs with red and brown macroalgae. In deeper waters it occurs in mixed habitat of sand, limestone or sandstone rubble, algae, sponges and gorgonian corals, often in high tidal flow environments, and does not extend into calmer gulf waters. The known depth range of the *marginata orientalis* form is relatively narrow (5m – 60+), but overall, *Z. marginata* in all its forms has a broader range (5m and 200m). In dive-able depths, *Z. marginata orientalis* occurs as a series of largely disconnected populations, mostly around islands, and rarely off the mainland coast of SA (P. Clarkson, pers. comm., 2011). Due to limited collecting (perhaps due to its existence in largely inaccessible habitat) and therefore limited market supply, *Zoila marginata orientalis* is highly valued in the international shell trade, in the order of hundreds of dollars per specimen. It is reported by some sellers to be rare now, likely based on the low availability of specimens rather than any reduction in the population, which has been observed to be locally abundant in some areas (P. Clarkson, pers. comm. 2011). It is also called *Z. orientalis* (by F. Lorenz) and *Z. marginata raybaudii*. This cowrie is taken by fish trawls in the GAB (more than 50m deep), and is also hand-collected in SA, including occasional collecting by abalone divers, and previous collecting by one commercial licensed diver for the shell trade. Catch records indicate that 48 were taken from one site off the Dudley Peninsula (Kangaroo Island) in 2002-03. Various sub-species in *Zoila marginata* were ranked as being moderately vulnerable to over-exploitation (categories "B", "C" and "D" in Ponder and Grayson 1998), but *Z. marginata orientalis* was not included in the Ponder and Grayson assessment.

Figure 14: *Zoila marginata orientalis*. Photo (c) P. Clarkson

Closely related to the *Zoila* subspecies or form above is *Z. marginata marginata* (Gaskoin 1849) the Broad-margined Cowrie (also known as Marginate Cowrie or Margin Cowrie). This subspecies is known mostly from the lower west and south-west coast of Western Australia, between Jurien Bay and Israelite Bay. However, genetics data (e.g. Florida Museum of Natural History) indicates a possible extension to Kangaroo Island in SA (Ezner Marine Environmental Consulting 2002; Wilson and Clarkson 2004; Ponder and Middelfart 2005, in ABRS 2011). This subspecies, which grows to about 8cm, has been recorded from more than 15 locations in WA. There are a few locations in SA where *Z. marginata marginata* has been recorded to date (**Table 14**). *Z. marginata marginata* occurs on reefs with *Geodia* sponges; often in caves and crevices, and the recorded depth range is 5m to 100m. This cowrie has a very specific food source (*Geodia* sponges). Genetic sequencing by the Florida Museum of Natural History, of *Z. marginata marginata* specimens from Ceduna, Port Lincoln and Kangaroo Island, indicate that this sub-species is not endemic within WA.

It is noted that *Z. marginata albanyensis* may be same subspecies or form. *Z. marginata marginata* has moderate value in the shell market, with specimens ranging from tens to hundreds of dollars. Previously, categories of vulnerability to over-exploitation were considered to be "D" in SA, "C" nationally, and category "B" in WA and also nationally as the form "*consueta*" (Ponder and Grayson 1998).

The final species in *Zoila* that extends into SA is the Delightful Cowrie or Much Desired Cowrie *Zoila venusta* Sowerby 1846, which ranges from Shark Bay in Western Australia to Cape Adieu in western South Australia. This sub-tropical species is unlikely to occur in the AMLR NRM region, and is thus not discussed here.

The Volutidae is another group of commercially valuable molluscs with representatives in AMLR NRM region. The shells of volutes are spiral shaped, and distinctively marked. Volutes are active predators, and often lived buried in sand. They emerge at night to feed on prey, which includes other molluscs. Volutes lay benthic egg capsules, which may be elaborate in shape (e.g. the spiralled cylinder of *Amoria undulata* - Smith et al. 1989). A study on the South American volute *Odontocymbiola magellanica* showed that males and females of this species mature at 7 to 8 years of age, and females aggregate at spawning time (Bigatti et al. 2008). Like the temperate cowries, in many species of volute the eggs hatch directly as small crawling snails, with no free-swimming veliger stage (e.g. Smith et al. 1989). The localised reproduction and limited dispersal of young often gives rise to distinct colour forms of volute shells over relatively small spatial scales.

Table 15: Volute shells of potential conservation concern found to date in South Australia, which either occur in AMLR NRM, or are likely to occur there, based on known presence in the SA gulfs region. GSV = Gulf St Vincent. GAB = Great Australian Bight; SE SA = south-eastern South Australia; TAS = Tasmania; VIC = Victoria; SA = South Australia; WA = Western Australia. For these species, specific location records in South Australia are intentionally not included here.

Genus & Species	Authority	Distribution	Type Locality	Other Known Records in SA (to 2011)
Amoria exoptanda	(Reeve, 1849)	SA, WA	Port Lincoln, SA	Thorny Passage and locations around south-eastern Eyre Peninsula / south-western Spencer Gulf; Tumby Bay area.
Amoria undulata	(Lamarck, 1804)	QLD, NSW, TAS, VIC, SA, WA	Bass Strait or Maria Island, TAS	E GAB; S Eyre Peninsula; Thorny Passage; S and W Spencer Gulf; Fleurieu Peninsula; Encounter Bay
Ericusa fulgetra / *fulgetrum*	(Sowerby, 1825)	SA, WA (plus unverified record from VIC)	Spencer Gulf, SA	GAB; Ceduna and Streaky Bay areas; Port Lincoln / Thorny Passage area; Sir Joseph Banks Group; Port Neill area; Tumby Bay area; Corny Point / Hardwicke Bay area; south-western GSV / south-eastern Yorke Peninsula; northern GSV; Encounter Bay
Ericusa papillosa	(Swainson, 1822)	QLD, NSW, VIC, TAS, SA, WA	possibly Port Lincoln (Reeve 1849); syntype from Cape Everard, VIC	central GAB; southern Eyre Peninsula; southern Yorke Peninsula (unverified); Backstairs Passage; Fleurieu Peninsula
Livonia mammilla	(Sowerby, 1844)	QLD, NSW, VIC, TAS, SA	Great Australian Bight, 90mls W of Eucla	Port Lincoln area

Table 15 (cont.):

Genus & Species	Authority	Distribution	Type Locality	Other Known Records in SA (to 2011)
Livonia nodiplicata	(Cox, 1910)	SA, WA	Great Australian Bight, 90mls W of Eucla	Port Lincoln area
Livonia roadnightae	(McCoy, 1881)	NSW, VIC, TAS, SA, WA	Ninety Mile Beach at Lakes Entrance, or Bass Strait (two holotypes)	Port MacDonnell area in SE SA; GAB
Lyria mitraeformis	(Lamark, 1811)	VIC, SA, WA	"New Holland"	Tumby Bay area; various southern Fleurieu Peninsula locations in GSV; eastern Kangaroo I.
Melo miltonis	(Gray in Griffith & Pidgeon, 1834)	WA, SA, rarely in VIC	Newland Head in SA	Ceduna, Streaky and Smoky bay areas in the eastern GAB
Nannamoria guntheri	(Smith, 1886)	SA, WA	Middleton in SA	Encounter Bay; GSV (unspecified); islands in Thorny Passage; Streaky Bay area; Nuyts Archipelago; deeper waters off Fowlers Bay; shelf edge off head of GAB
Nannamoria johnclarki / johnclarkei	(Bail & Limpus 1997)	SA, WA	SW of Esperance, Recherche Archipelago	Backstairs Passage; Port MacDonnell
Notopeplum translucidum	(Verco, 1896)	SA, WA	Newland Head	Backstairs Passage
Notovoluta kreuslerae	(Angas, 1865)	VIC, SA, WA		GAB; Pt Lincoln / Thorny Passage area; mid-eastern Spencer Gulf; central Spencer Gulf, W of Moonta; Neptune Is., GSV (unspecified); Encounter Bay
Notovoluta verconis	(Tate, 1892)	SA, WA	Yankalilla Bay	GAB (including deeper waters off the Head of the Bight); St Francis Is.; Streaky Bay area; Thorny Passage area; Investigator Strait; various locations in GSV; upper SE SA

There are 14 volute shells of potential conservation concern in South Australia and at least 10 or 11 of these are likely to occur in the AMLR NRM region (**Table 15**), based on existing records. **Table 15** also includes species known to date in South Australia from southern Spencer Gulf, because, given the similarity in oceanography and habitat to parts of GSV, they are likely to occur in the latter gulf, and thus also in AMLR NRM region.

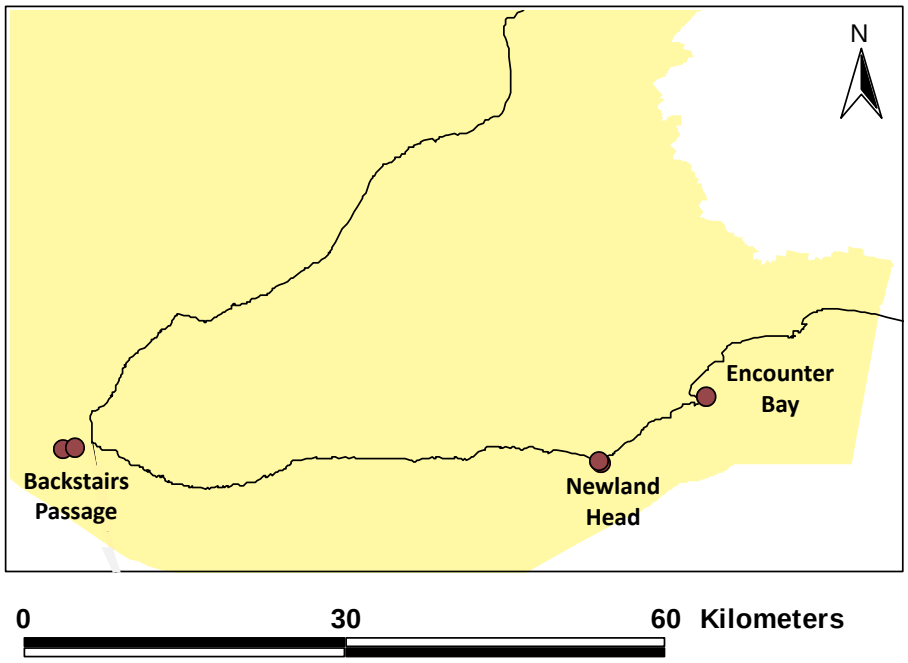
Amoria exoptanda (Reeve, 1849), the Desirable Volute or Much Desired Volute (**Figure 15**, **Map 6**) is known from both SA and the south coast of WA (Wilson et al. 1994; Academy of Natural Sciences 2006). It grows to about 15cm, and occurs on sand in seagrass beds, and in sand and gravel habitats, between 10m and 100m deep. This species is collected commercially in SA and WA, and has moderate value in the shell market. It is considered to be widespread and locally common (P. Clarkson, pers. comm. 2011). Between 1996 and 1997, 343 specimens were exported from WA. Reported landings in WA between 1999 and 2003 were 2 specimens (Department of Fisheries WA 2005).

The decline in landings of *Amoria exoptanda* in WA reflects the cessation of active collection in the area of Esperance, which supplied the commercial market during the 1990s. One shell expert reported that numbers have not declined in the area, despite the previous collecting effort (P. Clarkson, pers. comm. 2011). In an assessment of molluscs in the shell trade that are vulnerable to over-exploitation, Ponder and Grayson (1998) classified this species as category "B" on a national scale.

Figure 15: *Amoria exoptanda.* Photo (c) L. Baade

Amoria undulata (Lamarck 1804) the Wavy Volute or Undulate Volute (**Figure 16**) has a broad distribution, from Queensland through to northern Western Australia, including Tasmania, but there are gaps in the distribution (Bail et al. 2001; Academy of Natural Sciences 2006; Edgar 2008; Beechey 2010; Grove 2010). There are various records from throughout South Australia, including parts of the Fleurieu Peninsula in GSV; Thorny Passage and other parts of southern Spencer Gulf; western Spencer Gulf; southern Eyre Peninsula, and eastern GAB (Currie et al. 2009, and specimen shell trade data). The Wavy Volute is found in sand (including shelly sand), over a very broad depth range, from the intertidal to about 500m deep. It is common in the shallows in South Australia and Victoria. In SA, this species migrates in the spring from deep water to shallow water sandbanks to breed (Smith et al. 1989). The egg mass consists of layers of capsules in a cylindrical spiral, and only one embryo per capsule develops and hatches as a well developed, crawling juvenile. The Wavy Volute is trawled in some areas (e.g. Bass Strait), and hand collected by divers in SA. It is also a bycatch in the Bass Strait scallop fishery in tens to hundreds (e.g. survey data in Haddon and Semmens 2002, 2003). This species has low value in the shell market.

Figure 16: *Amoria undulata*. Photo (c) D. Muirhead



Map 6: Examples of approximate locations in AMLR NRM region where 4 volute species of potential conservation concern have been recorded. Collectively these include: *Amoria exoptanda*, *Notopeplum translucidum*, *Nannamoria johnclarki / johnclarkei* and *Melo miltonis.* Geographically accurate locations are not presented for specimen shells.

Ericusa fulgetra (= *E. fulgetrum*) (Sowerby 1825), which grows to about 20cm is another volute found in SA and south-western WA, and there is also an unverified record from Victoria (Leehman 1974; Wilson et al. 1994; Debelius 1996; Australian Government DEH 2004; Academy of Natural Sciences 2006). There are various records from throughout the SA coast, ranging from the GAB through to Encounter Bay (see **Table 15** for examples). This species is found in sand, including sand near seagrass and reef. *E. fulgetra* may occur in deeper water seasonally, and move to shallower water to lay eggs (Poppe and Goto 1992). This species has a broad depth range, from the intertidal to about 250m deep. *E. fulgetra* (**Figure 17**) is highly variable in colour and pattern, and some forms are considered rare (Leehman 1974; Wilson et al. 1994). It is fished commercially, and is of moderate value in the shell market. This species is considered vulnerable to over-exploitation (category "C" in WA, and "D" in SA (Ponder and Grayson 1998). Some populations, particularly inshore, are considered to be depleted from collecting (Coleman 2008; Edgar 2008; Gowlett-Holmes 2008). The related species *Ericusa papillosa* (Swainson, 1822) has a broad distribution (Queensland through to WA) and depth range (to more than 700m deep) (Academy of Natural Sciences 2006; Beechey 2010).

Figure 17: *Ericusa fulgetra*. Photo (c) P. Mercurio

There are three volute species in *Livonia* that may occur in the AMLR NRM, but no published records within the region could be found for this report. *Livonia mammilla* (Sowerby 1844) has a broad distribution, from southern Queensland through to Western Australia (Abbotsmith 1969). Although there are numerous records from WA (Cervantes, Rottnest I., Esperance, Binningup Beach), it is noted that some references (e.g. Academy of Natural Sciences 2006; Beechey 2010) exclude WA from the distribution. There are South Australian records from the Great Australian Bight, and Port Lincoln / Thorny Passage area in Spencer Gulf. This species occurs on sand, over a broad depth range (3m to about 200m). *Livonia mammilla* is taken by trawlers off eastern and southern Australia (Sutton 1973), including low numbers in shark fishery bycatch (e.g. Walker et al. 2002).

Livonia nodiplicata (Cox 1910) Cotton's Volute / Dannevig's Volute is found in SA and WA (as far north as Jurien Bay area) (Wilson et al. 1994; Academy of Natural Sciences 2006). This large species grows to about 40cm, and is found on sand, from 3m to about 200m deep. *L nodiplicata* is taken in lobster pots and shark nets, and by divers, and also trawled. It has high value in the international shell market, with gem specimens being sold for up to $1000 during 2008 – 2010. *Livonia nodiplicata* has been considered vulnerable to overexploitation (category "B" in WA and "C" in SA, according Ponder and Grayson (1998). There appear to be no published records of this species in the AMLR NRM region, but it might occur here.

The third *Livonia* species in SA, *L. roadnightae* (McCoy, 1881) Roadnight's Volute, has a broad distribution from approximately Crowdy Head in NSW to Rottnest Island in WA (Wilson et al. 1994; Academy of Natural Sciences 2006; Beechey 2010). It is considered rare in NSW, and uncommon in southern Australia (Beechey 2010). In South Australia, there are occasional records in various parts of the State, such as Port MacDonnell in the South-East, and the GAB in the west. This species ranges in depth from about 18m to 370m, in sand and mud habitats. It is trawled in some parts of range, and traded in the shell market (moderate value). *L. roadnightae* is possibly vulnerable to overexploitation (categories "D" and "E" in Ponder and Grayson 1998).

The Southern Lyre Shell *Lyria mitraeformis* (Lamark, 1811), also known as the Mitre-shaped Lyria or Mitre Volute (**Figure 18**), ranges from Bass Strait in Victoria to Cape Leeuwin in Western Australia (Wilson et al. 1994; Academy of Natural Sciences 2006; Ponder and Middelfart 2005, in ABRS 2011). The western form may be a sub-species. It is one of the smaller volutes (about 5cm maximum). Southern Lyre Shell is found in sand an under rocks, often in sand pockets on reef, on both sheltered and exposed coasts (Gowlett-Holmes 2008). This shell is widely traded in the international shell market, and has low to moderate value. Despite its broad distribution, it has been classified as being quite highly vulnerable to overexploitation (category "B" nationally: Ponder and Grayson 1998).

Figure 18: *Lyria mitraeformis*. Photo (c) L. Baade

The largest gastropod shell in southern Australia is *Melo miltonis* (Gray, in Griffith and Pidgeon 1834), the Southern Bailer Shell or Milton's Melon Shell, which grows to about 45 cm. It occurs mainly from western South Australia to Abrolhos Islands in Western Australia, but also is rarely recorded in eastern SA and western Victoria (Wilson et al. 1994; Academy of Natural Sciences 2006; Edgar 2008). There have been occasional records from the AMLR NRM region (e.g. **Map 6**). This species occurs in sand and seagrass habitats, and on sand near reefs. The reported depth range is 0m to 100m (Edgar 2008). *Melo miltonis* is an oviparous species with direct development. Large shells, over 350mm, are considered to be very uncommon (Wilson et al. 1994). This species has moderate value in the shell market.

There are two volute species in *Nannamoria* in South Australia, both are small (about 5cm long), and both are sought after by collectors, particularly Clarke's Volute *Nannamoria johnclarki* / *johnclarkei* (Bail and Limpus 1997). This species ranges from approximately Rottnest I. in WA to south-eastern SA (Bail and Limpus 1997; Academy of Natural Sciences 2006; Edgar 2008), and occurs in the AMLR NRM region (**Map 6**). It is found in sand and rubble, and in sandy patches amongst macroalgae, in moderately exposed areas. It is also found on limestone reefs. The recorded depth range is 15m to 120m. Clarke's Volute is considered uncommon (Edgar 2008), and very rare in the shell trade (Moylan 2003). This species has moderate to high value in shell market, and is rarely available or traded. The second *Nannamoria* species, Gunther's Volute *N. guntheri* (Smith, 1886), also occurs in SA and the south coast of WA (Wilson et al. 1994; Academy of Natural Sciences 2006). This species is found in sand, including bryozoan-rich sands, and there are records from sand in mixed seagrass and macroalgae habitats. The depth range extends to at least the edge of the continental shelf. There are several named forms e.g. *Nannamoria guntheri adcocki* from South Australia and *Nannamoria guntheri weaveri* from Dongara and Abrolhos Is in WA. Gunther's Volute (**Figure 19**) has moderate value in the shell trade. In South Australia, 3 specimens were reported to have been collected between July 2001 and June 2002 (PIRSA 2004).

Figure 19: *Nannamoria guntheri.* Photo (c) P. Clarkson

Less well known amongst the volute shells is *Notopeplum translucidum* (Verco 1896), found in South Australia (including the AMLR NRM: **Map 6**) and south-western WA (Wilson et al. 1994; WA Department of Fisheries 2005; Academy of Natural Sciences 2006). This small (5cm) volute is found in exposed areas, between 10m and 180m deep. It is collected in WA for the shell trade, with only 4 specimens reported between 1999 and 2003 (WA Department of Fisheries 2005), and it is not known if the low number of collected specimens reflects uncommonness of the shell, or low collecting effort due to low demand / low prices. *N. translucidum* has previously been considered vulnerable to overexploitation (category "B" in WA and "C" in SA, according to Ponder and Grayson 1998).

There are two species in *Notovoluta* found in SA. The first of these, Verco's Volute *Notovoluta verconis* (Tate 1892), also occurs along the south coast of Western Australia (Poppe and Goto 1992; Wilson et al. 1994; Academy of Natural Sciences 2006). It is a small volute (to 4cm), found amongst sponges (and corals, in some parts of the range) between 20m and more than 190m deep. Most records are from less than 40m deep, but there is a record from more than 180m, in the Great Australian Bight (Smithsonian Institution 2010). There are various records from the AMLR NRM region (**Table 16**). This species is traded in the shell market; shells are often of low to moderate value, but albino and gem quality specimens are of moderate and increasing value. In SA, there were 4 specimens reported to have been collected in the specimen shell fishery from July 2001 to June 2002 (PIRSA 2004). A larger species in *Notovoluta*, Kreusler's Volute *N. kreuslerae* (Angas 1865) ranges from about Cape Otway in western Victoria through to southern Western Australia (Wilson et al. 1994; Academy of Natural Sciences 2006). This species is collected commercially in SA and WA, and is of moderate value in the shell market. In the WA specimen shell fishery, 15 specimens were reported as being collected between 1999 and 2003 (Department of Fisheries WA 2005). This species is considered to be possibly vulnerable to overexploitation (category "D" in all States, according to Ponder and Grayson 1998).

Another group of prosobranch gastropods with representatives that are rarely recorded in SA is the Turridae. This family is a very large one, with more than 4,000 species described globally. The taxonomy of turrid shells has been revised a number of times during the past two decades, and there may still be no globally accepted classification of the sub-families in this large group. Turrid shells show a diversity of shell shapes, but are usually slender and elongated. One common feature of all turrids is a sinus - an indentation or slit at the upper end of the outer lip, which accommodates the exhalent canal (Beechey 2003). Turrids are carnivorous, mainly predatory, and polychaete worms are the major prey of the species of which the diet has been studied. Female turrids lay benthic egg capsules, and the eggs develop through trochophore and early veliger stages before hatching as free-swimming veligers, which may remain in the water for weeks or months before settling (Shimek 1983, 2008). Many southern Australian turrids have a broad distribution, but there are seven turrid shells known to date only from South Australia, and at least four of these are likely to occur in the AMLR NRM region (**Table 16**).

Table 16: Turrid shells of found to date only in South Australia, which either occur in AMLR NRM, or are likely to occur there, based on known presence in the SA gulfs region. GSV = Gulf St Vincent. GAB = Great Australian Bight; SE SA = south-eastern South Australia.

Genus & Species	Authority	Currently a Valid Species?	Type Locality	Other Known Records (to 2011)
Austrodrillia (*Austrodrillia*) *agrestis*	(Verco, 1909)	Uncertain	Beachport	Backstairs Passage; site 40 miles S of Cape Wiles (southern Eyre Peninsula)
Austrodrillia (*Austrodrillia*) *dimidiata*	(Sowerby, 1897)	Uncertain	off Beachport	site 40 miles S of Cape Wiles (southern Eyre Peninsula); Yankalilla Bay in GSV; Backstairs Passage
Daphnella (*Daphnella*) *diluta*	Sowerby, 1897	Yes	Gulf St Vincent	Backstairs Passage; Cape Borda on Kangaroo I.
Daphnella (*Daphnella*) *stiphra*	Verco, 1909	Yes	off Cape Jaffa	Wallaroo in Spencer Gulf; Cape Martin in SE SA
Epidirona perksi	(Verco, 1896)	Yes	off Thistle Island	
Scrinium impendens	(Verco, 1909)	Uncertain	Gulf St Vincent	off Ardrossan in GSV; off Newland Head near Encounter Bay

Two South Australian turrid shells whose current taxonomic status is uncertain are *Austrodrillia* (*Austrodrillia*) *agrestis*, and *A.* (*A.*) *dimidiata* (**Figure 20A,B**) (Hedley 1922; Wilson et al. 1994; Academy of Natural Sciences 2006; SA Museum specimens D13544 and D13545). A site off Beachport is the type locality for both species. *A. A. dimidiata* has also been recorded off southern Eyre Peninsula, and also at Yankalilla Bay in GSV, and Backstairs Passage (syntype). The recorded depth ranges are similar, based on the few, old specimens found to date, from dredging (30-75m for *A. A. agrestis* and 29-183m for *A. A. dimidiata*). There is very little information on both species, which were previously assigned to the genus *Drillia*. Neither species under the previous or current name is currently recognised in CSIRO's Codes for Australian Aquatic Biota database.

Figure 20A, B: (A) *Austrodrillia* (*Austrodrillia*) *agrestis*, and (B) *A.* (*A.*) *dimidiata*. Photographs (C) South Australian Museum, in OZCAM (2011).

Austrodrillia (*Austrodrillia*) *subplicata* (Verco, 1909) has been recorded only from Beachport and Cape Jaffa (upper south-east SA). It is known from very few old specimens, collected between 73 and 237m (Hedley 1922; Wilson et al. 1994; Academy of Natural Sciences 2006). As with *A. agrestis* and *A. dimidiata*, the current validity of this species is not known, and it is not recognised under either the current name or the previous name (*Drillia subplicata*) in CSIRO's CAAB database (2011). It is not known if this species occurs in the AMLR NRM region, but it is unlikely, given the depth range.

Daphnella (*Daphnella*) *diluta* Sowerby 1897 (**Figure 21**) is also known from a few old specimens. It has been recorded in Gulf St Vincent, Backstairs Passage and off Kangaroo Island, between 30m and 100m deep (Hedley, 1922; South Australian Museum data; Academy of Natural Sciences 2006; SA Museum specimen D13560). For the related species, *Daphnella* (*Daphnella*) *stiphra* Verco 1909, there are no published records from the AMLR NRM region, but it might occur here, based on its presence both east and west of the region. *D. d. stiphra* has been recorded over an unusually broad depth range on the continental shelf and slope (15 fathoms to 365 fathoms = 27m to 668m deep).

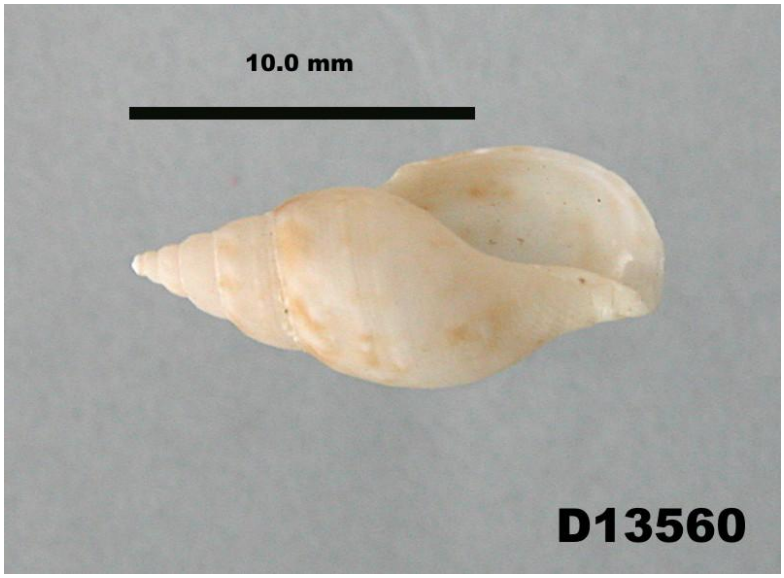


Figure 21: *Daphnella* (*Daphnella*) *diluta*. Photo (C) South Australian Museum, in OZCAM (2011)

Another small turrid shell dredged by Verco and known from an old record is *Epidirona perksi* (Verco 1896), reported from the type locality off Thistle Island in Spencer Gulf (Wilson et al. 1994; Academy of Natural Sciences 2006; SA Museum specimen D13533). This species was previously known as *Turricula perksi*, and its presence in AMLR NRM region is uncertain.

Gulf St Vincent is the type locality for *Scrinium impendens* (Verco 1909), a shell of uncertain affinity, in either the Turridae, Conidae or Clathurellidae family (Hedley 1922; Academy of Natural Sciences 2006; Museum Victoria specimen F30427). The status of the type is unknown. This species has also been recorded off Ardrossan in western GSV, and also off Newland Head near Encounter Bay. The depth range of 25m – 44m is based on two specimens listed in Hedley (1922), from 14 and 24 fathoms. Very little information about this species exists.

The Muricidae is another prosobranch gastropod family containing members which are highly valued in the shell trade, often due to the spines or fronds that ornament the shells, and in some cases due to the apparent rarity of the shells. In contrast, some of the commonest intertidal species on reefs across southern Australia are also in the Muricidae (e.g. mulberry shells, cartrut shells). **Table 17** lists members of the Muricidae (murex shells) that may be of potential conservation concern in SA, due to either their high commercial value (which may promote localised over-collecting), and/or their apparent rarity, based on lack of records. There are no published records from AMLR NRM region for any of these species, and it is not known for this report whether these murex shells occur in the region.

Table 17: Murex shells of potential conservation concern in South Australia, but for which there are no records to date from the AMLR NRM. GSV = Gulf St Vincent. GAB = Great Australian Bight; SE SA = south-eastern South Australia; WA = Western Australia.

Genus & Species	Authority	Type Locality	Other Known Records (to 2011)
Favartia (Murexiella) / Murexiella (Subpterynotus) tatei	(Verco, 1895)	Backstairs Passage	Smoky Bay in SA; Bunbury in WA; 0.25-0.5 miles off Peppermint Grove Beach, between Bunbury & Busselton in WA
Hexaplex conatus (previously called *Murexsul conatus*)	(McMichael, 1964)	GAB	Point Sinclair in western SA; off Albany and Esperance in WA
Litozamia longior	(Verco, 1909)	off Beachport	-
Monstrotyphis / Typhina / Typhis bivaricata Also known as *Typhis (Monstrotyphis) bivaricata* or *Monstrotyphis bivaricata*	(Verco, 1909)	off Neptune Island	35mls south-west of Neptune Is.; 40ml south of Cape Wiles; a site south-west of Cape Carnot
Pterynotus (*Pterochelus*) *westralis* (or *Pterochelus westralis*)	Ponder & Wilson 1973	NW of Rottnest Island (type)	St Francis I. in Nuyts Archipelago in SA; Geraldton & Karratha in WA

The first of these is Tate's Murex *Favartia* (*Murexiella*) or *Murexiella* (*Subpterynotus*) *tatei*, also known as *Murexiella tatei* Verco 1895. It is known from Backstairs Passage and Smoky Bay in SA, and from a few locations in southern WA (Wilson et al. 1994; Ponder and Middelfart 2005, in ABRS 2011; Academy of Natural Sciences 2006). This small species (to about 3cm) has been dredged from shallow water, and is considered rare (Wilson et al. 1994). The holotype was collected from 36m, but there are trawled specimens from deeper water (e.g. 120m). Five specimens were reported to have been collected commercially from 1999 to 2003 in the WA specimen shell fishery (WA Dept Fisheries 2005), and Tate's Murex has high value in the shell market.

Two small murex shells apparently known to date only from SA are *Litozamia longior* (Verco 1909) a 7mm shell known from the holotype, dredged at 73m deep off Beachport in the South East, and *Monstrotyphis* (or *Typhina*, or *Typhis*) *bivaricata* (Verco, 1909), the 5mm Twin Varix Cyphonochelus from 208m deep off the Neptune Islands, and also recorded as paratypes from around 190m deep, at a few sites near that area (Wilson et al. 1994; Ponder and Middelfart 2005, in ABRS 2011; Academy of Natural Sciences 2006). There little information about distribution and depth range for these species.

A larger murex, *Hexaplex conatus* (McMichael, 1964), which grows to 6 or 7cm, is known from the eastern Great Australian Bight / western South Australia and the south coast of Western Australia. (Wilson et al. 1994; Ponder and Middelfart 2005, in ABRS 2011). There are records from shallow waters (e.g. 20m) but also from trawls in deeper waters from 200m to 300m, where the holotype was collected. Seven specimens were reported to have been collected between 1999 and 2003 in the WA specimen shell fishery (Department of Fisheries WA 2005). This species has moderate to high value in the commercial shell market.

Pterynotus (*Pterochelus*) *westralis* Ponder & Wilson 1973 is a 3cm murex known mainly from the central western and lower west coast of Western Australia (e.g. mainly Bunbury to at least Point Cloates), but there are also records from the eastern Great Australian Bight in SA, and as far north as Karratha in WA (Wilson et al. 1994; Academy of Natural Sciences 2006; Ponder and Middelfart 2005, in ABRS 2011; Queen Victoria Museum and Art Gallery specimen record). This species has a broad depth range (15m to 220m), and has been found on fine calcareous sand on the continental shelf. The holotype was from 146m deep, and the SA record from Nuyts Archipelago came from 15m deep.

The Turbinidae is another family which contains several species of potential conservation concern. Turbinids are herbivorous snails, with strong, spiral shells. Some species are collected as a food, and this practice is now illegal in South Australia, due to the formal protection under legislation of intertidal reefs (e.g. PIRSA 2010). **Table 18** lists members of the Turbinidae (turban shells) that may be of potential conservation concern in SA, either due to their commercial value (which may promote localised over-collecting), and/or their apparent rarity, based on lack of records.

Table 18: Turban shells of potential conservation concern in South Australia, which might occur in AMLR NRM region. GSV = Gulf St Vincent. GAB = Great Australian Bight; SE SA = south-eastern South Australia; WA = Western Australia. The taxonomic assignment at family level is uncertain for the species marked * (i.e. may be in the Turbinidae or Colloniidae).

Genus & Species	Authority	Type Locality	Other Known Records (to 2011)
Tricolia gabiniana	(Cotton & Godfrey, 1938)	"Roysten Head" SA	Windy Harbour; Hopetoun; Torbay; Esperance; Albany; Two Peoples Bay and Mississippi Bay (western GAB) in WA
Argalista roseopunctata *	(Angas, 1880)	Holdfast Bay, Gulf St Vincent	Cape Borda on Kangaroo I.; Port MacDonnell (Possibly also WA, if synonymous with *Collonia roseopunctata*)
Argalista / *Leptothyra fugitiva* *	(Hedley, 1911)	40 miles S of Cape Wiles, off Eyre Peninsula	Beachport
Turbo (*Dinassovica*) *jourdani*	Keiner, 1839	?	Abrolhos Is., Dongara, Geraldton, Jurien Bay, Carnac I., Cape Leeuwin, Albany in WA; Fowlers Bay; Nuyts Archipelago; Streaky Bay; Althorpe I.; Kangaroo I.; Moonta area in Spencer Gulf (taken in 1880s); sub-fossilised specimen from Port Adelaide River, taken 1890s (Verco 1908) in SA

The first of these is *Tricolia gabiniana* (Cotton and Godfrey 1938), a small (7mm) tricolia shell known mainly from the south-west coast of Western Australia, between Recherche Archipelago and Cape Naturaliste (Wilson et al. 1993; Academy of Natural Sciences 2006; Malacology collection at ANS, Philadelphia). However, the holotype is reported to have been collected at Roysten Head in South Australia (SA Museum specimen D13414, type locality confirmed by B. Hamilton-Bruce, SA Museum, 2010), which is outside of the published distribution of WA. There are also photographs of specimens (identity unconfirmed) from Gleesons Landing on Yorke Peninsula. This species is found on macroalgae in the intertidal (reported depth range is 0m-2m), and was previously known as *Pellax gabiniana* Cotton and Godfrey 1938 (sometimes misspelled "*galbiniana*").

There are two argalista (top) shells, which might be in the Turbinidae or the Colloniidae, and for which there is little information. *Argalista roseopunctata* (Angas 1880), the Rose Dotted Argalista, is known from shelly sand at several locations in SA, including Glenelg area in Gulf St Vincent, where the type was collected (Cotton 1945, 1959; Ponder and Middelfart 2005, in ABRS 2011; Academy of Natural Sciences 2006). Cotton (1945) reported an example from 62 fathoms (113m) off Cape Borda on Kangaroo Island. This species is reported to be synonymous with *Collonia roseopunctata* (Academy of Natural Sciences 2006). The full geographic range is uncertain, because Marwick (1943) reported that: "the West Australian *Collonia roseopunctata* Angas was synonymised with the earlier *Monilea, rosea* Ten.-Woods by Hedley (1916), and put in the genus *Charisma*". If *Argalista roseopunctata* and *Collonia roseopunctata* are synonymous, then the published distribution of South Australia only for *Argalista roseopunctata* would be incorrect. The second argalista shell is *Argalista* (or *Leptothyra*) *fugitiva* (Hedley 1911), known to date from very few locations in SA (Hedley 1911; Cotton 1945; Wilson et al. 1993; Academy of Natural Sciences 2006; SA Museum specimen D17440). The holotype was collected from 40 miles S of Cape Wiles (off Eyre Peninsula), and there is also a record from Beachport, the full depth range not known, but the collective depth range of the holotype, paratypes and one other collection is 183m to 201m. Numerous specimens were dredged from the type locality, but there is little information available about this species. Given the depth range and location of previously collected specimens, it is unlikely that this species occurs in AMLR NRM region.

The largest turban shell of potential conservation concern in South Australia is *Turbo* (*Dinassovica*) *jourdani* Keiner, 1839, which grows to about 20cm. Jourdan's Turban (also known as the Giant Turban) ranges from western South Australia to Geraldton in Western Australia (Wilson et al. 1993; Academy of Natural Sciences 2006; Ponder and Middelfart 2005, in ABRS 2011). This species occurs on reef with large brown and red macroalgae, and also in tide pools. The published depth range is 2m to about 40m. This species has moderate value in the commercial shell market. According to the WA Department of Fisheries (2005), 448 specimens were collected in WA between 1999 and 2003. In an assessment of molluscs in the shell trade that are vulnerable to over-exploitation, Ponder and Grayson (1998) classified this species as vulnerability category "C". This species is not common SA, but was previously widespread (Verco 1908). *Turbo jourdani* requires population assessment in both SA and WA.

Table 19 lists members of the Trochidae (top shells) that may be of potential conservation concern in SA, either due to their potential endemism within South Australia, or their apparent rarity, based on lack of records. The first of these is *Cantharidella ocellina* / *ocelllina* (Hedley, 1911), the very small (4mm) Eyelet Top Shell, known from the holotype collected at 183m deep off Cape Wiles on Eyre Peninsula (Wilson et al. 1993; Ponder and Middelfart 2005, in ABRS 2011; Academy of Natural Sciences 2006). The full distribution and depth range of this small shell are not known. Two other small top shells (both of which grow to about 6mm) known only from South Australia are *Minolops* (or *Ethminolia*) *cincta* (Cotton and Godfrey 1938), the Girdled Top Shell, and *Fossarina* (*Minopa*) *reedi* (Verco 1907). *M. cincta* is known from Beachport in south-eastern SA to Spencer Gulf, and is possibly more widespread. It has been recorded over a wide depth range in SA, from as shallow as 16m, but also in deeper continental slope waters (365m is the deepest specimen recorded to date) (Wilson et al. 1993; Ponder and Middelfart 2005, in ABRS 2011; Academy of Natural Sciences 2006; SA Museum specimen D13389). Glenelg area in Gulf St Vincent is the type locality of *F. reedi* (formerly called *Gibbula reedi*) and this species is known from the shallow subtidal (Cotton 1959; Wilson et al. 1993; Ponder & Middelfart 2005, in ABRS 2011). It is traded in the shell market, for low value.

Table 19: Top shells (Trochidae) of potential conservation concern in South Australia, which either occur in AMLR NRM region, or are likely to occur there, based on known presence in the SA gulfs region. GSV = Gulf St Vincent; GAB = Great Australian Bight; SE SA = south-eastern South Australia; SG = Spencer Gulf

Genus & Species	Authority	Type Locality	Other Known Records (to 2011)
Cantharidella ocellina / *ocelllina*	(Hedley, 1911)	Cape Wiles	
Charisma carinata	Verco, 1907	Backstairs Passage	GAB (St Francis I.); Newland Head; possibly also occurs in the gulfs
Fossarina (Minopa) reedi	(Verco, 1907)	Holdfast Bay (i.e. Glenelg area of GSV)	
Minolops / *Ethminolia cincta*	(Cotton & Godfrey, 1938)	Levens Beach, SG	Beachport in SE SA; Hardwicke Bay in Spencer Gulf

The fourth top shell known only from SA is *Charisma carinata* Verco 1907, recorded from sand at a few locations in the Fleurieu Peninsula area and the Great Australian Bight (Cotton 1945, 1959; Wilson et al. 1993; Academy of Natural Sciences 2006). The full depth range is not known, but the few old specimens known have ranged from 6 to 20 fathoms (11 to 36m).

There are two members of the Epitoniidae (wentletrap shells) that may be of potential conservation concern in SA, due to their apparent rarity, based on lack of records. One is the small (5mm) wentletrap shell *Epitonium* (*Nitidiscala*) *platypleura* / *platypleurum* (Verco, 1906), which occurs in South Australia, but possibly also Victoria (Wilson et al. 1993; Ponder and Middelfart 2005, in ABRS 2011; Academy of Natural Sciences 2006, and references therein). This species is known mainly from the holotype, SA Museum specimen D13460 (as *Scala platypleura*), from 40m deep in Backstairs Passage. The full distribution and depth range are not known. Another little known wentletrap is *Opalia* (*Nodiscala*) *subcrassa* Cotton & Godfrey 1938, known from the holotype collected in Gulf St Vincent (Wilson et al. 1993; Ponder and Middelfart 2005, in ABRS 2011; Academy of Natural Sciences 2006; SA Museum specimen D13301). *Opalia* (*Nodiscala*) *apostolorum* (Iredale, 1936) from NSW may be the same species (Wilson et al. 1993). Wentletraps generally live as ecto-parasites, and are closely associated with sea anemones, scleractinian corals, or zoanthids (Gittenberger and Hoeksema 2006).

Two small dove shells (Columbellidae) of uncertain taxonomic affinity, and potentially known from a narrow geographic range in South Australia are:

(i) *Anachis fenestrata* (Verco, 1910) a 4mm shell known from Venus Bay and St Francis Island in the eastern GAB (Verco 1910; Wilson et al. 1994; Academy of Natural Sciences 2006; SA Museum specimen D13497 - as *Pyrene fenestrata*). The taxonomic identity of this species is uncertain. Based on appearance, this species is unlikely to be synonym for *Columbella fenestrata* from St Vincent in the West Indies, despite Hendy et al. in Palaeobiology Database (2008) reporting that "*Columbella fenestrata* is recombined as *Anachis fenestrata* according to da Silva 1969", and

(ii) *Anachis* (Unplaced) *dolicha* (Verco 1910), known from Gulf St Vincent. This 5mm dove shell might be a variant of the widely distributed southern Australian *Anachis atkinsoni* (Verco 1910; Wilson et al. 1994; Academy of Natural Sciences 2006; SA Museum specimen D13496 - as *Pyrene dolicha*).

Unlike many of the large gastropods discussed in this review, dove shells have planktonic larvae (Scheltema and Scheltema 1963; Hatfield 1980) which increases their ability to disperse and populate nearshore areas.

Table 20 lists miscellaneous shells of commercial value that are found in SA, and are likely to occur in the AMLR NRM region. These include the Punctate Harp / Spotted Harp *Austroharpa* (*Palamharpa*) *punctata* (Verco, 1896), which ranges from South Australia at least to west of Esperance in WA, and possibly also occurs in Victoria (based on one record from Museum Victoria, reportedly collected off Cape Otway) (Wilson et al. 1994; Academy of Natural Sciences 2006; Museum of Victoria data). Very little is known of the biology, habitat or diet of *Austroharpa* species, but they are members of the family Harpidae, which are carnivorous (Beechey 2010), and related taxa (e.g. *Morum*) lay benthic eggs, which hatch as crawling young (Hughes 1990). The Punctate Hap, which grows to about 4cm, has been found between 20m and 200m deep, often on macroalgae. In the assessment of molluscs in the shell trade that are vulnerable to over-exploitation, Ponder and Grayson (1998) classified this species as category "B" in SA and WA and also nationally (Ponder and Grayson 1998), and considered this species to have a restricted range in South Australia. It was classified as category "C" in Victoria, using Ponder and Grayson's criteria (O'Hara and Barmby 2000). This is a high value species: specimens were selling for $US200-$2,200 in 2008 to 2010. The WA Department of Fisheries (2005) reported 42 specimens collected in that State, between 1999 and 2003. A second harp shell in SA is the small (2cm) *Austroharpa learorum* Hart and Limpus 1998, known so far from the type specimens collected at 140m in the western Great Australian Bight near the SA / WA border (SA Museum data). This species is not discussed further here due to lack of information on full distribution and depth range.

Table 20: Miscellaneous shells (mixed families) of commercial value, and of potential conservation concern in South Australia, which are likely to occur in AMLR NRM region, based on presence in the SA gulfs region or surrounding areas. GSV = Gulf St Vincent. GAB = Great Australian Bight; NSW = New South Wales; SE SA = south-eastern South Australia; TAS = Tasmania; VIC = Victoria; WA = Western Australia

Family	Genus & Species	Authority	Type Locality	Other Known Records (to 2011)
Cassidae	*Semicassis* (*Antephalium*) *sinuosum*	(Verco, 1904)	Backstairs Passage	Thorny Passage in SA GAB; Capes Coast, Recherche Archipelago and Esperance in WA
Cassidae	*Semicassis adcocki*	(Sowerby, 1896)	Yankalilla Bay	Bass Strait southern Fleurieu; Port Lincoln / Thorny Passage area in Spencer Gulf; Coffin Bay area on southern Eyre Peninsula; eastern GAB (e.g. Elliston – Venus Bay area); Eucla area in central GAB; Esperance & other locations in south-western WA;
Conidae	*Conus klemae*	(Cotton, 1953)	Corny Point in SA	Pearson I.; N and S Kangaroo I. in SA Esperance; Cowaramup; Yallingup; Ellensbrook; Rottnest I. in WA
Harpidae	*Austroharpa* (*Palamharpa*) *punctata*	(Verco, 1896)	Newland Head, near Encounter Bay	S of Esperance; W GAB in WA; Neptune Is; Thorny Passage; S Kangaroo I. in SA; 60km W Cape Otway in VIC
Ranellidae	*Sassia* (*Austrotriton*) *bassi*	(Angas, 1869)	Corner Inlet in VIC	Twofold Bay in NSW; Port Welshpool in VIC; Bass Strait (S of Waratah Bay); Eastern Bass Strait (off Golden Beach, and also near VIC / NSW border); N & E TAS (59 records); Thorny Passage & Fleurieu Peninsula in SA
Turbinellidae	*Vasum (Altivasum) flindersi*	(Verco, 1914)		South Australian gulfs; Pt Lincoln area; Pearson Is.; GAB in SA; Albany; off Busselton; Fremantle; Jurien Bay in WA

Two of the less common species in Cassidae (helmet shells and bonnet shells) may also be of conservation concern in the AMLR NRM region. Helmet shells commonly feed on echinoderms (Hughes 1986; Gowlett-Holmes 2008), and lay benthic eggs that hatch as crawling juveniles. *Semicassis* (*Antephalium*) *sinuosum* (Verco, 1904), the Curved Helmet or Narrow Helmet, is a small (to 3 or 4cm) specimen shell known from SA and southern WA (as far west as approximately Bunbury) (Wilson et al. 1993; Academy of Natural Sciences 2006; SA Museum specimen D13477; **Table 20**). Iredale (1927) also included Victoria in the distribution. The Curved Helmet is found on sand / silt and low reef, from about 18m to more than 100m. This species has been considered rare, and taken mainly in relatively deep water (Wilson et al. 1993). It has moderate value in the commercial shell market. Some specimens in the shell market were trawled from 100m; others taken by divers at ~ 20m to 40m. There is, apparently, no information on population sizes.

Another commercial species in *Semicassis* is *S. adcocki* (Adcock's Bonnet), which is found across southern Australia. It is caught in low numbers in the SA and WA specimen shell fisheries. Specimens have been taken by diving, and by trawling on silty bottom in the GAB, at about 100m deep. Specimens have been recorded down to about 180m deep. In the WA specimen shell fishery, only 2 specimens were reported to have been taken between 1999 and 2003 (Department of Fisheries in WA 2005). Rare forms are of moderate value in the shell market (e.g. low hundreds of dollars).

The only two species of cone shell that commonly occur in southern Australia are *Conus anemone* (Lamarck, 1810) and *Conus rutilus* Menke 1843. *Conus anemone* has a broad range from southern Queensland across southern Australia (including Tasmania) to Port Gregory in WA (Edgar 2008; Gowlett-Holmes 2008). This cone forms spawning aggregations seasonally (Kohn 2003). Female cone shells lay clusters of egg capsules which hatch into crawling miniature cone shells (i.e. no free-swimming larval stage). There are reports from Victoria of unusual regional forms (e.g. pure white, and a spiral form) that have been over-collected (O'Hara and Barmby 2000). *Conus anemone* is traded in the shell market, and is of low value. *Conus rutilus* is a small species of cone, and ranges from New South Wales through to south-western WA, including Tasmania. Examples of locations in SA where this species has been recorded include Edithburgh (Beechey 2010) and northern Kangaroo Island (Kinloch et al. 2007). A less common temperate Australian cone species is Klem's Cone *Conus klemae* (Cotton, 1953, found in South Australia and Western Australia, as far north as the Geraldton / Houtman Abrolhos area (Kohn and Almasi 1993; Wilson et al. 1994; Academy of Natural Sciences 2006; SA Museum specimen D14465). This shell (**Figure 22**), which grows to about 8cm, is found on rocky reefs (and corals reefs, in WA), and also in sand under rocks; in pockets of sand or algal turf, or on bare limestone, from the intertidal to about 80m deep. It is an aggregating species that is traded in the commercial shell market, and currently has low to moderate value. According to the Department of Fisheries in WA (2005), 111 specimens were reported between 1999 and 2003 in the WA specimen shell fishery. Ponder and Grayson (1998) considered this species potentially vulnerable to overexploitation, but with a low level of risk (category E in SA and WA) compared with many other specimen shells. There is little publicly available information about catches of this shell species.

Figure 22: *Conus klemae*. Photo (C) South Australian Museum, in OZCAM (2011)

Another commercial species of uncertain status in South Australia is Bass's Triton *Sassia* (*Austrotriton*) *bassi* (Angas, 1869), which grows to about 4 or 5cm (**Figure 23**). *S. bassi* is in the Ranellidae (trumpet or triton shell) family, whose members produce few larvae. Most of the laid eggs become a food source for the few viable larvae, which emerge free-swimming, and drift in the plankton in open water for up to three months. This species is commonly recorded in Tasmania (Grove 2010), but also occurs in New South Wales (rarely), Victoria, and South Australia, and there is an unverified record from WA (Wilson et al. 1993; Academy of Natural Sciences 2006; Ponder and Middelfart 2005; WA Department of Fisheries 2005; Grove 2010). Bass's Triton is found on intertidal and subtidal boulders and rocky reef, and rubble, down to more than 60m deep. Due to its reportedly limited distribution in Victoria (apparently found mainly off Port Welshpool, where it has been trawled, but see note below), this species has been considered vulnerable to overexploitation in that State (Willan 1986; O'Hara and Barmby 2000). It is noted that there are also museum records in Victoria from off the Gippsland area (eastern Victoria), and also near the New South Wales border. Despite WA not being part of the published distribution, Department of Fisheries (2005) reported 1 *Sassia bassi* collected in the WA specimen shell fishery between 1999 and 2003. *Sassia bassi* has low to medium value in the specimen shell market.

Figure 23: *Sassia* (*Austrotriton*) *bassi*. Photo (C) B. Frank, Jax Shells: http://www.jaxshells.org/bassi.htm

Flinders' Vase Shell *Vasum* (*Altivasum*) *flindersi* (Verco 1914) is a large shell (to 18cm), that ranges from Backstairs Passage in South Australia to Jurien Bay in Western Australia (Wilson et al. 1994; Academy of Natural Sciences 2006; Museum Victoria records). This species has a relatively broad depth range, from about 20m to 220m. *Vasum flindersi* is in the Turbinellidae family, whose members reproduce directly, with juveniles emerging from egg capsules laid on the bottom (e.g. Matthews-Cascon et al. 2009). Flinders' Vase Shell is widely traded in the shell market, and spiny deeper water forms are the most valuable (i.e. in the hundreds of dollars). This species is taken in lobster pots and in nets, and occasionally on SCUBA. According to the Department of Fisheries in WA, 48 specimens were collected between 1999 and 2003 in that State. Ponder and Grayson (1998) considered Flinders Vase Shell to be moderately vulnerable to overexploitation (category "C") over the range. The status of this species in South Australia is uncertain. It has been recorded from the eastern GAB, and from Spencer Gulf, but there appear to be no published records from the AMLR NRM region.

Another specimen shell of uncertain status in SA is Torr's Whelk *Cominella* (*Godfreyna*) *torri* (Verco, 1909), also known as *Godfreyna torri*, which also occurs in WA (Verco 1912; Wilson et al. 1994; Academy of Natural Sciences 2006). This shell, which grows to around 7cm, is found on sand and rubble, between about 5m and at least 180m deep. Other species in *Cominella* are reported to undergo direct development in benthic egg capsules and emerge as crawling juveniles (Hoskin 1997). *C. torri* is moderately to highly valued in the commercial shell market (e.g. $250 for average quality specimen) due to apparent (or reported) rarity. One example was taken live by trawl net in the Great Australian Bight, at 12m deep. Some specimens have been taken in fish traps. The type locality is St Francis Island, and there are also records from off Point Sinclair in western SA; also 40 miles W of Eucla, and off Esperance and Denmark in WA. It is not known if Torr's Whelk occurs in the AMLR NRM region. The full distribution of this species and its status in SA are unknown.

Table 21 lists members of the Ovulidae (egg cowrie and spindle cowrie shells) that may be of potential conservation concern in SA, either due to their potential endemism within South Australia, or their apparent rarity, based on lack of records. Egg cowries and spindle cowries are small, carnivorous gastropods that live mainly in tropical waters. They feed mostly on the polyps and tissues of soft corals and sea fans, and they are usually anchored to the host Anthozoan by a long and narrow foot. Many species of egg cowries have white shells, but some are pink or reddish, and most have brightly coloured or decorated mantles, which cover the shell in life. The mantle is often the same colour as the host coral, thus providing effective camouflage (Lorenz and Fehse 2009).

Members of the Ovulidae are associated with corals, particularly gorgonians, and there is often a high degree of host specificity. Egg cowries lay their eggs on the host coral (Knudsen 1997). The eggs hatch into miniature snails, close to the parent.

Species of note in South Australia include:

(i) *Primovula heleneae* Cate 1973 also known as *Cuspivolva heleneae*, an egg cowrie (allied cowrie) recorded from southern Gulf St Vincent and northern Spencer Gulf (Gowlett-Holmes and Holmes 1989; Wilson et al. 1993; Academy of Natural Sciences 2006; SA Museum specimen D15943). This egg cowrie is found on *Euplexaura* coral in areas of strong tidal movement, and the full distribution and depth range are not known. *P. heleneae* is traded in shell market, and is of medium value;

(ii) *Primovula cruenta* (Gowlett-Holmes and Holmes 1989), known to date only from northern Spencer Gulf, where it has been found on *Echinogorgia* coral. The holotype was collected at 15m (Gowlett-Holmes and Holmes 1989; Wilson et al. 1993; Academy of Natural Sciences 2006; SA Museum specimen D18431). The full distribution and depth range of this species are not known. There are specimens in the commercial market that are claimed to be this species, but are from Queensland; and

(iii) *Primovula verconis* (Cotton and Godfrey 1932), a species known from the holotype collected at St Francis Island in the eastern Great Australian Bight (Wilson et al. 1993; Academy of Natural Sciences 2006; Ponder and Middelfart 2005, in ABRS 2011; SA Museum specimen D13476). This egg cowrie is also known as *Crenavolva verconis*. The full distribution and biology are unknown, but it might be more widespread, including other parts of SA, and the southern coasts of WA) (Wilson et al. 1993). One shell website reports Philippines as the distribution for *Crenavolva verconis* (http://www.gastropods.com/3/Shell_6973.shtml)

A species of spindle cowrie was recorded in 2011 in the AMLR NRM region, by diver P. Mercurio, from SA Conservation Research Divers. This represents the first record of a species of spindle cowrie (likely to be in the genus *Phenacovolva*) in South Australia, and will be discussed in a forthcoming report for AMLR NRM Board (Baker et al., in prep.)

Table 21: Egg cowrie and spindle cowrie shells of potential conservation concern in South Australia, including two species which occur in AMLR NRM region, and another which is likely to occur there, based on known presence in the SA gulfs region. GSV = Gulf St Vincent. GAB = Great Australian Bight; SE SA = south-eastern South Australia.

Genus & Species	Authority	Type Locality	Other Known Records (to 2011)
Primovula heleneae / *Cuspivolva heleneae*	Cate, 1973 (Cate, 1973)	southern end of GSV	Point Douglas in Spencer Gulf
Primovula cruenta	(Gowlett-Holmes & Holmes, 1989)	1.6 km E. of Point Douglas, northern Spencer Gulf	Point Douglas
Primovula verconis / *Crenavolva verconis*	(Cotton and Godfrey 1932)	St Francis I., Nuyts Archipelago	Nuyts Archipelago; possibly occurs in other parts of SA, and WA
unnamed spindle cowrie (probably in *Phenacovolva)*	-	-	Fleurieu Peninsula

There are two auger shells (Terebridae) known mainly from SA, and one is of uncertain taxonomic affinity and distribution. *Duplicaria fictilis* (Hinds 1844) has been recorded from Farm Beach in Coffin Bay (as *Pervicacia helenae* Cotton, 1952 = a junior synonym), and from the Port Lincoln area, but there are also unverified records from Taiwan and Mozambique (according to conchology and shell collection web sites) (Bratcher and Cernohorsky 1987; Wilson et al. 1994; Academy of Natural Sciences 2006). Depth records to date extend down to about 40m. Chang et al. (2007) reported this species from Taiwan. The second auger shell is *Euterebra* (or *Terebra* or *Gradaterebra*) *scalarifomis* (Cotton & Godfrey 1932), for which the holotype was collected from Newland Head at 20 fathoms (36m) (Bratcher and Cernohorsky 1987; Academy of Natural Sciences 2006; OZCAM 2011). The full distribution and depth range are not known.

Table 22 lists the remaining prosobranch gastropods (from a variety of families) that are (i) known from few records across the range; and/or (ii) known only from South Australia (and thus might be endemic), and/or (iii) known from a very narrow depth range; and/or (iv) may have limited dispersal, due to direct mode of reproduction.

Table 22: Miscellaneous prosobranch gastropods of potential conservation concern found in South Australia, which either occur in AMLR NRM, or are likely to occur there, based on known presence in the SA gulfs region. GSV = Gulf St Vincent. GAB = Great Australian Bight; NSW = New South Wales; SE SA = south-eastern South Australia; TAS = Tasmania; VIC = Victoria; WA = Western Australia.

Family	Genus & Species	Authority	Type Locality	Other Known Records (to 2011)
Assimineidae	*Cryptassiminea adelaidensis*	Fukuda & Ponder, 2005	Dry Creek	Port Wakefield; St Kilda; Largs North Beach; Outer Harbour
Diastomatidae	*Diastoma melanioides*	(Reeve, 1849)		Anxious Bay; St Francis I.; Thistle I. & Sir Joseph Banks group in SA Cheyne Beach, E of Albany in WA
Xenophoridae	*Xenophora (Austrophora) flindersi flindersi*	(Cotton & Godfrey, 1938)	Petrel Bay, St. Francis I., SA	King George Sound & Esperance in WA; isles of Nuyts Archipelago (e.g. S of St Peter I.) and Port Lincoln in S.A.

One example of a shell with limited known geographic distribution and depth range is *Cryptassiminea adelaidensis* Fukuda and Ponder 2005, a tiny (5mm) an assimineid shell known so far only from a few sites in Gulf St Vincent (Fukuda and Ponder 2005; CSIRO 2010). This small shell has been found on mud and under wood and leaves, in mangroves and saltmarsh. The reported depth range is 0m to 1m. Although it is known date only from Gulf St Vincent, the authors considered that it might have wider distribution in South Australia (Fukuda and Ponder 2005). Another example of a shell with an apparently narrow geographic range is the costellate mitre shell *Austromitra arnoldi* (Verco, 1909), which has been recorded in western South Australia, but possibly also occurs in south-western Western Australia (Wilson et al. 1994; Academy of Natural Sciences 2006). This species is found in muddy sand and sandy mud, and also under stones, in the intertidal and shallow subtidal, to about 10m deep. There is very little information about this small species, which grows to about 1 or 2 cm, and there appear to be no published records of *A. arnoldi* in the AMLR NRM region.

For some gastropod shells in SA, there is very little information other than the holotype. One example is the small creeper shell *Altispecula geniculose* (Hedley 1911), the holotype of which was collected from 183m (100 fathoms), 40 miles south of Cape Wiles, southern Eyre Peninsula (Wilson et al. 1993; Academy of Natural Sciences 2006). Another small creeper shells in SA is *Hypotriphora subula* (Verco 1909) a triphorid known mainly from dredge samples. The holotype was collected in Gulf St Vincent, and this species has also been recorded off Cape Borda. The published depth range is 18m to 101m (Wilson et al. 1993; Academy of Natural Sciences 2006; SA Museum specimen D13454). A third creeper shell is the small (4mm) *Tetraphora mcgilpi* (Cotton 1952) a cerithiopsid / creeper shell for which there is very little information. Henley Beach is the type locality, and there are also records from Glenelg and possibly other beaches in Gulf St Vincent (Marshall 1983; Wilson et al. 1993; Academy of Natural Sciences 2006). This species might be more widespread but overlooked due to its small size.

Another uncommonly known shell in AMLR NRM region is *Diastoma melanioides* (Reeve, 1849), which ranges from south-western WA to SA (Verco 1922; Wilson et al. 1993; Museum Victoria data; Academy of Natural Sciences 2006; ABRS 2011). This species grows to about 4 or 5cm, and occurs in sand, amongst seagrasses and turf macroalgae. This uncommon shell is the only living relative of a fossil genus and family that was common in the Tethys Sea during the Tertiary (Houbrick 1981; Wilson et al. 1993). It is also found as a fossil in the Roe calcarenite in WA (James and Bone 2007)

There are two limpet species known so far only from South Australia, and the first of these might occur in the AMLR NRM region, but there are no published records. The White Rayed Sugar Limpet *Asteracmea alboradiata* (Verco 1906) has been recorded in shelly sand off Moonta Bay in Spencer Gulf (Verco 1906; Academy of Natural Sciences 2006; Ponder and Middelfart 2005, in ABRS 2011). The other is *Cornisepta* (or *Puncturella*) *fumarium* (Hedley 1911), the Cap Slot Limpet, a keyhole limpet known from the type, collected at 183m deep, 64km south of Cape Wiles (Cotton 1959; Wilson et al. 1993; Academy of Natural Sciences 2006; McLean and Geiger 1998; CSIRO 2010). It is not known of this species occurs in the AMLR NRM region, and there is very little information available, other than the type specimen. Another species for which the type was collected at 183m is the 2cm olive shell *Alocospira beachportensis* (Verco, 1909), also known as *Ancilla beachportensis*, and recorded from few locations in South Australia, but it might also occur in Bass Strait (Wilson et al. 1994; Academy of Natural Sciences 2006; SA Museum specimen D13504. The type was collected in deeper waters near the edge of the continental shelf, off Beachport in the south-east of SA, and few specimens are known, from 183 - 201m (Wilson et al. 1994). As with the Cap Slot Limpet, it is not known if this olive shell occurs in the AMLR NRM region, because there is very little information available on full geographic distribution and depth range.

One of the most unusual shells in South Australia is Flinders Carrier Shell *Xenophora* (*Austrophora*) *flindersi flindersi* (Cotton and Godfrey 1938), also found in south-western WA (as far west as King George Sound) (Wilson et al. 1993; Ponder and Middelfart 2005, in ABRS 2011; Academy of Natural Sciences 2006). In SA, there are records of this shell from the eastern GAB and Spencer Gulf.

There appear to be no published records from the AMLR NRM region, but it may occur here. Flinders Carrier Shell is found on sand and shell substrate, and has been found so far over a narrow depth range (20m – 40m). Xenophorid shells cement small shells and pebbles to the periphery of their own shell. Unlike many other gastropod shells, this carrier shell may exhibit direct development of young, without a larval phase prior to benthic settlement. Species with direct development have limited provision for population dispersal. This shell is closely related to the Lower Pleistocene fossil *Xenophora flindersi ludbrookae* Ponder 1983. It has low to moderate value in the commercial shell market.

There are a few shells of uncertain distribution, whose presence in AMLR NRM has not been confirmed. One example is *Rissoina* (*Rissoina*) *crassa* Angas 1871, a small rissoid shell from New South Wales, known from locations such as Iluka, Solitary I., Sydney (e.g. Port Jackson, La Perouse, Middle Harbour, Broken Bay), Woolgoolga, and Catherine Hill Bay (Academy of Natural Sciences 2006 and Australian Museum records). This shell might be more widespread, or the records from outside New South Wales might be misidentifications. There are recent unverified records from Kangaroo Island and Gulf St Vincent in South Australia (Benkendorff et al. 2007; Dutton and Benkendorff 2008). There are also shell collection trade records from South Africa, and the Philippines as well as Australia, despite the first two countries not being included in the published distribution. Most museum records are old (early - mid 1900s). There are records from the shallow subtidal, under stones / rocks, and one record from 15m deep.

For the prosobranch gastropods discussed above, a proposed category of threat is provided in section **7**.

Pycnogonida (Sea Spiders)

Pycnogonids or sea spiders are related to terrestrial spiders, mites and scorpions, being members of the subphylum Chelicerata. Most species have four narrow body segments (a few species have five or six), each bearing a pair of walking legs. The body is much reduced, and looks like a narrow connector between each pair of legs. Sea spiders use a proboscis to suck nutrients from soft-bodied invertebrates (e.g. hydroids, worms, sea anemones, bryozoans), and part of the digestive tract of sea spiders extends into their legs. Respiration is by means of diffusion. The sexes are normally separate, and males care for the laid eggs, and often also the first moult stage (which is legless).

At least four types of pycnogonid larvae have been described (Bain 2003):

(i) *Typical protonymphon larva*: a free-living larva that gradually turns into an adult;
(ii) *Encysted larva*: a parasite that hatches from the egg and finds a host (e.g. polyp colony) where it burrows into and turns into a cyst, and will not leave the host before it has turned into a young juvenile;
(iii) *Atypical protonymphon larva*: adults are free-living but larvae and the juveniles live on or inside temporary hosts such as polychaetes and clams;
(iv) *Attaching larva*: hatches in an immature state and attaches itself to the legs of the father, where it stays until it has turned into a small and young juvenile with two or three pairs of walking legs ready for a free-living existence.

There are 3 species of sea spider that are known to date only from South Australia. One of these, *Nymphon conirostrum* Stock 1973 is known only from West Island out of Encounter Bay, where it was recorded on hydroids, on the sides and floor of a cave (Müller 1993; Staples 1997; Bamber and El Nagar 2010; Bain 2002, in ABRS 2011). The type was collected at 13m deep. The geographic distribution and depth range of this species are not known.

The small (16mm) sea spider *Pseudopallene inflata* Staples 2005 is known to date from the type locality, 300m N-NW of The Monuments, at Althorpe Island, and paratypes were collected at Mooring Bay on Althorpe Island, and also at the nearby Western Isles (Staples 2005; Bamber and El Nagar 2010). This species has been found so far on *Orthoscuticella* and *Scuticella* bryozoans, between 3m and 23m deep (Staples 2005).

A third pycnogonid species known to date only from South Australia is *Parapallene gowlettae* Staples 2007. The holotype (35mm) was collected in macroalgae at Elliston in the eastern to Great Australian Bight. The full distribution and depth range are not known. Although this species has been recorded to date only from type locality, it is likely to be more widespread (D. Staples, pers. comm. 2008).

One other species has a broader distribution, but is considered to be uncommon. *Pallenoides stylirostrum* Stock 1973 is known from Bass Strait (e.g. Wilsons Promontory) in Victoria and West Island in South Australia, the latter being the type locality (Staples 1997; Bamber and El Nagar 2010; Bain 2002, in ABRS 2011). This species has been collected on macroalgae (e.g. the brown *Acrocarpia paniculata*), and on hydroids (e.g. *Symplectoscyphus subdichotomus*), between 5m and 13m deep. It is considered to be an uncommon species (Staples 1997).

Stomatopoda (Mantis Shrimps)

The Stomatopoda is an order of crustaceans whose members have large, inward-folding claws that are spiny (for spearing prey), or hammer-like (for stunning and smashing prey). Mantis shrimps also have large eyes. They live in burrows in soft sediments, and are rarely seen out of their burrows (Gowlett-Holmes 2008). There are more than 140 species of mantis shrimp in Australia (CSIRO 2011), and most of these occur in the tropics. There are few stomatopods of limited distribution in southern Australia, and some are quite common, even though they are rarely seen. Only one species of note in South Australia could be found during a search of the literature. *Austrosquilla middletoni* Ahyong 2001, which grows to about 4 or 5cm long, is known from Spencer Gulf through to south-eastern South Australia (Ahyong 2001; Ahyong, in Poore 2004; Davie 2001, in ABRS 2011). The northern end of the foreshore beach at Whyalla is the type locality, and other records come from Eight Mile Creek near Whyalla, Corny Point in southern Spencer Gulf; Reevesby Island in the Sir Joseph Banks Group, and Kingston in the south-east. This species is found in pairs, in burrows in intertidal flats of fine, anoxic sand. On intertidal sand flats at Whyalla, the stomatopod *A. middletoni*, the polychaete worm *Arenicola* sp. and the decapod *Biffarius ceramica* are sympatric, and their burrow entrances are in close proximity (Ahyong 2001). The depth range may be 0m to approximately 2m.

6. Threatening Processes

Fishing and Collecting

Of the species identified above as potentially threatened, a number of specimen shells may be considered potentially at risk, from a combination of illegal and legal collecting. However, in South Australia, although the commercial fishing effort for specimen shells was higher during the early 1990s, it is currently low, and there has been only one operator during the 2000s. That operator is licensed to take species in the following families: Cassidae, Olividae, Spondylidae, Cardiidae, Mactridae, Conidae, Solenidae, Clavagellidae, Carditidae, Marginellidae, Cypraeidae, Cymatidae, Chitonidae, Naticidae, Neritidae, Harpidae, Turridae, Nassaridae, Columbellidae, Patellidae, Voluntidae, Vasidae, Eulimidae, Muricidae, Scalidae, Fasciolariidae, Siphonariidae, Mitridae, Cancellariidae, Liotiidae, Tellinidae, Thaididae, Triviidae, Trochidae, and Veneridae (PIRSA 2010). The Black Cowrie (*Zoila friendii thersites*) may not be taken in excess of the bag limit prescribed in the *Fisheries Management (General) Regulations 2007* of 1 per person per day. Shells on egg masses, or those depositing eggs, are not to be taken (PIRSA 2010).

Commercial data for the SA Specimen Shell Fishery are confidential (PIRSA 2004, 2010), but it is noted that a less than 50 shells were reported to have been taken in 2006, and less than 30 shells in 2009. Around 150 shells were taken in 2005, and between 200 and 225 shells in each of 2004, 2007 and 2008. The species composition of these catches is not publicly available information. However, for previous years, summary data published by PIRSA (2004) indicated that 128 shells were taken over a total of 11 days fishing in 2001/02 (of which 78 were *Amoria undulata*, taken from eastern GAB), and 61 shells were taken over a total of 5 days fishing in 2002/03 (48 of which were *Zoila marginata*, from north-eastern Kangaroo Island).

Specimen shells are taken from at least 10 of the 1-degree fishing blocks used for management in South Australia (PIRSA 2004).

In South Australia, there are no stock assessments undertaken for specimen shells, and the industry is largely self-regulated due to its small nature. According to PIRSA, it is common practice for the commercial diver to pass over many shells (e.g. as many as 50 *Zoila friendii thersites* black cowries, 20 *Zoila marginata* and 50 *Amoria undulata*: Kingdon, pers. comm., cited by PIRSA 2004) before a shell with perfect features and thus optimum value is selected. The late P. Clarkson, a southern Australian shell expert, similarly reported (pers. comm. February 2011) that most commercial operators do take only the best shells and leave the majority of specimens (which are flawed or juvenile or laying eggs) *in situ* to sustain populations, and that experienced recreational collectors would abide by the same code.

Similarly in WA, the Department of Fisheries assumes adequate stock of commercially valuable cowries, based on fishers' reports that only high quality specimens are taken, and others are left on the bottom to perpetuate the stock. The act of searching for species perfection is therefore a passive means of controlling commercial over-collecting of some species, and therefore aids stock sustainability. However, it is uncertain whether this form of "self-regulation" is adequate for the rarest species of shells, for which there may be very few individuals in the population, regardless of shell quality.

Independent stock assessments of the status of specimen shells in SA and WA (including analysis of both the commercial and recreational take) have not been undertaken, but it is noted that in recent years, assessment reports have been written in both States by the shell fishery licensing departments, for the Australian Government's Department of the Environment, in order to comply with export regulations under the Australian Government's *EPBC Act 1999* (MacDonald 1996, 1997; PIRSA 2004, 2010; Department of Fisheries WA undated, 2005 and 2010). The Department of Environment assessed and continued approval for the operation of both fisheries (Australian Government DEH 2004, 2005), based on the State agency submissions.

The recreational harvest of specimen shells in South Australia is under investigation, and substantial progress is reported to have been made (PIRSA 2010). Recreational fishing for shells falls into two categories: (i) the incidental take of a shell because it is considered attractive, or whilst diving for other species, such as abalone, rock lobster or scallops; (ii) dedicated collecting by hobbyists who seek to find and exchange shells with other collectors. The provisions of the *Fisheries Management (General) Regulations 2007* apply to both groups. Subtidal populations of specimen shells in some areas are provided with "de facto" refuge from recreational collecting, due to their location in deeper, less accessible waters, such as Backstairs Passage.

Over the past two decades there have been unpublished reports of over-collecting of some specimen shells (such as Black Cowrie *Zoila friendii thersites*) by recreational collectors in some parts of South Australia. Divers have reported this *Zoila* as being over-exploited off the Stansbury to Edithburgh area in Gulf St Vincent, with habitat damage to sponges in that area. A draft management plan for the SA Specimen Shell Fishery (Macdonald 1996) admitted that over-exploitation has occurred, in some regions such as southern Fleurieu Peninsula and Yorke Peninsula. Although the limit is "one shell per person per day" for Black Cowrie, under the *Fisheries Management (General) Regulations 2007*, there are inadequate regulations controlling the take of other valued specimen shells by recreational collectors in this State. In South Australia, the illegal take of specimen shells (i.e. collection and sale of shells by non-licensed divers) has not been quantified, but should be, given the long term reports of over-collecting at specific locations.

In the intertidal area, a number of studies have reported over-collecting of shells, for food and ornaments. As early as 1966, Hiscock (cited by Benkendorff et al. 2008) reported impacts on intertidal invertebrate populations due to collecting by shore parties, and by overturning boulders, which can expose invertebrates and egg masses to desiccation.

During the mid 1990s, despite a ban on shore collecting, intertidal molluscs were observed to have been regularly taken, sometimes in large numbers (hundreds per person) from the Marino and Hallett Cove area (J. Baker, pers. obs.), and it is likely that similar activity occurred in other parts of the AMLR NRM region. It is noted that multi-language signs about the intertidal collecting ban have since been placed in those areas where illegal collecting was occurring. A visitor survey to the reefs at Port Noarlunga and Aldinga (both of which are Aquatic Reserves) indicated high levels of use by reef walkers (Williams 1996), which can result in trampling of small molluscs and crustaceans. Although impacts are most likely on localised populations of common species, rather than rare species, collectors and tramplers would be unlikely to discriminate, and in terms of invertebrate species conservation, it is important that a code of conduct for "low impact" reef activity is adhered to, by visitors to all intertidal reef areas of South Australia.

Introduced Species

Invertebrate species have been introduced to South Australian waters in two main ways: accidentally by vessels (hull fouling, ballast water and sea chests / holds) or by attachment to floating marine debris, or deliberately by aquaculture (e.g. Pacific Oyster *Crassostrea gigas*). The marine aquarium trade also presents a third possible source of introductions.

A review of introduced pest species in South Australia was undertaken by SARDI staff in 2009 (Wiltshire et al. 2010), and indicated the presence of at least 20 or 21 invertebrate species in Gulf St Vincent that have either been introduced, or are cryptogenic (of uncertain origin), plus several more that have been recorded in the past (**Table 23**). Therefore, this is the minimum number of introduced and cryptogenic species occurring in the AMLR NRM region, because sites at the southern end of the Fleurieu and in Encounter Bay have not been surveyed as regularly as boat ramps, ports and harbours and marinas in metropolitan Gulf St Vincent, and therefore additional species may be present.

Table 23: Introduced (I) and cryptogenic (C) invertebrate species in the AMLR NRM Region. Compiled from map, text and references in Wiltshire et al. (2010). Other references: Coleman (1999); Westphalen (2010); K. Wiltshire, SARDI, pers. comm. 2011. Y = Yes, N = No, U = Uncertain.

Latin Name	Common Name	Recent Records in AMLR NRM Region (during the 2000s) (Y/N)	Established in AMLR NRM? (Y/N/U)
Sabella spallanzanii (I)	European Fan Worm	Y	Y
Carcinus maenas (I)	European Shore Crab	Y	Y
Charybdis japonica (I)	Asian Paddle Crab / Lady Crab	Y (single specimen)	N
Musculista senhousia (I)	Asian Bag Mussel / Asian Date Mussel	Y (but none since 2001)	U (if Y, then population levels now low)
Crassostrea gigas (I)	Pacific Oyster	Y	N (deliberate introduction of 147 individuals removed by PIRSA Biosecurity in 2009)
Plumularia setacea (C)	Little Seabristle / a hydroid	N (recorded at Barker Inlet, but no recent records)	U
Cassiopea ndrosia (I)	a jellyfish	N (most recent record 1995)	U
Myxicola infundibulum (C)	a sabellid fan worm	Y	Y
Hydroides "*elegans*" (I or C)	a serpulid tube worm	Y	Y
Cirriformia punctata (C)	a polychaete worm	N (most recent record 1985)	U
Polydora "ciliata" (C)	a spionid polychaete worm	N	U

Table 23 (cont.)

Latin Name	Common Name	Recent Records in AMLR NRM Region (during the 2000s) (Y/N)	Established in AMLR NRM? (Y/N/U)
Pseudopolydora paucibranchiata (C)	a spionid polychaete worm	Y	Y
Caprella penantis (C)	a caprellid amphipod	Y	Y
Corophium acherusicum (I)	an amphipod	Y	Y
Eurylana arcuata (I or C)	an isopod	N (most recent record 1925)	N
Paracerceis sculpta (I)	a sphaeromatid isopod	Y	Y
Palaemon macrodactylus (I)	Oriental Shrimp	N	U
Perna canaliculus (I)	New Zealand Greenlip Mussel	Y (NB specimens removed by PIRSA Biosecurity)	U (probably N)
Polycera hedgpethi (I)	Hedgpeth's Polycera / a nudibranch	Y	Y
Bugula flabellata (I)	a bryozoan	N	U (probably N)
Bugula neritina (C)	a bryozoan	Y	Y
Tricellaria occidentalis (I)	a bryozoan	U	U
Tricellaria porteri (C)	a bryozoan	U	U
Cryptosula pallasiana (C)	a bryozoan	N (most recent record 1980s)	U (probably Y)
Membranipora membranacea (C)	a bryozoan	U (probably Y)	U (probably Y)
Schizoporella errata (I or C)	a bryozoan	Y	Y
Watersipora arcuata (C)	a bryozoan	Y	Y
Watersipora subtorquata (C)	a bryozoan	Y	Y
Zoobotryon verticillatum (C)	a bryozoan	U (recorded at Dry Creek in 1999 by F. Coleman)	Y
Barentsia benedeni (C)	a kamptozoan / an entoproct / a nodding head	U	U
Ascidiella aspersa (I)	a solitary ascidian	Y	Y
Ciona intestinalis (I)	a solitary ascidian	Y	Y
Styela plicata (I)	a solitary ascidian	Y	Y
Botrylloides leachi (C)	a colonial ascidian	Y	Y
Botryllus schlosseri (C)	a colonial ascidian	U	Y

The first 5 species in **Table 23** are considered to be "trigger species", regarded as marine pests of particular concern, as listed in the Australian Marine Pest Monitoring Manual, produced by the National System for the Prevention and Management of Marine Pest Incursions (Commonwealth of Australia 2010). National control plans have been developed for most of these species. One of the introduced invertebrate species currently of greatest concern in the AMLR NRM region is the European Fan Worm *Sabella spallanzanii*. There are numerous records from the Outer Harbour and North Haven area, and since the species was recorded in SA in 1986, it has spread along the metropolitan coastline and further west (e.g. Wiltshire et al. 2010; Westphalen 2010; Dittman et al. 2010). The fan worm may vary in abundance seasonally, even in areas where it occurs at high densities, and "carpets" hard structures and sea bottom. Surveys by the community-based reef monitoring group Reef Watch recorded this species at 9 sites in the AMLR NRM region between 2008 and 2009, ranging from Largs Bay Jetty down to Wirrina (Westphalen 2010). The fan worm has been found at most of the metropolitan jetties (Largs, Semaphore, Grange, Henley Beach, Glenelg, Brighton and Noarlunga), and at least four metropolitan boat ramps.

The European Fan Worm may have a preference for artificial substrates (Boxall and Westphalen 2003, cited by Westphalen 2010). In addition to the spread of *S. spallanzanii* along eastern Gulf St Vincent, in recent years it has also been recorded (and removed) at several locations on north-eastern Kangaroo Island, most likely due to transportation by recreational craft (Kinloch et al. 2010). This large sabellid worm (which can grow to 40cm long), forms dense colonies and can significantly modify local water currents and rates of sediment deposition (Ponder et al. 2002). There is concern that this species may compete with native suspension-feeding species for food and space, and interfere with their recruitment.

S. spallanzanii colonies also alter the structure of benthic habitat, by forming a canopy of filamentous feeding structures suspended above the substrate, on slender tubes (Holloway and Keough 2002). Distribution records across southern Australia indicate that this species can proliferate in shallow, sheltered, nutrient-rich waters. Experimental work at Outer Harbour in AMLR NRM region, and at St Kilda in Victoria, has indicated that over a short time scale (e.g. approx. 2 months), abundance of other benthic species can be altered by the presence of *S. spallanzanii*, but over a longer scale (e.g. 6 months), the impacts of this fan worm on assemblage structure may be lessened, particularly in areas where native benthic assemblages are well established. Results of the aforementioned experimental work on cleared and fan worm-covered plates on jetty piles has also indicated that there may be significant effects of the *S. spallanzanii* canopy on survival and growth rates of epifaunal taxa, and that there may be temporal variability in the processes that cause such changes (Holloway and Keough 2002). Effects over time frames longer than 6 months were not determined in the aforementioned study. In South Australia, manual removal of new infestations may be one of the most successful strategies for controlling the spread of this species.

The European Shore crab *Carcinus maenas* is another of the introduced invertebrate species that has been of concern in the AMLR NRM region, but less so now than during the 1970s to 1990s. It was first recorded at West Lakes and in the Outer Harbour area in the mid to late 1970s (Zeidler 1978, cited by Wiltshire et al. 2010), and was previously abundant in the Port River – Barker Inlet system. This species was also recorded at various locations along the eastern GSV coast at various times from the 1970s to the 1990s (e.g. Port Stanvac, Kingston Park beach, Hallett Cove, Onkaparinga river, Port Noarlunga), and there are recent records (during the 2000s) from Outer Harbour, North Haven, Barker Inlet, West Lakes and Port Wakefield (Cohen et al. 2002; Tanner 2007; Wiltshire et al. 2010). It has been reported (Wiltshire et al. 2010) that the European Shore Crab is now likely to be present in lower numbers in GSV than in the previous several decades.
In other parts of Australia, a number of studies have shown that *C. maenas* can have a significant impact on native species such as mud cockles and other bivalves (Mackinnon 1997; Walton 1997). For example, Mackinnon (1997) showed that a large portion of the European Shore Crab's diet in Tasmania consists of bivalves such as mud cockles, and small mussels of two species. The study also reported that the crab is capable of consuming vast quantities of the juveniles of various bivalve species over short time periods, and that the European Shore Crab has the ability to drastically reduce numbers of smaller sized mussels and clams (cockles), and alter bivalve assemblages. Over the long term, this crab may be of continuing concern in southern Australia, because its distribution has moved southwards over time, and increasing ocean warming in southern Australia may be beneficial for survival and expansion of shore crab populations (Hobday et al. 2006).

Regarding another species in the "trigger list" of the most significant exotic invertebrates in AMLR NRM, the previous populations of the Asian Bag Mussel *Musculista senhousia* in the Outer Harbour area are reported to have disappeared (Wiltshire et al. 2010), and populations of this species may now be at low levels in the region. Wild populations of another "trigger list" invertebrate, the aquaculture species Pacific Oyster *Crassostrea gigas*, appear not to have established in the AMLR NRM region, due to eradication programs by PIRSA Biosecurity.

In South Australia, populations of several relatively large and invasive invertebrates that have been recently introduced from other countries are obvious where they exist, but there are many other species of cosmopolitan distribution whose locations in South Australia and potential impacts remain unknown.

The “natural” state in terms of species composition and abundance of invertebrates prior to widespread introduction of exotic species is not known, because many such introductions may have occurred even prior to the 19th century (Carlton 1999, cited by Ponder et al. 2002) when the marine invertebrate fauna in South Australia first became a topic for research. Additionally, for some marine groups such as bryozoa and colonial ascidians, it is usually difficult to distinguish between native and introduced species, particularly in the field.

In South Australia, there is a limited (but growing) research into the impacts that pest species may have - and may have had in the past - on native invertebrates. Nevertheless, there is evidence that such introductions may degrade natural systems, and have a negative impact on species richness and abundance. It is also likely that some introduced species carry with them both internal and external parasites that may not be host specific and could impact on native species (I. Whittington pers. comm., cited by Ponder et al. 2002).

A prime (and rare) example of such research comes from Tasmania, where Edgar and Samson (2004) and Edgar et al. (2005) reported that inshore mollusc biodiversity has decreased, mainly due to the proliferation of a few invasive species. The researchers found that mollusc species richness decreased from an average of 21 species per 5-cm slice for sediment cores dated at the start of the 20th century to 7 species per slice in 1990. For all 13 sites across the span of study (100km), the mean number of shell fragments belonging to introduced species increased from <2% of total shells in 1900 to 50% in 1990 (Edgar and Sampson 2004). During the late 1990s, comparable data by G. Edgar for live molluscs collected during more extensive surveys across south-eastern Tasmania (279 core or grab samples from 93 sites) indicated that 39% of total mollusc numbers and 83% of total mollusc biomass belonged to introduced taxa (Edgar et al. 2005).

Such detailed quantitative studies have not been undertaken in South Australia, but a number of university-based projects have been undertaken on introduced crab species in northern Spencer Gulf, and PIRSA is also involved with monitoring populations. Despite limited information to date in South Australia for impacts of exotic invertebrate pests on native species abundance and diversity, vigilance and pro-active management must be exercised in all cases where fast-growing and invasive marine pest species exist. This is particularly important in the coming decades as warmer water temperatures are predicted in the Southern Ocean. Additionally, increased international trade by shipping, and the proliferation of marinas for recreational vessels (and associated coastal canal estates) are further likely to increase the number of invasive marine species in South Australian waters, and the relatively warm shallow, nutrient-enhanced waters of north-eastern Gulf St Vincent would provide ideal conditions for many exotics to establish, particularly tropical species.

Siltation / Sedimentation and Eutrophication

Intertidal and subtidal reefs, seagrass beds, sand, mud, areas of shell bottom and areas of soft bottom, all provide habitat for marine invertebrates, including rare and endemic species, and other species of conservation concern. There are many interacting processes the impact upon the habitats of the AMLR NRM region, and the invertebrate populations therein. Concern about the degradation of habitats in the AMLR NRM area has prompted much research and reporting during the past decade, both in universities and government research organisations. For example, a theoretical "reconstruction" of the condition of metropolitan reefs has been undertaken, utilising data from several time periods (Connell et al. 2008). An analysis of these data indicated that historically, the metropolitan sites in AMLR NRM region were indistinguishable from current reference sites across 70km of Gulf St. Vincent, which have healthy cover of canopy-forming macroalgae. However, the metropolitan sites now have much sparser canopies compared with equivalent locations and times in the gulf. According to the reef cover reconstruction study, there is evidence of loss of up to 70% of the canopy-forming macroalgae on parts of the Adelaide metropolitan coast since major urbanisation (Connell et al. 2008). There is strong evidence to indicate that increased nutrients and sedimentation in the AMLR NRM region has led to the declines in canopy-forming kelp and other large brown macroalgae, and an increase in the cover of sediment-trapping, turf-forming algae (Turner 2005, Turner and Kildea 2006, Turner et al. 2007, Gorman 2009). Once turfs become established in the place of canopy flora, they can trap sediment and further inhibit the re-establishment of canopy-forming species such as *Ecklonia* kelp and fucoid algae (e.g. species of *Sargassum* and *Cystophora*) (Gorman 2009). Loss of canopy macroalgae has flow-on impacts to other species that occupy that habitat, including invertebrates that live on the blades, or the holdfast, as well as benthic invertebrates that utilise the shelter provided by canopies of macroalgae. When cover of kelp or other large macroalgae declines, opportunistic species can proliferate in the spaces formerly occupied by macroalgae, and create conditions that limit further recruitment of macroalgae. For example, reef monitoring work in the AMLR NRM region indicated during the late 1990s and early 2000s that mussels can periodically proliferate on reefs at Christies Beach (Horseshoe Reef) and Noarlunga, and these mussel beds are an indication of a disturbed system (Smith 2000; Turner et al. 2007).

In addition to (and synergistic with) nutrient-induced impacts, sedimentation from coastal discharges, and also from dredging works, can also have a detrimental effect on coastal reefs. There are pertinent point-source examples in the AMLR NRM region, from previous dredging operations at specific locations, including Port Stanvac during the 1990s (e.g. Turner and Cheshire 2002, Turner 2005), and O'Sullivans Beach during the late 2000s (Baker et al. 2009).

A significant, ongoing source of sedimentation to coastal reefs is from coastal rivers, creeks and stormwater drains. A reef sediment study has been undertaken by the AMLR NRM Board in conjunction with SARDI Aquatic Sciences to determine where sediments on metropolitan reefs originate (Fernandes et al. 2008, AMLR NRM 2009b). Some of the most heavily impacted reefs in terms of sediment load include Noarlunga and Aldinga, due to sediment from the Onkaparinga River and adjacent eroding cliffs. Agricultural runoff and sedimentation onto seagrass and reef in the Aldinga area has long been an ongoing issue (Environment Protection Council of South Australia 1992). Storm activity may re-suspend and transport sediments previously deposited by the Onkaparinga River during winter (Fernandes et al. 2008, AMLR NRM 2009b). As shown in this report, as number of specimens of apparently rare invertebrates (particularly bivalves) have come from the Aldinga area.

Initial results of the aforementioned sediment study indicate that most of the sampled reefs in the area are subject to sedimentation, including (i) the area between Port Noarlunga North and Hallett Cove (the Field River and Christies Creek are considered to be major contributors of sediments to these reefs), and (ii) Semaphore and Broken Bottom (off Glenelg), where sediments in the area are also high in nitrogen. The higher nitrogen loads on the northern reefs may be due to a combination of long-term discharges of domestic and industrial wastewaters, the Bolivar and Glenelg wastewater treatment plants, and the Penrice soda factory which discharges to the Port River (AMLR NRM 2009b).

Some of the main threats identified to water quality (and thus nearshore marine habitats) in eastern Gulf St Vincent include nutrients from the SA Water wastewater treatment plants (WWTPs) and turbidity from urban stormwater; ammonia from Penrice soda factory, and elevated temperature from the Torrens Island power station (Gaylard 2009).

In addition to impacts on reefs in the AMLR NRM region is the well-publicised degradation of seagrass beds. This has been occurring in the region since the late 1930s or early 1940s, and has been known about at least as early as the 1960s (Shepherd 1970). Seagrass degradation in GSV has been the subject of numerous investigations over the ensuing decades, including mapping of metropolitan and southern beaches seagrass decline over several decades (e.g. Hart 1996, 1997), and many investigatory and confirmation projects as part of the multi-project, multi-agency Adelaide Coastal Waters Study during the early 2000s. Baker (2004) provided reviews of impacts resulting in seagrass loss in the north-eastern GSV area, and Westphalen et al. (2004), and Fox et al. (2007) reviewed seagrass loss over the entire metropolitan area of GSV. The latter authors discussed the retreat of the 'blue line', which marks the near-shore edge of the seagrass beds. This retreat may have started sometime between 1935 and 1949 in Holdfast Bay, perhaps stimulated sewage discharges from Glenelg (which commenced in 1943). The Penrice soda-ash plant at Osborne in the Port River also started operating in 1940. Further losses in the north were associated with the discharge of wastewaters from Bolivar in the late 1960s (Fox et al. 2007). The retreat of the "blue line" was very pronounced by the 1980s. Sludge outfalls which operated between the 1960s and 1993 caused loss of seagrasses further offshore. Although some re-colonisation has occurred in the areas of loss around the old sludge outfalls, there has been no re-colonisation inside the 'blue line' along the beaches (Fox et al. 2007). Erosion (including "blow-outs") and fragmentation of the seagrass meadows in central and southern Holdfast Bay continue to the present (Westphalen et al. 2004; Fox et al. 2007).

In addition to the metropolitan area, coastal discharges and sedimentation are also an issue along many parts of the Fleurieu Peninsula. Baker (2004) provided a summary of community concerns during the past two decades, including the following:

- Agricultural runoff (fertilisers, farm chemicals as well as sediments) onto reef and seagrass beds in a number of areas in the Southern Fleurieu region;
- Nutrients and other pollutants (e.g. agricultural chemicals, sediments etc) flowing from the Yankalilla, Bungala and Myponga Rivers and from Waitpinga Creek, into the near-shore area (DEH 1996, unpublished data; Bryars 2003). Yankalilla and Bungala rivers are classified as being in moderate to poor condition based on their elevated concentrations of nutrients (Elsdon et al. 2009 and unpublished data, cited by Irving 2009). An increased level of nutrients has been listed as a perceived threat to the estuarine habitats in these areas (Bryars 2003). The point source pollution from the Bungala River was the subject of a community-based impact monitoring program during the mid 1990s, and more recently, an estuary action plan has been prepared for the Bungala estuary (AECOM Australia Pty Ltd 2010);
- Community submissions received by government during 1991, described land-based impacts in the southern Fleurieu area (e.g. Lady Bay - Carrickalinga - Normanville - Second Valley), such as: declining quality of the near-shore reef and seagrass ecosystems due to land clearing and coastal development, farming and grazing (causing pollution of local estuaries from agricultural runoff including sediments, herbicides and pesticides, cattle wastes, dairy runoff at Second Valley), and effluent overflow from septic tanks at Carrickalinga, Second Valley and Rapid Bay) (Schiansky pers. comm. to S.A. Department of Fisheries 1991; Bryars 2003). One report suggested that pollutants from river outlets in the area have resulted in reduced variety of macroalgae in the shallow waters near river outlets, and siltation of near-shore reefs resulting in reduced diversity of reef biota (Christie, pers. comm. to S.A. Department of Fisheries 1991);
- Decreased freshwater flows cased by abstraction from the Waitpinga Creek catchment has been listed as a potential threat to near-shore habitat in that area (Bryars 2003);

- There has also been some impact on reefs in the increasingly urbanised area of Victor Harbor, possibly due to increased runoff and nutrient and sediment loads from the Hindmarsh and Inman Rivers (Turner et al. 2007, cited by Gaylard 2009). Estuary action plans have recently been written for both of these rivers (Sinclair Knight Merz 2010a,b).
- Land clearing and coastal soil disturbance associated with coastal development (e.g. housing sub-divisions) (see section below, on Coastal Development).

Other Pollution (Oil, Industrial Chemicals, Heated Water)

In the past, periodic oil spills in AMLR NRM region have threatened invertebrate populations (e.g. Piller 1998). Oil may be spilled during transport, transfer or loading. There is a large literature on the effects of spilled oil and oil dispersants on marine invertebrates, and only a few examples will be provided here. Experimental work in south-eastern Australia has indicated that when combined with oil, the dispersants used to break up spilled oil have a greater toxic effect upon invertebrates such as amphipods and gastropod molluscs, than does crude oil alone (Gulec et al. 1997). Other experimental work on oil impacts has shown that biochemistry and behaviour of asteroids (NB the eleven-armed seastar *Coscinasterias muricata* was used as the test organism) can be adversely affected by dispersed oil (Georgiades et al. 2003). It is noted that the threat of spilled oil in AMLR NRM region has reduced to the decommissioning of the oil terminal at Port Stanvac during the early 2000s.

Heavy metal contamination may also adversely affect invertebrate populations. Examples include the impact of tributyl tin (a boat antifoulant) on reproduction in gastropods (Nias et al. 1993), and the reduction in assemblages of epifaunal invertebrates due to the bioaccumulation of metals (such as copper) in macroalgae (Roberts et al. 2006 and 2008, Riosmena-Rodríguez et al. 2010).

Assorted industrial chemicals may also affect invertebrate populations, particularly sediment-dwelling taxa that take up pollutants that occur in mud or sand. Phillips et al. (1992) and Ponder et al. (2002) provided some examples of the impacts of chemical pollutants on various marine invertebrates, particularly the mussel *Mytilus*, which is widely used as an experimental organism in marine pollution studies. In the central part of the AMLR NRM region, many different organic and inorganic contaminants (including toxic compounds), drain from industrial and municipal stormwater drains and point source outfalls in the Port Adelaide area, into Barker Inlet and the Port River. A number of industries have discharged directly into the Port River-Barker Inlet system over a long period. Surface waters flowing into Barker Inlet area are also contaminated with effluent, heavy metal discharges from industry, road runoff contaminants, oil, grease, and pesticides (PPK et al. 1992). During the past few decades, common contaminants in the Port Adelaide system, from a combination of industrial outfalls and stormwater outlets, have included nutrients; particulates (e.g. rubber, grain, asbestos, and many others); sediments; organic wastes (animal faeces, leaf litter, lawn clippings, fertilisers); chemicals from industrial effluent and run-off (e.g. soda ash from a salt processing plant, and pollutants from paint factories, sugar refinery, fertiliser factory, and other industries); oil from boats, ships and motor vehicles; chlorine; polychlorinated biphenyls (PCBs); mercury, lead, copper and zinc and other metals; thermal effluent (particularly from the two power stations) and litter (such as plastic bags and bottles, rope, thongs etc) (Hine et al. 1989; Thomas et al. 1991; PPK et al. 1992a and 1992b; Edyvane 1992, submission to MFP Australia Gillman - Dry Creek Urban Development Proposal Draft EIS; J. Carey and A. Kutlaca, Adelaide University, pers. comm. 1993; Petrusevics et al. 1998; Parliament of South Australia 2000; EPA 2003; Harbison 2009).

Heated waste water is an additional impact for invertebrate populations in AMLR NRM region. Previous studies in the thermally affected area of Torrens Island Power station (Port Adelaide area), which discharged into Angas Inlet water at eight to nine degrees above the intake water temperature, showed the following impacts:

- a reduced infaunal biodiversity, with a cerratulid worm species dominating the benthic fauna in the vicinity of the heat-affected area of Angas Inlet (Zed 1972);
- an opportunistic polychaete dominated the infauna in the thermally affected area, with a low diversity of infauna in the thermally affected area. The impacts on infaunal diversity were not limited to Angas Inlet, with some reduction also noted in North Arm and Barker Inlet (Thomas et al. 1986); and
- reduction in biomass of intertidal fauna in response to thermal effluent (ETSA 1986). It has also been hypothesised the low dissolved oxygen levels in the system may also be a contributing factor to the low levels of infaunal species diversity in the area (Fargher Maunsell 1985, cited by PPK et al. 1992).

Apart from the many pollutants discussed above, prawn trawling offshore has had impacts on deeper water seagrass beds, and other habitats of significance to invertebrates in the AMLR NRM. Tanner's (2003, 2005) benthic survey work has dramatically illustrated the significant changes that have occurred to the benthos of Gulf St Vincent and Investigator Strait since the 1960s (including hard bottoms as well as seagrass beds), and particularly due to the effects of prawn trawling.

Other benthic habitat types, such as shells beds and other combined hard/soft substrates, are also important for invertebrate populations in AMLR NRM. Tanner (2003, 2005) provided examples of locations in AMLR NRM region where such beds have been significantly degraded over time. The deeper water habitats of Backstairs Passage, which are dominated by large sessile invertebrates (Baker 2004; DEH 2009), are subjected to fewer threats that coastal waters in AMLR NRM, and dredging or trawling in such areas should be prohibited, due to the unique nature of the habitat, and its inherent fragility and susceptibility to physical damage.

Many of the aforementioned issues in the metropolitan area and Fleurieu Peninsula also apply to Encounter Bay, an increasingly urbanised area at the edge of the AMLR NRM region. During the early 2000s, this area attracted around 1.1 million visitors per annum (Tourism Victor Harbor 2010). Between 1990 and 2000, the base population reportedly increased nearly 50%, a growth rate 10 times that of the State as a whole. Victor Harbor has continued to grow at around 3% per annum for the past 10 years to 2008. In 2008, the base population of the Victor Harbor Council area was 12,900. The base population increases to about 30,000 in summer due to temporary holiday residency (City of Victor Harbor 2008). Baker (2004) provided a summary of impacts in the Encounter Bay area that may affect near-shore reef and seagrass habitats that are of significance to invertebrate populations.

Coastal Development

Over the past two decades, there has been a growing trend along some parts of AMLR NRM coastal region for further housing developments, and for marina and boat harbour construction. Coastal and waterfront housing developments and marina / boat harbour construction and maintenance can impact beaches, intertidal and subtidal reefs, seagrass beds and sand bottoms in the AMLR NRM region (e.g. Emmett 2007), and therefore adversely affect invertebrate populations associated with each of these habitats. General impacts of marinas and waterfront housing and coastal housing developments include the following (from Harvey 1993; Eyre Peninsula NRM Board 2009).

- hydrocarbon pollution of water, sediments and benthos from bilge and ballast waters, and fuel spills;
- contamination of sediments and biota with metals and other pollutants from hull cleaning, painting and antifouling agents associated with increased recreational and commercial boating;
- physical damage to supratidal, intertidal and shallow subtidal habitats from dredging and construction;
- damage to benthos and reduction of benthic habitat quality - including destruction of saltmarsh, wetlands, mangroves, dune systems, seagrass, macroalgae and benthic fauna - from channel dredging and maintenance, waterfront housing construction, anchor damage, and boat hull scouring;
- increased turbidity and/or sedimentation from channel dredging and maintenance;
- nutrient contamination from increased effluent loads, and
- exotic species introductions.

Housing developments on the coast, including residential subdivisions and holiday housing developments, can result in nearshore pollution from stormwater and effluent discharge (see section above on **Siltation**, **Eutrophication, and other Pollution**), and coastal erosion issues. Contaminants in residential stormwater runoff (such as fertilisers and other garden supplements) may result in increased nutrient levels in the nearshore area, and also, freshwater runoff may have a detrimental effect on some nearshore habitats, by changing the water quality (e.g. reducing salinity).

Land clearing and coastal soil disturbance associated with coastal development (e.g. housing sub-divisions) contributes to sedimentation in the near-shore Southern Fleurieu marine environment (e.g. Carrickalinga / Lady Bay / Rapid Bay / Normanville area and other coastal areas of increasing sub-division) (CCSA 2000). When stormwater runoff occurs from urbanised and rural areas, particularly areas undergoing building site clearance, a large amount of sediment from coastal developments ends up in coastal waters (Caton 1997, cited by Brook 2000), which can smother marine invertebrates (amongst other impacts). Community submissions received by government during 1991 described impacts upon the near-shore environment due to coastal subdivisions and marina development in the southern Fleurieu area (e.g. Lady Bay - Carrickalinga – Normanville area) (e.g. Wells pers. comm. to S.A. Department of Fisheries 1991).

In the metropolitan area of GSV, coastal development contributes to sand loss, as many dune reservoirs of sand have been removed and replaced by hard structures such as buildings, roads and storm walls. In addition, the loss of more than 5,000 hectares of seagrass from the Adelaide metropolitan coastline since the 1940s (see previous section) would also have contributed to loss of beach sand, because seagrass beds assist with sand stability and retention. The consequent sand loss along the approximately 28km-long metropolitan beach strip has been so pronounced during the past 50 years that the beach system is now essentially artificial, and persists largely due to regular sand transport and replenishment, in the order of 100,000 cubic metres per year. Populations of many of the possibly rare invertebrate species previously recorded from the intertidal and shallow subtidal in the Adelaide area during the early 20th century are unlikely to have persisted due to the extensive changes that have occurred to the beach system. This would include both sand-dwelling species in the intertidal and shallow subtidal, as well as species that are associated with seagrass in an obligatory way.

A major coastal development in the AMLR NRM region is a recently constructed desalination plant in the Port Stanvac area. There are concerns about the potential impacts of brine discharge on marine ecosystems in GSV (e.g. AMLR NRM Board 2008), and this would include potential impacts on various invertebrates, particularly those whose reproductive success may be impacted by changes in salinity.

Climate Change

According to McInnes et al. (2003), sea surface temperatures over much of the South Australian continental shelf, including the gulfs region, may increase in the range of 0.2/0.3 to 1.2°C by 2030 and 0.6/0.8 to 3.6°C by 2070. Some of the anticipated consequences of climate change generally include the following (McInnes et al. 2003; Hobday et al. 2006; Suppiah et al. 2006; Caton et al. 2007):

- sea level rise, and increased episodes of inundation from coastal flooding, coastal erosion, sedimentation, habitat change and damage. Effects of sea level rise could be more pronounced in northern, low lying areas with extensive intertidal and supratidal area;
- ocean acidification from increased levels of carbon dioxide;
- changes to UV radiation and light penetration;
- changes to salinity;
- changes to tidal and current patterns; and
- change in species composition in marine habitats due to warmer ocean waters.

Of particular concern is the likely impact of climate change on invertebrate species with calcareous shells, because decreased calcification rates have been shown to occur in response to increased CO_2 (Feely et al. 2004; Harley et al. 2006; Fabry et al. 2008). Although groups with shells of aragonite (e.g. pteropod molluscs) are likely to be worse affected than those with shells of calcite (due to the higher stability and lower solubility of the latter form of calcium carbonate), the potential impacts on all calcareous organisms should not be under-estimated (e.g. review of Hobday et al. 2006). Increased acidification due to CO_2, and lowered pH as a consequence, may also increase physiological stress on marine animals. Metabolic efficiency and growth rates of bivalves, mussels and other molluscs may be impaired (e.g. Michaelidis et al. 2005; Berge et al. 2006, cited by Hobday et al. 2006). Experiments have also shown that under lowered pH conditions, fertilisation rate of the eggs of intertidal echinoderms declined, and larvae were severely malformed (Kurihara et al. 2004, cited by Hobday et al. 2006).

Ocean acidification may also impact upon primary and secondary production, due to reduction in the number of planktonic organisms with calcareous shells (due to increased ocean acidification and therefore reduced ability for organisms to produce calcareous shells). This may in turn affect populations of invertebrates that feed on such organisms. Impacts on shell-producing organisms may also affect soft sediment biota because the two are often tightly coupled in terms of food transfer (Hobday et al. 2006). In addition to direct impacts on the biota, changes in pH will also change the composition and nature of sea floor sediment (which in some areas is largely composed of calcareous grains and fragments), thereby modifying the habitat and causing indirect impacts to the soft sediment biota.

Some of the other ways in which global warming may impact marine invertebrates include:

- changes to recruitment due to increasing water temperatures, and changing ocean circulation patterns;
- interruption to larval settlement in the shallow subtidal (e.g. due to increased levels of inundation, and/or changing tide lines over time;
- reduction in the cover of seagrass meadows, with consequent impacts on calcareous organisms which live in seagrass; and
- increased potential for marine pest species to flourish, due to nutrient changes (particularly from nearshore contamination with rising sea levels), increased CO_2 levels, and ecosystem disturbance (EP NRM Board 2009).

It is not possible to protect some groups of organisms (such as calcareous plankton) from changes in sea chemistry and other deleterious impacts of climate change, but efforts are required to protect the populations and habitats of larger calcareous biota - such as molluscs, echinoderms, some types of bryozoans, and the crustacean groups which have calcified shells - from additional anthropogenic stresses such as physical damage (e.g. from dredging etc), sediment smothering, and nutrient enrichment. Such protection may help calcareous organisms to persist longer in the face of ongoing stresses which are harder to control, such as ocean acidification from climate change.

According to recent research in a kelp-dominated habitat in South Australia, current nutrient concentrations and modelled future concentrations of CO_2, may combine synergistically to degrade kelp habitat further than would be the case from nutrient enrichment alone, i.e. the increased abundance of turfs due to nutrient pollution may be exacerbated by the effects of ocean acidification. The research concluded that local-scale amelioration of stressors such as nutrient pollution can help build resilience of habitats such as kelp forests to larger scale stressors such as increased CO_2 and consequent ocean acidification (e.g. Russell et al. 2009; Falkenberg et al. 2010), and this would have consequences for invertebrate species that live in such habitats.

7. Recommended IUCN Listings

The 1994 version of IUCN Red List's categories and criteria recognises several categories of threat, and a summary of these categories and criteria is shown in **Table 2** above. The main category of relevance to this assessment is *Vulnerable* (VU). A species is Vulnerable when it is not Critically Endangered or Endangered (see **Table 2**, and IUCN 1994) but is facing a high risk of extinction in the wild in the medium-term future, as defined by any of the criteria (A to E).

Also of importance is the category of *Lower Risk* (LR). A species is Lower Risk when it has been evaluated, does not satisfy the criteria for any of the categories Critically Endangered, Endangered or Vulnerable. Taxa included in the Lower Risk category can be separated into three subcategories: Conservation Dependent (CD), Near Threatened (NT) and Least Concern (LC).

None of the species discussed in this report may qualify for listing as Conservation Dependent (CD). This category applies to species which are the focus of a continuing species-specific or habitat-specific conservation programme targeted towards the species in question, the cessation of which would result in the species qualifying for one of the threatened categories (E,N, VU or LR) within a period of five years.

Near Threatened (NT), refers to species which do not qualify for Conservation Dependent, but which are close to qualifying for Vulnerable.

Least Concern (LC) is a category that can be applied to species which do not qualify as Conservation Dependent or Near Threatened (IUCN 1994).

Of significance to the assessment of rare, endemic and other potentially threatened invertebrates in South Australia (including AMLR NRM region) is the category of *Data Deficient* (DD). According to IUCN (1994), a species is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A species in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. *Data Deficient* is therefore not a category of threat or Lower Risk. Listing of species in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate (IUCN 1994).

The category "Rare (R), which is no longer used by IUCN, is also included here, due to its presence as a category in South Australia threatened species legislation. Application of the Rare category is discussed above in section **2**.

An assessment of the characteristics that render marine invertebrates vulnerable to population decline (**Table 3**) against each species discussed in this report (**Table 25**), and the requirements of each IUCN category (**Table 2**), provides the following summary statistics for proposed category of threat (**Table 24**). Note that in some cases, it is uncertain whether the species would better qualify as DD or a category of threat, and therefore both options are suggested. A small number of species which are Data Deficient may qualify as Rare and/or Vulnerable, depending on the interpretation of available data, and the results of further research on those species. For example, based on the current small number of records, a species may qualify in theory for listing as VU D2, but there have been no targetted searches. This is particularly so for small, cryptic species. The species may be more abundant and widely distributed than records indicate, hence DD may be a more appropriate category until more is known of the distribution and relative abundance.

Table 24: Summary of proposed IUCN categories for species discussed in this report, according to assessments detailed in Table 25.

Proposed Category (modified from IUCN)	Number of Rare, Endemic or Potentially Threatened Species in AMLR that may Qualify
Data Deficient (DD)	92
Data Deficient (DD) or Rare (R)	11
Data Deficient (DD) or Lower Risk (LR)	12
Lower Risk (LR)	2
Data Deficient (DD) or Near Threatened (NT)	19
Near Threatened (NT)	1
Data Deficient (DD), Rare (R) or Near Threatened (NT)	1
Data Deficient (DD) or Vulnerable (VU)	4
Data Deficient (DD), Rare (R) or Vulnerable (VU)	1

Table 25: Recommended IUCN categories for species of conservation concern in the AMLR NRM region, based on summary of characteristics that render marine invertebrates vulnerable to population decline and eventual extinction. Species which might occur in the region are also included, based on existing records in adjacent regions (e.g. Spencer Gulf, or Kangaroo Island), and habitat. Hard corals occurring in AMLR NRM region are not included here, due to the reasons specified in the section above on Anthozoa. Codes in the column "Vulnerable Characteristics" are listed in Table 3 above. GSV = Gulf St Vincent; KI = Kangaroo Island; NSW = New South Wales; SA = South Australia; SG = Spencer Gulf; SE SA = South Eastern South Australia; VIC = Victoria; WA = Western Australia. In "IUCN Category and Criteria" column: DD = Data Deficient; NT = Near Threatened; LR = Lower Risk (a category no longer used by IUCN Red List); R = Rare; VU = Vulnerable. Criteria for VU category are outlined in Table 2 above. # = Data are lacking, but retrospective population analysis would likely indicate VU A population reduction in SA.

Genus & Species (Alphabetical Order)	Vulnerable Characteristics (Codes from Table 3)	IUCN Category & Criteria	Rationale
Acanthochitona saundersi	possibly 16, 17, possibly 18, 21, possibly 24 and 25, possibly 26 (unlikely), possibly 27	DD, possibly R	A small chiton (1.5cm) that has been reported so far only from the gulfs region and the GAB in South Australia. Known to date from few specimens in sand on reefs, over a narrow depth range (6m – 12m). Little information about full distribution, depth range and relative abundance. Considered by Gowlett-Holmes and Zeidler (1987) to be relatively rare, since few have ever been found, despite extensive collecting of chitons in South Australia. However, the small size and cryptic habit is noted here, which would reduce the probability of finding specimens unless specific searches are made, on and under sand-embedded rocks in reef habitats.
Actiniid sp. 3 (in Edgar 2008)	21, possibly 24 and 25, possibly 26, possibly 27	DD	The White-striped Anemone is known to date from the South Australian gulfs, and may be locally abundant where present. Currently known over a narrow depth range (8m – 15m) but no targetted surveys have been undertaken, so depth range might be wider. Similarly, full distribution and relative abundance within SA are not known.
Ammotrophus cyclius	17, 21, possibly 24 and 25, possibly 26 (if distinct species), possibly 27	DD	An uncommonly recorded sand dollar known to date from locations in the GAB, SA gulfs, Encounter Bay, and south-eastern SA. Known to date from 20m to 45m. Might not be a distinct species (Mortensen 1948), but synonymous with other species such as *A. platycerus* (see below) and *A. arachnoides*.
Ammotrophus platyterus	17, 21, possibly 24 and 25, possibly 26 (if distinct species), possibly 27	DD	An uncommonly recorded sand dollar, known to date only from Gulf St Vincent. Might not be a distinct species (Mortensen 1948), but synonymous with other species such as *A. cyclius* (see above) and *A. arachnoides*.

Genus & Species (Alphabetical Order)	Vulnerable Characteristics (Codes from Table 3)	IUCN Category & Criteria	Rationale
Amoria exoptanda	possibly 9, possibly 12, 13, possibly 14 (due to aggregation), 16, 17, 18, 21, possibly 27, 33, 34	DD or NT	A large volute known from SA and the south coast of WA. Found on sand in seagrass beds, and in sand and gravel habitats, between 10m and 100m deep. This species is collected commercially in SA and WA, and has moderate value in the shell market. It is considered to be widespread and locally common. Catch data have been highly variable during the 1990s and 2000s, and reflect periods of both active collecting and cessation of collecting (see section above, on Volutidae). In an assessment of molluscs in the shell trade that are vulnerable to over-exploitation, Ponder and Grayson (1998) classified this species as category "B" on a national scale. Potentially vulnerable to over-exploitation due to commercial value, and life history traits (possible delayed age at maturity, aggregation at spawning time, direct development of young, low dispersal of young and low adult mobility).
Amoria undulata	possibly 9, possibly 12, 13, possibly 14 (due to aggregation), 16, 17, 18, 21, 33, 34	DD or LR	A large volute shell with a broad distribution, from Queensland through to northern WA, but there are gaps in the distribution. Various records from SA, mainly from GSV through to eastern GAB. Found in sand / shelly sand, over a very broad depth range, from intertidal to about 500m deep. In South Australia, this species migrates in the spring from deep water to shallow water sandbanks to breed. Common in SA, and hand collected by divers. Low value in the shell market. Potentially vulnerable to over-exploitation due to commercial value, and life history traits (possible delayed age at maturity, aggregation and shallow water migration at spawning time, direct development of young, low dispersal of young and low adult mobility). However, common over a broad geographic and depth range which reduces species vulnerability to decline.
Amphiura (Amphiura) trisacantha	possibly 15 and 16 (uncertain), 21, possibly 24 and 25, 31	DD	A brittlestar known from a few locations in each of Victoria, Tasmania and SA, and several unconfirmed records from a location in NSW. Most of the South Australian records come from areas of Spencer Gulf, including Port Pirie. Known mostly from *Posidonia* and *Heterozostera* seagrass beds, between 0m and 10m. Like *Ophiocomina australis*, *A. trisacantha* is protected under legislation in Victoria, and considered vulnerable there, due to reliance on embayments, and population vulnerability in areas of seagrass dieback. Occurs in shallow seagrass beds, a habitat type at risk across much of southern Australia, due to coastal pollution (e.g. eutrophication & sedimentation), coastal development, & possible future impacts from sea level rise & ocean acidification. The status of this broadly distributed species in SA in uncertain due to lack of knowledge of full distribution and population sizes in this State. A number of temperate brittlestars brood the young, but reproductive mode in this species requires research.

Genus & Species (Alphabetical Order)	Vulnerable Characteristics (Codes from Table 3)	IUCN Category & Criteria	Rationale
Anachis dolicha	17, 21, possibly 24 and 25, possibly 26 (unlikely)	DD or LR	Known from GSV and possibly endemic, if it is not a variant of the widely distributed *Anachis atkinsoni*. Full distribution and depth range not known (probably due to small size and lack of targetted searches).
Aphelodoris lawsae	17, 21, possibly 24 and 25, possibly 26, possibly 27, possibly 28	DD	A possibly endemic sea slug known from Ceduna in the eastern GAB through to Kangaroo Island and GSV. Eats sponges, and recorded so far on reef and under stones over a narrow depth range (0m – 10m). Full distribution and relative abundance within SA are not known.
Aplidium gastrolineatum	21, possibly 24 and 25	DD	A possibly endemic ascidian known to date from few locations in the SA gulfs and the eastern GAB. Type specimen collected at 23m. Full distribution, depth range and relative abundance within SA are not known.
Aplidium bacculum	21, possibly 24 and 25	DD	A possibly endemic ascidian known to date from the few locations in the SA gulfs and eastern GAB. Type specimen collected at 12m. Full distribution, depth range and relative abundance within SA are not known.
Aplidium acroporum	21, possibly 24 and 25, possibly 26	DD	Requires assessment. A possibly endemic ascidian known to date from few locations in Spencer Gulf and KI. Type specimen collected at 12m. Full distribution, depth range and relative abundance within SA are not known.
Aplidium petrosum	21, possibly 24 and 25	DD	A possibly endemic ascidian known to date from few exposed locations across SA (eastern GAB to South East). Full distribution, depth range and relative abundance within SA are not known.
Apsolidium alvei	Possibly 15 and 16, 17, 21, probably 24 and 25, probably 26, possibly 27	DD or R (less likely VU D2)	A possibly endemic sea cucumber known from few records, between Yorke Peninsula and Encounter Bay in SA. Records known to date over a narrow depth range (0m to about 10m). May be an external brooder, as are other species in the genus. Based on small number of records, may qualify for listing as VU D2, but there have been no targetted searches. May be more abundant and widely distributed than records indicate, hence DD may be a more appropriate category until more is known of the distribution & relative abundance.
Apsolidium handrecki	Possibly 15 and 16, 17, 21, probably 24 and 25, possibly 27	DD (possibly VU D2)	A small (20mm), possibly endemic sea cucumber known from very few locations in Victoria, SA and Western Australia. Records known to date over a very narrow depth range (0m to about 3m). Occurs on shallow rocky platforms and on jetty piles, on plants of the green macroalga *Caulerpa*. Known in Victoria from only six specimens taken from Merrick, and no others have been found following 10 years of searches. There is only one record from SA (Arno Bay), and *A. handrecki* is also known from two metropolitan coastal locations in WA. Listed as a threatened species in Victoria. It may be an external brooder. Potential threats are considered to include reef trampling, coastal development and discharges, declining water quality, oil spills, and introduced species and pathogens (DSE Victoria undated). Based on small number of records, may qualify for listing as VU D2, but there have been no targetted searches. May be more abundant and widely distributed than records indicate but easy to overlook due to small size, hence DD may be a more appropriate category until more is known of the distribution & relative abundance in SA.

Genus & Species (Alphabetical Order)	Vulnerable Characteristics (Codes from Table 3)	IUCN Category & Criteria	Rationale
Argalista roseopunctata	17, 21, possibly 26 (unlikely)	DD	Uncertain if this species occurs only in SA, due to taxonomic confusion about its relationship with *Collonia roseopunctata* Angas. Habitat in part of the range has been extensively degraded over the mid 20th to early 21st century (e.g. metro Glenelg beach off Adelaide, where the type was collected in 1945).
Austrocypraea reevei	13, 16, 17, 18, 21, possibly 27, 33, 34	DD or NT	A cowrie that ranges from South Australia to about Geraldton in WA, with most known examples from the southern coast of WA. Moderate value in the commercial shell market. The annual catch of this species in South Australia is not publicly available, but in WA it is taken in the dozens to low hundreds per annum. In an assessment of molluscs in the shell trade that are vulnerable to over-exploitation, Ponder and Grayson (1998) classified this species as category "B" in WA and SA. Little information in SA about full distribution, depth range (but known to extend to at least 40m deep) and relative abundance. Potentially vulnerable to over-exploitation due to commercial value, and life history traits (direct development of young, low dispersal of young and low adult mobility).
Austroharpa (Palamharpa) punctata	16, 17, 18, 21, possibly 27, 33	DD or NT	Probably not common in SA. In a family whose members lay benthic eggs that hatch *in situ* as crawling juveniles, hence have low dispersal ability. Traded in the shell market (high value). There is little publicly available information about catches of this shell species, other than data from 1999 to 2003 in the WA specimen shell fishery.
Asteracmea alboradiata	17, 21, possibly 24 and 25, possibly 26	DD	Presence in AMLR NRM uncertain; known from type locality in Spencer Gulf, and possibly endemic within SA. Very few records.
Austrodrillia (Austrodrillia) agrestis	17, 21, possibly 27	DD	Species validity uncertain. Known from very few records.
Austrodrillia (Austrodrillia) dimidiata	17, 21, possibly 27	DD	Species validity uncertain. Known from very few records.
Austromitra arnoldi	17, 21, 24, possibly 26	DD	Known from western SA, but might extend to south-western WA. Very little information about this small (1 – 2cm) species.
Austrosquilla middletoni	17, 21, 24, 25, 28, possibly 31	DD	Full distribution and relative abundance not known due to cryptic habitats in burrows. May occur over a very narrow depth range. Occurs in fine, anoxic sand in the intertidal area, in sympatric association with 2 other burrowing species.
Bassethullia porcina (previously *Acanthochiton Notoplax porcina*)	possibly 16, 17, possibly 18, 21, possibly 24 and 25, possibly 26 (unlikely), possibly 27	DD	A small (3cm), possibly endemic chiton known to date from a few locations, ranging from Robe in the upper South East to Kangaroo Island and GSV. Little information about full distribution, depth range and relative abundance.

Genus & Species (Alphabetical Order)	Vulnerable Characteristics (Codes from Table 3)	IUCN Category & Criteria	Rationale
Brechites / Foegia / Kendrickiana veitchi	17, 21, possibly 24 and 25, possibly 26, 31, possibly 33, 34	DD, R, or NT (less likely VU D2)	A large (to ~ 17cm), tube-building bivalve which has been recorded in coarse sand and seagrass habitat to 12m deep, off the Port Lincoln and Thorny Passage areas of southern SG. Also known in fossil form from Roe Plains (Eucla Basin) in WA, and from earliest Pleistocene beds on Yorke Peninsula, SA. Very little is known about this species; full distribution & depth range have not been recorded. Possibly rare, as few have ever been recorded, despite its large size. Based on small number of records, may qualify for listing as VU D2, but there have been no targetted searches. May be more abundant and widely distributed than records indicate, hence DD may be a more appropriate category until more is known of the distribution & relative abundance. Occurs in shallow seagrass beds, a habitat type at risk across much of southern Australia, due to coastal pollution (e.g. eutrophication & sedimentation), coastal development, & possible future impacts from sea level rise & ocean acidification, hence may also qualify for NT listing, particularly if population numbers in *Posidonia* habitat are low.
Capnella shepherdi	21, possibly 24 and 25, possibly 26, possibly 27	DD	A soft coral known to date only from Wedge Island in southern Spencer Gulf. It is not known if this species occurs in AMLR NRM. Currently known from a single depth (12m) where the holotype was collected. Cryptic habitat, and no targetted surveys have been undertaken to determine full distribution, depth range and relative abundance within SA.
Carditella (Carditella) subtrigona	17, 21, possibly 24 and 25, possibly 27	DD	A cockle, possibly endemic within SA, but full distribution and depth range not known. Very little information (probably due to small size and lack of targetted searches). Known mainly from a few early- and mid-20th century specimens ranging from Streaky Bay in eastern GAB through to Newland Head near Encounter Bay. Depth range of specimens to date reported to be 31 – 44m. There is no recent information
Charisma carinata	17, 21, possibly 24 and 25, possibly 27	DD	Possibly endemic within SA, but full distribution and depth range not known. Very little information (probably due to small size and lack of targetted searches). Known mainly from a few early- and mid-20th century specimens, collected between 11 and 36m, ranging from St Francis I. in eastern GAB to Newland Head near Encounter Bay.
Chromonephthea cornuta	21, possibly 24 and 25, possibly 26, possibly 27	DD	A soft coral known to date only from Wedge Island in southern Spencer Gulf. It is not known if this species occurs in AMLR NRM. Currently known from a narrow depth range (12 - 15m) at the type locality. Cryptic habitat (vertical reef face under a cliff). No targetted surveys have been undertaken to determine full distribution, depth range and relative abundance within SA.
Claudenus antipodus (previously *Ctenicella antipoda)*	21, possibly 24 and 25, possibly 26, possibly 27	DD	A possibly endemic ascidian known to date from Yankalilla Bay in GSV / AMLR NRM region. Full distribution, depth range and relative abundance within SA are not known.

Genus & Species (Alphabetical Order)	Vulnerable Characteristics (Codes from Table 3)	IUCN Category & Criteria	Rationale
Clitella / *Clitellum nutricula*	21, possibly 24 and 25, possibly 26, possibly 27	DD	A possibly endemic ascidian known from two collections (Edithburgh in GSV, and Marum I. in Spencer Gulf). Full distribution, depth range and relative abundance within SA are not known.
Cnemidocarpa amphora	21, possibly 24 and 25, possibly 26, possibly 27	DD	A possibly endemic ascidian known from Sir Joseph Banks group in Spencer Gulf. May also occur in eastern GAB. Holotype collected at 7m. Full distribution, depth range and relative abundance within SA are not known.
Cnemidocarpa tribranchiata	21, possibly 24 and 25, possibly 26, possibly 27	DD	A possibly endemic ascidian apparently known only from the type locality (Seal Rocks in Encounter Bay). Holotype collected at 15m. Full distribution, depth range and relative abundance within SA are not known.
Cominella (Godfreyna) torri / *Godfreyna torri*	probably 13, 16, 17, 18, 21, possibly 27; 33, 34	DD	No published records from AMLR NRM region, but occurs in other parts of SA (and WA). Full distribution and relative abundance not known. Reported to be rare (but unverified by population assessment data). Probably reproduces by direct development, as do other species in *Cominella*. Taken by hand, trawls, and fish traps. Moderately to highly valued in the commercial shell market.
Conus anemone	12, 16, 17, 18, 21, 33, 34	LR (in SA)	Broad distribution (southern Australia) and depth range (0 to 100m), but lays benthic eggs which hatch *in situ* and have no larval stage, hence low dispersal ability. Forms spawning aggregations. High visibility and therefore easily collected when found. Some reports of over-collecting of specific forms in Victoria. Traded in the shell market (low value).
Conus klemae	12, 16, 17, 18, 21, 33, 34	DD	An aggregating species that is probably less common than *Conus anemone*, and has a narrower range (SA and WA). Lays benthic eggs which hatch *in situ* and have no larval stage, hence low dispersal ability. Commonly traded in the shell market (low value). There is little publicly available information about catches of this shell species.
Corynactis sp. (in Gowlett-Holmes, 2008)	21, possibly 24 and 25, possibly 31	DD	This jewel anemone is known to date from the SA gulfs, and south-eastern SA and Victoria. Currently known over a narrow depth range (1m – 8m) but no targetted surveys have been undertaken, so depth range might be wider. Similarly, full distribution and relative abundance within SA are not known. Associated with shallow seagrass, which is a habitat type at risk across much of southern Australia, due to coastal pollution (e.g. eutrophication and sedimentation), coastal development, and possible future impacts from sea level rise and ocean acidification.
Cryptassiminea adelaidensis	17, 21, 24, 25, 26, 28, 31	DD	Known from only a few sites in GSV, on mud and under wood and leaves, in mangrove and saltmarsh habitat (a threatened habitat of limited distribution in SA). Recorded over a very narrow depth range. May have a wider distribution in SA but not recorded due to very small size, and lack of targetted searches.

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Cryptocnemus vincentianus	17, 21, possibly 24 and 25, possibly 27	DD or R (less likely VU D2)	A small crab known from the low intertidal and subtidal, but the full depth range is not known. Based on currently known records (3), would qualify as Rare, or Vulnerable category with criterion D2 (small or restricted population, known from less than or equal to 5 records). However, given the small size of *Cryptocnemus vincentianus* (7mm) and the wide geographic separation between records (SA and WA), it might be more common than records indicate but would be easy to overlook unless specifically searched for in targetted surveys (e.g. using dredge), which have not occurred. Therefore DD (Data Deficient) may be a more appropriate category.
Daphnella (Daphnella) diluta	17, 21, possibly 27	DD or LR	Known from very few old specimen records. Full distribution unknown. Moderately broad depth range (shallows to mid continental shelf).
Daphnella (*Daphnella*) *stiphra*	17, 21, possibly 27	DD or LR	Known from very few specimen records. Full distribution unknown (but has very broad depth range).
Diastoma melanioides	17, 21, possibly 24 and 25	DD	Ranges from south-western WA to SA, and considered to be uncommon. This shell is the only living relative of a fossil genus and family that was common in the Tethys Sea during the Tertiary.
Didemnum delectum	21, possibly 24 and 25	DD	A possibly endemic ascidian known to date from at least 7 collections, ranging from the GAB through to GSV and KI. Mostly known from 6-8m, but depth range likely broader. Full distribution, depth range and relative abundance within SA are not known.
Didemnum effusium	21, possibly 24 and 25	DD	An ascidian known to date from SA gulfs, Kingston in the South-East, and Hobsons Bay in Victoria. There is very little information about this species. Full distribution, depth range and relative abundance are not known.
Didemnum microthoracicum	21, possibly 24 and 25, possibly 26, possibly 27	DD	A possibly endemic ascidian known to date from at Avoid Bay (Eyre Peninsula), Reevesby Island in southern Spencer Gulf, and KI. Full distribution, depth range and relative abundance within SA are not known.
Didemnum minisculum	21, possibly 24 and 25, possibly 26, possibly 27, possibly 31	DD	A possibly endemic ascidian known to date from Stansbury on the Yorke Peninsula. Full distribution, depth range and relative abundance within SA are not known. Associated with shallow seagrass, which is a habitat type at risk across much of southern Australia, due to coastal pollution (e.g. eutrophication and sedimentation), coastal development, and possible future impacts from sea level rise and ocean acidification.
Discodoris sp. (in Coleman 2001 and McDonald 2006)	17, 21, possibly 24 and 25, possibly 26, possibly 27, 28, 35	DD, possibly R	A small (2cm) nudibranch known from Edithburgh in South Australia. Possibly occurs over a narrow depth range, but published records are lacking (other than one example from 5m on sponge). Eats sponges, and forms mating groups. Taxonomic work is required on to determine the relationship with named species in *Discodoris*. May be the same species as "*Rostanga* sp. 1".

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Doris sp. (in Coleman 2001 and McDonald 2006)	17, 21, possibly 24 and 25, possibly 26, possibly 27	DD, possibly R	A nudibranch known from Edithburgh in GSV. Possibly occurs over a narrow depth range, but published records are lacking (other than one example from 3m, on jetty piles). The distribution may extend beyond SA but there are no published records. Taxonomic work is required to determine the relationship with named species in *Doris*.
Edwardsia vivipara	13, 18, 21, possibly 24 and 25	DD	Requires assessment. An anemone, reportedly live-bearing (reproduces by direct development of young *in situ*), and therefore has limited dispersal ability. Known from SA gulfs and Victoria over a narrow depth range (1 – 10m) but no targetted surveys have been undertaken, so depth range might be wider. Similarly, full distribution and relative abundance within SA are not known.
Epidirona perksi	17, 21, possibly 24 and 25, possibly 26, possibly 27	DD	A turrid shell known from the type locality off Thistle Island in Spencer Gulf, where specimen was dredged during the 1890s. Possibly endemic within SA, but full distribution (and depth range) unknown.
Epitonium (Nitidiscala) platypleura / platypleurum	17, 21, possibly 27, 28	DD or R	Occurs in SA and possibly also VIC, but apparently uncommon. Full distribution and depth range are not known. Known mainly from the holotype. In the Wentletrap family, members of which have specific habitat needs (ecto-parasitic on sea anemones, corals or zoanthids).
Ericusa fulgetra / E. fulgetrum and *E. papillosa*	possibly 9, possibly 12, 13, possibly 14 (due to aggregation), 16, 17, 18, 21, 33, 34	DD	There are various records from throughout the SA coast, ranging from GAB through to Backstairs Passage and Encounter Bay. Both species found over a broad depth range. May occur in deeper water seasonally, and move to shallower water to lay eggs. Fished commercially, and of moderate value in the shell market (higher price for rare forms). Some populations of *E. fulgetra*, particularly inshore, are considered to be depleted from collecting. In an assessment of molluscs in the shell trade that are vulnerable to over-exploitation, Ponder and Grayson (1998) classified *E. fulgetra* as category "C" in WA and "D" in SA. Inshore populations potentially vulnerable to over-exploitation due to commercial value, and life history traits (possible delayed age at maturity, aggregation and shallow water migration at spawning time, direct development of young, low dispersal of young and low adult mobility).
Euantedon paucicirra	21, probably 24 and 25, possibly 27	DD	A crinoid, known from SA gulfs and Bass Strait in Victoria, over a shallow depth range. Uncommonly sighted, and known from few records.
Eudistoma aureum	21, possibly 24 and 25, possibly 26, possibly 27	DD	A possibly endemic ascidian known to date from the SA gulfs. West Beach in AMLR NRM is the type locality. Full distribution, depth range and relative abundance within SA are not known.

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Eugaimardia perplexa	21, possibly 24 and 25, possibly 26, possibly 27	DD	A bivalve mollusc, possibly endemic within SA, but full distribution and depth range not known. Very little information (probably due to small size and lack of targetted searches). Known mainly from specimens collected in the Pt Lincoln area, between 0m and 16m. (Published lower depth limit may be based on holotype only, collected at 9 fathoms).
Euherdmania translucida	21, possibly 24 and 25, possibly 26, possibly 27	DD	A possibly endemic ascidian known to date from Marum I. (Sir Joseph Banks Group) and Flinders I. in Investigator Group (eastern GAB). Not known if present in AMLR NRM or other parts of GSV, but present in Spencer Gulf. Full distribution, depth range and relative abundance within SA are not known.
Euterebra / Terebra / Gradaterebra scalarifomis	17, 21, possibly 26, possibly 27	DD	An auger shell known from type locality at Newland Head, but full geographic distribution and depth range not known due to lack of targetted sampling.
Favartia (Murexiella) / Murexiella (Subpterynotus) tatei (=Murexiella tatei)	17, 21, possibly 27, 33	DD or R	A murex shell, considered rare; known from few locations in SA (and WA). High value in the shell market.
Flindersoplax vincentiana	17, 21, possibly 24 and 25, possibly 26, possibly 27	DD, R or VU D2	A small crab, possibly endemic within SA, and known only from the type specimens. Based on currently known records, would qualify for Rare status, or Vulnerable category status with criterion D2 (small or restricted population, known from less than or equal to 5 records), because this species is apparently known to date only from the type locality at Port Willunga in GSV (Davie 1989, 2001; Poore 2004), and there are no other specimens in the SA Museum (T. Laperousaz, pers. comm. 2011), or in the literature, or published surveys. However, it might be more common than records indicate but would be easy to overlook (due to small size of 3cm) unless specifically searched for in targetted surveys, which have not occurred. Therefore DD (Data Deficient) may be a more appropriate category.
Fossarina (Minopa) reedi	17, 21, possibly 24 and 25, possibly 26, 33	DD	Possibly endemic within SA (with Holdfast Bay being the type locality), but full distribution not known. Records from shallow subtidal, and it is not known if the species is restricted to that depth range. Very little information (probably due to small size and lack of targetted searches). Traded in shell market for low value.
Grimpella thaumastocheir	possibly 8, possibly 16, 17, possibly 18, 21	LR	Although reproduction in this species is unstudied, cephalopods normally reproduce only once per lifetime. Possibly uncommon in SA, but has a relatively broad geographic distribution, and occurs in various habitats over a broad depth range, to several hundred metres deep (see section above, on Cephalopoda).

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Haledromia bicavernosa	probably 13 and 15, possibly 16, 17, 21, possible 24 and 25, possibly 26, 34	DD or NT	A crab which grow to about 9 or 10cm, possibly endemic within South Australia, with records ranging from the GAB through to Encounter Bay. Records to date range from 2m to 40m deep. May be common within the range. Poore (2004) reported that this species may have direct development of young, and crabs of this type are also known to brood the young. Life history characteristics of this species increase vulnerability of populations to decline.
Hypotriphora subula	17, 21, possibly 26	DD	Very little information, and known mainly from dredge samples. Holotype collected in GSV and also known from off north-western KI. Might be endemic within SA.
Ischnochiton (*Ischnochiton*) *pilsbryi*	possibly 16, 17, possibly 18, 21, possibly 24 and 25, possibly 26, possibly 27	DD	A chiton known to date from the SA gulfs and the GAB. Various records from across the range, and may not be uncommon. Little information about full distribution, depth range and relative abundance.
Jorunna sp.	17, 21, possibly 24 and 25, possibly 26, possibly 27, possibly 28	DD	An uncommon sea slug that apparently has been recorded so far only in South Australia. Recorded under rocks on reef, between 0m and 10m deep, on sheltered to moderately exposed coasts. The full distribution and relative abundance of this unnamed species is not known.
Leptoclinides variegatus	21, possibly 24 and 25	DD	A possibly endemic ascidian known to date from eastern GAB through to GSV and Kangaroo I, in waters 1m – 20m deep. Full distribution, depth range and relative abundance within SA are not known.
Lithophaga (*Lithophaga*) *cuneiformis*	17, 21, possibly 24 and 25, possibly 26, possibly 27	DD	The Southern Date Mussel, possibly endemic, and known from Port Victoria in SG. Few records. Presence in AMLR NRM uncertain. Recorded from 0m – 16m, in habitat described as “consolidated shell ooze”. Taxonomy uncertain. Full distribution, depth range and relative abundance unknown.
Lipotrapeza ventripes	possibly 15 and 16, 17, 21, possibly 24 and 25, possibly 27	DD	An uncommon sea cucumber recorded from few locations in Victoria, and South Australia (gulfs, and Kangaroo I.). There is very little information on this species, and the full distribution, relative abundance and depth range are not known. Reproduction not recorded, but it is noted that some species in the family Phyllophoridae brood the young.
Lissoclinum laneum	21, possibly 24 and 25, possibly 26, possibly 27	DD	A possibly endemic ascidian known to date from only two locations (Port Victoria in eastern Spencer Gulf, and Encounter Bay), over a narrow depth range (3m – 4m). Full distribution, depth range and relative abundance within SA are not known.

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Livonia mammilla	possibly 9, possibly 12, 13, possibly 14 (due to aggregation), 16, 17, 18, 21, 33, 34	DD	A large volute with a broad distribution, from southern Queensland through to WA. SA records mainly from eastern GAB and Spencer Gulf. Presence in AMLR NRM region uncertain. Occurs on sand, over a broad depth range (3m to about 200m). Taken by trawlers off eastern and southern Australia, including low numbers in shark fishery bycatch. More information required on distribution, relative abundance and depth range in SA, and commercial and recreational collecting effort. Potentially vulnerable to over-exploitation due to commercial value, and life history traits (possible delayed age at maturity, possibly aggregation at spawning time, direct development of young, low dispersal of young and low adult mobility).
Livonia nodiplicata	possibly 9, possibly 12, 13, possibly 14 (if aggregation occurs), 16, 17, 18, 21, 33, 34	DD or NT	A large volute found in SA and WA, (as far north as Jurien Bay area). SA records mainly from eastern GAB and Spencer Gulf. Presence in AMLR NRM region uncertain. Found on sand, from 3m to about 200m deep. Taken in lobster pots and shark nets, and by divers, and also trawled. High value in the international shell market, with gem specimens being sold for up to $1000 during 2008 – 2011. In an assessment of molluscs in the shell trade that are vulnerable to over-exploitation, Ponder and Grayson (1998) classified this species as category “B” in WA and “C” in SA. More information required on distribution, relative abundance and depth range in SA, and commercial and recreational collecting effort. Potentially vulnerable to over-exploitation due to high commercial value, and life history traits (possible delayed age at maturity, possible aggregation at spawning time as occurs in related species, direct development of young, low dispersal of young and low adult mobility).
Livonia roadnightae	possibly 9, possibly 12, 13, possibly 14 (if aggregation occurs), 16, 17, 18, 21, 33, 34	DD or NT	A large volute with a broad distribution, from Crowdy Head in NSW through to Rottnest I. in WA. Uncommon in southern Australia. In SA, there are occasional records in various parts of the State, such as Port MacDonnell in the South-East, and GAB in the west. Ranges in depth from about 18m to 370m, in sand and mud habitats. Trawled in some parts of range, and of moderate value in the shell market. In an assessment of molluscs in the shell trade that are vulnerable to over-exploitation, Ponder and Grayson (1998) classified this species as categories “D” and “E”. More information required on distribution, relative abundance and depth range in SA, and commercial and recreational collecting effort. Potentially vulnerable to over-exploitation due to commercial value, uncommonness, and life history traits (possible delayed age at maturity and possible aggregation at spawning time as occurs in related species, direct development of young, low dispersal of young and low adult mobility).

Genus & Species (Alphabetical Order)	Vulnerable Characteristics (Codes from Table 3)	IUCN Category & Criteria	Rationale
Lyria mitraeformis	possibly 12, 13, possibly 14 (if aggregation occurs), 16, 17, 18, 21, 33	DD	A relatively small volute shell that ranges from Bass Strait in Victoria to Cape Leeuwin in Western Australia. The western form may be a sub-species. Found in sand an under rocks, often in sand pockets on reef, from about 0m to 50m. Widely traded in the shell market, and of low to moderate value. In an assessment of molluscs in the shell trade that are vulnerable to over-exploitation, Ponder and Grayson (1998) classified this species as category "B" nationally, despite its broad distribution. Potentially vulnerable to over-exploitation due to commercial value, popularity with recreational collectors, and life history traits (possible aggregation at spawning time as occurs in related species, direct development of young, low dispersal of young and low adult mobility). More information required about distribution, relative abundance, depth range, and commercial and recreational take in SA.
Melo miltonis	possibly 9, possibly 12, 13, possibly 14 (if aggregation occurs), 16, 17, 18, 21, 33, 34	probably NT	A very large volute shell that occurs mainly from western South Australia to Abrolhos Islands in Western Australia, but also is rarely recorded in eastern SA and western Victoria. Found in sand and seagrass habitats, and on sand near reefs, between 0m and about 100m. An oviparous species with direct development. Large shells, over 350mm, are considered to be very uncommon. Moderate value in the shell market. Potentially vulnerable to over-exploitation due to commercial value, popularity with recreational collectors, and life history traits (possible delayed age at maturity and aggregation at spawning time as occurs in related species, direct development of young, low dispersal of young and low adult mobility). More information required about distribution, relative abundance and depth range in SA, and commercial and recreational collecting effort.
Minolops / Ethminolia cincta	17, 21, possibly 27	DD or LR	Possibly endemic within SA, but full distribution not known. Very little information (probably due to small size and lack of targetted searches). Broad depth range (to continental slope), and distribution from at least SE SA to SG.
Monitilora (Monilitora) paupera	17, 21, possibly 24 and 25, possibly 27	DD	A small cockle, known from Hardwicke Bay in SA, but there is a possible record from Ocean Beach, Point Nepean in Victoria, as *Lucina paupera*. Full distribution and depth range not known, but specimens have been collected to 14m deep. Very little information (probably due to small size and lack of targetted searches).
Montacuta meridionalis	17, 21, possibly 27, 33	DD or LR	A small bivalve known mainly from GSV and the GAB in SA, but there is also a museum record from Victoria. Broad depth range (10m to 200+m). Occasionally sold in the shell market.

Genus & Species (Alphabetical Order)	Vulnerable Characteristics (Codes from Table 3)	IUCN Category & Criteria	Rationale
Nannamoria johnclarki / johnclarkei	possibly 12, 13, possibly 14 (if aggregation occurs), 16, 17, 18, 21, 33	DD or NT	A relatively small volute that ranges from approximately Rottnest I. in WA to south-eastern SA. Occurs in sand and rubble; in sandy patches amongst macroalgae, and on limestone reefs, in moderately exposed areas. Recorded depth range is 15m to 120m. Considered uncommon (Edgar 2008), and very rare in the shell trade (Moylan 2003). Sought after by collectors. Has moderate to high value in shell market, and is rarely available or traded. Potentially vulnerable to over-exploitation due to high commercial value, and life history traits (possible aggregation at spawning time as occurs in related species, direct development of young, low dispersal of young and low adult mobility). More information required about distribution, relative abundance and depth range in SA, and commercial collecting effort.
Nannamoria guntheri	possibly 12, 13, possibly 14 (if aggregation occurs), 16, 17, 18, 21, 33	DD	A relatively small volute species which occurs in SA (from GAB to at least Encounter Bay) and southern coast of WA. Found in sand, including bryozoan-rich sands, and sand in mixed seagrass and macroalgae habitats. Depth range extends to at least the edge of the continental shelf. Several named forms e.g. *N. guntheri adcocki* from SA and *N. guntheri weaveri* from Dongara and Abrolhos Is in WA. Moderate value in the shell trade. In SA, taken in low numbers by a commercial collector (e.g. 3 specimens reportedly collected between July 2001 and June 2002 (PIRSA 2004). Potentially vulnerable to over-exploitation due to commercial value, and life history traits (possible aggregation at spawning time as occurs in related species, direct development of young, low dispersal of young and low adult mobility). More information required about distribution, relative abundance and depth range in SA, and commercial and recreational collecting effort.
Neodistoma mammillatum	21, possibly 24 and 25, possibly 27	DD	A possibly endemic ascidian known to date from eastern GAB (Flinders I.; Ward I.) and GSV (Seacliff), over a narrow depth range (8m – 12m). Full distribution, depth range and relative abundance within SA are not known.
Notocypraea angustata	13, 16, 17, 18, 21, possibly 27, 33	DD or LR	A cowrie that ranges from Eden in NSW through to Eyre Peninsula in South Australia, and the distribution includes Tasmania, where it is common. There are some rare forms over the range. Found over a broad depth range, from the shallow to about 150m deep. Moderate value in the commercial shell market. In an assessment of molluscs in the shell trade that are vulnerable to over-exploitation, Ponder and Grayson (1998) classified this species as category "C" nationally. Little information about full distribution in SA, and relative abundance. Potentially vulnerable to over-exploitation due to commercial value, and life history traits (direct development of young, low dispersal of young and low adult mobility).

Genus & Species (Alphabetical Order)	Vulnerable Characteristics (Codes from Table 3)	IUCN Category & Criteria	Rationale
Notocypraea comptoni casta	13, 16, 17, 18, 21, possibly 26, possibly 27, 33	DD or LR	A subspecies of cowrie (southern form of Compton's Cowrie) that is found in SA, including the Great Australian Bight. Published depth range of 5m to 150m. Low value in the commercial shell market. Little information about full distribution in SA, and relative abundance. Potentially vulnerable to over-exploitation due to life history traits (direct development of young, low dispersal of young and low adult mobility).
Notocypraea comptoni comptoni	13, 16, 17, 18, 21, possibly 27, 33	DD or LR	A subspecies of cowrie (western form of Compton's Cowrie) that occurs along the lower west and south west coast of Western Australia, and in South Australia. Published depth range of 0m to 100m. Low value in the commercial shell market. Little information about full distribution in SA, and relative abundance. Potentially vulnerable to over-exploitation due to life history traits (direct development of young, low dispersal of young and low adult mobility).
Notocypraea piperita	13, 16, 17, 18, 21, possibly 27, 33	DD or LR	A cowrie that ranges from southern NSW through to Cape Naturaliste in Western Australia, and the distribution includes Tasmania. Found over a broad depth range, from the shallow to about 200m deep. There are various named forms over range, such *as N. piperita bicolor* in WA, and *N. piperita piperita* in south-eastern Australia. Peppered Cowrie is common in south-eastern Australia, except albino forms. Low to moderate value in the commercial shell market. In an assessment of molluscs in the shell trade that are vulnerable to over-exploitation, Ponder and Grayson (1998) classified this species as category "C" nationally. Little information about full distribution in SA, and relative abundance. Potentially vulnerable to over-exploitation due to commercial value, and life history traits (direct development of young, low dispersal of young and low adult mobility).
Notopeplum translucidum	possibly 12, 13, possibly 14 (if aggregation occurs), 16, 17, 18, 21, 33	DD, possibly NT	A relatively small volute shell found in SA and south-western WA, in exposed habitats from 10m to about 180m deep. Collected in WA for the shell trade, and it is not known if low number of collected specimens reflects uncommonness of the shell, or low collecting effort due to low demand / low prices. More information is required about distribution, relative abundance, depth range, or commercial and recreational collecting effort in SA. In an assessment of molluscs in the shell trade that are vulnerable to over-exploitation, Ponder and Grayson (1998) classified this species as category "B" in WA and "C" in SA. Potentially vulnerable to over-exploitation due to commercial value, and life history traits (possible aggregation at spawning time as occurs in related species, direct development of young, low dispersal of young and low adult mobility).

Genus & Species (Alphabetical Order)	Vulnerable Characteristics (Codes from Table 3)	IUCN Category & Criteria	Rationale
Notovoluta kreuslerae	possibly 12, 13, possibly 14 (if aggregation occurs), 16, 17, 18, 21, 33, possibly 34 (larger specimens)	DD	A moderate sized volute that ranges from about Cape Otway in western Victoria through to southern WA. Collected commercially in SA and WA in low numbers (see section above, on Volutidae). In an assessment of molluscs in the shell trade that are vulnerable to over-exploitation, Ponder and Grayson (1998) classified this species as category "D" in all States. More information is required about distribution, relative abundance, depth range, or commercial and recreational collecting effort in SA. Potentially vulnerable to over-exploitation due to commercial value, and life history traits (possible aggregation at spawning time as occurs in related species, direct development of young, low dispersal of young and low adult mobility).
Notovoluta verconis	possibly 12, 13, possibly 14 (if aggregation occurs), 16, 17, 18, 21, 33	DD	A small volute which occurs in WA and SA (ranging in the latter state from GAB through to at least upper South East). Found amongst sponges (and corals, in some parts of the range) between 20m and more than 190m deep. Most records are from less than 40m deep. Mainly low to moderate value in the shell market, except for albino and gem quality specimens, which are of moderate and increasing value. In SA, taken in low numbers by a commercial collector (e.g. 4 specimens reportedly collected between July 2001 and June 2002: PIRSA 2004). Potentially vulnerable to over-exploitation due to high commercial value, and life history traits (possible aggregation at spawning time as occurs in related species, direct development of young, low dispersal of young and low adult mobility). More information required about distribution, relative abundance and depth range in SA, and commercial collecting effort.
Nymphon conirostrum	15, 16, 17, 21, 26, possibly 27, 28	DD	A sea spider known only from the type locality, but full geographic distribution and depth range not known due to lack of survey effort.
Octopus superciliosus	possibly 8, 16, 17, 18, 21, 29	DD	The Frilled Pygmy Octopus has a broad distribution (TAS, VIC and SA) and relatively broad depth range (so far known from 0m – 70m). Mostly known from VIC, but there are a few records in GSV and GAB in SA. Found in a variety of habitats (sand, mud, seagrass blades and roots, macroalgae, shell bottom), but this benthic-living species has a strong site association, and females produce large, benthic eggs that become bottom-living young, hence dispersal is limited. Although reproduction in this species is unstudied, cephalopods normally reproduce only once per lifetime May be vulnerable to trawl impacts in some areas (majority of specimens have come from trawls).
Opalia (Nodiscala) subcrassa	17, 21, possibly 24 and 25, possibly 26, possibly 27, 28	DD	A wentletrap shell, possibly endemic within SA, if *Opalia* (*Nodiscala*) *apostolorum* (Iredale, 1936) from NSW is not the same species. Full distribution and depth range are not known. Known mainly from the holotype. In the Wentletrap family, members of which have specific habitat needs (ecto-parasitic on sea anemones, corals or zoanthids).

Genus & Species (Alphabetical Order)	Vulnerable Characteristics (Codes from Table 3)	IUCN Category & Criteria	Rationale
Ophiacantha shepherdi	possibly 15 and 16 (uncertain), 21, possibly 24 and 25	DD	An uncommon brittlestar that has been recorded from Victoria and South Australia (GFSV, and Encounter Bay). The depth range may be from 1m to at least 25m deep, according to records. A number of temperate brittlestars brood the young, but reproductive mode in this species requires research. Its status in SA in uncertain due to lack of knowledge of full distribution and population sizes in this State.
Ophiocomina australis	possibly 15 and 16 (uncertain), 21, possibly 24 and 25, 31	DD	A small (12mm) brittlestar known from Bass Strait in Victoria, and from the SA gulfs region and Kangaroo Island. Known from *Posidonia* and *Heterozostera* seagrass beds, with records ranging from 1m to 20m deep. Listed as a threatened species in Victoria, and considered vulnerable due to reliance on embayments, and population vulnerability in areas of seagrass dieback. Occurs in shallow seagrass beds, a habitat type at risk across much of southern Australia, due to coastal pollution (e.g. eutrophication & sedimentation), coastal development, & possible future impacts from sea level rise & ocean acidification. However, this species has a relatively broad distribution in south-eastern Australia, and is not uncommon. Its status in SA in uncertain due to lack of knowledge of full distribution and population sizes in this State. A number of temperate brittlestars brood the young, but reproductive mode in this species requires research.
Onithochiton ashbyi	possibly 16, 17, possibly 18, 21, possibly 24 and 25, possibly 26, possibly 27	DD, possibly R	A chiton reported to date only from the SA gulfs coast, mainly metropolitan GSV & upper Fleurieu. Very little information about full distribution, depth range or relative abundance.
Pallenoides stylirostrum	15, 16, 17, 21, possibly 28	DD	A sea spider known from few locations in Victoria and SA, and considered to be an uncommon species. Full geographic distribution and depth range not known due to lack of targetted sampling.
Parapallene gowlettae	15, 16, 17, 21, 26	DD	A sea spider known only from type locality, but full geographic distribution and depth range not known due to lack of survey effort. Possibly more widespread than the few records indicate.
Pentocnus bursatus	possibly 15 and 16, 17, 21, 24 and 25, possibly 27, 31	DD or NT	A small (15mm), brooding sea cucumber known from few records in Victoria and WA, and one record from south-eastern SA (not in AMLR NRM region). Listed as a threatened species in Victoria. Occurs amongst algal tufts and sponge in intertidal and shallow subtidal (0m – 4m) rocky habitats, in moderately exposed, well flushed areas. This species might be susceptible to localised habitat damage, marine pollution, marine pests, and future impacts from global warming.
Periclimenes carinidactylus	17, 21, possibly 24 and 25, possibly 27, possibly 28	DD	A shrimp species with an apparent disjunct distribution, probably uncommon in SA, but more common in NSW. Known from a narrow depth range. Lives on reefs, commensally on the crinoid *Comanthus trichoptera*, and is known from few confirmed specimens.

Genus & Species (Alphabetical Order)	Vulnerable Characteristics (Codes from Table 3)	IUCN Category & Criteria	Rationale
Philinopsis troubridgensis	17, 21, possibly 24 and 25, possibly 26, 31 (in part), 34	DD	A large (to 10cm) sea slug that is known from the South Australian gulfs, and there are also unconfirmed records from WA. Associated with seagrass beds, but not exclusively. Shallow seagrass is a habitat type at risk across much of southern Australia, due to coastal pollution (e.g. eutrophication & sedimentation), coastal development, & possible future impacts from sea level rise & ocean acidification. The full distribution and relative abundance of this species are not known.
Polyandrocarpa simulans	21, possibly 24 and 25	DD	A possibly endemic ascidian known to date from several locations, ranging from the eastern GAB (St Francis I.) through to Investigator Strait, south of Foul Bay on Yorke Peninsula. Type was collected at 23m. Full distribution, depth range and relative abundance within SA are not known.
Polycitorobeliscus / obeliscum	21, possibly 24 and 25, possibly 26, possibly 27	DD	A possibly endemic ascidian known to date from the type locality in Investigator Strait, at 23m. Full distribution, depth range and relative abundance within SA are not known.
Polysyncraton pedunculatum	21, possibly 24 and 25	DD	A possibly endemic ascidian known to date from several locations, ranging from Nuyts Archipelago in the eastern GAB to Kangaroo Island, between 5m and 20m. Full distribution, depth range and relative abundance within SA are not known.
Polysyncraton rica	21, possibly 24 and 25	DD	A possibly endemic ascidian known to date from several locations, ranging from Investigator Group islands in the eastern GAB to Kangaroo Island, between 5m and 25m. Full distribution, depth range and relative abundance within SA are not known.
Polysyncraton tegetum	21, possibly 24 and 25	DD	A possibly endemic ascidian known to date from several locations, ranging from Great Australian Bight (32°4'S, 133°30'E) to Kangaroo I., and including SA gulfs coast but specific published records are lacking. Full distribution, depth range and relative abundance within SA are not known.
Primovula / Cuspivolva heleneae	possibly 15, 16, 17, 18, 21, possibly 24 and 25, possibly 26, possibly 27, 28, 31, 33	DD or NT, R	An egg cowrie / allied cowrie, possibly endemic within SA. Known from very few records (in southern GSV and northern SG), from very specific habitat (*Euplexaura* coral in areas of strong water movement, which is a rare micro-habitat in South Australia). Full geographic distribution and depth range not known due to lack of targetted sampling. Moderate value in the shell market.
Primovula cruenta	possibly 15, 16, 17, 18, 21, possibly 24 and 25, possibly 26, possibly 27, 28, 31, possibly 33	DD or NT, R	An egg cowrie / allied cowrie, possibly endemic within SA. Presence in AMLR NRM uncertain, as it has been recorded so far only from northern Spencer Gulf. Known from very few records, from very specific habitats (*Echinogorgia* coral, which is a rare micro-habitat in South Australia). Full geographic distribution and depth range not known due to lack of targetted sampling. Possibly moderate value in the shell market (based on sales of similar species from SA such as *P. helenae*).

Genus & Species (Alphabetical Order)	Vulnerable Characteristics (Codes from Table 3)	IUCN Category & Criteria	Rationale
Primovula verconi / Crenavolva verconis	possibly 15, 16, 17, 18, 21, possibly 24 and 25, possibly 26 (but unlikely), possibly 28, possibly 33	DD	An egg cowrie / allied cowrie. Presence in AMLR NRM uncertain, as it has been recorded so far from St Francis Island, but might occur more widely in SA, and also southern WA (possibly also Philippines, but might be a closely related species). Full geographic distribution and depth range not known due to lack of targetted sampling. Habitat not recorded, but egg cowries typically closely associated with particular corals, hence have specific habitat requirements. Possibly moderate value in the shell market (based on sales of similar species from SA such as *P. helenae*).
Pseudopallene inflata	15, 16, 17, 21, 26, possibly 27, 28	DD	A sea spider, known only from type locality and one other nearby location, but full geographic distribution and depth range not known due to lack of targetted sampling.
Raeta (*Raeta*) *meridionalis*	17, 21, possibly 24 and 25, possibly 27	DD	A clam, described by Tate in 1889 from a single valve found on the beach at Aldinga. May also be known from Chinaman's Beach in Middle Harbour (Sydney) in NSW (specimens confirmed by Tate). Full distribution (which may be disjunct), depth range and relative abundance not known.
Rostanga sp. 1 (in Rudman 2000)	17, 21, possibly 24 and 25, possibly 26, possibly 27, possibly 28	DD or R	An uncommon sea slug that apparently has been recorded so far only in South Australia. Well camouflaged, and resembles the sponges on which it feeds. It has been recorded uncommonly at Edithburgh in Gulf St Vincent. The full distribution and relative abundance of this unnamed species are not known. May be the same species as "*Discodoris* sp."
Rumptunucula vincentiana	17, 21, possibly 27	DD	A small (3cm) nut shell, recorded to date in sand down to 112m. Known from GSV but might also occur in NSW, and therefore have a disjunct distribution. Full distribution and relative abundance not known.
Sassia (Austrotriton) bassi	21, 22, 33, 34	DD, possibly LR	Broad distribution in south-eastern Australia, but reportedly uncommon and limited distribution in NSW & VIC). Species in the Ranellidae family produce few larvae (most of the laid eggs become a food source for the few viable larvae). Low to moderate value in the shell market.
Scrinium impendens	17, 21, possibly 24 and 25, possibly 26, possibly 27	DD	A gastropod mollusc, for which GSV is the type locality. Very little information, and known from few specimens. Possibly endemic within SA, and possibly narrow depth range, but based on very few specimens. Full distribution and depth range not known.
Semele ada	17, 21, possibly 26, possibly 27	DD	A small bivalve, possibly endemic within SA, but there is little published information about collection locations, other than an old record from "Port Adelaide creek" (North Arm area). Found in rubble, sand and seagrass. Full distribution, depth range and relative abundance not known. Might be more widespread than the few existing records indicate, but overlooked due to its small size, and lack of targetted sampling.
Semicassis (Antephalium) sinuosum	16, 17, 18, 21, 33	DD or R	A helmet shell, considered rare. Occurs in SA and WA but full distribution and relative abundance not known. This specimen shell is taken by diving, and by trawling in deeper waters. Moderate value in the shell market.

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Semicassis adcocki	16, 17, 18, 21, 33	DD	A helmet shell that occurs in VIC, SA and WA but full distribution and relative abundance not known. This specimen shell is taken by diving, and by trawling in deeper waters (to at least 100m). Caught in low numbers in the SA and WA specimen shell fisheries. Moderate value in the shell market (rare forms more costly).
Semipallium / *Notochlamys hallae*	17, 21, possibly 24 and 25, possibly 26, possibly 27, possibly 31, possibly 32	DD, R or NT	A scallop that was described by Cotton in 1960 from specimens at Larg's Bay. Recorded on sand and reefs over a narrow depth range (2m – 15m) on sheltered and moderately exposed coasts. Considered to be rare, and known to date only from the waters of GSV. Full distribution, depth range and relative abundance not known. Smaller than the scallop *Equichlamys bifrons* that is taken by divers for food; not known if *S. hallae* is also taken, as it is similar in appearance to *E. bifrons*. Possibly qualifies as NT due to the limited known distribution, and occurrence in degraded habitats such as the metropolitan coast of GSV.
Sepiadarium sp. (in Norman and Reid 2000, and Gowlett-Holmes 2008)	possibly 8, possibly 16, 17, possibly 18, 21, 24, 25, possibly 26	DD, possibly NT	A small squid, possibly endemic within SA gulfs (and may be common there), but more research on the full distribution and relative abundance is required. Apparently occurs over a narrow depth range. Although reproduction in this species is unstudied, cephalopods normally reproduce only once per lifetime. May qualify as Near Threatened in status if distribution is limited to shallow, SA gulf waters, because waters of both gulfs (particularly the northern ends), are subject to numerous habitat impacts.
"*Staurothyone*" *vercoi* (NB taxonomic revision pending)	possibly 15 and 16, 17, 21, possibly 24 and 25, probably 26, possibly 27	DD or R (possibly VU D2)	An uncommonly recorded and possibly endemic species of sea cucumber, known to date from Glenelg in GSV, plus the unknown location of the holotype. The reported depth range is 0m – 10m. The species is considered rare (Rowe 1982) and appears to be a short-range endemic (O'Hara 2002). There is very little information on this species, and the full distribution and relative abundance in SA are not known. Reproduction not recorded, but it is noted that some species in the family Cucumariidae brood the young. Based on small number of records, may qualify for listing as VU D2, but there have been no targetted searches. May be more abundant and widely distributed than records indicate but easy to overlook, hence DD may be a more appropriate category until more is known of the distribution & relative abundance in SA.
Stenochiton nubilus (previously *Ischnochiton nubilus*)	possibly 16, 17, possibly 18, 21, possibly 24 and 25, possibly 26, possibly 27, possibly 31	DD	A chiton known from various locations in the SA gulfs and eastern GAB. Little information about full distribution, depth range and relative abundance. Occurs in pebble, sand and seagrass habitats, the latter being a habitat type at risk across much of southern Australia, due to coastal pollution (e.g. eutrophication & sedimentation), coastal development, & possible future impacts from sea level rise & ocean acidification.

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Talabrica / *Crassatella carnea*	17, 21, possibly 26, possibly 27	DD	A cockle, possibly endemic within SA, but there is little published information about collection locations, other than Yankalilla Bay. Broad depth range (10m – 364m).
Taringa (previously *Aporodoris*) *merria*	17, 21, possibly 26 (unlikely), possibly 27, possibly 28	DD	A sea slug known from SA (the GAB, and possibly Spencer Gulf). Might also occur in Victoria, but published records are lacking. Feeds on brown encrusting sponges in genus *Clathria* (*Dendrocia*) (Gowlett-Holmes 2008). Full distribution and relative abundance in SA are not known.
Tetraphora mcgilpi	17, 21, possibly 25, possibly 26, possibly 27, 31	DD	Known from few locations in the metropolitan beach area of GSV (now a highly modified habitat, compared with the 19th and early 20th century). There is very little information on this small (4mm) species. Might be more widespread than the few existing records indicate, but overlooked due to its small size, and lack of targetted sampling.
Thelmactis sp. (in Gowlett-Holmes 2008)	21, possibly 24 and 25, possibly 26, possibly 27	DD	A possibly endemic anemone known from SA gulfs and Kangaroo Island over a narrow depth range (1 – 10m) but no targetted surveys have been undertaken, so depth range might be wider. Similarly, full distribution and relative abundance within SA are not known.
Thracia (Thracia) concentrica	17, 21, possibly 26	DD	A possibly endemic bivalve known to date from Backstairs Passage, at 46m (old record, from Verco). Full distribution, depth range and relative abundance within SA are not known.
Thyone nigra (NB taxonomic revision pending)	possibly 15 and 16, 17, 21, possibly 24 and 25, possibly 27, possibly 31	DD	A widespread sea cucumber known from various locations in Tasmania, Victoria, SA (gulfs, and GAB) and WA. Found on soft sediments in seagrass beds (*Zostera*, *Heterozostera*) and in mixed beds with filamentous algae, from 0m to 20m. Reproduction not recorded, but it is noted that some species in the family Phyllophoridae brood the young. Occurs in shallow seagrass beds, a habitat type at risk across much of southern Australia, due to coastal pollution (e.g. eutrophication & sedimentation), coastal development, & possible future impacts from sea level rise & ocean acidification. Listed as a threatened species in Victoria. This species is considered to be vulnerable to: habitat degradation and pollution of seagrass-lined bays; marine pests, and climate change (DSE Victoria, undated).
Tozeuma pavoninum	17, 21, probably 24 and 25, possibly 27, 31, possibly 35	DD, possibly R or NT	An uncommonly recorded hump-baked shrimp with a disjunct distribution, known mainly from Queensland, and the SA gulfs coast. There is also an unverified record from Shark Bay in WA. Has been recorded to date over a narrow depth range (18-24m). There is no information on abundance over the range. Occurs in shallow seagrass beds, a habitat type at risk across much of southern Australia, due to coastal pollution (e.g. eutrophication and sedimentation), coastal development, and possible future impacts from sea level rise and ocean acidification.

Genus & Species (Alphabetical Order)	Vulnerable Characteristics (Codes from Table 3)	IUCN Category & Criteria	Rationale
Tozeuma elongatum	17, 21, possibly 24 and 25, possibly 27, 31, possibly 35	DD, possibly R	An uncommonly recorded hump-baked shrimp known from few records in SA and Victoria. There is little information on abundance over the range (apart from a survey at Portland: Parry et al. 1997), but the species is considered to be uncommon (Edgar 2000) Occurs in shallow seagrass beds, a habitat type at risk across much of southern Australia, due to coastal pollution (e.g. eutrophication and sedimentation), coastal development, and possible future impacts from sea level rise and ocean acidification.
Trididemnum spumosum	21, possibly 24 and 25, possibly 27, possibly 31	DD	A possibly endemic ascidian known to date from SA gulfs, over a narrow depth range (1-5m). Full distribution, depth range and relative abundance within SA are not known. Occurs in shallow seagrass beds, a habitat type at risk across much of southern Australia, due to coastal pollution (e.g. eutrophication and sedimentation), coastal development, and possible future impacts from sea level rise and ocean acidification.
Trochodota shepherdi	possibly 15 and 16, 17, 21, possibly 24 and 25, possibly 27, possibly 31	DD or NT	A sea cucumber known from two locations in Victoria, and from the SA gulfs and Kangaroo Island. Associated with sand and seagrass (*Posidonia*, *Heterozostera*) habitat, and epiphytic macroalgae (e.g. the brown *Lobospira bicuspidata*) on seagrass. The published range is 0m–15m. Reproductive mode uncertain, but it is noted that a number of species in the Chiridotidae brood the young (e.g. McEdward and Miner 2001). Occurs in shallow seagrass beds, a habitat type at risk across much of southern Australia, due to coastal pollution (e.g. eutrophication & sedimentation), coastal development, & possible future impacts from sea level rise & ocean acidification. In Victoria, *T. shepherdi* is known from less than 5 records, in isolated populations, and it is listed as a threatened species in that State, and considered threatened in areas of seagrass decline (O'Hara and Barmby 2000; O'Hara 2002). Its status in South Australia is unclear, because the full distribution within this State is unknown, and no population censuses have been undertaken.
Turbo (Dinassovica) jourdani	21, 24 and 25, possibly 27, 33, 34	DD or NT **#**	A large turban shell, no longer common in SA, but was reported by Verco (1908) to previously be widespread in this State. Still taken in relatively large numbers in WA shell fishery (e.g. 448 specimens between 1999 and 2003).

Genus & Species (Alphabetical Order)	Vulnerable Characteristics (Codes from Table 3)	IUCN Category & Criteria	Rationale
Umbilia armeniaca	13, 16, 17, 18, 21, 27, 31, 33, 34	DD or VU A3d	A highly valuable cowrie which ranges from north coast of Kangaroo Island in SA through to Rottnest I. in WA. Found over a broad depth range, from about 25m deep through to 320m. It is a large species (to about 12.4cm), and occurs as small sub-populations confined in highly localised areas. Less rarely found than in previous decades, due to trawling, which has uncovered previously unknown populations. Apparently absent throughout much of the total range (Edgar 2008). It is highly valued in the international shell market, and is taken by divers; also trawled on the outer shelf (e.g. in south-western WA). Found occasionally in lobster pots, scallop trawls and fish stomachs. In an assessment of molluscs in the shell trade that are vulnerable to over-exploitation, Ponder and Grayson (1998) classified this species as category "A" in SA and WA (and therefore nationally). Potentially vulnerable to over-exploitation due to very high commercial value, presence in trawled areas, and life history traits (direct development of young, low dispersal of young and low adult mobility).
Uniophora nuda	21, possibly 26, 34	DD or LR	A sea star known from various locations in the SA gulfs, Backstairs Passage, Kangaroo Island and possibly Pages Is., between 0m and 60m deep. May be a smooth form of the more widespread *Uniophora granifera.*
Unnamed burrowing anemone in Edwardsiidae (in Gowlett-Holmes 2008)	21, possibly 24 and 25, possibly 26, possibly 27	DD	A burrowing anemone for which genus and species have not been described. Known to date from GSV, but it is uncertain whether this species is endemic within SA. Currently known over a narrow depth range (3m – 20m) but no targetted surveys have been undertaken, so depth range might be wider. Similarly, full distribution and relative abundance within SA are not known.
Unnamed burrowing anemone in Edwardsiidae (in Gowlett-Holmes 2008)	21, possibly 24 and 25, possibly 26, possibly 27	DD	A burrowing anemone for which genus and species have not been described. Known to date from SA gulfs and KI. Currently known over a narrow depth range (1m – 12m) but no targetted surveys have been undertaken, so depth range might be wider. Similarly, full distribution and relative abundance within SA are not known.
Unnamed burrowing anemone in Edwardsiidae (in Gowlett-Holmes 2008)	21, possibly 24 and 25	DD	A burrowing anemone for which genus and species have not been described. Known to date from SA and Victoria. Full distribution, relative abundance and depth range are not known.
Unnamed stinging anemone in Aliciidae (in Gowlett-Holmes 2008)	21, possibly 24 and 25 Possibly 26 (if taxonomically separate from related tropical species)	DD	A stinging anemone for which genus and species have not been described. Known to date from SA gulfs, Kangaroo I. & GAB. Currently known over a narrow depth range (1m – 8m) but no targetted surveys have been undertaken, so depth range might be wider. Similarly, full distribution and relative abundance within SA are not known.

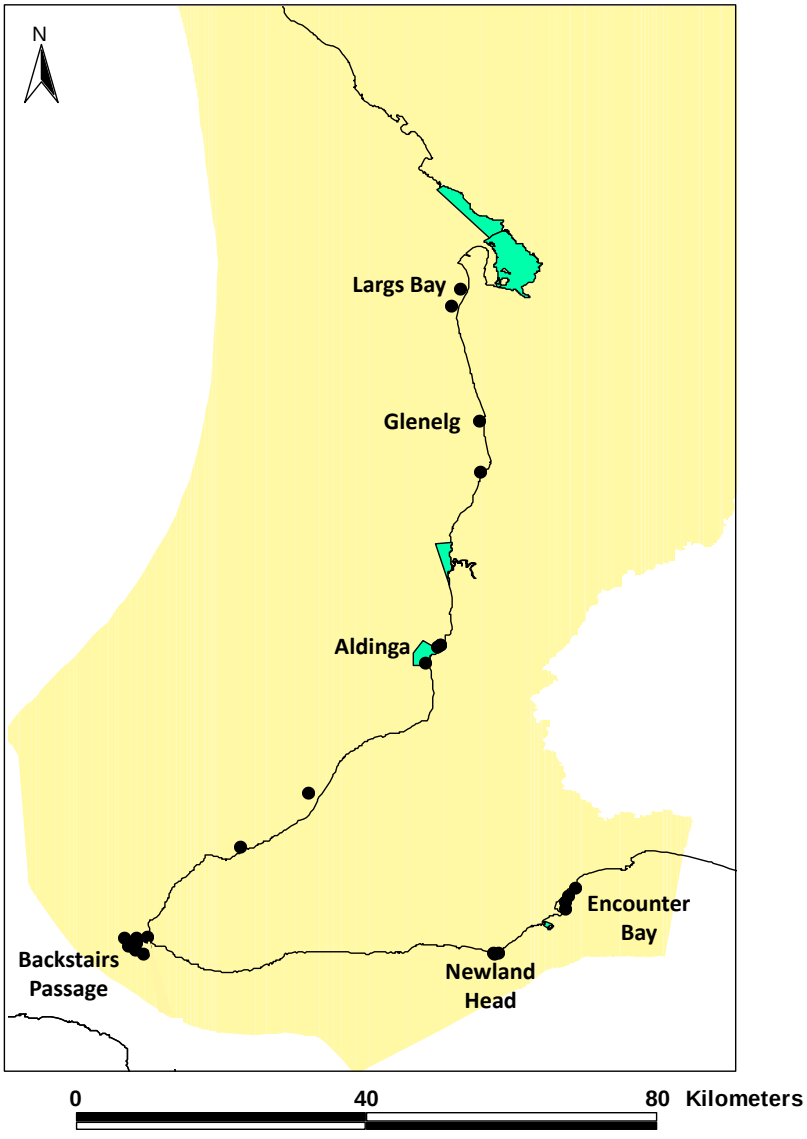
Genus & Species (Alphabetical Order)	Vulnerable Characteristics (Codes from Table 3)	IUCN Category & Criteria	Rationale
Unnamed species in *Phenacovolva*	17, 18, 21, 26, 28, 31, 33	DD	Known from a single record from Fleurieu Peninsula
Unnamed stinging anemone in Aliciidae (in Gowlett-Holmes 2008)	21, possibly 24 and 25, possibly 26 (if taxonomically separate from related tropical species), possibly 27	DD, possibly LC	A stinging anemone for which genus and species have not been described. Known to date from SA gulfs and Kangaroo I., and commonly sighted in some areas. Currently known over a narrow depth range (1m – 8m) but no targetted surveys have been undertaken, so depth range might be wider. Similarly, full distribution and relative abundance within SA are not known.
Unnamed tube anemone in Cerianthidae (in Gowlett-Holmes 2008)	21, possibly 24 and 25, possibly 26, possibly 27	DD	An unnamed, possibly endemic tube anemone known from SA gulfs and northern KI. Currently known over a narrow depth range (2m – 15m) but no targetted surveys have been undertaken, so depth range might be wider. Similarly, full distribution and relative abundance within SA are not known.
(White anemone, for which family, genus and species have not been named: Gowlett-Holmes 2008)	21, possibly 24 and 25, possibly 26, possibly 27	DD	A possibly endemic anemone of uncertain distribution. Known from western SA, but might also occur in SA gulfs and/or Kangaroo Island. Known from a narrow depth range (1–15m) but no targetted surveys have been undertaken, so depth range might be wider. Similarly, full distribution and relative abundance within SA are not known.
Vasum (Altivasum) flindersi	13, 16, 17, 18, 21, possibly 27, 33, 34	DD or NT	A vase shell. There are no published records from AMLR NRM region, but this specimen shell occurs in other parts of SA (and WA). Full distribution and relative abundance not known. Due to its membership within the family Turbinellidae, highly likely to reproduce by direct development of young (from benthic egg capsules laid by the parent), and therefore limited dispersal ability. A large, conspicuous shell that is widely traded in the commercial shell market, with deeper water spiny forms the most valuable.
Xenophora (Austrophora) flindersi flindersi	probably 13, 16, 17, 18, 21, 25, possibly 26, possibly 27, 33	DD or NT	Presence in AMLR NRM region uncertain. Known to date from western SA and south-western WA, over a narrow depth range in upper shelf waters. Unusual appearance and habits for a shell (see section above, on Prosobranchs). May have direct development of young, with no larval phase, which restricts dispersal ability and increased potential vulnerability of local population to decline. Also traded in the commercial shell market (low to moderate value).
Zalasius australis	17, 21, possibly 24 and 25, possibly 26 (unlikely), possibly 27	DD, possibly R	A small (18mm) crab, known to date from the gulfs region in South Australia, and is rarely recorded. It was previously known as *Trichia australis* or *T. dromiaeformis australis*. Might not be endemic, based on discussion of the type (Guinot 1976), and more recent reports of its occurrence in Madagascar (Serene and Crosnier 1984), but Poore (2004) listed this species as occurring only in South Australia. Small, and would be easily overlooked unless specifically searched for in targetted surveys, which have not occurred.

Genus & Species (Alphabetical Order)	Vulnerable Characteristics (Codes from Table 3)	IUCN Category & Criteria	Rationale
Zoila friendii thersites	13, 16, 17, 18, 21, 27, possibly 29, 31, 33, 34	DD or NT	A cowrie which ranges from approximately Apollo Bay in western Victoria through to Point Fowler in western SA. There are records from reefs across South Australia, over a broad depth range (2m to more than 50m deep, with the "contraria" form extending to 100m - 300m. Mainly found in association with sponges. Hand-collected by divers (e.g. 20-45m+), and also trawled, and sold in the shell trade. Apparently still relatively abundant in some less accessible areas area, but over-collected in others, with consequent habitat damage to sponge beds. In SA, there is a recreational bag limit of 1 per day. More information is required on current distribution in SA, and relative abundance. In an assessment of molluscs in the shell trade that are vulnerable to over-exploitation, Ponder and Grayson (1998) classified this species as category "C" nationally. In Victoria, O'Hara and Barmby (2000) classified it as being vulnerability category "B" in that State, using Ponder and Grayson's criteria. Potentially vulnerable to over-exploitation due to commercial value, popularity with recreational collectors, ease of collection in some areas, and life history traits (direct development of young, low dispersal of young and low adult mobility).
Zoila marginata marginata	13, 16, 17, 18, 21, probably 27, 28, 31, 33, 34, probably 35	DD, possibly VU A3d	A subspecies of the cowrie *Z. marginata*, which is found in WA and SA. Z. *marginata marginata* is known mostly from the lower west and south-west coast of WA, between Jurien Bay and Israelite Bay. However, genetics data (e.g. Florida Museum of Natural History) indicates a possible extension to Kangaroo Island in SA. There are a few locations in SA where *Z. marginata marginata* has been recorded to date. It occurs on reefs with *Geodia* sponges; often in caves and crevices, over a relatively broad depth range (5m to 100m). This cowrie has a very specific food source (*Geodia* sponges). Moderate value in the shell market, with specimens ranging from tens to hundreds of dollars. More information is required on current distribution in SA, and relative abundance. In an assessment of molluscs in the shell trade that are vulnerable to over-exploitation, Ponder and Grayson (1998) classified this species as category "C" nationally, "B" in WA (and also nationally for the form "*consueta*", and "D" in SA". Potentially vulnerable to over-exploitation due to commercial value, popularity with recreational collectors, ease of collection in some areas, and life history traits (direct development of young, low dispersal of young and low adult mobility).

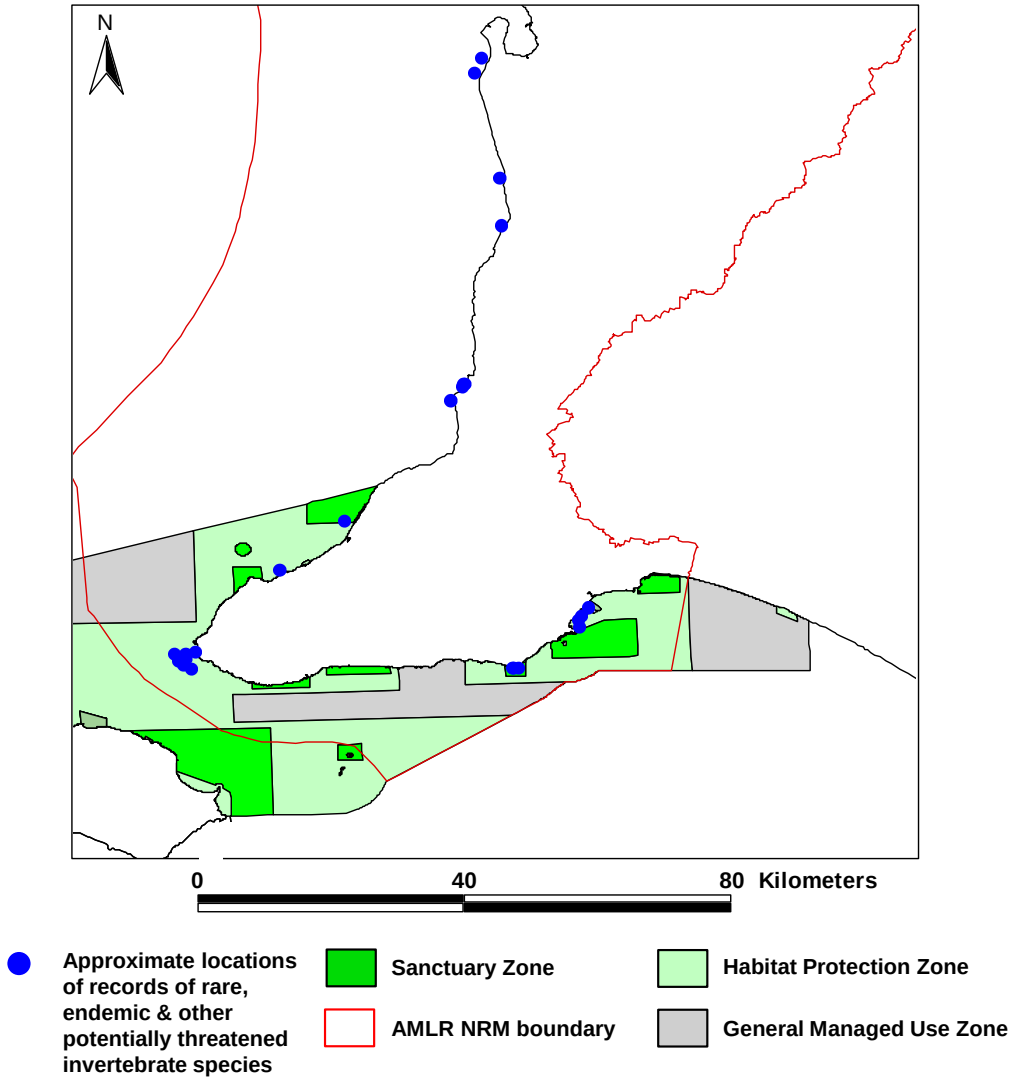
Genus & Species (Alphabetical Order)	Vulnerable Characteristics (Codes from Table 3)	IUCN Category & Criteria	Rationale
Zoila marginata orientalis	13, 16, 17, 18, 21, possibly 24 and 25, 26, 27, 31, 33, 34, probably 35	DD, possibly VU A3d	A subspecies of the cowrie *Z. marginata*, which is found in WA and SA. *Zoila marginata orientalis* is known to date only from SA, between Encounter Bay and the head of the GAB. Occurs on exposed reef (including in crevices) with the host sponge *Trachycladus laevispirulifer*, and also on reefs with red and brown macroalgae. In deeper waters it occurs in mixed habitat of sand, limestone or sandstone rubble, algae, sponges and gorgonian corals, often in high tidal flow environments, and does not extend into calmer gulf waters. The known depth range of the *marginata orientalis* form is relatively narrow (5m – 60+), but overall, *Z. marginata* all its forms has a broader range (5m and 200m). In dive-able depths, *Z. marginata orientalis* occurs as a series of largely disconnected populations, mostly around islands, and rarely off the mainland coast of SA. Due to limited collecting (perhaps due to its existence in largely inaccessible habitat) and therefore limited market supply, *Zoila marginata orientalis* is highly valued in the international shell trade. Taken by fish trawls in the GAB (more than 50m deep 50m), and is also hand-collected in SA, including occasional collecting by abalone divers, and previous collecting by one commercial licensed diver for the shell trade. Potentially vulnerable to over-exploitation due to commercial value, limited distribution, and life history traits (direct development of young, low dispersal of young and low adult mobility).

8. Summary of Information Gaps

The map below provides examples of approximate locations in AMLR NRM region where species from **Table 25**, for which proposed category of threat is higher than DD or LR (i.e. NT or VU), have been recorded.
A number of uncommon and/or potentially threatened mollusc species are known from the Backstairs Passage area (**Map 7**), due to the dredging work of Sir Joseph Verco from the late 19th century to early 20th century, particularly between 30m and 40m deep. Invertebrate collecting efforts during that period were also concentrated in Encounter Bay, Newland Head, and parts of the metropolitan and southern coast of GSV, including locations such as Glenelg, and Aldinga. A number of rare and/or endemic invertebrates have been recorded in the vicinity of the Aldinga Aquatic Reserve. More recent surveys, mainly to assess species composition and relative abundance of common marine invertebrates at various sites around SA, are discussed in the **Introduction** (section **1**).



Map 7: Examples of approximate locations in AMLR NRM region where species from Table 25 for which proposed category of threat is higher than DD or LR (i.e. NT or VU) have been recorded. Note that geo-coordinates are not available for a number of species for which published locations of specimens are indistinct (e.g. "GSV, or "southern end of GSV"), and thus those locations are not mapped here. Approximate, rather than exact, locations of various type specimens and other records are shown here. Locations of specimens of species in *Zoila* are not provided here, due to the vulnerability of these species to over-collecting in shallow waters. Locations in Backstairs Passage shown here are approximate only. Locations of Aquatic Reserves (green polygons) are also indicated.



Map 8: Locations of invertebrate records as for Map 7, presented as an overlay on the proposed zones of the Encounter Marine Protected Area.

Similar to **Map 7**, **Map 8** shows the locations of species from **Table 25**, for which proposed category of threat is higher than DD or LR (i.e. NT or VU), in comparison with zoning of the proposed, multi-zone Encounter Marine Park. Of the 24 geo-referenced records available, 16 occur inside the perimeter of this park. Of those 16, 7 records occur in or directly adjacent to Sanctuary Zones (three of these at Newland Head), or at the boundary of those zones. Note that there are various species for which VU or NT listing may be appropriate, but no geo-referenced records exist. Also there are species for which exact location data exist (and hence geo-referenced records can be made), but Data Deficient may be a suitable conservation status category (see **Table 25**), hence they are not mapped here.

As shown in this report, little is known of the current distribution and local abundance of many apparently uncommon or rare marine invertebrates, including a number of SA endemic species, because

(i) few areas have been comprehensively surveyed (and previous surveys were not targetted towards finding rare or endemic species) hence there are substantial gaps in survey and collecting effort for numerous areas;

(ii) the inability to compare “like with like”, because records are an amalgamation of data using different sampling techniques, variable survey or collecting intensity per area, and different time scales (ranging from the present back to more than 100 years);

(iii) the majority of such species are known from few specimen records, some of which date back to the early or mid 20th century;

(iv) many possibly rare and/or endemic invertebrate species live in cryptic and under-surveyed habitats, such as the underside of boulders. For other species, such as various specimen shells, published location data are scarce and often confidential, to discourage illegal collecting. For many parts of the AMLR NRM region, little is known of the rare and endemic invertebrate fauna. Examples include the northern metropolitan coast (between Glenelg and Largs, a highly modified area), southern metropolitan coast (e.g. Hallett Cove to Christies area), parts of the Fleurieu (e.g. Sellicks, Myponga, Carrickalinga, Normanville, Second Valley, Rapid Bay / Rapid Head area and southwards), the coast east of Cape Jervis (including Tunkalilla and Waitpinga, through to Newland Head), and much of Encounter Bay.

Many invertebrate species may be considered rare or data deficient, based on the paucity of records. A high but currently unquantifiable number of the apparently rare species are likely to be more widespread but have not yet been sampled due to their small size and/or cryptic habits. Without substantial survey and collecting effort, it is not possible to determine true "rarity" over any spatial scale, or to produce reliable systematic maps of the range of various invertebrate species, such as those discussed in this report. Such maps and reliable assessments of abundance are required for robust diversity analyses (e.g. Whittaker 2005).

This report has provided some indication of the locations of currently known rare, endemic and other potentially threatened species in the AMLR NRM region, based mainly on historical records from early collections, supplemented by available survey data, and trade data for commercially valuable species. Many gaps in terms of species distributions and adequate sampling across the region are evident. More field research is required, based on careful observation, collection and macro-photography. Additionally, further conservation status assessment (including a Statewide assessment) is required. A comprehensive description of the true biodiversity, biogeography and value of marine invertebrates in South Australia cannot be undertaken without considering the rare, endemic and other potentially threatened invertebrates. These species deserve more emphasis, because invertebrate studies to date have focussed on the common intertidal and shallow subtidal invertebrates, and commercially valuable species for food or medical applications.

9. Summary of Recommendations

- Continued assistance for watercourse improvement and land management. This includes continued restoration and management of rivers and land upstream to stop erosion and reduce the amount of sediment and nutrients that enters rivers and creeks (and thus ends up on coastal reefs and seagrass beds), particularly during peak load times as occurs after major storms.

- Building of settlement or sediment ponds to reduce the amount of stormwater reaching the sea;

- Continued treatment and recycling of wastewaters on land, and reduction of effluent-rich flows to the sea.

- Long-term and regular water quality monitoring to improve coastal water quality and the condition of marine and coastal habitats, as is currently occurring with the AMLR NRM Board's monitoring and report card program.

- Where possible, particular protection of existing Aquatic Reserves and proposed Sanctuary Zones of marine parks from physical impacts, nutrient enrichment, and sedimentation, especially those which are known to provide habitat for apparently endemic / limited range species of invertebrates. Examples include the Aldinga Aquatic Reserve, and proposed sanctuary zones in and around Encounter Bay (e.g. Newland Head).

- Target studies to determine the current distribution and relative abundance of species known only from very few records (particularly old records from the late 19th and early 20th century). In some cases only a single specimen has ever been collected. Many of these species are small and inconspicuous, and require trained taxonomists for their precise identification.

- Undertake surveys to better determine the composition, distribution and abundance of South Australian rare and endemic species from key invertebrate groups, particularly in and adjacent to Aquatic Reserves and proposed MPA sanctuary zones; also in data-poor areas (as discussed in section **8**), and in port areas, boat harbours and metropolitan bays (and other highly modified areas where threatening processes exist).

- Specialised training of marine scientific officers in government, and volunteer divers, to identify rare, endemic and other invertebrates of conservation concern, at sites across the AMLR NRM region (see examples in point above). Training should also include improved sample preparation techniques so that, once collected, specimens are properly preserved for expert taxonomic analysis.

- Protect calcareous invertebrates that currently exists in and around AMLR NRM, from additional anthropogenic stresses such as physical damage (e.g. from boats, anchors, dredging etc), sediment smothering, and nutrient enrichment. Such protection may help calcareous organisms to persist longer in the face of ongoing stresses which are harder to control, such as ocean acidification from climate change.

- Establishment of a reliable and sensitive monitoring program for Aquatic Reserves and sanctuary zones of Marine Parks, to determine the composition of invertebrate fauna (including rare and endemic species), and provide baseline data to assist in detecting change over time due to local and global stressors.

- Further assessment of the conservation status of marine invertebrates in South Australia, particularly a Statewide assessment (as recommended in the SA Government's 2007 *No Species Loss* nature conservation strategy).

- Following a Statewide assessment (see above), consideration of listings under the schedules of the *SA National Parks and Wildlife Act* or other suitable legislation. Complimentary to listing would be the development of regional and local conservation strategies. Recovery plans may also be required in future - for example, in the case of some exploited species such as specimen shells.

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