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Introduced marine species in South Australia: a review of records and distribution mapping

Kathryn Wiltshire, Keith Rowling and Marty Deveney

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Government of South Australia

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LIST OF ABBREVIATIONS

The following abbreviations are used throughout the text.

Institutions, Government departments and other sources (*former name or no longer active):

Abbreviation	Description
ABRS	Australian Biological Resources Study
AFD	Australian Faunal Directory
AM	Australian Museum
AMBS	Australian Museum Business Services
AVH	Australia's Virtual Herbarium
CCSA	Conservation Council of South Australia
CCSA	Conservation Council of South Australia
CRIMP	Centre for Research on Introduced Marine Pests*
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAFF	Australian Government Department for Agriculture Fisheries and Forestry
DEHAA	South Australian Department for Environment, Heritage and Aboriginal Affairs*
EP NRM	Eyre Peninsula Natural Resource Management board
EPA	South Australian Environmental Protection Agency
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
KI NRM	Kangaroo Island Natural Resource Management board
MAFRI	Marine And Freshwater Research Institute*
MAGNT	Museum and Art Gallery of the Northern Territory
MV	Museum Victoria
NHNSW	National Herbarium of New South Wales
NIMPIS	National Introduced Marine Pests Information Service
NPSD	National Port Surveys Database
OZCAM	Online Zoological Collections of Australian Museums
PIRSA	Primary Industries and Resources South Australia
SAM	South Australian Museum
SARDI	South Australian Research and Development Institute
SASQAP	South Australian Shellfish Quality Assurance Program
SHSA	State Herbarium of South Australia
TH	Tasmanian Herbarium
TMAG	Tasmanian Museum and Art Gallery
WAH	Western Australian Herbarium
WAM	Western Australian Museum
WoRMS	World Register of Marine Species

Geographical terms:

Abbreviation	Description
GAB	Great Australian Bight
GSV	Gulf St Vincent
KI	Kangaroo Island
N,S,E,W	North, South, East, West
NSW	New South Wales
PPB	Port Phillip Bay, Victoria
RSAYS	Royal South Australian Yacht Squadron (Marina at Outer Harbor)
SA	South Australia
USA	United States of America
WA	Western Australia

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The cover photograph of *Sabella spallanzanii* on the hull of a yacht in Wirrina marina was kindly provided by KI NRM.

EXECUTIVE SUMMARY

Knowledge of the distribution of introduced marine species is important for understanding when a range extension or new incursion has occurred, managing or attempting to eradicate existing pest infestations, assessing risks, and ensuring accurate communication and reporting. No list of introduced marine species that are recorded in SA has been compiled since 1998, and how that list was verified is unclear. Records have not been compiled spatially and the range of many introduced marine species in SA is unknown or unconfirmed.

To address these issues, we:

i) collated records of introduced marine species reported in SA,
ii) located voucher material of introduced marine species that are deposited in collections and other evidence (photographs, published records, unpublished data etc) of occurrences, and
iii) built a GIS-linked database to spatially record South Australian marine introductions.

Not all introduced species included in this report are pests and this review does not analyse or investigate impacts of introduced species in SA. Species on the *National System for the Prevention and Management of Marine Pest Incursions* Monitoring Manual trigger list (trigger list species) are noted and we attempt to clarify each species status as introduced (non-native, probably spread by human activity), cryptogenic (of uncertain origin) or native (but previously reported as introduced). Non-trigger list species may be considered a lower management priority, but we include them here primarily for completeness, and also for clarity because many have been reported in lists of “pest species”. The status of these species may change in the future as knowledge about them improves or their distribution changes.

Ninety nine species, consisting of 62 animals (59 invertebrate, 3 vertebrate), and 37 “algae” (4 protist, 12 chromist, 21 plant) have been reported. These include 13 trigger list species and 36 other probable introduced species. Most of the reported species (50) are best regarded as cryptogenic and 3 are now considered to be native.

Specimens that were collected from SA waters and that have been identified to species exist for 44 of the reported animals, with one further confirmed to occur. Reliable but unconfirmed records exist for a further 6 species, but little to no

supporting evidence could be found for the occurrence of 11 species and it is particularly doubtful that 7 of these occur in SA. A search of the AVH found records from SA for all 30 multicellular algal species reported from SA. The 7 unicellular microalgae are recorded in monitoring carried out by SASQAP and in published literature.

Some species that have been recorded probably did not establish in SA, and the status of many is uncertain. Some previously established species, notably *Carcinus maenas* and *Musculista senhousia*, appear to have declined in numbers and have rarely been recorded recently. Eight of the trigger list species, 11 other introduced species and 30 cryptogenic species are considered established, with 1, 2, and 4 additional species in each of these categories respectively likely to be present based on recent records.

For each species we present a map of record locations and summarise the type and temporal nature of records, as well as presenting current taxonomic classifications and any further relevant information obtained during the review.

1. INTRODUCTION

In an environment of increased world trade, passenger movement and the threat of climate change, nations face new challenges from pests and diseases (Deveney and Scott 2008). Australia's *National System for the Prevention and Management of Marine Pest Incursions* (the National System) was established to address the threats posed by marine pests. The National System aims to prevent the introduction of new marine pests, respond if new marine pests are introduced, and minimise the spread and impact of marine pests already established in Australia (Commonwealth of Australia 2009). Knowledge of the distribution of introduced marine species is an important factor in achieving these aims, for understanding when a range extension or new incursion has occurred, managing or attempting to eradicate existing pest infestations, assessing risks, and ensuring accurate communication and reporting.

Information on the distribution of introduced marine species in South Australia is lacking. A list of introduced species in SA compiled in 1998 (EPA and DEHAA 1998; Lewis *et al.* 1998) has not been maintained or updated, and it is uncertain what attempt, if any, was made to verify that list. The list was largely based on a preliminary national review (Furlani 1996), which included several inferred or presumed introductions. Species listed as being present do not appear to have been checked against voucher specimens, and the original source of reports is unclear. Records of introduced species in SA, both from this list and other sources, have not been compiled spatially, and many introduced marine species in SA have an unknown or unconfirmed range.

To address these issues, we:

i) collated records of introduced marine species reported in SA,
ii) located voucher material of introduced marine species that are deposited in collections, and other evidence (photographs, published records, unpublished data etc) of occurrence, and
iii) built a GIS-linked database to spatially record South Australian marine introductions.

Not all introduced species covered by this report should be considered pests. Several have not displayed invasive characteristics or established in SA waters. Furthermore, some reported “pest” species are cryptogenic, i.e., it is uncertain whether they were introduced or if Australia is part of their native range, and several reported species

may have been mis-identified. This review does not seek to analyse the impacts or potential impacts of introduced species in SA, but, for species reported as being present, we attempt to classify their incursion type. Species that are included on the current trigger list in the Marine Pest Monitoring Manual (trigger list species) are noted, as these are regarded as species of particular concern (National System for the Prevention and Management of Marine Pest Incursions 2010a, b). Other species are classed as introduced (non-native, probably spread by human activity), cryptogenic (of uncertain origin) or native (previously reported as introduced). Compared to the trigger list species, other introduced species are considered a lower priority for management. We include them for completeness and for clarity, because many have been reported in lists of "pest species", and because the status of these species may change as we gain additional knowledge or their distribution changes.

For each species we provide a map of records (where possible), with a summary of record types and an assessment of their reliability. We also provide information on the temporal nature of records and attempt to clarify which species may be considered established in SA, those that are likely to be present, though not established, those that have occurred only as isolated records, and those that may previously have been established but cannot currently be considered so.

We also provide taxonomic classification and synonyms under which species have been reported in SA.

2. METHODS

2.1. Collation of records

To compile a list of species that have been reported as introduced to SA, several approaches were taken. Firstly, the NIMPIS database was searched using the advanced search "by distribution" option (NIMPIS 2009c) with South Australia selected. Secondly, databases of published literature (Web of Science, Aquatic Science and Fisheries Abstracts) and internet search engines (Google, Scirus) were searched using several combinations of keywords. Keywords used included "pest", "feral", "invasive", "introduced", "exotic", "non-native", "non-indigenous" and "cryptogenic", along with geographical terms such as "South Australia", "SA" and "Adelaide". Finally, institutions including SAM, SHSA, PIRSA Marine Biosecurity and SASQAP, as well as SA Universities and Natural Resource Management boards were approached with a request for information on introduced species that they had

recorded. A number of these institutions also provided additional information on their records including published and unpublished data, and personal communications regarding the location and date of records.

For each species found as being reported as introduced to SA, further information was obtained by conducting searches of databases and search engines as above, using a combination of the species name (and synonyms) and relevant geographical terms. Distribution maps and other information were also obtained from NIMPIS (2009b), AFD (ABRS 2009), WoRMS (Appeltans *et al.* 2009), and AlgaeBase (Guiry and Guiry 2009). For three species we requested queries to be run on the NPSD which has been integrated into the NIMPIS database, now administered by DAFF (McEnnulty *et al.* 2005; Sliwa *et al.* 2006).

To verify reports of physical specimens, the marine invertebrate collection of SAM was searched on the 4th December 2009. For specimens of the species of interest, the collection site and date were recorded, where available. Not all relevant specimens lodged with SAM had been registered to the collection at this time, so we do not report accession numbers. Further information on invertebrate specimens was provided by Thierry Laperousaz and Wolfgang Zeidler, while Terry Bertozzi provided information on SAM specimens of introduced fish species. Collections of other institutions were searched using the OZCAM database, via both the KE EMu data portal (OZCAM 2009) and the Biomaps portal (Australian Museum and Rio Tinto 2009). Not all museums have their full catalogues available through OZCAM, so requests for further information were sent to WAM and TMAG. Details of algal specimens held by Australian herbaria were obtained from the AVH using the South Australian Partnership for Advanced Computing (SAPAC) portal (SAPAC 2009). Data on the occurrence of introduced algae collected by SASQAP were provided by Clinton Wilkinson.

A database of sightings of several introduced (and native) species is maintained by the “Feral or In Peril” program of Reef Watch SA, a community monitoring program for reef health (Reef Watch SA 2009b). This database was consulted, with the location and date of sightings recorded.

All records were collated in a database and classified as one of seven types:

1) Specimen – voucher specimen exists in museum, herbarium or other collection with reliable identification.

2) Published – The species was recorded or collected from SA as reported in peer-reviewed literature or reference text.
3) Photographic – Photographic evidence exists from which the species is identifiable with reasonable to high confidence.
4) Scientific data – records from scientific institutions including reports and unpublished data.
5) Personal communication – direct communication from scientists or institutions.
6) Grey literature – reports from other sources, identification may be by non-experts or is uncertain.
7) Citation – reference to the occurrence of a species without detailed information, or secondary citation.

For the purpose of mapping (see section 2.3), these categories were grouped as followed:

1) Confirmed record (specimen exists)
2) High confidence (published or photographic evidence or scientific data exist)
3) Medium confidence (direct personal communication from credible source, but no corroborating evidence exists)
4) Unconfirmed (grey literature, non-expert communication, uncertain identification or secondary citation only)

Identifications of specimens held by institutions and species names given in publications were accepted in all cases, no attempt was made to check identifications as part of the current review. Where we consider that there may be reason to question the identification of a species, this is discussed in the text.

2.2. Species information

For each species, the following information is given: taxonomic classification, type of incursion, current status in SA, a map of records in SA (where possible) and notes on the nature and temporal occurrence of records.

The validity of scientific names was checked and taxonomic classification determined using WoRMS (Appeltans *et al.* 2009). Additional information provided includes common name (for species where a common name is in frequent use) and synonyms. Synonyms presented are not a complete list for each species, but we include any synonyms encountered during the literature review. Where species have

been reported in SA under a synonym, that name is highlighted in the results with an asterix, with further information given in the species' summary.

Species covered by this report are classed as "trigger list species", "introduced", "cryptogenic", or "native". "Trigger list species" are those listed among the 55 trigger list species in the Marine Pest Monitoring Manual; these are regarded as introduced species of particular concern based on their potential invasiveness and impacts (National System for the Prevention and Management of Marine Pest Incursions 2010a, b). Results for the trigger list species are presented in section 3.2, with results for other species presented in section 3.3. We make no attempt to discuss the impacts or invasive potential of any of the reported species in SA beyond noting those that are trigger list species. Those classed as "introduced" are other species believed to be non-native to SA, and likely to have been spread by human activity. "Cryptogenic" refers to species that have probably been spread by human activity, but their native range, and hence origin, is unknown. This classification is also used for species where identification is uncertain and for species native to other temperate areas of Australia. "Native" refers to species that, although reported previously as introduced or cryptogenic, are now believed to be native to southern Australia. We base our classification of incursion types primarily on information from the literature, but where this is unclear we have classed species as cryptogenic unless it appears highly probable that they are introduced, e.g. recent, isolated records in SA (especially around ports) for species known only from other disjunct locations.

The current status of each species in SA is given as "established", "previously established", "present", "isolated occurrence", "uncertain" or "unconfirmed". Species that evidently have self-sustaining populations in at least one location are classed as "established", while "previously established" refers to species for which there is evidence of a population decline (whether natural or due to eradication measures) and that can no longer be regarded as certainly established, although they may still be present. "Present" refers to species that are known or likely to currently be in SA based on recent records, but are not necessarily established. "Isolated occurrence" designates that the species is confirmed to have occurred, but is not likely to have established or be present now. "Uncertain" is used for species where their previous occurrence is confirmed, but there is insufficient information to determine their current status, and "unconfirmed" refers to species which have been reported but for which records could not be substantiated. Occurrences of a species were accepted as being confirmed only where supported by a museum or herbarium specimens or a

large quantity (> 20) of high confidence (scientific data or published) records. We have only used the classifications “previously established” and “isolated occurrence” where there is a reasonable probability that the species has declined or no longer occurs, e.g., it has not been found by targeted surveys or for a very long period. Where the probability of a species being detected is not high (e.g. bryozoans, hydroids, macroalgae) we do not regard the absence of recent records as evidence of its disappearance.

Due to time constraints, priority was given to researching the occurrence of trigger list species, followed by other species known to be introduced and those specifically recorded on lists of introduced species in SA (EPA and DEHAA 1998; Lewis *et al.* 1998; Edyvane 1999; EPA 2003). Thus, information on the occurrence and current status of some cryptogenic and native species may be incomplete. As we found a large number (>100) of species reported as introduced or possibly introduced to SA (see section 3.1) it was not possible to investigate all reports. We therefore did not investigate species that were reported as “cosmopolitan, possibly introduced” by only a single source. Reports of additional species came to our attention near completion of the project when reference to these was found in material sourced during the investigation of other species, and also due to a recent survey for introduced species on Eyre Peninsula (Dittmann *et al.* 2010). The species that were not reviewed by the current project are discussed briefly in section 3.4 and may require future investigation to verify their occurrence and range.

2.3. Mapping

Records of introduced species were compiled spatially by assigning co-ordinates (latitude, longitude) for each record, where possible. Where the record included accurate positional data this was used, otherwise a nominal position was determined based on the description of the occurrence. Where co-ordinates were provided that did not match the stated location (possibly due to use of a different chart datum or low resolution of positional recording, e.g. only to nearest minute of latitude), the record was also mapped using a nominal position. The nominal position for towns, suburbs, and other localities was taken as a point immediately offshore from that location. For larger towns (e.g. Port Lincoln), where more specific information was provided (e.g. wharf, jetty, marina), these records were assigned with specific co-ordinates. For records where the location as described is a water body (e.g. lake, creek, or bay) or small island, without further specific information, the nominal

location was taken near the centre of the water body or next to the island. Records without sufficient specification of their locality, including those pertaining only to a large area (river, gulf, bioregion, KI), were not mapped but are discussed in the text. Maps are not shown for species where no confirmed or high confidence records were found, or no specific locality information was found for their occurrence.

The Geographic Information Systems (GIS) package ArcView (ver 9.3. ESRI California) was used to produce maps.

For species where maps are provided, all records with positional data are shown. The maps shown for each species include an overall SA map of records and a larger-scale map of the Adelaide metropolitan coast to provide greater resolution of records in this area. In some cases a very large number of records occur within a small area. This does not necessarily indicate a greater density of the species in that area, but may be due to greater sampling effort, e.g. around Port Adelaide. Due to all records being shown, maps may not reflect current distribution, particularly for species that have suffered natural declines or been subject to control or eradication measures. Records of unattached algae are shown, but that these do not necessarily indicate an occurrence at that location, as algal fragments may be carried long distances by tide or currents. The accompanying text should be consulted for information on the temporal nature of records and likely current extent and status of each species. The absence of a record for a particular location should also not be taken as evidence that a species is not present in that area, only that no specific record was found. Where targeted surveys have failed to find a species in a particular area, this is noted in the text.

A map of SA, with insets of 7 regions, showing IMCRA bioregions and the location of major centres and several of the locations named in the text, is provided in Figure 1.

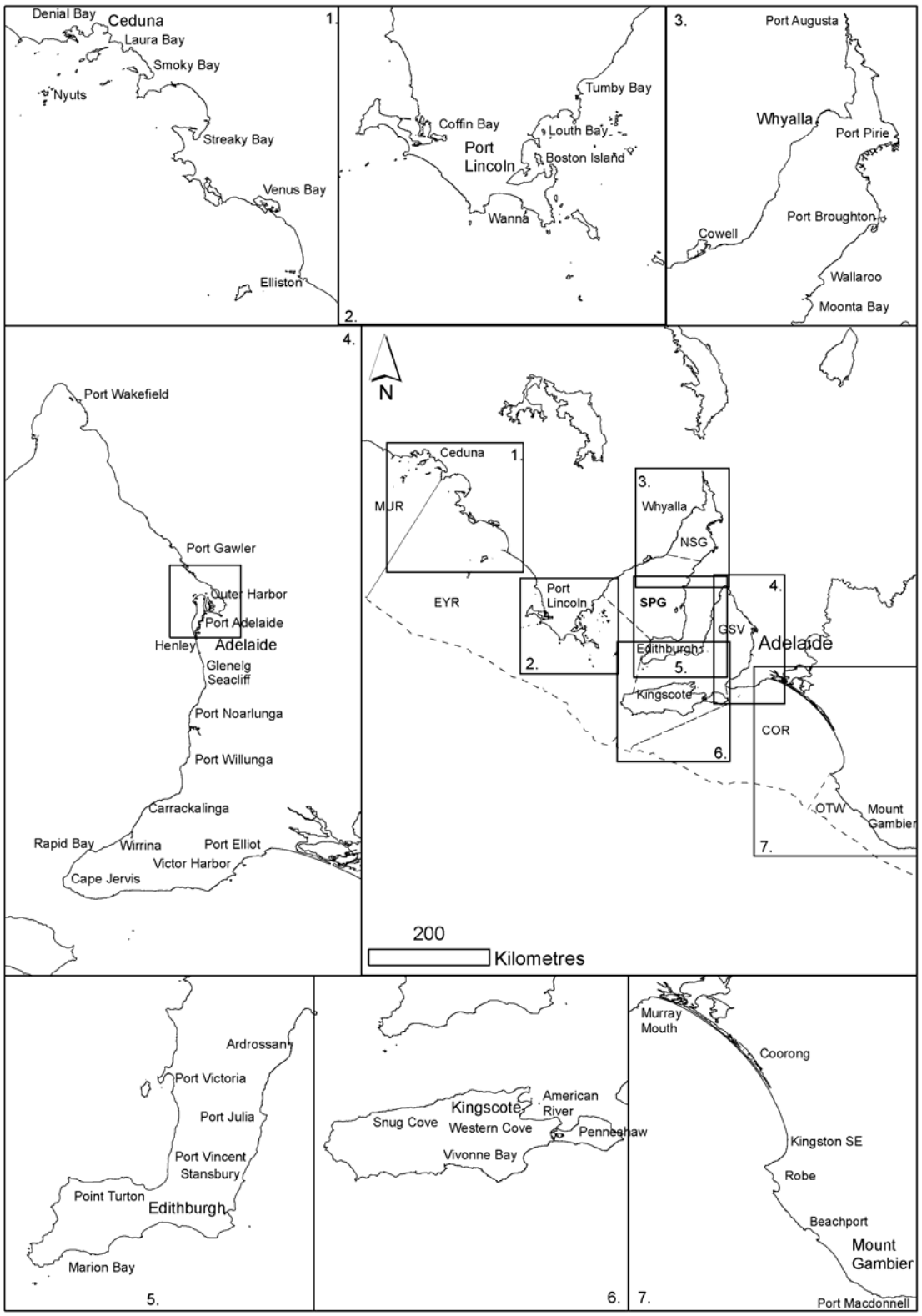

Figure 1. Map of SA, excluding the far west coast region where no records of introduced species were found, with boundaries of IMCRA bioregions and major centres shown, and insets showing further localities within coastal regions: 1. west coast, 2. lower Eyre Peninsula, 3. upper Spencer Gulf, 4. eastern Gulf St Vincent, 5. Yorke Peninsula, 6. Kangaroo Island, and 7. south-east. The Port Adelaide region, defined by the rectangle shown in inset 4, is shown in more detail in Figure 2.

SA waters are covered by 8 IMCRA bioregions: Eucla (EUC), which also extends into WA, Murat (MUR), Eyre (EYR), Spencer Gulf (SPG, elsewhere denoted as SG or SGF), northern Spencer Gulf (NSG), Gulf St Vincent (GSV, elsewhere denoted SVG), Coorong (COR) and Otway (OTW) which extends into Victoria and King Island in Bass Strait, Tasmania (Commonwealth of Australia 2006). The far west coast, including all of the Eucla bioregion and most of the Murat bioregion, is not shown in Figure 1 as no records of introduced species were found west of Denial Bay. Due to the large number of localities for which records were found, it was not possible to show all locations on these small-scale maps. In the text, localities will be referenced to towns or features that are shown in Figure 1 and the nominal co-ordinates used for mapping record locations are given in the Appendix. A detailed map of the Port Adelaide region and surrounds is shown in Figure 2.

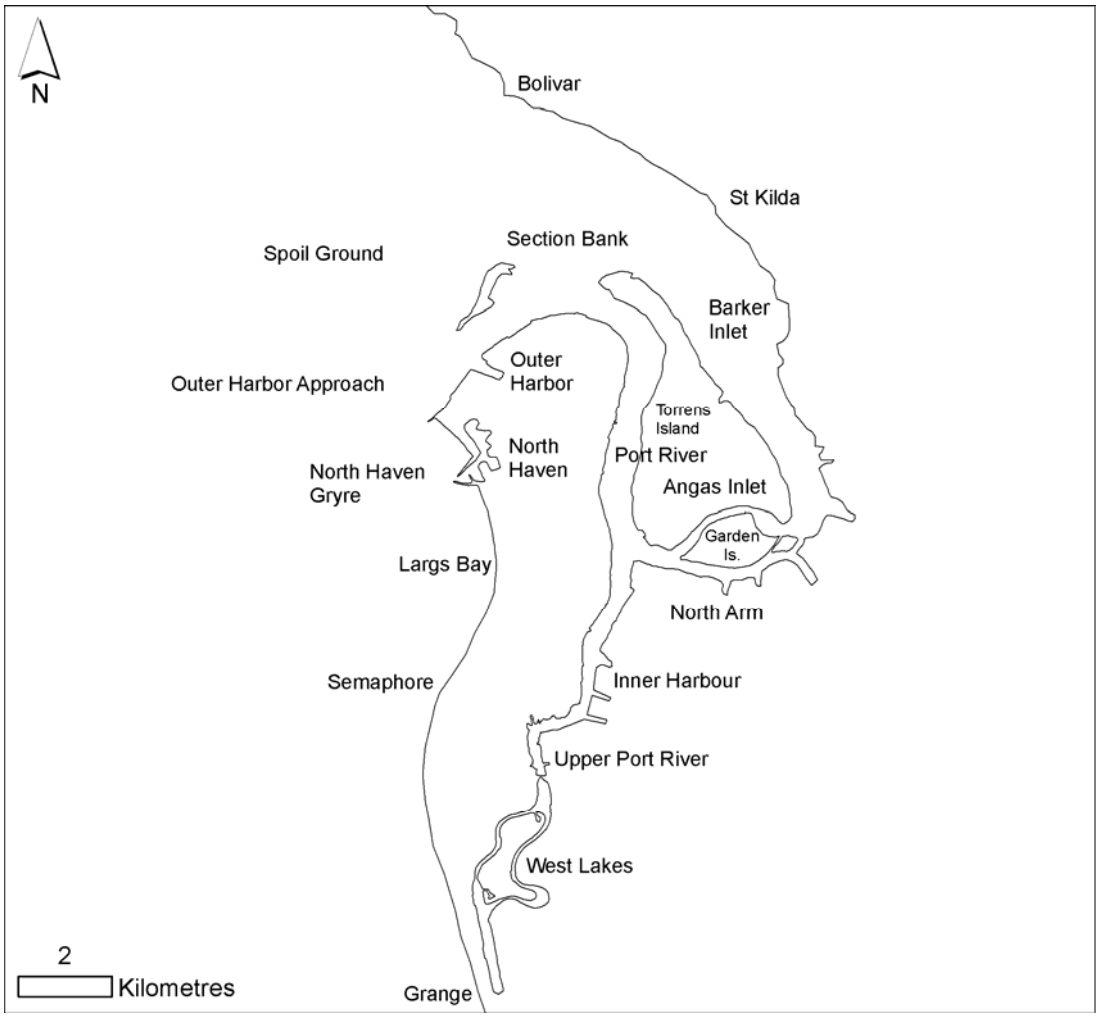

Figure 2. Map of the Port Adelaide region and surrounds.

A database containing all records for which spatial information was available is held by SARDI Aquatic Sciences.

3. RESULTS

3.1. Species reported as being introduced in SA

Ninety nine species, consisting of 62 animals (Kingdom: Animalia) and 37 algae (Kingdoms: Plantae, Chromista and Protocista), were found by the initial stage of the review as being reported to be introduced or possibly introduced in SA (Table 1). Each of these species was investigated further, with results presented in section 3.2 for trigger list species and 3.3 for other species.

The animals reported comprise 59 invertebrates and 3 vertebrates. The invertebrates include 7 Cnidaria (1 Anthozoa, 5 Hydrozoa, 1 Scyphozoa), 9 Annelida (Polychaeta), 13 Arthropoda (Subphylum Crustacea: 11 Malacostraca, 2 Maxillopoda), 10 Mollusca (8 Bivalvia, 2 Gastropoda), 11 Bryozoa, 1 Entoprocta, and 6 Chordata (Ascidiacea). The 3 vertebrates are all fishes (Chordata: Actinopterygii) of the family Gobiidae. The algal species consist of 4 Protocista (Dinomastigota: Dinophyceae), 12 Chromista (Ocrophyta: 3 Rapidophyceae, 8 Phaeophyceae, 1 Xanthophyceae) and 21 Plantae (Chlorophyta: 4 Bryopsidophyceae, 5 Ulvophyceae; Rhodophyta: 12 Florideophyceae) (Table 1).

Lists of species introduced to SA were compiled in 1998-99. Two 1998 publications (EPA and DEHAA 1998; Lewis *et al.* 1998) provide an identical list of 29 introduced species for SA. The same list, with 6 species added, appeared in Edyvane (1999), with a further species *Cirriformia punctata* referred to as introduced in the text. These SA lists were based largely on a 1996 national review of introduced species by CRIMP (Furlani 1996). Furlani (1996) reported 23 introduced species as being in SA (Table 1), although, of these, only 15 were listed as “known” introductions, with the remainder being listed as “inferred” or “presumed”. The 1998 SA list (EPA and DEHAA 1998; Lewis *et al.* 1998) includes 19 of the species shown in SA by Furlani (1996). The 6 species added by Edyvane (1999) are the 4 that had been excluded from the 1998 list, plus 2 species (*Gymnodinium catenatum, Boccardia proboscidea*) shown as occurring in Victoria to the SA border by Furlani (1996)

The 2003 State of the Environment Report for SA (EPA 2003) provides a list of 13 introduced species occurring in the Adelaide region, giving the source as PIRSA; this

list appears to be based on the 1998 list, excluding those species with unknown distributions, and adding one species: *Caulerpa taxifolia*, which was first detected in SA in 2002 (Cheshire *et al.* 2002).

Surveys for introduced marine species in SA are rare. Surveillance has primarily targeted the Port Adelaide region (Cohen *et al.* 2002; Rowling 2009b; Wiltshire and Rowling 2009b) although a survey for introduced species was also conducted at Port Lincoln by CRIMP, in conjunction with Flinders University, in 1996 (Hewitt *et al.* 1997) and a recent survey by Flinders University has been carried out around Eyre Peninsula for the EP NRM (Dittmann *et al.* 2010). The Port Adelaide surveys were conducted by MAFRI in 2001 (Cohen *et al.* 2002) following CRIMP protocols (see below) and by SARDI in 2007-08 (Rowling 2009b) pursuant to the National System (National System for the Prevention and Management of Marine Pest Incursions 2010a, b), with a companion survey of mangrove areas conducted by SARDI in 2009 (Wiltshire and Rowling 2009b).

Several port surveys, including that of Port Lincoln, were carried out around Australia by CRIMP following protocols outlined in Hewitt and Martin (1996). The protocols include a list of target species divided into 3 schedules:

1) Australian Ballast Water Management Advisory Council (ABWMAC) target species,
2) species that pose a threat to Australia, and
3) known or likely introductions to Australia.

Of the species on these lists, 19 are shown as being present in SA (Hewitt and Martin 1996). The CRIMP protocols were also used in surveys undertaken by NSW Fisheries at Port Kembla and Botany Bay (Pollard and Pethebridge 2002a, b), by AMBS in Sydney Harbour (AMBS 2002) and by Aquenal Pty Ltd at Hobart (Aquenal Pty Ltd 2002). Each of these reports also discusses several species not on the schedules that are believed to be introduced, and mentions their occurrence in SA in several cases (see Table 1).

Table 1. List of species reported as introduced or possibly introduced to SA generated from a review of literature and correspondence with relevant institutions.

Y species in SA, ? species possibly in SA (including records that are inferred or presumed), – source lists this species not in SA at the time of publication.

Blank cells indicate the species is not discussed by the source, at least not specifically with respect to SA. Records for these species were investigated with results given in the following sections. Scientific names and taxonomic classifications in this table are currently accepted according to Appeltans *et al*. (2009). Sources given for each species are those found during the initial literature review, additional references for each species are given in the species information section. Sources are (a) personal communications 2009; (b) port surveys Port Lincoln 1996, Port Adelaide 2001, 2007-9; (c) Furlani (1996); (d-g) SA pest lists 1998-2003; (h-k) national port surveys 1996-2002; (l-o) CRIMP/NIMPIS based 2005-2008; (p-q) introduced algae reports 1999-2003. See end of table for full source details and definition of superscripts.

PHYLUM **Class** Order Family *Species name* (*trigger list species)	Sources listing or citing introduced species in SA Y : present, ? : possibly present, – : absent, blank : not discussed																
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q
KINGDOM Animalia																	
CNIDARIA **Anthozoa** Actinaria Haliplanellidae *Haliplanella lineata*		?[1]	?	?	?	?			?								
Hydrozoa Anthoathecata Oceanidae *Cordylophora caspia*										Y		?	Y				
Corynidae *Coryne eximia*		Y[4]											Y				
Leptothecata Haleciidae *Halecium delicatulum*		Y[4]								–			Y				
Halopteridiidae *Antennella secundaria*													Y				
Plumulariidae *Plumularia setacea*													Y	Y			

PHYLUM **Class** Order Family *Species name* (*trigger list species)	Sources listing or citing introduced species in SA Y : present, ? : possibly present, – : absent, blank : not discussed																
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q
CNIDARIA **Scyphozoa** Rhizostomeae Cassiopeidae *Cassiopea ndrosia*		Y[1]		Y	Y	Y	Y										
ANNELIDA **Polychaeta** Phyllodocida Nereididae *Alitta succinea*												Y	–				
Sabellida Sabellidae *Myxicola infundibulum*		Y[1]											Y				
*Sabella spallanzanii**		Y[1,2]	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y			
Serpulidae *Hydroides "elegans"*										–	–		Y	Y			
Spionida Cirratulidae *Cirriformia punctata*						Y											
Spionidae *Boccardia chilensis*									Y								
Boccardia proboscidea			?[1]			?				Y	–	Y	Y				
Polydora "ciliata"			–							–	–	–	Y	Y			
Pseudopolydora paucibranchiata		?[1]	?	?	?	?			Y	–	–	Y	Y	Y			
ARTHROPODA **Malacostraca** Amphipoda Caprellidae *Caprella penantis*		Y[1]													Y[1]		
Corophiidae *Corophium acherusicum*		Y[1]										–	Y	Y			
Corophium insidiosum										Y		Y	Y		Y[1]		

PHYLUM **Class** Order Family *Species name* (*trigger list species)	Sources listing or citing introduced species in SA Y : present, ? : possibly present, – : absent, blank : not discussed																
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q
ARTHROPODA																	
Malacostraca																	
Isopoda																	
Cirolanidae																	
Eurylana arcuata		Y[1]	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y[1]		
Sphaeromatidae																	
Paracerceis sculpta		Y[1]	–						–	–	–		Y	Y			
Sphaeroma quoyanum		Y[1]															
Tanidacea																	
Tanaidae																	
Tanais dulongii				Y	Y	Y		Y	Y	Y	Y						
Decapoda																	
Palaemonidae																	
Palaemon macrodactylus		?[1]	?			?			Y	–	–						
Portunidae																	
*Carcinus maenas**			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y			
*Charybdis japonica**	Y[3]	Y[1]															
Sesarmidae																	
Parasesarma erythodactyla	Y[3]																
Maxillopoda																	
Sessilia																	
Archaeobalanidae																	
Elminius modestus		Y[1]								Y							
Balanidae																	
*Balanus improvisus**								Y		?	?	–					
Megabalanus tintinnabulum			–							–		?	Y				

PHYLUM **Class** Order Family *Species name* (*trigger list species)	Sources listing or citing introduced species in SA Y : present, ? : possibly present, – : absent, blank : not discussed																
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q
MOLLUSCA **Bivalvia** Euheterodonta incertae sedis Semelidae *Theora lubrica*			–						–	Y	–	Y	Y		Y[2]		
Veneridae *Ruditapes largillierti*			–							–	–		Y	Y			
Myoida Teredinidae *Teredo navalis*				?	?	Y						Y	Y	Y			
Mytiloida Mytilidae *Musculista senhousia**		Y[1], –[2]	?			?					–	Y	Y	Y			
Mytilus galloprovincialis			?			?											
Perna canaliculus	Y[3]		–	Y	Y	Y	Y			–	–				Y[2]		
Ostreoida Ostreidae *Crassostrea gigas**	Y[3]	?[1]	?	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y			
Pteroida Pteriidae *Pinctada albina sugillata*	Y[3]																
Gastropoda Nudibranchia Polyceridae *Polycera hedgpethi*			–							–	–		Y				
Sorbeoconcha Turritellidae *Maoricolpus roseus*			Y	Y	Y	Y	Y			Y	–		–				

PHYLUM **Class** Order Family *Species name* (*trigger list species)	Sources listing or citing introduced species in SA Y : present, ? : possibly present, – : absent, blank : not discussed																
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q
BRYOZOA																	
Gymnolaemata																	
Cheilostomatida																	
Bugulidae																	
Bugula flabellata		Y[1]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y[3]		
Bugula neritina		Y[1]	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y[3]		
Candidae																	
Tricellaria occidentalis									Y	Y	Y	Y			Y[3]		
Tricellaria porteri		Y[1]															
Cryptosulidae																	
Cryptosula pallasiana		Y[4]		?	?	Y				Y	Y	Y	Y	Y	Y[3]		
Electridae																	
Conopeum seurati											Y						
Membraniporidae																	
Membranipora membranacea		?[1]	?			?		Y		Y	Y						
Schizoporellidae																	
Schizoporella errata		Y[1]															
Schizoporella unicornis		Y[4],?[1]	?	?	?	?		Y	Y	Y	Y	Y	Y	Y	Y[3]		
Watersiporidae																	
Watersipora arcuata		Y[1]	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y[3]		
Watersipora subtorquata		Y[4]							–	Y	Y	?					
Ctenostomatida																	
Vesiculariidae																	
Zoobotryon verticillatum											Y	Y					
ENTOPROCTA																	
Coloniales																	
Barentsiidae																	
Barentsia benedeni				?	?	?			–			Y	Y	Y			

PHYLUM **Class** Order Family *Species name* (*trigger list species)	Sources listing or citing introduced species in SA Y : present, ? : possibly present, – : absent, blank : not discussed																
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q
CHORDATA																	
Ascidiacea																	
Enterogona																	
Ascidiidae																	
Ascidiella aspersa		Y[1,2]	Y	Y	Y	Y	Y	Y		Y	Y		Y	Y	Y[3]		
Cionidae																	
Ciona intestinalis		Y[1,2]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y[3]		
Pleurogona																	
Styelidae																	
Botrylloides leachi			Y	Y	Y	Y	Y			Y	Y		Y	Y			
Botryllus schlosseri		Y[1]	Y	Y	Y	Y	Y						Y	Y			
Styela clava										–	–	–	Y	Y	–		
Styela plicata		Y[1]	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y			
Actinopterygerii																	
Perciformes																	
Gobiidae																	
Arenigobius frenatus	Y[2]																
Cristatogobius gobioides	Y[2]																
Tridentiger trigonocephalus	Y[2,3]		–														
KINGDOM Protocista																	
DINOMASTIGOTA																	
Dinophyceae																	
Gymnodiniales																	
Gymnodiniaceae																	
*Gymnodinium catenatum**	Y[4]	Y[2,4]	?[1]			Y			Y	Y	–	Y	Y				
Peridiniales																	
Gonyaulacaceae																	
*Alexandrium catenella**	Y[4]	Y[1,2]	–	?	?	?	Y	Y		Y	Y		Y	Y			
*Alexandrium minutum**	Y[4]	Y[1,2]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y			
*Alexandrium tamarense**	Y[4]	Y[1,2]	Y	Y	Y	Y	Y	Y		Y	Y		Y				

PHYLUM **Class** Order Family *Species name* (*trigger list species)	Sources listing or citing introduced species in SA Y : present, ? : possibly present, – : absent, blank : not discussed																
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q
KINGDOM Chromista																	
OCHROPHYTA																	
Raphidophyceae																	
Chattonellales																	
Chattonellaceae																	
Chattonella globosa	Y[4]																
Chattonella marina	Y[4]																
Heterosigma akashiwo	Y[4]																
Phaeophyceae																	
Desmarestiales																	
Arthrocladiaceae																	
Arthrocladia villosa																Y	Y
Discosporangiales																	
Choristocarpaceae																	
Discosporangium mesarthrocarpum				?	?	?		Y		Y	Y					Y	Y
Sphacelariales																	
Sphacelariaceae																	
Sphacella subtilissima				?	?	?		Y		Y	Y					Y	Y
Ectocarpales																	
Acinetosporaceae																	
Hincksia sandriana										Y						Y	
Chordariaceae																	
Elachista orbicularis																Y	Y
Stictyosiphon soriferus																Y	Y
Striaria attenuata																Y	Y
Zosterocarpus sp.				?	?	?		Y		Y	Y						

PHYLUM **Class** Order Family *Species name* (*trigger list species)	Sources listing or citing introduced species in SA Y : present, ? : possibly present, – : absent, blank : not discussed																
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q
OCHROPHYTA **Xanthophyceae** Vaucheriales Vaucheriaceae *Vaucheria piloboloides*																Y	
KINGDOM Plantae																	
CHLOROPHYTA **Bryopsidophyceae** Bryopsidales Bryopsidaceae *Bryopsis plumosa*										Y						Y	
Caulerpaceae *Caulerpa racemosa* var. *cylindracea**		$Y^{2,3}$												Y			Y
*Caulerpa taxifolia**		$Y^{2,3}$	–				Y			–	–		Y	Y			Y
Codiaceae *Codium fragile* ssp. *fragile**		Y^{2}	–						–	–	–	–	–	Y		–	Y
Ulvophyceae Cladophorales Anadyomenaceae *Anadyomene stellata*																	Y
Cladophoraceae *Cladophora prolifera*												Y				Y	
Ulvales Ulvaceae *Ulva fasciata*													Y	Y		Y	
Ulva lactuca		Y^{1}														–	
Ulva taeniata																	Y

PHYLUM **Class** Order Family *Species name* (*trigger list species)	Sources listing or citing introduced species in SA Y : present, ? : possibly present, – : absent, blank : not discussed																
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q
RHODOPHYTA **Florideophyceae** Acrosymphytales Acrosymphytaceae *Acrosymphyton taylorii*																	Y
Ceramiales Ceramiaceae *Antithamnion cruciatum*																Y	Y
Antithamnionella spirographidis												Y				Y	Y
Delesseriaceae *Caloglossa ogasawaraensis*	Y[1]																
Rhodomelaceae *Chondria arcuata*																–	Y
Polysiphonia brodiei		Y[1]	Y	Y	Y	Y	Y			Y		Y				Y	
Sarcomeniaceae *Cottoniella fusiformis*																	Y
Gigartinales Phyllophoraceae *Gymnogongrus crenulatus*												Y				Y	Y
Schottera nicaeënsis										Y		Y				Y	Y
Sarcodiaceae *Trematocarpus affinis*	Y[1]																
Solieriaceae *Solieria filiformis*																	Y
Gracilariales Gracilariaceae *Gracilariopsis "lemaneiformis"*	Y[1]																

Sources for the occurrence of introduced species in SA (see text for further details):
Personal communication:

a. [1] Bob Baldock and C.Fred Gurgel (SHSA), [2] Terry Bertozzi (SAM), [3] John Gilliland and Michael Sierp (PIRSA Marine Biosecurity), [4] Clinton Wilkinson (SASQAP)

Port surveys in SA:

b. Port Adelaide: [1] Cohen *et al.* (2002), [2] Rowling (2009), [3] Wiltshire and Rowling (2009b), Port Lincoln: [4] Hewitt *et al.* (1997)

CRIMP guide to introduced species:

c. Furlani (1996), ?[1]species shown in Victoria to SA border only

Lists of species occurring in SA, based on Furlani (1996), CRIMP, and PIRSA data:

d. EPA and DEHAA (1998)
e. Lewis *et al.* (1998)
f. Edyvane (1999)
g. EPA (2003)

National port surveys reports using CRIMP species schedules:

h. Hewitt and Martin (1996)
i. AMBS (2002)
j. Aquenal Pty Ltd (2002)
k. Pollard and Pethebridge (2002a, b)

National lists of introduced species:

l. Hayes *et al.* (2005)
m. NIMPIS (2009c)

Introduced species in GSV, based on NIMPIS and SARDI data:

n. Westphalen (2008)

Chapters from Hewitt *et al.* (1999) - report on introduced species in PPB and southern Australia:

o. [1] Poore and Storey (1999) [2] Boyd (1999) [3] Keough and Ross (1999)

Introduced macroalgae of southern Australia:

p. Lewis (1999)
q. Womersley (2003) Appendix of possible introduced species

Cohen *et al.* (2002) listed 25 introduced species believed to occur around Port Adelaide. Their survey detected 19 species that were considered introduced or cryptogenic, 8 of which were not on their list of expected species. The SARDI surveys (Rowling 2009b; Wiltshire and Rowling 2009b) targeted only trigger list species (as per National System for the Prevention and Management of Marine Pest Incursions 2010) and no attempt was made to identify all collected organisms to species, although the presence of some non-target introduced (e.g. *Ciona intestinalis*, *Ascidiella aspersa*) and native (e.g. blue swimmer crabs *Portunus pelagicus*) species was noted. In addition to the 2 introduced (non-trigger list) ascidians, these surveys detected 7 target species, all of which were known to occur in the region (Rowling 2009b; Wiltshire and Rowling 2009b).

In a study ranking the risk posed by a number of introduced species, Hayes *et al*. (2005) provide the distributional information on known introduced species by IMCRA bioregion. SA waters are covered by 8 bioregions as described in the Methods (see section 2.3, Figure 1). A total of 31 species are shown as occurring within the relevant bioregions, but 6 are reported only in the Otway bioregion (of the SA bioregions); 1 is stated as occurring in SA, while for 5 the text does not specify whether or not they are recorded from SA (Hayes *et al.* 2005). Two of these 5 are not mentioned elsewhere as occurring in SA so were not included, while the other 3 are shown in Table 1 as possible reports for SA.

The NIMPIS database is a national internet-accessible resource providing information on the ecology and distribution of introduced marine species (NIMPIS 2009a). It was developed by CRIMP and launched in 2002 (Sliwa and Bax 2002). The CRIMP publications website states that NIMPIS should be considered the updated version of Furlani (1996) (CSIRO 2009). NIMPIS was revised in 2005-6 in preparation for its integration into the National System (Sliwa *et al.* 2006), which took place in 2009 when DAFF assumed responsibility for NIMPIS (NIMPIS 2009a). Part of this revision involved collation and integration of data from the NPSD into NIMPIS, with such data being referenced within NIMPIS as “port survey data” (McEnnulty *et al.* 2005; Sliwa *et al.* 2006).

The current NIMPIS database, which includes information on 80 species, searched by distribution with SA selected (NIMPIS 2009c), returns a total of 43 species, with the previous (2002) version of NIMPIS (NIMPIS 2002), which is still presently available, showing the same 43 species when searched in 2010. Westphalen (2008) states that NIMPIS, searched in 2006, returned 43 species for SA, although the

complete list of these is not provided. It would appear likely that these are the same species, and hence that information for species relevant to SA in the current NIMPIS database has not been updated since the 2006 review (Sliwa *et al.* 2006). Investigation of distribution information (NIMPIS 2009b) for the 43 species listed reveals that two of these (*Varicorbula gibba*, *Euchone limnicola*) have not actually been recorded in SA, bringing the true total to 41. As in Hayes *et al.* (2005), the distribution information in NIMPIS is based on IMCRA bioregions; these two species have been recorded in Portland, Victoria, which is in the Otway bioregion, and so these species appear in the results list for SA. A search for further information found no other reference to these species occurring in SA[1], hence they were not considered further in this review.

Westphalen (2008) provides a list of 30 introduced species for the GSV region sourced from NIMPIS and lists 2 additional species: *Caulerpa racemosa* var. *cylindracea* and *Codium fragile* ssp. *tomentosoides* (now recognised as *C. fragile* ssp. *fragile*).

The 41 species shown in SA currently by NIMPIS (2009c) include 20 that were reported by Furlani (1996). Many of the species listed elsewhere are not among the 80 species in the NIMPIS database. Three that are, *Alitta succinea*, *Maoricolpus roseus* and *Codium fragile* ssp. *fragile*, are shown by NIMPIS to have distributions that do not include SA (NIMPIS 2009b).

A CRIMP publication detailing introduced species in PPB (Hewitt and Campbell 1999) also discusses the wider distribution of some species and specifically lists several as occurring in SA (see Table 1).

Introduced and cryptogenic species of macroalgae in southern Australian waters are discussed in two publications. An appendix to the marine benthic flora of southern Australia series (Womersley 2003) lists 24 possibly introduced macroalgae but does

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[1] A brochure produced by PIRSA includes SA in the list of invaded States for *Varicorbula gibba*, but the brochure earlier indicates that it is one of three species of concern that are not yet present in the State (PIRSA 2007). The inclusion of SA in the distribution for this species is therefore regarded as being incorrect. Both *V. gibba* and *Euchone limnicola* are listed as being in OTW by Hayes *et al.* (2005) but not in any other SA bioregion.

not specify the distribution of most. A search of the AVH showed that specimens from SA exist for 19 of these species. No reference to the other 5 species occurring in SA was found so these were not considered further. Lewis (1999) reviewed introduced and cryptogenic macroalgae of southern Australia and reports a number of species as being present in SA. Several of these are regarded as cosmopolitan (see section 3.4); these were not included in the current review unless considered introduced or cryptogenic elsewhere; hence 17 species reported by Lewis (1999) were included (Table 1), 15 of which were also on the list of possible introductions in Womersley (2003). A further three species not included in the Womersley (2003) list are also possible introductions (R. Baldock and C. Gurgel, SHSA, pers. comm.).

Communications from other institutions reported 2 crab and 3 bivalve species (J. Gilliland, PIRSA Marine Biosecurity, pers. comm.), 3 Raphidophyceae (C. Wilkinson, SASQAP, pers. comm.) and 3 gobies (T. Bertozzi, SAM, pers. comm.).

3.2. Maps and information – trigger list species

Of the 99 species reported to be introduced in SA, 13 are currently listed as trigger list species in the National System Marine Pest Monitoring Manual (National System for the Prevention and Management of Marine Pest Incursions 2010b). These include 1 Annelida (Polychaeta), 3 Arthropoda (2 Malacostraca, 1 Maxillopoda), 2 Mollusca (Bivalvia), 4 Dinomastigota (Dinophyceae), and 3 Chlorophyta (Bryopsidophyceae). Results of the investigation into records for these 13 species are discussed in this section, with the remaining 86 species discussed in section 3.3. In both sections species are listed in taxonomic groups in the same order as their listing in Table 1 under headings showing Phylum and Class. Order and Family classification for each species are given in Table 1.

Note that common names are given only where they are in frequent use for the species. Synonyms are not a complete list, but where a species has been reported under a synonym in SA, that name is highlighted with an asterix.

Localities named in the text for each species are shown in Figure 1 for the State as a whole, Figure 2 for the Port Adelaide region, or are referenced to localities shown in Figure 1. Co-ordinates used for mapping locations named in the text are given in the appendix. Records pertaining to large areas (gulf, river, bioregion) without specific information are not shown on maps (see Methods) and co-ordinates were not assigned.

ANNELIDA: Polychaeta

3.2.1. *Sabella spallanzanii* (Gmelin, 1791) - European fan worm

Synonym(s): *Spirographis spallanzanii*

Category: trigger list species (introduced)

Status: established

Summary: *Sabella spallanzanii* is known from around Port Adelaide, the Adelaide coast and on KI, with unconfirmed records elsewhere in the state.

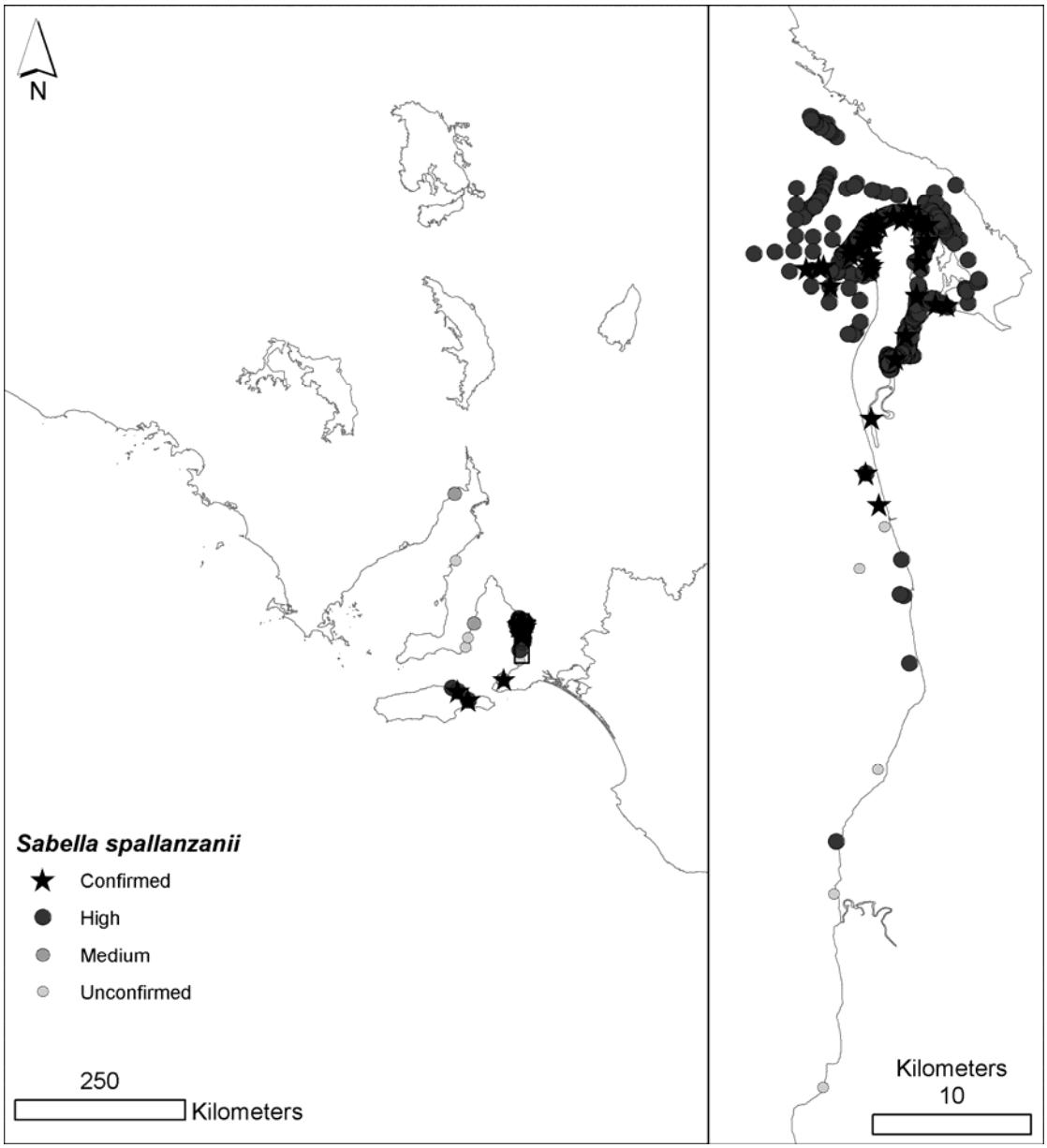

Figure 3. Map of records of *Sabella spallanzanii.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Sabella spallanzanii was first recorded in SA in 1986 (Boxall and Westphalen 2003) and was introduced from the Mediterranean (Patti and Gambi 2001), probably via WA, where it may have occurred as early as 1965 (Clapin and Evans 1995).

Between 1995 and 2001 *S. spallanzanii* was found in North Haven marina, West Lakes, Garden Island (North Arm), Grange (on jetty), Henley Beach (~6 km N of Glenelg) (SAM specimens), Outer Harbor (RSAYS) (Holloway and Keough 2002a, b) and at Largs Bay (Styan and Strzelecki 2002). The 2001 Port Adelaide survey (Cohen *et al.* 2002) found that *S. spallanzanii* was widespread around Outer Harbor and also occurred in North Haven marina and the Outer Harbor approach. *Sabella spallanzanii* was also recorded in the Port River, North Arm, Outer Harbor, North Haven marina and boat ramp, and North Haven gyre in the 2007-8 Port Adelaide survey (Rowling 2009b). Voucher specimens have been lodged with SAM from both these surveys.

The Reef Health surveys conducted by SARDI in 2005 found *S. spallanzanii* at the Glenelg Blocks (just offshore from Glenelg) (Turner *et al.* 2007). In 2006-7, large scale video surveys of seagrass distribution along the Adelaide coast detected *S. spallanzanii* at several locations around the Outer Harbor approach - spoil ground area (Bryars and Rowling 2008), while surveys of Adelaide metropolitan boat ramps conducted as part of the annual surveys for *Caulerpa taxifolia* (Rowling 2007, 2008; Wiltshire and Rowling 2009a) have recorded *S. spallanzanii* at North Haven, St Kilda, West Beach (~2 km N of Glenelg) and O'Sullivan Beach (~3.5 km N of Port Noarlunga) boat ramps (SARDI unpublished data).

Several reports of *S. spallanzanii* at other locations along the Adelaide metropolitan coastline and elsewhere in SA have been made, but while many are credible, not all were able to be substantiated during the current review. On KI, *S. spallanzanii* has been found at Kingscote (on the jetty and slipway), American River (identity confirmed by SAM), and Bay of Shoals (~7.5 km NW of Kingscote) (Kinloch *et al.* 2009, 2010). Specimens are held by SAM from Kingscote and American River. The yacht found with *S. spallanzanii* at the Bay of Shoals had sailed from Wirrina (Marina St Vincent) where it had been for ~18 months (M. Kinloch, KI NRM, pers. comm.); it is therefore likely *S. spallanzanii* settled while the yacht was at Wirrina. The occurrence of *S. spallanzanii* at Wirrina is confirmed by photographs (Kinloch *et al.* 2009) and the recent (2010) collection of specimens held by SARDI. PIRSA Biosecurity has records of *S. spallanzanii* occurring at Whyalla, and Port Vincent marina (J. Gilliland, PIRSA Marine Biosecurity, pers. comm.), and Boxall and

Westphalen (2003) report *S. spallanzanii* as occurring at Edithburgh, but these occurrences could not be confirmed due to a lack of specimens. In American River worms were found only on the hulls of yachts so *S. spallanzanii* may not have established on substrates in this area yet, but in the Bay of Shoals several worms that had clearly come from a vessel hull were found growing in soft sediment (Kinloch *et al.* 2010). All *S. spallanzanii* so far found on KI have been removed, so the species may not still be present, although not all possibly infested areas within the Bay of Shoals had been searched as of May 2010 (Kinloch *et al.* 2010). The several occurrences of *S. spallanzanii* at Kingscote suggests there may have been repeated introductions (Kinloch *et al.* 2009, 2010), but it cannot be ruled out that a source population is established in this area. The current status of the species at Whyalla and Port Vincent is unknown, although the discovery of empty tubes at Whyalla in spring 2009 (Dittmann *et al.* 2010) suggests it may regularly occur in this location.

The Reef Watch Feral or in Peril database (Reef Watch SA 2009b) lists 16 reported sightings of *S. spallanzanii* as of 14/12/09, with the reports having been made between 28/12/03 and 13/12/09. Although these reports may be by non-experts, *S. spallanzanii* is a large and readily recognisable species (Clapin and Evans 1995). Locations for these reports include Whyalla, Wallaroo, Klein Point (~7 km SW of Stansbury), and Kingscote, and, within the Adelaide metropolitan area: Port Willunga (Star of Greece wreck), Port Noarlunga (with a note that worms were removed), Hallett Cove (~6.5 km S of Brighton), Brighton (on jetty), Broken Bottom reef (~2 km NW of Glenelg), Semaphore (jetty), Largs Bay (jetty) and West Lakes. A clean-up organised by Reef Watch removed large numbers of *S. spallanzanii* from Brighton jetty in 2008-9 (Reef Watch SA 2009a).

Targeted scientific surveys in 1995-96 did not find any *S. spallanzanii* at Port Bonython (~18 km ENE of Whyalla) (Butler and Connolly 1999), Wallaroo, Edithburgh, or Ardrossan (Styan and Strzelecki 2002), but recent scientific survey data are lacking. A number of surveys by Reef Watch targeting the “Feral or in Peril” species (including *S. spallanzanii*) have not found *S. spallanzanii* at several sites where it has been reported, including Broken Bottom (surveyed 2008, 2009), Edithburgh (5 surveys in 2009), Wallaroo (2009), Hallett Cove (2 surveys in 2009) and Port Noarlunga (14 surveys in 2008-9) (Reef Watch SA 2009b). Thus, while *S. spallanzanii* is likely to have occurred at these sites, it may not be regularly or permanently present, or it may occur at low population densities. Reef Watch also did

not find *S. spallanzanii* during 2009 “Feral or in Peril” surveys of Stansbury, Ardrossan, Moonta Bay and Rapid Bay jetties (Reef Watch SA 2009b).

The occurrence of *S. spallanzanii* at boat ramps is also inconsistent, with none found at O’Sullivan Beach in 2008 or 2009 after a small number were found in 2007 (SARDI unpublished data); *S. spallanzanii* may not, therefore, have established at this location. The abundance of *S. spallanzanii* may vary seasonally even at sites where it occurs at high density. None were found at North Haven boat ramp in September 2005 when an attempt was made to collect them by SARDI staff, and only a few worms were found in July 2009, while in November 2009 *S. spallanzanii* was abundant. No live worms, only casings, were found at West Beach boat ramp (~2 km N of Glenelg) in June 2009, while worms were abundant there in April 2008 and October 2009 (SARDI unpublished data). Spawning is known to occur primarily in early winter (Currie *et al.* 2000), so the increase in abundance from June-July to October-November may represent settlement of new recruits. The factors that may result in loss of worms over winter are unknown.

ARTHROPODA: Malacostraca

3.2.2. *Carcinus maenas* (Linnaeus, 1758) - European shore crab

Synonym(s): *Carcinides maenas*

Category: trigger list species (introduced)

Status: previously established

Summary: *Carcinus maenas* has been recorded from Port Adelaide, the Adelaide coast, Port Vincent, and the Coorong at “Ti Tree”. It has rarely been found in recent years.

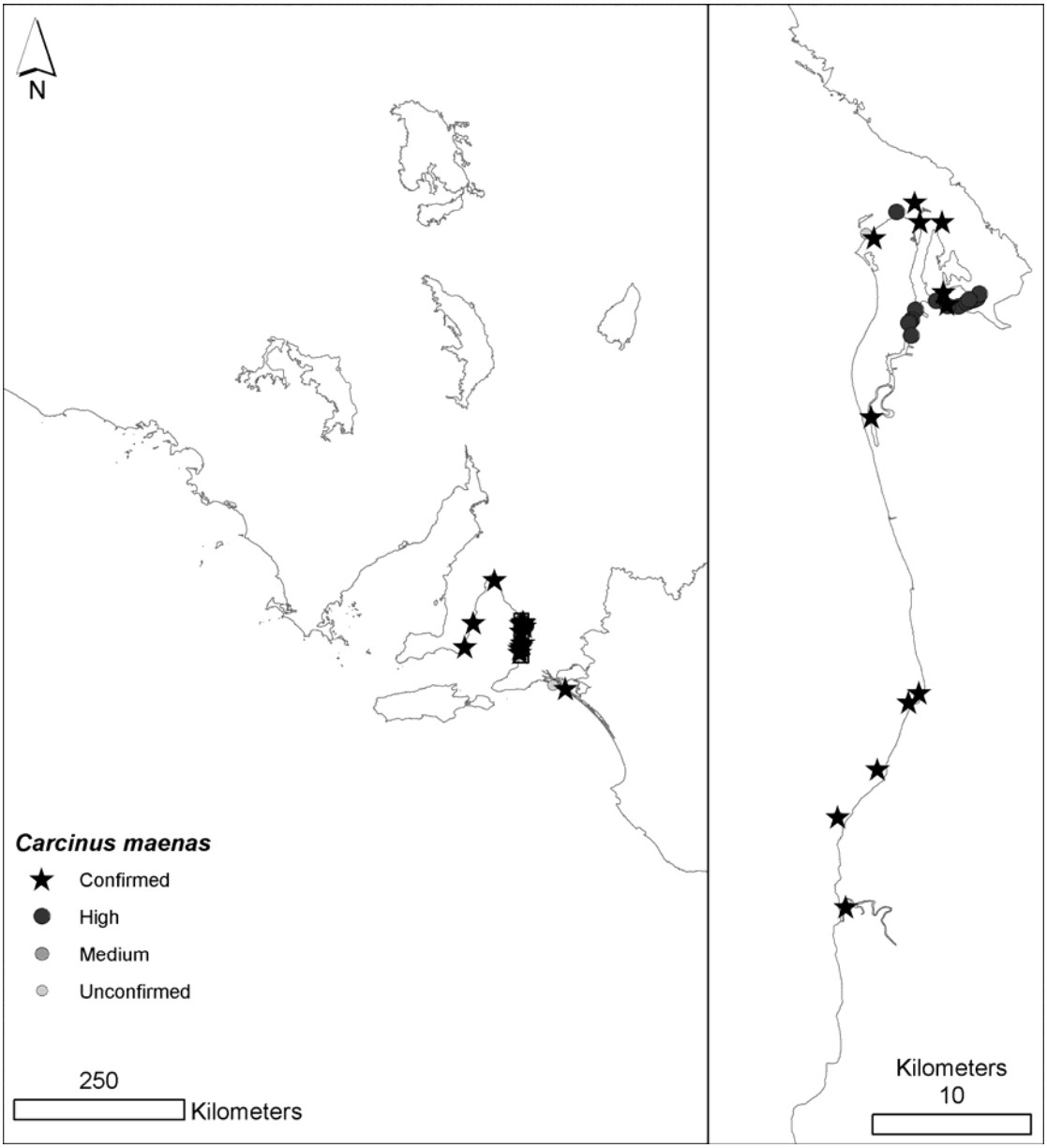

Figure 4. Map of records of *Carcinus maenas.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Carcinus maenas was first recorded in SA in 1976 from West Lakes (Zeidler 1978; SAM specimen). It is native to the NE Atlantic, and has been known from PPB, Victoria, since the late 19th century, with PPB being the likely source for other populations in Australia (Pollard and Hutchings 1990b).

Carcinus maenas appeared to be well-established but with a range restricted to the Outer Harbor region and West Lakes when discovered (Zeidler 1978, 1997), although specimens were soon after found along the southern metropolitan coast, at Port Stanvac, ~4.5km N of Port Noarlunga (1977), and Hallett Cove, ~6.5 km S of Brighton (1980) (Rosenzweig 1984; SAM specimens). Further specimens held by SAM from the Adelaide metropolitan area were collected from St Kilda (2002), Barker Inlet (1995), North Arm (1995), Onkaparinga River at Port Noarlunga (1994) and Kingston Park Beach, ~2 km S of Brighton (1998). Zeidler (1988) reported *C. maenas* in the Coorong (at "Ti Tree", ~20 km SE of the Murray Mouth) in January 1987 and SAM holds a specimen that confirms this record. Additional SAM specimens from outside the Adelaide area are from Edithburgh (2005), Port Vincent (2008) and Port Wakefield (2006).

Zeidler (1997) reported that *C. maenas* was moderately common around Adelaide and a national survey for the crab in 1998 detected it at all four Adelaide sites sampled: three around Port Adelaide-Barker Inlet and one on the southern metropolitan coast (Thresher *et al.* 2003). In 2001 *C. maenas* was abundant in Barker Inlet, where it was collected for competition experiments (Tanner 2007), and several individuals were captured in the Port River, Angas Inlet and Barker Inlet during surveys for *Charybdis japonica* (see 3.2.3.), although none were found around Outer Harbor (Hooper 2001, SARDI unpublished data). The 2001 Port Adelaide survey detected *C. maenas* only in marinas (the RSAYS marina at Outer Harbor, and North Haven) and not at any other sampled sites around Outer Harbor or the Port River (Cohen *et al.* 2002).

The abundance of *C. maenas* in the Port Adelaide-Barker Inlet region fluctuated between years (Zeidler 1997) and a substantial decline in numbers was noted subsequent to the 2001 work reported by Tanner (2007). *Carcinus maenas* has not been collected in the Adelaide area recently (W. Zeidler, SAM, pers. comm.), although one was sighted in West Lakes in 2009 (M. Sierp, PIRSA Marine Biosecurity, pers. comm.). Several crabs were detected in Angas Inlet, Eastern Passage, North Arm and Barker Inlet in 2003 and 2004 during surveys for *Caulerpa taxifolia* (Westphalen *et al.* 2004), but none were observed in the annual surveys

undertaken from 2005 to 2009 (SARDI unpublished data). The 2007-2009 Port Adelaide surveys did not detect *C. maenas*, despite traps capturing several portunid crabs (Rowling 2009b; Wiltshire and Rowling 2009b). It is not clear whether *C. maenas* established at other locations; surveys failed to detect further crabs at Hallett Cove (Rosenzweig 1984), the Coorong (Zeidler 1988), and Port Vincent (W. Zeidler, SAM, pers. comm.). Surveys in 1998 of two sites in the Coorong and two on the western side of GSV (unnamed, but likely to be Ardrossan and Edithburgh from their mapped locations) also did not detect any *C. maenas*, nor did the 1996 CRIMP survey of Port Lincoln (Thresher *et al.* 2003). Nonetheless, their relatively recent occurrence at Port Vincent (2008) and West Lakes (2009) indicates *C. maenas* may still occur, albeit in low numbers, in GSV.

3.2.3. *Charybdis japonica* (Milne-Edwards, 1861)

Category: trigger list species (introduced)

Status: isolated occurrence

Summary: A single adult male was caught at Outer Harbor. No further *Charybdis japonica* have been found.

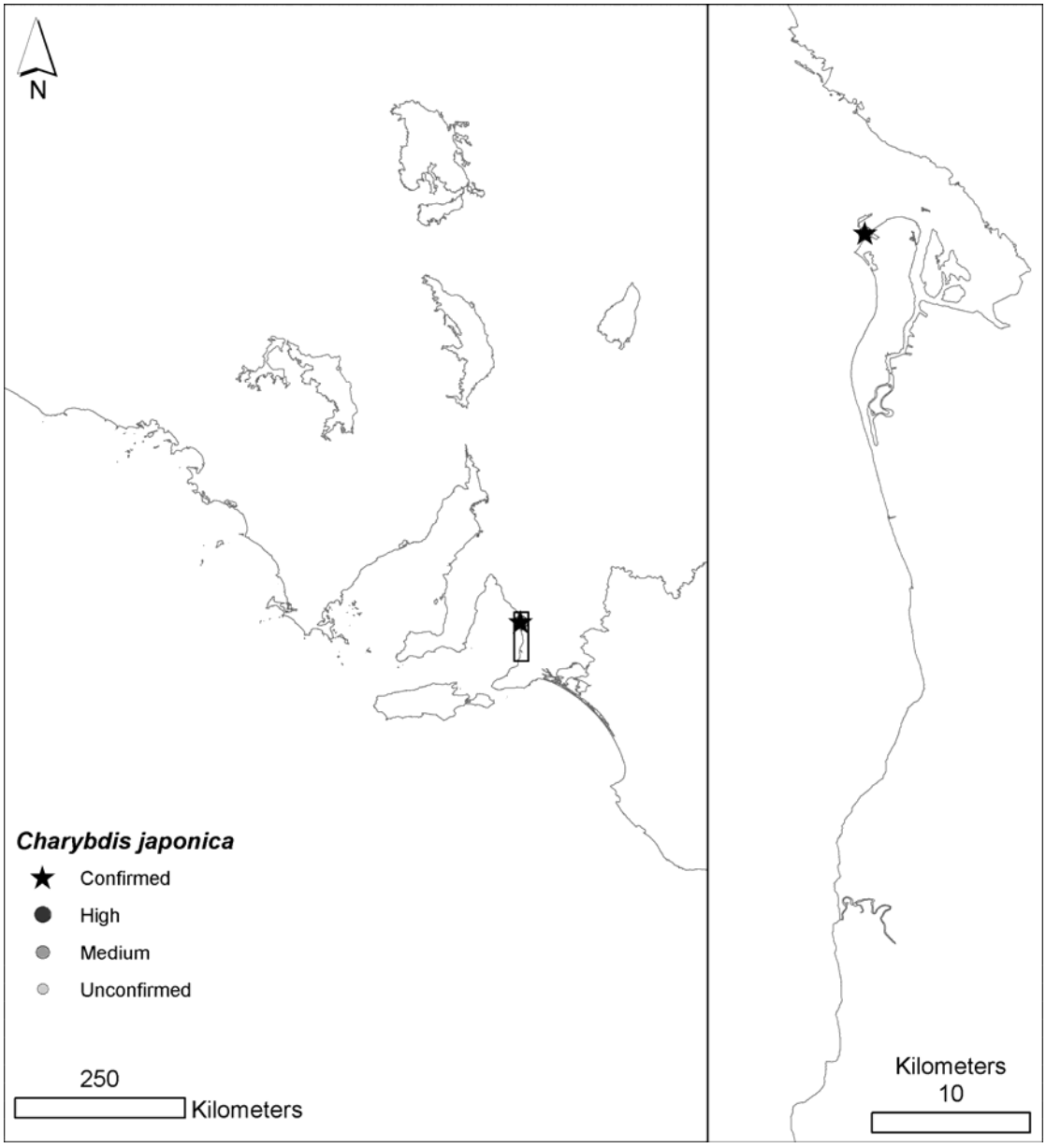

Figure 5. Map of records of *Charybdis japonica.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Charybdis japonica is native to China, Japan, Korea, Taiwan and Malaysia, and has been introduced to New Zealand (Smith *et al.* 2003).

In December 2000 a single adult male *Charybdis japonica* was caught by a recreational fisher at Outer Harbor (Hooper 2001; J. Gililand, PIRSA Marine Biosecurity, pers. comm.). The specimen was identified and is held by SAM. Following the confirmation of the identification, SARDI surveyed the Port River, Barker Inlet and Angas Inlet in January and February 2001 to determine if any further *C. japonica* were present. None were found, although several *Carcinus maenas* and the native *Portunus pelagicus* were caught (Hooper 2001). The 2001 and 2007-2009 Port Adelaide surveys also did not detect this species (Cohen *et al.* 2002; Rowling 2009b; Wiltshire and Rowling 2009b). There have been no subsequent reports of this species in SA, and it appears that the initial specimen was an isolated occurrence and it is unlikely that *C. japonica* is still present in SA waters.

ARTHROPODA: Maxillopoda

3.2.4. *Balanus improvisus* Darwin, 1854

Category: trigger list species (introduced)
Status: unconfirmed
Summary: Reports of *Balanus improvisus* cannot be substantiated.

Balanus improvisus is native to the north-west Atlantic and introduced in several countries including USA, Canada, and Japan (Hayes *et al.* 2005). The species was recorded on a ship that had sailed from southern Australia, with settlement of the barnacle believed to have occurred in this region (Bishop 1951). This report likely led to the inclusion of *B. improvisus* as one of the known introduced species of Australia in the species schedules used for the CRIMP port surveys (Hewitt and Martin 1996), where it was listed as being in SA. Later versions of these species schedules (Aquenal Pty Ltd 2002; Pollard and Pethebridge 2002a, b) qualify the presence of *B. improvisus* in SA with a question mark, but do not discuss this further.

One of the earliest reviews of introduced fouling species in Australia (Allen 1953) cast doubt on the occurrence of *B. improvisus* in Australia, stating that there was no evidence to confirm the report by Bishop (1951). Pollard and Hutchings (1990b), Jones (1992) and Hayes *et al.* (2005) also regarded the occurrence of *B. improvisus* as unconfirmed and there are no further records of the species in Australia. The current review also found no recent reports of this species or evidence to substantiate its occurrence in SA. It appears unlikely that this species occurred in SA.

MOLLUSCA: Bivalvia

3.2.5. *Musculista senhousia* (Benson in Cantor, 1842)

Category: trigger list species (introduced)

Status: previously established

Summary: *Musculista senhousia* was common in Port Adelaide but has not been recently found.

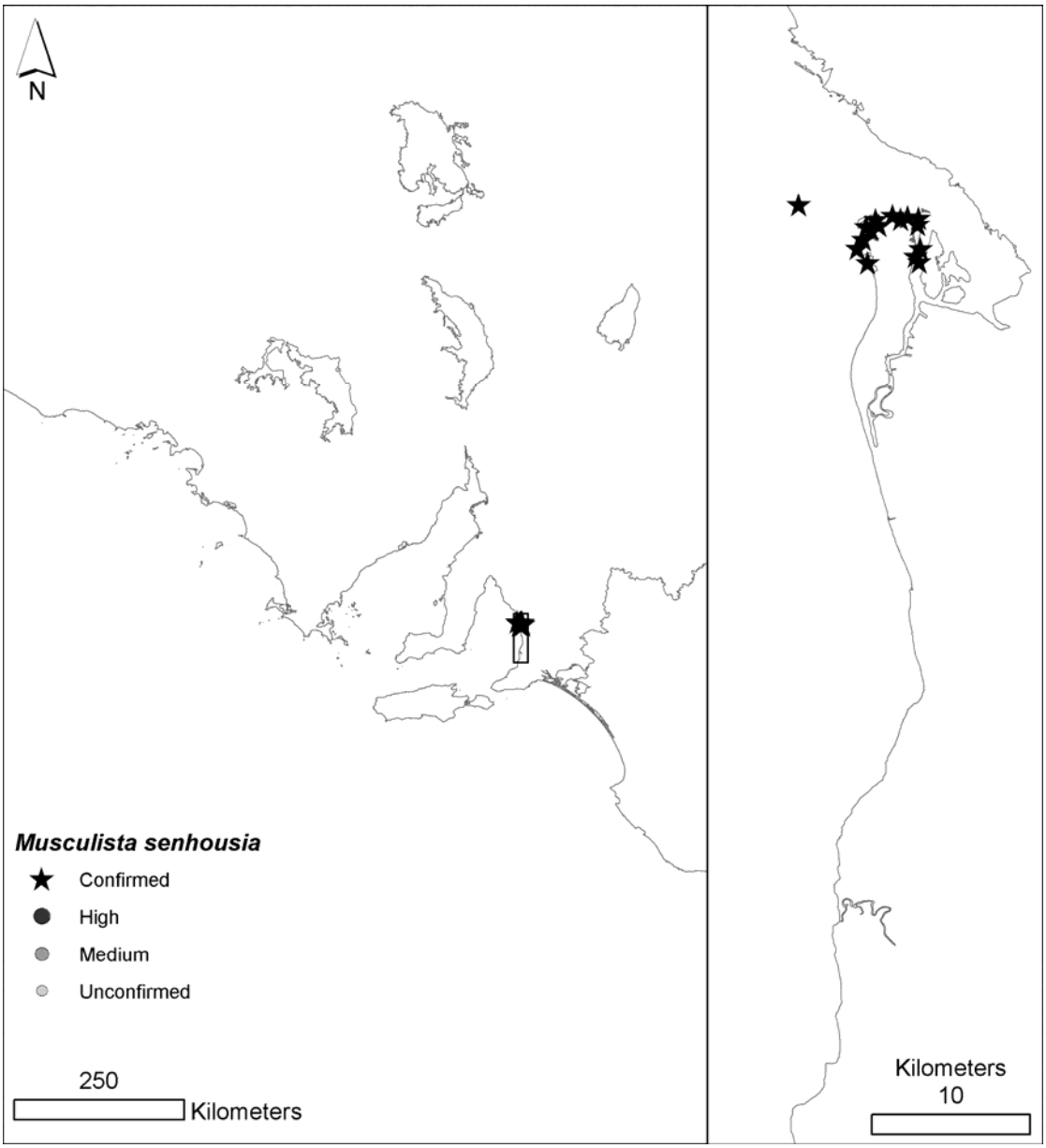

Figure 6. Map of records of *Musculista senhousia.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Musculista senhousia is native to a large area in the north-west Pacific from Siberia to Singapore, and has been introduced to New Zealand and Australia, first occurring

in WA in 1982 (Willan 1987). The species was first mentioned as being in SA by Furlani (1996), who listed it as a presumed introduction after several individuals were found on a trawler in Port Adelaide in 1988. Specimens from this vessel are held by SAM. It was not shown as being in SA by the species schedules of the CRIMP and other port surveys (Hewitt and Martin 1996; Aquenal Pty Ltd 2002; Pollard and Pethebridge 2002a, b), but was included in lists of introduced species of SA published around the same time (EPA and DEHAA 1998; Lewis *et al.* 1998; Edyvane 1999), albeit as "presumed" in most cases.

The first evidence that *M. senhousia* was established in Port Adelaide comes from the 2001 survey (Cohen *et al.* 2002; SAM specimens), which detected the mussel at several sites throughout the survey area (Port River to Outer Harbor, North Haven marina) with very high densities found in some samples. Since this survey numbers appear to have declined dramatically. Attempts to collect individuals for the development of PCR assays (see Ophel-Keller *et al.* 2007) were made by SARDI in 2005-6, with staff visiting the sites sampled by Cohen *et al.* (2002) but failing to find any individuals (M. Loo, SARDI, pers. comm.). The 2007-8 survey of Port Adelaide (Rowling 2009b) did not find any live individuals of *M. senhousia*. Positive results for DNA of this species were found by PCR analysis of some sediment and plankton samples in 2008; however, there were known issues with the specificity of the assay used at that time, making these positive results unreliable given the lack of live animals (Rowling 2009b). While the presence of *M. senhousia* in Port Adelaide cannot be excluded, there is little evidence that an established population currently exists there.

3.2.6. *Crassostrea gigas* (Thunberg, 1793) - Pacific oyster

Category: trigger list species (introduced)

Status: present

Summary: Wild settlement of *Crassostrea gigas* has been recorded in several oyster growing areas. Removal by farmers and eradication programs have prevented the species establishing.

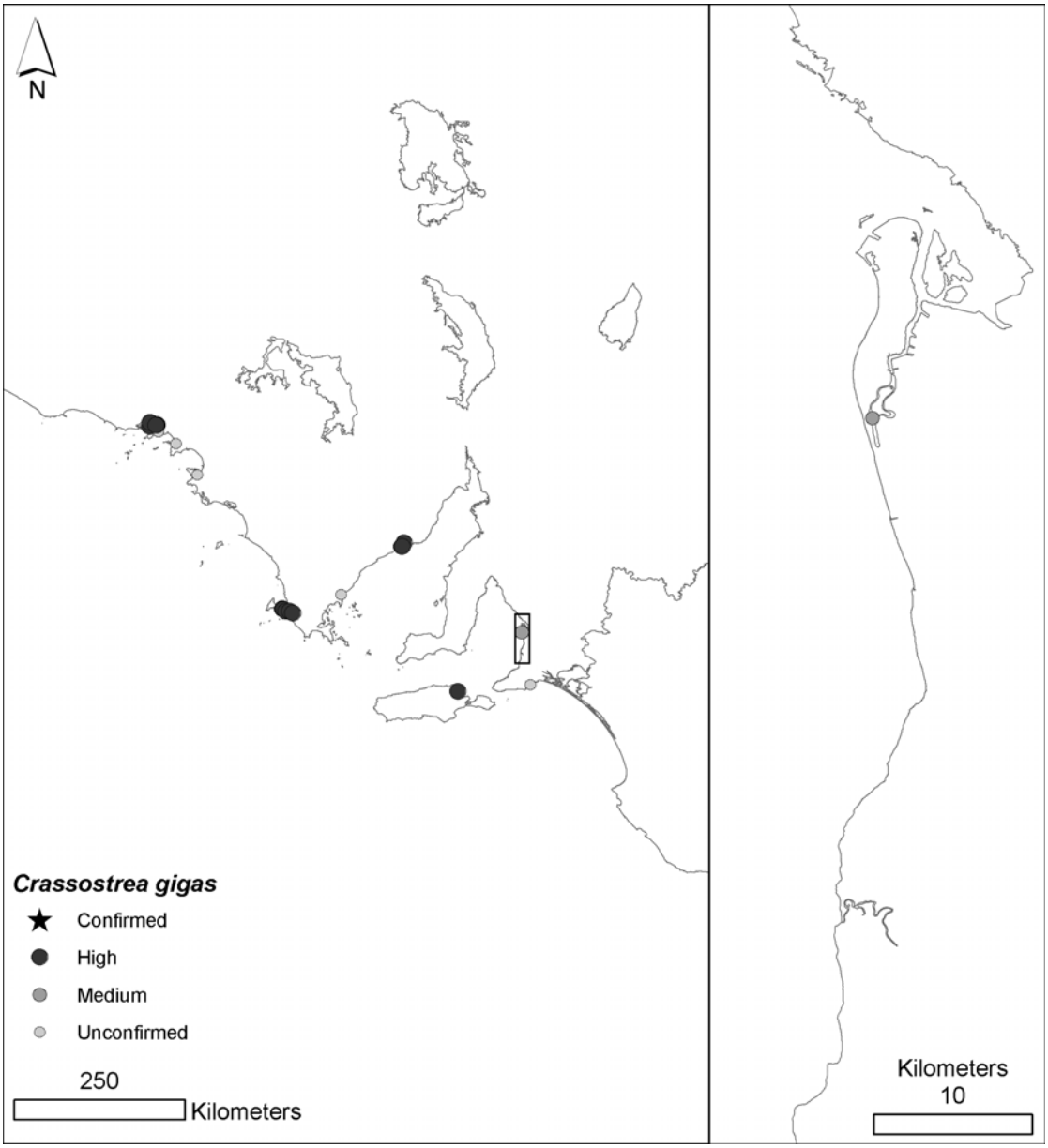

Figure 7. Map of records of *Crassostrea gigas.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Pacific oysters, which are native to the Pacific coast of Asia, were first introduced and naturalised in Australia in the early 1950s (Thompson 1952, 1959), and aquaculture of *C. gigas* in SA began in 1969 (Olsen 1994). As in other regions, a successful

aquaculture industry has been established, with direct output (business turnover) from SA Pacific oyster farms valued at $32 million in 2007/2008 (Econsearch 2009). Farms are currently located around Ceduna (Denial Bay and St Peter Island, ~12 km south of Ceduna), Smoky Bay, Haslam (~30 km N of Streaky Bay), Streaky Bay, Coffin Bay, Port Lincoln, Cowell (Franklin Harbour), Port Broughton, the east coast of Yorke Peninsula (Coobowie, 5 km N of Edithburgh, to Port Julia), and, on KI, around Western Cove and American River (PIRSA Aquaculture 2010).

Settlement resulting from spawning of farmed oysters has led to the establishment of wild populations of *C. gigas* in some areas where they are now considered a pest species, including New Zealand (Medcof and Wolf 1975; Dinamani 1991), Tasmania (Mitchell *et al.* 2000), and Port Stephens, NSW, (Medcof and Wolf 1975; Ayres 1991). It was originally believed that the relatively high salinity of SA coastal waters would prevent reproduction of *C. gigas* in SA (Medcof and Wolf 1975; Grove-Jones 1985; Ayres 1991; Olsen 1994), and the industry relies on spat from land-based hatcheries. Some wild settlement has occurred in SA, however, being first recorded on Cowell jetty and a nearby oyster lease in Franklin Harbour in 1990 (Hone 1993). After this discovery, oyster growing areas were surveyed for wild *C. gigas*, first by dedicated field trips, and later as a part of the Oyster Environmental Monitoring Program (OEMP) (Hone 1993, 1996b). The OEMP incorporates responses from the Environmnetal Monitoring Program proforma that oyster farm licence-holders are required to submit annually; this includes questions on the occurrence of wild oysters. PIRSA Aquaculture collates these data and produces summary reports (e.g. PIRSA 2004), although not all summaries have been published. As these reports are anecdotal, we class them here as citations. Distinguishing between species of Ostreidae is often difficult due to their morphological plasticity (Poutiers 1998); therefore, some records may be of native oyster species. For example, early surveys for *C. gigas*, which collected specimens for identification, also found native oysters (*Ostrea angasi*, *O. crenulifera* and *O. virescens*) growing on oyster farm structure and adjacent hard substrate in Denial Bay, Franklin Harbour, Smoky Bay and Streaky Bay (Hone 1993; Madigan and Clarke 1998). We class records from these surveys as scientific data since identification was performed by Shirley Slack-Smith of WAM, although we were not able to ascertain whether specimens are still held.

Between 1990 and 1992, wild *C. gigas* were found around farm leases in Franklin Harbour and also in Denial Bay (Hone 1993). Pacific oysters continue to be reported from these two growing areas, and also from Coffin Bay (2002-3, 2005-6, 2007-8),

Smoky Bay (1996, 2002-3, 2005-6, 2007-8), Streaky Bay (1996, 2002-3, 2005-6, 2007-8), Western Cove, KI (1998, 2005-6), and eastern Yorke Peninsula (2005-6, 2007-8) (Madigan and Clarke 1998; PIRSA 2004, PIRSA unpublished data). In recent years, the occurrence of wild oysters has been most common in Coffin Bay, with >50% of farms reporting some wild oysters (PIRSA 2004, PIRSA Aquaculture unpublished data).

In all locations, nearly all wild *C. gigas* are removed by oyster growers when found on or near farm infrastructure (PIRSA 2004, PIRSA unpublished data); however, recent work has investigated the occurrence of Pacific oysters over wider areas of Coffin Bay and Denial Bay, and found them to be widespread in these two regions in 2007 and 2009 respectively (Hill-Ling 2008; M. Sierp, PIRSA Biosecurity, pers. comm.). A recent survey of Eyre Peninsula (Dittmann *et al.* 2010) found low numbers of Pacific oysters at several sites, including Tumby Bay, where they are not previously reported, although specimens collected for this survey are yet to be identified, so this occurrence is unconfirmed.

Most occurrences of *C. gigas* around farmed leases have involved the detection of <40 individuals per year, and, except within Coffin Bay, the proportion of growers finding wild oysters is low (PIRSA 2004, PIRSA unpublished data). Occurrences are sporadic at some sites: no *C. gigas* were reported from either Streaky Bay or Smoky Bay in 1998, and none from KI growing areas in 2002-3 or 2007-8. PIRSA Biosecurity surveys of Smoky Bay in 2007 and 2010 also found no *C. gigas* (M. Sierp, PIRSA Marine Biosecurity, pers. comm.). Eradication programs have been carried out by PIRSA Biosecurity on the Kingscote Jetty, KI, and around Coffin Bay, and by the end of February 2010 all known wild *C. gigas* had been removed from these areas (M. Sierp, PIRSA Biosecurity, pers. comm.). The generally low level of wild oyster occurrence, combined with regular removal by growers and eradication programs, makes it unlikely that *C. gigas* is established in SA. Where farming occurs, it is possible that wild settlement will continue, with this risk appearing to be variable across the growing regions.

Isolated records of *C. gigas* from deliberate introductions exist: several individuals that had clearly grown from hatchery spat were found and removed from Encounter Lakes in Victor Harbor (Hone 1996a). Similarly a deliberate introduction of 147, 6+ year old hatchery bred individuals was detected and removed from West Lakes during a regular survey dive by PIRSA Biosecurity in 2009 (M. Sierp, PIRSA Biosecurity, pers. comm.).

DINOMASTIGOTA: Dinophyceae

3.2.7. *Gymnodinium catenatum* Graham, 1943

Category: trigger list species (introduced)

Status: established

Summary: *Gymnodinium catenatum* is widespread in SA.

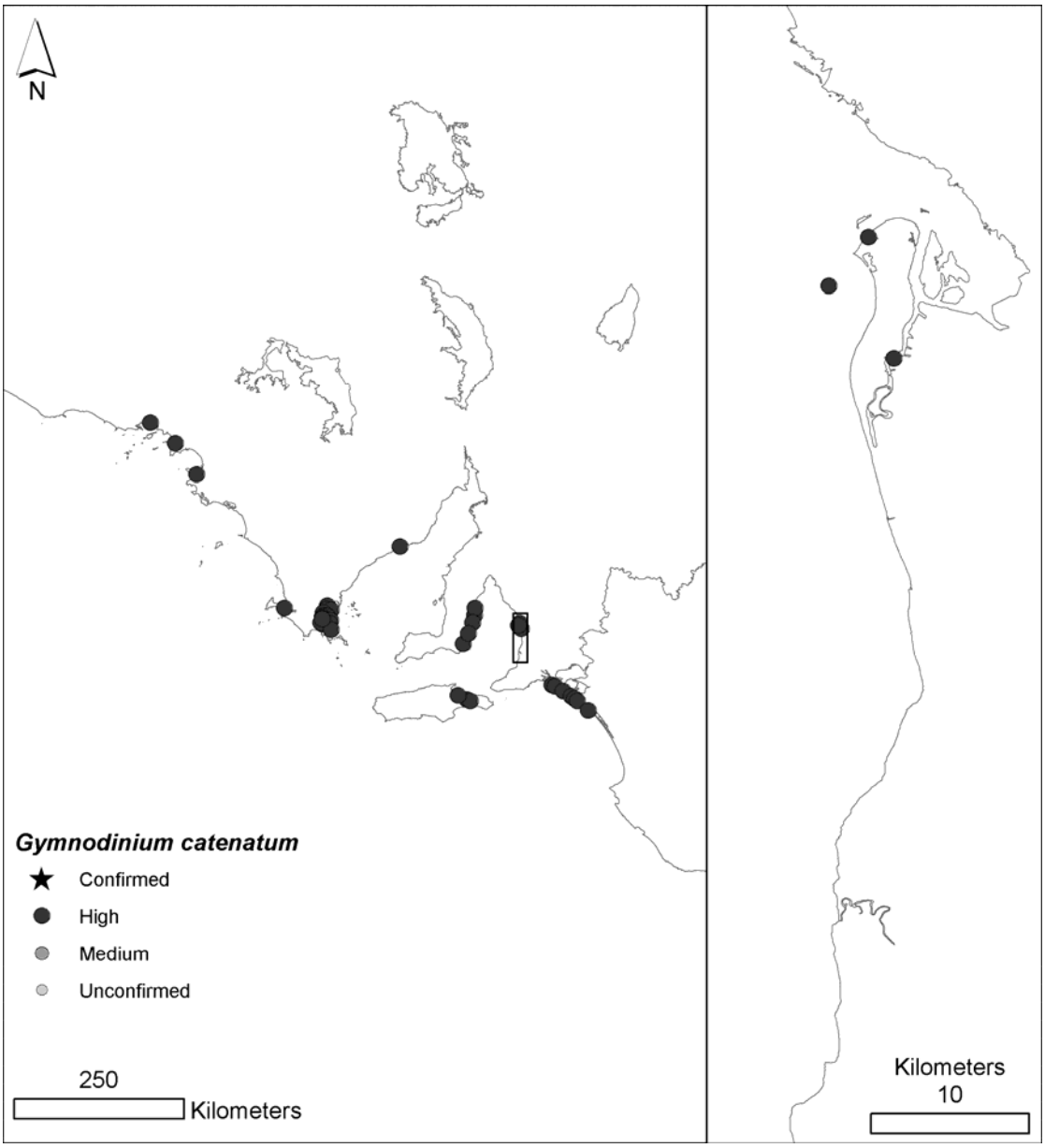

Figure 8. Map of records of *Gymnodinium catenatum.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Gymnodinium catenatum was first discovered in Australia in 1980 in Tasmania, where it was determined to be a new introduction, as it had been previously absent in the region (McMinn *et al.* 1997; Hallegraeff 1998). In SA it was classed as

cryptogenic by NIMPIS (2009b) and Hayes *et al.* (2005) due to uncertainty regarding its origin and date of first occurrence (Hayes *et al.* 2005). There is evidence, however, that Tasmanian and SA strains are similar and that *G. catenatum* may have spread from Tasmania to SA (Bolch *et al.* 1999; Negri *et al.* 2001). Molecular evidence supports the hypothesis that *G. catenatum* was introduced, probably from Japan or south-east Asia (Bolch and de Salas 2007).

Furlani (1996) reported *G. catenatum* as occurring in Victoria to the SA border, which probably led to the inclusion of *G. catenatum* on the 1999 list of introduced species in SA (Edyvane 1999), as this states it as “known from Victorian border”. The first confirmed record of *G. catenatum* in SA occurred at around the same time, from Port Lincoln, where cysts were discovered during a comprehensive phytoplankton survey carried out after a fish kill in 1996 (McMinn *et al.* 1997; McMinn *et al.* 2001).

Gymnodinium catenatum has been recorded since then in SASQAP sampling from nearly all monitored sites around SA, including Denial Bay (2003, 2004, 2007, 2009), Smoky Bay (2002, 2003), Streaky Bay (2002-4, 2007-9), Cowell (2003), Yorke Peninsula from Port Julia to Stansbury (2002, 2003), KI: American River (2005) and Eastern Cove (SE of American River) (2002), and Coorong coast (ocean beaches extending SE from Murray Mouth, 2002, 2003, 2007). Around Port Lincoln it has been found annually (2002-9) in Boston Bay and Proper Bay, and once in Louth Bay (2002) (SASQAP unpublished data). Cysts and positive DNA results have been detected in Port Adelaide (Wilkinson 2007; Rowling 2009b), although records of motile cells for this site were not found in the SASQAP database (SASQAP unpublished data). Cysts have been recorded from Port Adelaide previously (C. Wilkinson, SASQAP, pers. comm.), but specific environmental conditions are required for germination into motile cells (van Ruth *et al.* 2009).

3.2.8. *Alexandrium catenella* (Whedon and Kofoid, 1936) Balech, 1985

Synonyms: *Gonyaulax catenella*, *G. washingtonensis*, *Protogonyaulax catenella*, *Gessnerium catenellum*

Category: trigger list species (cryptogenic)

Status: established

Summary: *Alexandrium catenella* is recorded from Port Adelaide-West Lakes, KI, Port Lincoln, Port Broughton and the Coorong coast

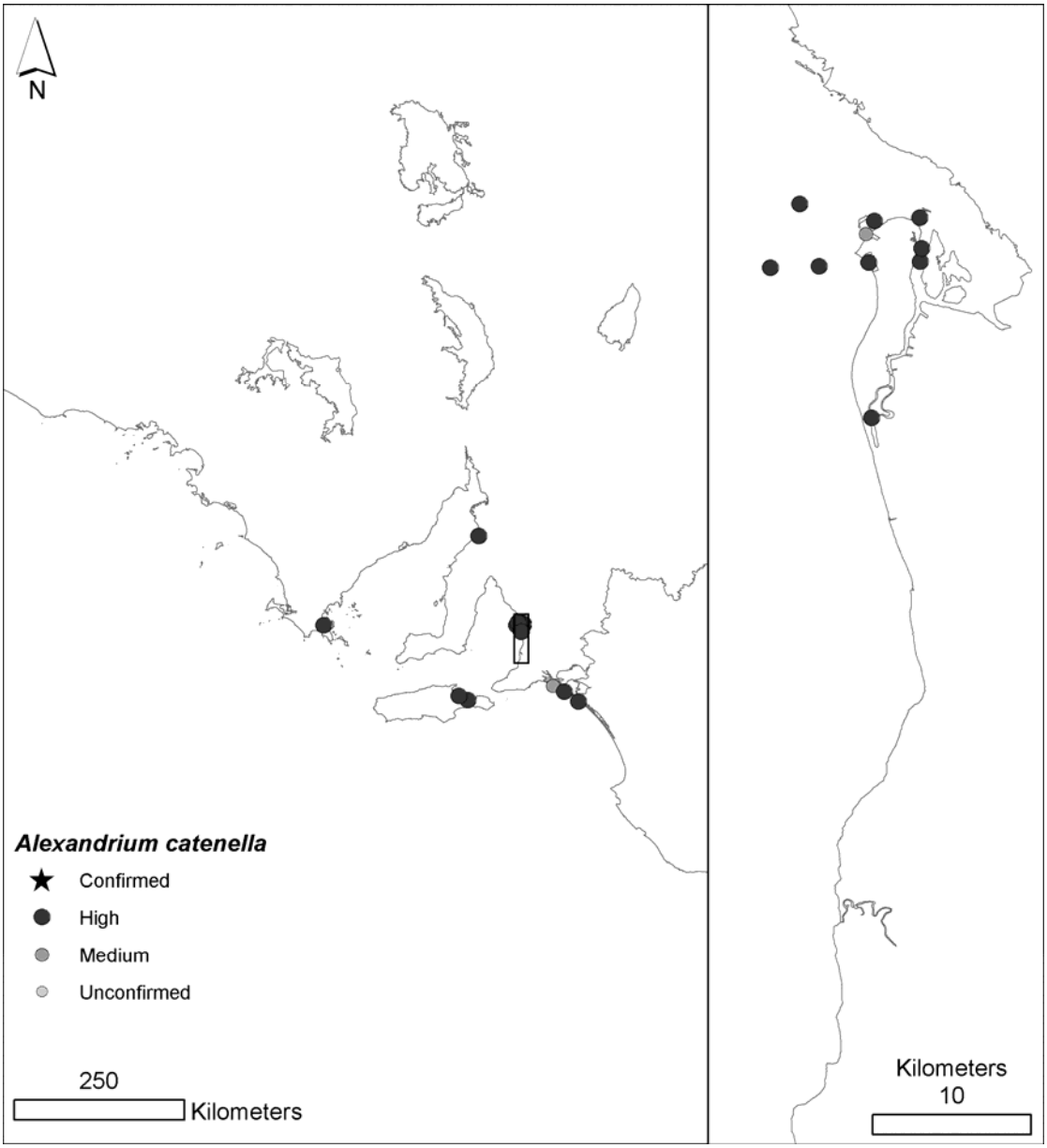

Figure 9. Map of records of *Alexandrium catenella.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Alexandrium catenella is widespread in the Northern Hemisphere and known from South Africa, Chile and New Zealand; it was first found in Australia in 1954

(Hallegraeff 2002). There is some evidence that this species is an introduction to Australia; ballast water is a likely vector, although natural dispersal cannot be ruled out (de Salas *et al.* 2001; Bolch and de Salas 2007). In SA, *A. catenella* has been found in the Port River since 1997, where it appears to have replaced *A. minutum* (see section 3.2.9) as the main bloom forming species (Hallegraeff 2002; Bolch and de Salas 2007); it was isolated from West Lakes in 2000 (Bolch and de Salas 2007; Harlow *et al.* 2007). The 2001 Port Adelaide survey recorded *A. catenella* cysts throughout the survey area, including the spoil ground and Outer Harbor approach (Cohen *et al.* 2002). This species has also been recorded since 2002 in several shellfish growing areas during SASQAP monitoring, including Proper Bay (Port Lincoln), Port Broughton, Western Cove and American River on KI, and the Coorong coast (ocean beaches extending SE from Murray Mouth) (SASQAP unpublished data).

3.2.9. *Alexandrium minutum* Halim, 1960

Synonyms: *Pyrodinium minutum*, *Alexandrium ibericum*, *A. angustitabulatum*, *A. lusitanicum*

Category: trigger list species (introduced)

Status: established

Summary: *Alexandrium minutum* is widespread in SA

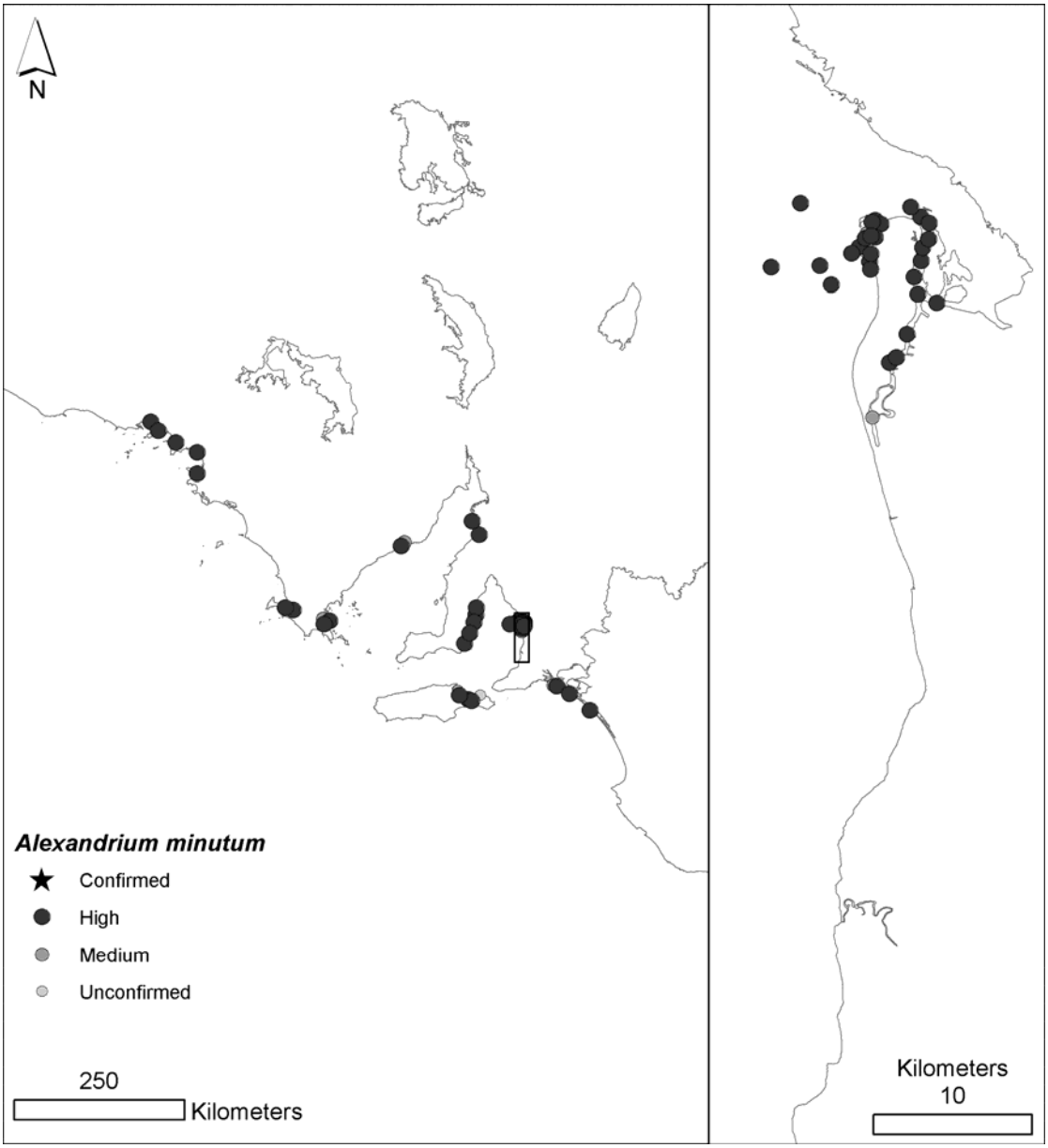

Figure 10. Map of records of *Alexandrium minutum.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Alexandrium minutum is known from Europe, Egypt, and New Zealand and was first found in Australia in WA in 1982 (Hallegraeff 2002). The SA population of this species appears genetically identical to *A. minutum* from the Mediterranean, while

populations from NSW group with those from New Zealand, suggesting these may comprise a native southern hemisphere genotype, while *A. minutum* in SA may have been introduced from Europe (de Salas *et al.* 2001; Hayes *et al.* 2005; Bolch and de Salas 2007). This species was found in the Port River in 1986 where it bloomed annually in October 1986-88 (Hallegraeff *et al.* 1988; Hallegraeff *et al.* 1991). It appears that *A. catenella* has subsequently become the main bloom-forming species in the Port River (Hallegraeff 2002; Bolch and de Salas 2007), but *A. minutum* continues to occur in the region, being detected by the 2001 and 2007-8 Port Adelaide surveys (Cohen *et al.* 2002; Rowling 2009b) and during SASQAP sampling (SASQAP unpublished data). SASQAP sampling has also regularly detected this species at several locations around the state from Denial Bay to the Coorong coast (ocean beaches extending SE from Murray Mouth) since 2002 (Figure 10).

3.2.10. *Alexandrium tamarense* (Lebour, 1925) Balech, 1985

Synonyms: *Gonyaulax tamarensis*, *G. tamarensis var. excavata*, *G. excavata*, *Gessnerium tamarensis*, *Protogonyaulax tamarensis*, *P. excavata*, *Alexandrium excavatum*

Category: trigger list species (cryptogenic)

Status: established

Summary: *Alexandrium tamarense* is widespread in SA

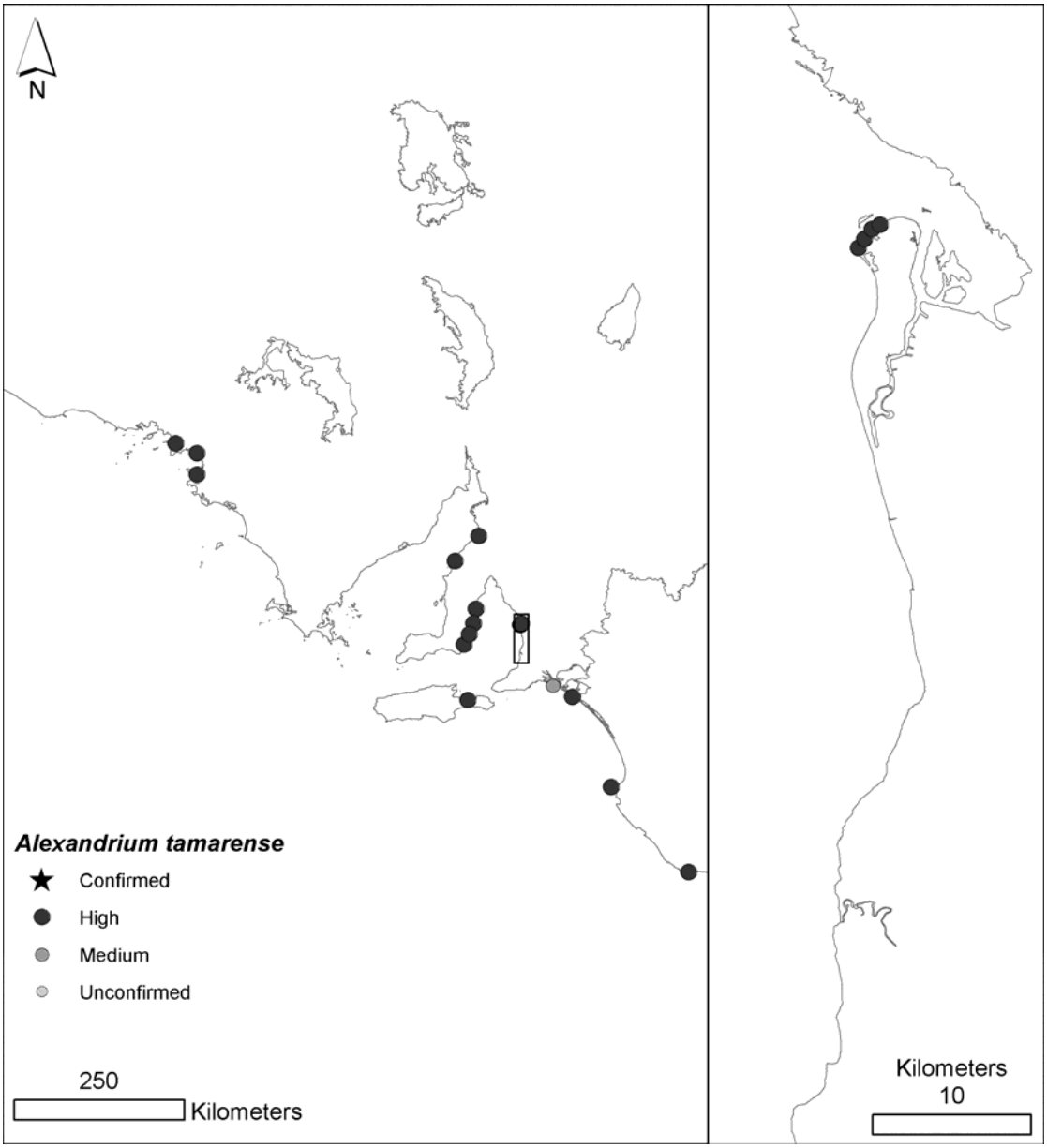

Figure 11. Map of records of *Alexandrium tamarense.*

Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Alexandrium tamarense is known from Japan, North America and Europe (Hallegraeff 2002), but nearly all Australian isolates of this species are non-toxic and

may represent a native strain (Bolch and de Salas 2007). This species was recorded from Port MacDonnell in SA in 1988 (Hallegraeff *et al.* 1991) and from Cape Jaffa, ~19 km SW of Kingston SE, in 2001 (Bolch and de Salas 2007). It was also recorded in 2001 by the Port Adelaide survey, but only around Outer Harbor; it was not as widespread as the other *Alexandrium* species (see 3.2.8, 3.2.9) (Cohen *et al.* 2002). It has since been recorded by SASQAP sampling from Streaky Bay to Smoky Bay on Eyre Peninsula, Port Broughton, Wallaroo, eastern Yorke Peninsula (Port Julia to Stansbury), American River on KI, and the Coorong coast (ocean beaches extending SE from Murray Mouth) (SASQAP unpublished data).

CHLOROPHYTA: Bryopsidophyceae

3.2.11. *Caulerpa racemosa* var*. cylindracea* (Sonder) Verlaque, Huisman & Boudouresque, 2003

Synonyms (*reported as): *Caulerpa cylindracea*, *Ahnfeldtia cylindracea*, *Chauvinia cylindracea*, *Caulerpa racemosa* var. *laetevirens* f. *cylindracea**

Category: trigger list species (cryptogenic)

Status: established

Summary: *Caulerpa racemosa* var*. cylindracea* occurs in the Port River system and boat ramps along the Adelaide coast.

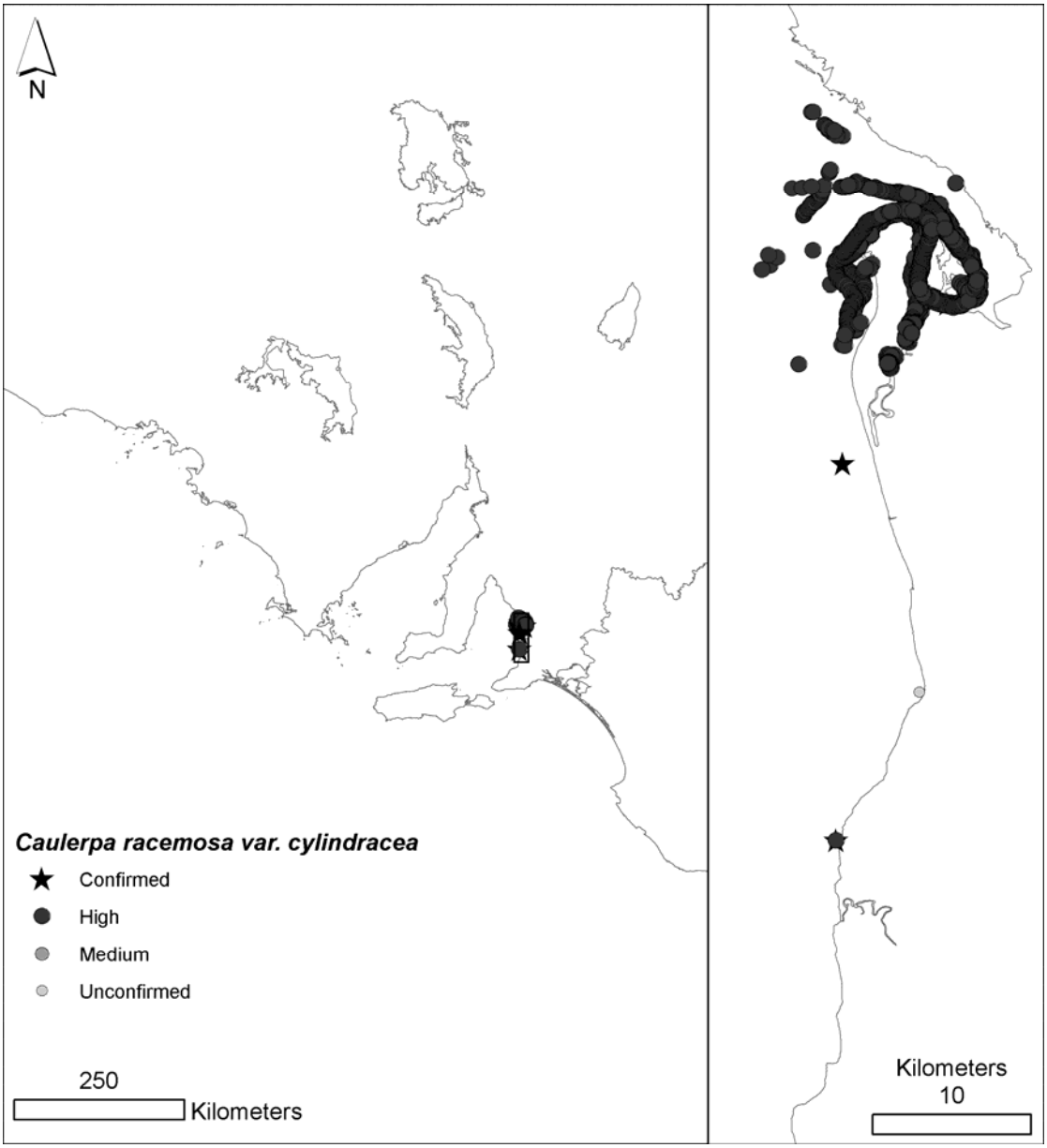

Figure 12. Map of records of *Caulerpa racemosa* var. *cylindracea.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Caulerpa racemosa var*. cylindracea* is native to tropical and temperate regions of WA (Womersley 1984). The first record of *C. racemosa* var*. cylindracea* (as *C. racemosa* var. *laetevirens*) in SA was from Outer Harbor, Port Adelaide, where it was found on settlement plates in 2002 (Womersley 2003; SHSA specimens). In 2003 it was recognised that a second invasive *Caulerpa* species spreading in the Mediterranean (along with *C. taxifolia*, see section 3.2.12) was the Western Australian *C. racemosa* var*. cylindracea* (see Verlaque *et al.* 2003), and that this was also the variety present in SA (Collings *et al.* 2004b). This species has subsequently been recorded throughout the Port River-Barker Inlet system (including North Arm, Barker Inlet, Outer Harbor, Inner Harbour and the upper Port River) and at Adelaide metropolitan boat ramps (North Haven, St Kilda and O'Sullivan Beach, ~3.5 km N of Port Noarlunga) during surveys for *Caulerpa* (most targeting *C. taxifolia*) (Westphalen *et al.* 2004; Theil *et al.* 2005; Rowling 2007, 2009a; Wiltshire and Rowling 2009a, SARDI unpublished data). *Caulerpa racemosa* var*. cylindracea* was also detected during the 2007-9 Port Adelaide surveys (Rowling 2009b; Wiltshire and Rowling 2009b) and specimens held by SHSA further confirm the identity of this species and its occurrence in and around Port Adelaide.

Outside of the Port River system and boat ramps, *C. racemosa* var*. cylindracea* has been observed along the Adelaide coast between Semaphore and North Haven in surveys carried out in 2005 (Westphalen and Rowling 2005), offshore from Section Bank during video surveys for seagrass distribution in 2007 (Bryars and Rowling 2008), and along the coastline near the Bolivar sewerage treatment plant outflow in 2009 (Wiltshire and Rowling 2009a). A specimen held by SARDI was collected off Grange in 2010, where it has been observed sporadically during SARDI seagrass research since 2006 (M. Theil, SARDI pers. comm.). Reef Watch recorded this species at Seacliff reef, ~3.5 km SW of Brighton, in a 2009 "Feral or in Peril" survey (Reef Watch SA 2009b), and it was also observed at nearby Hallett Cove, ~6.5 km S of Brighton, in February 2010 (Bruce Miller-Smith, SARDI, pers. comm.).

This species is classed here as cryptogenic as it is native to south-western Australia. There is evidence that its occurrence in SA could be as the result of a human-mediated translocation given its relatively recent discovery and occurrence around Port Adelaide and boat harbours. Targeted surveys for *C. racemosa* var*. cylindracea* in 2004 failed to find the species at either ports (where it may also have been spread by human activity) or other intermediate locations (where its presence would indicate a natural range expansion was likely) in western SA from Fowlers Bay on the far

west coast (~109 km W of Denial Bay) to Ardrossan on Yorke Peninsula, despite recording a total of 11 native *Caulerpa* species (Collings *et al.* 2004b). It therefore appears that the distribution of *C. racemosa* var*. cylindracea* in SA is restricted to the Adelaide region, primarily around Port Adelaide and boat harbours, with its presence in SA unlikely to be the result of a natural range expansion.

3.2.12. *Caulerpa taxifolia* (M. Vahl) C. Agardh, 1817

Synonyms: *Fucus taxifolius*

Category: trigger list species (introduced)

Status: established

Summary: *Caulerpa taxifolia* is established in the Port River-Barker Inlet system. It was recorded from West Lakes, but eradicated from that location.

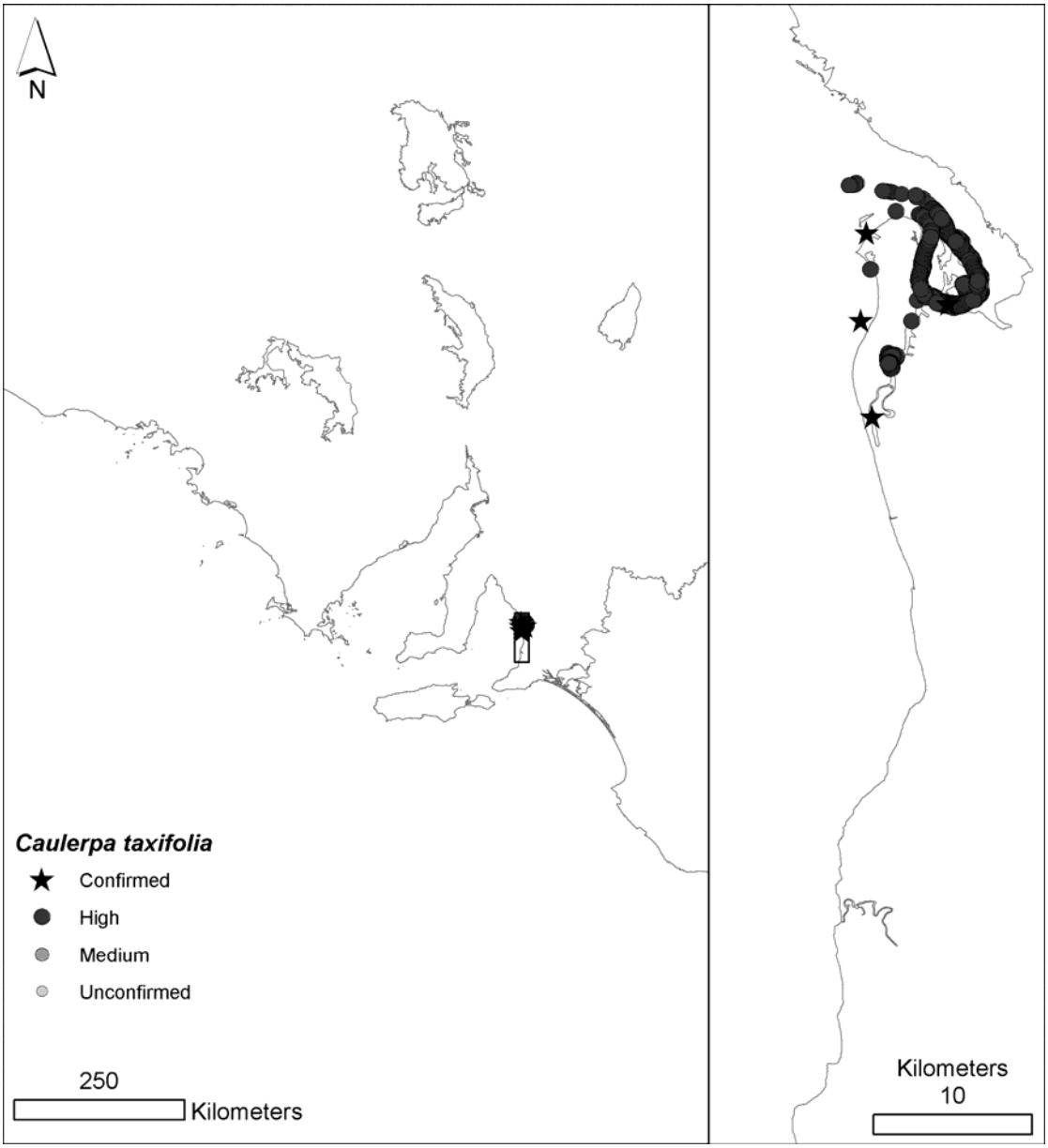

Figure 13. Map of records of *Caulerpa taxifolia.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution. Specimens from Outer Harbor and Largs Bay are of drift algae, see text.

Caulerpa taxifolia has a wide native distribution through the tropical Atlantic, Indian and Pacific oceans (Phillips and Price 2002) and has been introduced to the

Mediterranean, North America and Japan (Meinesz *et al.* 1993; Jousson *et al.* 2000; Komatsu *et al.* 2003). This species was first observed in SA by SARDI staff in March 2002, when it was discovered growing in the semi-enclosed West Lakes system, which connects the upper Port River to the coast (Cheshire *et al.* 2002; Womersley 2003). West Lakes and the Port River-Barker Inlet system were surveyed in April-May 2002 to determine the extent of the alga. Patchy to dense *C. taxifolia* was found throughout West Lakes, with some dense beds of the alga recorded in the upper Port River (Cheshire *et al.* 2002). In 2003, eradication of *C. taxifolia* was carried out in West Lakes by isolating the system, pumping out salt water, and diverting storm water run off from the Torrens River to reduce salinity (Collings *et al.* 2004a). Follow-up surveys in 2004 indicated the eradication from West Lakes was successful (Collings *et al.* 2004a), but *C. taxifolia* remained in the upper Port River despite attempts to eradicate it there using salt treatment, smothering and manual removal (Westphalen *et al.* 2004). Additional outbreaks were detected in 2003-4 at the southern end of Barker Inlet, in North Arm, and at the North Arm-Port River junction (Westphalen *et al.* 2004) and the alga is now regarded as ineradicable in the Port River-Barker Inlet system (Rowling 2007; Westphalen 2008).

Since 2003 SARDI has annually surveyed the Port River-Barker Inlet system for *C. taxifolia*, with a database of results maintained at SARDI and reports on the distribution of the alga published in 2004 and in 2007-9 (Westphalen *et al.* 2004; Rowling 2007, 2008; Wiltshire and Rowling 2009a). The upper Port River was not included in these surveys but was surveyed separately in 2004 (Westphalen *et al.* 2004) and 2008 (Rowling 2009a). Data from these surveys show that *C. taxifolia* persists in the upper Port River and is well-established in the Port River along the western side of Torrens Island, through North Arm and into southern Barker Inlet, with sparse and sporadic occurrence of the algae as far north as Section Bank. Specimens held by SHSA confirm the identity and distribution of this alga (although some specimens are from drift algae, e.g. Largs Bay and Outer Harbor specimens). *Caulerpa taxifolia* was also detected, in areas of known infestation, during the 2007-9 Port Adelaide surveys (Rowling 2009b; Wiltshire and Rowling 2009b).

In May 2008, *C. taxifolia* was discovered during dredging operations in North Haven marina. PIRSA Marine Biosecurity eradicated this outbreak in 2008 using suction dredging and has subsequently surveyed the site regularly. Small individual plants were found in the summer following the eradication, but appeared to succumb to

winter senescence in 2009 and have not reoccurred (M. Sierp, PIRSA Marine Biosecurity, pers. comm.).

In 2005, a drift fragment of *C. taxifolia* was found on the beach at Largs Bay, leading to fears the alga may have established outside the Port River-Barker Inlet system. Following this discovery, surveys of the North Haven coast were conducted (Westphalen and Rowling 2005), and this area was also covered, although not as extensively, in 2008 (Rowling 2008). Since 2007 the annual SARDI surveys have also incorporated Adelaide Metropolitan boat ramps (St Kilda, West Beach, ~2 km N of Glenelg, and O'Sullivan Beach, ~3.5 km N of Port Noarlunga), with North Haven included in 2007 only (since surveyed by PIRSA, see above) (Rowling 2007; Wiltshire and Rowling 2009a). As part of a risk assessment for dredging in the Port River, Inner Harbour (Theil *et al.* 2005) and the proposed dredge spoil site (Rowling and Tanner 2005) were also surveyed for *C. taxifolia* (and *C. racemosa* var. *cylindracea*) in 2005. In 2009 the coastline adjacent to the Bolivar sewage treatment plant outfall was also surveyed (Wiltshire and Rowling 2009a). None of these surveys found any *C. taxifolia*; hence, aside from the outbreak in North Haven marina and discovery of drift fragments, *C. taxifolia* has not occurred outside the Port River-Barker inlet system. The alga has not been found in West Lakes since its eradication, despite regular surveys by PIRSA Marine Biosecurity (J. Gilliland, PIRSA Marine Biosecurity, pers. comm.).

It has not been determined whether the source of the introduction of *C. taxifolia* to SA was from an Australian or Mediterranean source population (Grewe *et al.* 2008), although it is almost certain that the introduction was human-mediated (Murphy 2003).

3.2.13. *Codium fragile* ssp. *fragile* (Suringar) Hariot, 1889

Synonyms (*reported as): *Codium fragile* ssp. *tomentosoides**, *Codium fragile* ssp. *capense*

Category: trigger list species (introduced)

Status: established

Summary: *Codium fragile* ssp. *fragile* is recorded from North Haven, West Lakes and American River.

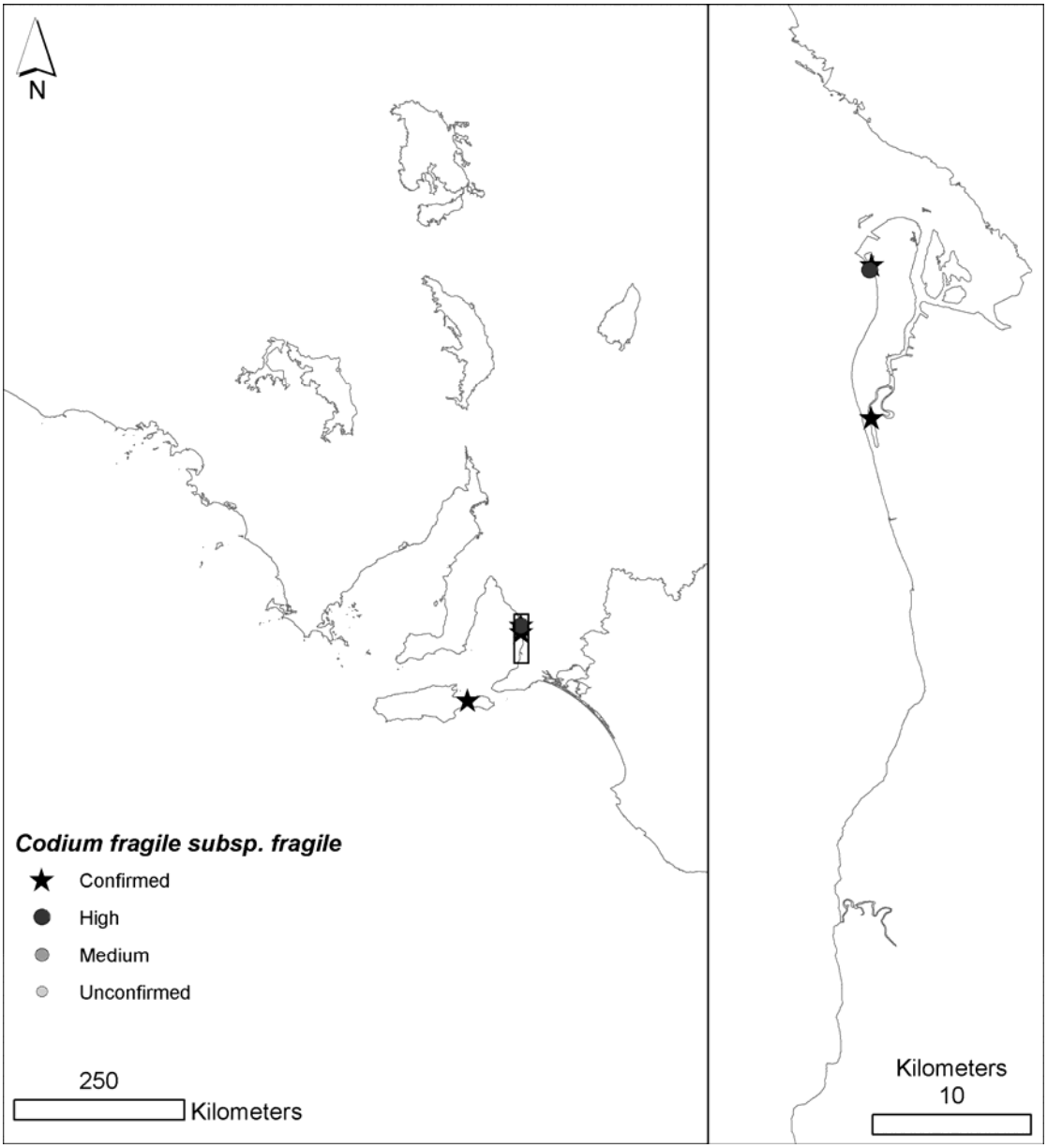

Figure 14. Map of records of *Codium fragile* ssp. *fragile.*

Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Codium fragile ssp. *fragile* is native to Japan and has been introduced to North America, the Mediterranean, New Zealand and Australia (Aquenal Pty Ltd 2002). The

first report of *C. fragile* ssp. *fragile* (as *C. fragile* ssp. *tomentosoides*) in SA was from West Lakes, where it was common in 2002 (Womersley 2003). *Codium fragile* ssp. *fragile* was found in North Haven marina in 2007 by the Port Adelaide pest survey (Rowling 2009b), and in 2008 it was found in American River, KI (M. Kinloch, KI NRM, pers. comm.). SHSA holds specimens to confirm these records. It is unknown if this distribution is continuous or if these records describe discrete populations of this alga. *Codium* species have been recorded along the Adelaide coast (SARDI unpublished data), but microscopic examination is required to separate *C. fragile* ssp. *fragile* from other *C. fragile* subspecies (Trowbridge 1996), of which several are native (Womersley 1984; Aquenal Pty Ltd 2002).

Despite being known from SA since late 2002, *C. fragile* ssp. *fragile* is not recorded in SA by NIMPIS (2009c) or Hayes *et al.* (2005).

3.3. Maps and information – non-trigger list species

Results for the 86 species reported as being introduced to SA that are not on the current trigger list are presented in this section, with species in taxonomic groups in the same order as their listing in Table 1.

Note that common names are given only where they are in frequent use for the species. Synonyms are not a complete list, but where a species has been reported under a synonym in SA, that name is highlighted with an asterix.

Localities named in the text for each species are shown in Figure 1 for the State as a whole, Figure 2 for the Port Adelaide region, or are referenced to localities shown in Figure 1. Co-ordinates used for mapping locations named in the text are given in the appendix. Records pertaining to large areas (gulf, river, bioregion) without specific information are not shown on maps (see Methods) and co-ordinates were not assigned.

CNIDARIA: Anthozoa

3.3.1. *Haliplanella lineata* (Verrill, 1870)

Synonyms (*reported as): *Aiptasiomorpha luciae*, *Diadumene lineata**, *D. luciae*, *Haliplanella luciae*, *Sagartia luciae*
Category: introduced
Status: unconfirmed
Summary: Reports of *Haliplanella lineata* could not be substantiated.

Haliplanella lineata (as *Diadumene lineata*) was shown as “inferred” to be in Port Adelaide by Furlani (1996), with the note “to be confirmed”. It was included as a presumed introduction in the 1998-99 lists of introduced species in SA (EPA and DEHAA 1998; Lewis *et al.* 1998; Edyvane 1999), with no further detail on its occurrence. No evidence could be found to substantiate these reports or to suggest that the species occurs in SA.

CNIDARIA: Hydrozoa

3.3.2. *Coryne eximia* Gaertner, 1774

Synonyms (*reported as): *Sarsia radiata**, *S. eximia**, *Coryne tenella*

Category: cryptogenic

Status: established

Summary: *Coryne eximia* is recorded at Port Lincoln and possibly widespread.

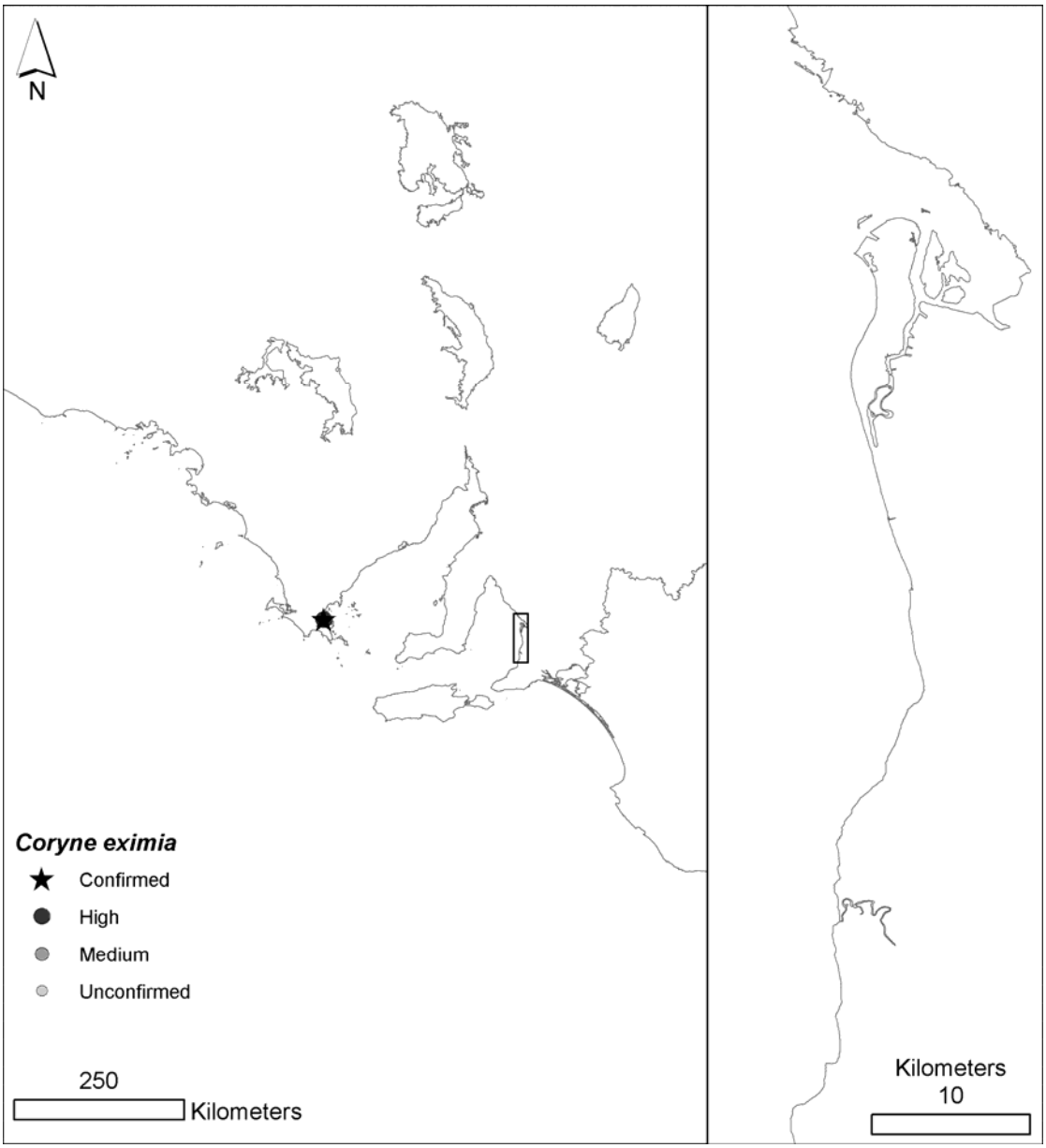

Figure 15. Map of records of *Coryne eximia.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Coryne eximia (reported as *Sarsia radiata*) was found at Port Lincoln by the 1996 CRIMP port survey (Hewitt *et al.* 1997; SAM specimen). This species is also known

from WA (Watson 1996), Victoria (Watson 1999) and Tasmania (Aquenal Pty Ltd 2002). Although reported as introduced by Hewitt *et al.* (1997), *Sarsia radiata* was originally believed to be endemic to southern Australia, but is now regarded as being the same species as the cosmopolitan *C. eximia*, formerly *Sarsia eximia* (see Watson 1999; Aquenal Pty Ltd 2002). It is therefore categorised here as cryptogenic. We found no further records of this species, but it is reported as being prolific in southern Australia (Watson 1982) so we class it as established.

3.3.3. *Cordylophora caspia* (Pallas, 1771)

Synonyms: *Cordylophora lacustris*
Category: introduced
Status: unconfirmed
Summary: *Cordylophora caspia* has been reported from freshwater lakes near Mount Gambier.

Cordylophora caspia is native to the Caspian and Black Seas, and so is regarded as introduced in Australia, although it has an almost cosmopolitan distribution (Aquenal Pty Ltd 2002; Hayes *et al.* 2005). Watson (1999) suggests that it is uncertain if *C. caspia* was spread by human activity. In Australia it is abundant in freshwater lakes in Victoria (Watson 1999) and in SA it has been reported from freshwater lakes near Mount Gambier (Aquenal Pty Ltd 2002; NIMPIS 2009b). The report of this species in SA is based on unpublished data supplied to NIMPIS by the hydroid expert J. Watson (NIMPIS 2009b). The report is therefore credible, but the current review could not find any further evidence to confirm the occurrence of this species in SA.

3.3.4. *Halecium delicatulum* Coughtrey, 1876

Synonyms: *Halecium gracile*, *H. parvulum*

Category: cryptogenic

Status: established

Summary: *Halecium delicatulum* is recorded from St Francis and Pearson Islands.

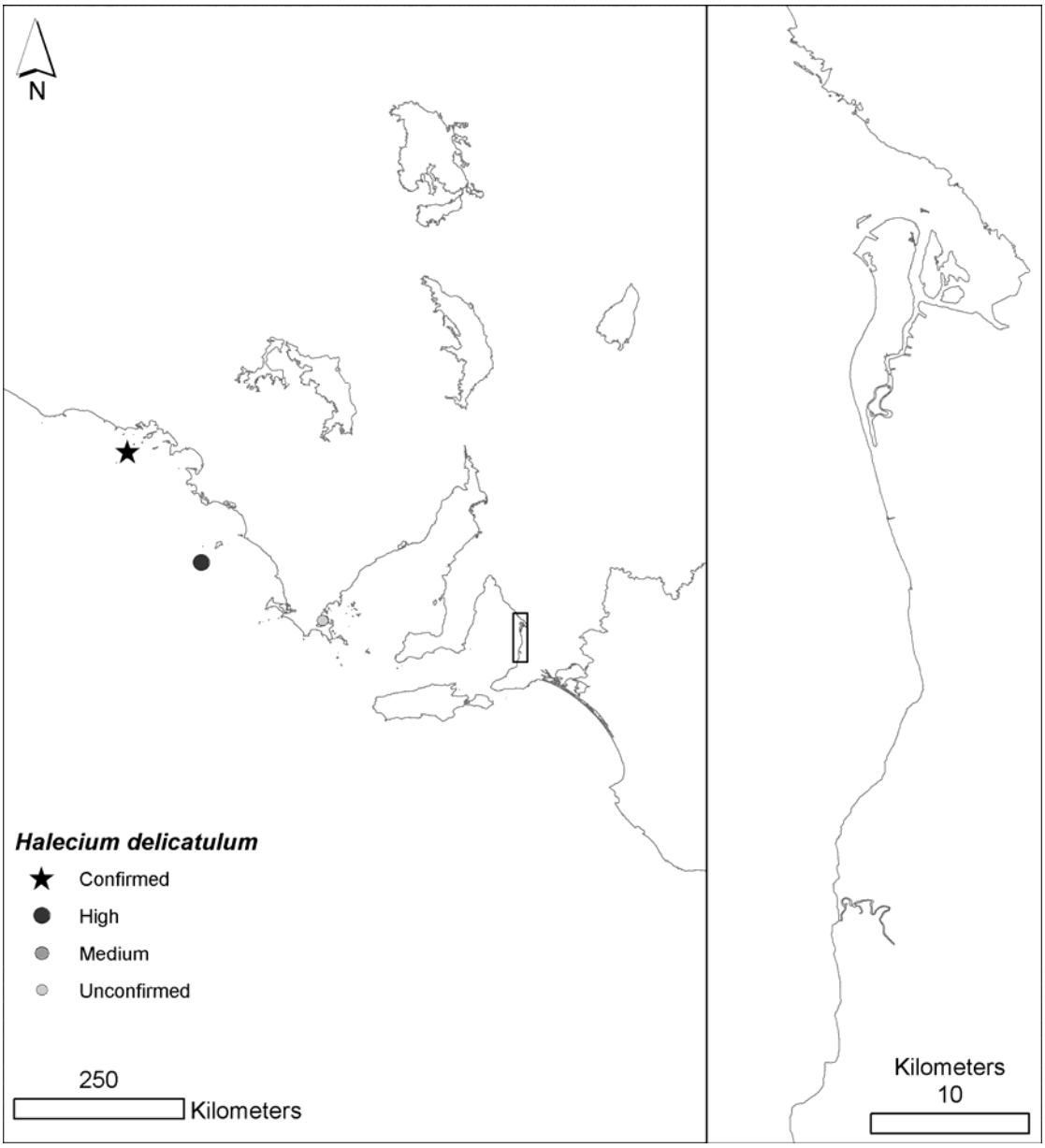

Figure 16. Map of records of *Halecium delicatulum.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Halecium delicatulum has an almost cosmopolitan in distribution, but is regarded as a possible introduction because it occurs predominantly around ports and harbours in Victoria (Watson 1999; Aquenal Pty Ltd 2002). The only records found of

H. delicatulum in SA, however, are from 45m depth off Pearson Island, ~65 km SW of Elliston (Watson 1973), and St Francis Island in the Nuyts archipelago, ~55 km SW of Ceduna (SAM specimen), both unlikely locations for human-mediated introduction. This species was recently recorded around Port Lincoln, but collected specimens are yet to be formally identified (Dittmann *et al.* 2010). NIMPIS indicates that its distribution includes the Coorong bioregion (NIMPIS 2009b); we did not find any other records pertaining to this part of SA, but Watson (1982) regarded it as being “common and widely distributed” in southern Australia so it may be more widespread. We therefore class it as established, despite the absence of more specific records.

3.3.5. *Antennella secundaria* (Gmelin, 1791)

Synonyms: *Antennella gracilis*

Category: cryptogenic

Status: established

Summary: *Antennella secundaria* is recorded from Pearson Island and Edithburgh.

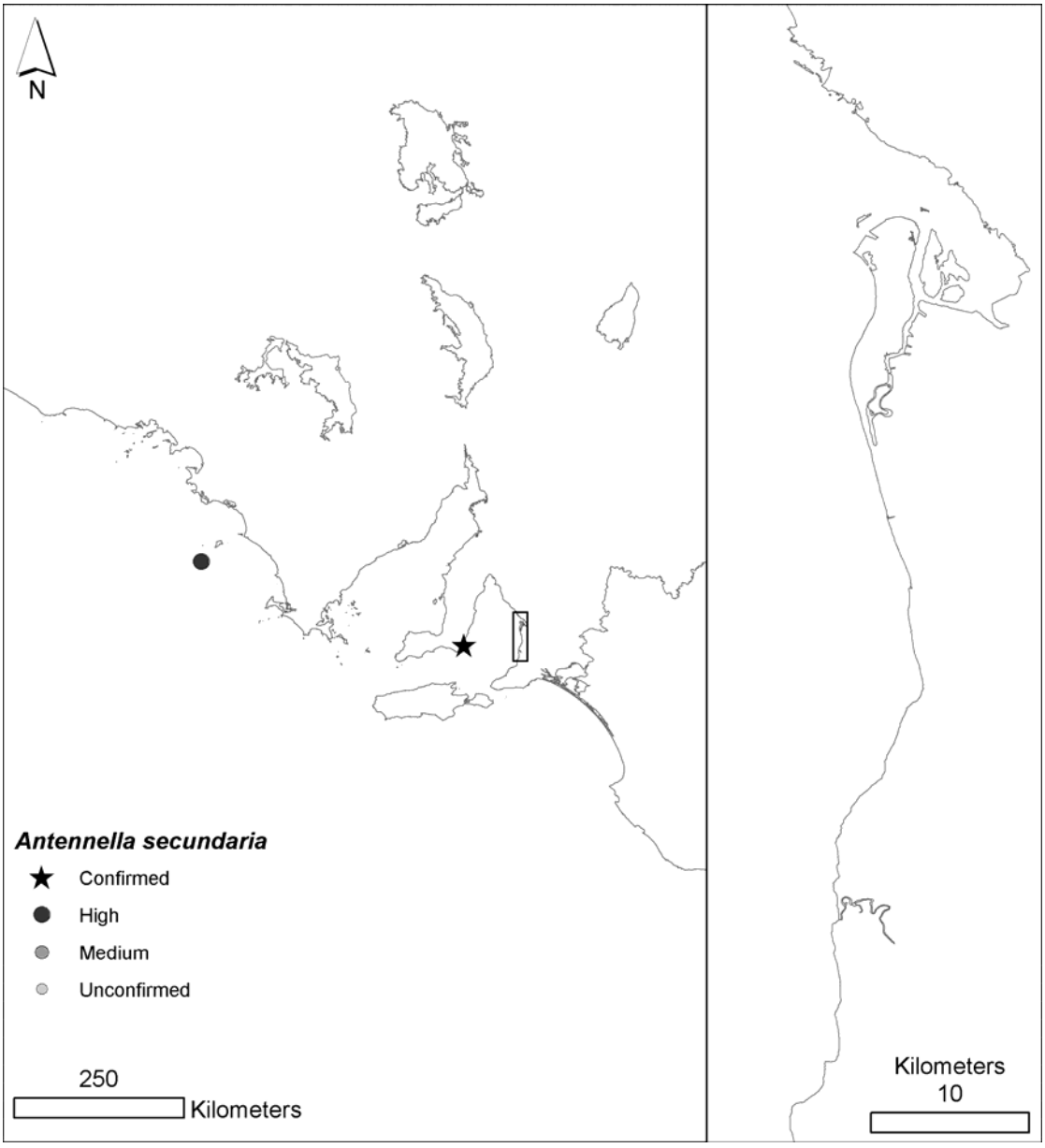

Figure 17. Map of records of *Antenella secundaria.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Antennella secundaria is considered almost cosmopolitan in temperate to sub-tropical regions (Watson 1999). In SA it has been reported from Pearson Island, ~65 km SW of Elliston (Watson 1973), and a specimen from Edithburgh is held by SAM.

Watson (1999) stated that the species is not common; but it is included in 'Marine Invertebrates of Southern Australia' (Watson 1982) so we class it as established.

3.3.6. *Plumularia setacea* (Linnaeus, 1758)

Synonyms: *Plumularia corrugata*, *P. tripartita*, *Corallina setacea*, *Sertularia setacea*

Category: cryptogenic

Status: uncertain

Summary: *Plumularia setacea* is recorded from Barker Inlet and Redcliff Point.

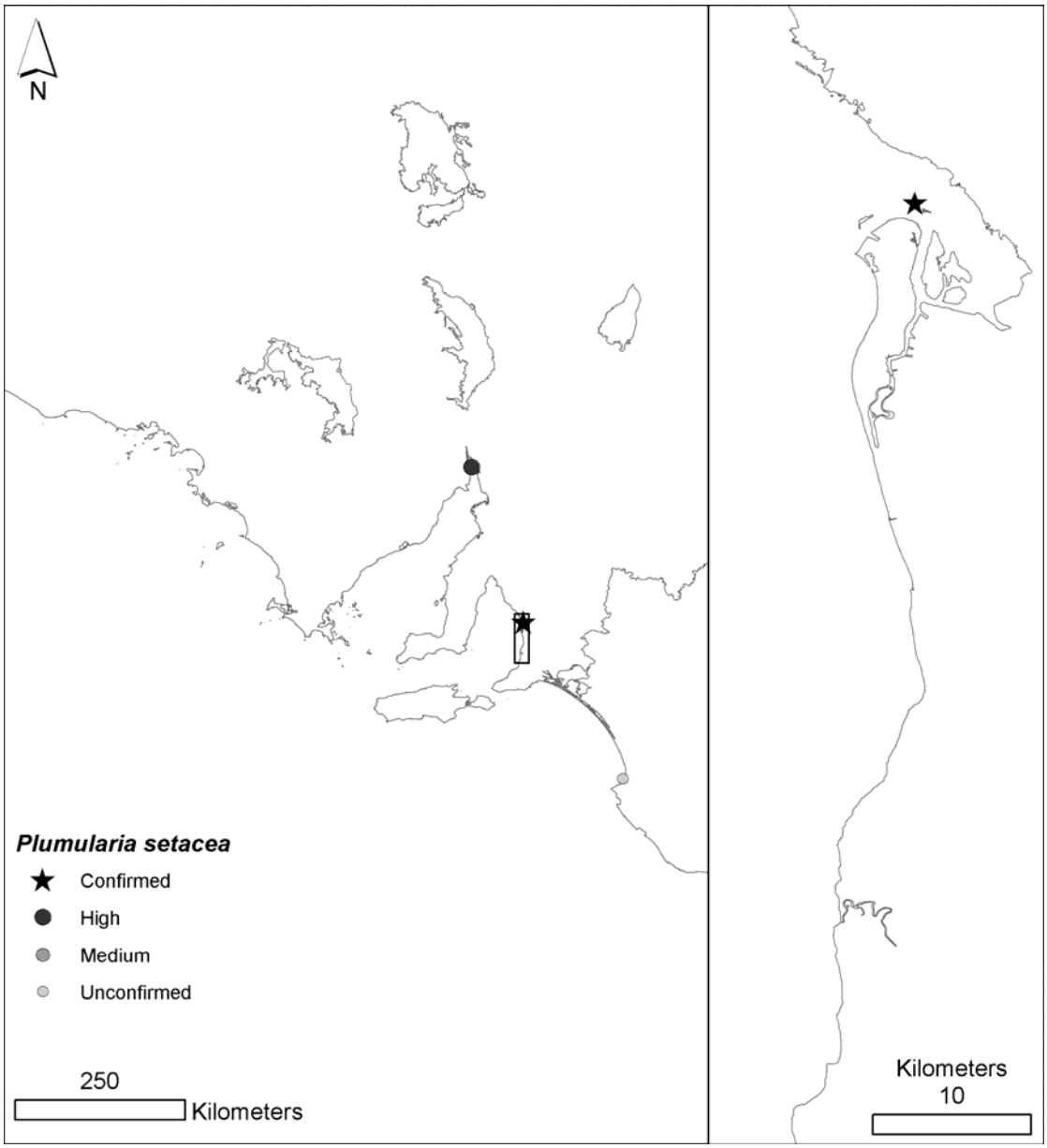

Figure 18. Map of records of *Plumularia setacea.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Plumularia setacea is considered almost cosmopolitan in temperate to sub-tropical regions (Watson 1999). In SA, this species has been reported from Kingston SE based on unpublished information from the hydroid expert J. Watson (NIMPIS 2009b). In Victoria it is reported to be widespread although uncommon (Watson 1999), but we did not find any records to confirm the occurrence of this species in the south-east of SA. A specimen in SAM is from Barker Inlet, and Shepherd (1983) recorded this species from Redcliff point, ~22.5 km SSE of Port Augusta. We regard the status of this species as uncertain due to the lack of information, although the widely dispersed nature of the records suggests that it may be widespread.

CNIDARIA: Scyphozoa

3.3.7. *Cassiopea ndrosia* Agassiz and Mayer, 1899

Synonyms: none known, but has been misspelt as *Cassiopea nodrosia* or *Crassiopea ndrosia* in some literature

Category: introduced

Status: previously established

Summary: *Cassiopea ndrosia* occurred in Angas Inlet but has not recently been found.

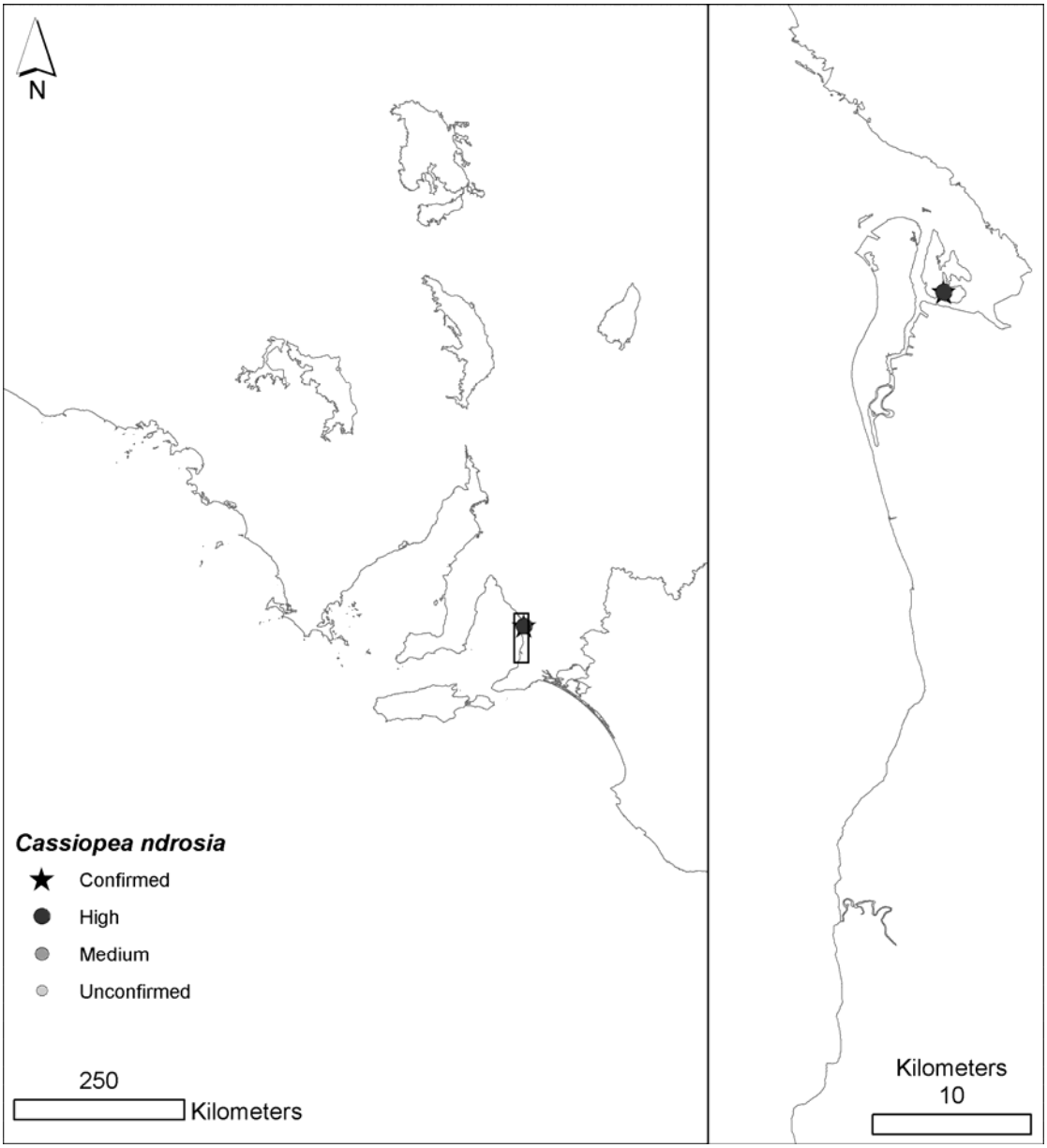

Figure 19. Map of records of *Cassiopea ndrosia.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Cassiopea ndrosia is known from Fiji, New Caledonia and northern Queensland; in SA the species was found in Angas Inlet, near the warm water outlet of the Torrens Island Power Station (Southcott 1982). SAM specimens were collected from this location between 1972 and 1975. This species was present between 1981 and 1995 (Jones 2008), but it has not been found there more recently despite targeted searches (W. Zeidler, SAM, pers. comm.).

ANNELIDA: Polychaeta

3.3.8. *Alitta succinea* (Frey and Leuckart, 1847)

Synonyms: *Neanthes perrieri*, *Neanthes succinea**, *Neanthes oxypoda**, *Nereis* (*Neanthes*) *australis*, *Nereis* (*Neanthes*) *saltoni*, *Nereis* (*Neanthes*) *succinea*, *Nereis acutifolia*, *Nereis belawanensis*, *Nereis glandulosa*, *Nereis limbata*, *Nereis reibischi*, *Nereis succinea*
Category: introduced
Status: unconfirmed
Summary: We could not confirm the report of *Alitta succinea* in SA.

Alitta succinea is native to the North Sea, but is now widely distributed throughout northern Europe and reported from Africa, Japan, China, North America and Australia (Wilson 1999; Cohen *et al.* 2001; Hayes *et al.* 2005). In Australia it was first recorded in the Swan River estuary (Perth, WA) in 1930 and since 1980 it has been recorded in south-eastern Australia (NSW and Victoria) (Cohen *et al.* 2001; Wilson *et al.* 2003). Hayes *et al.* (2005) includes the GSV bioregion as one where *A. succinea* is known, along with the relevant bioregions for records in WA, NSW and Victoria. NIMPIS (2009b), however, while showing the species in WA, NSW and Victoria, does not show it as occurring in SA. The report in Hayes *et al.* (2005) may have been based on a draft report for the AFD that included SA in the distribution of this species (C. Glasby, MAGNT pers. comm.). The current AFD shows the distribution of *A. succinea* as including NSW, Victoria and WA (ABRS 2009); the species has also recently been recorded in QLD and Tasmania but there is no evidence for its current occurrence in SA (C. Glasby, MAGNT, pers. comm.).

3.3.9. *Myxicola infundibulum* (Renier, 1804)

Synonyms: *Terebella infundibulum*

Category: cryptogenic

Status: established

Summary: *Myxicola infundibulum* is recorded in Port Adelaide, Tumby Bay and Port Lincoln and likely to be widespread in SA.

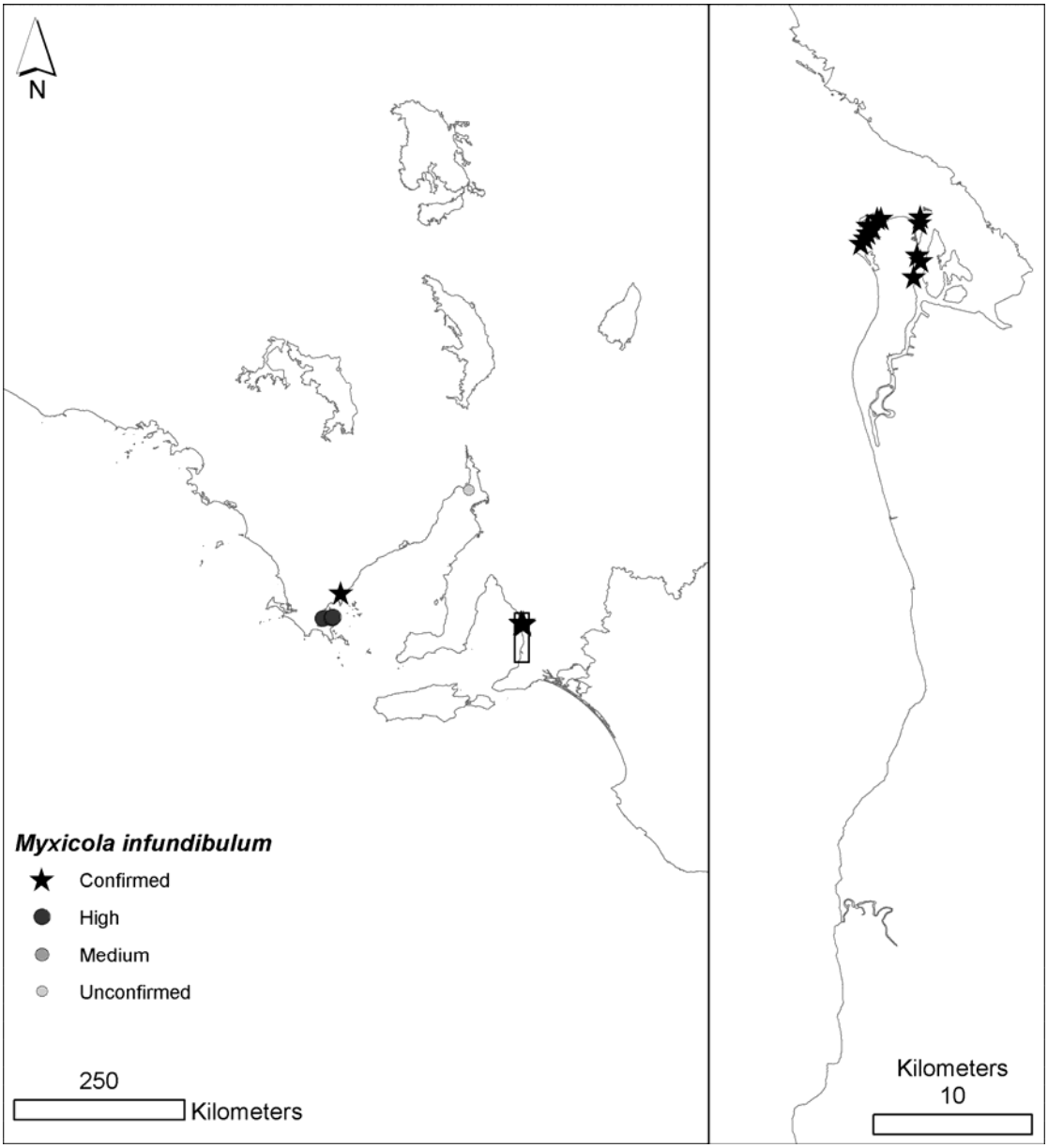

Figure 20. Map of records of *Myxicola infundibulum.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Myxicola infundibulum is native to the Mediterranean but has a near cosmopolitan distribution (Parry *et al.* 1997). Its status as an introduction to Australia is unclear as it is possible that not all worms ascribed to *M. infundibulum* are the same species

(Cohen *et al.* 2002; Gowlett-Holmes 2008). Cosmopolitan polychaetes are rare, with many that appear widely distributed actually consisting of several species (Wilson *et al.* 2003). In SA *M. infundibulum* was found by the 2001 Port Adelaide survey throughout the survey area (Cohen *et al.* 2002; SAM specimens); it is also recorded from Tumby Bay (MV specimens) and Port Lincoln, where it was very common around the town jetty and near tuna leases off Cape Donington (SARDI unpublished data). The species has also been reported to occur at Port Bonython, ~18 km ENE of Whyalla, based on unpublished BHP Billiton data (Arup and ENSR 2008). Gowlett-Holmes (2008) and Edgar (2008) show the species as ranging from Perth, WA to PPB, Victoria, suggesting it is likely to be found throughout SA.

3.3.10. *Hydroides "elegans"*

Synonyms: see text, most records as *Hydroides norvegica*, now regarded a separate species

Category: cryptogenic

Status: established

Summary: *Hydroides "elegans"* has been reported as an introduced species in SA, but identification of the species is uncertain.

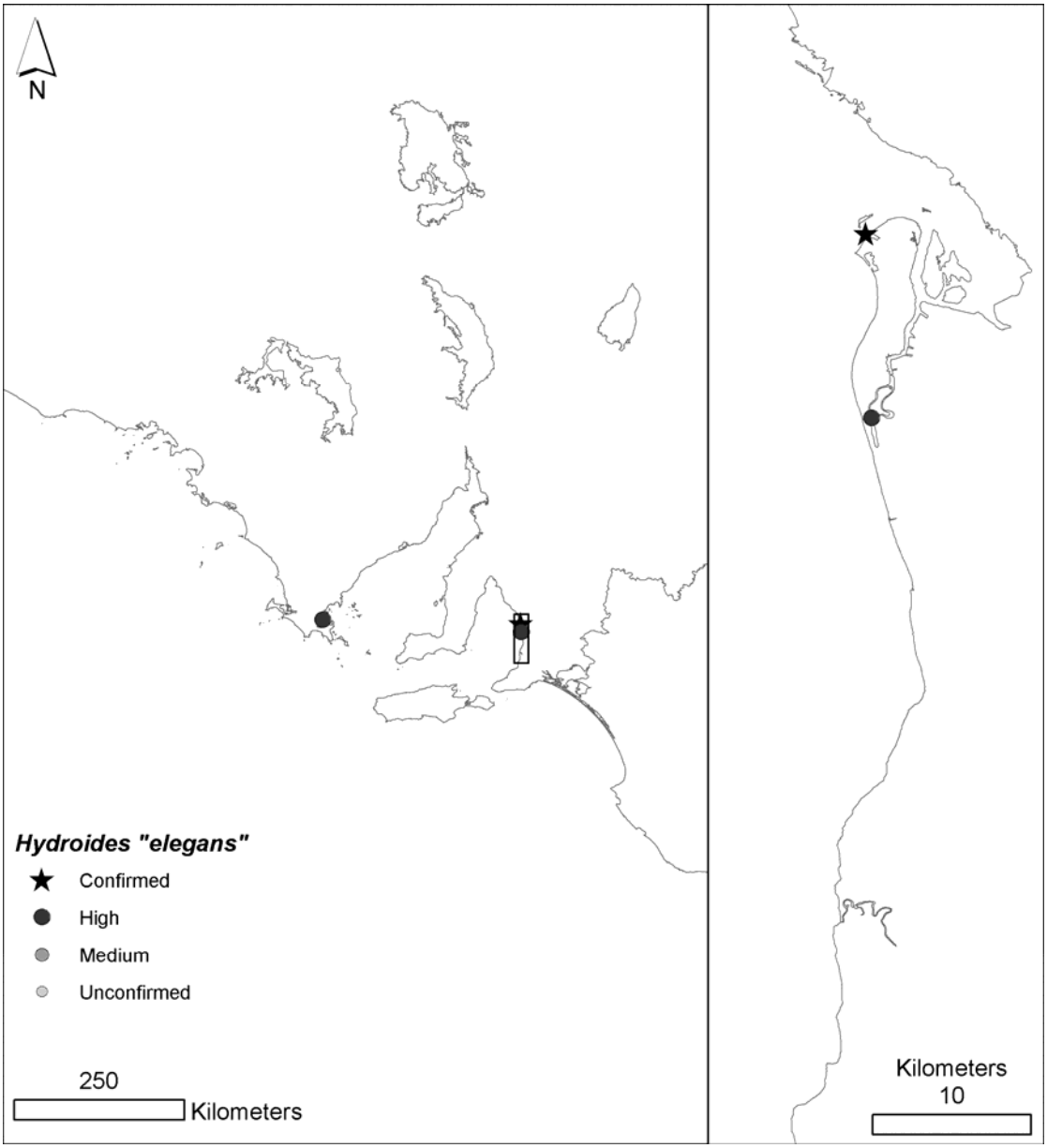

Figure 21. Map of records of *Hydroides "elegans".*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Hydroides elegans was described as *Eupomatus elegans* Haswell, 1883 from Sydney Harbour, but was later synonymised with the European species *Hydroides norvegica* Gunnerus, 1768 (Allen 1953; Straughan 1967). Most reports from Australia are as *H. norvegica*, although the synonymy was rejected in 1974 (ten Hove 1974 in Wilson *et al.* 2003) and *Hydroides elegans* (Haswell, 1883) was accepted as a valid species (Appeltans *et al.* 2009). *Hydroides elegans* has a global distribution and may have been spread by shipping, but it is impossible to determine whether Australia forms part of its original native range (Wilson *et al.* 2003). In SA, this species has been reported (as *H. norvegica*) from West Lakes (Keough 1983) and Port Lincoln (Dew 1959). A specimen in SAM (identified as *H. elegans*) was found on the shell of the *Charybdis japonica* collected at Outer Harbor (see section 3.2.3). *Hydroides elegans* was also recorded in the 2001 Port Adelaide survey (Cohen *et al.* 2002), but it was not considered introduced by these authors and so no detailed information was provided on its distribution in the survey region. We class it as established based on its occurrence in the Port Adelaide region over many years, although its status at Port Lincoln is unknown.

3.3.11. *Cirriformia punctata* (Grube, 1859)

Synonyms: *Audouinia punctata*, *Cirratulus multicirratus*, *Cirratulus niger*, *Cirratulus nigromaculatus*, *Cirrhatulus punctatus*

Category: cryptogenic

Status: unconfirmed

Summary: *Cirriformia punctata* is reported from Angas Inlet.

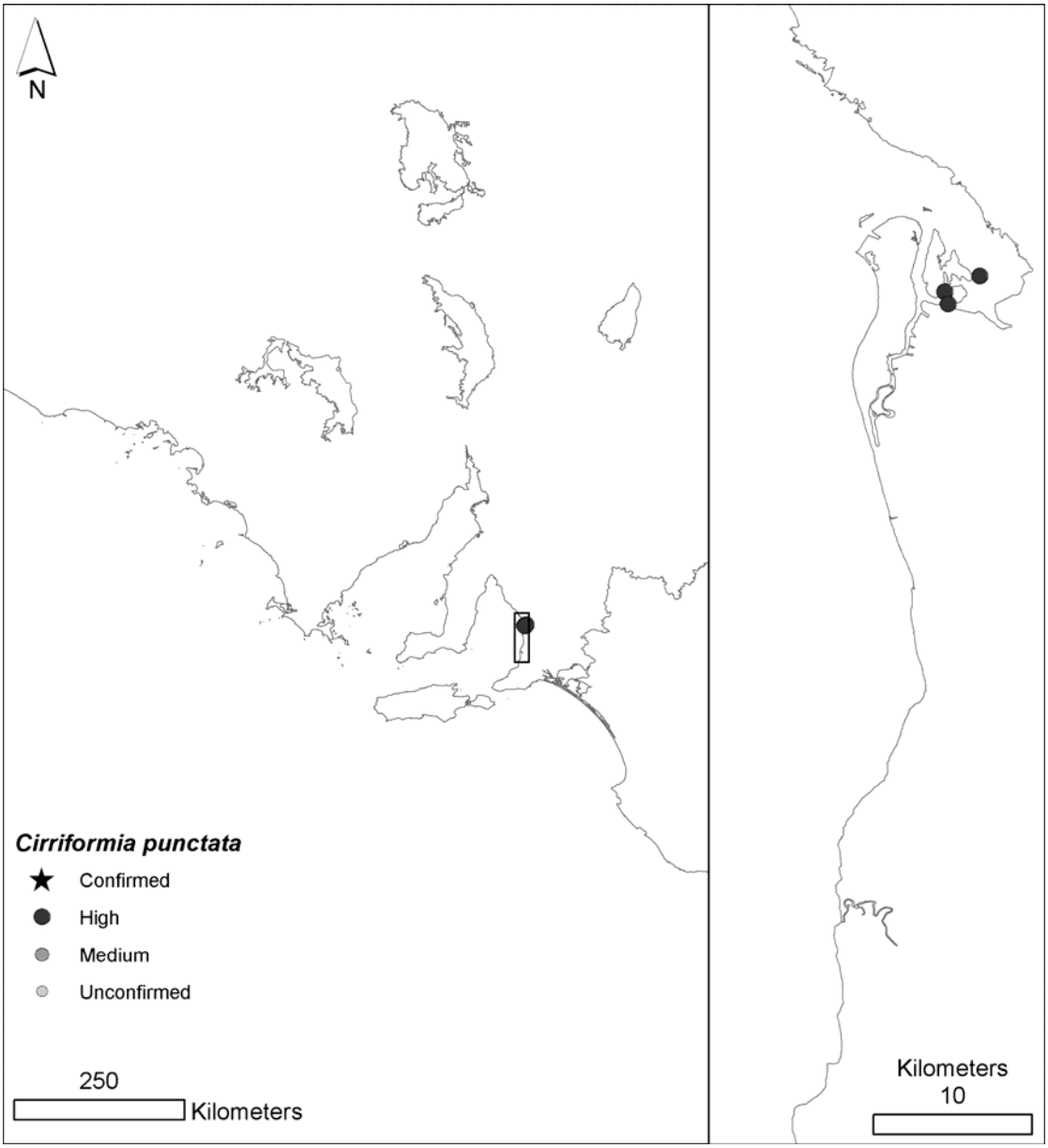

Figure 22. Map of records of *Cirriformia punctata.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Cirriformia punctata has a circumtropical distribution (Glasby and Fauchald 2003) and in Australia is known from Lizard Island, Queensland (Thomas *et al.* 1986). It was found in Angas Inlet and southern Barker Inlet between 1972 and 1985, where it

may have been introduced by yachts mooring in the Angas Inlet boat harbour. It was reported as the dominant benthic species in Angas Inlet prior to 1982, but was then largely replaced by a *Pseudopolydora* sp. (Thomas *et al.* 1986). We were unable to verify the existence of any specimens of this species, and did not find any more recent reports of its presence, so we class it as unconfirmed although it appears likely to have occurred. Its current status is unknown.

3.3.12. *Boccardia chilensis* Blake and Woodwick, 1971

Category: introduced

Status: established

Summary: *Boccardia chilensis* is recorded from Port Lincoln, Venus Bay, Cowell and the Coorong.

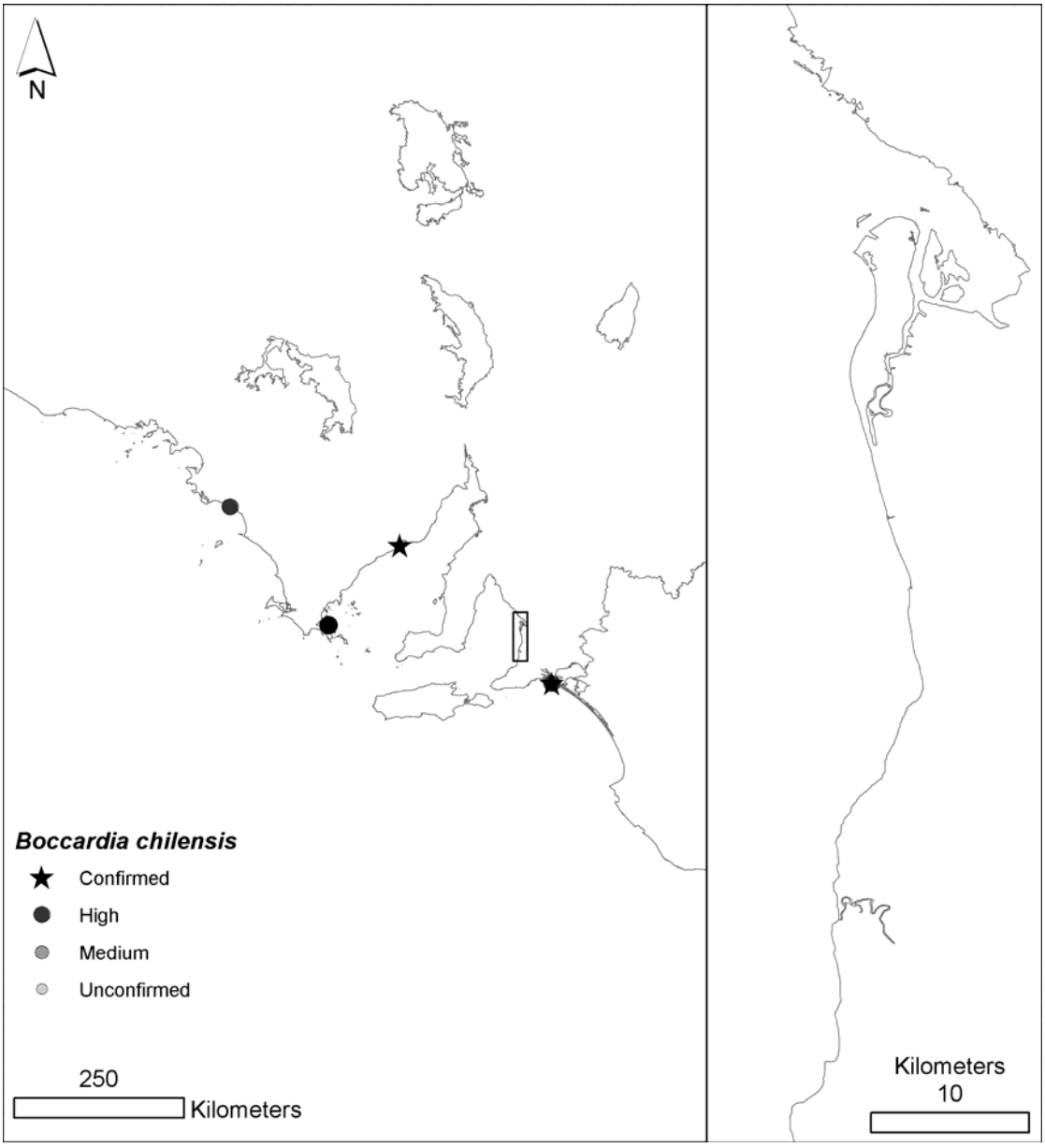

Figure 23. Map of records of *Boccardia chilensis.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Boccardia chilensis is native to Chile and was first recorded in Australia in NSW in 1971 (AMBS 2002). This species was first recorded in SA by Hutchings and Turvey (1984), who identified specimens from Venus Bay and the Coorong. A specimen from the Coorong is held by AM, but the exact collection locality is unknown (we

show it as near the Murray Mouth, but this is uncertain). SAM holds specimens of this species from the shells of farmed oysters in Franklin Harbour (Cowell) collected in 1994, and it was also found in Port Lincoln by the 1996 CRIMP port survey (TMAG unpublished data), although it was not discussed in the accompanying report (Hewitt *et al.* 1997). We class this species as established due to the multiple collection localities over several years.

3.3.13. *Boccardia proboscidea* Hartman, 1940

Synonyms: *Polydora proboscidea*

Category: introduced

Status: uncertain

Summary: *Boccardia proboscidea* is recorded from Elliston.

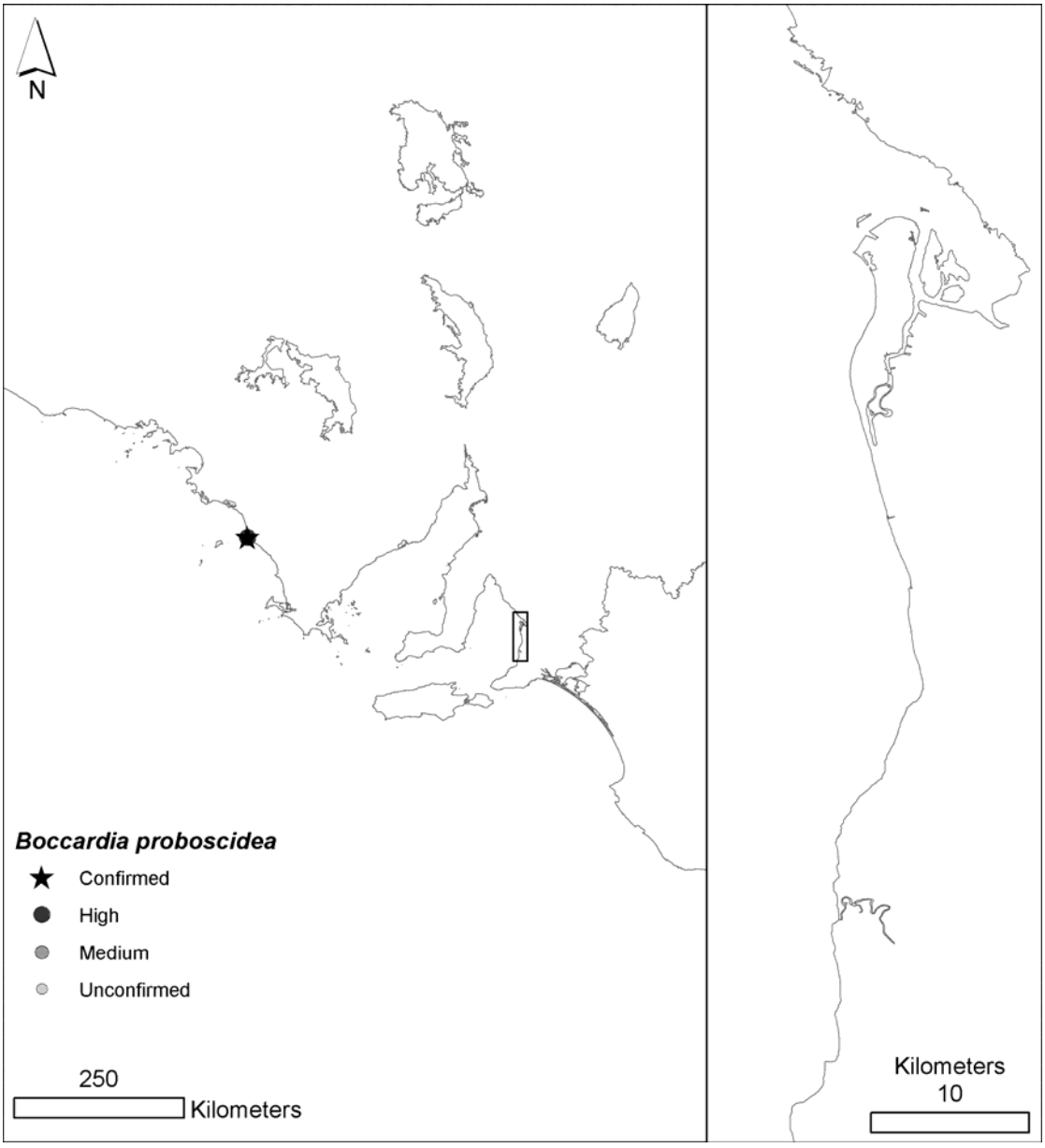

Figure 24. Map of records of *Boccardia proboscidea.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Boccardia proboscidea is native to the Northern Hemisphere with a distribution including North America, Panama and Japan, and was first recorded in Australia in 1975 in WA, followed by PPB, Victoria in 1976 (Wilson 1999; Aquenal Pty Ltd 2002; Hayes *et al.* 2005). This species was shown as occurring throughout Victoria to the

SA border by Furlani (1996), leading to it being included on a list of introduced species in SA as a presumed introduction, with no distribution information provided (Edyvane 1999). *Boccardia proboscidea* has been recorded from Elliston (Hutchings and Turvey 1984); a specimen from that location is held by AM, confirming this record. This species is also reported from the Otway bioregion (Hayes *et al.* 2005; NIMPIS 2009b), due to a record from Portland, Victoria (Cohen *et al.* 2001), but we found no records for this species in the SA part of that bioregion. Hutchings and Turvey (1984) commented that it was common at Elliston, but recent records are lacking, so we class its current status as uncertain.

3.3.14. *Polydora "ciliata"*

Synonyms: see text, may be reported as *Polydora websteri*
Category: cryptogenic
Status: unconfirmed
Summary: Reports of *Polydora "ciliata"* from GSV could not be confirmed.

NIMPIS (2009b) reports *Polydora ciliata* (Johnston, 1838) as occurring in the GSV bioregion. Several polydorid polychaetes (family Spionidae) have been reported as introduced to Australia, but misidentification may have occurred in some cases (e.g. see Pollard and Hutchings 1990b) because polydorids suffer from confused taxonomy and are difficult to identify (Blake and Kudenov 1978; Beesely *et al.* 2000). *Polydora* species may have been introduced to Australia with the import of Pacific oysters, but some species may also be native, and it is not possible currently to differentiate between these (Beesely *et al.* 2000).

Polydora ciliata was first recorded from Australia in 1885, when worms found in blisters inside oyster shells were ascribed to this European species, despite *P. ciliata* not being known as shell-boring. It has recently been shown by a combined molecular and morphological approach that the shell-boring form of *P. "ciliata"* is a distinct species (Walker 2008). Shell-boring polydorids from NSW originally identified as *P. ciliata* are often regarded as being *Polydora websteri* (Hartman, in Loosanoff and Engle, 1943) (see Blake and Kudenov 1978; Hayes *et al.* 2005), hence NIMPIS shows *P. ciliata* as absent from the east coast of Australia (NIMPIS 2009b). Other *Polydora* species considered introduced include *P. cornuta* Bosc, 1802, which Hayes *et al.* (2005) report from the GSV bioregion. Aside from the GSV bioregion, the distribution of *P. cornuta* given by Hayes *et al.* (2005) does not correspond to that of *P. ciliata* given by NIMPIS (2009b), so it appears this in an independent report and not the result of confusion between these species. *Polydora cornuta* may be considered synonymous with *P. ligni* Webster, 1879 (e.g. Walker 2008), which has been recorded from Angas Inlet in 1979 (Hutchings and Turvey 1984) and Port Lincoln in 1996 (TMAG unpublished data), but the two are regarded as distinct species by WoRMS, as well as being distinct from *P. ciliata* (see Appeltans *et al.* 2009).

NIMPIS records *P. ciliata* in GSV from "port survey data" (NIMPIS 2009b), but this species was not included in the report for the Port Adelaide survey (which is the only survey applicable to GSV), although one *Polydora* (c.f. *flava*)[2] is listed (Cohen *et al.* 2002). Given the difficulty in identifying *Polydora* species, we did not request further data on the record of *P. ciliata* from the NPSD; especially as it appears this occurrence was not confidently identified. *Polydora* species are present in SA, SAM holds specimens of shell-boring *Polydora* spp. found in Pacific oysters, but these have not been identified to species. We found no specific records of *P. ciliata*, *websteri* or *cornuta* in SA to substantiate reports. *Polydora ligni* is likely to have occurred based on published records, but its current status is unknown.

[2] *Polydora flava* Claparède, 1870 is another valid, distinct species (Appletans *et al.* 2009). Blake and Kudenov (1978) record *P. flava* from Victoria and NSW.

3.3.15. *Pseudopolydora paucibranchiata* (Okuda, 1937)

Synonyms: *Polydora* (*Carazzia*) *paucibranchiata*

Category: cryptogenic

Status: established

Summary: *Pseudopolydora paucibranchiata* has been recorded from Port Adelaide and Port Lincoln.

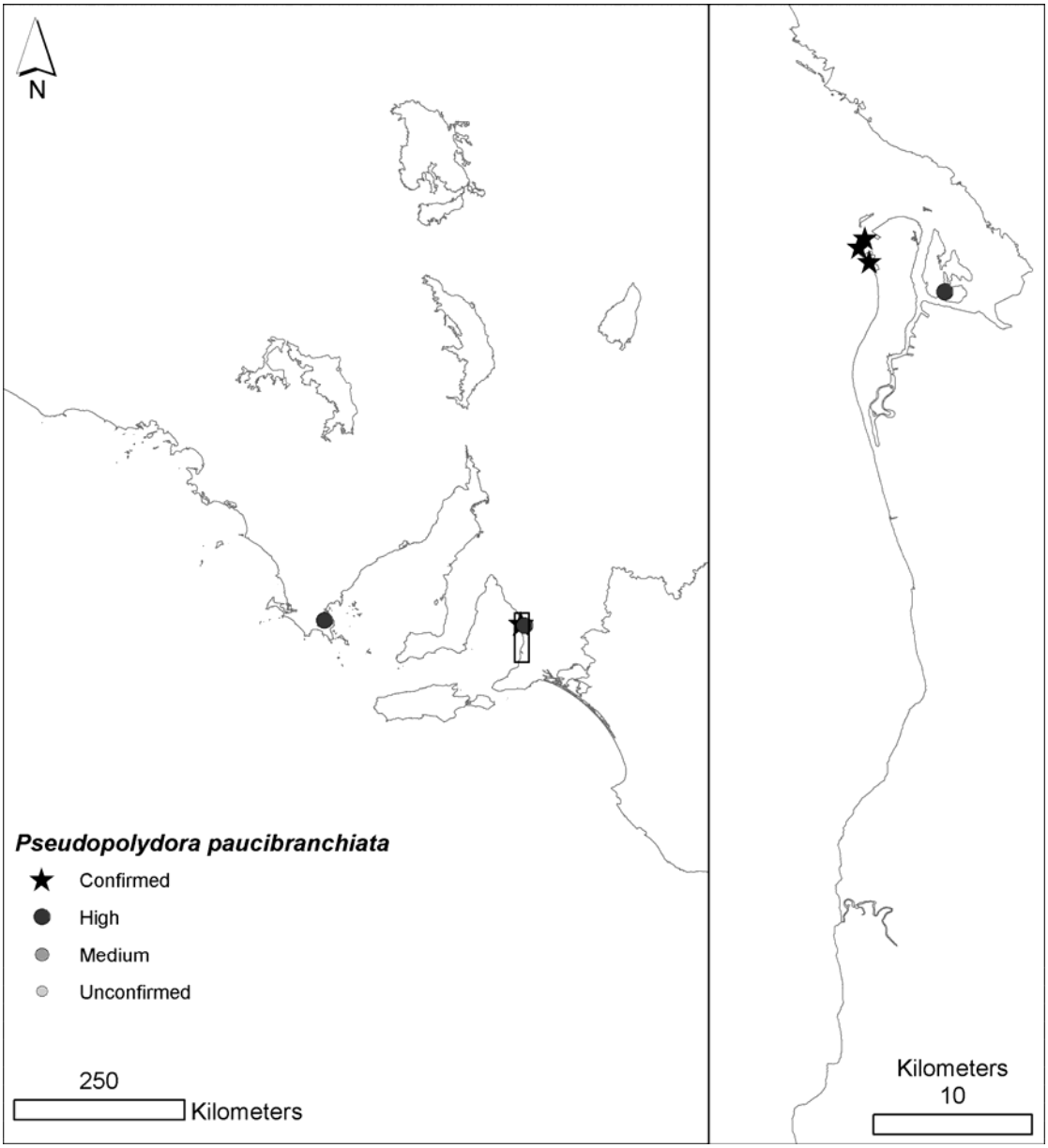

Figure 25. Map of records of *Pseudopolydora paucibranchiata.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Pseudopolydora paucibranchiata is considered native to Japan, but is widely distributed through the Pacific, having possibly been transported on edible oysters (Wilson 1999; Wilson *et al.* 2003). It is also possible, however, that the species is

native to Australia (Pollard and Hutchings 1990b; Wilson 1999) or represents a complex of species (Hutchings and Turvey 1984), so it is classed here as cryptogenic. Hutchings and Turvey (1984) record *P. paucibranchiata* from Angas Inlet and Port Lincoln. This species was also found in Angas Inlet in 2000-01, where it was the dominant spionid (Indarjani 2003) and around Outer Harbor and North Haven marina in 2001 (Cohen *et al.* 2002; SAM specimens). It is not known whether the *Pseudopolydora* sp. described as being dominant in Angas Inlet between 1982 and 1985 (Thomas *et al.* 1986) was also this species; other *Pseudopolydora* spp. also occur in the inlet (Hutchings and Turvey 1984). Given that *P. paucibranchiata* was common in this location in both 1984 and 2000-01, as well as found elsewhere in Port Adelaide, we class it as established.

ARTHROPODA: Malacostraca

3.3.16. *Caprella penantis* Leach, 1814

Category: cryptogenic

Status: established

Summary: *Caprella penantis* is widespread through the Port River and recorded from Port Stanvac and Port Noarlunga.

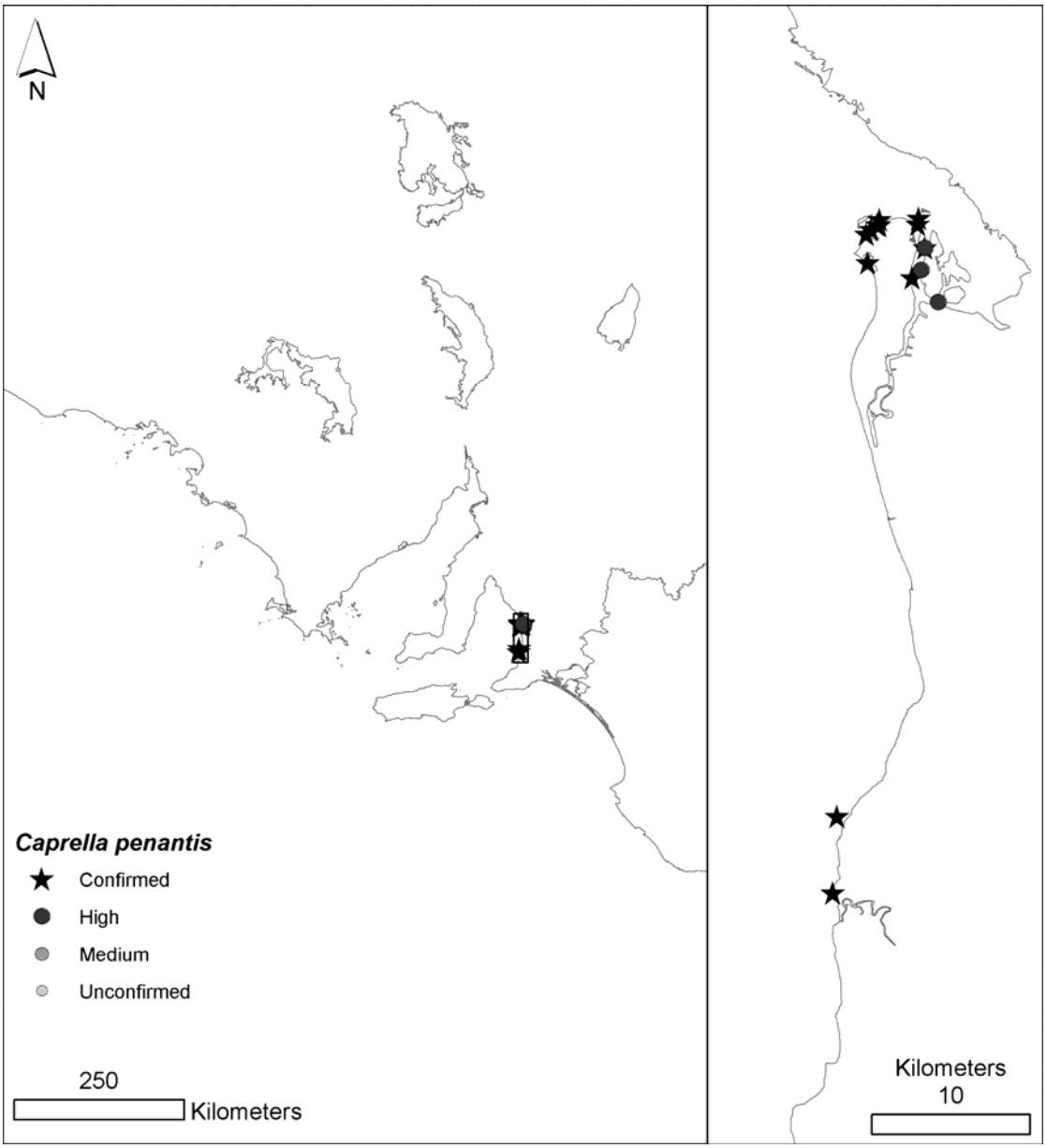

Figure 26. Map of records of *Caprella penantis.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Caprella penantis has a wide global distribution suggesting possible transport by shipping, although it is also possible the species has dispersed naturally (Poore and

Storey 1999; Cohen *et al.* 2002). The earliest record from SA is from Hale (1929), who gave no specific locality for its occurrence. The species has subsequently been found at Port Noarlunga and Port Stanvac, ~4.5km N of Port Noarlunga (SAM specimens from 1996 and 2001), and in 2001 was found to be widespread by the Port Adelaide survey (Cohen *et al.* 2002), with further specimens collected from the Port River and North Arm in 2006 during research into *Caulerpa taxifolia* (SARDI unpublished data, reference collection specimens). As *C. penantis* has occurred in SA over a long time period and appears common in Port Adelaide we class it as established.

3.3.17. *Corophium acherusicum* Costa, 1857

Synonym(s) (*reported as): *Monocorophium acherusicum**

Category: introduced

Status: established

Summary: *Corophium acherusicum* is widespread through the Port River-Barker Inlet and recorded from Mundoo channel.

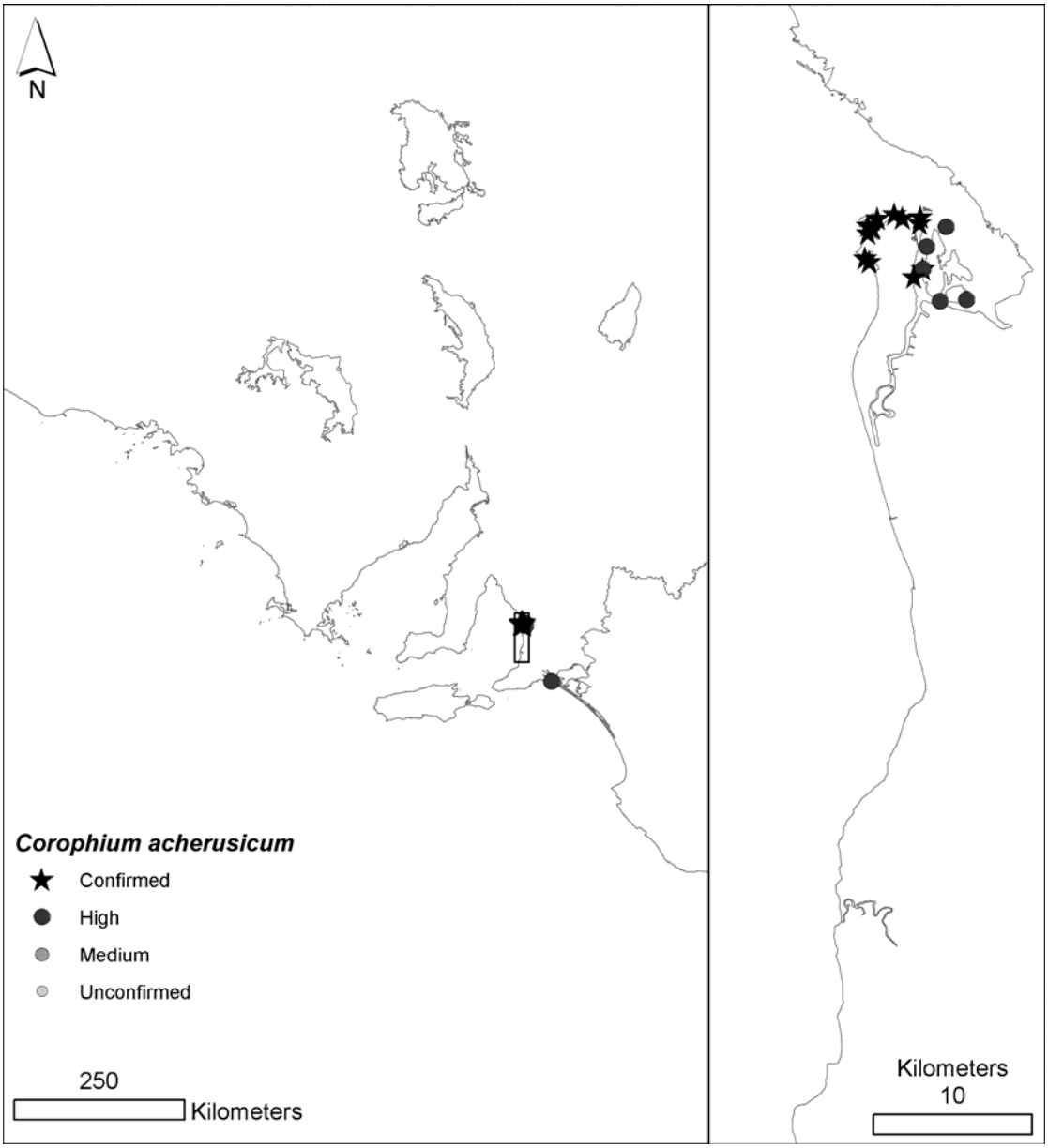

Figure 27. Map of records of *Corophium acherusicum.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Corophium acherusicum is likely to have been introduced to Australia from Europe, although it has a wide global distribution (Poore and Storey 1999; Cohen *et al.* 2002). In SA, this species was found in the Port River and North Haven marina in 2001 by

Cohen *et al.* (2002), and between 2006-8 it was collected by SARDI in the Port River, North Arm and Barker Inlet during research into *Caulerpa taxifolia* (SARDI unpublished data, reference collection specimens). It was also recorded in infaunal samples collected from Mundoo channel in the Coorong (~2.5 km NNE of the Murray mouth) in 2008 (SARDI unpublished data).

3.3.18. *Corophium insidiosum* Crawford, 1937

Synonym(s) (*reported as): *Monocorophium insidiosum**

Category: introduced

Status: uncertain

Summary: *Corophium insidiosum* is recorded from Port MacDonnell.

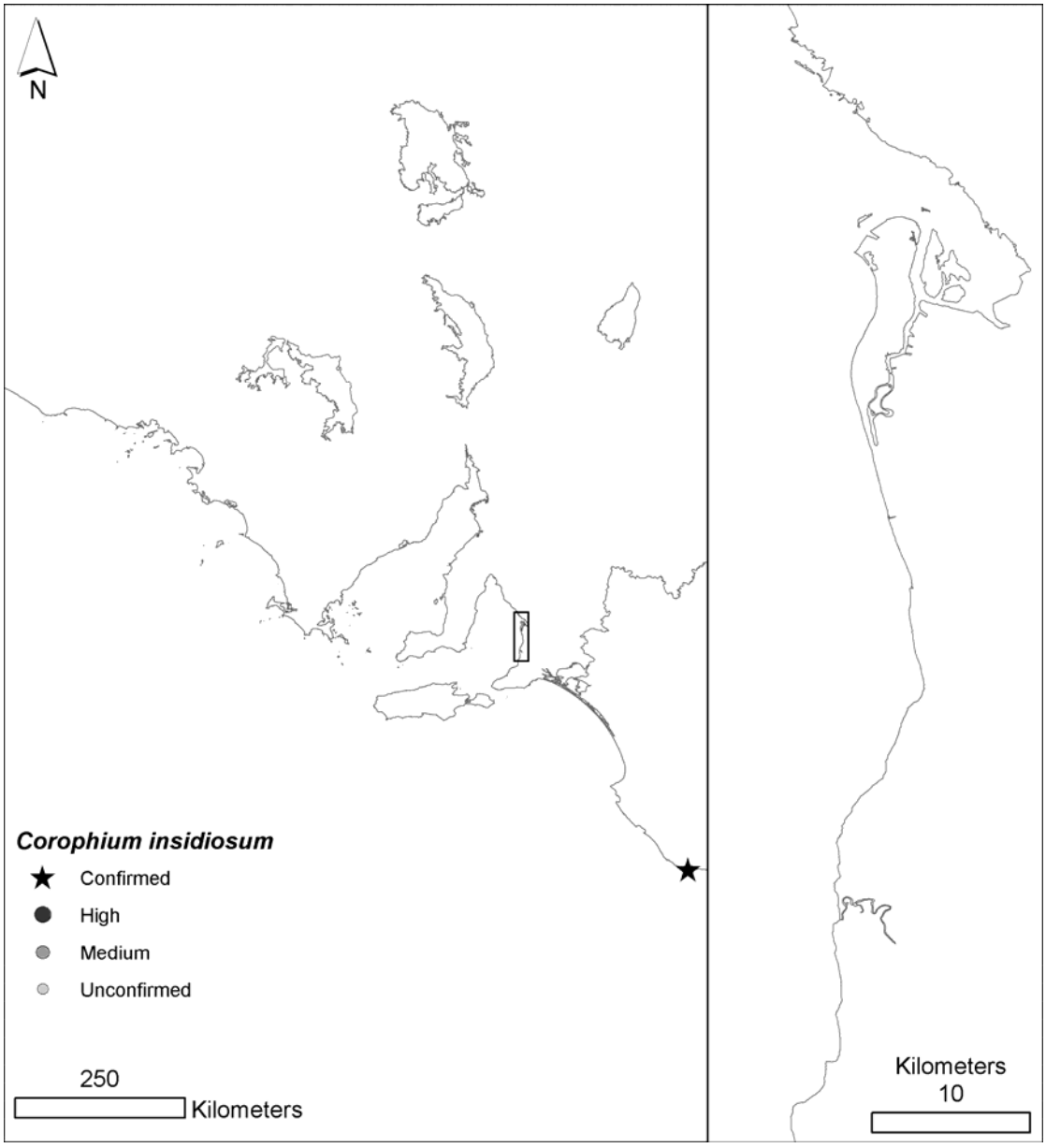

Figure 28. Map of records of *Corophium insidiosum.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Corophium insidiosum was described from England and is known from the north Atlantic and eastern Pacific. In Australia it was first reported from PPB in 1973 (Poore and Storey 1999). Poore and Storey (1999) report this species as being collected from Port MacDonnell pier in 1990, and a specimen held by MV confirms this record.

There are no other records of this species in SA, so we class its current status as uncertain.

3.3.19. *Eurylana arcuata* (Hale, 1925)

Synonym(s) (*reported as): *Cirolana arcuata**, *C. robusta*, *C. concinna*

Category: cryptogenic

Status: isolated occurrence

Summary: *Eurylana arcuata* was found at Port Willunga in 1925 but there are no recent records of the species.

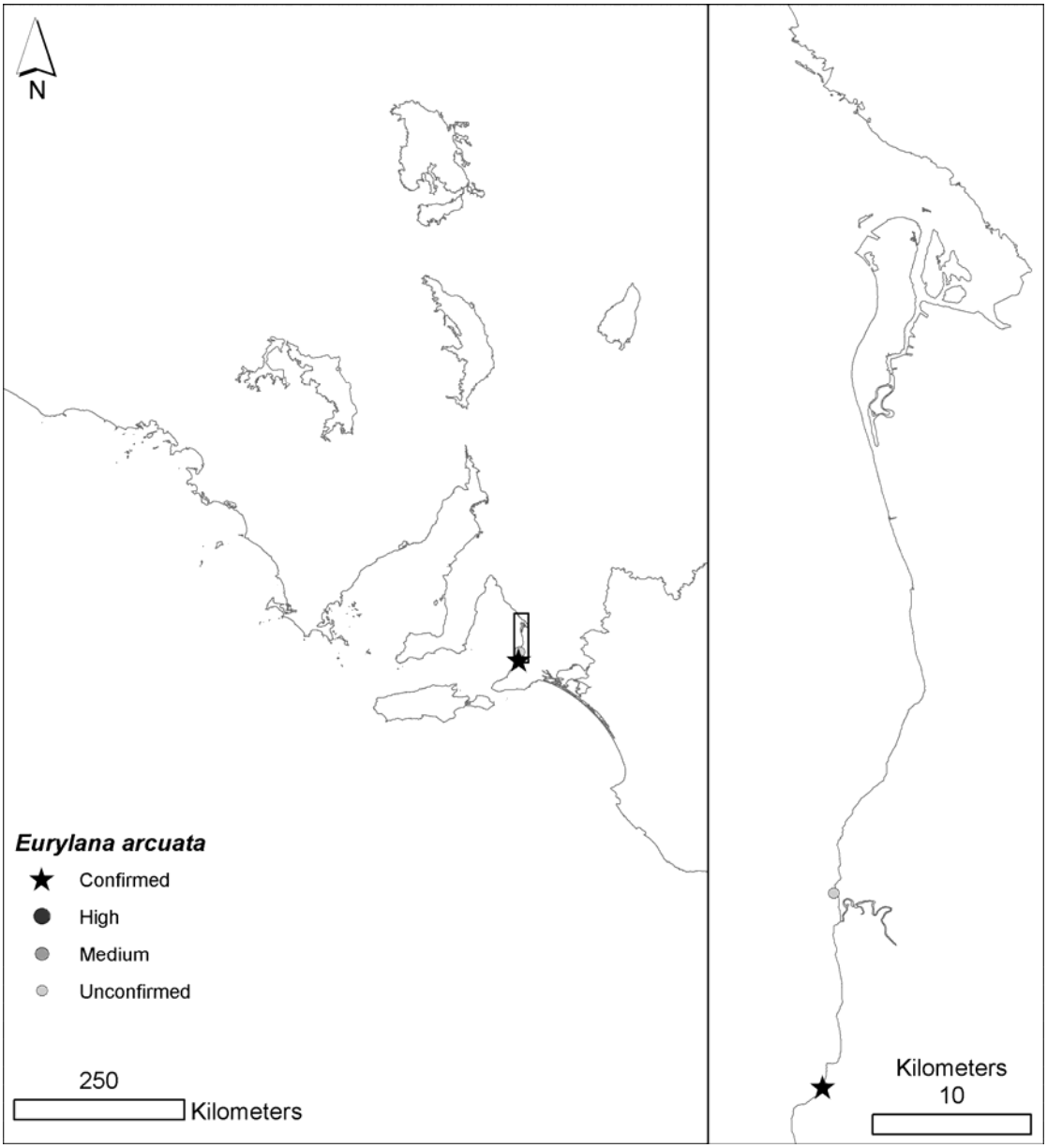

Figure 29. Map of records of *Eurylana arcuata.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

The global distribution of *Eurylana arcuata* includes New Zealand, the west coast of North and South America, and south-eastern Australia, making it likely that the species has been spread by shipping. The distribution of the native population is unclear; although it was described initially from Australian specimens, *E. arcuata* is rare in Australia compared to New Zealand and Chile; it has not been recorded since its description in 1925. It is possible the species was introduced to Australia, but did not establish (Bowman *et al.* 1981; Bruce 1986). SAM holds a specimen collected from Port Willunga in 1925. *Eurylana arcuata* is included on several lists of introduced species (see Table 1), some of which record it at Port Noarlunga (DEH 2001; Lewis *et al.* 1998) or at both Port Willunga and Port Noarlunga (Edyvane 1999; EPA 2003). We found no evidence for its occurrence at Port Noarlunga and it is likely reports of *E. arcuata* at Port Noarlunga are based on confusion of the two localities. The absence of records after 1925 suggests that this species did not establish and is unlikely to still be present.

3.3.20. *Paracerceis sculpta* (Holmes, 1904)

Synonym(s): *Dynamene sculpta*, *Cilicaea sculpta*, *Sergiella angra*

Category: introduced

Status: established

Summary: *Paracerceis sculpta* is found in the Port River system.

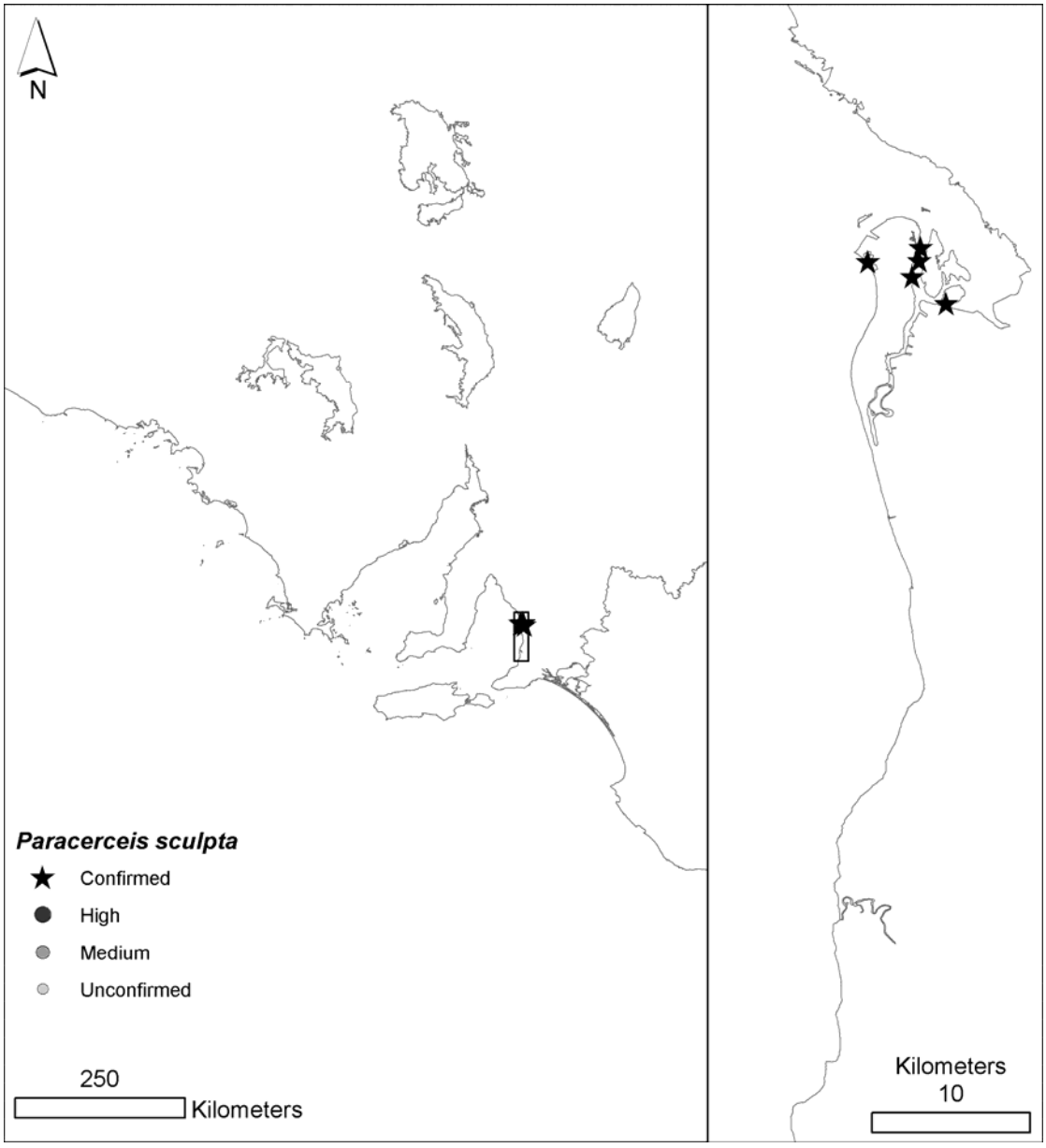

Figure 30. Map of records of *Paracerceis sculpta.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Paracerceis sculpta is believed to be native to North America and introduced to parts of South America, Europe, Asia and Australia, occurring first in Townsville, Queensland in 1975 (Poore and Storey 1999; Hewitt and Campbell 2001). The species has since been recorded from ports around Australia (Hewitt and Campbell

2001) and was first found in SA in 2000 from the fishing wharf in the North Arm of the Port River (SAM specimens). This locality was reported by Hewitt and Campbell (2001) as “North Haven Marina” and “New Haven Marina”, but their report was based on SAM specimens and it is likely that the location name was confused. The specimen labels indicate that North Arm is the correct locality. The species was subsequently recorded at North Haven marina, and in the Port River (Cohen *et al.* 2002; SAM specimens). Relatively large numbers of this isopod were found by Cohen *et al.* (2002); it is likely that this species is established in the region.

3.3.21. *Sphaeroma quoyanum* Milne-Edwards, 1840

Synonym(s) (*reported as): *Sphaeroma quoyana**, *S. quoianum**

Category: native

Status: established

Summary: *Sphaeroma quoyanum* is now considered native to Australia; it is recorded around Adelaide and possibly more widespread.

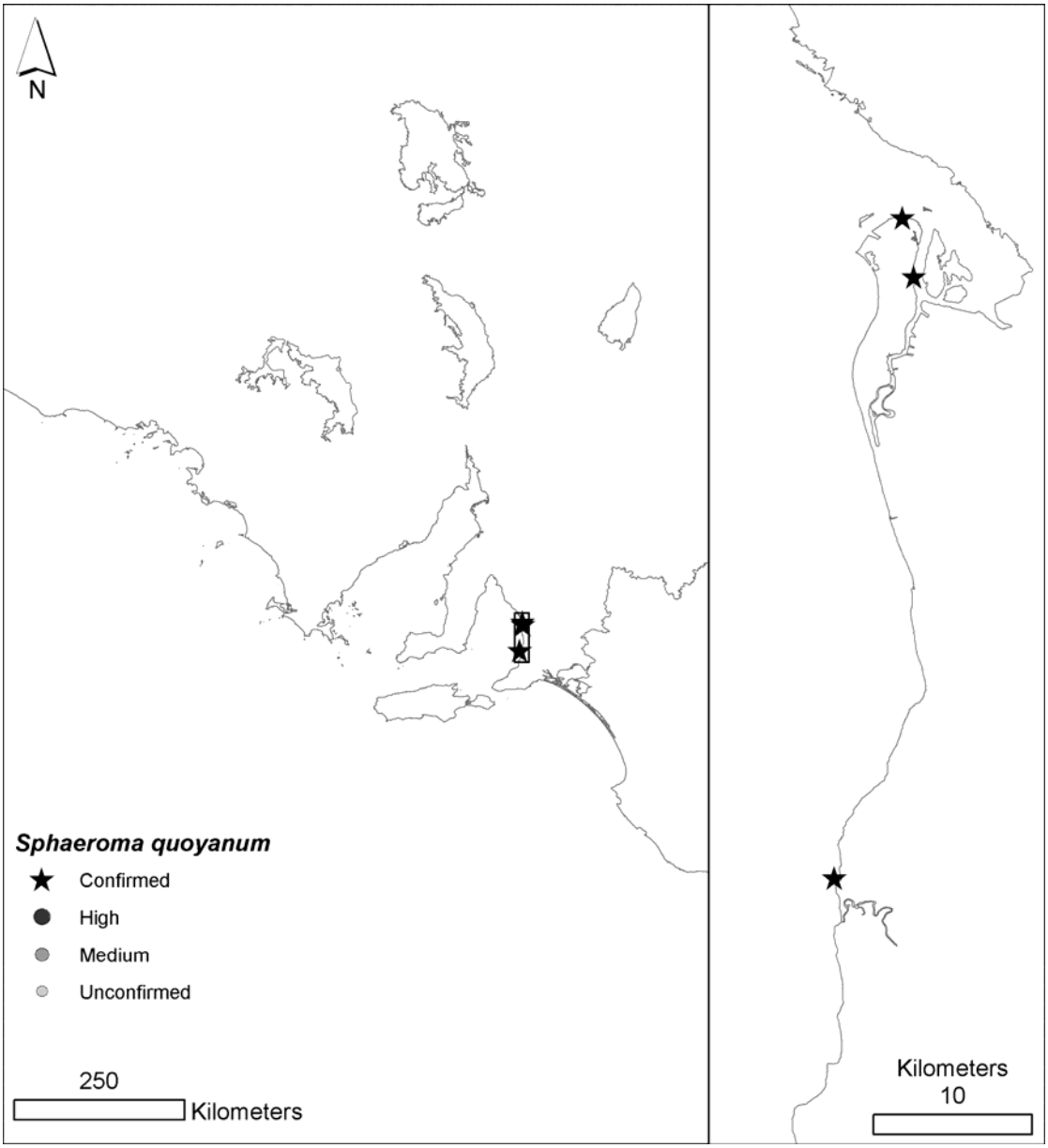

Figure 31. Map of records of *Sphaeroma quoyanum.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Sphaeroma quoyanum was described from Tasmania and is found in southern Australia, New Zealand, and the west coast of North America (Hale 1929; Cohen *et al.* 2002). This species was included (as *S. quoianum*) in the list of "introduced

species" found during the 2001 Port Adelaide survey; it occurred in low numbers at two sites within the Port River (Cohen *et al.* 2002; SAM specimens). It is likely that this species has been spread by shipping, but it is generally believed to have originated in Australia (Bowman *et al.* 1981; Poore and Storey 1999; Cohen *et al.* 2002; Westphalen 2008). In SA it was also recorded from Christies Beach, ~1 km N of Port Noarlunga, in 1959 (SAM specimen) and is likely to be widespread, having been described as common throughout southern Australia (Hale 1929).

3.3.22. *Tanais dulongii* (Audouin, 1826)

Synonym(s): *Anatanais gallardoi*, *Crossurus vittatus*, *Eupheus ligusticus*, *Gammarus dulongii*, *Tanais cavolinii*, *T. gallardoi*, *T. hirticaudatus*, *T. tomentosus*, *T. vittatus*

Category: introduced

Status: unconfirmed

Summary: *Tanais dulongii* is reported from Port Pirie.

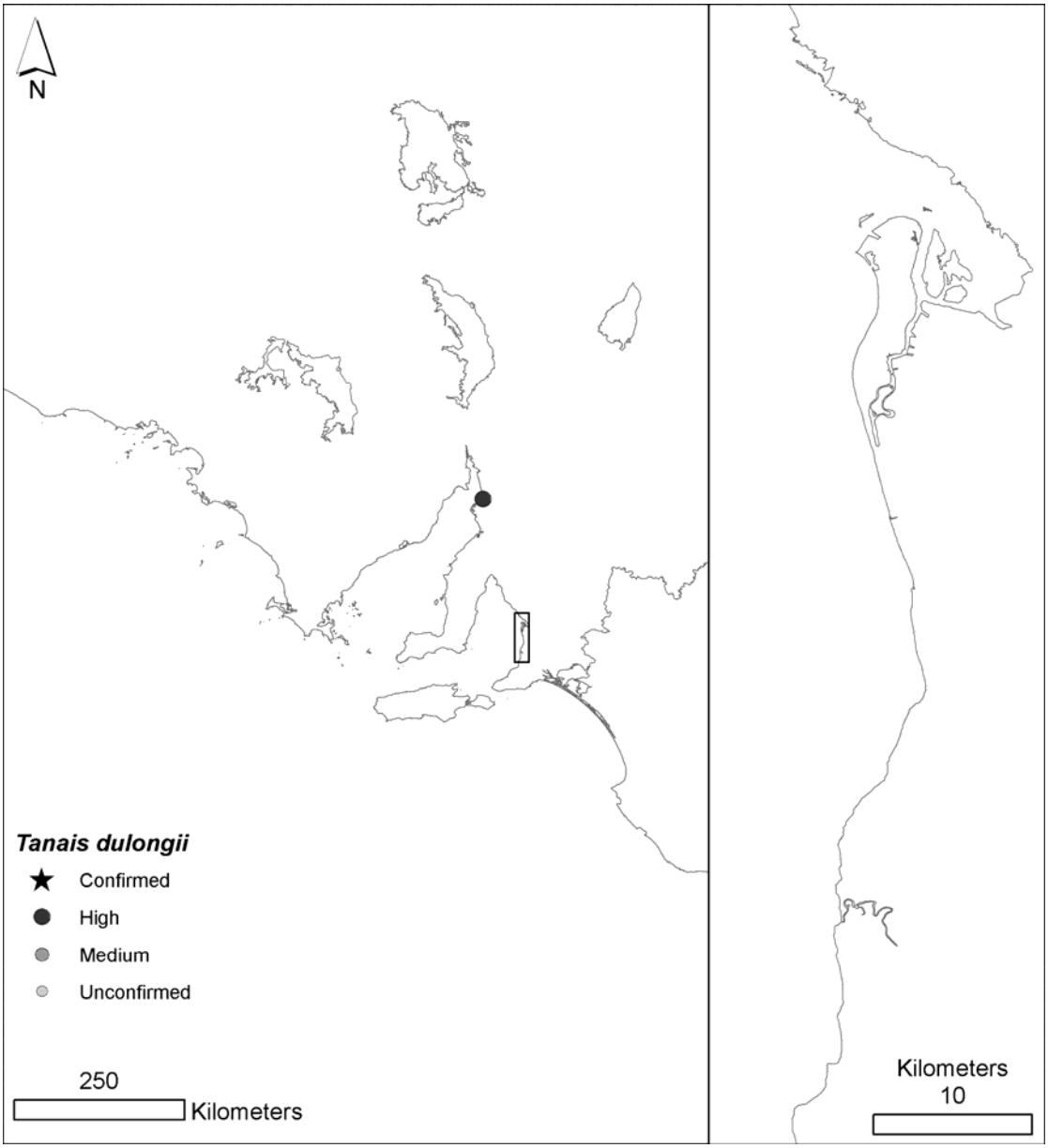

Figure 32. Map of records of *Tanais dulongii.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Tanais dulongii was first reported from Spencer Gulf, based on a personal communication in Jones (1991), who regarded it as a likely introduction from Europe. Based on this report, the species was included on lists of introduced species in SA

(EPA and DEHAA 1998; Lewis *et al.* 1998; Edyvane 1999), and it was also shown as occurring in SA on schedules of introduced species used in the national port surveys (Hewitt and Martin 1996; AMBS 2002; Aquenal Pty Ltd 2002; Pollard and Pethebridge 2002b). Where these sources provide a reference for the occurrence they cite Jones (1991). The record was published with further detail: in 1979-80 studies conducted around Port Pirie, *T. dulongii* was the dominant species in the intertidal zone of sites contaminated by heavy metals (sediments having up to 5.3 mg g^{-1} lead, 16.7 mg g^{-1} zinc) from the lead smelter (Hutchings *et al.* 1993; Ward and Hutchings 1996). No specimens exist, however, to confirm this record. The species appeared well established at that time, but no more recent information is available so its current status is uncertain.

3.3.23. *Palaemon macrodactylus* Rathbun, 1902

Category: introduced
Status: unconfirmed
Summary: Reports of *Palaemon macrodactylus* from SA could not be confirmed.

Palaemon macrodactylus is native to Asia (Furlani 1996) and has been introduced to the north Pacific (Williams *et al.* 1988; Poore and Storey 1999) and to NSW (Pollard and Hutchings 1990b; Poore and Storey 1999). This species was listed as occurring in SA by Williams *et al.* (1978), a record repeated by Furlani (1996) but with a note that the occurrence needed verification. The report of this species in SA was considered doubtful by Pollard and Hutchings (1990b) and we found no further records to substantiate its occurrence in SA.

3.3.24. *Parasesarma erythodactyla* (Hess, 1865)

Synonym(s): *Sesarma erythrodactyla*, *Parasesarma erythrodactyla*

Category: cryptogenic

Status: established

Summary: *Parasesarma erythodactyla* is recorded from Whyalla and Port Augusta.

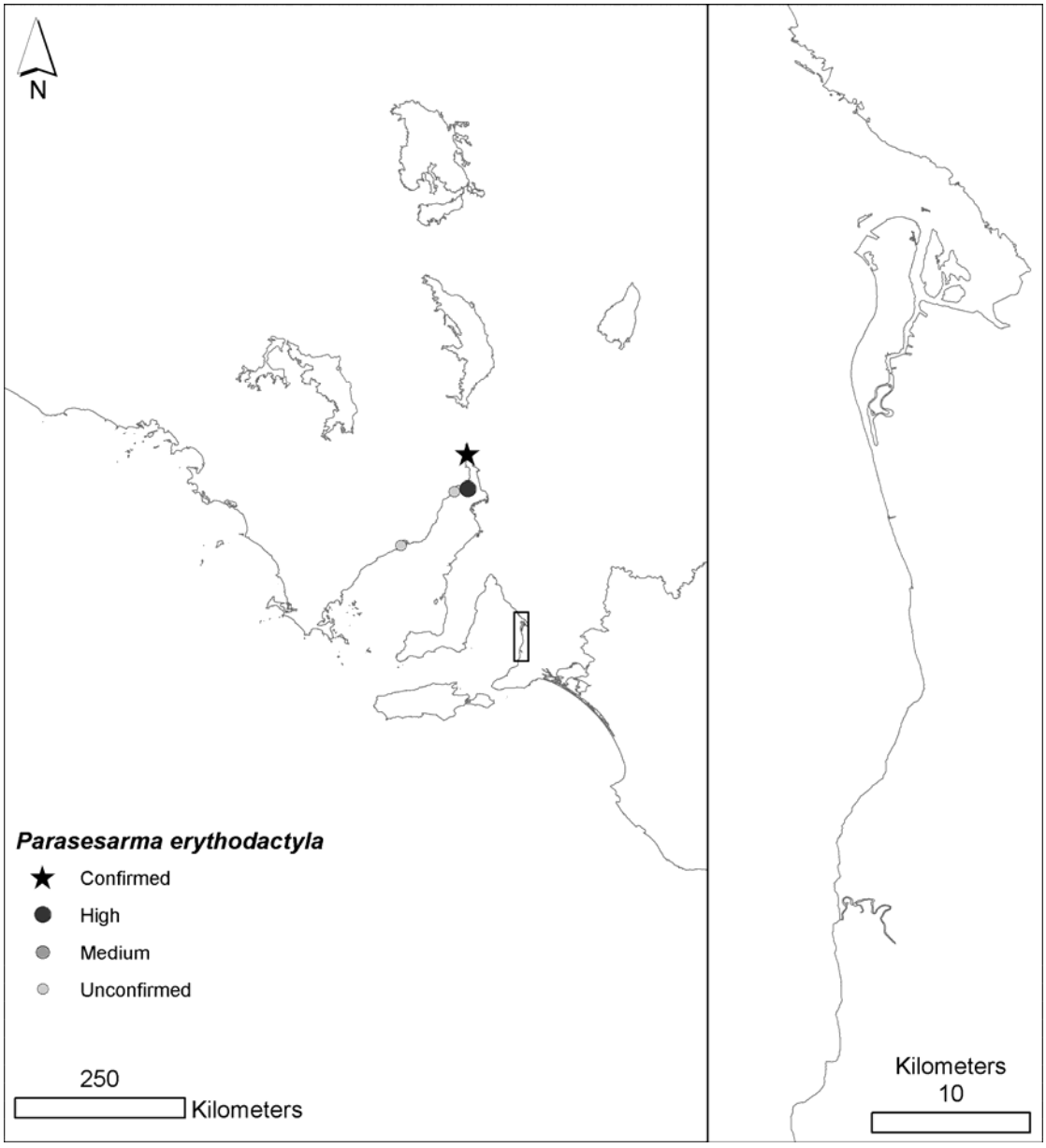

Figure 33. Map of records of *Parasesarma erythodactyla.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Parasesarma erythodactyla is native to the east coast of Australia, with a distribution extending from Western Port, Victoria to Queensland (Edgar 2008). It has only recently been recorded from SA, firstly in mangroves at Port Augusta in 2008 (SAM specimen) with a sighting (supported by photographs) at Point Lowly, ~18 km ENE of

Whyalla, in April 2009 (T. Laperousaz, SAM, pers. comm.). A survey for introduced species also collected crabs believed to be this species in high numbers in mangroves near Whyalla in October 2009, with a single crab also found at Franklin Harbour (Cowell) (Dittmann *et al.* 2010), although the identity of specimens collected by that survey are yet to be confirmed. This species appears to be established and may be extending its range southwards on Eyre Peninsula.

ARTHROPODA: Maxillopoda

3.3.25. *Elminius modestus* Darwin, 1854

Synonym(s) (*reported as): *Elminius* (*Austrominius*) *modestus*, *Austrominius modestus**

Category: native

Status: established

Summary: *Elminius modestus* is now considered native; it is widespread in SA.

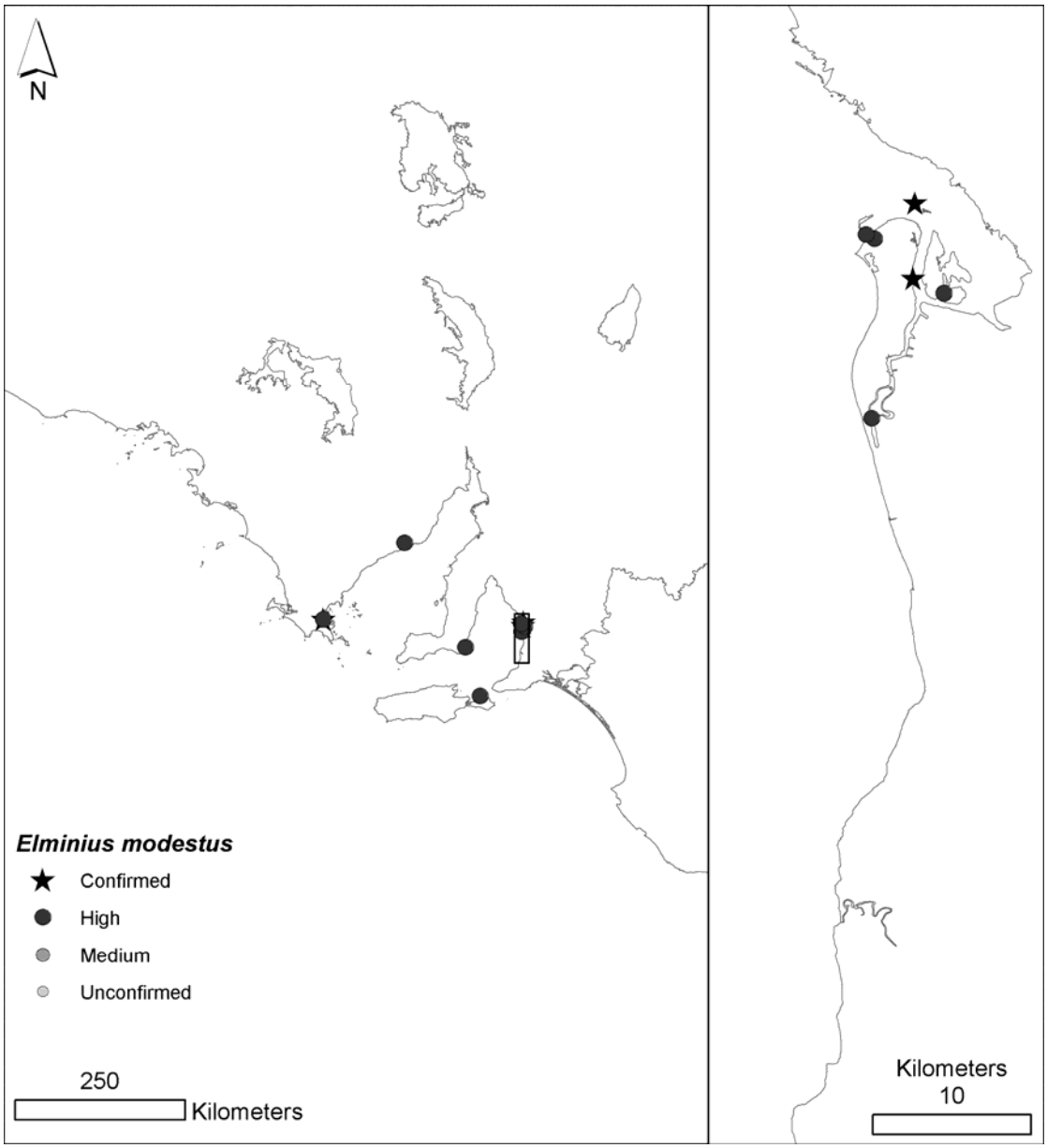

Figure 34. Map of records of *Elminius modestus.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Elminius modestus occurs in Australia and New Zealand and has been introduced to Europe; although it may have been introduced to Australia from New Zealand (Keough and Ross 1999), it is generally considered native to Australia (Bishop 1951; Jones 1992; Westphalen 2008; Poore and Syme 2009). In SA, this species was recorded in Angas Inlet during studies of the warm water outflow of the Torrens Island Power Station between 1972 and 1985, but only occurred prior to 1981 (Thomas *et al.* 1986). In 1977-80 it was recorded on settlement plates in West Lakes, with high settlement variability between years (Keough 1983). Several new species of *Elminius* Leach, 1825 were described in the 1980s and 1990s (Buckeridge 1983; Bayliss 1988, 1994) and, prior to this, these species may have been reported as *E. modestus* (Bayliss 1994; Keough and Ross 1999; Aquenal Pty Ltd 2002), but there are more recent records of *E. modestus*. A single specimen was collected in the 2001 Port Adelaide survey (Cohen *et al.* 2002), while in 2002 the barnacle was common in the RSAYS marina at Outer Harbor (Holloway and Keough 2002a; Holloway and Keough 2002b). *Elminius modestus* was also recorded in the 1996 survey of Port Lincoln (TMAG unpublished data; SAM specimens) but was not discussed in the accompanying report (Hewitt *et al.* 1997), probably being considered native. It was included in a checklist of barnacles for the GAB region (defined as extending to the southern tip of Eyre Peninsula in SA) (Jones *et al.* 1990) and shown to occur at Cowell, Port Lincoln, Edithburgh, Penneshaw and Adelaide by Bayliss (1994). It is believed to be distributed throughout southern Australia from southern WA to NSW and around Tasmania (Edgar 2008; Gowlett-Holmes 2008).

The Australasian members of the subfamily Elminiinae were placed in the subgenus *Austrominius* by Buckeridge (1983), with the sole South American representative placed in the subgenus *Elminius.* Since the 1990s *Austrominius* has been used as a genus by workers in New Zealand, with this change adopted soon after in Europe, and by 2007 in some Australian literature (Poore and Syme 2009; Buckeridge and Newman 2010). The adoption of the genus *Austrominius* was accepted by Buckeridge and Newman (2010), but this change is not yet reflected in WoRMS (Appeltans *et al.* 2009). We therefore have retained the combination *Elminius modestus* in this review, but note that this species will most likely be recognised as *Austrominius modestus* in the near future.

3.3.26. *Megabalanus tintinnabulum* (Linnaeus, 1758)

Synonym(s) (*reported as): *Balanus tintinnabulum**

Category: cryptogenic

Status: established

Summary: *Megabalanus tintinnabulum* has been recorded from Western River Cove, KI but is probably widespread.

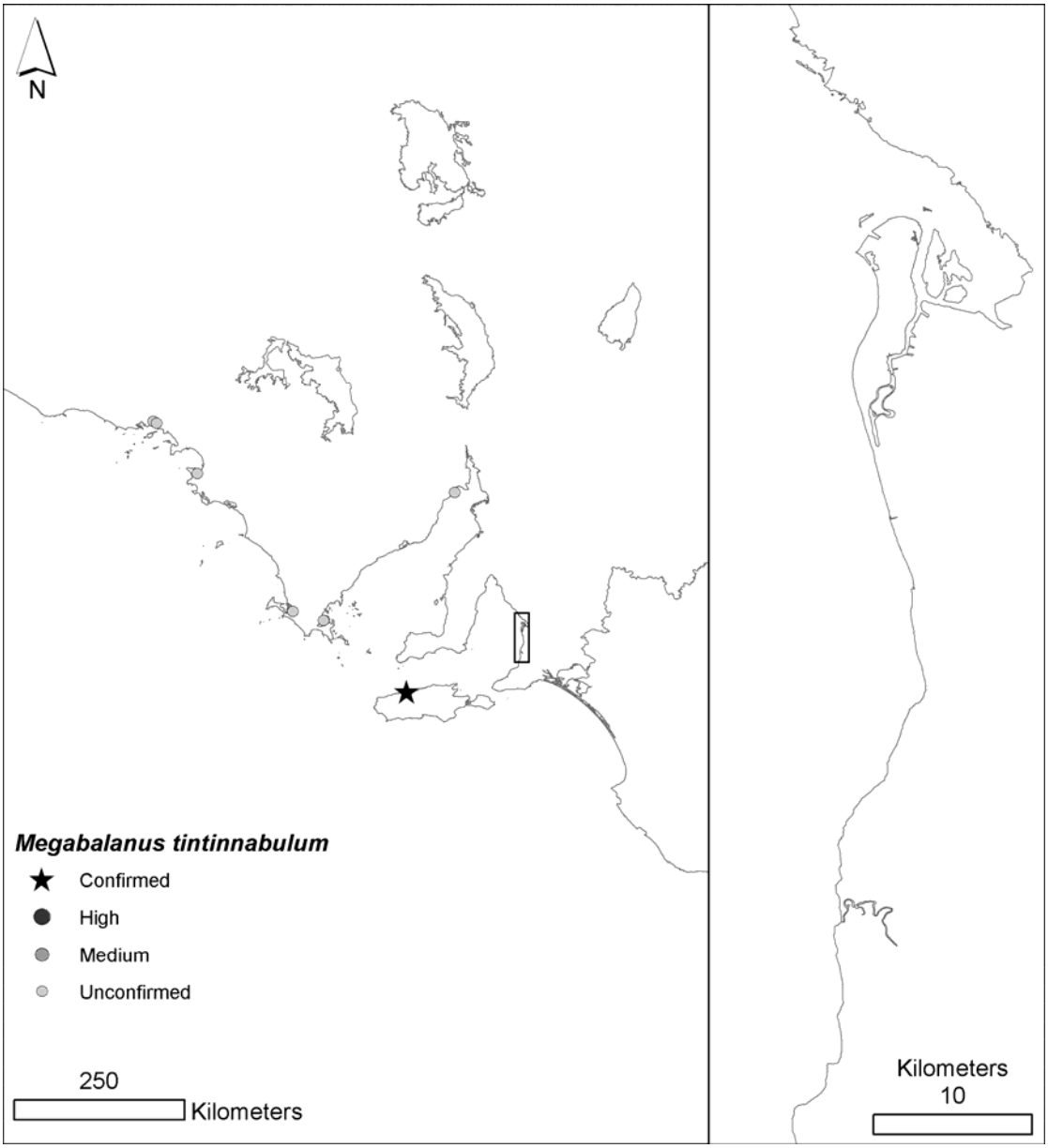

Figure 35. Map of records of *Megabalanus tintinnabulum.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Megabalanus tintinnabulum is regarded as cosmopolitan and is likely to have been spread by shipping as a hull-fouling organism (Jones 1992; Gowlett-Holmes 2008). It was first recorded in Australia in WA in 1949, with possible earlier records from NSW

being considered doubtful (Allen 1953; Jones 1992). NIMPIS (2009b) and Hayes *et al.* (2005) list the species as occurring only in the Otway bioregion of SA, but we did not find any records from this area. A specimen from SAM is from a vessel hull from Western River Cove, ~15 km E of Snug Cove on the north coast of KI, and *M. tintinnabulum* has also been recorded (though with identification yet to be verified) from several locations around Eyre Peninsula from Denial Bay to Whyalla (Dittmann *et al.* 2010). It appears likely, however, that this species is widespread, having been reported to occur from Spencer Gulf through eastern SA to NSW and around Tasmania, as well as in parts of WA (Gowlett-Holmes 2008), so we class it as established.

MOLLUSCA: Bivalvia

3.3.27. *Theora lubrica* Gould, 1861

Synonym(s): may have been misidentified as *Theora fragilis* in Victoria
Category: cryptogenic
Status: unconfirmed
Summary: *Theora lubrica* has been reported to occur in Spencer Gulf, but this record could not be substantiated.

Theora lubrica is native to Japan and the Pacific coast of Asia and introduced to California (Boyd 1999; Aquenal Pty Ltd 2002). It may also be native to Australia and New Zealand (Pollard and Hutchings 1990b), although the first Australian records of the species are from 1958 (PPB) and 1971 (WA) (Pollard and Hutchings 1990b; Boyd 1999). It has been reported from upper Spencer Gulf, with the source for the report stated as "SA Museum specimens" (Boyd 1999; NIMPIS 2009b). Only a single specimen is held by SAM, however, and this has no collection locality recorded. We could not find any other records of *T. lubrica* in SA to substantiate this report; therefore the occurrence of this species is unconfirmed.

3.3.28. *Ruditapes largillierti* (Philippi, 1849)

Synonym(s): *Paphia fabagella*, *Paphies intermedia*, *Paphirus largillierti*, *Tapes fabagella*, *Tapes intermedia*, *Venerupis fabagella*, *Venerupis largillierti*, *Venus intermedia*, *Venus largillierti*
Category: introduced
Status: unconfirmed
Summary: We could not confirm the occurrence of *Ruditapes largillierti* in SA.

Ruditapes largillierti is native to New Zealand, and is believed to have been introduced to Tasmania during attempts to introduce New Zealand oysters *Ostrea chilensis* Phillipi, 1845 (Pollard and Hutchings 1990b; Boyd 1999; Aquenal Pty Ltd 2002). The species has been reported to occur in the GSV bioregion of SA based on "port survey data" from the 2001 Port Adelaide survey (NIMPIS 2009b, NPSD unpublished data), but the species is not recorded in the report for that survey (Cohen *et al.* 2002), nor were specimens lodged with SAM (T. Laperousaz, SAM, pers. comm.). The NPSD indicates identification of this reported occurrence is not

confirmed (NPSD unpublished data). We found no other records of *R. largillierti* in SA and therefore class its occurrence as unconfirmed.

3.3.29. *Teredo navalis* Linnaeus, 1758

Synonym(s): *Pholas teredo*, *Teredo vulgaris*, *T. sellii*, *T. japonica*, *T. beachi*, *T. beufortana*, *T. novagliae*, *T. sinensis*, *T. pocilliformis*, *T. borealis*, *Sellius marina*
Category: cryptogenic
Status: unconfirmed
Summary: Reports of *Teredo navalis* could not be confirmed.

Reports of *T. navalis* in Australia (Hayes *et al.* 2005; NIMPIS 2009b) are based on the record of Turner (1971), who noted that it was common across 67 sites in Australia, Papua New Guinea and unspecified “offshore” islands. Its general distribution is reported as the subtropical to warm temperate waters of southern Australia, consisting of the entire coastline south of ~30°S latitude (Turner 1971), but specific localities for its occurrence are not shown. The native range of this species is unknown (Gollasch 2006; Didžiulis 2007). A specimen of *T. navalis* exists in SAM, but contains no information on the date or locality of collection. We could not find any specific records of this species in SA so class the occurrence of *T. navalis* as unconfirmed.

3.3.30. *Mytilus galloprovincialis* Lamarck, 1819 – Blue mussel

Synonym(s): see text

Category: cryptogenic

Status: uncertain

Summary: The identity of *Mytilus* spp. in Australia cannot be reliably established at present, but blue mussels that may be *M. galloprovincialis* are widespread.

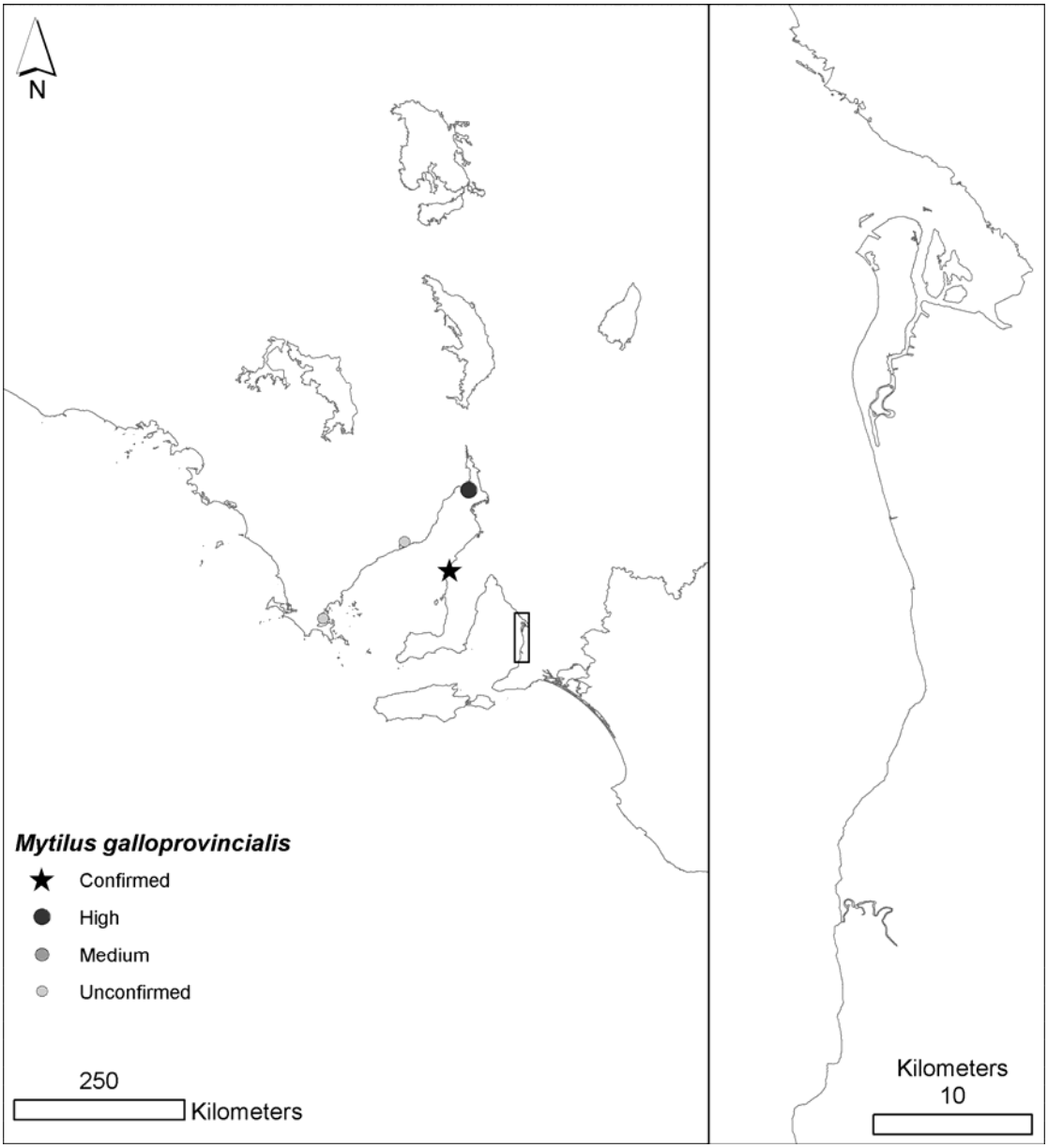

Figure 36. Map of records of *Mytilus galloprovincialis.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Mussels of the genus *Mytilus* L. are found throughout all global temperate seas, and have sometimes been considered as a single cosmopolitan species: *M. edulis* L., although several other species have been described including *M. galloprovincialis*

from the Mediterranean and *M. trossolus* Gould, 1850 from North America (McDonald *et al.* 1991). Blue mussels collected from Australia in 1798 were described as *Mytilus planulatus* Lamarck, 1819, later regarded as a subspecies of *M. edulis* (see Wells *et al.* 2009). This subspecies was considered endemic to Australia, and shell middens suggest it was present well before European settlement (AMBS 2002), but the identity of Australian *Mytilus* species is under question (Svane 2009). A combination of morphological and genetic techniques is needed to separate the three species *M. edulis*, *M. galloprovincialis* and *M. trossolus*, with such studies suggesting that Australian *Mytilus* are most closely related to *M. galloprovincialis*, (Hilbish *et al.* 2000; McDonald *et al.* 1991), although these were based on only small numbers of mussels (McDonald *et al.* 1991) and did not include material from SA (Hilbish *et al.* 2000; Svane 2009). Genetic investigation of *Mytilus* spp. from locations around Eyre Peninsula showed all to be the same species, with genetic profile broadly similar to that of *M. galloprovincialis*, but confirmation of the identity of the specimens was not possible due to a lack of reference material (Svane 2009). Further confusion may occur through the fact that *Mytilus* species are known to hybridise (McDonald *et al.* 1991). It is possible that more than one species of *Mytilus* is present in Australia, the introduced *M. galloprovincialis* and a native species (Edgar 2008), or that there have been two introduction events: one natural occurring during the Pleistocene, and a more recent introduction by shipping (Hilbish *et al.* 2000). Questions regarding both the identity and origin of Australian *Mytilus* spp. must therefore be resolved before populations can be determined to be native or introduced.

We found only three specific records ascribed to *M. galloprovincialis*: specimens held by SAM which were collected from a vessel hull in Port Adelaide and from the jetty at Port Hughes, ~2 km SW of Moonta Bay, and a published record of the species at Port Bonython, ~18 km ENE of Whyalla (Butler and Connolly 1999). Other blue mussel specimens held by SAM are identified as *M. edulis planulatus.* A recent survey around Eyre Peninsula has suggested that *M. galloprovincialis* may also occur at Cowell and Port Lincoln (Dittmann *et al.* 2010), but the identity of the mussels is questioned by the authors based on the same issues discussed here. Blue mussels are an aquaculture species in SA, with farms located at Port Lincoln, Wallaroo and Port Julia (PIRSA Aquaculture 2010); the farmed mussels are not imported but grown from spat collected from wild populations (PIRSA Aquaculture 2000), therefore, their identity is also not confirmed. If it is accepted that the blue mussels found throughout southern Australia and recorded as *M. edulis*, *M.*

planulatus or *M. edulis planulatus* are *M. galloprovincialis* then this species can be regarded as widespread, occurring from southern WA around the south coast to NSW, and around Tasmania (Edgar 2008; Gowlett-Holmes 2008).

3.3.31. *Perna canaliculus* (Gmelin, 1791) – New Zealand Greenlip mussel

Category: introduced

Status: isolated occurrence

Summary: *Perna canaliculus* was found at Outer Harbor in 1996 and on a vessel in Port Adelaide in 2008.

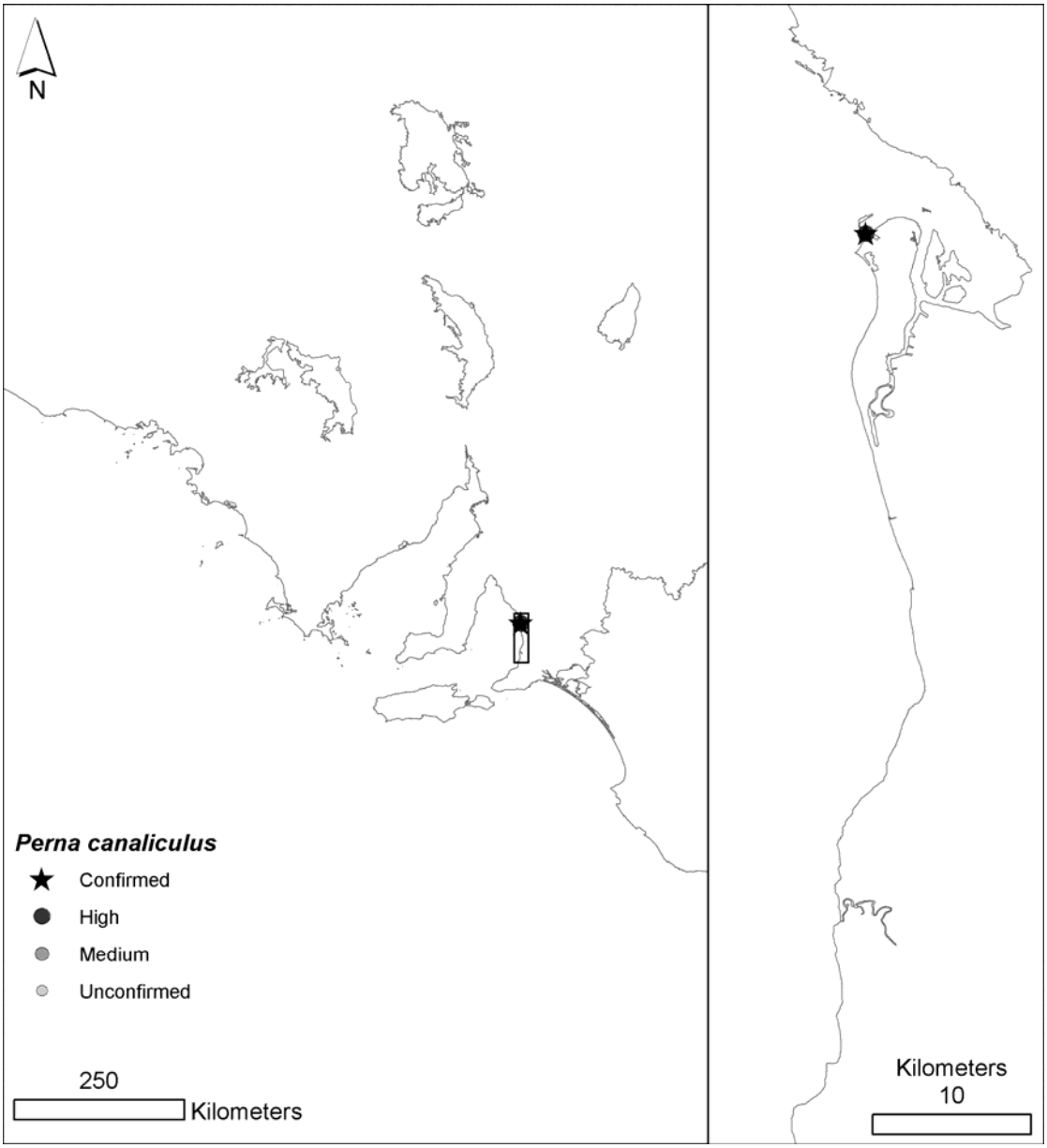

Figure 37. Map of records of *Perna canaliculus.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Perna canaliculus is native to New Zealand. In 1996 a small population, consisting of approximately two dozen mature mussels, was found at Outer Harbor in Port Adelaide, and removed. Further surveys found and removed another single individual (McEnnulty *et al.* 2001; URS Australia 2004). The species was included on lists of introduced species of SA published in 1998-99 (EPA and DEHAA 1998; Lewis *et al.* 1998; Edyvane 1999), but the eradication was regarded as successful (McEnnulty *et al.* 2001; URS Australia 2004). *Perna canaliculus* was also found on a barge towed to Port Adelaide from New Zealand in September 2008 (PIRSA Marine Biosecurity unpublished data); specimens from this discovery are held by SARDI. There is no evidence that the species has established in SA.

3.3.32. *Pinctada albina sugillata* (Reeve, 1857) – Pearl oyster

Synonym(s): *Pinctada sugillata*

Category: cryptogenic

Status: established

Summary: *Pinctada albina sugillata* occurs in upper Spencer Gulf.

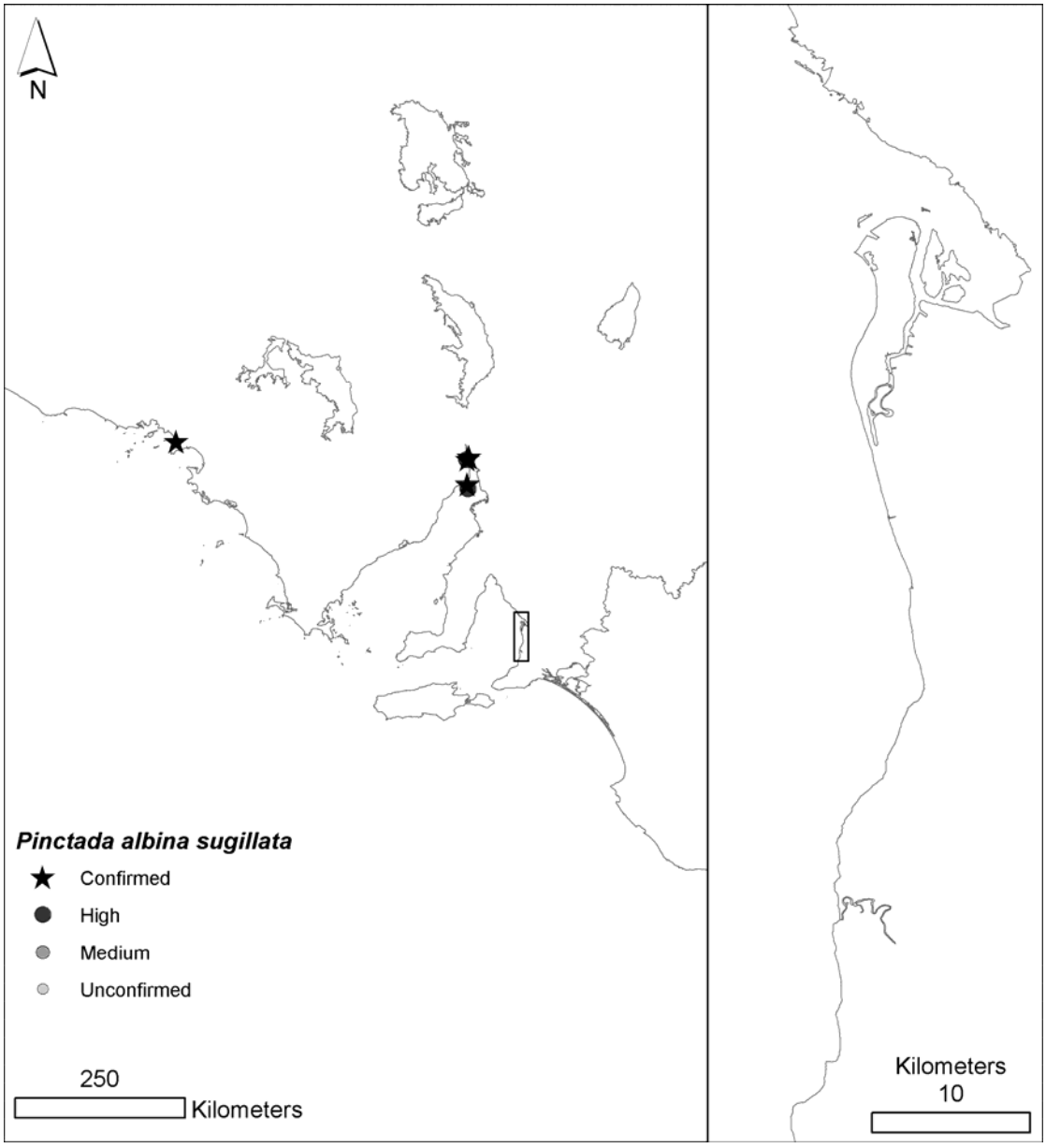

Figure 38. Map of records of *Pinctada albina sugillata.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Two subspecies of the pearl oyster *Pinctada albina* are known from Australia: *P. albina albina* from north-western Australia and *P. albina sugillata* from the Torres Strait and the east coast of Australia to central NSW (Hynd 1960; Lamprell and Healy 1998). Pearl oysters identified as *P. albina sugillata* have been found in upper

Spencer Gulf around Port Bonython (~18 km ENE of Whyalla) and the proposed landing facility site for the Olympic Dam expansion, ~5 km S of Port Augusta (Arup and ENSR 2008). SAM also holds specimens collected from around Port Augusta in 2008, a specimen collected from Fitzgerald Bay (~19km NE of Whyalla) in 2003 and a specimen from Smoky Bay collected in 2004. This species has anecdotally been reported as occurring in upper Spencer Gulf (north of Whyalla) since the 1980s (S. Shepherd, SARDI, pers. comm.) and was recently found, so we class it as established, although its status at Smoky Bay is unknown.

MOLLUSCA: Gastropoda

3.3.33. *Polycera hedgpethi* Er. Marcus, 1964

Category: introduced

Status: established

Summary: *Polycera hedgpethi* occurs in North Haven marina.

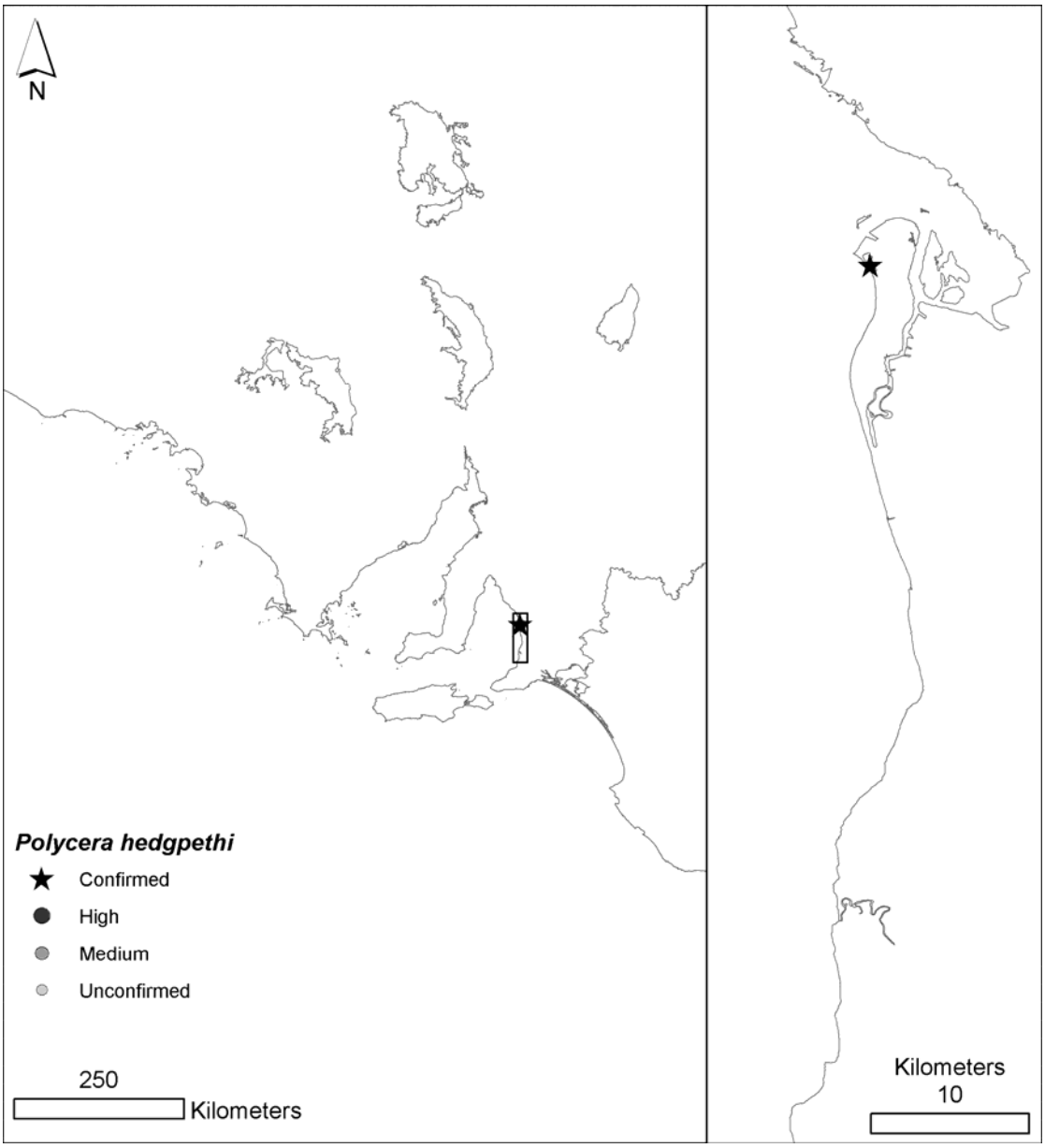

Figure 39. Map of records of *Polycera hedgpethi.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Polycera hedgpethi was described from California but is now almost cosmopolitan, having been widely distributed by shipping (Keough and Ross 1999; Wilson 2006). This nudibranch was first found in SA in 2004, when it was photographed in North Haven marina (Wilson 2006), and specimens held by SAM were collected there soon thereafter. In 2004 it was evident that the species was breeding (egg masses often present), and further sightings were made in 2006 (Wilson 2006). SAM holds a specimen collected from North Haven marina in 2008, so it appears likely that *P. hedgpethi* is established there.

3.3.34. *Maoricolpus roseus* (Quoy and Gaimard, 1834) – New Zealand screwshell

Synonym(s): *Turritella rosea*, *T. difficilis*, *Gazameda rosea*
Category: introduced
Status: unconfirmed
Summary: Reports of *Maoricolpus roseus* in SA could not be substantiated.

Maoricolpus roseus is native to New Zealand, and, in Australia has been reported as occurring throughout SA to southern Queensland and around Tasmania (Furlani 1996). It was also included, with the same distribution given, on lists of introduced species of SA published in 1998-99 (EPA and DEHAA 1998; Lewis *et al.* 1998; Edyvane 1999). A more recent investigation of the range of the species in Australia, however, shows it as occurring in Tasmania, Victoria and NSW only (Bax *et al.* 2003), as does NIMPIS (2009b). SAM holds specimens of *M. roseus* from Bass Strait (east of Flinders Island) (Bax *et al.* 2003), New Zealand, and Tasmania, but none from SA. Since its introduction to Tasmania in the 1920s the species appears to be spreading northwards, by 2000 it had reached central NSW (Bax *et al.* 2003). It appears unlikely that the species occurs in SA.

BRYOZOA: Gymnolaemata

3.3.35. *Bugula flabellata* (Thompson, in Gray, 1848)

Synonym(s): *Avicularia flabellata*

Category: introduced

Status: unconfirmed

Summary: *Bugula flabellata* has been reported from Outer Harbor.

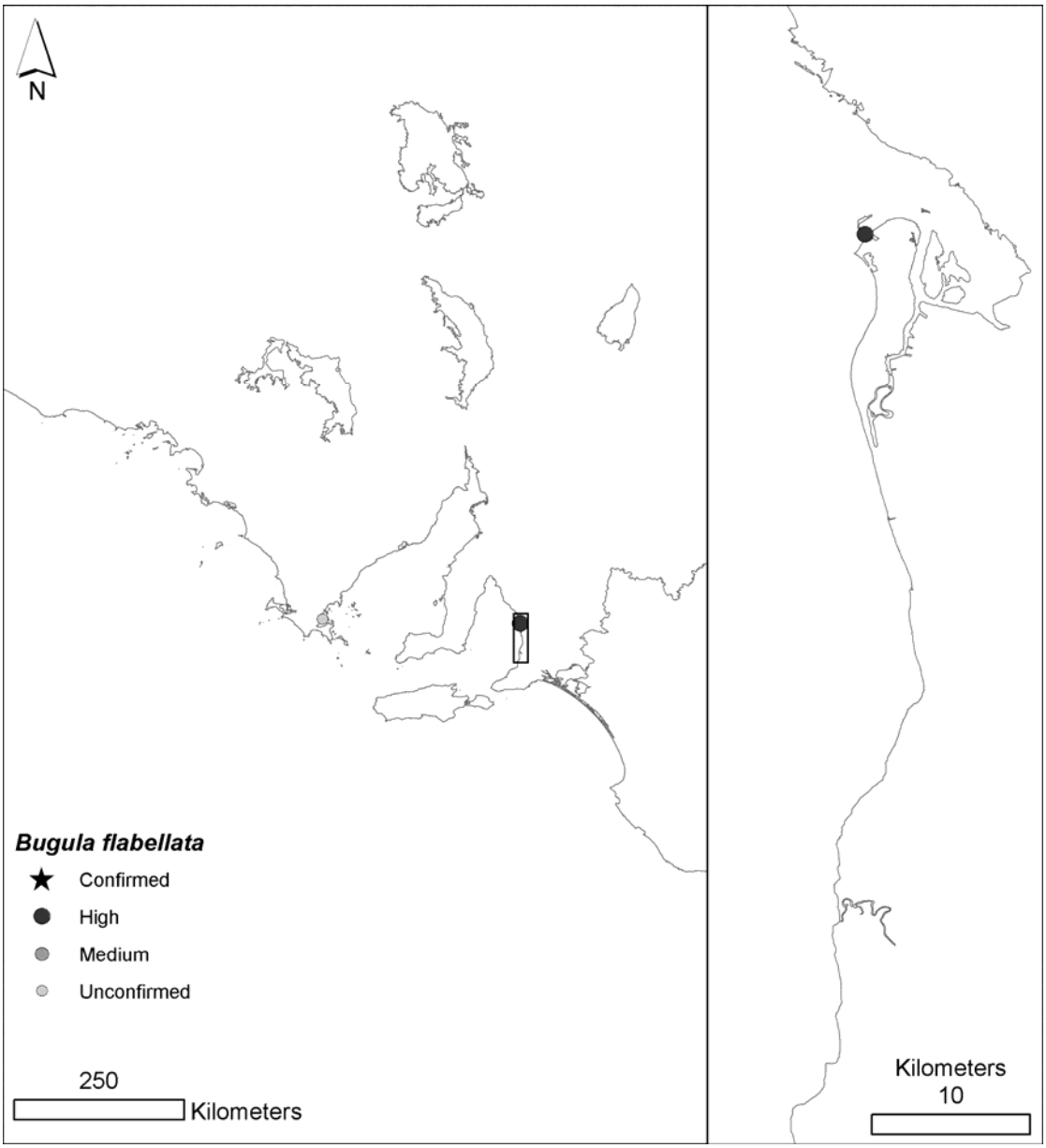

Figure 40. Map of records of *Bugula flabellata.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Bugula flabellata is native to the Atlantic and Mediterranean, although its distribution is now almost cosmopolitan (Aquenal Pty Ltd 2002). It was first reported in SA at Outer Harbor, Port Adelaide (Allen 1953) and it is recorded as a minor fouling species at that locality (Brock 1985). It was also recorded from qualitative visual samples in the 1996 port survey for Port Lincoln, leading to it being shown to also occur in the Eyre bioregion by NIMPIS (2009b), but without verification of the identification (NPSD unpublished data); no specimen was collected (TMAG unpublished data) and it is not mentioned in the report (Hewitt *et al.* 1997). We therefore class this record as unconfirmed. There are no specimens of this species from SA held by SAM (there is one specimen in the collection from PPB, Victoria). There are no recent reports of this species in SA.

3.3.36. *Bugula neritina* (Linnaeus, 1758)

Synonym(s): *Sertularia neritina*

Category: cryptogenic

Status: established

Summary: *Bugula neritina* is widespread in SA.

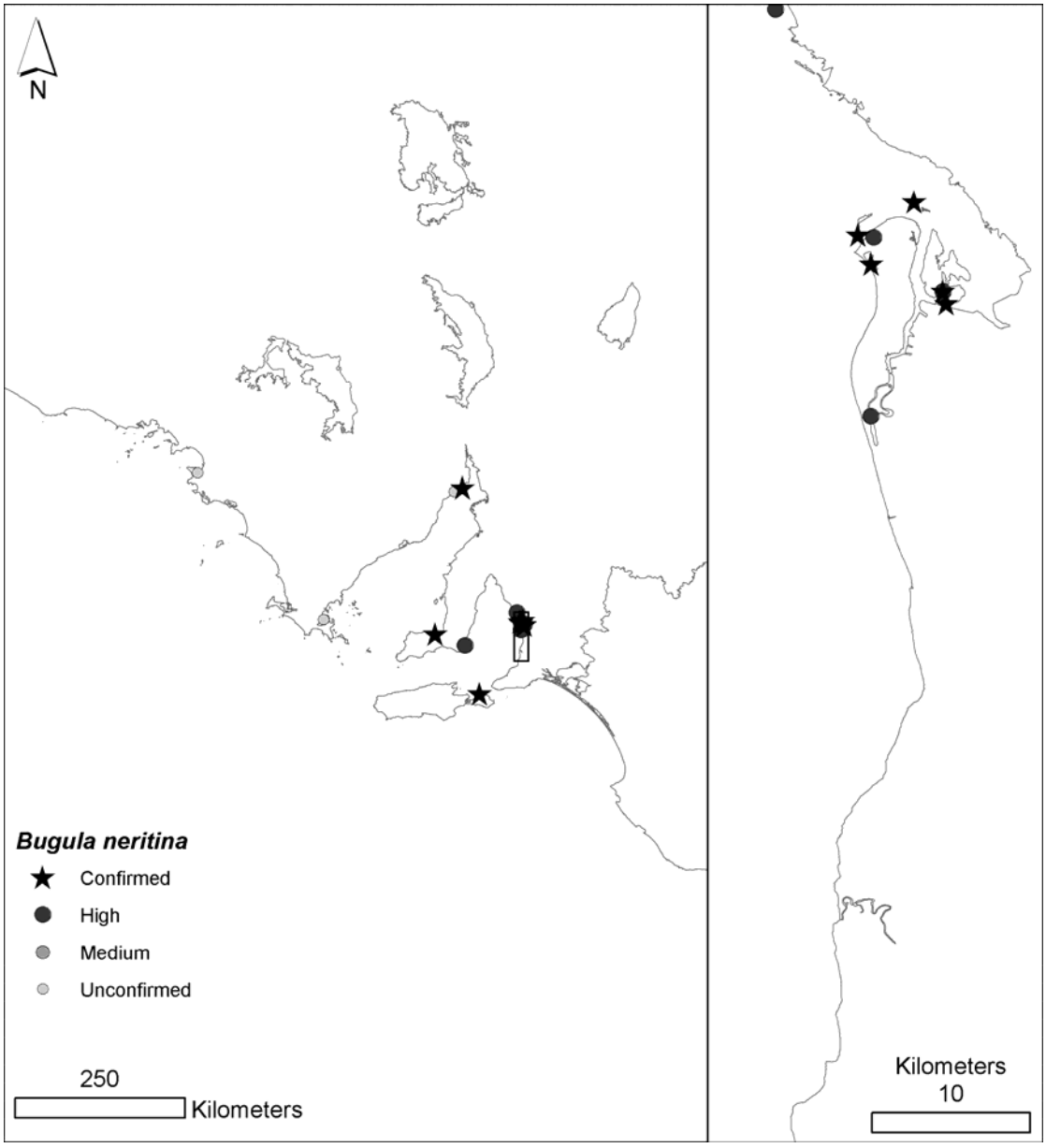

Figure 41. Map of records of *Bugula neritina.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Bugula neritina is a cosmopolitan species, probably spread by shipping, and first recorded in Australia in Victoria in the 1880s (Keough and Ross 1999; Aquenal Pty Ltd 2002). The species appears to be widespread in SA. Bock (1982) reported it as common in southern Australia, there are published records from around Port

Adelaide-West Lakes (Keough 1983; Brock 1985; Holloway and Keough 2002b; Mackie *et al.* 2006), Port Gawler (Mackie *et al.* 2006), and Edithburgh (Keough 1983), and several specimens are held by SAM and MV from locations including St Kilda, Stony Point (~12 km NE of Whyalla), Point Turton, and Penneshaw, KI. A single individual was found by the 2001 Port Adelaide survey (Cohen *et al.* 2002). A recent survey of Eyre Peninsula collected specimens that may be *B. neritina* at Streaky Bay, Port Lincoln and Whyalla, but identity of the collected material is yet to be confirmed (Dittmann *et al.* 2010).

3.3.37. *Tricellaria occidentalis* (Trask, 1857)

Synonym(s): may be considered synonymous with *T. porteri* (MacGillivray, 1889)
Category: introduced
Status: unconfirmed
Summary: *Tricellaria occidentalis* has been reported from Glenelg.

Tricellaria occidentalis is considered native to the northern hemisphere and introduced to Australia and New Zealand (Aquenal Pty Ltd 2002). It is sometimes considered synonymous with *T. porteri* (e.g. Keough and Ross 1999), although the two species are recognised as distinct by WoRMS (Appeltans *et al.* 2009). Records of *T. occidentalis* in Australia may therefore be confused with those of *T. porteri*. In SA *T. occidentalis* has been reported to occur in the Eyre and GSV bioregions (Hayes *et al.* 2005), but this may be based on records of *T. porteri* (see section 3.3.38). The only record we found for *T. occidentalis* was from the Marine Life Society of SA newsletter (Brock 2006). The author, Brian Brock, is considered credible as he has studied the Bryozoa in SA (e.g. Brock 1985) but he suggests further material would be needed to confirm the identification (Brock 2006). The occurrence of *T. occidentalis* in SA is therefore unconfirmed.

3.3.38. *Tricellaria porteri* (MacGillivray, 1889)

Synonym(s): *Menipea porteri*, may also be considered synonymous with *T. occidentalis*

Category: cryptogenic

Status: unconfirmed

Summary: *Tricellaria porteri* has been reported from Outer Harbor but may be widespread.

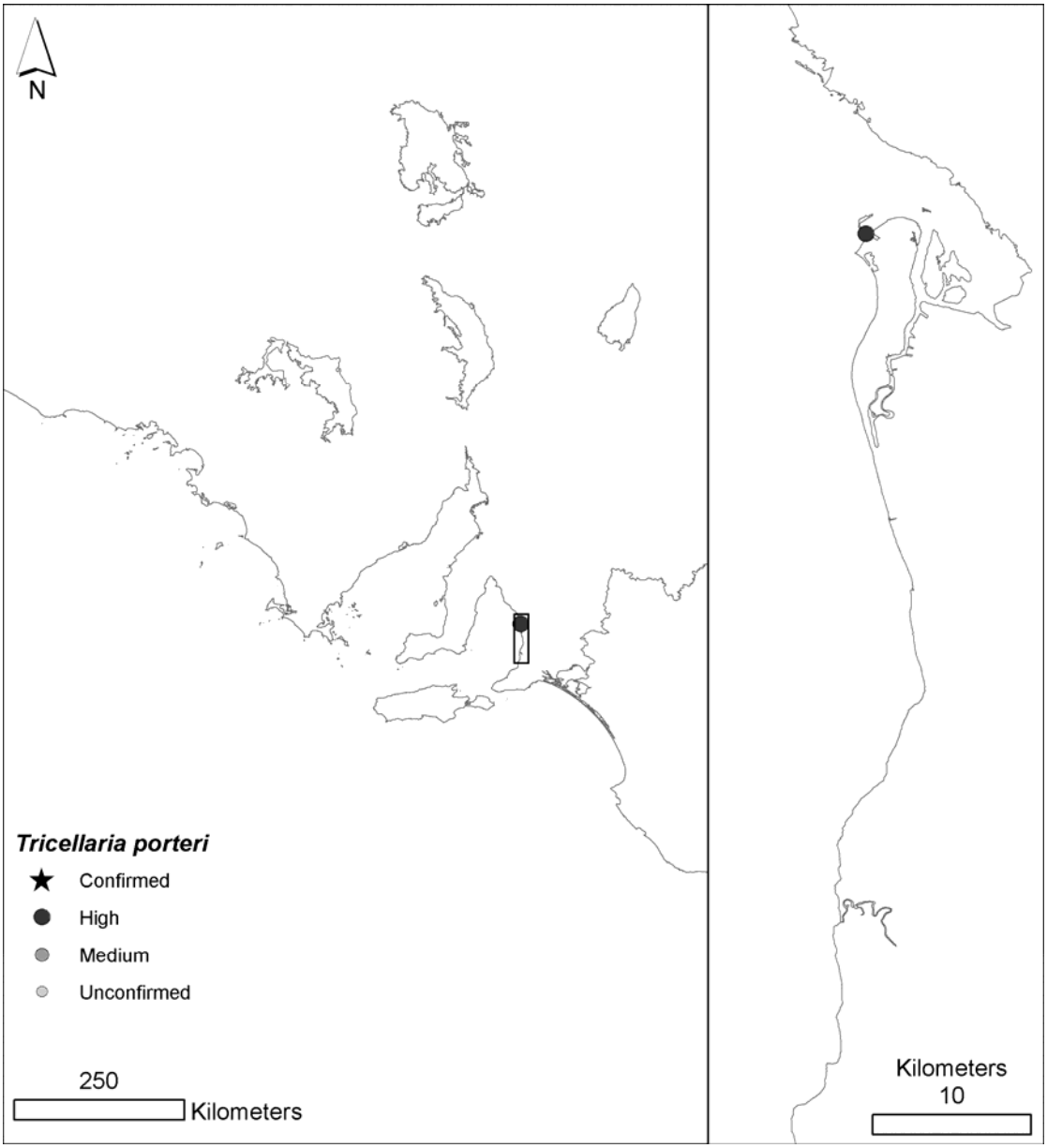

Figure 42. Map of records of *Tricellaria porteri.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Tricellaria porteri has sometimes been considered as synonymous with *T. occidentalis* (e.g. Keough and Ross 1999), but the two species are currently

recognised as distinct by WoRMS (Appeltans *et al.* 2009). *Tricellaria porteri* has been reported as a minor fouling species at Outer Harbor (Brock 1985, 2006). It was considered common in southern Australia by Bock (1982), so may be widespread, although no specimens of this species from SA exist to confirm this.

3.3.39. *Cryptosula pallasiana* (Moll, 1803)

Synonym(s): *Eschara pallasiana*, *Lepralia pallasiana*

Category: cryptogenic

Status: unconfirmed

Summary: *Cryptosula pallasiana* is likely to occur in SA.

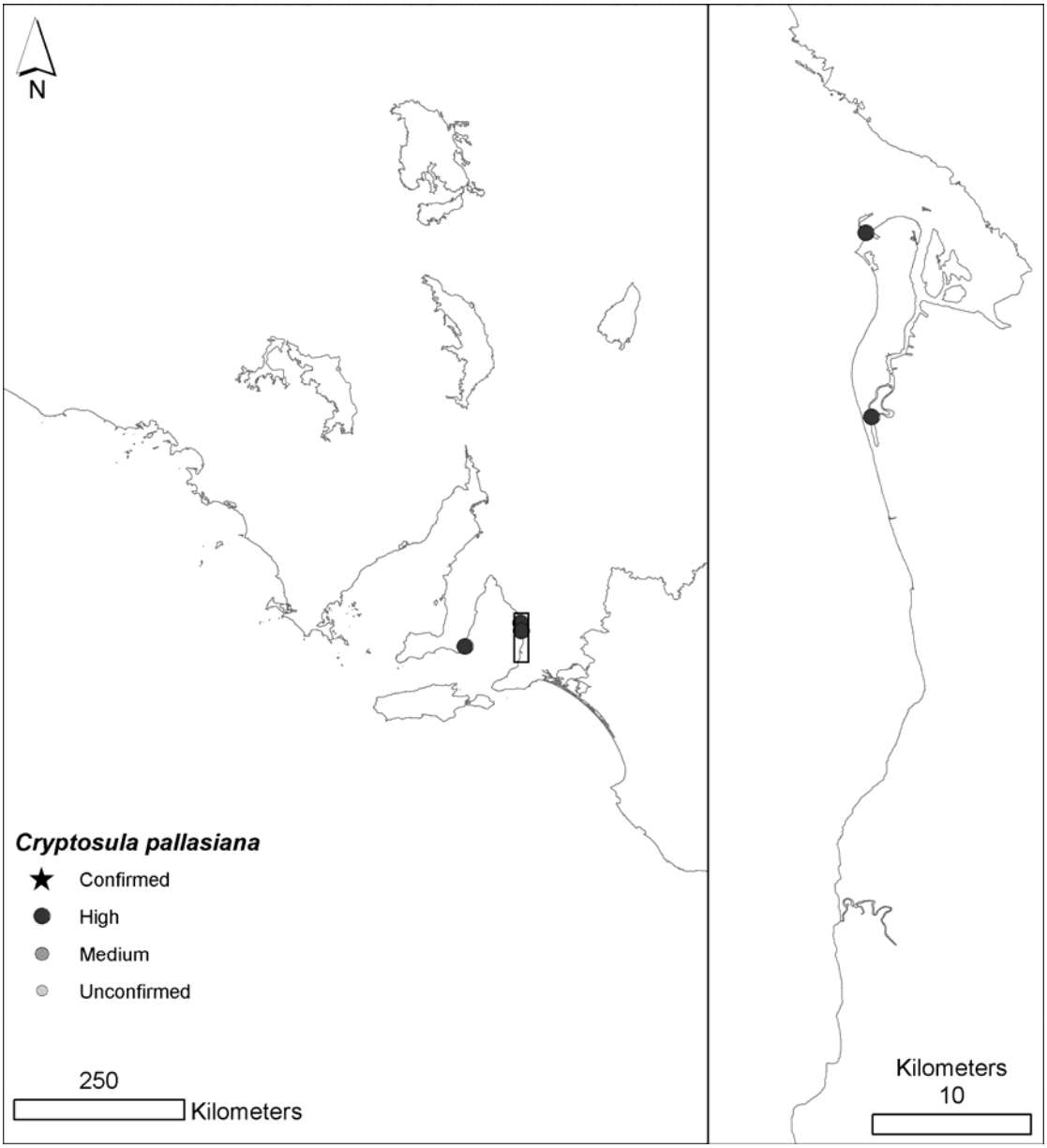

Figure 43. Map of records of *Cryptosula pallasiana.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Cryptosula pallasiana is a cosmopolitan fouling species, recorded in Australia since the late 1800s (Bock 1982; Keough and Ross 1999). The species has been reported as common in southern Australia (Bock 1982), with published records from around Port Adelaide and West Lakes (Keough 1983; Brock 1985), and Edithburgh (Kay and Keough 1981; Keough 1983). We found no specimens of this species, however, so we class it as unconfirmed although it appears likely to occur.

3.3.40. *Conopeum seurati* (Linnaeus, 1767)

Category: introduced

Status: uncertain

Summary: *Conopeum seurati* has been recorded near Coffin Bay.

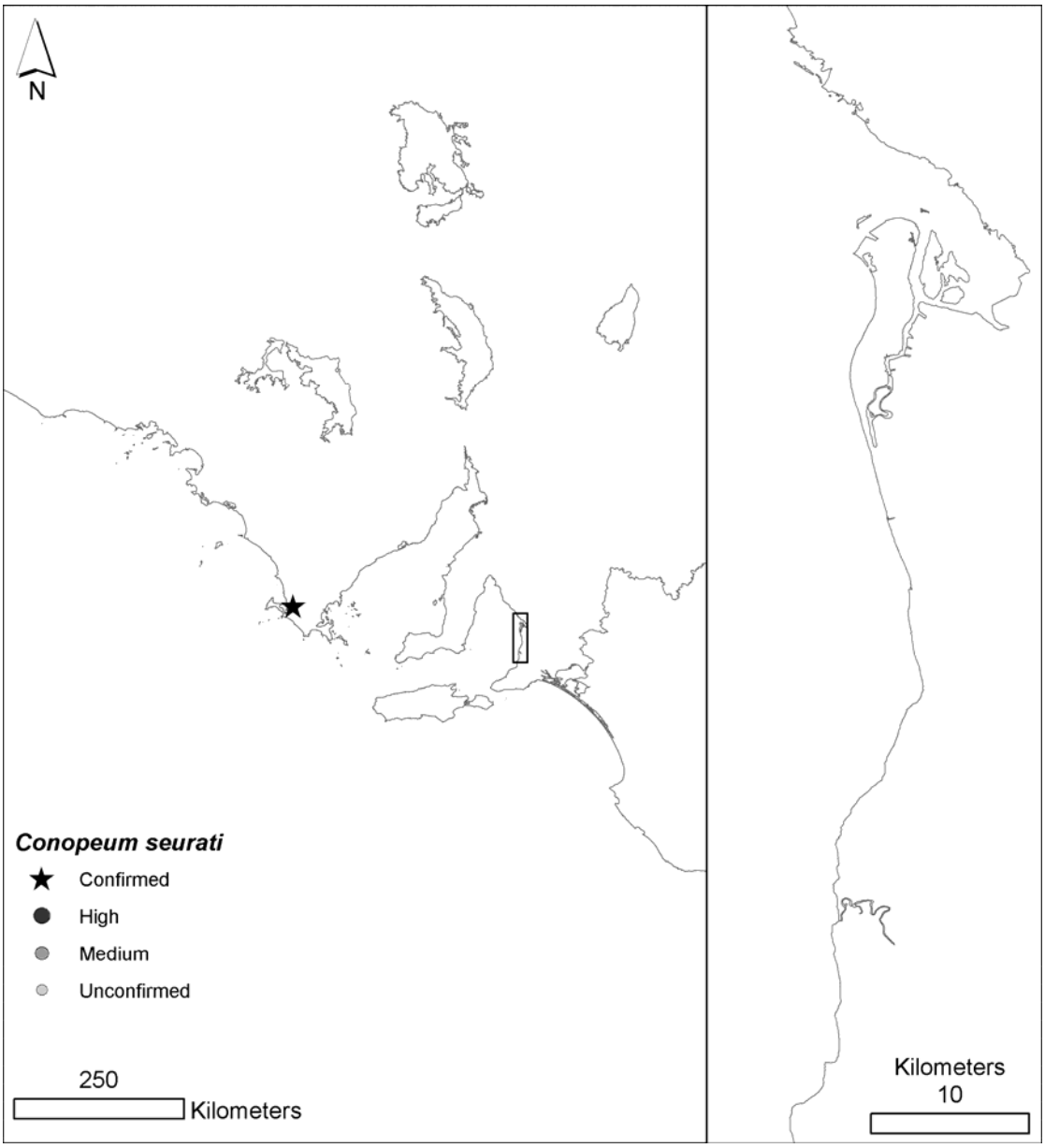

Figure 44. Map of records of *Conopeum seurati.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Conopeum seurati is native to the northern Atlantic and is regarded as introduced to Europe, North America, New Zealand and Australia; it is primarily an estuarine species but has been recorded in freshwater and seawater (Aquenal Pty Ltd 2002; Pollard and Pethebridge 2002b). Pollard and Pethebridge (2002b) stated that *C. seurati* occurs in SA, but the only record of this species is a specimen held by

SAM, which was collected in 1980 from Minribbie Creek, near Lake Wangary, ~ 8 km N of Coffin Bay. We class its current status as uncertain due to the lack of further records.

3.3.41. *Membranipora membranacea* (Linnaeus, 1767)

Synonym(s): *Flustra membranacea*

Category: cryptogenic

Status: established

Summary: *Membranipora membranacea* is widespread in SA.

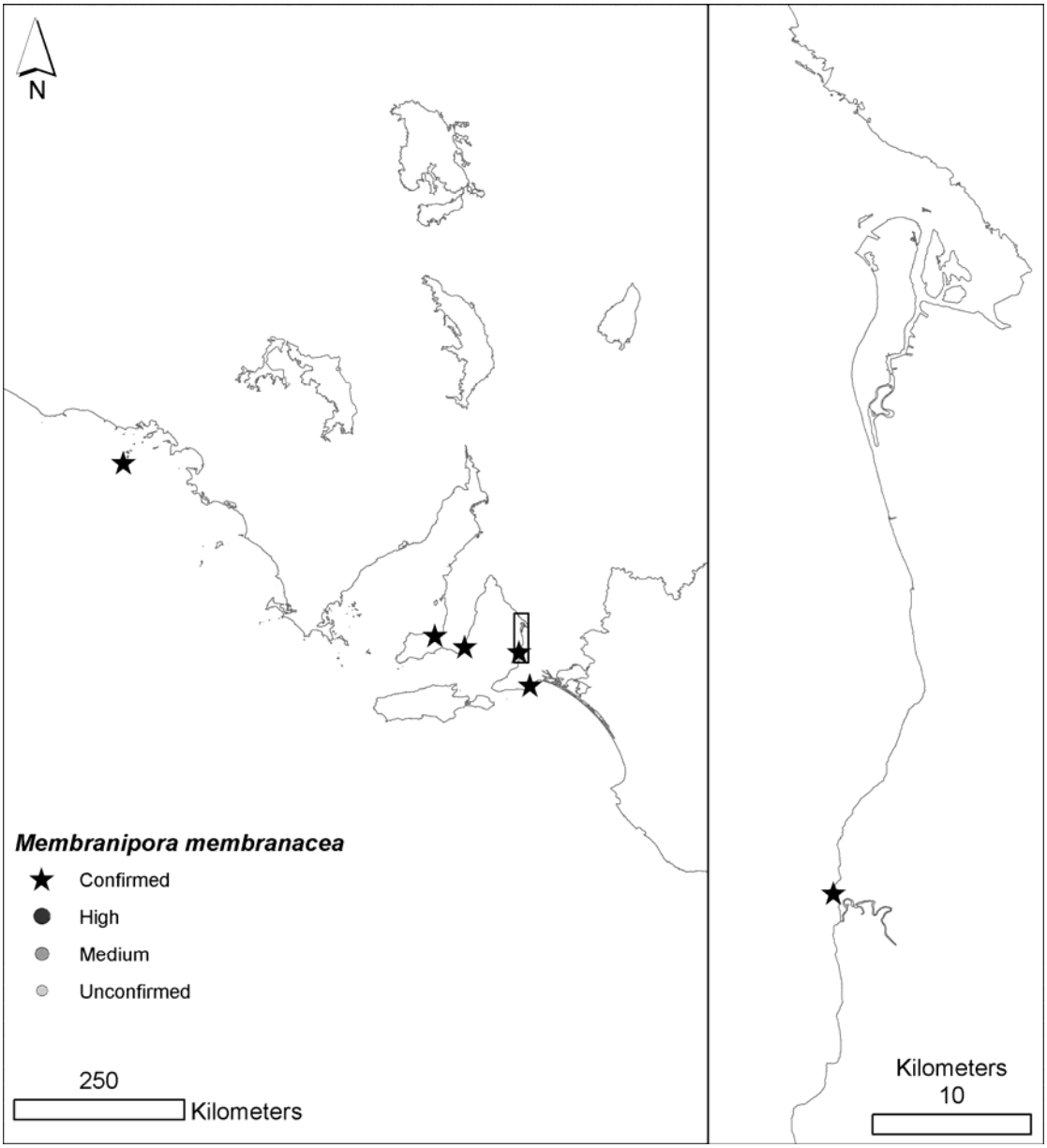

Figure 45. Map of records of *Membranipora membranacea.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Membranipora membranacea is a cosmopolitan fouling species that is highly seasonal and often encrusts kelp fronds (Bock 1982; Keough and Ross 1999; Aquenal Pty Ltd 2002). It is likely to be widespread in SA, with SAM holding specimens collected from Canan Reef at the southern end of the Nuyts Archipelago, Point Turton, Edithburgh, Port Noarlunga, and Wright Island, ~3.5 km SW of Victor Harbor.

3.3.42. *Schizoporella errata* (Waters, 1878)

Synonym(s): may be confused with *S. unicornis*

Category: cryptogenic

Status: established

Summary: *Schizoporella errata* is found around Port Adelaide.

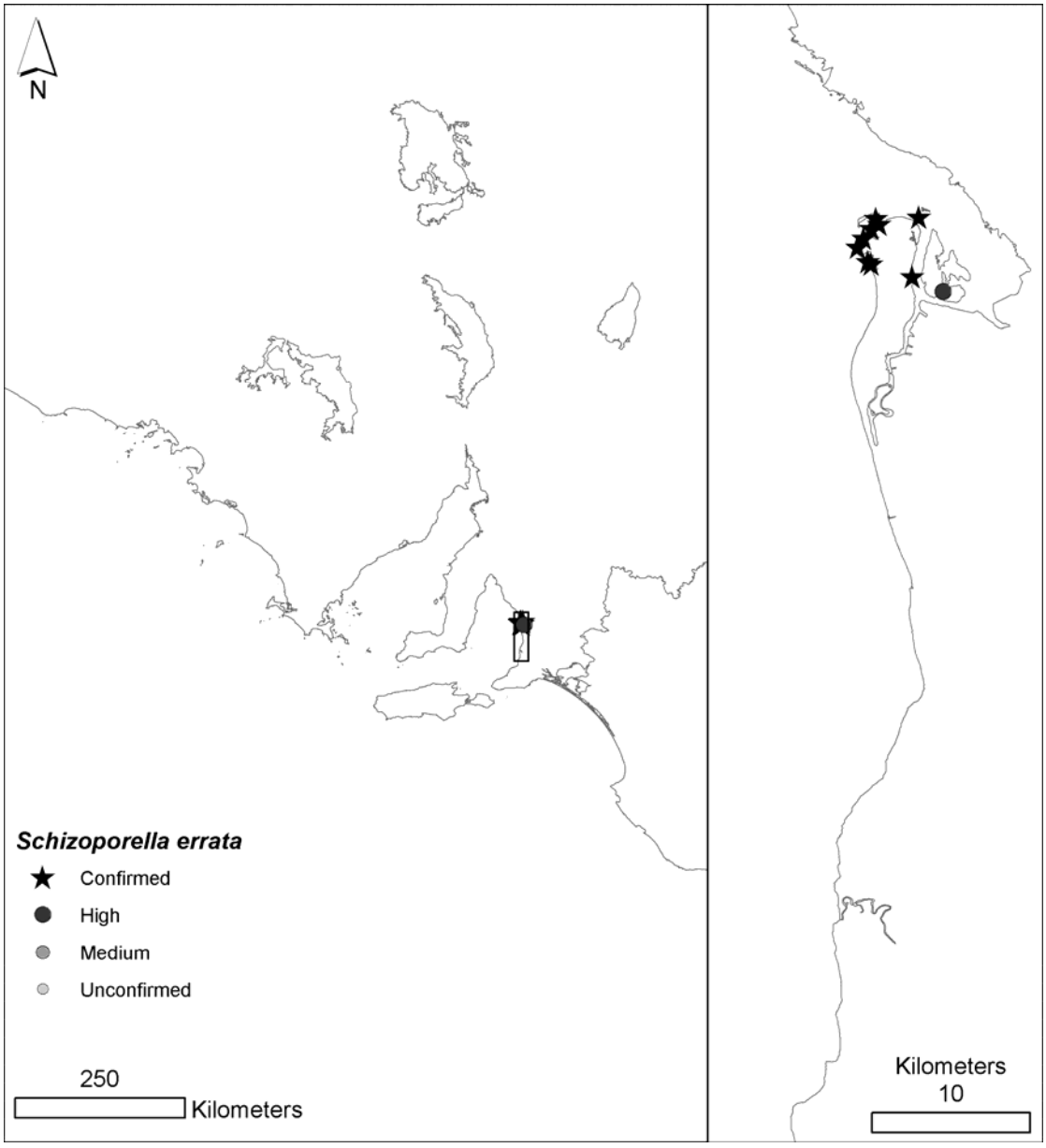

Figure 46. Map of records of *Schizoporella errata.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

The *Schizoporella* species most frequently reported from Australia (including SA) is *S. unicornis* (Johnston, 1874) (e.g. Allen 1953; Furlani 1996; Lewis *et al.* 1998; Edyvane 1999; AMBS 2002; NIMPIS 2009b; Table 1). Brock (1985) suggested, however, that the *Schizoporella* found around Port Adelaide was more likely to be

S. errata. This is further supported by the material collected from Outer Harbor, the Port River and North Haven marina during the 2001 Port Adelaide survey being identified as *S. errata* (Cohen *et al.* 2002; SAM specimens). SAM also holds a specimen of *S. errata* collected from North Haven marina in 1998. Gowlett-Holmes (2008) regarded this species as occurring around south-eastern Australia. *Schizoporella errata* is believed to be native to the Mediterranean (Hewitt *et al.* 2004), but has an almost cosmopolitan distribution (Cohen *et al.* 2002; Gowlett-Holmes 2008) so we class it as cryptogenic.

3.3.43. *Schizoporella unicornis* (Johnston, 1874)

Synonym(s): may be confused with *S. errata*

Category: cryptogenic

Status: uncertain

Summary: *Schizoporella unicornis* has been recorded at Port Lincoln.

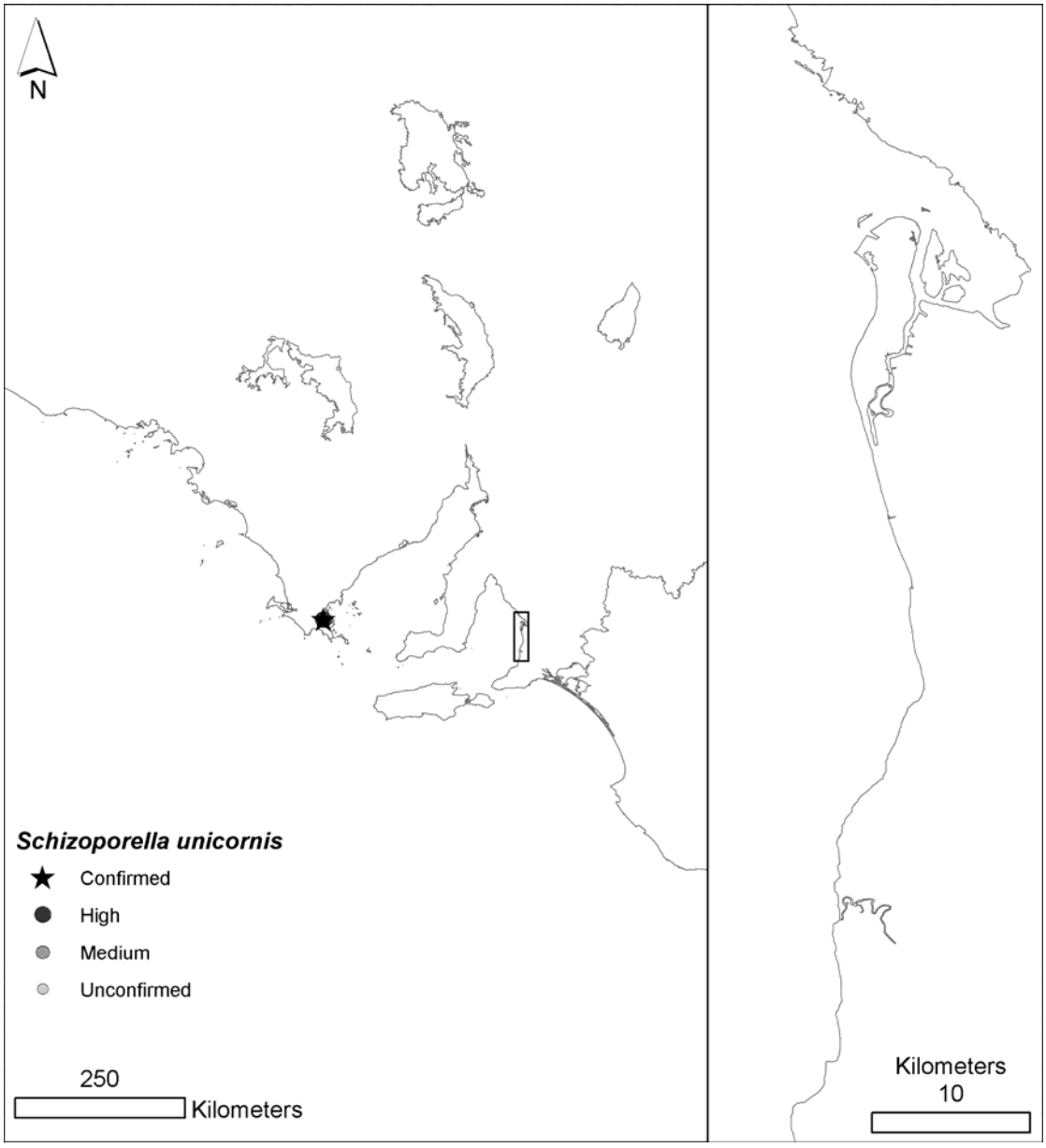

Figure 47. Map of records of *Schizoporella unicornis.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Schizoporella unicornis is considered native to Japan, but has an almost cosmopolitan distribution, although some records may be as the result of misidentification (Keough and Ross 1999; AMBS 2002). *Schizoporella unicornis* has been reported from Australia (including SA) by many sources (e.g. Allen 1953;

Furlani 1996; Lewis *et al.* 1998; Edyvane 1999; AMBS 2002; NIMPIS 2009b; Table 1), but it is likely that in Port Adelaide at least, these records are misidentifications of *S. errata* (see section 3.3.42). A specimen held by SAM and collected during the 1996 CRIMP survey of Port Lincoln is, however, *S. unicornis*. We class the current status of this species as uncertain due to the lack of records.

3.3.44. *Watersipora arcuata* Banta, 1969

Synonym(s): may have been reported as *Watersipora cucullata* or *W. subvoidea*

Category: cryptogenic

Status: established

Summary: *Watersipora arcuata* is widespread in SA.

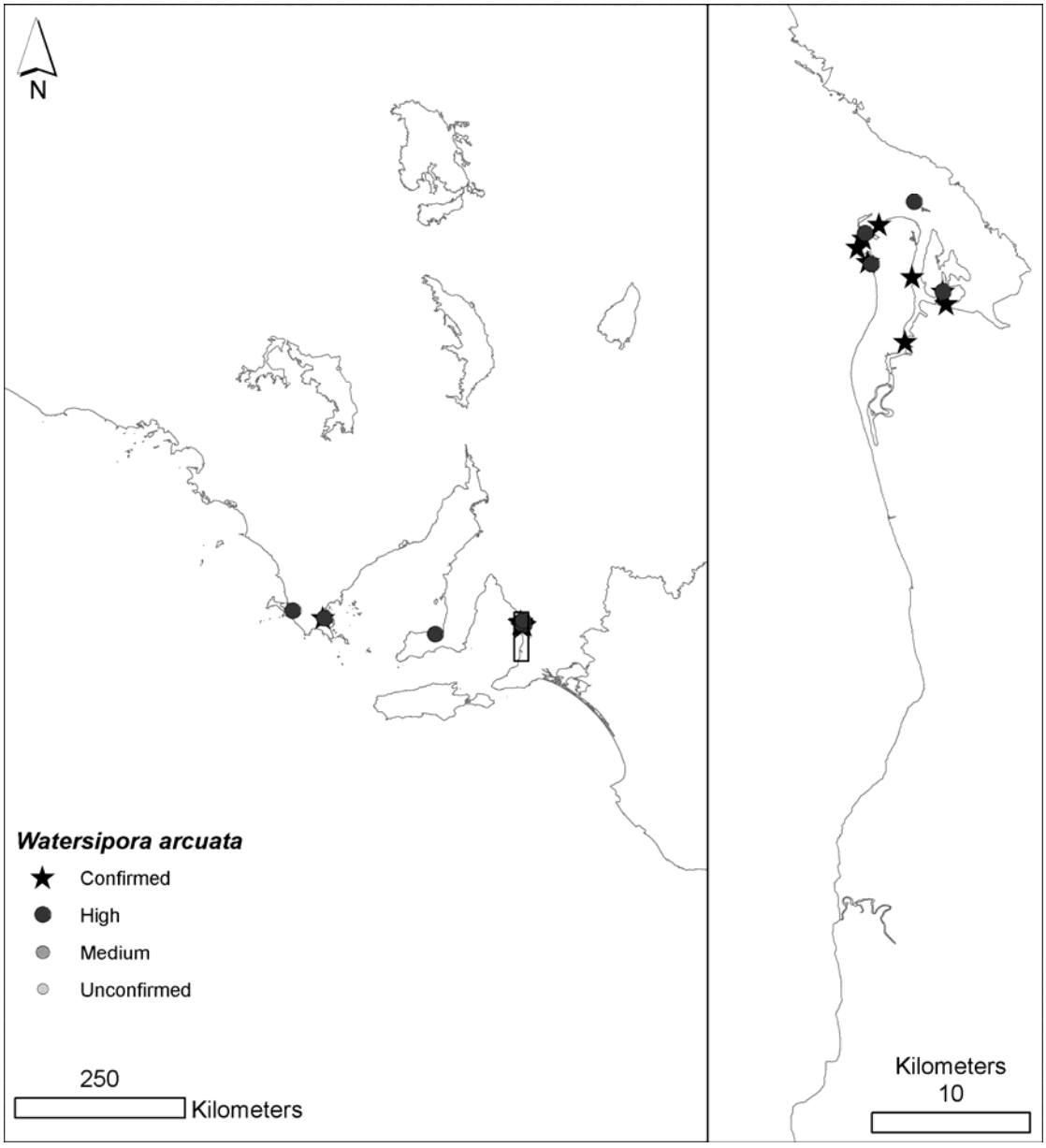

Figure 48. Map of records of *Watersipora arcuata.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Two distinct *Watersipora* species, now recognised as *W. subtorquata* and *W. arcuata* (see Appeltans *et al.* 2009), were originally regarded as morphological variations of the same species, then known as *W. cucullata* (Busk, 1854) (see Keough and Ross 1999). Some records of *W. cucullata* or *W. subvoidea* (now both recognised as *W.*

subtorquata, see section 3.3.45) may therefore be attributable to *W. arcuata* (see Keough and Ross 1999). *Watersipora arcuata* is considered native to the eastern Pacific, but is widely distributed (Bock 1982; Keough and Ross 1999). This species is reported as common and widespread in southern Australia (Bock 1982; Gowlett-Holmes 2008), and this is supported by SAM specimens from Port Adelaide and Port Lincoln and additional published records from these locations (Brock 1985; Mackie *et al.* 2006; Burgess *et al.* 2009) and from Point Turton and Coffin Bay (Brock 1985). *Watersipora arcuata* was also found around Port Adelaide by the 2001 survey (Cohen *et al.* 2002) and in Port Lincoln by the 1996 CRIMP survey (Hewitt *et al.* 1997; TMAG unpublished data).

3.3.45. *Watersipora subtorquata* (d'Orbigny, 1852)

Synonym(s): *Watersipora subvoidea**, *W. cucullata*

Category: cryptogenic

Status: established

Summary: *Watersipora subtorquata* is established around Port Adelaide and recorded from Port Noarlunga and Port Lincoln.

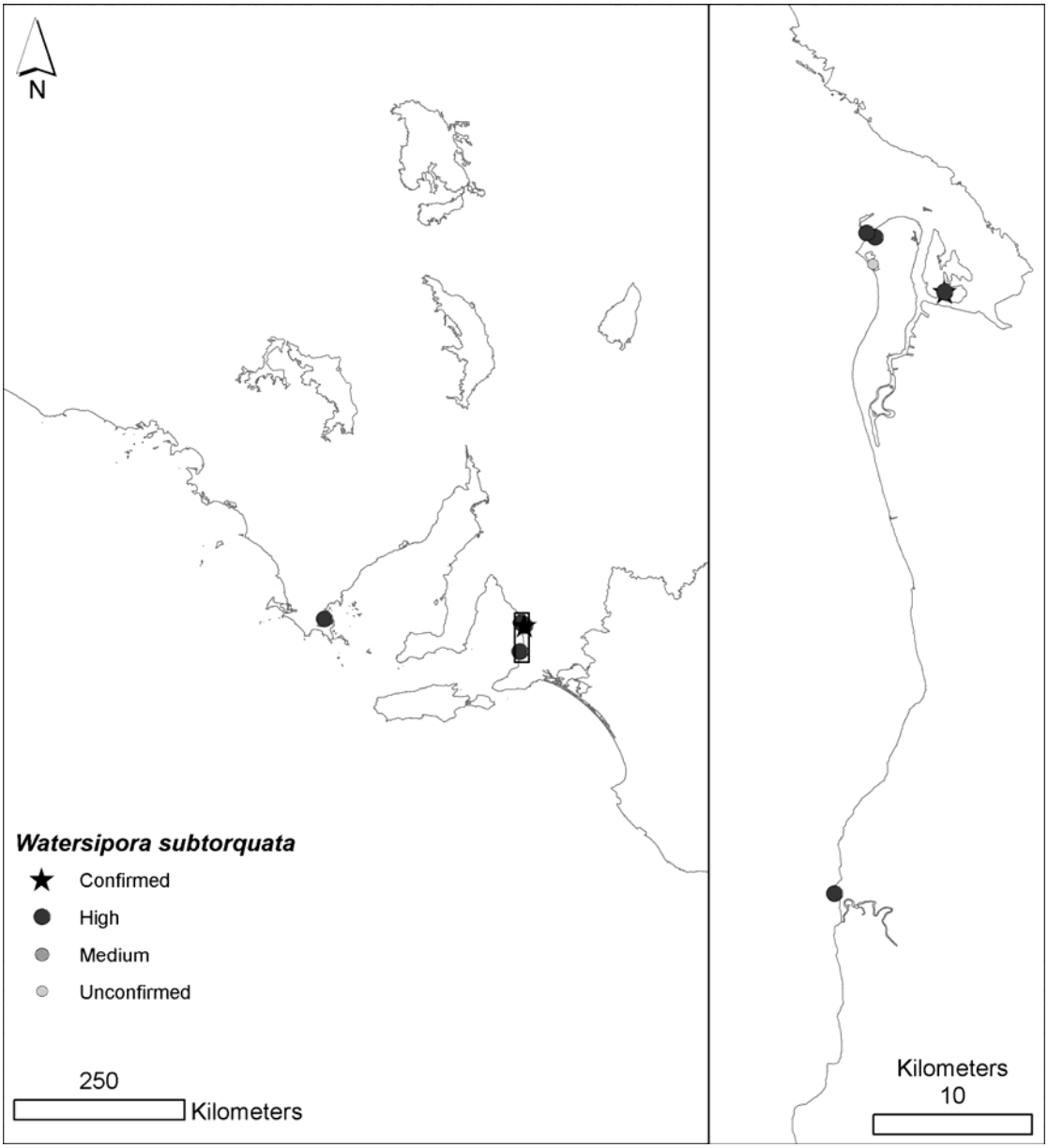

Figure 49. Map of records of *Watersipora subtorquata.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

The native range of *W. subtorquata* is unclear due to taxonomic confusion, although it appears to be widespread (Keough and Ross 1999). Records of *W. subtorquata* may be confused with those of *W arcuata* (see section 3.3.44) because both may

have been recorded as *W. cucullata* or *W. subvoidea* (see Keough and Ross 1999). Both *W. cucullata* and *W. subvoidea* are now regarded as synonyms of *W. subtorquata* (see Appeltans *et al.* 2009). In SA this species (as *W. subvoidea*) was recorded as a major fouling species around Port Adelaide from 1975-77, but by 1983 *W. arcuata* had become the dominant species (Brock 1985). It appears that both species continue to be present, with *W. subtorquata* being reported from 1997-98 in the RSAYS marina at Outer Harbor (Holloway and Keough 2002a), and also at Port Noarlunga (1998-2001) (Mackie *et al.* 2006) and North Haven marina (1999-2000) (J. Mackie pers. comm. in Cohen *et al.* 2002). *Watersipora subtorquata* was found by the 1996 CRIMP survey of Port Lincoln (TMAG unpublished data) but is not discussed in the report (Hewitt *et al.* 1997). In Victoria, *W. subtorquata* is more common than *W. arcuata*, indicating a possible preference of this species for cooler water (Keough and Ross 1999; Cohen *et al.* 2002).

3.3.46. *Zoobotryon verticillatum* (delle Chiaje, 1822)

Category: cryptogenic

Status: established

Summary: *Zoobotryon verticillatum* has been recorded at Port Adelaide and Coffin Bay.

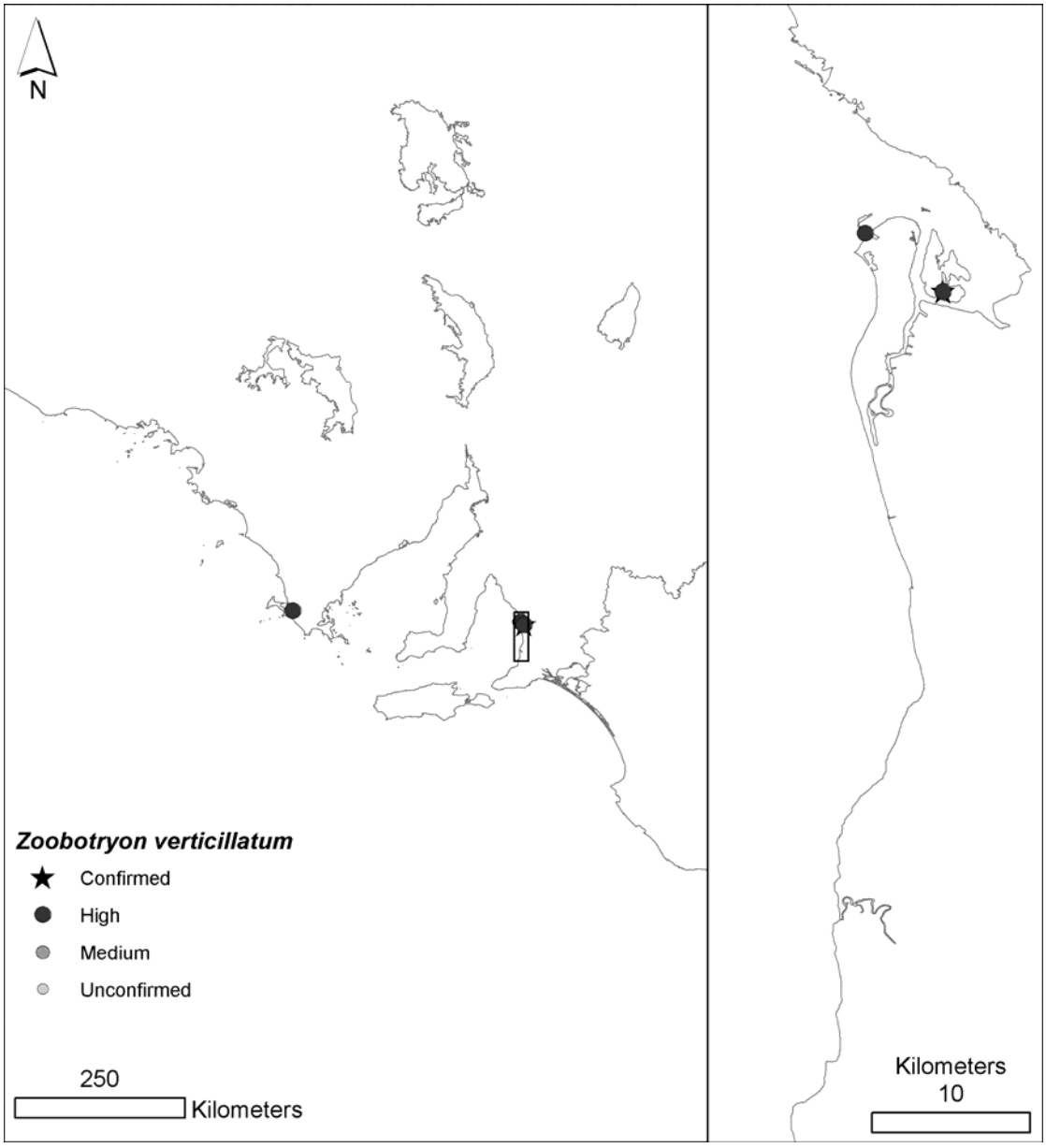

Figure 50. Map of records of *Zoobotryon verticillatum.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Zoobotryon verticillatum is a widely distributed species found in Europe, North and South America, Japan and Australia (Keough and Ross 1999). It was reported as occurring around Adelaide by Bock (1982) and has been recorded from Angas Inlet, Outer Harbor and Coffin Bay (Brock 1985; SAM specimens).

ENTOPROCTA

3.3.47. *Barentsia benedeni* (Foettinger, 1887)

Synonym(s) (*reported as): *Arthropodaria benedenii*, *Arthropodaria kovalevskii*, misidentified as *Barentsia gracilis**

Category: cryptogenic

Status: established

Summary: *Barentsia benedeni* is recorded around Port Adelaide.

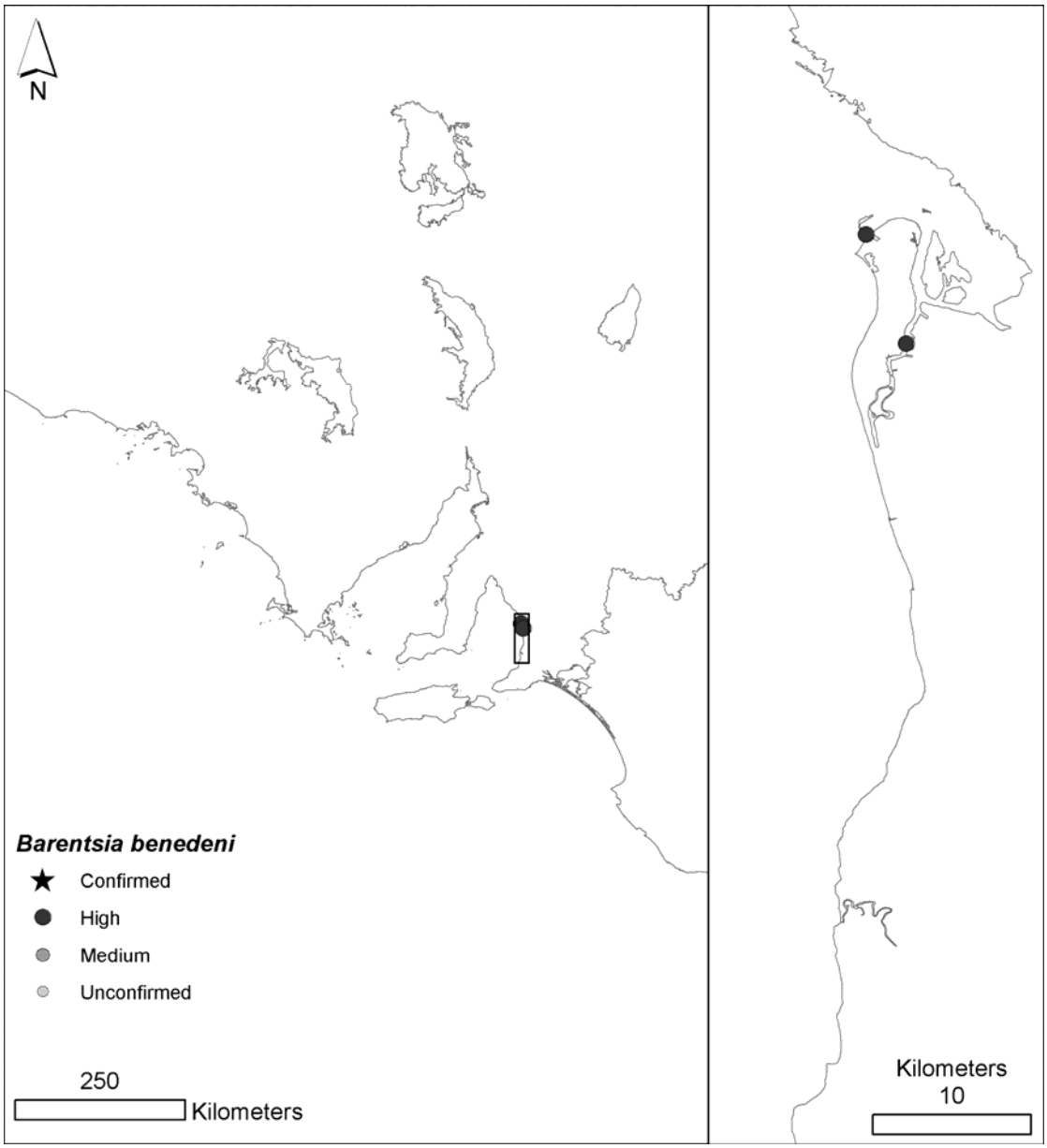

Figure 51. Map of records of *Barentsia benedeni.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Barentsia benedeni is a cosmopolitan fouling species reported in SA from Outer Harbor and the Inner Harbour of Port Adelaide (Wasson and Shepherd 1997; Wasson 2002), with a specimen held by SAM (originally misidentified as *B. gracilis*) confirming that it occurred in Port Adelaide (exact collecting locality not stated) in 1948. This species appeared on the 1998-99 lists of introduced species in SA (EPA and DEHAA 1998; Lewis *et al.* 1998; Edyvane 1999).

CHORDATA: Ascidiacea

3.3.48. *Ascidiella aspersa* (Müller, 1776)

Synonym(s) (*reported as): *Ascidia aspersa**, *Ascidia pustulosa*, *Ascidia affinis*, *Phallusia aspersa*, *Ascidiella cristata*

Category: introduced

Status: established

Summary: *Ascidiella aspersa* occurs around Port Adelaide, North Haven and West Lakes with records from Port Noarlunga and Port Lincoln.

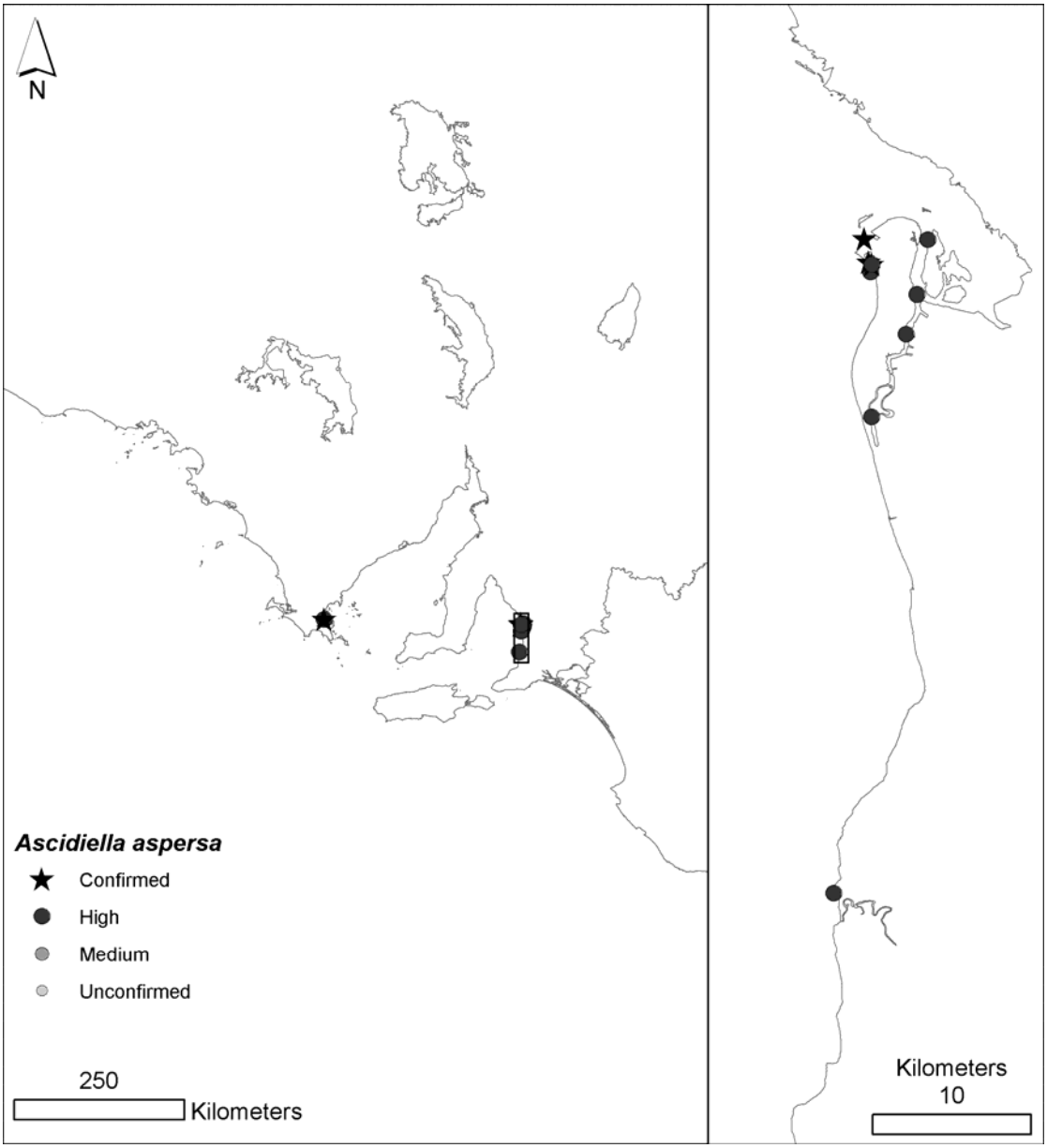

Figure 52. Map of records of *Ascidiella aspersa.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Ascidiella aspersa is regarded as native to Europe from the Mediterranean to the Shetland Isles and may have been spread to the southern hemisphere by shipping (Kott 1985, 1997; Keough and Ross 1999). The first record of the species (as *Ascidia aspersa*) in SA was from Port Noarlunga (Kott 1952) but it has mainly been recorded around Port Adelaide, North Haven and West Lakes. It was found by the 2001 Port Adelaide survey (Cohen *et al.* 2002; SAM specimens) and also recorded in several samples of the 2007-8 Port Adelaide surveys despite not being one of the target species (Rowling 2009b). Further published records are from North Haven marina (Bolton and Havenhand 1996; SAM specimens) and West Lakes (Keough 1983). This species was also found in Port Lincoln by the 1996 CRIMP survey (Hewitt *et al.* 1997; SAM specimens).

3.3.49. *Ciona intestinalis* (Linnaeus, 1767)

Synonym(s): many, see Kott (1990)

Category: introduced

Status: established

Summary: *Ciona intestinalis* occurs around Port Adelaide, North Haven and West Lakes with records from Port Lincoln, Wallaroo, and American River, KI.

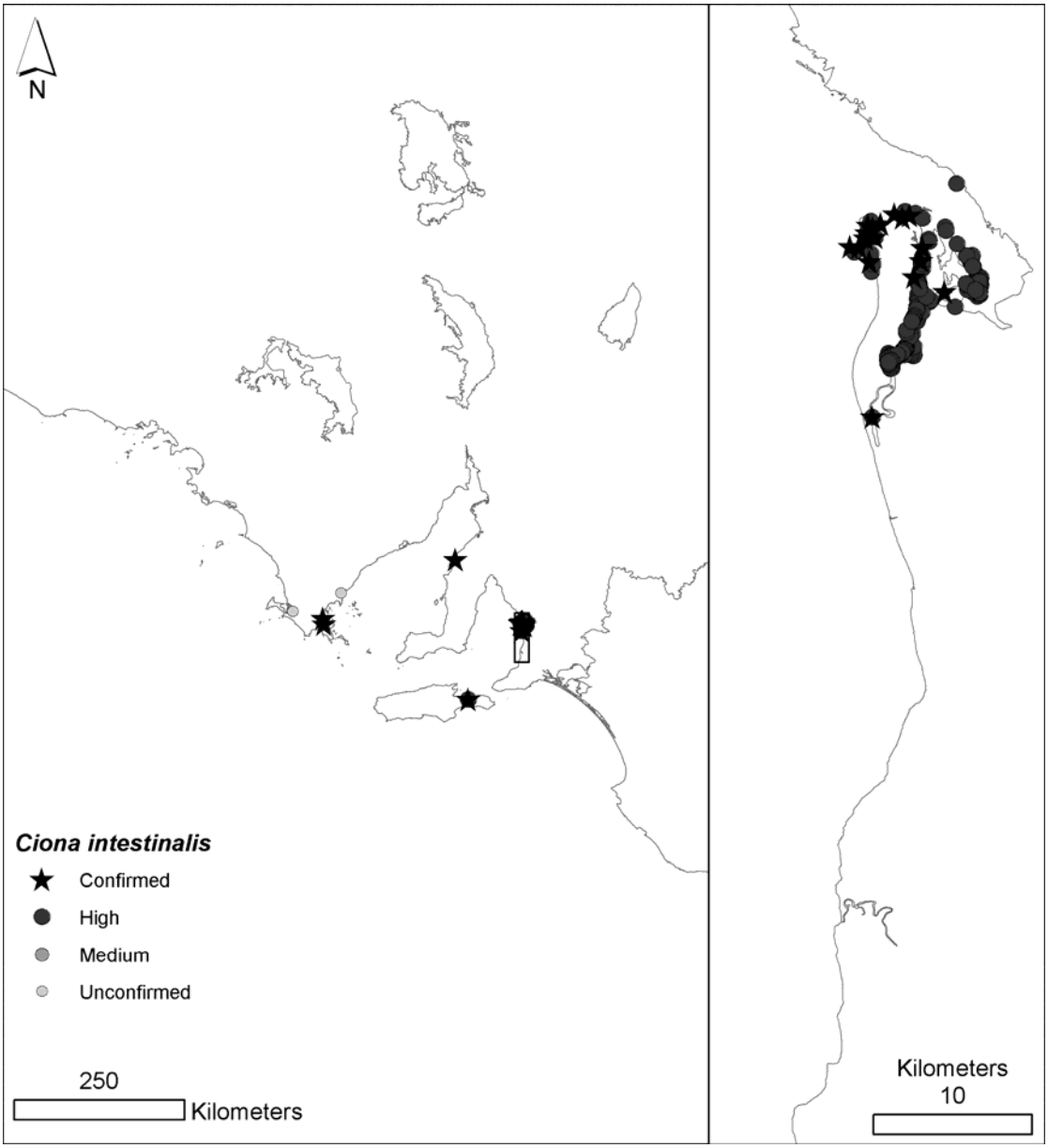

Figure 53. Map of records of *Ciona intestinalis.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Ciona intestinalis is a widely distributed species assumed to have been spread by shipping (Kott 1952; Kott 1997; Keough and Ross 1999); it is considered native to the North Atlantic (Hayes *et al.* 2005). It has been known in Australia since the 1870s (Keough and Ross 1999) and was first recorded in SA from Port Adelaide by Kott (1952). *Ciona intestinalis* was found throughout the Port River from the upper Port River to Outer Harbor by the 2001 (Cohen *et al.* 2002) and 2007-8 Port Adelaide surveys (Rowling 2009b), and during SARDI surveys for *Caulerpa taxifolia* (SARDI unpublished data). SAM specimens and published records from the RSAYS marina at Outer Harbor (Holloway and Keough 2002a), North Haven marina (Bolton and Havenhand 1996) and West Lakes (Keough 1983) confirm its ongoing occurrence in the region. SAM also holds specimens from Port Lincoln (1999 and 2005), Wallaroo (2000) and American River, KI (2008). A recent survey of Eyre Peninsula recorded *C. intestinalis* from Coffin Bay, Port Lincoln and Tumby Bay but the identification of collected specimens is yet to be verified (Dittmann *et al.* 2010). *Ciona intestinalis* was reported to be in decline in several locations (Kott 1990, 1997), but recent records show it is still common and well established in SA, at least around Port Adelaide.

3.3.50. *Botrylloides leachi* (Savigny, 1816)

Synonym(s): many, see Kott (1985)

Category: cryptogenic

Status: established

Summary: *Botrylloides leachi* is widespread in SA.

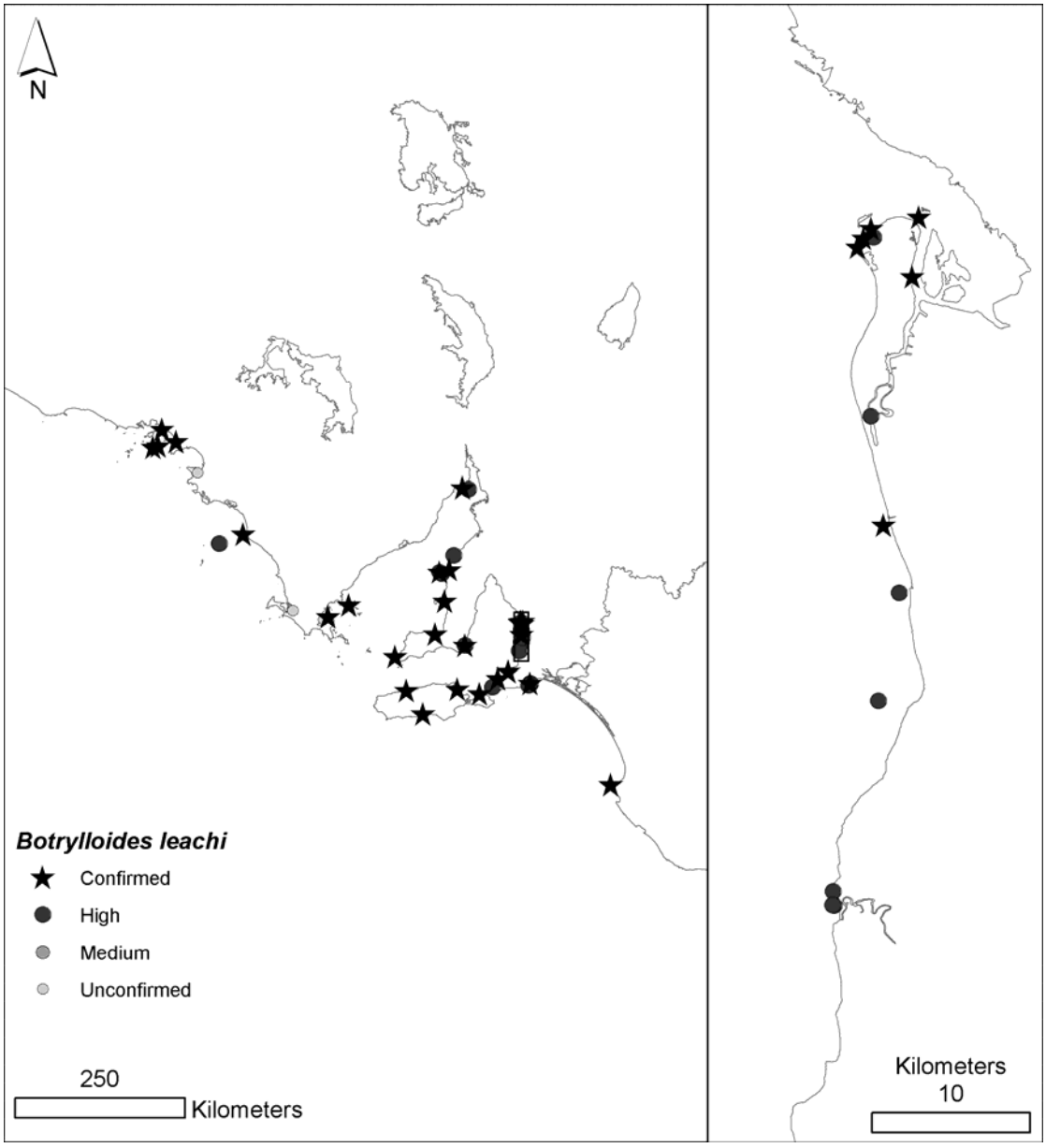

Figure 54. Map of records of *Botrylloides leachi.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Botrylloides leachi is known from the Mediterranean, Red sea, north-east Atlantic and around Australia except the northern coast (Kott 1985; Edgar 2008). A new record of this species from Topgallant Island (~37 km SW from Elliston) was published by Kott (1985) and this appears to be the basis for the description of the distribution of this

species in Furlani (1996) and on lists of introduced species for SA (EPA and DEHAA 1998; Lewis *et al.* 1998; Edyvane 1999; EPA 2003). Specimens from SAM have been collected from throughout the State (Figure 54). The date of collection is not known for all specimens, but early records include GSV offshore from Outer Harbor (1967), Waldegrave Island, ~7.5km NW of Elliston (1970), West Beach, ~4.5 km N of Glenelg, and Carrackalinga (1971). Other published records of *B. leachi* are from West Lakes (Keough 1983), Outer Harbor (Holloway and Keough 2002a, b), Edithburgh (Kay and Keough 1981; Keough 1983), Port Bonython, ~18 km ENE of Whyalla (Butler and Connolly 1999), Wright and West Islands (~3.5 km and 6 km SW of Victor Harbor respectively), Port Noarlunga, and Tiparra Reef, ~14 km SW of Moonta Bay (Kott 1972). This species was observed at several locations during the 2005 Reef health surveys (SARDI unpublished data). A recent survey of Eyre Peninsula collected specimens that may be *B. leachi* at Streaky Bay, Coffin Bay, and Port Lincoln, but identity of the collected material is yet to be confirmed (Dittmann *et al.* 2010). It is likely *B. leachi* is widespread in SA; it is seasonal (Kay and Keough 1981), becoming a dominant species in winter (Gowlett-Holmes 2008).

3.3.51. *Botryllus schlosseri* (Pallas, 1766)

Synonym(s): many, see Kott (1985)

Category: cryptogenic

Status: established

Summary: *Botryllus schlosseri* is widespread in SA.

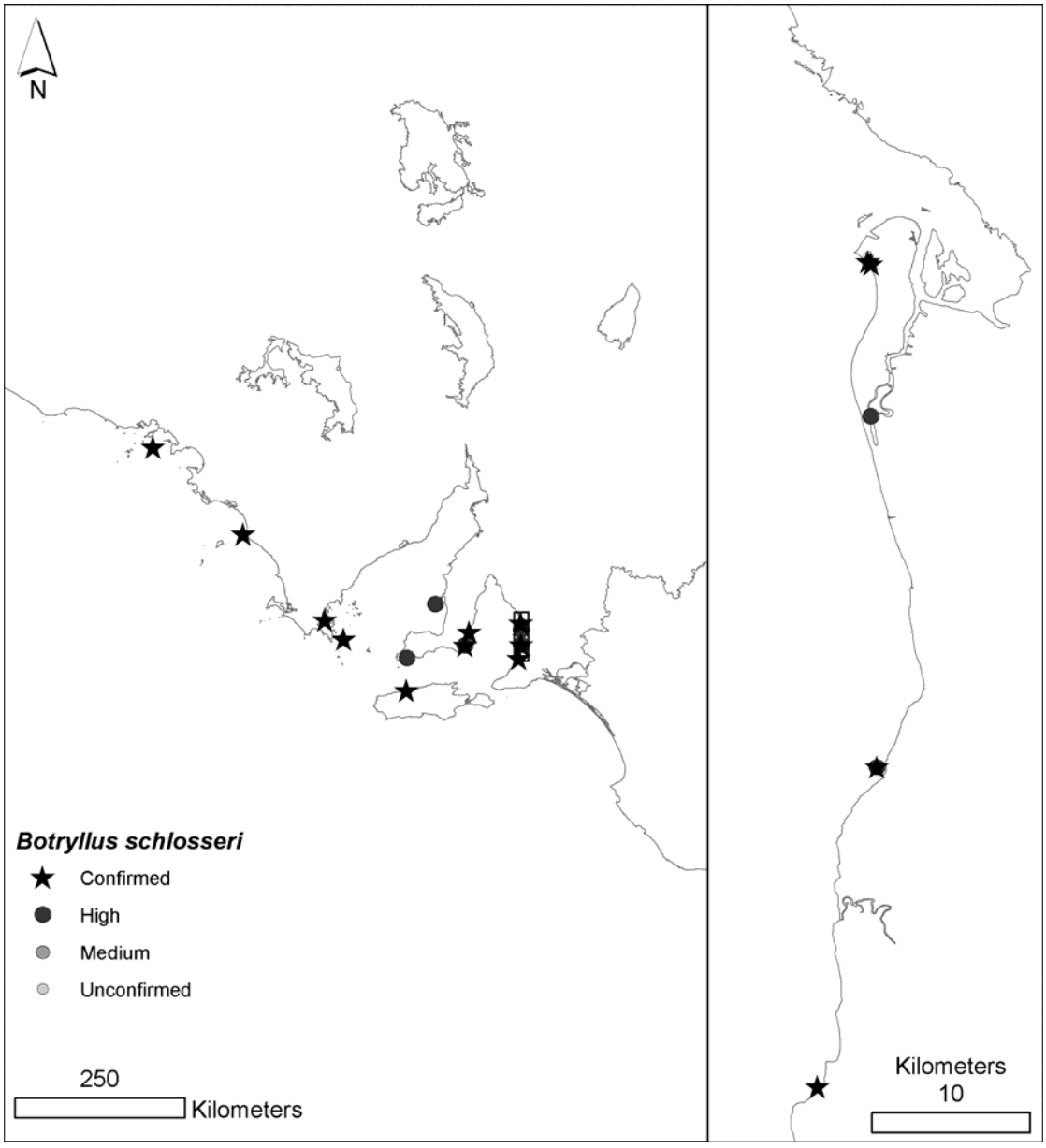

Figure 55. Map of records of *Botryllus schlosseri.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Botryllus schlosseri is a near cosmopolitan species found in the Atlantic, Mediterranean and north-east Pacific and in New Zealand and Australia (Kott 1985; Cohen *et al.* 2002). It is often found growing on *Posidonia* spp. seagrass (Kott 1972). The first Australian records of this species were from 1905 in WA (Kott 1952; Keough

and Ross 1999), with the earliest published record of its occurrence in SA being of a specimen from Hallett Cove, ~6.5 km S of Brighton (Kott 1972, SAM specimen), although a specimen held by SAM was collected earlier (1955) from Aldinga, ~1 km S of Port Willunga. Another SAM specimen was collected from Waldegrave Island (~7.5km NW of Elliston) in 1971, suggesting the species was widespread by that time. SAM holds other specimens collected around the State (see Figure 55) and other published records are from West Lakes and Edithburgh (Keough 1983), and unspecified locations in the eastern GAB, GSV, and Yorke Peninsula (Kott 1985). This species was also observed at Wardang Island, ~10 km W of Port Victoria, and at Marion Bay during the 2005 Reef health surveys (SARDI unpublished data). As for *Botrylloides leachi* (see section 3.3.50), reports of *Botryllus schlosseri* in Furlani (1996) and on lists of introduced species for SA (EPA and DEHAA 1998; Lewis *et al.* 1998; Edyvane 1999; EPA 2003) give the same distribution information as provided by Kott (1985). This species is now known from all around Australia (Kott 1997; Gowlett-Holmes 2008).

3.3.52. *Styela clava* Herdman, 1881

Category: introduced
Status: unconfirmed
Summary: Reports of *Styela clava* at Port Adelaide could not be substantiated.

Styela clava is native to the north-western Pacific and was first recorded in Australia in PPB (Kott 1985). This species is reported to occur in the GSV bioregion of SA (NIMPIS 2009b). This report is based on “port survey data” (NIMPIS 2009b) which the NPSD shows as being from the 2001 Port Adelaide survey. This species is recorded in the NPSD and appears in the appendix of recorded species in the report for this survey, but in the text it is explicitly stated that *Styela clava* did not occur in Adelaide (Cohen *et al.* 2002). There was no specimen of *S. clava* sent to SAM from this survey (T. Laperousaz, SAM, pers. comm.), with the only specimen of this species held by SAM being from PPB, and the NPSD data shows that identity of the “*S. clava*“ from the Port Adelaide survey is not confirmed. We could find no other records of this species in SA so it appears unlikely to occur.

3.3.53. *Styela plicata* (Lesueur, 1823)

Synonym(s): *Ascidia plicata*, *Tethyum plicata*

Category: introduced

Status: established

Summary: *Styela plicata* is widespread in SA.

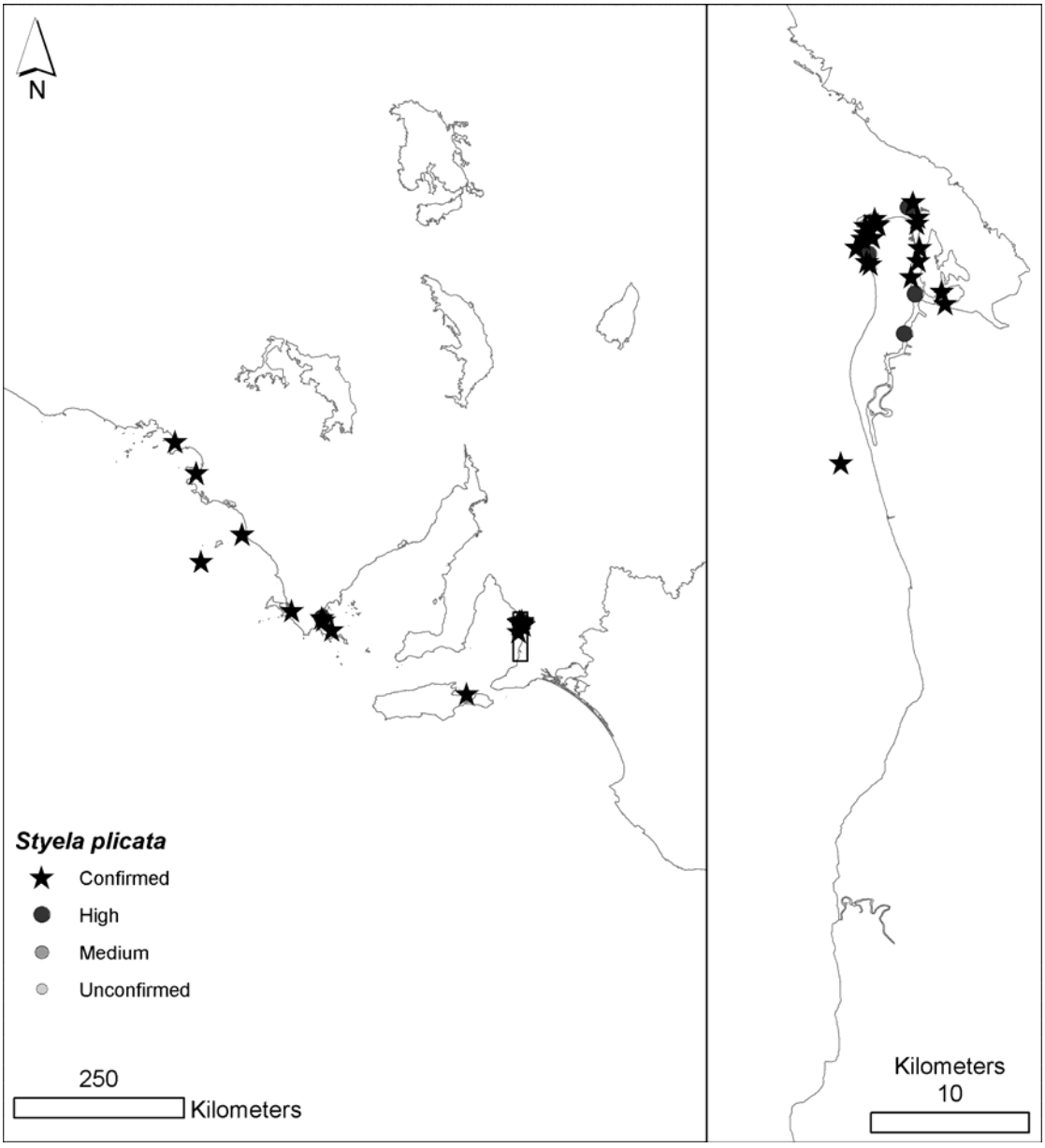

Figure 56. Map of records of *Styela plicata.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Styela plicata is known from the Mediterranean and Atlantic and is regarded as introduced to Australia based on the lack of records for this species in the Indo-west Pacific to the north of Australia (Kott 1985). It was reported as occurring around the southern coast of Australia, from Fremantle WA to Botany Bay NSW, by Kott (1952).

SAM holds numerous specimens from locations around the State, including Streaky Bay (see Kott 2006), Smoky Bay (2005), Coffin Bay (1970), Port Lincoln (multiple), Waldegrave Island (~7.5km NW of Elliston, 1970), Pearson Island (~65 km SW of Elliston, 1969), and Point Morrison, ~5.5 km N of American River, KI (1997), as well as from around Port Adelaide, St Kilda and North Haven. This species was found to be abundant during the 2001 Port Adelaide survey (Cohen *et al.* 2002) and also observed in samples from the 2007-8 survey (Rowling 2009b). A specimen in the SARDI reference collection was collected off Grange in 2010.

CHORDATA: Actinopterygii

3.3.54. *Arenigobius frenatus* (Günther, 1861) – Half-bridled goby

Synonym(s): *Acentrogobius frenatus*, *Gobius frenatus*

Category: cryptogenic

Status: present

Summary: *Arenigobius frenatus* has recently been found at Port Augusta.

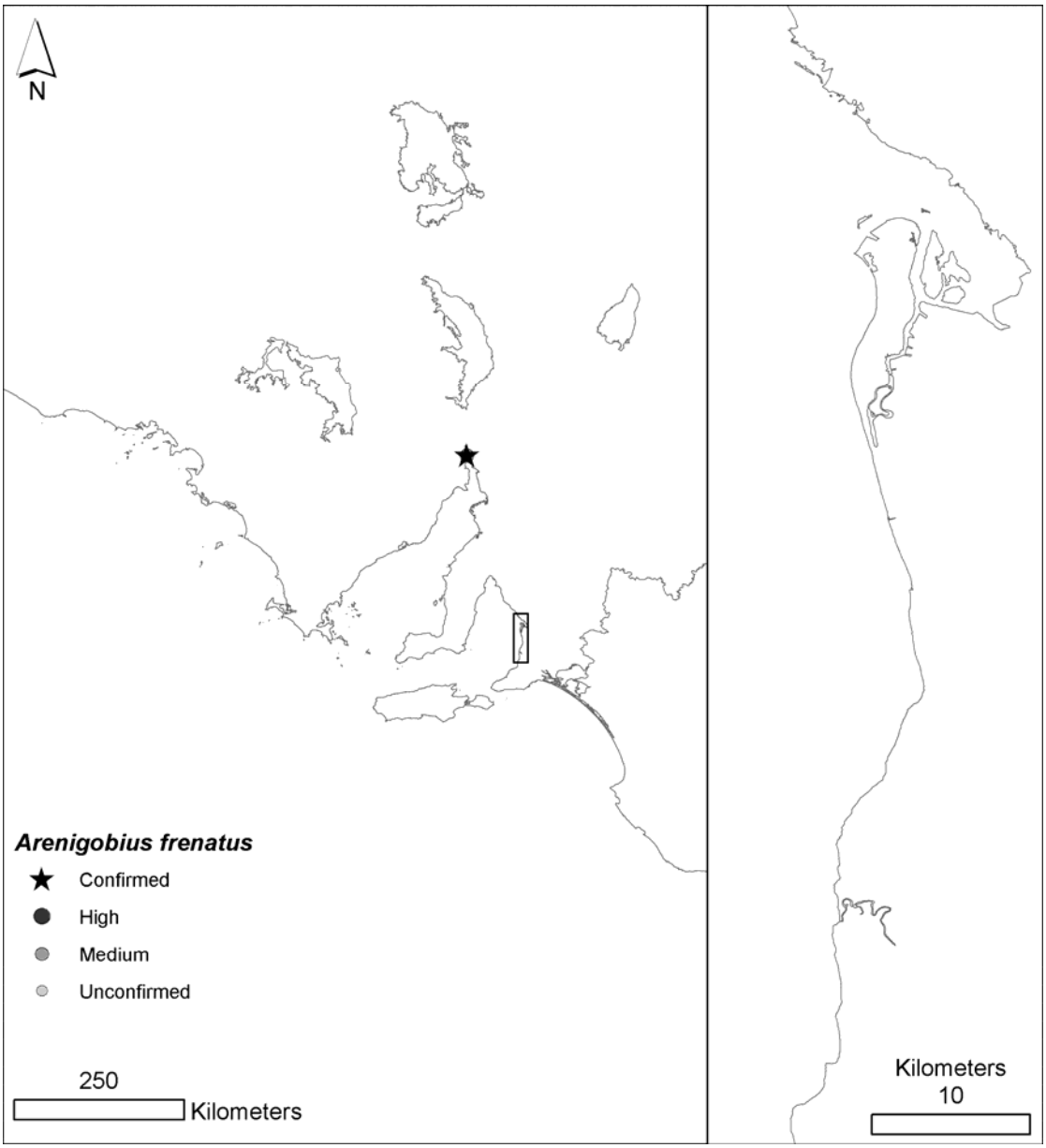

Figure 57. Map of records of *Arenigobius frenatus.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Arenigobius frenatus is known from the east coast of Australia from southern Queensland to central NSW (Kuiter 2000). In 2009 this species was found in Port

Augusta (T. Bertozzi, SAM, pers. comm.); specimens held by SAM confirm its occurrence in this location.

3.3.55. *Cristatogobius gobioides* (Ogilby, 1886) – Oyster goby

Synonym(s): *Cryptocentroides gobioides*, *Gobius cristatus*, *G. gobioides*

Category: cryptogenic

Status: present

Summary: *Cristatogobius gobioides* has recently been found in Angas Inlet.

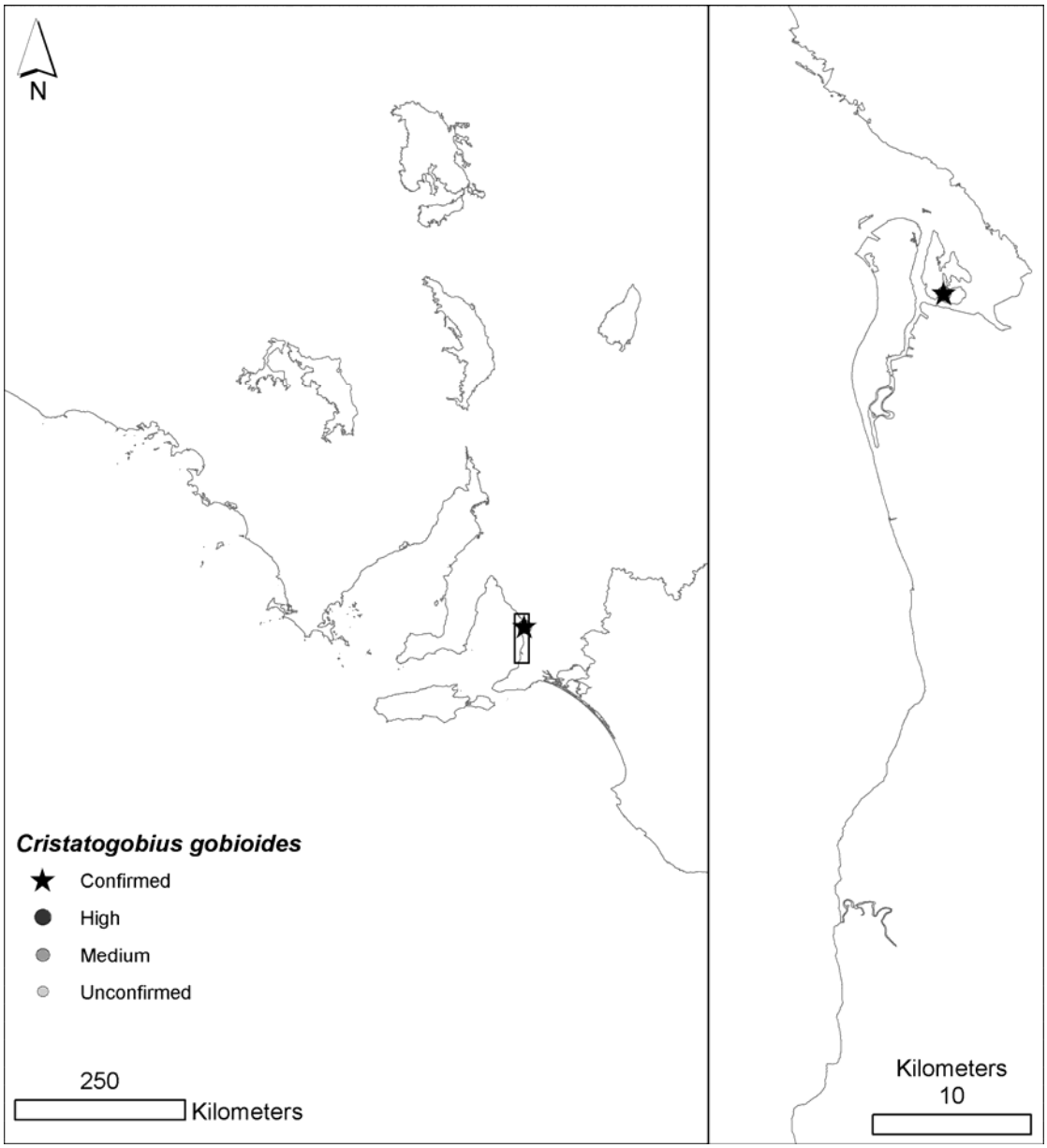

Figure 58. Map of records of *Cristatogobius gobioides.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Cristatogobius gobioides is known from the east coast of Australia from northern Queensland to Western Port, Victoria and north-eastern Tasmania (Kuiter 2000; Gomon *et al.* 2008). In 2009 this species was found in Angas Inlet (T. Bertozzi, SAM, pers. comm.); specimens held by SAM confirm this record.

3.3.56. *Tridentiger trigonocephalus* (Gill, 1859) – Trident goby

Category: introduced

Status: present

Summary: *Tridentiger trigonocephalus* has been found in West Lakes.

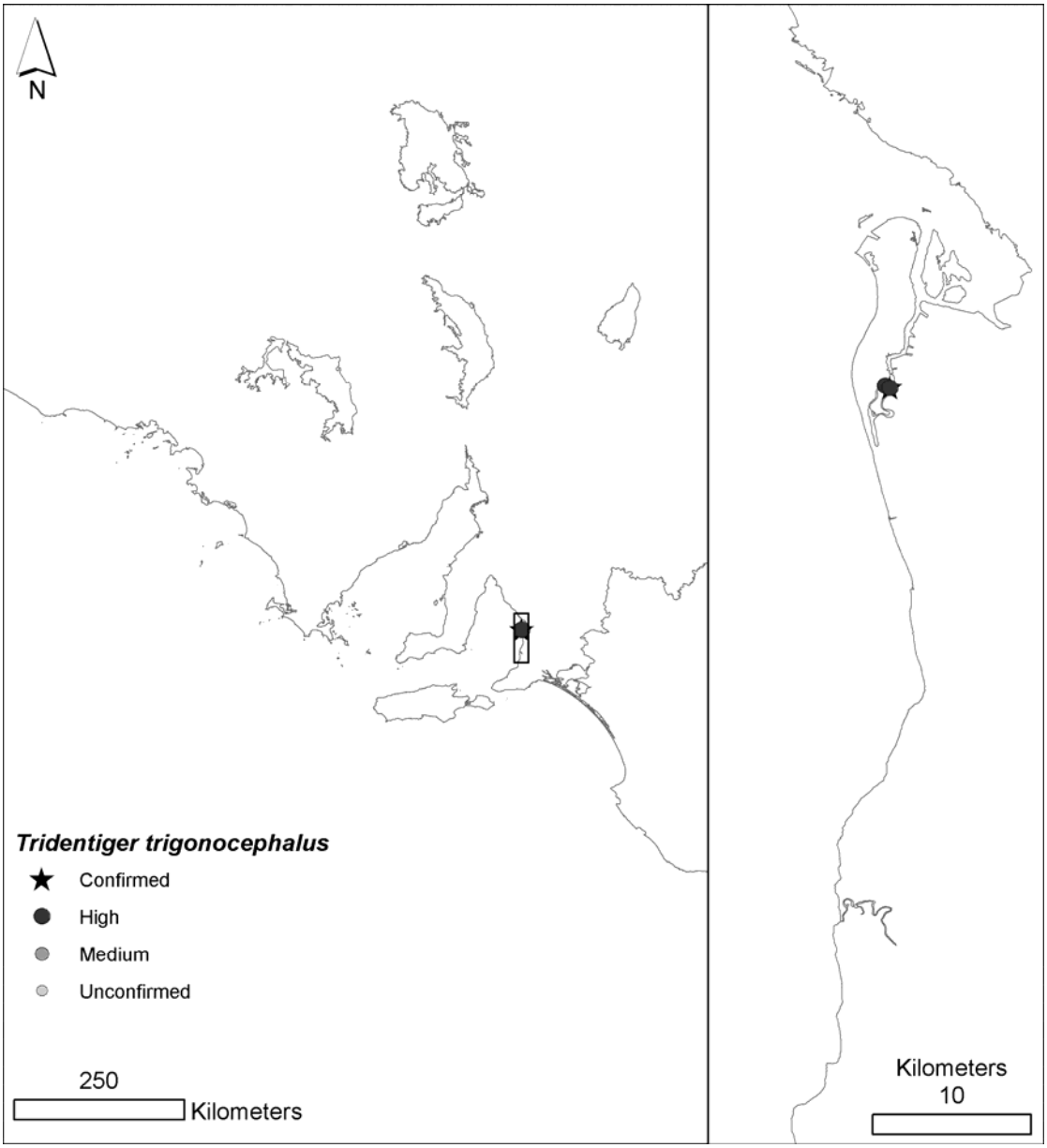

Figure 59. Map of records of *Tridentiger trigonocephalus.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Tridentiger trigonocephalus is native to the north-western Pacific region around Japan, Korea and China, and has been introduced to North America and Australia (Cohen *et al.* 2001; Gomon *et al.* 2008). In Australia, it occurred first in Sydney Harbour in 1973 (Pollard and Hutchings 1990a), and has subsequently established in several ports, including Sydney, Newcastle, and Port Kembla, NSW, PPB, Victoria, and Perth, WA (Cohen *et al.* 2001; Gomon *et al.* 2008).

In 2001 and 2004, *T. trigonocephalus* was collected in West Lakes during surveys targeting goby species (Hammer 2006; SAM specimens). Only one individual was found on each occasion, so it is unclear whether this species has established there. The population in PPB, Victoria, may not be self-sustaining but may rely on new introductions via shipping for recruitment (Cohen *et al.* 2001).

OCHROPHYTA: Raphidophyceae

3.3.57. *Chattonella globosa* Hara and Chihara, 1994

Category: cryptogenic

Status: established

Summary: *Chattonella globosa* occurs around Port Lincoln.

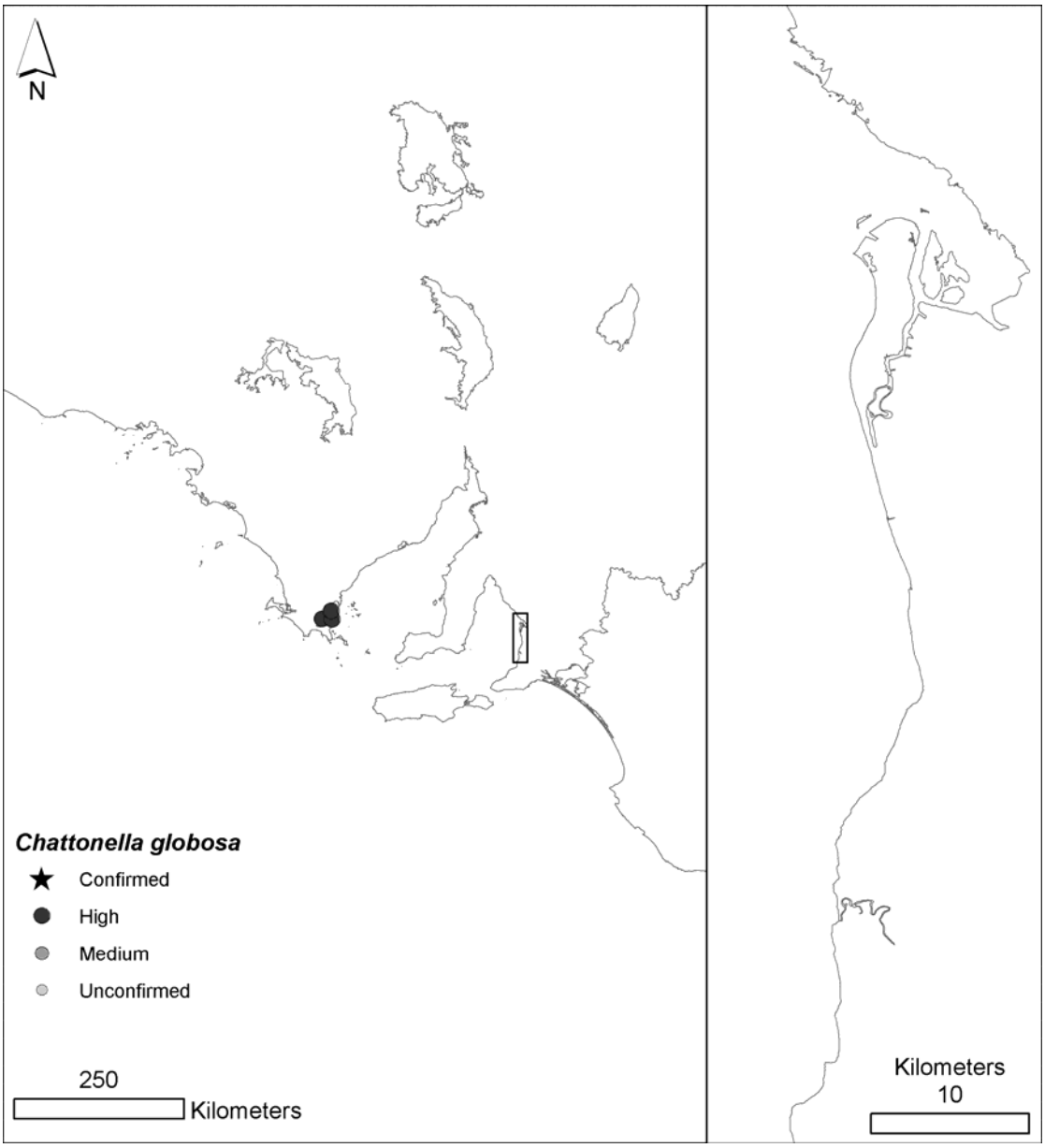

Figure 60. Map of records of *Chattonella globosa.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Chattonella globosa was originally described from Japan (Appeltans *et al.* 2009) but is also known from south-east Asia, Canada and the British Isles, as well as Australia (Hallegraeff 2002; Marshall 2003). In SA, this species was recorded around Port Lincoln in 1999 (Cartwright 1999; van Ruth *et al.* 2009) and has subsequently been recorded regularly during SASQAP monitoring of the region (SASQAP unpublished data; C. Wilkinson, SASQAP, pers. comm.).

3.3.58. *Chattonella marina* (Subrahmanyan) Hara and Chihara, 1982

Category: cryptogenic

Status: established

Summary: *Chattonella marina* occurs around Port Lincoln, Denial Bay, Smoky Bay and Port Broughton.

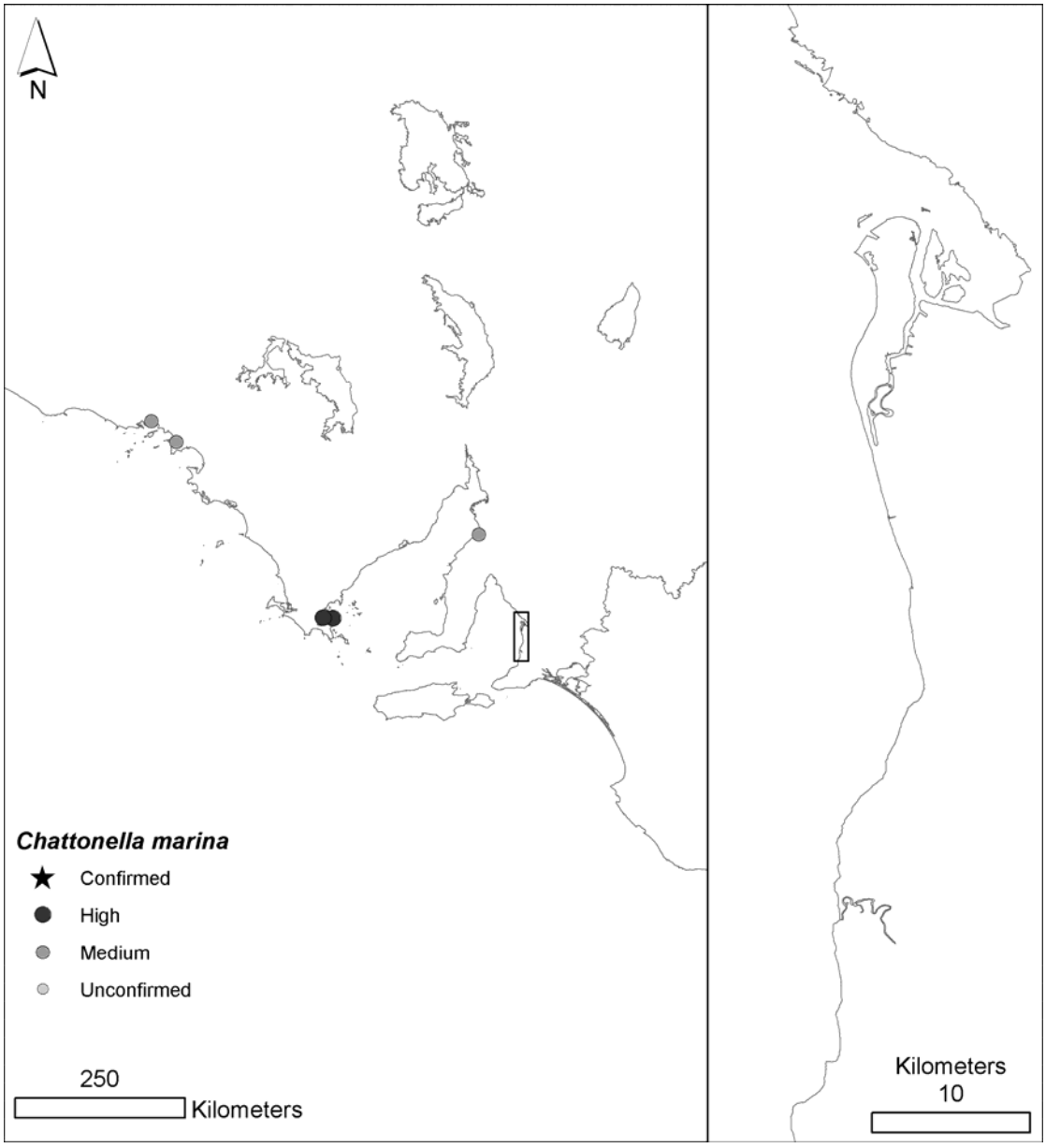

Figure 61. Map of records of *Chattonella marina.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Chattonella marina is widespread in temperate to tropical waters globally (Hallegraeff 2002; Marshall 2003; Guiry and Guiry 2009). In SA, this species was detected in 1996 when it was found in high concentrations following a fish kill near Port Lincoln (Munday and Hallegraeff 1998). It has subsequently been recorded during SASQAP

monitoring of this region (SASQAP unpublished data), and also from Denial Bay, Smoky Bay and Port Broughton (C. Wilkinson, SASQAP, pers. comm.).

3.3.59. *Heterosigma akashiwo* (Hada 1967) Hada ex Hara and Chihara, 1987

Synonym(s) (*reported as): *Enterosigma akashiwo*, *Heterosigma carterae**, *Olisthodiscus carterae*

Category: cryptogenic

Status: established

Summary: *Heterosigma akashiwo* occurs in West Lakes, around Port Lincoln, and Kingscote to American River, KI.

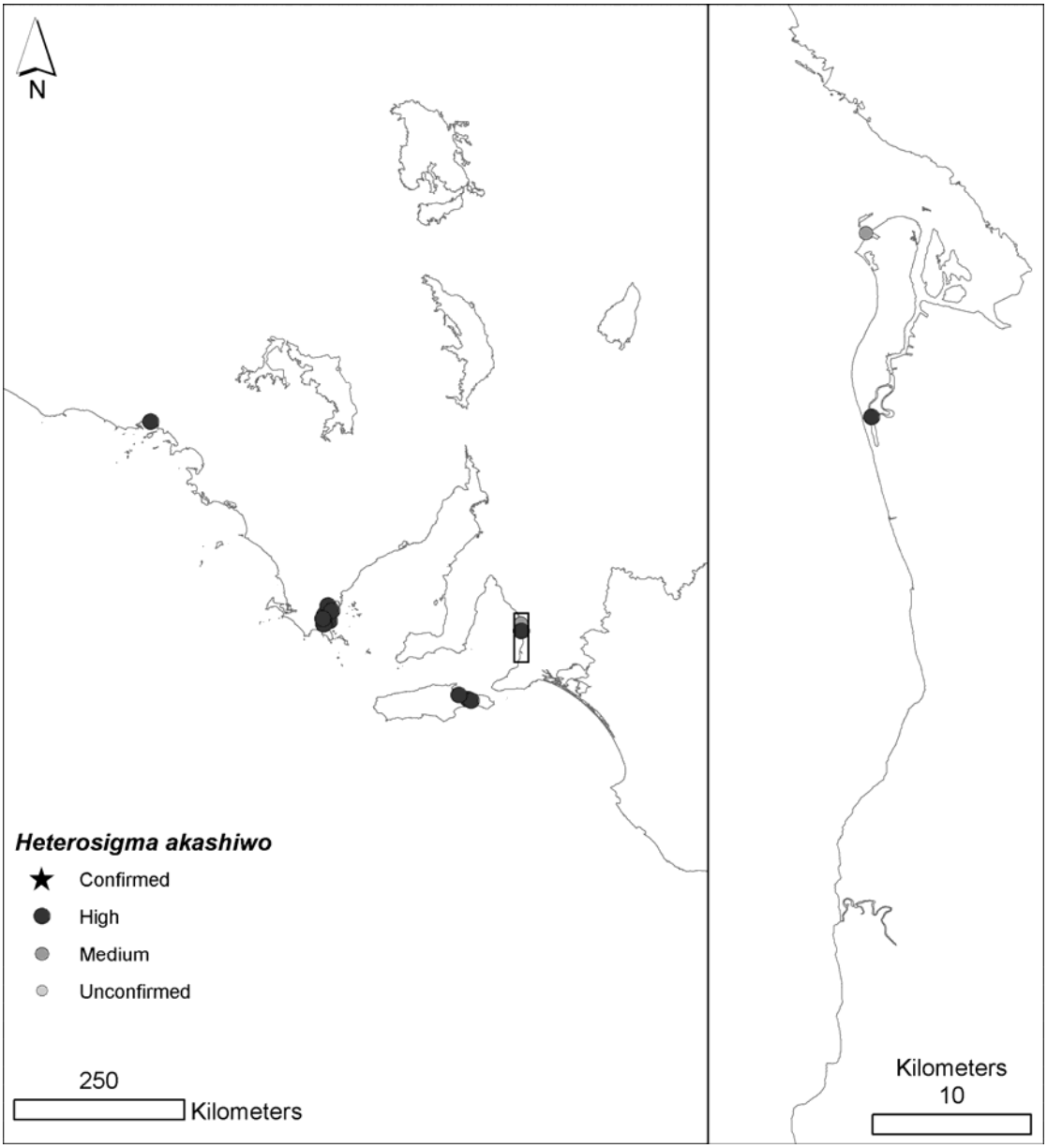

Figure 62. Map of records of *Heterosigma akashiwo.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Heterosigma akashiwo has a wide global distribution (Marshall 2003). In SA it has been known from West Lakes since 1983 (Vesk and Moestrup 1987). It was recorded in Port Lincoln in 1996 (Munday and Hallegraeff 1998) and has also been found there and on KI (between Kingscote and American River) by SASQAP sampling (SASQAP unpublished data; C. Wilkinson, SASQAP, pers. comm.).

OCHROPHYTA: Phaeophyceae

3.3.60. *Arthrocladia villosa* (Hudson) Duby 1832

Synonym(s): *Conferva villosa*, *Chordaria villosa*, *Sporochnus villosus*

Category: introduced

Status: isolated occurrence

Summary: Unattached *Arthrocladia villosa* was found at Port Stanvac.

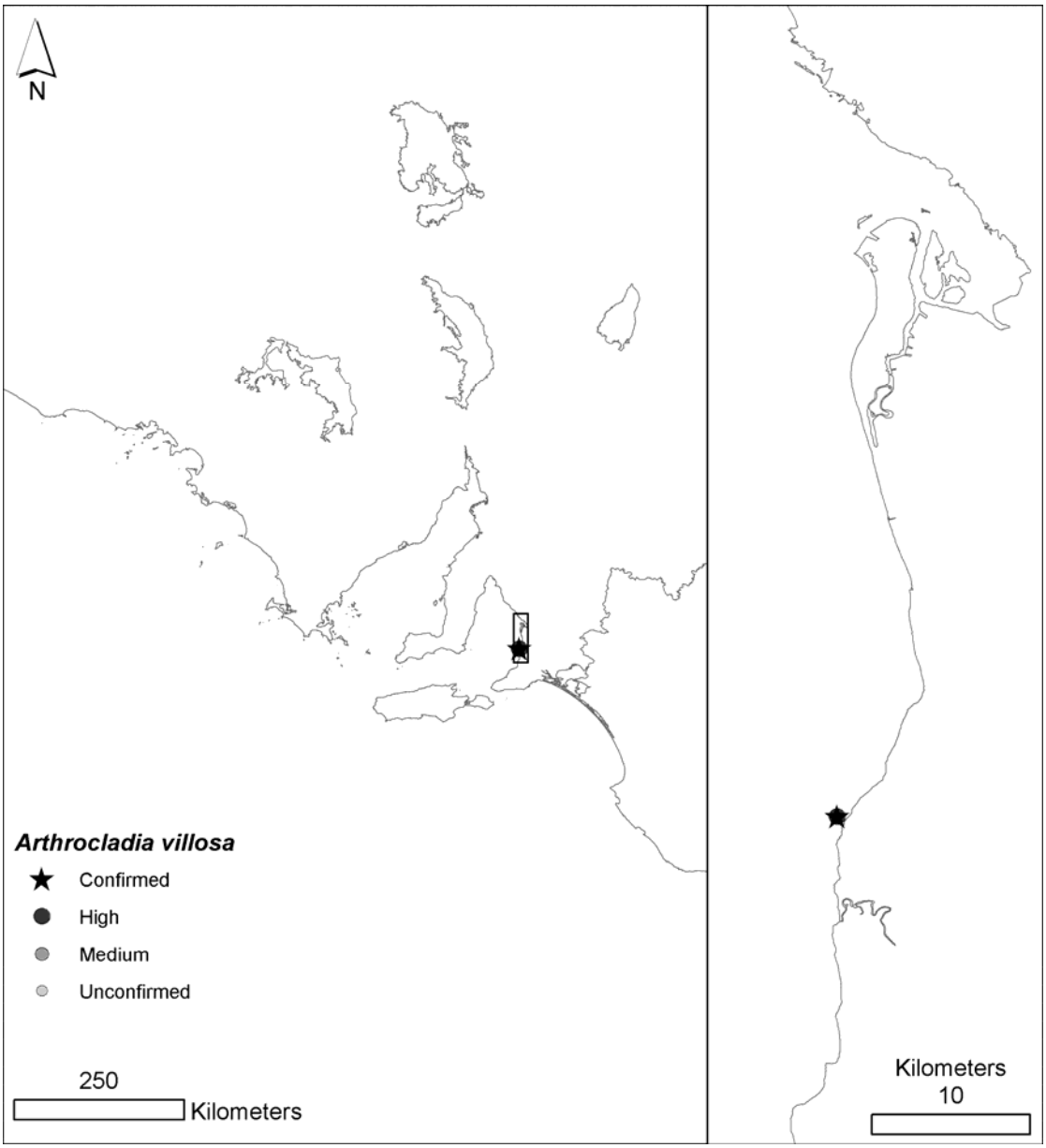

Figure 63. Map of records of *Arthrocladia villosa.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Arthrocladia villosa is known from the temperate north Atlantic and the Mediterranean (Skinner and Womersley 1983; Womersley 1987). In 1981 unattached plants were found near Port Stanvac (~4.5km N of Port Noarlunga), the dock for ships servicing the then active oil refinery; this represents the only record of algae in the Desmarestiales from southern Australia and suggests an introduction by shipping (Skinner and Womersley 1983; SHSA specimen). It does not appear that *A. villosa* established (Womersley 2003) and there are no subsequent records of this species.

3.3.61. *Discosporangium mesarthrocarpum* (Meneghini) Hauck 1885

Synonym(s): *Callithamnion mesarthrocarpum*, *Discosporangium subtile*

Category: introduced

Status: uncertain

Summary: *Discosporangium mesarthrocarpum* is recorded from Grange and Glenelg.

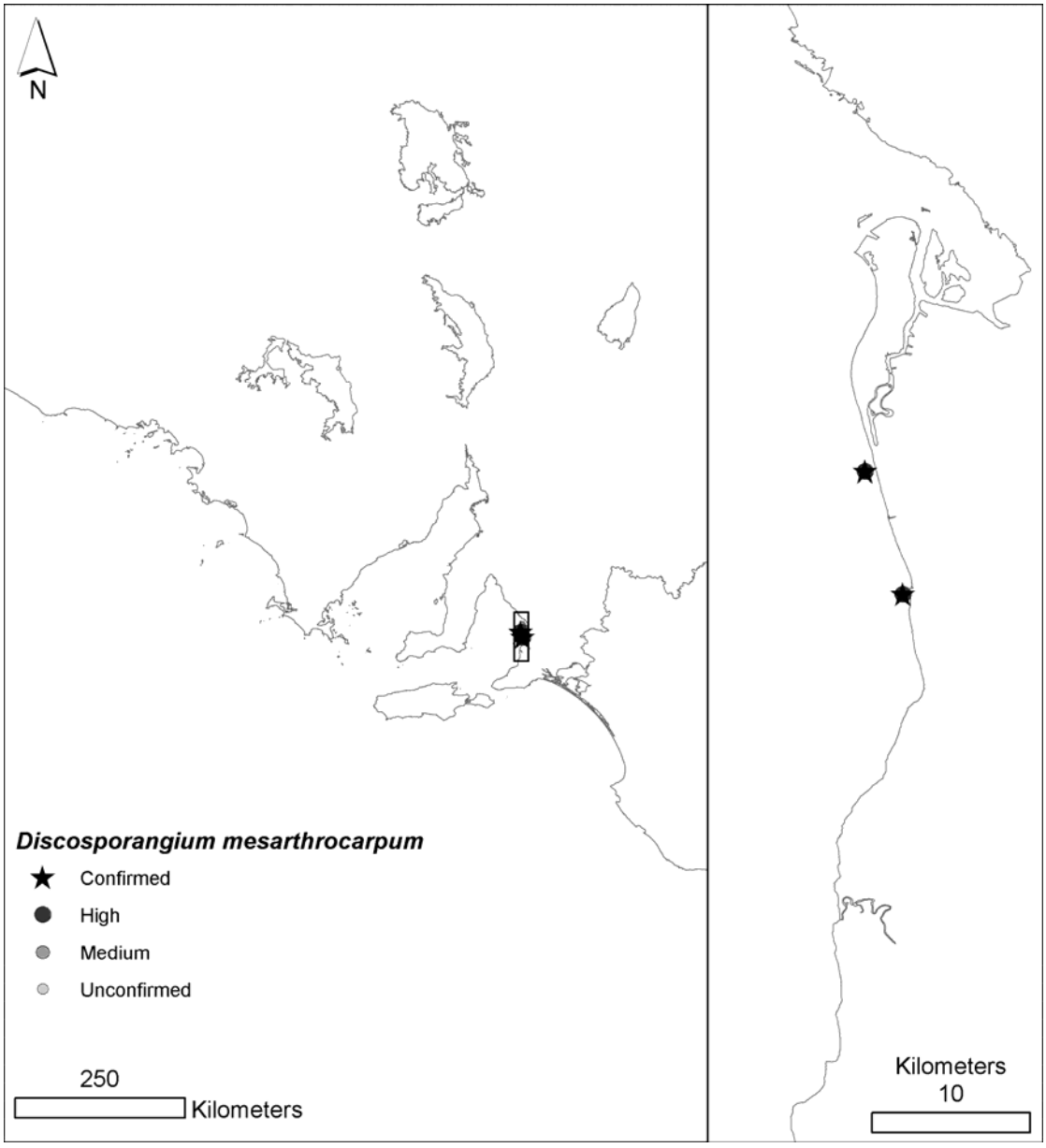

Figure 64. Map of records of *Discosporangium mesarthrocarpum.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Discosporangium mesarthrocarpum is known from the Adriatic and Mediterranean. Between 1985 and 1987 this species was collected from the artificial tyre reefs located off Grange and Glenelg, where it was epiphytic on other algae (Womersley 1987; SHSA specimens), but it has not been recorded subsequently. This species

was included on the 1998-99 lists of introduced species in SA (EPA and DEHAA 1998; Lewis *et al.* 1998; Edyvane 1999), but its current status is uncertain.

3.3.62. *Sphacella subtilissima* Reinke, 1890

Synonym(s): misspelt as *Spacella subtilissima* in some reports

Category: cryptogenic

Status: uncertain

Summary: *Sphacella subtilissima* has been found in Investigator Strait and at Pearson Island.

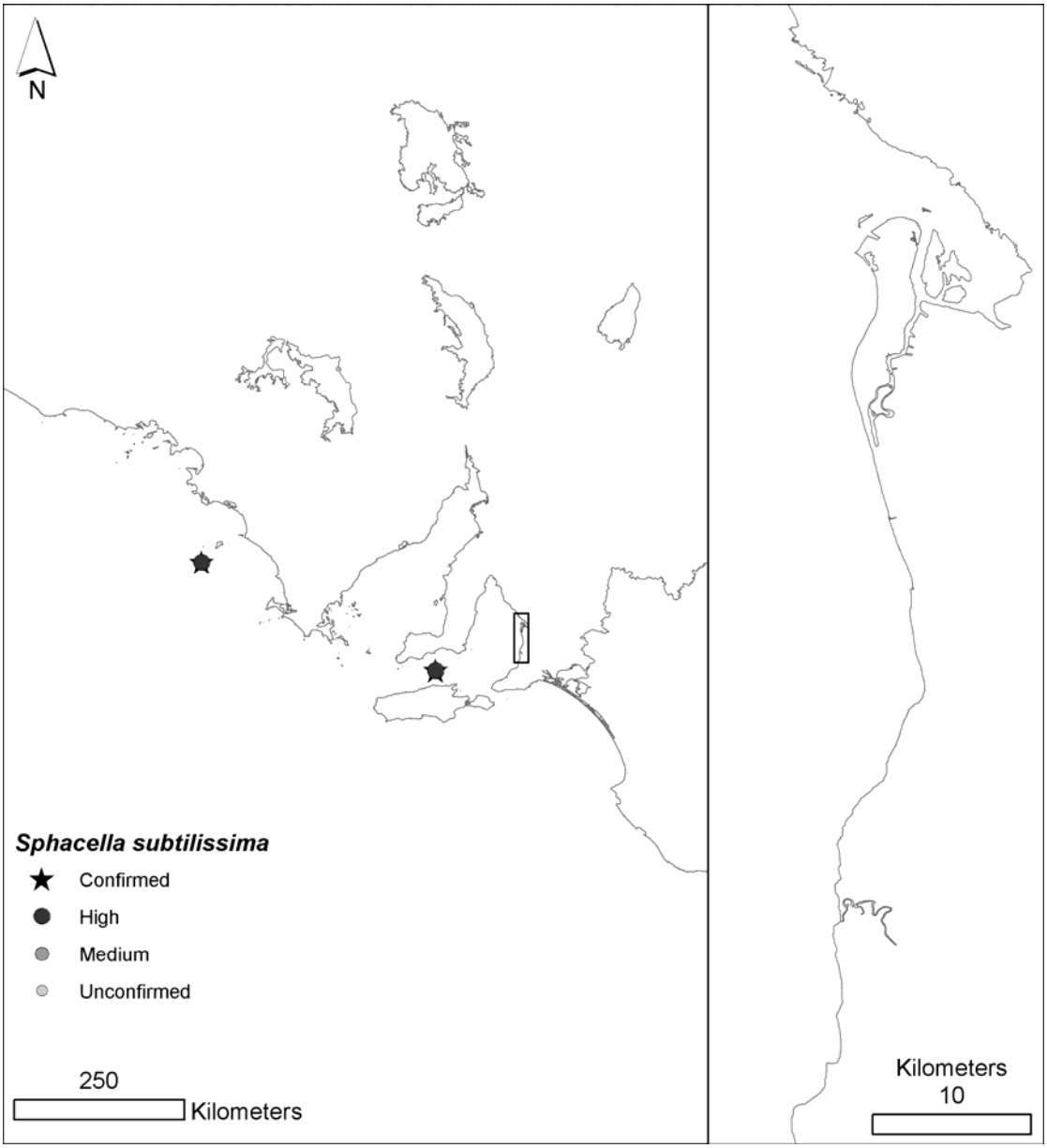

Figure 65. Map of records of *Sphacella subtilissima.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Sphacella subtilissima was known only from the western Mediterranean prior to the collection of specimens from Pearson Island (~65 km SW of Elliston) and Investigator Strait (between Yorke Peninsula and KI) in 1969 and 1971 (Womersley 1987; SHSA specimens). *Sphacella subtilissima* was included on lists of introduced species in SA (EPA and DEHAA 1998; Lewis *et al.* 1998; Edyvane 1999), in some cases spelt as *Spacella subtilissima.* The deep-water collecting localities are far from ports, leading to some question about whether this species is introduced; it may be an endemic species that is similar to the Mediterranean species or its distribution may be more cosmopolitan than described (R. Baldock, SHSA, pers. comm.). *Sphacella subtilissima* has not been recorded subsequently, so its current status is uncertain.

3.3.63. *Hincksia sandriana* (Zanardini) P.C. Silva in Silva, Meñez & Moe 1987

Synonym(s) (*reported as): *Ectocarpus sandrianus*, *E. elegans*, *E. granulosoides*, *E. parksii*, *Giffordia sandriana**, *G. granulosoides*, *G. elegans*

Category: cryptogenic

Status: established

Summary: *Hincksia sandriana* has been found at St Kilda, Robe and American River.

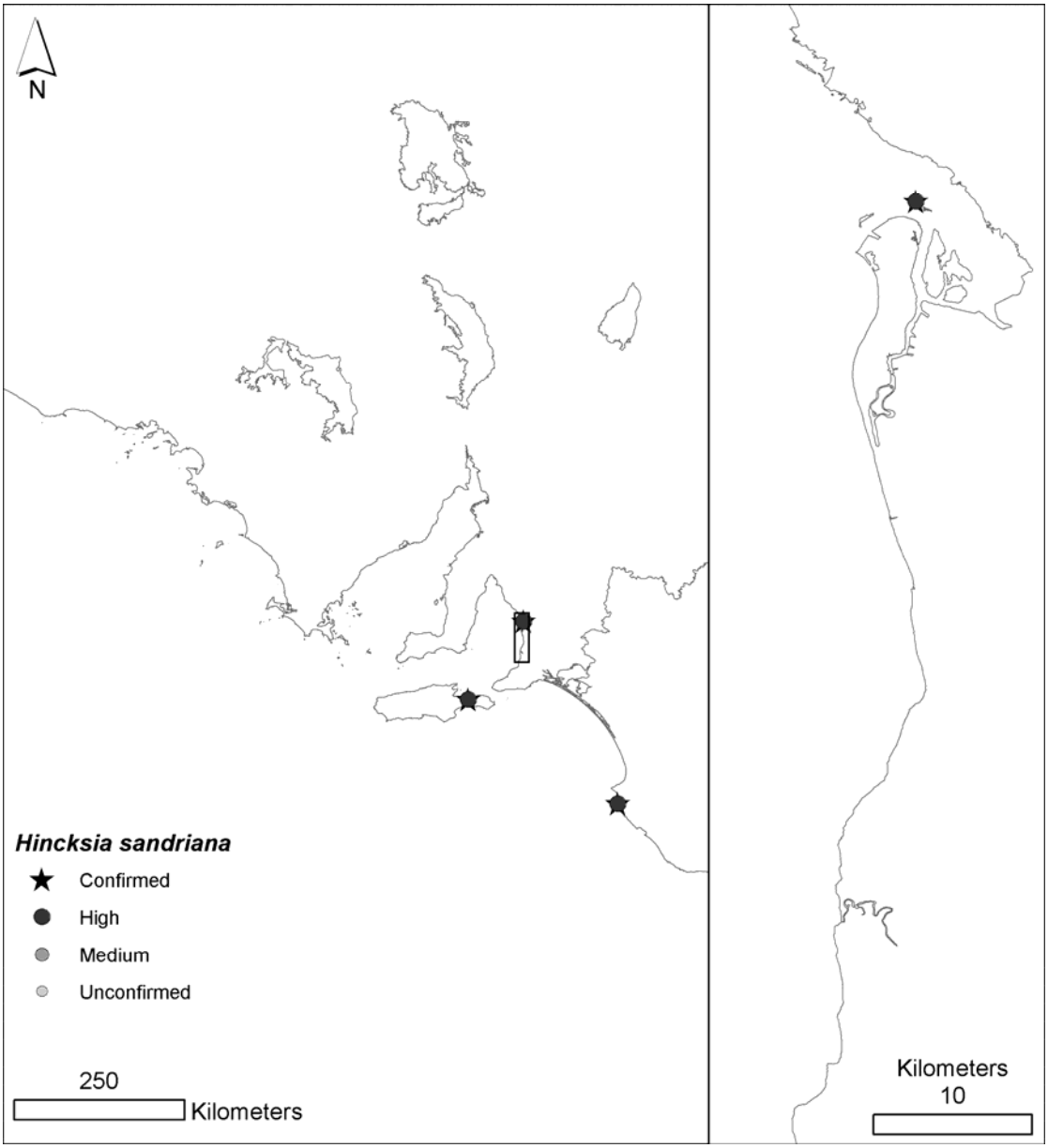

Figure 66. Map of records of *Hincksia sandriana.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Hincksia sandriana occurs globally in temperate seas (Womersley 1987). It was not considered as a possible introduction by Womersley (1987, 2003), but is regarded as cryptogenic by other sources (e.g. Aquenal Pty Ltd 2002). In SA this species has been recorded (as *Giffordia sandriana*) from St Kilda, American River, and Robe (Womersley 1987; SHSA specimens collected 1963-1975). Although not a common species, it is distributed from SA to NSW (Womersley 1987). We class it as established based on the wide range of collection dates and localities, despite the lack of more recent records in SA.

3.3.64. *Elachista orbicularis* (Ohta) Skinner, 1983

Synonym(s): *Gonodia orbicularis*

Category: introduced

Status: established

Summary: *Elachista orbicularis* has been recorded from Victor Harbor and Port Noarlunga.

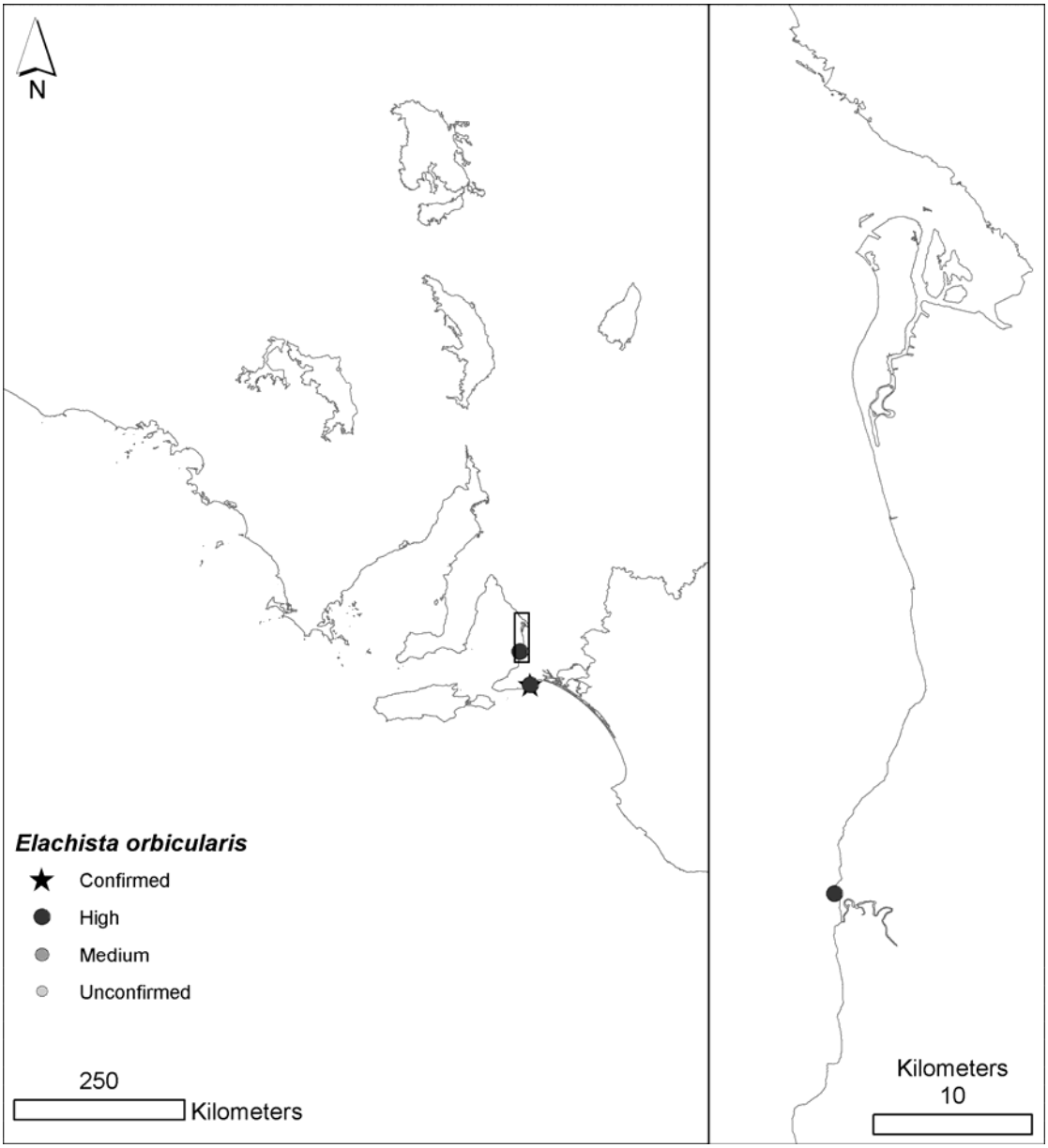

Figure 67. Map of records of *Elachista orbicularis.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Elachista orbicularis is considered native to Japan; in southern Australia it has been found from Rottnest Island, WA to Victor Harbor, SA, and from NSW (Womersley 1987). In SA it is recorded from Port Noarlunga and Victor Harbor (Womersley 1987; SHSA specimens collected 1976-79). Further specimens collected from an unspecified location in the Adelaide region in 1991 are held by WAH, NHNSW, and TH, so we class it as established.

3.3.65. *Stictyosiphon soriferus* (Reinke) Rosenvinge, 1935

Synonym(s): *Kjellmania sorifera*, *K. striarioides*, *K. arasakii*

Category: introduced

Status: uncertain

Summary: *Stictyosiphon soriferus* has been found at Port Lincoln.

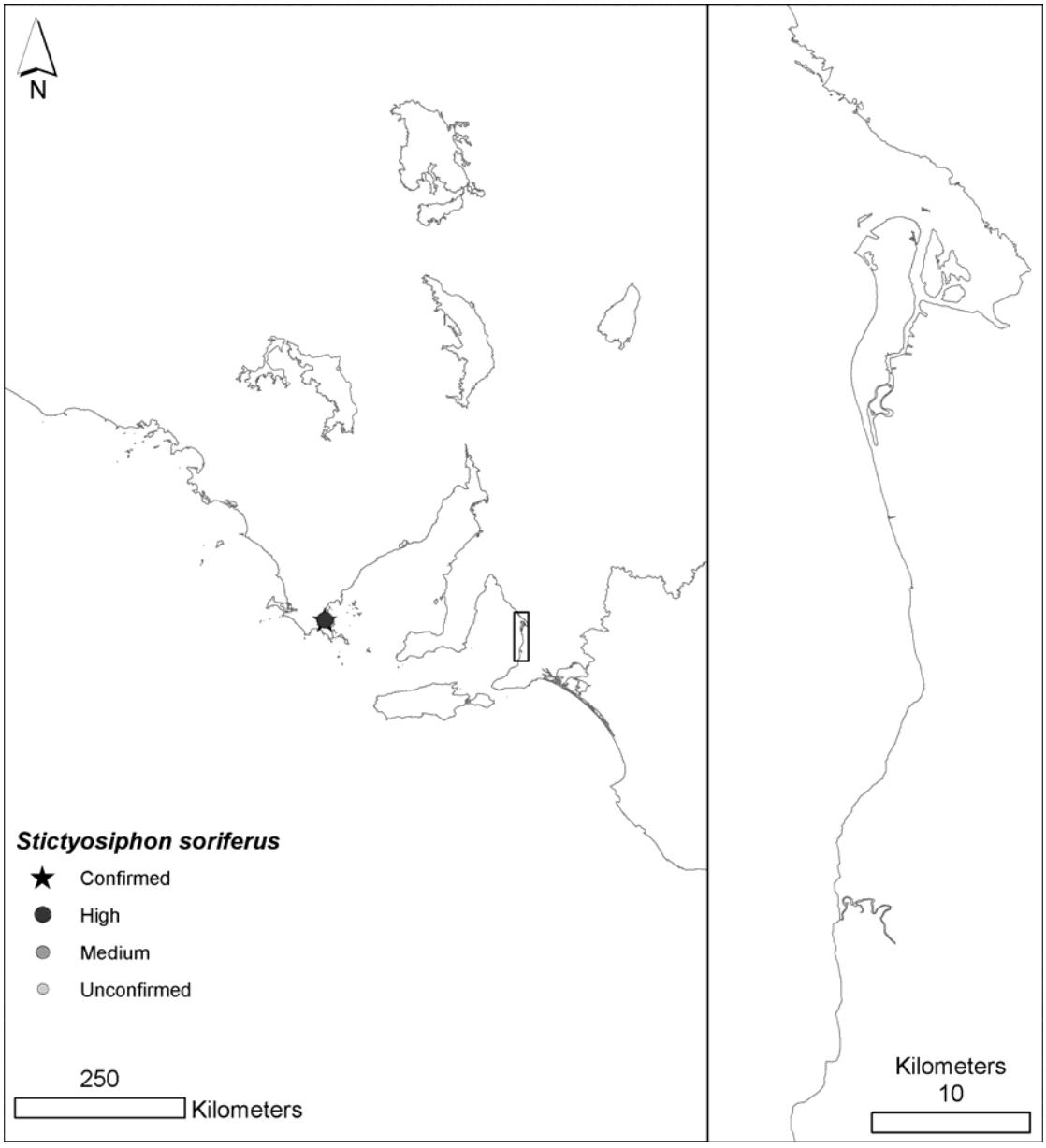

Figure 68. Map of records of *Stictyosiphon soriferus.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Stictyosiphon soriferus is considered native to the north Atlantic and Mediterranean (Skinner and Womersley 1983; Womersley 1987). It has been found in southern Australia from Albany, WA to PPB, Victoria, and in SA was found at Port Lincoln in

1975 (Skinner and Womersley 1983; Womersley 1987; SHSA specimen). There are no more recent records from SA, so we class its status as uncertain.

3.3.66. *Striaria attenuata* (Greville) Greville 1828

Synonym(s): *Striaria fragilis*, *S. crinita*, *Solenia crinita*, *Carmichaelia attenuata*

Category: cryptogenic

Status: uncertain

Summary: *Striaria attenuata* has been found at West Lakes and Cowell.

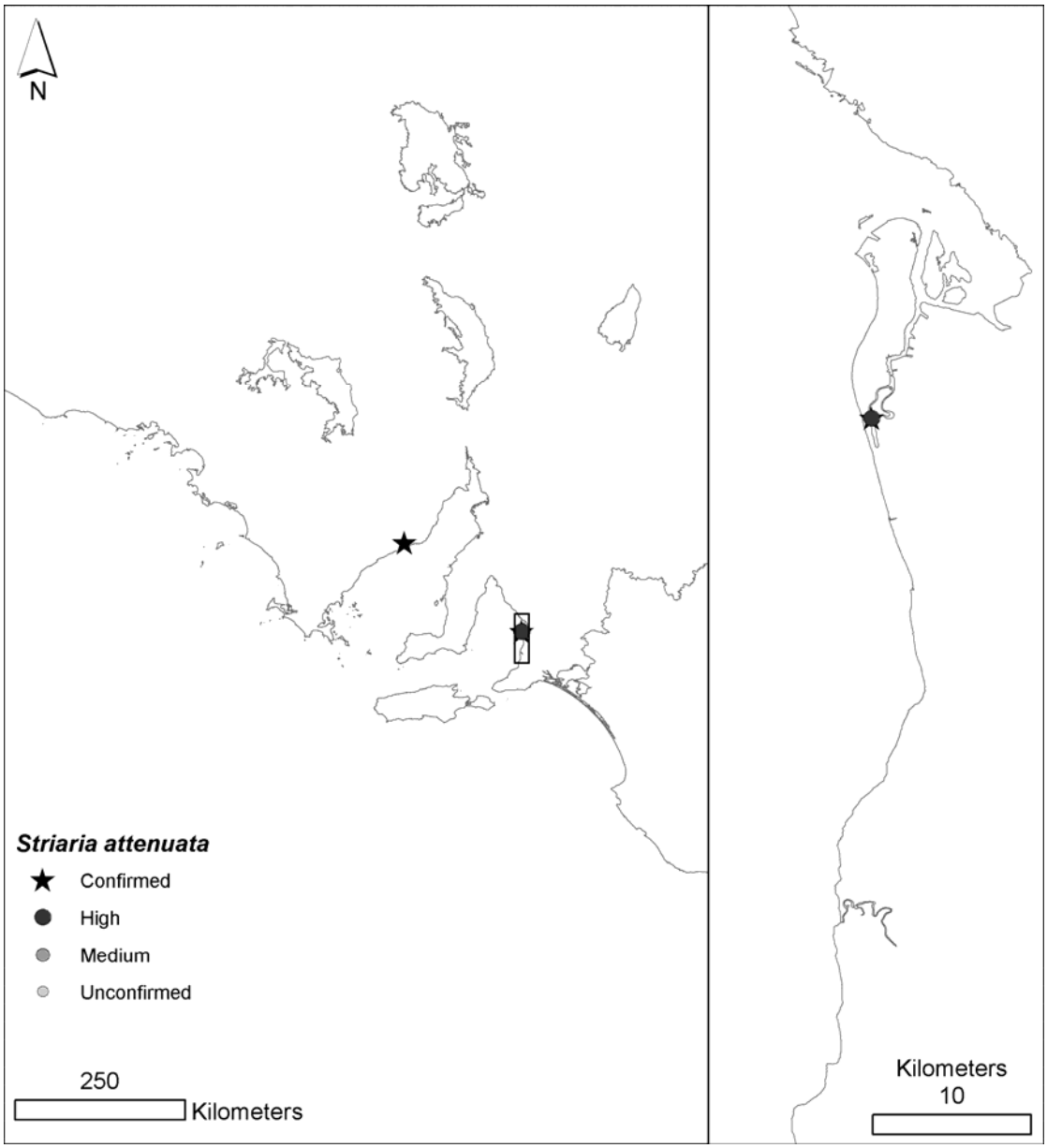

Figure 69. Map of records of *Striaria attenuata.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Striaria attenuata is known from the Mediterranean, north Atlantic (including Europe and North America), Japan and New Zealand (Skinner and Womersley 1983; Womersley 1987). In SA it was found in West Lakes in 1978 (Skinner and Womersley 1983; Womersley 1987). Womersley (1987) noted that this species may not have established in southern Australia, but it has subsequently been found in Cowell (SHSA specimen collected 1993) suggesting it may still be present. We class its status as uncertain, however, due to the paucity of records, and as cryptogenic due to its uncertain native range.

3.3.67. *Zosterocarpus* sp.

Category: native

Status: uncertain

Summary: Reports of *Zosterocarpus* sp. as an introduced species possibly refer to *Zosterocarpus australica* Womersley, 1987.

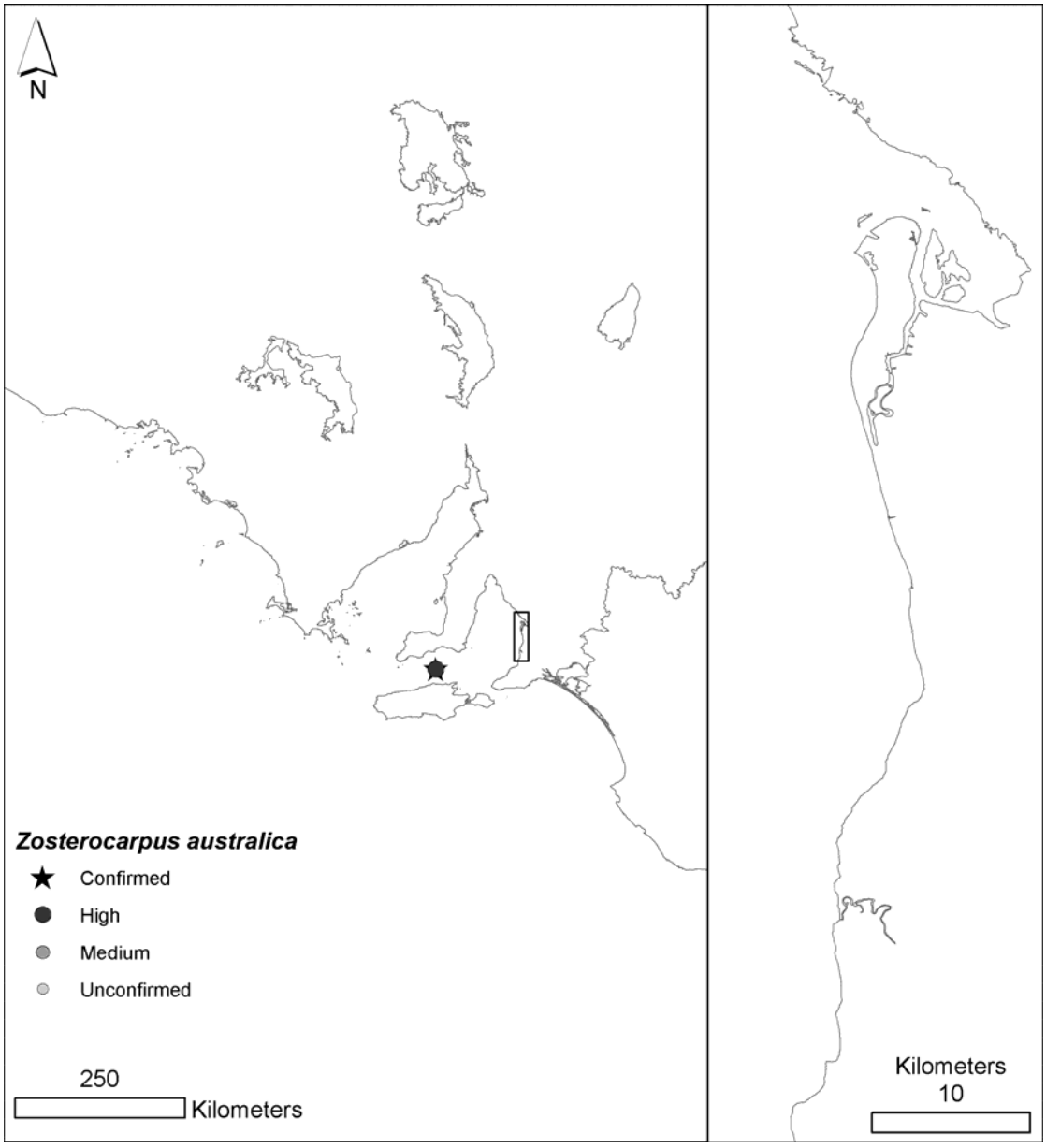

Figure 70. Map of records of *Zosterocarpus australica.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Lists of introduced species in SA (EPA and DEHAA 1998; Lewis *et al.* 1998; Edyvane 1999) include *Zosterocarpus* sp., referred to as "seagrass", although *Zosterocarpus* is a genus of ectocarpic alga (see Table 1 for taxonomy). *Zosterocarpus* sp. is included in the schedule of known introduced species used by the CRIMP and other

port surveys (Hewitt and Martin 1996; Aquenal Pty Ltd 2002; Pollard and Pethebridge 2002a, b); these also show it as occurring in SA and state the source for the introduction as the Mediterranean. Only three species of *Zosterocarpus* have been described (Guiry and Guiry 2009); one of these, the type species *Z. oedogonium* (Meneghini) Bornet, 1890, is from the Mediterranean (Womersley 1987; Guiry and Guiry 2009), but there are no records of this species from SA. Womersley (1987) described a new species, *Z. australica*, from material collected in Investigator Strait, between Yorke Peninsula and KI, at 35-41 m depth in 1971 (SHSA specimens); he noted similarities between *Z. australica* and *Z. oedogonium*. It is possible that reports of an "introduced" *Zosterocarpus* sp. in SA were based on the assumption that the SA material from Investigator strait was the Mediterranean species, despite the collection locality appearing to be an unlikely one for a human-mediated introduction, and the description of the species being published prior to the lists of introduced species. The current status of this species is uncertain; Womersley (1987) notes that it is an apparently rare, deep-water species, and there are no further records of its occurrence.

OCHROPHYTA: Xanthophyceae

3.3.68. *Vaucheria piloboloides* Thuret 1854

Synonym(s): *Vaucheria fuscescens*

Category: cryptogenic

Status: uncertain

Summary: *Vaucheria piloboloides* was found at O'Sullivan Beach.

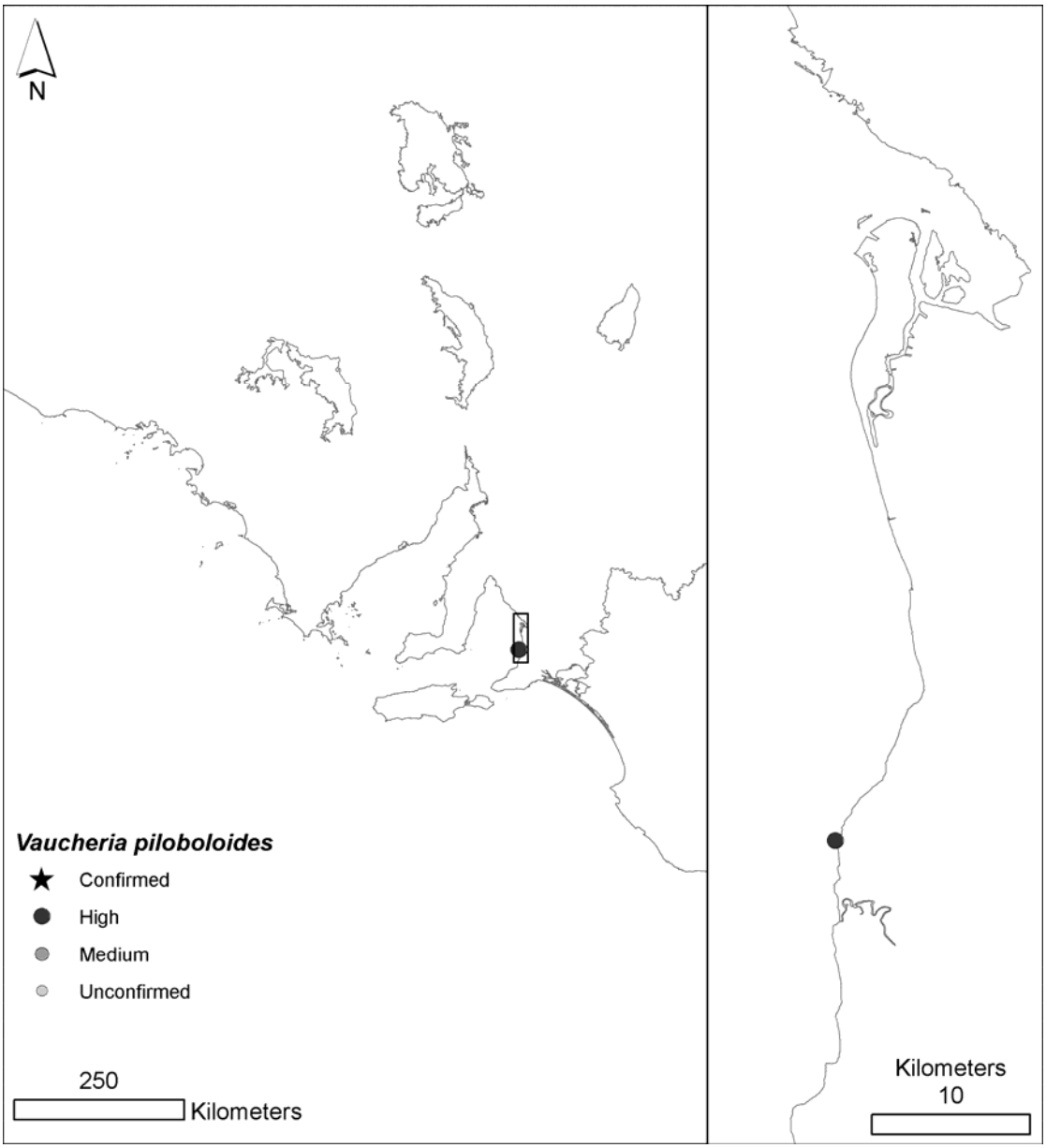

Figure 71. Map of records of *Vaucheria piloboloides.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Vaucheria piloboloides occurs widely in temperate seas, but the only record of the species in southern Australia is a specimen collected from O'Sullivan Beach (~3.5 km

N of Port Noarlunga) in 1986 (Womersley 1987; SHSA specimen). Although Womersley (1987) considers *V. piloboloides* a possible introduction, it is not included in the later published list of possible introduced species (Womersley 2003). There are no further records of this species in Australia.

CHLOROPHYTA: Bryopsidophyceae

3.3.69. *Bryopsis plumosa* (Hudson) C. Agardh 1846

Synonym(s): *Bryopsis plumosa* var. *nuda*, *Ulva plumosa*

Category: cryptogenic

Status: established

Summary: *Bryopsis plumosa* is widespread in SA.

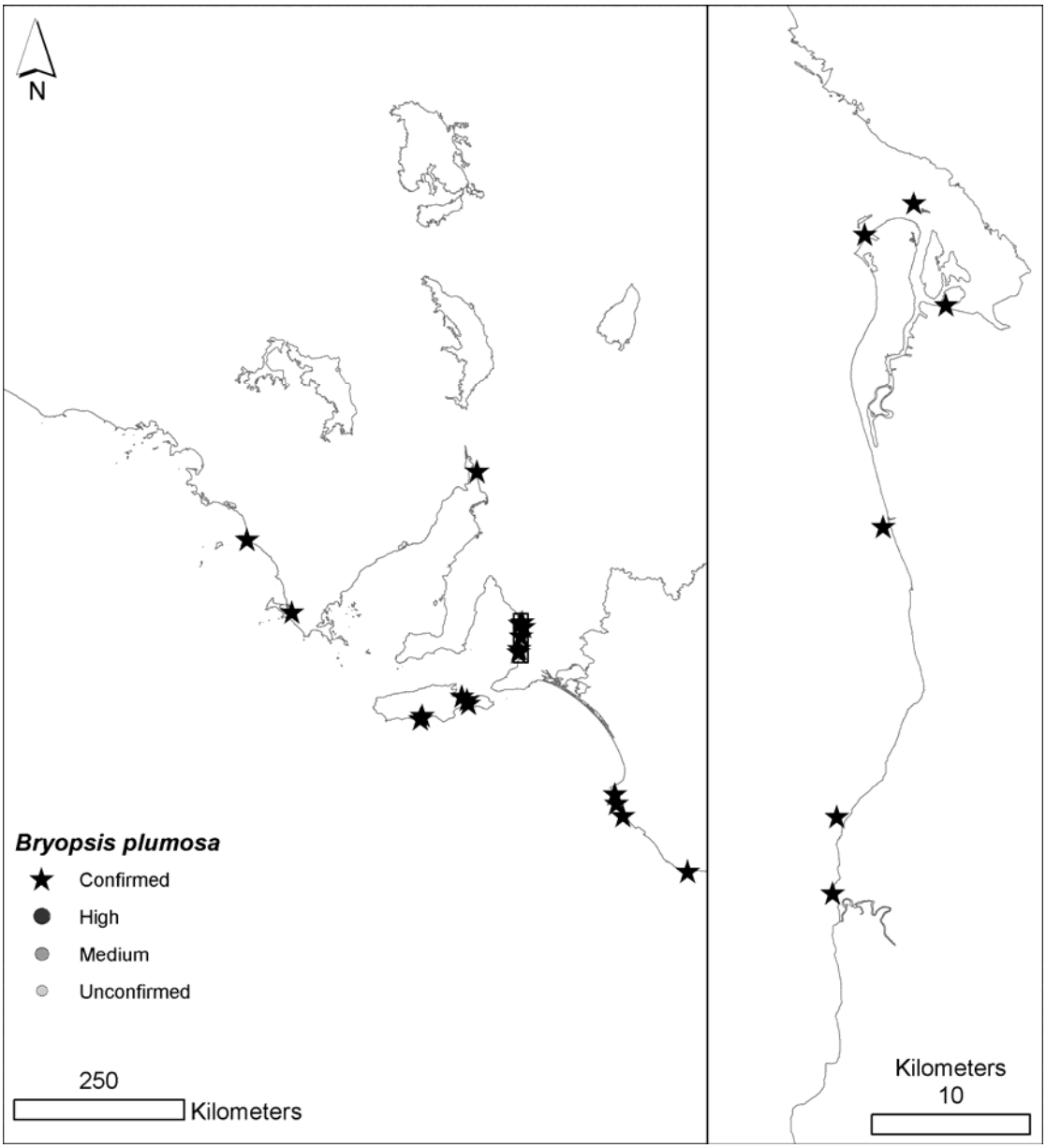

Figure 72. Map of records of *Bryopsis plumosa.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Bryopsis plumosa is a widespread and morphologically variable species (Womersley 1984). Although similarities have been noted between the southern Australian and European material of this species (Womersley 1984), it was not considered as a possibly introduced species by Womersley (2003) but it is regarded as cryptogenic by other sources (e.g. Aquenal Pty Ltd 2002). Specimens of *B. plumosa* held by SHSA have been collected from a wide range of localities over many years (1945-2004). Collection localities include Elliston and Coffin Bay on Eyre Peninsula, Yatala Harbour ~27 km SSE of Port Augusta, locations around KI, the south-east between Kingston SE and Port MacDonnell, around Port Adelaide and along the Adelaide metropolitan coast (Figure 72). This species is widespread and well established, but its status as a possible introduction is unclear. The highly variable forms displayed by *B. plumosa* may indicate that it is actually a complex of species, but molecular investigation may be required to clarify this (R. Baldock, SHSA, pers. comm.).

CHLOROPHYTA: Ulvophyceae

3.3.70. *Anadyomene stellata* (Wulfen) C. Agardh, 1913

Synonym(s): *Ulva stellata*, *Anadyomene flabellata*, *A. cutleriae*, *A. brownii*

Category: cryptogenic

Status: established

Summary: *Anadyomene stellata* occurs at Cape Lannes.

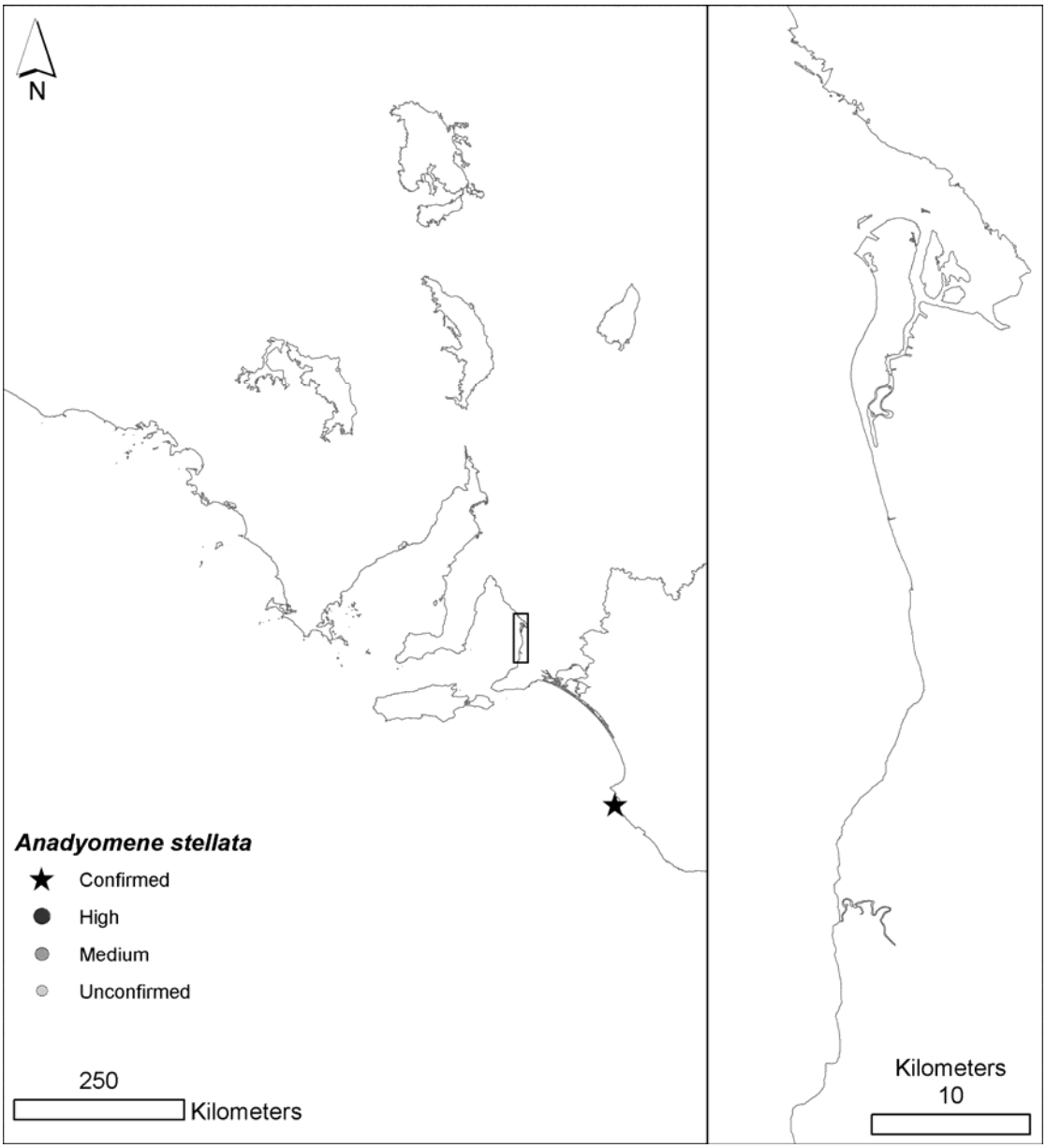

Figure 73. Map of records of *Anadyomene stellata.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Anadyomene stellata is widely distributed in the Mediterranean, the Americas and the Indo-Pacific, but it is recorded from only a single locality in southern Australia: Cape Lannes ~4 km S of Robe (Womersley 1984). Specimens held by the SHSA have been collected from this location on several occasions between 1977 and 1987, so we class it as established despite the lack of more recent records.

3.3.71. *Cladophora prolifera* (Roth) Kützing 1963

Synonym(s): *Cladophora multifida*, *C. scoparia*, *C. rugulosa*, *Chloronitum proliferum*, *Chantransia prolifera*, *Conferva prolifera*, *Conferva scoparia*, *Apjohnia rugulosa*

Category: cryptogenic

Status: established

Summary: *Cladophora prolifera* occurs around Adelaide, on KI and at Victor Harbor.

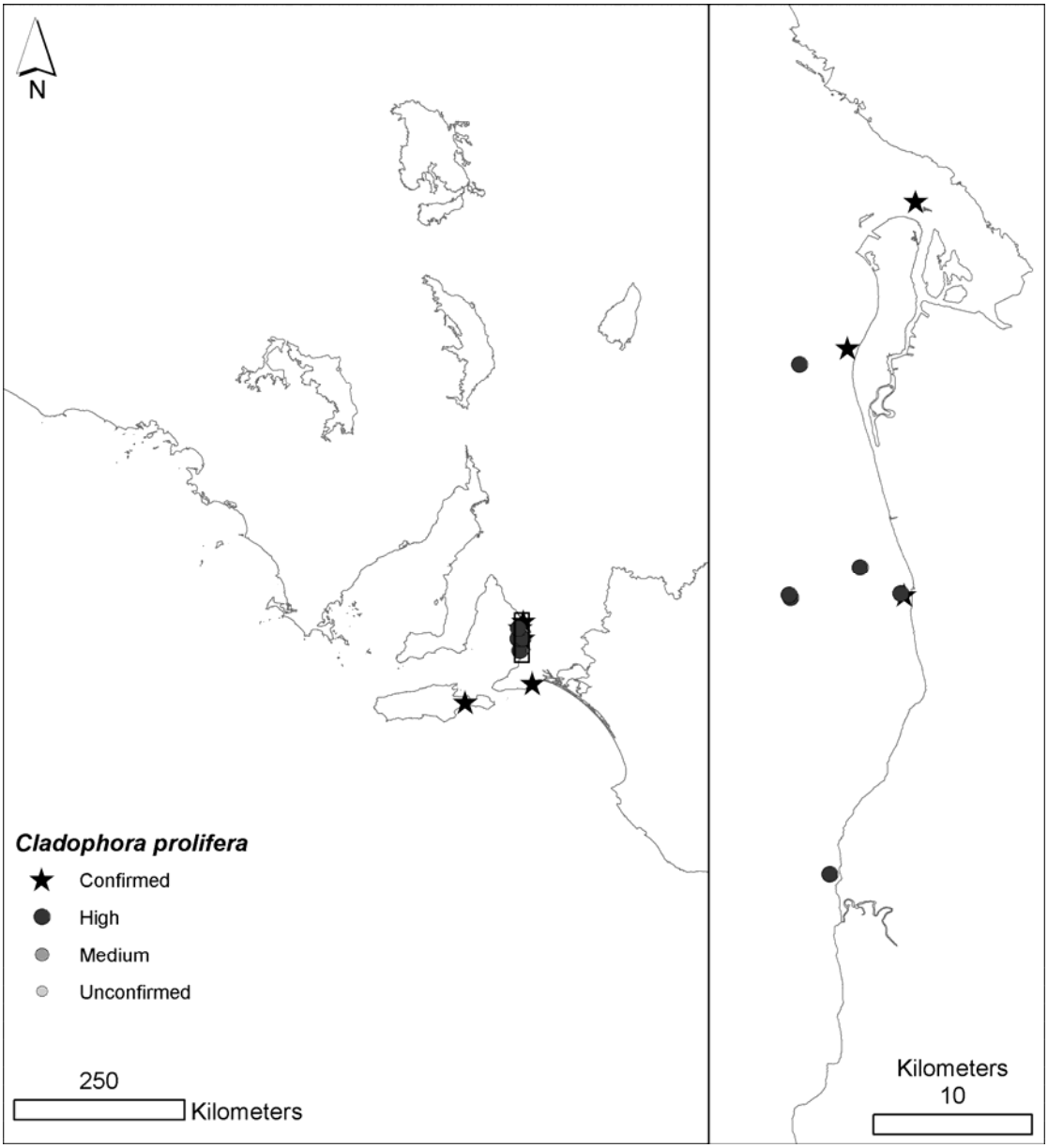

Figure 74. Map of records of *Cladophora prolifera.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Cladophora prolifera is widespread in warm temperate areas of Europe, the Mediterranean, tropical areas of Africa and the Americas, and occurs in New Zealand and Australia (Womersley 1984). It was not regarded as a possible introduction by Womersley (1984, 2003), but transport by shipping has been suggested as a possible explanation for its distribution in southern Australia (Lewis 1999; Hayes *et al.* 2005). Specimens of *C. prolifera* held by SHSA were collected between 1972 and 2005 from locations along the Adelaide metropolitan coast (St Kilda, Semaphore, Glenelg), Muston (~5 km along the inlet from American River, KI), and Granite Island, Victor Harbor. This species was also commonly observed along the Adelaide coast during the 2005 Reef Health surveys (SARDI unpublished data).

3.3.72. *Ulva fasciata* Delile 1813

Synonym(s): *Ulva lactuca* f. *fasciata*, *Phycoseris fasciata*

Category: cryptogenic

Status: present

Summary: *Ulva fasciata* has been found at Wanna, West Lakes, and Glenelg.

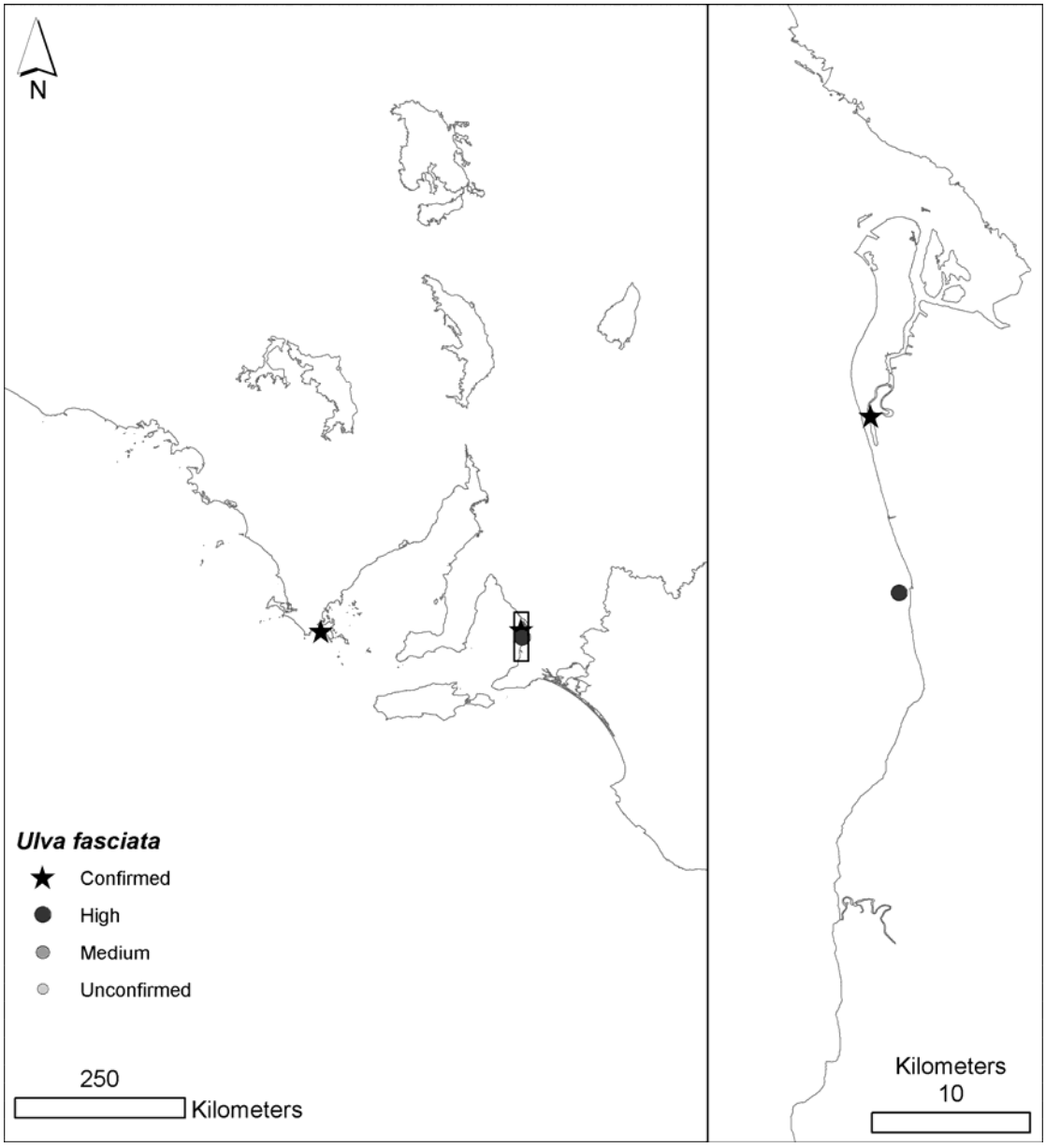

Figure 75. Map of records of *Ulva fasciata.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Ulva fasciata appears to be distributed widely in warm temperate seas, but taxonomic confusion means some records are doubtful (Womersley 1984). It was found at Wanna in 1959, in West Lakes in 1980 (Womersley 1984; SHSA specimens) and recorded at Glenelg during the 2005 Reef health surveys (SARDI

unpublished data). It is not regarded as possibly introduced by Womersley (1984, 2003), but is by NIMPIS (2009b, c), probably based on the observations of Phillips (1988), repeated by Lewis (1999), that the species has a disjunct distribution and is found around ports, and is therefore likely to have been introduced by shipping. We class this species as present due to the recent record at Glenelg, although it should be noted that, in the absence of a specimen, identification of this species may not be reliable. Although there are few records in SA, *U. fasciata* is common in parts of NSW and in Fremantle, WA (Phillips 1988). It was also recently recorded in Albany, WA (McDonald *et al.* 2009).

3.3.73. *Ulva lactuca* Linnaeus, 1753

Synonym(s): *Ulva lactucaefolia*, *U. fenestrata*, *U. stipitata*, *U. crassa*

Category: cryptogenic

Status: established

Summary: *Ulva lactuca* is widespread in SA.

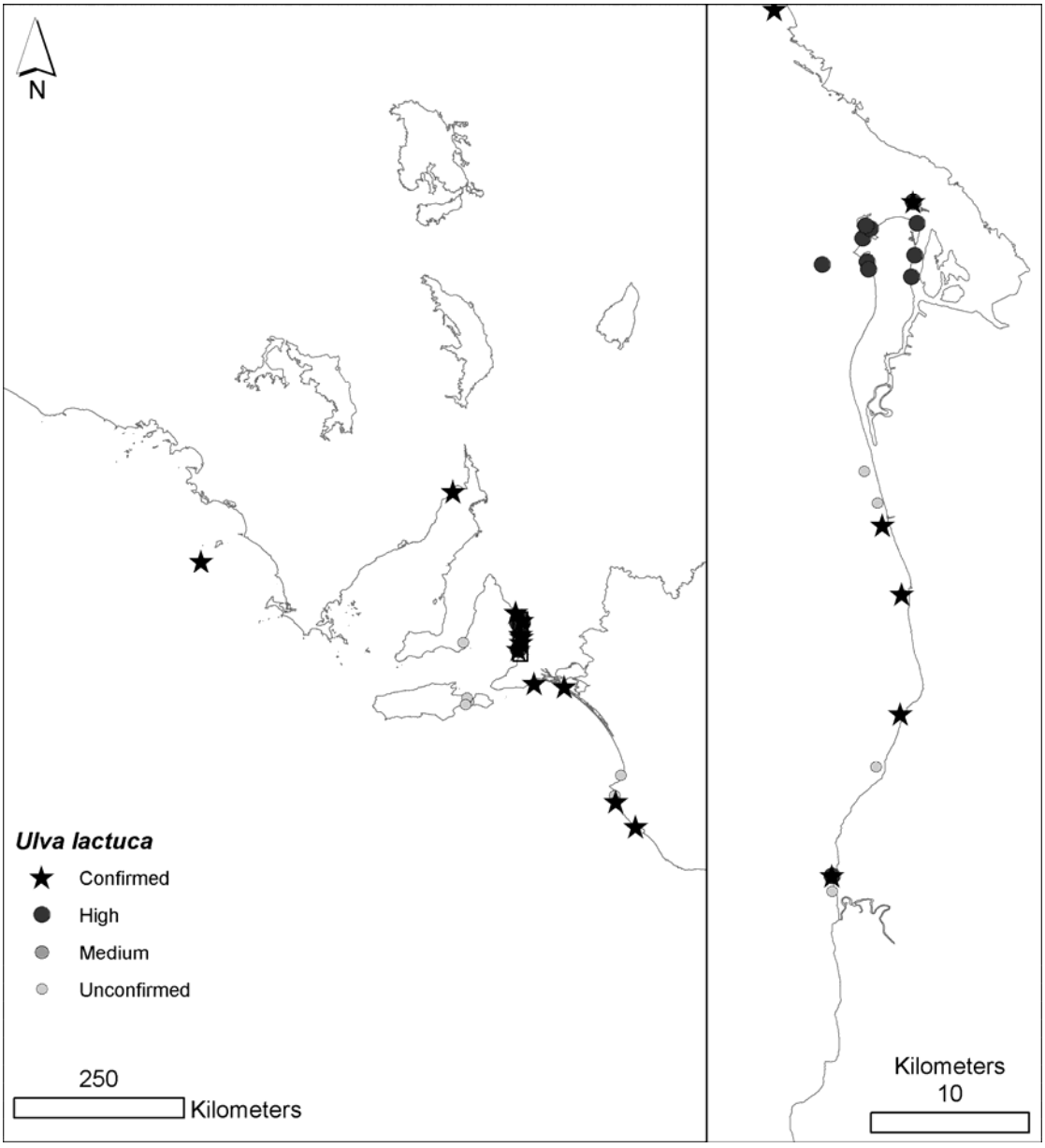

Figure 76. Map of records of *Ulva lactuca.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Ulva lactuca is a cosmopolitan species, and all *Ulva* in southern Australia was originally assumed to be this species (Womersley 1984). Further investigation has led to a total of six *Ulva* species being recognised in southern Australia, with *U. lactuca* regarded as relatively uncommon (Womersley 1984). This species was not

regarded as a possible introduction by Womersley (1984, 2003), but is included in the list of introduced species found by the 2001 Port Adelaide survey (Cohen *et al.* 2002). This survey recorded *U. lactuca* in the Port River, Outer Harbor, North Haven marina and along the Outer Harbor approach. SHSA holds numerous specimens ascribed to this species, but it is unclear whether all have been checked to verify their identification. Womersley (1984) states that the species is known from St Kilda and Christies Beach, while other records require verification. Specimens were collected from St Kilda in 1972 and 1975, and Christies Beach in 1980-81. We therefore regard early (pre-1970) and undated records as unconfirmed, but it is also possible that some later records are unverified, and equally possible that some of these early records have been confirmed. It should be noted that specimens from as early as 1948 are ascribed now to other *Ulva* species, e.g. *U. taeniata* (see section 3.3.74). While some records may be unconfirmed, it is clear that this species is established and widespread in SA, even if not as common as other *Ulva* spp. Since 1984 *U. lactuca* has been collected from Glenelg, Port Adelaide, Whyalla and the Coorong (SHSA specimens).

3.3.74. *Ulva taeniata* (Setchell) Setchell and Gardner, 1920

Synonym(s): *Ulva fasciata* var. *taeniata*, *U. fasciata* f. *taeniata*, *U. dactylifera*

Category: introduced

Status: established

Summary: *Ulva taeniata* is widespread in SA.

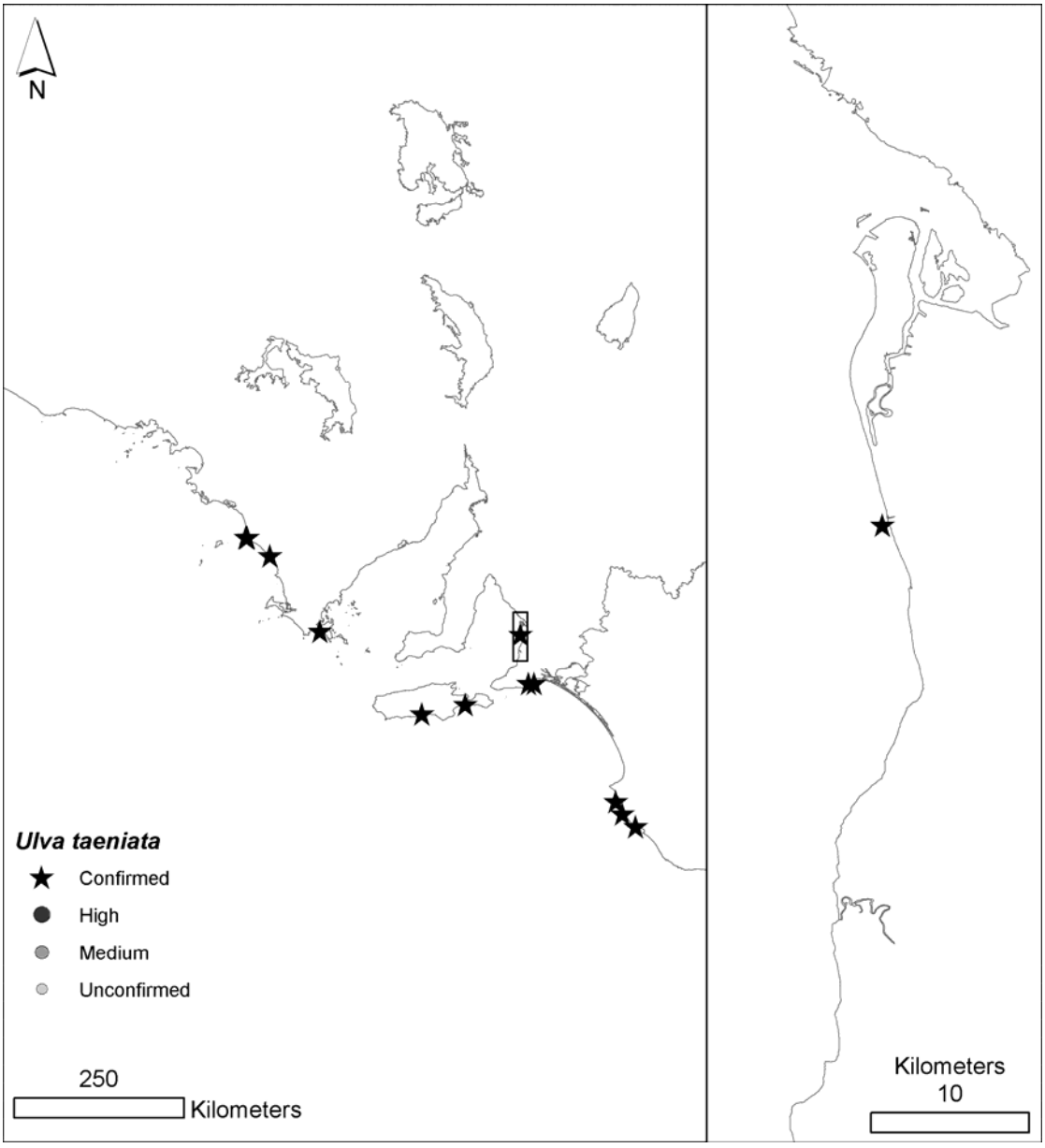

Figure 77. Map of records of *Ulva taeniata.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Ulva taeniata is considered native to California, although it is also found in New Zealand (Womersley 1984). This was the only *Ulva* species regarded as a possible introduction by Womersley (2003). Womersley (1984) and specimens held by the

SHSA (collected since 1948) indicate that this species is widespread in southern Australia, occurring in a range of localities from Elliston to Beachport (Figure 77).

RHODOPHYTA: Florideophyceae

3.3.75. *Acrosymphyton taylorii* Abbott, 1962

Category: cryptogenic

Status: uncertain

Summary: *Acrosymphyton taylorii* was found at Egg Island in the Nuyts archipelago.

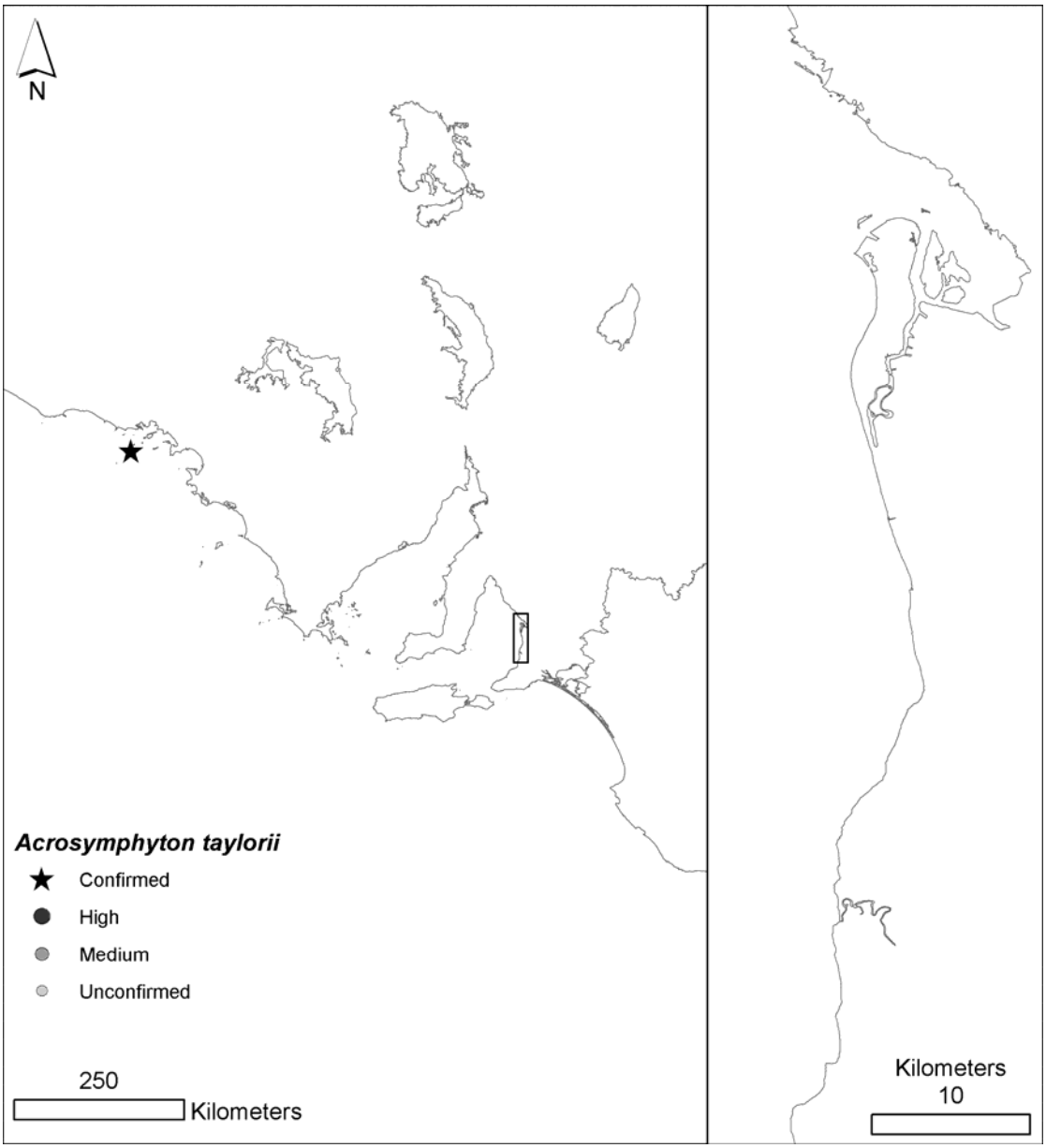

Figure 78. Map of records of *Acrosymphyton taylorii.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Acrosymphyton taylorii is considered native to Hawaii, with isolated records from Lord Howe Island, NSW, the Queensland-NSW border and Egg Island in the Nuyts Archipelago, SA (Womersley 1994). The SA specimen, held by the SHSA, was collected in 1971. This species was included in the list of possible introduced species in Womersley (2003), probably based on this being the only temperate occurrence of this tropical species (Womersley 1994), although the SA collecting location is not indicative of a likely human-mediated introduction. There do not appear to be any more recent records of this species so we class its status as uncertain.

3.3.76. *Antithamnion cruciatum* (C. Agardh) Nägeli, 1847

Synonym(s): *Callithamnion cruciatum*, *C. pumilum*, *C. imbricatum*

Category: introduced

Status: uncertain

Summary: *Antithamnion cruciatum* was found in Whyalla.

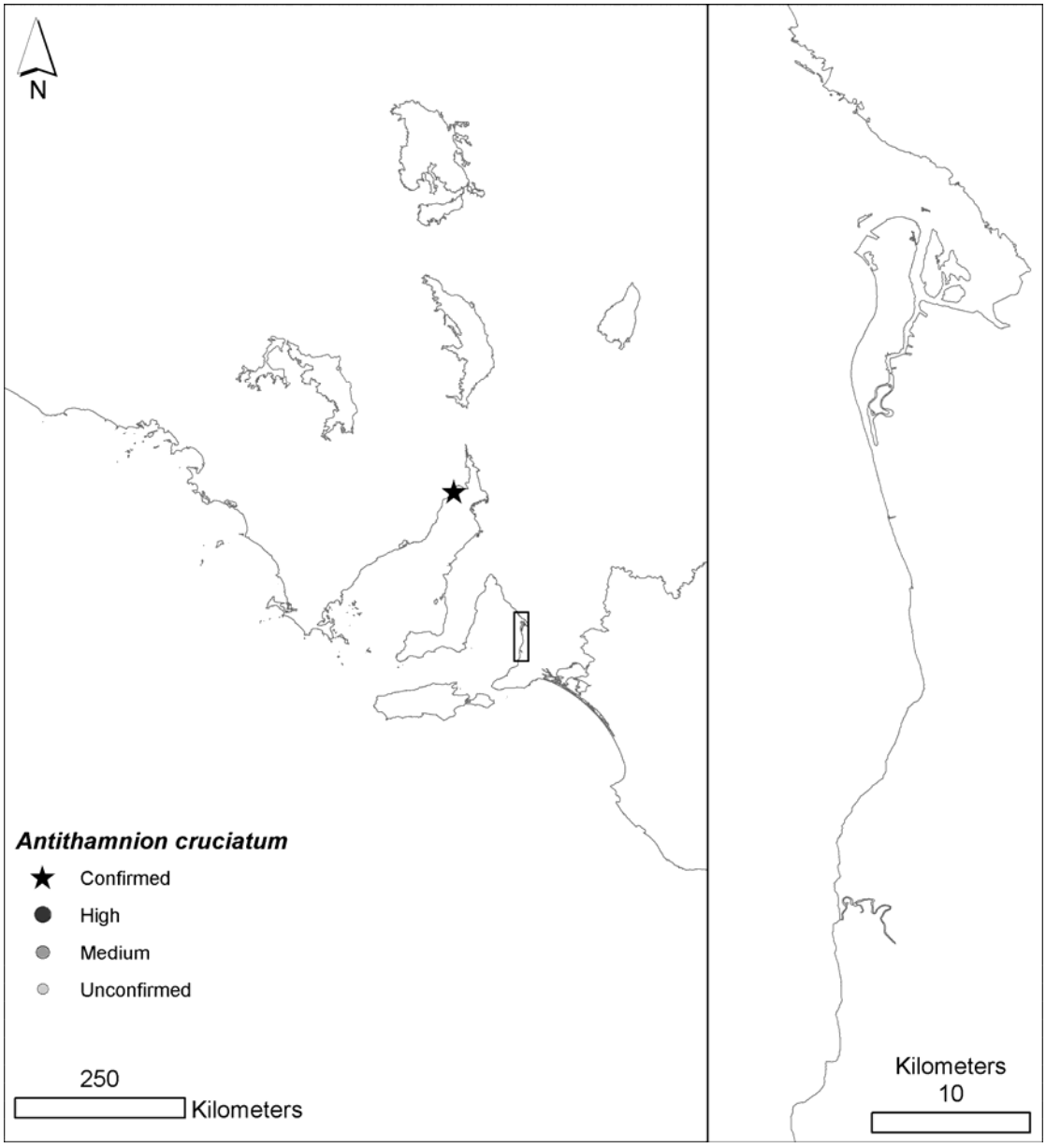

Figure 79. Map of records of *Antithamnion cruciatum.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Antithamnion cruciatum is recorded from the temperate Atlantic and Mediterranean (Womersley 1998). Its only recorded occurrence in southern Australia is at Whyalla, where several specimens were collected in 1994 (Womersley 1998; SHSA specimens). The proximity of this collecting location to the major port of Whyalla led

Womersley (1998, 2003) to consider this a possible introduction. The current status of this species is unclear as there are no more recent records.

3.3.77. *Antithamnionella spirographidis* (Schiffner) Wollaston, 1968

Synonym(s): *Antithamnionella glandulifera*, *Antithamnionella miharai*, *Antithamnion spirographidis*, *Antithamnion glanduliferum*, *Antithamnion tenuissima*, *Antithamnion miharai*, *Irtugovia spirographidis*

Category: introduced

Status: established

Summary: *Antithamnionella spirographidis* has been found at Port Adelaide and Port Stanvac.

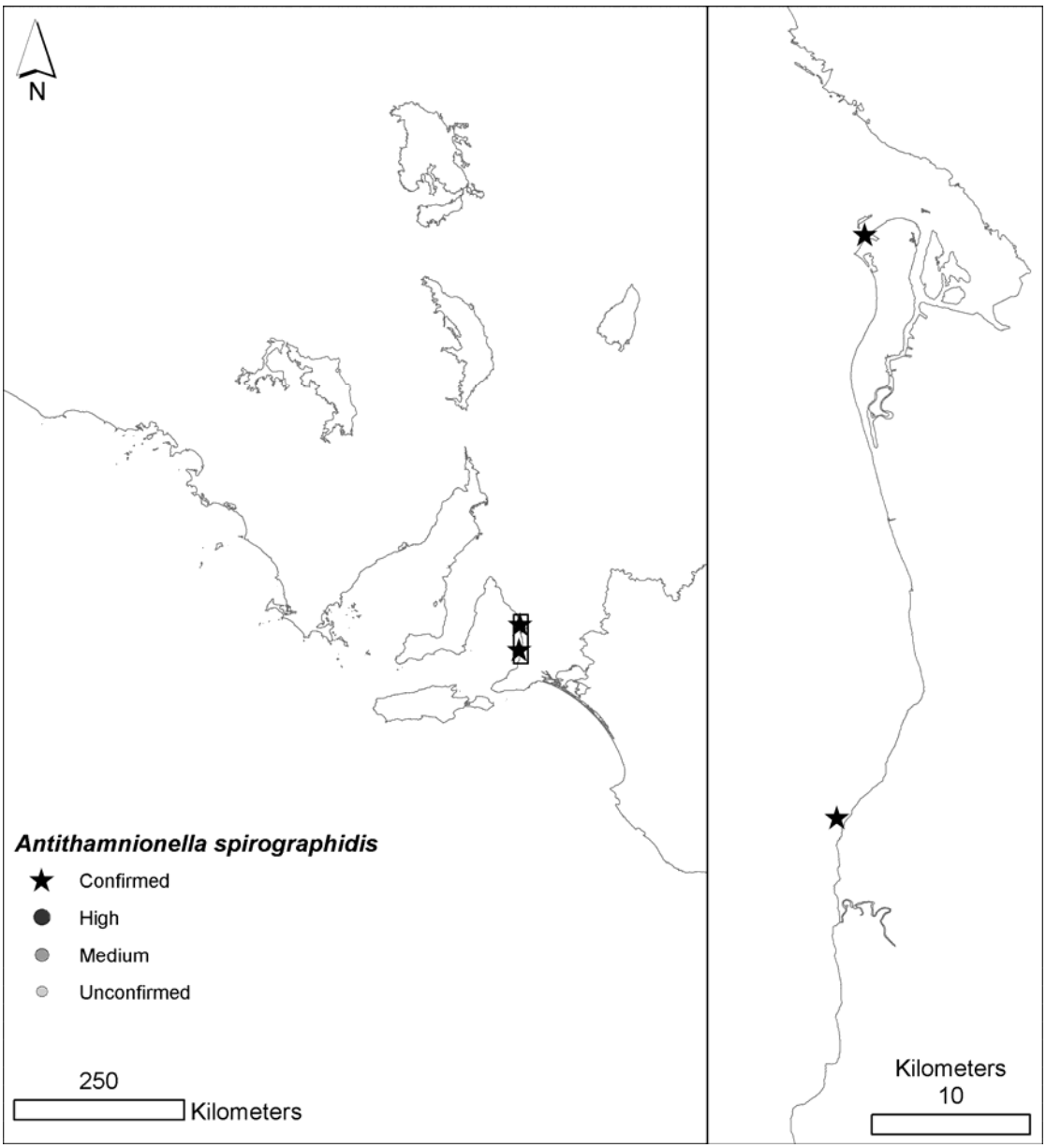

Figure 80. Map of records of *Antithamnionella spirographidis.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Antithamnionella spirographidis is recorded from Europe, the northern Pacific and in Australia, where it has been found mainly in ports and harbours, leading to it being considered as probably introduced (Wollaston 1968; Womersley 1998, 2003). In SA, several specimens were collected from Port Adelaide between 1950 and 1958 (Wollaston 1968; SHSA specimens) and this species was also collected from Port Stanvac (~4.5 km N of Port Noarlunga) in 1972 (Womersley 1998; SHSA specimen). The occurrence around Port Adelaide was the first record of this species in Australian waters (Wollaston 1968). We did not find any recent records of this species, but Womersely (1998) reports it as being common and widespread, so we class it as established.

3.3.78. *Caloglossa ogasawaraensis* Okamura, 1897

Synonym(s): *Delesseria zanzibariensis*

Category: cryptogenic

Status: established

Summary: *Caloglossa ogasawaraensis* has been found around Garden Island.

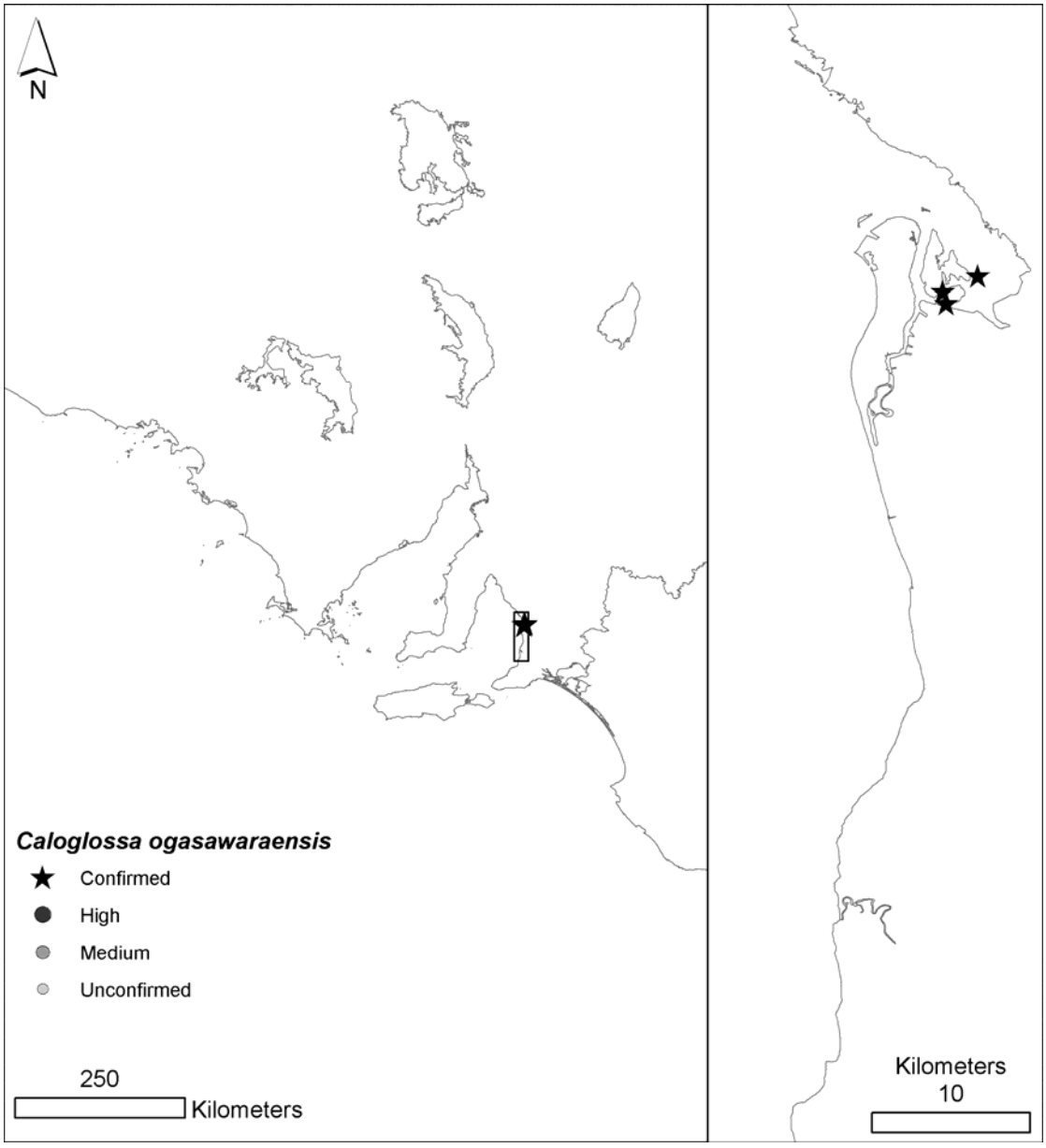

Figure 81. Map of records of *Caloglossa ogasawaraensis.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Caloglossa ogasawaraensis is known from Japan, SE Asia, South America and eastern Australia, but in southern Australia is recorded only from around Garden Island in the Port River-Barker Inlet system, an area influenced by the warm-water outflow of the Torrens Island Power Station, leading to it being considered a possible

introduction (Womersley 2003). Specimens from around Garden Island, including locations in North Arm and Barker Inlet, were collected between 1982 and 2000 (Womersley 2003; SHSA specimens). It is likely that *C. ogasawaraensis* is established in this area.

3.3.79. *Chondria arcuata* Hollenberg, 1945

Category: cryptogenic

Status: uncertain

Summary: *Chondria arcuata* has been found at Port Noarlunga.

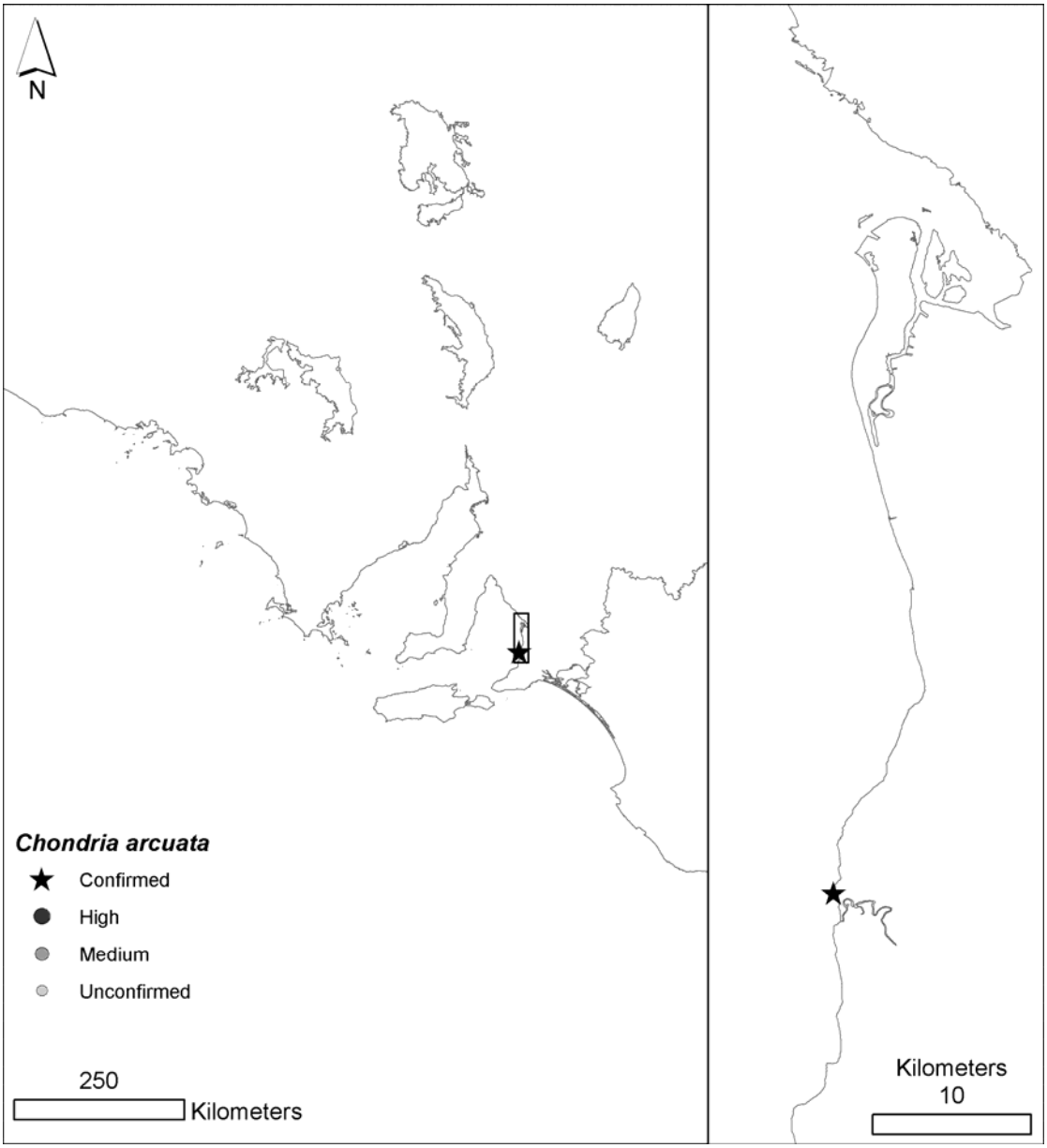

Figure 82. Map of records of *Chondria arcuata.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Chondria arcuata is recorded from California, Mexico and southern Australia (Womersley 2003). In SA this species was found at Port Noarlunga in 1987 (Womersley 2003; SHSA specimen). The occurrence of this species around harbours led to Womersley (2003) considering it as possibly introduced. The current status of this species in SA is uncertain as only one record exists.

3.3.80. *Polysiphonia brodiei* (Dillwyn) Sprengel, 1827

Synonym(s): *Conferva brodiei*, *Ceramium brodiei*, *Hutchinsia brodiei*, *Polysiphonia penicillata*, *Hutchinsia penicillata*, *Vertebrata brodiei*, misspelt *Polysiphonia brodiaei**

Category: cryptogenic

Status: established

Summary: *Polysiphonia brodiei* occurs around Robe and American River.

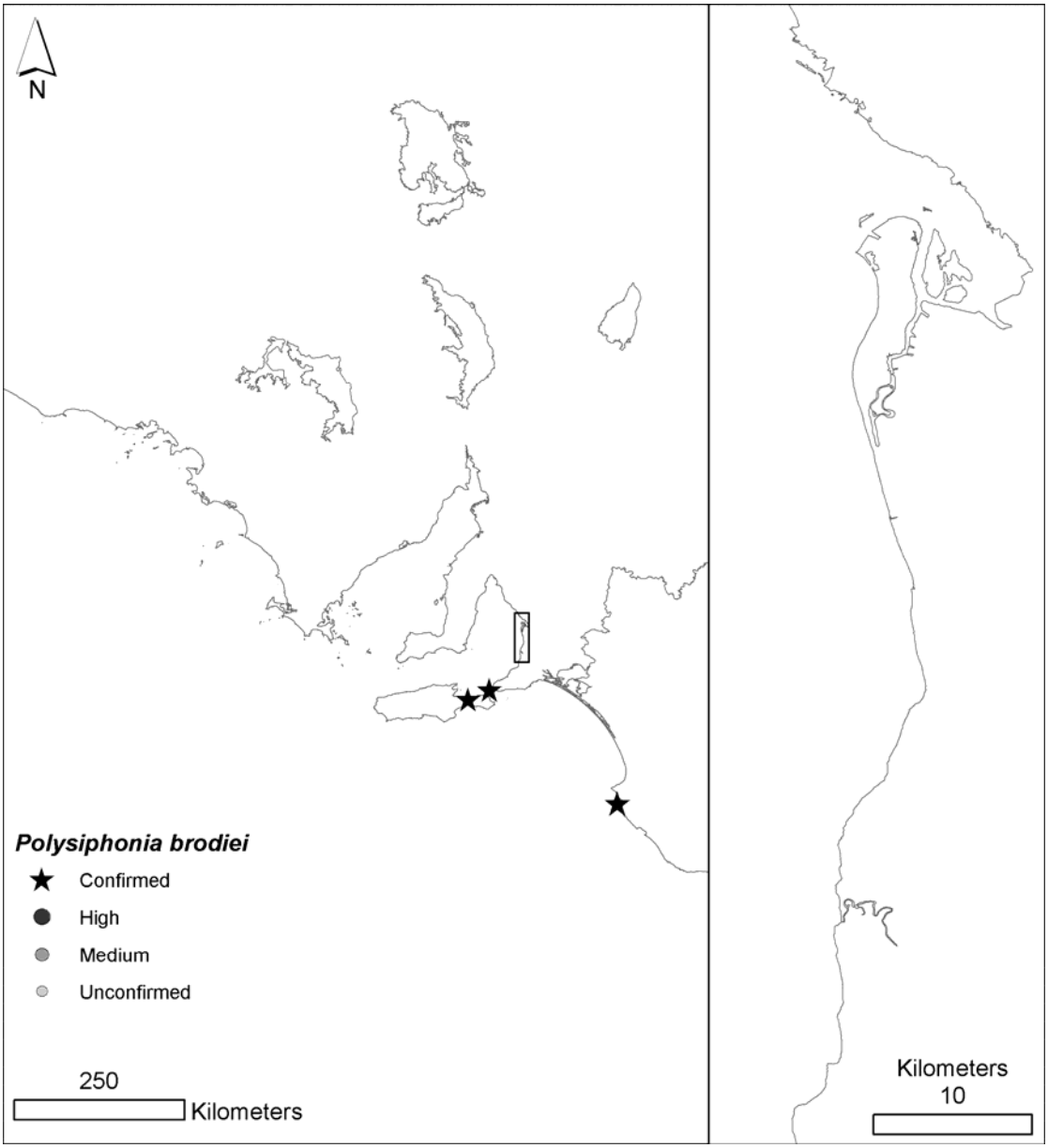

Figure 83. Map of records of *Polysiphonia brodiei.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Polysiphonia brodiei is widely distributed across the Mediterranean, the Atlantic coast of North America, Japan, the Indian Ocean, New Zealand and parts of southern Australia (Womersley 2003). It may have been spread by shipping (Womersley

1979), and is one of the few macroalgal species discussed by Furlani (1996). The SHSA holds several specimens from American River, KI, collected between 1948 and 1997, and from Robe, collected between 1973 and 1981. The multiple records of this species from these two locations suggest it is established in these areas. An undated specimen is described as having been collected from 60m depth in GSV, with exact locality not specified (Womersley 1979, 2003). The only region in GSV that is this deep is Backstairs Passage near Cape Jervis (Bye and Kämpf 2008), so we have assigned this nominal locality to this record. This species' name is commonly misspelt as *P. brodiaei* (e.g. Furlani 1996; EPA and DEHAA 1998; Lewis *et al.* 1998; Edyvane 1999; Cohen *et al.* 2002; Hayes *et al.* 2005).

3.3.81. *Cottoniella fusiformis* Børgesen, 1930

Category: introduced

Status: uncertain

Summary: *Cottoniella fusiformis* is recorded along the Adelaide metropolitan coast.

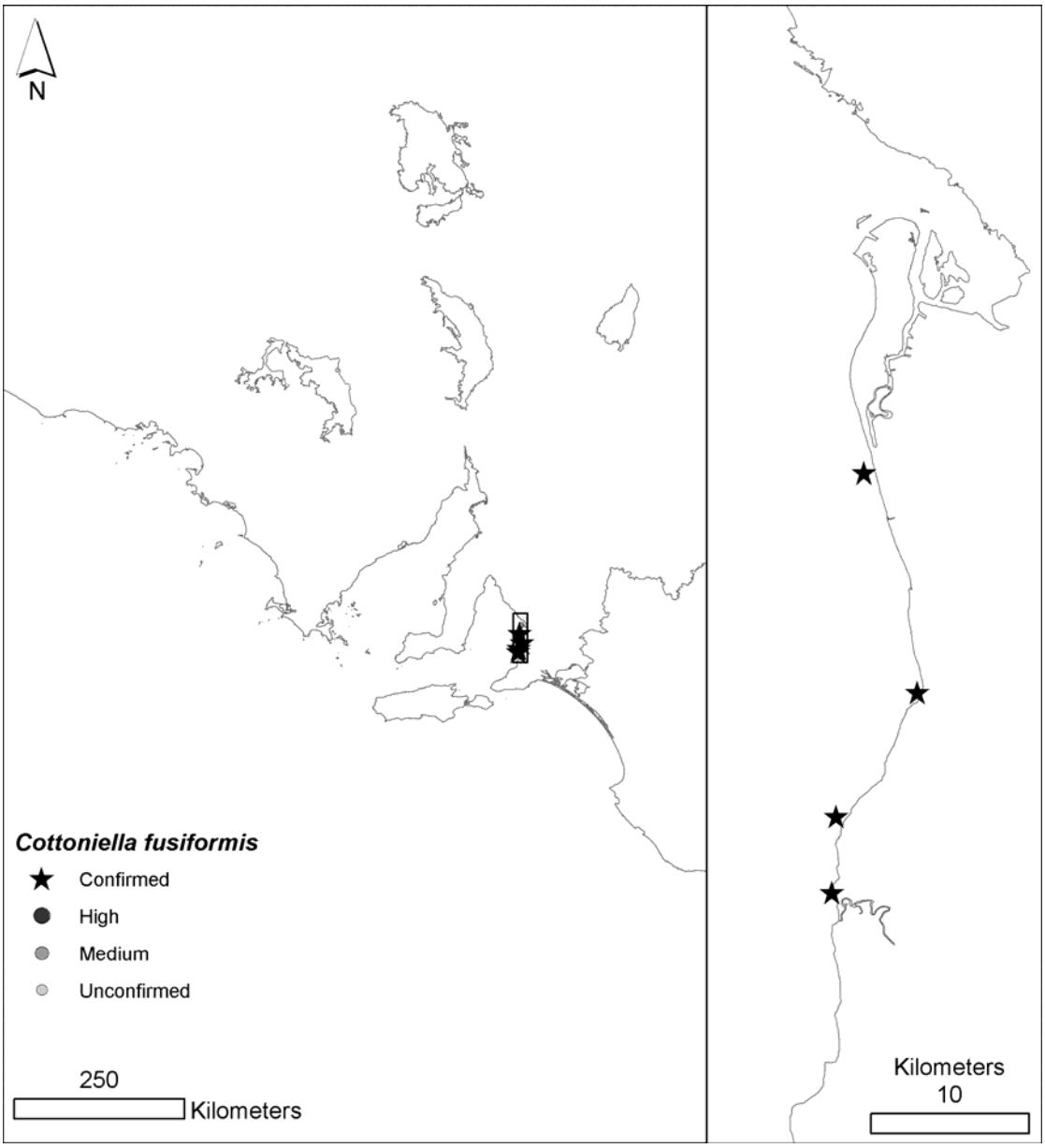

Figure 84. Map of records of *Cottoniella fusiformis.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Cottoniella fusiformis is known from the Canary Islands and Pakistan (Womersley 2003). The only records of this species in southern Australia are specimens collected from the Adelaide coast between 1985 and 1988 (Womersley 2003; SHSA specimens). These were collected from Grange, Seacliff (~2.5 km S of Brighton),

Port Stanvac (~4.5 km N of Port Noarlunga) and Port Noarlunga. The current status of this species is unknown; Womersley (2003) notes that it may not have persisted.

3.3.82. *Gymnogongrus crenulatus* (Turner) J. Agardh, 1851

Synonym(s): *Fucus crenulatus*, *Gymnogongrus norvegicus*, *Actinococcus peltaeformis*

Category: introduced

Status: established

Summary: *Gymnogongrus crenulatus* occurs at Port Noarlunga with additional records from Henley Beach, Robe and Topgallant Island.

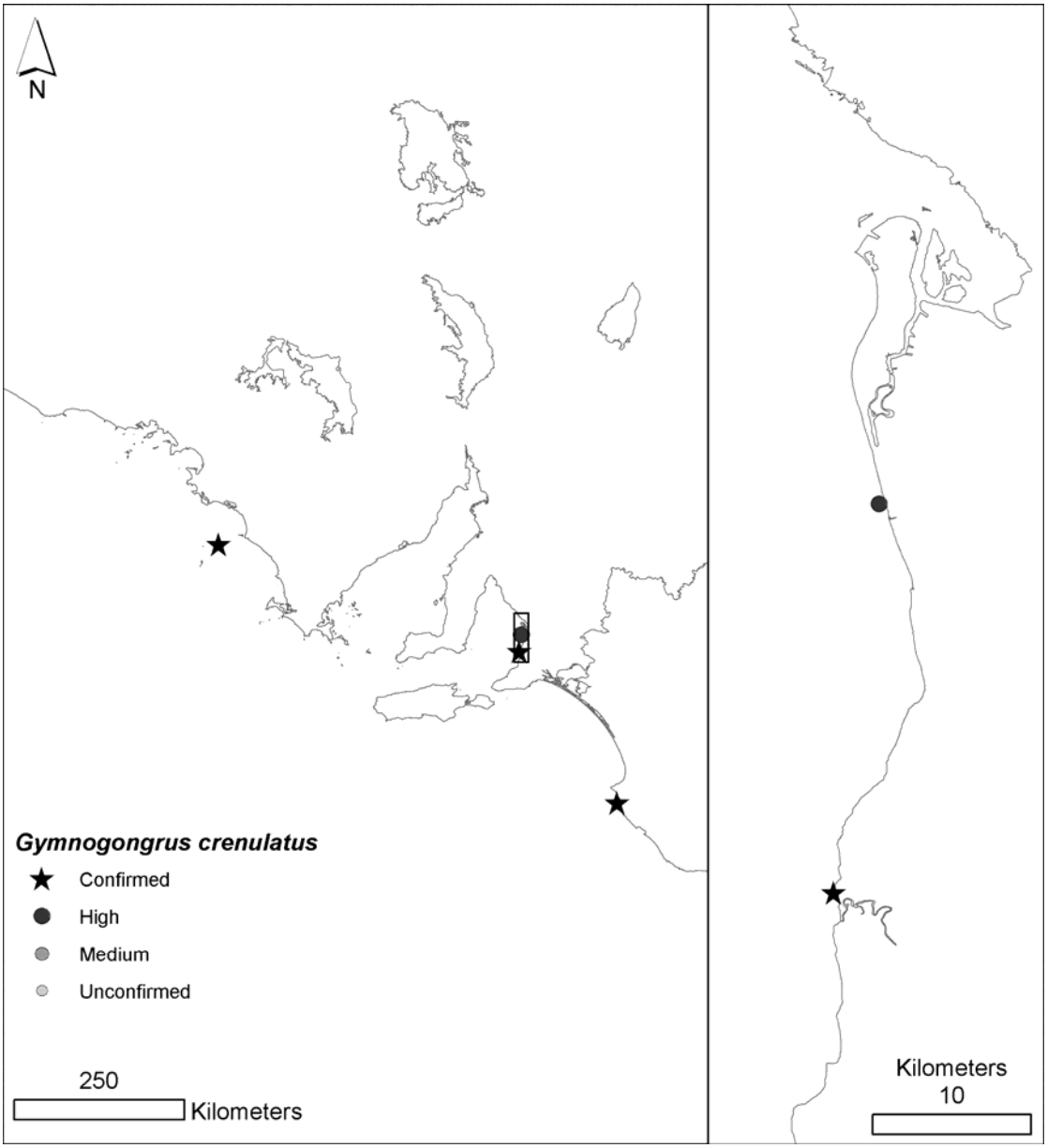

Figure 85. Map of records of *Gymnogongrus crenulatus.*

Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Gymnogongrus crenulatus is native to Europe and North America; in Australia it occurs primarily around harbours suggesting it is introduced (Womersley 1994; Hayes *et al.* 2005). In SA it was collected at Port Noarlunga between 1991 and 1998, Henley Beach (~6 km N of Glenelg) in 1992, Robe (1991) and Topgallant Island (~37 km SW from Elliston, 1992) (Womersley 1994; SHSA specimens). Based on the multiple records from Port Noarlunga, this species appears to be established there, but its status at other localities is unknown.

3.3.83. *Schottera nicaeënsis* (Lamouroux ex Duby) Guiry and Hollenberg, 1975

Synonym(s): *Halymenia nicaeënsis*, *Rhodymenia palmetta* var. *nicaeënsis*, *Rhodymenia nicaeënsis*, *Gymnogongrus nicaeënsis*, *Phyllophora nicaeënsis*, *Phyllophora morinii*, *Petroglossum nicaeënsis*

Category: introduced

Status: present

Summary: *Schottera nicaeënsis* has been found at Glenelg and Stony Point.

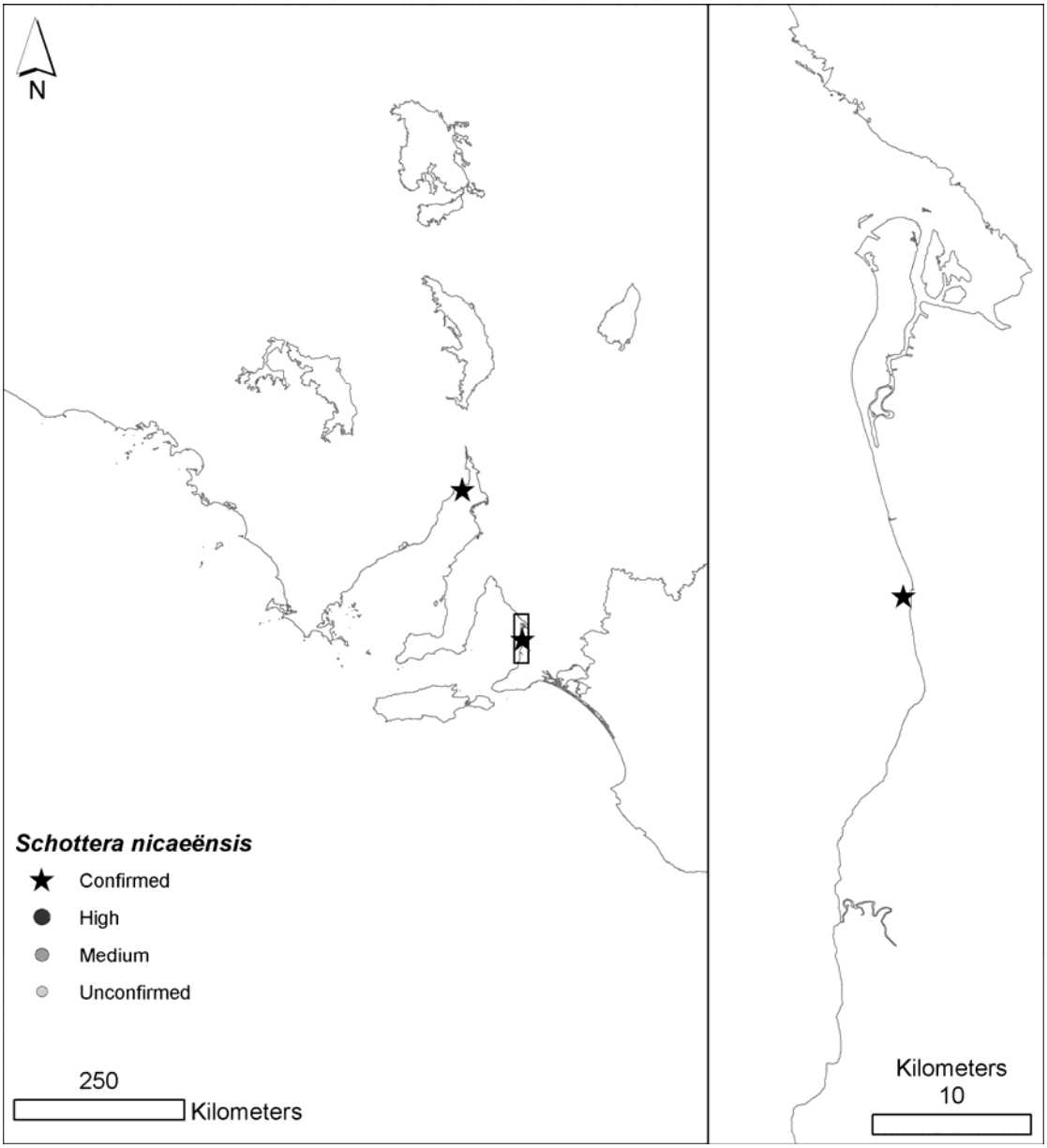

Figure 86. Map of records of *Schottera nicaeënsis.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Schottera nicaeënsis is probably native to Europe and introduced to South Africa and Australia (Womersley 1994; Hayes *et al.* 2005). In SA it was reported off Glenelg in 1970 (Womersley 1994), and at Stony Point near Port Bonython, ~18 km ENE of Whyalla, in 2006 (Arup and ENSR 2008); SHSA specimens confirm these records. We class *S. nicaeënsis* as present due to the recent Spencer Gulf record, but it is not clear whether it has established.

3.3.84. *Trematocarpus affinis* (J. Agardh) De Toni, 1900

Synonym(s): *Dicurella affinis*

Category: cryptogenic

Status: uncertain

Summary: *Trematocarpus affinis* was found at West Island, Victor Harbor.

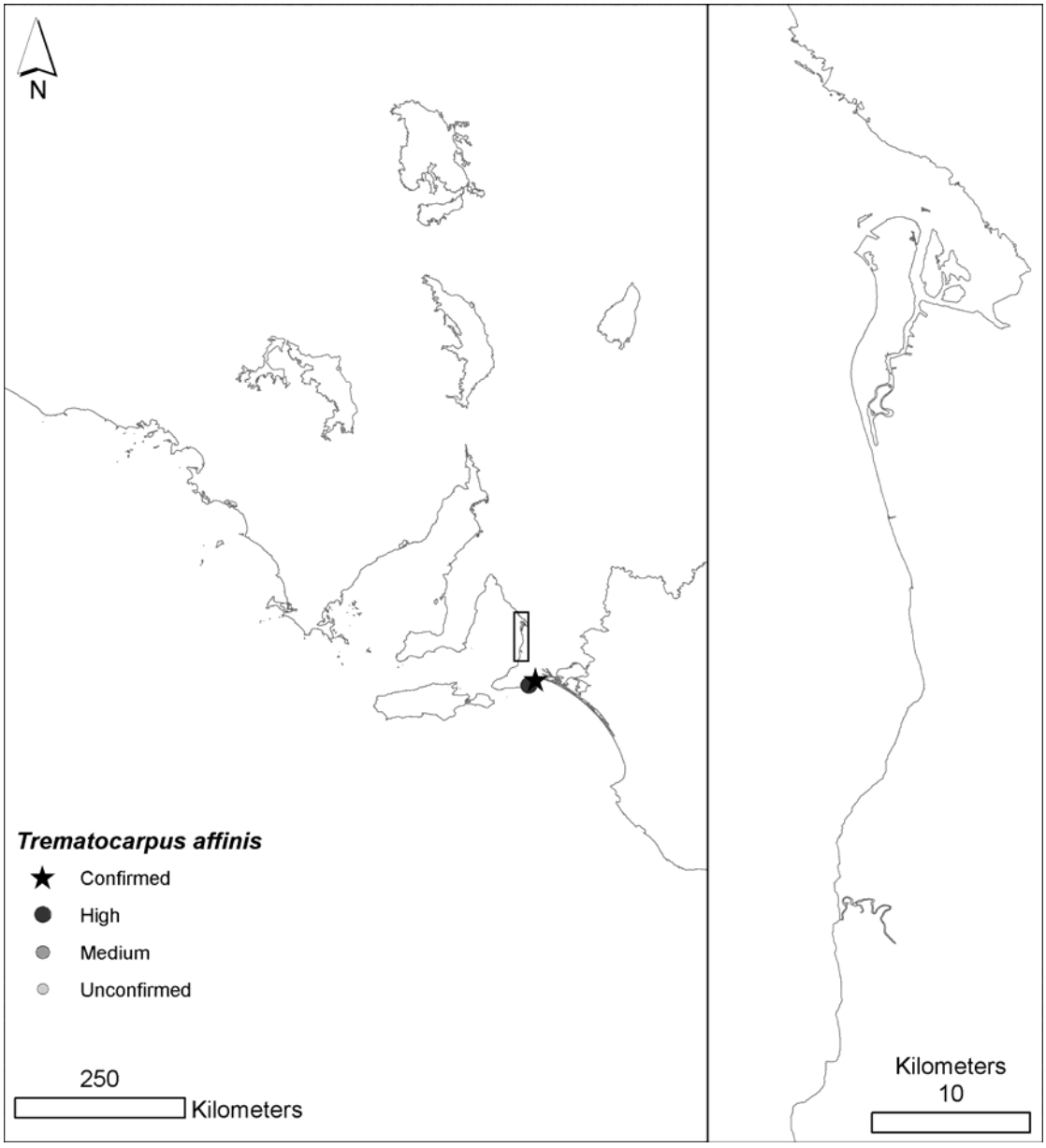

Figure 87. Map of records of *Trematocarpus affinis.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Trematocarpus affinis is considered native to South Africa but several specimens were collected from around West Island, ~ 6 km southwest of Victor Harbor in 1967 (Womersley 1994). The SHSA also holds a specimen from Port Elliot collected in 1948. The current status of this species is unknown.

3.3.85. *Solieria filiformis* (Kützing) Gabrielson, 1985

Synonym(s) (*reported as): *Euhymenia filiformis*, *Mychodea filiformis*, *Solieria tenera**

Category: cryptogenic

Status: present

Summary: *Solieria filiformis* has recently been found at Port Stanvac

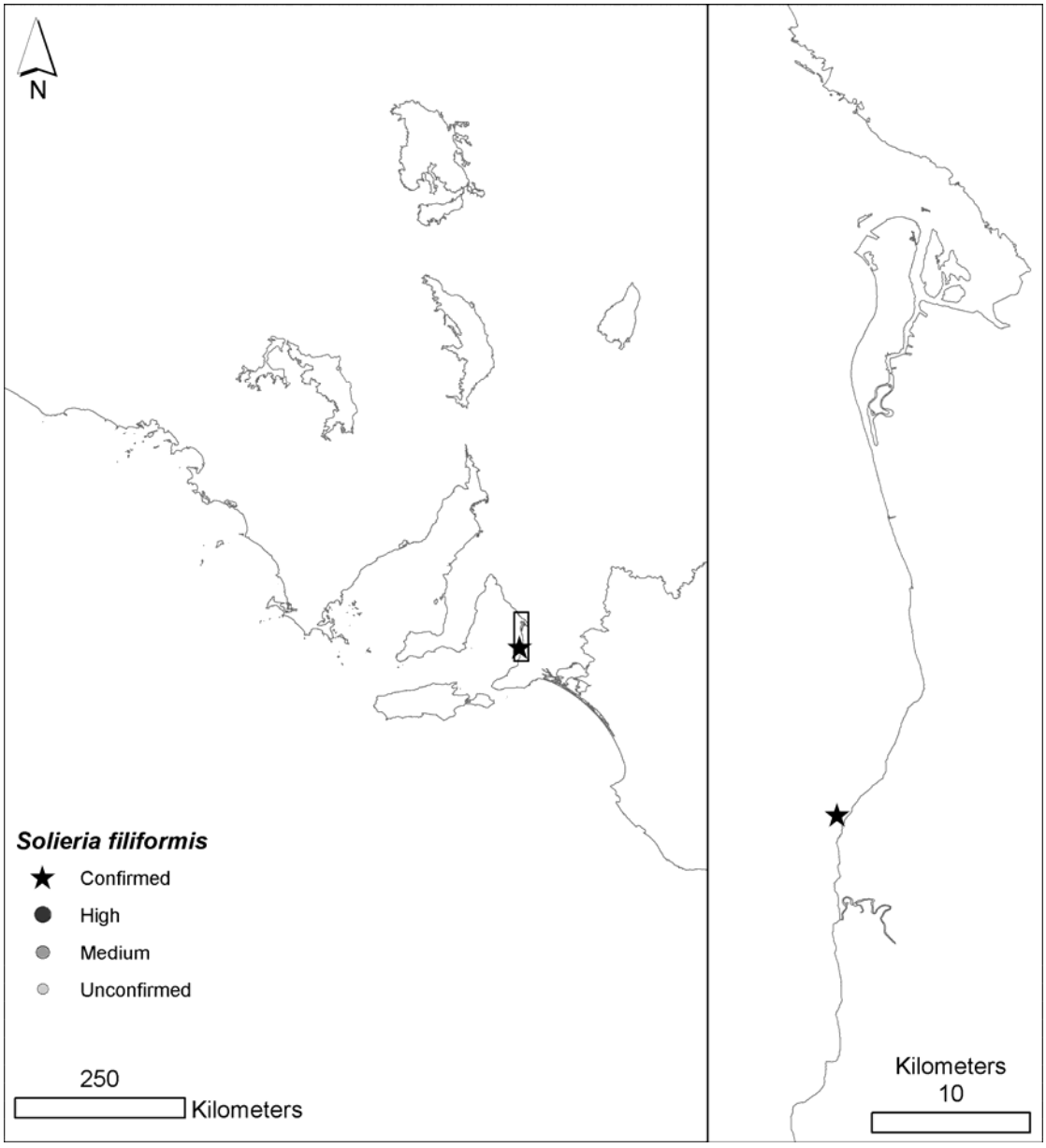

Figure 88. Map of records of *Solieria filiformis.*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

Solieria filiformis is widely distributed across western Europe, west Africa, and North and South America (Womersley 1994; Guiry and Guiry 2009). In Australia it is known from PPB since 1972 (Womersley 1994) and is considered a possible introduction (Womersley 2003). SARDI staff collected a specimen from Port Stanvac, ~4.5 km N

of Port Noarlunga, in 2008 (SARDI unpublished data; SHSA specimen). We class this species as present due to this recent record, but note that it may not be established.

3.3.86. *Gracilariopsis* "*lemaneiformis*"

Category: cryptogenic

Status: established

Summary: *Gracilariopsis* "*lemaneiformis*" occurs at Robe.

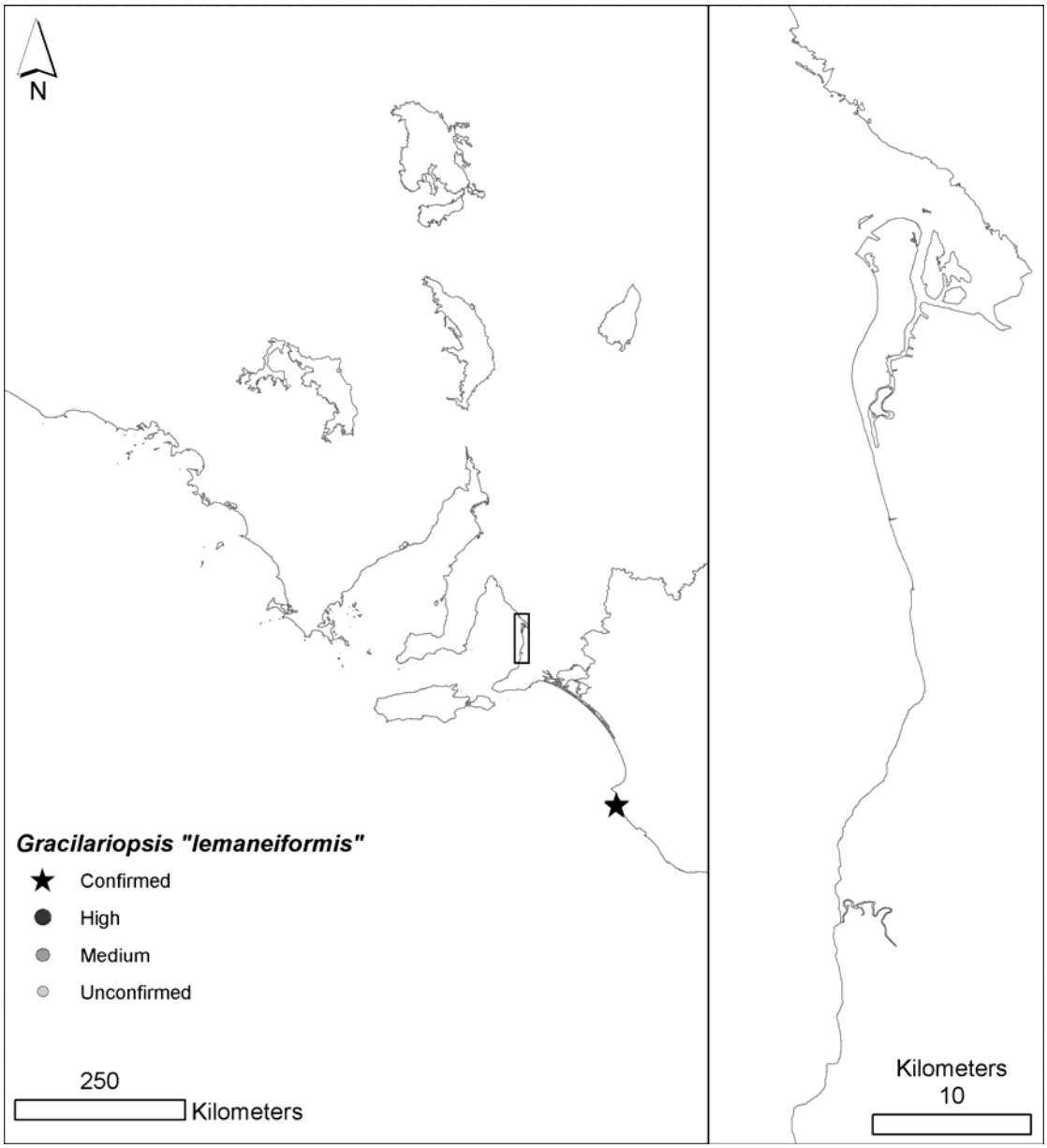

Figure 89. Map of records of *Gracilariopsis "lemaneiformis".*
Only records with specific spatial information available are shown, with nominal location mapped for some records. Map may not represent current distribution.

A species of *Gracilariopsis* with invasive characteristics that has been ascribed to *G.* "*lemaneiformis*", is found in the fishing marina at Robe (Womersley 1996; Gurgel *et al.* 2003), with SHSA specimens collected between 1994-96 confirming its occurrence. *Gracilariopsis lemaneiformis* (Bory de Saint Vincent) Dawson, Acleto and Foldvik, 1964 requires review; molecular data indicates that this is a complex of several species, with the true *G. lemaneiformis* probably restricted to the type locality in Peru (Gurgel *et al.* 2003). Other records ascribed to *G.* "*lemaneiformis*" are other *Gracilariopsis* spp. The specimens from SA are related to *Gracilariopsis longissima* (Gmelin) Steentoft, Irvine and Farnham, 1995, and form a close group with *G.* "*lemaneiformis*" from California and Mexico but require further investigation to ascertain their identity (Gurgel *et al.* 2003). Although the locality in a marina and its disjunct distribution suggests an introduction, its native range is unknown so we categorise it as cryptogenic.

3.4. Possible introduced species not considered by the review

Due to the large number of species reported as possibly introduced to SA we did not investigate species that were reported as "cosmopolitan possibly introduced" that were not regarded by at least one additional source as either introduced or cryptogenic. Additionally, reports of some species came to our attention near completion of the project when reference to these was found in material sourced during the investigation of other species, and also due to a recent survey for introduced species on Eyre Peninsula (Dittmann *et al.* 2010). We list and briefly discuss the species that we did not investigate below but it should be noted that neither the presence nor categorisation of these species as possibly introduced has been verified. We have also not checked the validity of scientific names for these species.

Several fouling species are included in the review of Keough and Ross (1999). Those listed as occurring in SA that were not considered by this review are the bryozoans *Bowerbankia gracilis*, *Bugula simplex*, *Bugula stolonifera*, *Scrupocellaria berthelottii*, and the polychaete *Ficopomatus enigmaticus.* All the Bryozoa listed here were recorded around Port Adelaide by Brock (1985), but reports of *Ficopomatus enigmaticus* in Australia are likely to result from incorrect identifications (Beesely *et al.* 2000). A recent report lists another bryozoan, *Amathia distans*, as occurring in SA (Wells *et al.* 2009); this species is also considered cosmopolitan (Keough and Ross 1999). It is discussed by other sources (e.g. Keough and Ross 1999; NIMPIS 2009b), but we did not note any other reference to its occurrence in SA.

Macroalgal species classed as cosmopolitan by Lewis (1999) and stated as being in SA that were not considered by this review include the Phaeophyta: *Kuckuckia spinosa*, *Pilayella littoralis*, *Myrionema strangulans*, *Leathesia difformis*, *Hincksia granulosa*, *Hincksia mitcheliae*, *Ectocarpus siliculosus*, *Ectocarpus fasciculatus*, *Feldmannia globifera*, *Feldmannia irregularis*, *Feldmannia lebelli*, *Acinetospoa crinita*, *Punctaria latifolia*, *Petalonia fascia*, *Scytosiphon lomentaria*, *Colpomenia sinuosa*, *Colpomenia peregrina*, *Sphacelaria fusca*, *Cladostephus spongiosus*, *Dictyota dichotoma*, and *Cutlaria multifida*, Rhodophyta: *Antithamnionella ternifolia*, *Centroceras clavulatum*, *Nemalion helminthoides*, *Gellidium pusillum*, *Pterocladia capilacea*, *Erythrotrichia carnea*, *Bangia atropurpurea*, *Audouinella simplex*, *Audouinella pacifica*, *Stylonema alsidii*, *Ceramium flaccidum*, *Ceramium rubrum*, and *Polysiphonia subtilissima* and Chlorophyta: *Ulva stenophylla*, *Ulva rigida*, *Chaetomorpha aerea*, *Chaetomorpha capillaris*, *Chaetomorpha linum*, *Enteromorpha compressa*, *Enteromorpha intestinalis*, and *Derbesia marina.* As other records in Lewis (1999) are based on herbarium specimens it is likely that all the above species do occur in SA as stated, but their classification as possible introductions is unclear.

Identification of specimens collected by the recent survey of Eyre Peninsula (Dittmann *et al.* 2010) is currently underway (T. Laperousaz, SAM, pers. comm.). Until identifications are verified, reports of possible introduced species found by this survey should be considered unconfirmed. Species found by the survey that were among those considered by this review are discussed in the relevant sections of the results, but several species tentatively identified as introduced by the Eyre Peninsula survey do not appear to have previously been reported from SA. These are the bivalves *Pinctada fucata*, *Electroma* cf. *papilionacea*, *Malleus malleus*, *Brachidontes maritimus* and *Musculus chinensis*, and the arthropods *Monocorophium sextonae*, *Ericthonius brasiliensis*, *Jassa marmorata* and *Jassa* sp. Empty shells of another possibly introduced mollusc, *Eucrassatella* sp., were also discovered (Dittmann *et al.* 2010). If identification of the above specimens is confirmed, further investigation will be necessary to establish the spatial and temporal extent of their occurrence in SA.

4. SUMMARY AND DISCUSSION

4.1. Summary of results

Of the 99 species reviewed, we confirmed the occurrence of 82. We accepted as confirmed some species for which specimens were not found; the occurrence of these species was supported by multiple (>20) high quality records (publications

and/or scientific data). Although not confirmed, 6 additional species appear likely to have occurred in SA based on published records or other evidence, but the occurrence of 7 reported species in SA is doubtful.

It is possible that some of the confirmed species are no longer present in SA. We consider 51 to be established, with 7 more likely to be present based on recent records. Four species appear to represent isolated occurrences, while 3 that appeared established are now rare and may no longer be present; there are insufficient data available to ascertain the status of the remaining 17 confirmed species.

The confirmed species include 12 from the current trigger list and 23 other probably introduced species. Most of the confirmed species (44) are of uncertain origin and classed as cryptogenic, while 3 are now regarded as native.

No list of introduced species is reliable for long, because constant revision and verification of records are necessary. Previous lists of species introduced to SA suffered from several issues; unverified records were repeated without confirmation, and little new information was incorporated. The species reported on these lists are discussed in detail in section 4.2. Below we summarise the status of all the reviewed species and provide a list of introduced species likely to be present (established or recently recorded) in SA at May 2010 (Table 2). This list is currently valid, but we note that it may not be complete. Recent reports (Wells *et al.* 2009; Dittmann *et al.* 2010) suggest further introduced species may occur in SA (see section 3.4). We have not included on this list species that have not been recently recorded or that are now rare (see Table 3), or for which we did not confirm records (see Table 6). If these species are found (or confirmed to occur) in the future they will also need to be added to this list.

Table 2. Distribution and record dates for trigger list and introduced species confirmed to occur and likely to be present currently in SA.

Scientific Name	Dates	Distribution / notes
Trigger list species		
Established		
Sabella spallanzanii	1995-2010	Pt Adelaide, Adelaide coast, sporadic at other ports
Gymnodinium catenatum	1996-2009	Widespread, common in Pt Lincoln
Alexandrium catenella	1997-2008	Widespread, common in Pt Adelaide
Alexandrium minutum	1986-2008	Widespread, common in Pt Adelaide
Alexandrium tamarense	1988-2009	Widespread, common around Yorke Peninsula
Caulerpa racemosa var. cylindracea	2002-2010	Port Adelaide, O'Sullivan Beach
Caulerpa taxifolia	2002-2009	Port River-Barker Inlet
Codium fragile ssp. *fragile*	2002-2009	North Haven marina, West Lakes, American River
Present		
Crassostrea gigas	1969-2009 (intentional)	Aquaculture areas, some wild settlement since 1990
Introduced species		
Established		
Boccardia chilensis	1979-1996	Venus Bay, Coorong, Port Lincoln
Corophium acherusicum	2001-2008	Pt Adelaide, Coorong
Paracerceis sculpta	2000-2001	Pt Adelaide
Polycera hedgpethi	1998-2004	North Haven marina
Ascidiella aspersa	1952-2007	Pt Adelaide, Pt Lincoln
Ciona intestinalis	1952-2009	Pt Adelaide, Pt Lincoln, Wallaroo, American River
Styela plicata	1969-2010	Widespread, common in Pt Adelaide
Elachista orbicularis	1979-1991	Victor Harbor, Adelaide coast
Ulva taeniata	1948-1982	Widespread
Antithamnionella spirographidis	1950-1972	Pt Adelaide, Pt Stanvac
Gymnogongrus crenulatus	1991-1997	Adelaide coast, Robe, Topgallant Is
Present		
Tridentiger trigonocephalus	2001, 2004	West Lakes
Schottera nicaeënsis	1970, 2006	Glenelg, Stony Point

We consider 19 species that are either introduced (11) or on the Marine Pest Monitoring Manual (National System for the Prevention and Management of Marine Pest Incursions 2010b) trigger list (8) as established, with a further 3 (1 trigger list, 2 introduced) recorded recently and likely to be present (Table 2). There are 13 additional trigger list/introduced species confirmed to have occurred but not recorded recently, 3 of these (1 trigger list) represent isolated occurrences, i.e. it is unlikely that they established (Table 3). The majority of reported species are best regarded as cryptogenic as it cannot be established with confidence that they are introduced to Australia. A total of 30 cryptogenic species are established in SA, with a further 4 likely to be present based on recent records (Table 4), and 10 more confirmed, but not recently recorded, including 1 isolated occurrence (Table 5). There are 17 species (1 trigger list, 11 introduced, 5 cryptogenic) for which we were unable to confirm occurrence (Table 6). Five of these (1 introduced, 4 cryptogenic) appear likely to have occurred based on published records, with 1 other introduced species likely based on being reported by a relevant expert, albeit not in primary literature. Another introduced species (*Tricellaria occidentalis*) is also reported by a relevant expert, but with some doubt regarding its identity, while a further cryptogenic species (*Polydora "ciliata"*) is subject to taxonomic confusion, making it impossible to determine currently which species of the genus are present. Specimens of 2 cryptogenic species (*Theora lubrica, Teredo navalis*) are held by SAM, but their collection locality is unknown, making it impossible to confirm that they occurred in SA. Records of 7 reported species (1 trigger list, 6 introduced) are doubtful, with no verification found for their occurrence. Three reported species are now considered to be native: the isopod *Sphaeroma quoyanum*, the barnacle *Elminius modestus*, and the macroalga *Zosterocarpus australica* (reported as *Zosterocarpus* sp.).

Table 3. Distribution and record dates for trigger list and introduced species that are confirmed to have occurred but that may not be present currently in SA.

Scientific Name	Dates	Distribution / notes
Trigger list species		
Previously established		
Carcinus maenas	1976-2008	Previously established in GSV, now rare
Musculista senhousia	1988-2001	Previously established in Pt Adelaide
Isolated occurrence		
Charybdis japonica	2000	Isolated occurrence at Outer Harbor

Introduced species		
Previously established		
Cassiopea ndrosia	1972-1995	Previously established in Angas Inlet
Isolated occurrence		
Perna canaliculus	2000, 2008	Port Adelaide, eradicated
Arthrocladia villosa	1981	Pt Stanvac, unattached
Uncertain current status		
Boccardia proboscidea	1979	Elliston
Corophium insidiosum	1990	Pt McDonnell
Conopeum seurati	1980	Brackish creek near Coffin Bay
Stictyosiphon soriferus	1975	Pt Lincoln
Discosporangium mesarthrocarpum	1985-1987	Grange, Glenelg
Antithamnion cruciatum	1994	Whyalla
Cottoniella fusiformis	1985-1988	Adelaide metropolitan coast

Table 4. Distribution and record dates for cryptogenic species confirmed to occur and likely to be present currently in SA.

Scientific Name	Dates	Distribution / notes
Cryptogenic species		
Established		
Coryne eximia	1996	Port Lincoln, may be widespread
Halecium delicatulum	1969-2009	Pearson Island, may be widespread
Antennella secundaria	1969-1996	Pearson Island, Edithburgh, may be widespread
Myxicola infundibulum	2001-2008	Pt Adelaide, Pt Lincoln, Pt Bonython
Hydroides "elegans"	1959-2000	Pt Adelaide, Pt Lincoln
Pseudopolydora paucibranchiata	1979-2001	Pt Adelaide, Pt Lincoln
Caprella penantis	1996-2006	Pt Adelaide, Adelaide coast
Parasesarma erythodactyla	2008-2009	Pt Augusta, Whyalla
Megabalanus tintinnabulum	2004-2009	Eyre Peninsula
Pinctada albina sugillata	2003-2008	Upper Spencer Gulf, Smoky Bay
Bugula neritina	1975-2009	Widespread
Membranipora membranacea	1988-1996	Widespread
Schizoporella errata	1975-2001	Pt Adelaide
Watersipora arcuata	1983-2008	Pt Adelaide, Pt Lincoln, Point Turton, Coffin Bay
Watersipora subtorquata	1975-2001	Pt Adelaide, Pt Lincoln
Zoobotryon verticillatum	1975-1983	Pt Adelaide, Coffin Bay
Barentsia benedeni	1948-1997	Pt Adelaide
Botrylloides leachi	1967-2009	Widespread
Botryllus schlosseri	1955-2005	Widespread
Chattonella globosa	1999-2009	Pt Lincoln
Chattonella marina	1996-2009	Pt Lincoln, Smoky Bay, Denial Bay, Port Broughton
Heterosigma akashiwo	1983-2009	Pt Adelaide, Pt Lincoln, Kingscote-American River
Hincksia sandriana	1963-1972	St Kilda, Robe, American River
Bryopsis plumosa	1945-2004	Widespread
Anadyomene stellata	1977-1985	Robe
Cladophora prolifera	1972-2005	Adelaide coast, Victor Harbor, American River
Ulva lactuca	1848-2009	Widespread
Caloglossa ogasawaraensis	1982-2000	Garden Island
Polysiphonia brodiei	1948-1997	American River, Robe

Gracilariopsis "lemaneiformis"	1994-1996	Robe
Present		
Arenigobius frenatus	2009	Port Augusta
Cristatogobius gobioides	2009	Angas Inlet
Ulva fasciata	1959, 2005	Wanna, West Lakes, Glenelg
Solieria filiformis	2008	Pt Stanvac

Table 5. Distribution and record dates for cryptogenic species that are confirmed to have occurred but that may not be present currently in SA.

Scientific Name	Dates	Distribution / notes
Isolated occurrence		
Eurylana arcuata	1925	Port Willunga
Uncertain current status		
Plumularia setacea	1973	Redcliff Point
Mytilus galloprovincialis	1995-2008	May be widespread, but identification of *Mytilus* spp in SA is under question
Schizoporella unicornis	1996	Port Lincoln
Sphacella subtilissima	1969, 1971	Pearson Island, Investigator Strait
Striaria attenuata	1978, 1993	West Lakes, Cowell
Vaucheria piloboloides	1986	O'Sullivan Beach
Acrosymphyton taylorii	1971	Egg Island
Chondria arcuata	1987	Pt Noarlunga
Trematocarpus affinis	1948, 1967	Victor Harbor, Port Elliot

Table 6. Summary of species reported but not confirmed to occur in SA.

Scientific Name	Notes
Trigger list	
Balanus improvisus	No verification found – doubtful occurrence
Introduced	
Haliplanella lineata	No verification found – doubtful occurrence
Cordylophora caspia	Credible report from Mt Gambier (freshwater)
Alitta succinea	No verification found – doubtful occurrence
Tanais dulongii	Published record from Pt Pirie
Palaemon macrodactylus	No verification found – doubtful occurrence
Ruditapes largillierti	No verification found – doubtful occurrence
Maoricolpus roseus	No verification found – doubtful occurrence
Bugula flabellata	Published record from Pt Adelaide
Tricellaria occidentalis	Credible report from Glenelg but question on ID
Styela clava	No verification found – doubtful occurrence
Cryptogenic	
Cirriformia punctata	Published record from Angas Inlet
Polydora ciliata	Taxonomic confusion – difficult to ID
Theora lubrica	Specimen from unspecified locality
Teredo navalis	Specimen from unspecified locality
Cryptosula pallasiana	Published records, may be widespread
Tricellaria porteri	Published record from Pt Adelaide

4.1.1. Trigger list species

The 13 trigger list species reported from SA include 8 that we consider established: the European fan worm *Sabella spallanzanii*, the chlorophytes *Caulerpa taxifolia*, *Caulerpa racemosa* var. *cylindracea*, and *Codium fragile* ssp. *fragile*, and the toxic dinoflagellates *Alexandrium minutum*, *A. catenella*, *A. tamarense* and *Gymnodinium catenatum* (Table 2). *Caulerpa taxifolia* is restricted solely to the Port River-Barker Inlet to North Haven region, and *Caulerpa racemosa* var. *cylindracea* to the Adelaide region, but the other 6 species are widely distributed. We do not classify the Pacific oyster *Crassostrea gigas* as established; the occurrence of wild oysters is sporadic and does not occur in all growing areas, and wild populations are currently subject to control and eradication programs.

Carcinus maenas and *Musculista senhousia* were established but populations have not been detected recently. *Carcinus maenas* was abundant in the Port River-Barker Inlet and common along the Adelaide metropolitan coast, with isolated confirmed reports from the GSV coast of Yorke Peninsula and in the Coorong. Abundant *Musculista senhousia* populations around Outer Harbor have disappeared. These species may still be present, but at sufficiently low population levels that they have not been detected by recent targeted surveys.

Two trigger list species reported are unlikely to be present. *Charybdis japonica* is confirmed to have occurred, but the single crab detected at Outer Harbor appears to be an isolated occurrence and the species has not been detected again. The report of *Balanus improvisus*, however, cannot be substantiated and appears highly doubtful.

4.1.2. Non-trigger list species

The 86 species considered by this report that are not on the current trigger list comprise 33 that are likely to be introduced, 50 that are cryptogenic and 3 that are now regarded as native.

Of the introduced species, 10 are not confirmed to have occurred (Table 6). Those that can be considered particularly doubtful include the anemone *Haliplanella lineata*, the polychaete *Alitta succinea*, the molluscs *Ruditapes largillierti* and *Maoricolpus roseus*, the decapod shrimp *Palaemon macrodactylus*, and the ascidian *Styela clava.* Species that appear likely to have occurred based on published records include the

bryozoan *Bugula flabellata*, and the tanaid *Tanais dulongii*, but a lack of specimens means verification of these occurrences is not possible and there are no recent records of these species. Of the 23 confirmed introduced species, we regard 11 as established in SA: the polychaete *Boccardia chilensis*, the crustaceans *Corophium acherusicum* and *Paracerceis sculpta*, the gastropod *Polycera hedgpethi*, the ascidians *Ascidiella aspersa*, *Ciona intestinalis* and *Styela plicata*, and the macroalgae *Elachista orbicularis*, *Ulva taeniata, Antithamnionella spirographidis* and *Gymnogongrus crenulatus* (Table 2). Three introduced species appear unlikely to persist: the mussel *Perna canaliculus* which was found twice at Port Adelaide but eradicated, the macroalga *Arthrocladia villosa* which was reported once as an unattached plant, and the jellyfish *Cassiopea ndrosia*, which was established, but has not been recorded recently despite targeted searches (Table 3). Two introduced species: the goby *Tridentiger trigonocephalus*, and the macroalgae *Schottera nicaeënsis,* have been recorded recently and we regard them as present, but it is not known if they have established. A lack of records means it is not possible to ascertain the current status of the remaining 7 introduced species, which include the polychaete *Boccardia proboscidea*, the bryozoan *Conopeum seurati*, the amphipod *Corophium insidiosum* and 4 species of macroalgae (Table 3). It should be noted that we categorise these species as introduced based on information from the literature, but the classification of some as introduced is uncertain, and some authors regard them as cryptogenic. This is particularly true of species with wide global distributions such as the ascidians *Ascidiella aspersa*, *Ciona intestinalis* and *Styela plicata*.

The cryptogenic species include 6 for which occurrence could not be confirmed (Table 6). Three of these appear likely to have occurred based on published records: the polychaete *Cirriformia punctata*, and the bryozoans *Tricellaria porteri* and *Cryptosula pallasiana*, although recent records of these species are lacking. No records were found to substantiate reports of the polychaete *Polydora ciliata* or the bivalves *Theora lubrica* and *Teredo navalis*; *Polydora* species do occur in SA, but identifying these to species is problematic, while the specimens of *Theora lubrica* and *Teredo navalis* do not specify collection localities. Of the 44 cryptogenic species confirmed to occur, most (30) are considered established (see Table 4). Four cryptogenic species (*Arenigobius frenatus*, *Cristatogobius gobioides*, *Ulva fasciata, Soliera filiformis*) are regarded as present since they have been recorded recently but it is not clear if they have established, and there is insufficient data to determine the current status of 9 cryptogenic species including the hydroid *Plumularia setacea*, the

bivalve *Mytilus galloprovincialis*, the bryozoan *Schizoporella unicornis* and 6 species of macroalgae (see Table 5).

4.2. Lists of introduced species in SA

The species included on published lists of introduced species for SA (EPA and DEHAA 1998; Lewis *et al.* 1998; Edyvane 1999; EPA 2003) and those shown as occurring in SA by NIMPIS (2009c) were of particular interest to this review. The incursion category and current status of these species is shown in Table 7.

Table 7. Incursion type category and current status of species reported in SA by (A) NIMPIS (2009c), and lists of introduced species in SA: (B) EPA and DEHAA (1998) and Lewis *et al.* (1988), (C) Edyvane (1999), (D) EPA (2003). "Y" species is stated in SA by this source, "N" species is not shown in SA (NIMPIS records only), "-" species not included in NIMPIS database.

Scientific Name	Category	Status	A	B	C	D
Haliplanella lineata	Introduced	Unconfirmed	-	Y	Y	
Cordylophora caspia	Introduced	Unconfirmed	Y			
Halecium delicatulum	Cryptogenic	Established	Y			
Antennella secundaria	Cryptogenic	Established	Y			
Plumularia setacea	Cryptogenic	Uncertain	Y			
Cassiopea ndrosia	Introduced	Previously established	-	Y	Y	Y
Myxicola infundibulum	Cryptogenic	Established	Y			
Sabella spallanzanii	Trigger list	Established	Y	Y	Y	Y
Hydroides elegans	Cryptogenic	Established	Y			
Boccardia proboscidea	Introduced	Uncertain	Y		Y	
Polydora ciliata	Cryptogenic	Unconfirmed	Y			
Pseudopolydora paucibranchiata	Cryptogenic	Established	Y	Y	Y	
Corophium acherusicum	Introduced	Established	Y			
Corophium insidiosum	Introduced	Uncertain	Y			
Eurylana arcuata	Cryptogenic	Isolated occurrence	Y	Y	Y	Y
Paracerceis sculpta	Introduced	Established	Y			
Tanais dulongii	Introduced	Unconfirmed	-	Y	Y	
Palaemon macrodactylus	Introduced	Unconfirmed	-		Y	
Carcinus maenas	Trigger list	Previously established	Y	Y	Y	Y
Megabalanus tintinnabulum	Cryptogenic	Established	Y			
Theora lubrica	Cryptogenic	Unconfirmed	Y			
Ruditapes largillierti	Introduced	Unconfirmed	Y			
Teredo navalis	Cryptogenic	Unconfirmed	Y	Y	Y	

Musculista senhousia	Trigger list	Previously established	Y		Y	
Mytilus galloprovincialis	Cryptogenic	Uncertain	-		Y	
Perna canaliculus	Introduced	Isolated occurrence	-	Y	Y	Y
Crassostrea gigas	Trigger list	Present	Y	Y	Y	Y
Polycera hedgpethi	Introduced	Established	Y			
Maoricolpus roseus	Introduced	Unconfirmed	N	Y	Y	Y
Bugula flabellata	Introduced	Unconfirmed	Y	Y	Y	Y
Bugula neritina	Cryptogenic	Established	Y	Y	Y	Y
Cryptosula pallasiana	Cryptogenic	Unconfirmed	Y	Y	Y	
Membranipora membranacea	Cryptogenic	Established	-		Y	
Schizoporella unicornis	Cryptogenic	Uncertain	Y	Y	Y	
Watersipora arcuata	Cryptogenic	Established	Y	Y	Y	Y
Barentsia benedeni	Cryptogenic	Established	Y	Y	Y	
Ascidiella aspersa	Introduced	Established	Y	Y	Y	Y
Ciona intestinalis	Introduced	Established	Y	Y	Y	Y
Botrylloides leachi	Cryptogenic	Established	Y	Y	Y	Y
Botryllus schlosseri	Cryptogenic	Established	Y	Y	Y	Y
Styela clava	Introduced	Unconfirmed	Y			
Styela plicata	Introduced	Established	Y	Y	Y	Y
Gymnodinium catenatum	Trigger list	Established	Y		Y	
Alexandrium catenella	Trigger list	Established	Y	Y	Y	Y
Alexandrium minutum	Trigger list	Established	Y	Y	Y	Y
Alexandrium tamarense	Trigger list	Established	Y	Y	Y	Y
Discosporangium mesarthrocarpum	Introduced	Uncertain	-	Y	Y	
Zosterocarpus sp.	Native	Uncertain	-	Y	Y	
Sphacella subtilissima	Cryptogenic	Uncertain	-	Y	Y	
Caulerpa taxifolia	Trigger list	Established	Y			Y
Codium fragile ssp. *fragile*	Trigger list	Established	N			
Ulva fasciata	Cryptogenic	Present	Y			
Polysiphonia brodiei	Cryptogenic	Established	Y	Y	Y	Y

The NIMPIS database contains distribution and ecological information for 80 species (Sliwa *et al.* 2006). Of these species, 44 were among those investigated by this review. A list of 43 species is returned when searching NIMPIS by distribution in SA, but two of these do not actually occur in SA and were not reviewed (see section 3.1), while three species reported elsewhere as occurring in SA are not shown in SA by NIMPIS.

The 41 species indicated by NIMPIS to occur in SA include 8 (4 introduced, 4 cryptogenic) for which we were unable to confirm records. Four of these are reported in SA based solely on “port survey data”, i.e. from data held by the NPSD (McEnnulty

et al. 2005). We requested queries to be run on the NPSD for 3 of these: *Ruditapes largillierti*, *Bugula flabellata* and *Styela clava*. In each case the NPSD data classes the identification of the taxon as unconfirmed, and we were not able to ascertain the existence of any specimens of these 3 species from SA. *Bugula flabellata* has been reported from Outer Harbor by Brock (1985), but we found no further reports of this species and the only specimen held by SAM is from PPB, Victoria. *Styela clava* is included in the species listing from the 2001 Port Adelaide survey, but the text of the final report states explicitly that this species was not found (Cohen *et al.* 2002) and there is no specimen of *S. clava* in the collection from this survey held by SAM (T. Laperousaz, SAM, pers. comm.), nor is there any specimen of *Ruditapes largillierti*, which does not appear in the species list. Aside from the record in NIMPIS we found no other reports of *Ruditapes largillierti* in SA. We did not request further information from the NPSD on the record of the fourth species, *Polydora ciliata*, as the confused taxonomy of this genus means that records may be unreliable (see section 3.3.14); it was also not on the species list for the 2001 Port Adelaide survey.

The other 4 species from NIMPIS for which we were unable to confirm records include two for which SAM holds specimens, but with no collection data (*Teredo navalis*, *Theora lubrica*). *Cordylophora caspia* is recorded in SA by NIMPIS based on unpublished data from the hydroid expert J. Watson. We found no other reports of these 3 species occurring in SA, aside from the report of *Teredo navalis* occurring around temperate Australia generally (Turner 1971). The report of *Cryptosula pallasiana* is supported by published records (see section 3.3.39), but we were unable to find specimens to confirm its occurrence.

The 33 species reported by NIMPIS that are confirmed to occur include 24 that can be regarded as established in SA, 6 of which are listed target species in the National System marine pest monitoring manual (National System for the Prevention and Management of Marine Pest Incursions 2010b): *Sabella spallanzanii*, *Gymnodinium catenatum*, *Alexandrium catenella*, *A. minutum*, *A tamarense* and *Caulerpa taxifolia*. Two other trigger list species recorded from SA by NIMPIS, *Carcinus maenas* and *Musculista senhousia*, are confirmed to have occurred but are now rare and we do not consider them currently established, while *Crassostrea gigas* is present as an aquaculture species but wild populations do not appear to have established (due in part to eradication programs). Another trigger list species, *Codium fragile* ssp. *fragile*, is not shown as occurring in SA by NIMPIS, although it has been recorded since 2002 (see section 3.2.13). The other trigger list species now known to occur in SA,

Caulerpa racemosa var. *cylindracea,* is not among the 80 species covered by NIMPIS.

We consider 6 of the established species reported by NIMPIS as introduced (*Corophium acherusicum, Paracerceis sculpta, Polycera hedgpethi, Ascidiella aspersa, Ciona intestinalis, Styela plicata*), and the remaining 12 established species cryptogenic (Table 7). The current status of 2 introduced (*Boccardia proboscidea, Corophium insidiosum*) and 2 cryptogenic species (*Plumularia setacea, Schizoporella unicornis*) reported by NIMPIS is uncertain. These are confirmed to have occurred but there is insufficient information available to determine if they are still present. One cryptogenic species (*Ulva fasciata*) appears likely to be present based on a recent record but it is unclear whether it has established, while *Eurylana arcuata* is known only from a single record in 1925 and appears unlikely to have persisted.

Of the 36 species reported on the lists of introduced marine species in SA, the occurrence of 7 was not confirmed by the current review: *Cryptosula pallasiana, Bugula flabellata*, *Teredo navalis* and *Maoricolpus roseus*, which are discussed above, plus *Tanais dulongii*, *Haliplanella lineata* and *Palaemon macrodactylus*. The report of *Tanais dulongii* is credible based on peer-reviewed publications, although the current status of this species is unknown. It is doubtful, however, that either *Haliplanella lineata* or *Palaemon macrodactylus* occurred in SA.

The 29 confirmed species from the SA lists include 22 that are also recorded in NIMPIS and these are discussed above. Confirmed species from the SA lists that are not covered by NIMPIS include the introduced *Cassiopea ndrosia*, which was common in Angas Inlet but has not been recently found, and *Perna canaliculus*, which was found twice at Port Adelaide but eradicated, and the cryptogenic species: *Membranipora membranacea,* which is established; and *Mytilus galloprovincialis*, which is of uncertain status due to question regarding the identity of Australian *Mytilus* spp. The remaining species from the SA lists that are not covered by NIMPIS are 3 macroalgae for which the current status is uncertain due to a paucity of records. One of these (*Zosterocarpus* sp.) is considered native, one (*Sphacella subtilissima*) is cryptogenic and one (*Discosporangium mesarthrocarpum*) introduced.

In total 17 species from the SA lists can be regarded as established currently, with 1 more classed as present. These include 6 trigger list, 3 introduced and 8 cryptogenic species (Table 7). The discoveries of other trigger list species now considered

established (*Caulerpa racemosa* var. *cylindracea* and *Codium fragile* ssp. *fragile*) occurred in late 2002, hence their absence from the SA lists is to be expected. *Caulerpa taxifolia*, discovered in SA in early 2002, is the only species to be added to the 2003 list (EPA 2003). Two species (1 introduced, 1 cryptogenic) reported on the SA lists appear unlikely to have established, while 3 were previously established but have not recently been recorded (Table 7).

It is unclear how the SA lists (EPA and DEHAA 1998; Lewis *et al.* 1998; Edyvane 1999; EPA 2003) were compiled. The 1998 lists (EPA and DEHAA 1998; Lewis *et al.* 1998) cite Furlani (1996) as the source, but only 19 of the 29 species on these lists are reported in SA by Furlani (1996) (Table 1). These lists did not include the species shown at the SA-Victoria border in Furlani (1996) that were included in the 1999 list (Edyvane 1999), and also did not include 4 species that were regarded as "presumed" or "inferred" in SA by Furlani (1996), although the other 4 species that were designated "presumed" or "inferred" were included. The list in Edyvane (1999) comprises 35 species (including all 29 from the 1998 lists) and cites Furlani (1996) as the source for records of 25 of these. The sources cited by Edyvane (1999) for the remaining 10 species (which are the same 10 appearing on the 1998 lists that are not in Furlani 1996) are CRIMP data (7 species), SARDI data (*Perna canaliculus*), Jones (1991) (*Tanais dulongii*) and Thomas *et al.* (1986) (*Cassiopea ndrosia*). The records citing CRIMP data include 4 species that are shown to occur in SA by the CRIMP port survey species schedules (Table 1), two other species (*Barentsia benedeni, Teredo navalis*) are listed but with no distribution data provided, while the other (*Cryptosula pallasiana*) is shown to occur in Tasmania only (Hewitt and Martin 1996). Three macroalgal species included on the 1998-99 lists (EPA and DEHAA 1998; Lewis *et al.* 1998; Edyvane 1999), *Discosporangium mesarthrocarpum*, *Sphacella subtilissima* and *Zosterocarpus* sp., are among the species shown in SA by the CRIMP schedules (Hewitt and Martin 1996), but it is unclear why these particular species were included while others were not. Although noted to be species known previously from Europe, neither *Discosporangium mesarthrocarpum* nor *Sphacella subtilissima* was suggested by Womersley (1987) to be introduced (although they were later included in the list of possibly introduced species, Womersley 2003), and Womersley (1987) describes *Zosterocarpus australica* as a new species endemic to SA, distinct from the Mediterranean *Zosterocarpus oedogonium*. Several species not included on the port survey schedules or SA lists had been described as probable introductions by that time, e.g. *Striaria attenuata* and *Stictyosiphon soriferus* (Skinner and Womersley 1983; Womersley 1987). The other macroalgae on the SA lists,

Polysiphonia brodiei, was discussed by Furlani (1996) and also included in the CRIMP schedules (Hewitt and Martin 1996), probably based on the report of Womersley (1979), who notes this species may have been spread by shipping, but again, it is unclear why this and not other species were considered. Hewitt and Martin (1996) list several other macroalgal species as known introductions but without providing any distribution information: these include *Antithamnionella spirographidis* and *Arthrocladia villosa* (incorrectly shown as a red alga), both of which had been recorded in SA by that time (Wollaston 1968; Skinner and Womersley 1983).

It is clear that there are some discrepancies between species reported to occur by the SA lists and NIMPIS, and those that have been confirmed to occur by this review. Problems with the SA lists include the repetition of reports stated as unconfirmed by the original source, e.g. *Haliplanella lineata* and *Palaemon macrodactylus*, and both NIMPIS and the SA lists report some species without apparent confirmation of their identity, e.g. *Styela clava*, *Ruditapes largillierti, Zosterocarpus* sp. and *Bugula flabellata* from Port Lincoln. The identification of some reported species is problematic generally and these may be mis-identified, e.g. *Polydora ciliata*, *Hydroides elegans*, *Schizoporella unicornis,* and *Mytilus galloprovincialis*. Neither the SA lists nor NIMPIS indicate whether the species recorded are likely to still be present. Some appear unlikely to have established but continue to be reported, e.g. *Eurylana arcuata* is listed by Westphalen (2008) based on NIMPIS data.

Many (21) of the species reported in NIMPIS and on the SA lists are cryptogenic, and nearly all of these have cosmopolitan distributions. These may have been spread by shipping, but determining their original native range is now not possible. The status of several as introductions, including *Myxicola infundibulum,* polydorids generally (*Polydora ciliata, Pseudopolydora paucibranchiata*), *Eurylana arcuata, Teredo navalis,* and *Mytilus galloprovincialis,* has been specifically questioned. Others, e.g. *Halecium delicatulum, Antenella secundaria* and *Sphacella subtilissima* appear predominantly to have been found at localities in SA that are remote from ports and harbours and so not indicative of human-mediated transport.

The distributions given for several species by NIMPIS and the SA lists also do not correspond to those found by the current review. The range of localities given for nearly all species on the SA lists corresponds exactly to the distributions given by Furlani (1996). This is particularly apparent for the ascidians (*Ascidiella aspersa, Ciona intestinalis, Botrylloides leachi, Botryllus schlosseri*) for which the stated distributions correspond exactly to their recorded locations in Kott (1985), although all

had been reported earlier (and subsequently) from other localities. The source for distribution information for most species reported by Furlani (1996) is unclear. *Gymnodinium catenatum* was stated by the 1999 SA list (Edyvane 1999) as presumed at the Victorian border, but it had by that time been recorded from Port Lincoln. *Bugula flabellata* is stated by Furlani (1996) and the SA lists to occur in northern GSV, but we found no records to support this. Several species were found by this review to be more widespread than indicated by NIMPIS, including *Alexandrium catenella, A. minutum, A. tamarense, Botrylloides leachi* and *Botryllus schlosseri.* In contrast, we could not confirm the occurrence of *Halecium delicatulum*, *Plumularia setacea*, or *Megabalanus tintinnabulum* in some regions reported by NIMPIS, although they were confirmed to occur elsewhere in SA and may be more widespread. Confusion regarding the distribution of several reported species has occurred subsequent to the publication of the SA lists, e.g. *Sabella spallanzanii* was reported to be established at Aldinga (DEH 2001), *Eurylana arcuata, Tanais dulongii, Crassostrea gigas* and *Polysiphonia brodiei* suggested to occur around Port Adelaide (Cohen *et al.* 2002; Johnston and Harbison 2005), with *T. dulongi* also reported at Port Noarlunga (DEH 2001) and P*. brodiei* around Holdfast Bay (Glenelg to Seacliff, ~5 km S of Brighton) (Earth Tech Engineering 2004). None of these are likely.

Another discrepancy is the absence in NIMPIS of SA occurrences of *Codium fragile* ssp. *fragile*, which has been recorded in SA since 2002 (Womersley 2003). The other species reported elsewhere as being in SA but not shown as such by NIMPIS (*Maoricolpus roseus*, *Alitta succinea*) do not appear likely to occur in SA, so in regard to these we consider NIMPIS to be correct.

4.3. Conclusions

The current review found that over 100 species have been reported as introductions in SA, and 99 of these were investigated further. Most reported species were confirmed to occur, but the occurrence of 7 is doubtful, and 10 others could not be confirmed, although reports are credible for 6 of these. Not all the species confirmed to occur are likely to still be present, nor are all necessarily introduced. There are 19 introduced species that we consider currently established in SA, 8 of which are on the trigger list for monitoring under the National System (National System for the Prevention and Management of Marine Pest Incursions 2010a, b). An additional 3, including 1 trigger list species, are likely to be present based on recent records, while 13 introduced species (3 trigger list) are confirmed, but not recently recorded, including 2 that were established but are now rare, and 2 that represent isolated

occurrences, i.e., probably did not establish. Occurrences of 11 introduced species (1 trigger list) were not confirmed.

Most (50) reported species are best considered cryptogenic, 30 of these are established, 4 recently recorded (i.e. present), and 10 confirmed but not recently found. Reports of 6 cryptogenic species were not confirmed. Three species formerly reported as introduced or cryptogenic are now considered to be native.

All reported macroalgal species were confirmed to occur. This may reflect the fact that expert identification is usually needed to identify macroalgae to species, thus, identification without the collection of a specimen for verification is rare, and reports of introduced species are made by relevant experts (e.g. Womersley 2003). In contrast, there do not appear to be specimens of several reported invertebrates. Even for many species confirmed to occur, specimens exist from few of their reported localities. This is of particular concern for the trigger list species, for which new incursions must be reported. In particular, the distribution of *Sabella spallanzanii* remains unclear, with reports of this species outside the Adelaide region being sporadic and inconsistent, and not supported by the deposition of voucher specimens in curated collections.

We found discrepancies between species reported on lists of introduced species in SA and NIMPIS and those that actually occur. It appears that the SA lists of species were compiled from a variety of sources but with little, if any, verification of records. No revised list of introduced species in SA has been compiled (until the current review) since 1998; relatively recent lists of introduced species in SA appear to be based on the 1998-99 lists (e.g. DEH 2001; EPA 2003; Earth Tech Engineering 2004) as they give identical distribution information for the species listed, and include no new introduced species except the high-profile *Caulerpa taxifolia* (since 2003). Until 2008, the list of introduced marine species displayed on the PIRSA website was the one reported by EPA (2003), this website cited the 1998 State of the Environment report (EPA and DEHAA 1988) as the source for the information (J. Gilliland, PIRSA Marine Biosecurity, pers. comm.). Other lists (e.g. Westphalen 2008) have sourced information from NIMPIS, but this database also suffers from several issues: it does not cover all species of potential interest, some records are based on personal communications or unverified data (e.g. from the CRIMP and other port surveys carried out between 1996 and 2002), and the information has not been updated since the 2006 review. It is hoped that information from the current review can be used to update NIMPIS.

It is clear that a review of introduced species in SA was overdue. While this report provides current information on the reviewed species we note that records of many are lacking, making it impossible to ascertain their current status. The lists of introduced and cryptogenic species provided may not be complete, as shown by a survey of Eyre Peninsula (Dittmann *et al.* 2010) possibly discovering several introduced species previously unreported from SA. Although we have listed these species in section 3.4, we emphasise that they are unconfirmed. This survey illustrates, however, that further research may lead to the discovery of additional introduced species. Continued surveillance is also required to detect changes in the distribution of the species that are known to occur. Specimens should be collected wherever possible and deposited in curated collections to ensure accurate identification and verification. Lack of taxonomic expertise and the confused taxonomy of some species mean that some possible introductions cannot be verified, while others may be spurious and represent previously undescribed native species. Without suitable voucher specimens, these issues cannot be resolved. It is also important that records are continually compiled, updated and recorded spatially, e.g. in a GIS-linked database such as produced for this report. This will allow new incursions and range expansions to be readily identified, thus assisting the management of introduced species and ensuring accurate reporting.

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APPENDIX

Nominal co-ordinates (Latitude and Longitude, WGS84) used for mapping records described in the text. Records for jetties or marinas were assigned different co-ordinates only for larger towns, e.g. Port Lincoln, and not for small towns or suburbs. In these cases, records pertaining to the jetty were assigned the same co-ordinates as records that did not specify exact location. Records pertaining to a large area (gulf, river, bioregion, KI) without specific information were not mapped and co-ordinates were not assigned. See Figures 1 and 2 for the location of these areas. Co-ordinates for records mapped using actual positional data are not shown below but are included in the database held by SARDI Aquatic Sciences.

Location	Latitude	Longitude
Adelaide	-34.9256	138.5997
Aldinga	-35.2601	138.4569
American River	-35.7757	137.7822
Anchor ground	-34.7900	138.3332
Angas Inlet	-34.8059	138.5285
Ardrossan	-34.4283	137.9248
Backstairs Passage	-35.6496	138.0647
Ballast Head	-35.7575	137.8074
Bay of Shoals	-35.6149	137.5736
Beachport	-37.4942	140.0180
Boston Bay	-34.6559	135.8892
Boston Island	-34.7026	135.9331
Brighton	-35.0176	138.5089
Broken Bottom reef	-34.9634	138.4803
Canan Reef	-32.6457	133.2410
Cape Donington	-34.7106	135.9839
Cape Jaffa	-36.9377	139.6776
Cape Jervis	-35.6065	138.0919
Cape Lannes	-37.1825	139.7393
Carrackalinga	-35.4249	138.3188
Ceduna	-32.1259	133.6683
Christies Beach	-35.1400	138.4658
Coffin Bay	-34.6195	135.4693
Coobowie	-35.0457	137.7351
Cowell	-33.6897	136.9392
Denial Bay	-32.1074	133.5916
Eastern Cove	-35.7938	137.8259
Edithburgh	-35.0848	137.7496
Egg Island	-32.4882	133.3357
Elliston	-33.6398	134.8795

Encounter Lakes (Victor Harbor)	-35.5684	138.6041
Fitzgerald Bay	-32.9435	137.7777
Franklin Harbour	-33.7493	136.8963
Garden Island	-34.8102	138.5408
Glenelg	-34.9793	138.5056
Grange	-34.9091	138.4841
Granite Island	-35.5625	138.6323
Hallet Cove	-35.0781	138.4907
Haslam	-32.5120	134.2083
Henley Beach	-34.9268	138.4915
Inner Harbour, Port Adelaide	-34.8343	138.5070
Investigator Strait	-35.3982	137.3619
Kingscote	-35.6556	137.6449
Kingston Park Beach	-35.0398	138.5086
Kingston SE	-36.8258	139.8287
Klein Point	-34.9611	137.7758
Largs Bay	-34.8221	138.4808
Location	**Latitude**	**Longitude**
Laura Bay	-32.2412	133.8156
Louth Bay	-34.5429	135.9381
Marion Bay	-35.2392	136.9853
Minribbie Creek	-34.5489	135.4877
Moonta Bay	-34.0521	137.5526
Mount Gambier	-37.8449	140.7800
Mundoo Channel	-35.5378	138.8853
Murray Mouth	-35.5583	138.8797
Muston	-35.8157	137.7478
North Arm	-34.8124	138.5289
North Haven boat ramp	-34.7933	138.4861
North Haven gyre	-34.8018	138.4640
North Haven marina	-34.7843	138.4864
Onkaparinga River	-35.1568	138.4728
O'Sullivan Beach boat ramp	-35.1194	138.4670
Outer Harbor	-34.7726	138.4841
Pearson Island	-33.9584	134.2713
Penneshaw	-35.7173	137.9434
Point Lowly	-33.0011	137.7867
Point Morrison	-35.7218	137.7839
Point Turton	-34.9333	137.3528
Port Augusta	-32.5402	137.7790

Port Bonython	-33.0040	137.7931
Port Broughton	-33.5997	137.9260
Port Elliot	-35.5349	138.6852
Port Gawler	-34.6447	138.4330
Port Hughes	-34.0750	137.5419
Port Julia	-34.6639	137.8833
Port Lincoln	-34.7164	135.8701
Port Lincoln marina	-34.7424	135.8761
Port Lincoln town jetty	-34.7164	135.8701
Port MacDonnell	-38.0560	140.7020
Port Noarlunga	-35.1491	138.4657
Port Pirie	-33.1238	137.9799
Port Stanvac	-35.1056	138.4682
Port Victoria	-34.4952	137.4804
Port Vincent	-34.7679	137.8607
Port Wakefield	-34.1963	138.1404
Port Willunga	-35.2593	138.4595
Proper Bay	-34.7907	135.8772
Rapid Bay	-35.5211	138.1852
Redcliff Point	-32.6951	137.8303
Robe	-37.1599	139.7565
Robe marina	-37.1622	139.7504
RSAYS marina	-34.7749	138.4890
Seacliff	-35.0343	138.5145
Section Bank	-34.7484	138.4990
Semaphore	-34.8377	138.4734
Smoky Bay	-32.3770	133.9277
Snug Cove	-35.6920	136.8062
St Francis Island	-32.5010	133.2963
St Kilda	-34.7544	138.5120
St Kilda boat ramp	-34.7439	138.5352
St Peter Island	-32.2257	133.6923
Stansbury	-34.9080	137.8005
Stony Point	-32.9850	137.7160
Streaky Bay	-32.7899	134.2082
Ti tree	-35.6259	139.0756
Tiparra reef	-34.1056	137.4107
Location	**Latitude**	**Longitude**
Topgallant Island	-33.7221	134.4912
Tumby Bay	-34.3779	136.1071

Upper Port River (Jervois Bridge)	-34.8460	138.4970
Venus Bay	-33.2358	134.6518
Victor Harbor	-35.5820	138.6021
Vivonne Bay	-35.9896	137.1889
Waldegrave Island	-33.6003	134.8125
Wallaroo	-33.9272	137.6167
Wanna	-34.8936	135.8449
Wardang Island	-34.4980	137.3902
West Beach	-34.9393	138.4945
West Beach boat ramp	-34.9582	138.5041
West Island	-35.6055	138.5927
West Lakes	-34.8774	138.4873
Western Cove	-35.7217	137.6633
Western River Cove	-35.6738	136.9708
Whyalla	-33.0370	137.6011
Wirrina	-35.5004	138.2417
Wright Island	-35.5830	138.6069
Yatala Harbour	-32.7530	137.9165