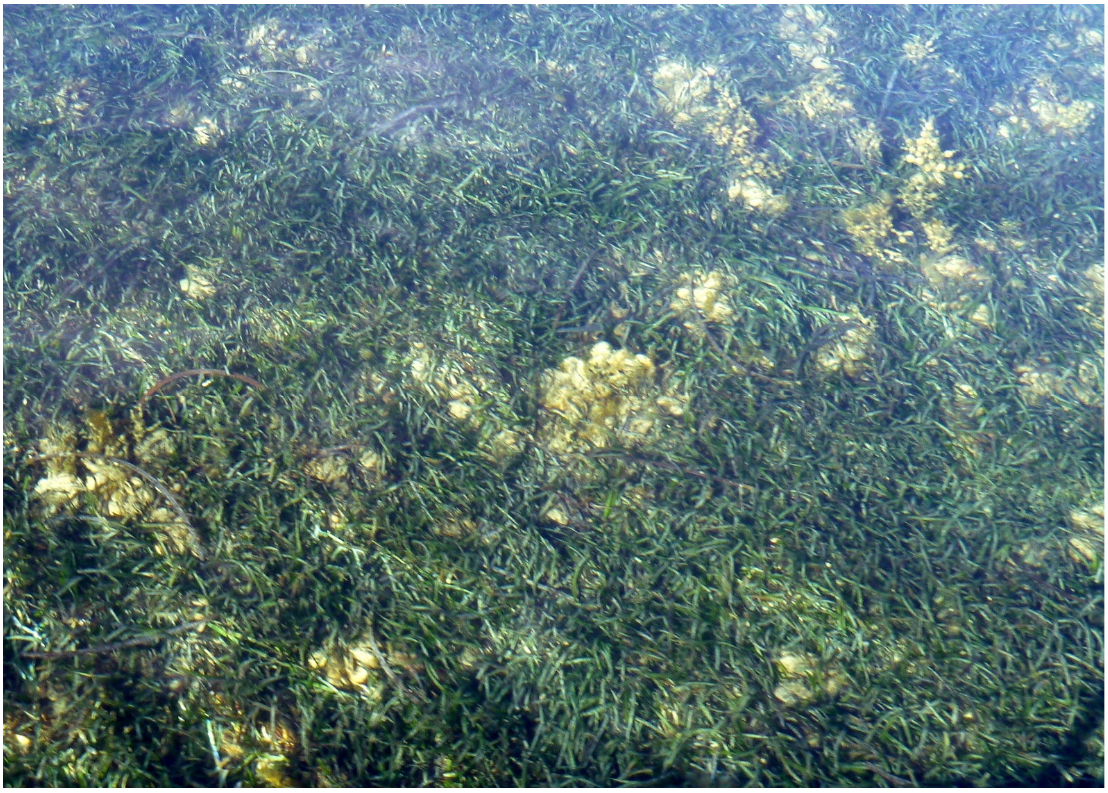
Spatial Distribution of the Pearl Oysters (*Pinctada albina sugillata*) within the upper Spencer Gulf, South Australia

A report to the Northern and Yorke Natural Resource Management Board



Henry Rutherford and David Miller

Department of Environment and Natural Resources, South Australia

August 2011

For further information please contact:

Department of Environment and Natural Resources
Phone Information Line (08) 8204 1910, or
see SA White Pages for your local
Department of Environment and Natural Resources office.

Online information available at: http://www.environment.sa.gov.au

Cite as: Rutherford, H. and Miller, D. 2011 Spatial Distribution of *Pinctada albina sugillata* within the upper Spencer Gulf, South Australia. Marine Parks, Department of Environment and Natural Resources, South Australia.

Acknowledgements

The authors would like to acknowledge the assistance provided by Shane Holland (DENR) with field work, Dimitri Colella (DENR) with processing video footage and Professor Peter Fairweather for guidance and advise regarding survey design, statistical analysis and for a review of this document. We also acknowledge and appreciate the input of the marine advisory committee of the Pt Augusta city council and community members relating to the location of pearl oysters in the area, and particular thanks go to Tim Liebelt (NYNRM) for his commitment to getting the project off the ground and assistance in the field. Finally we thank the Northern and Yorke NRM for funding this project.

Photography: D Miller

Government of South Australia

Department of Environment and Natural Resources

Contents

Executive Summary

In early 2011, upper Spencer Gulf community members raised concerns through the Northern and Yorke NRM (Natural Resource Management) Board over the invasive nature of pearl oysters in their region, with particular reference to the colonisation of razorfish beds. The Northern and Yorke NRM Board then contracted the Department of Environment and Natural Resources (DENR) to determine the spatial extent of pearl oysters in the upper reach of the Spencer Gulf.

Two field surveys conducted in March and June 2011 collected geo referenced video data. Data on the presence and density of pearl oysters, razorfish and habitat type were extracted from video footage and used to produce a map of pearl oyster distribution within the study area.

Results indicate that pearl oyster colonies tended to be denser in the northern half of the study area and in particular along the edges of the main channels. Density and frequency of confirmed colonies were lower in the southern half of the study area. Pearl oysters were often associated with razorfish; however, they were also found colonising areas with few or no razorfish.

Observations made during this study also suggest pearl oysters may be invading habitat previously dominated by the seagrass *Posidonia* spp. (strapweed), gaining a foothold on razorfish, then progressively colonising outward on shell debris from previous generations of oyster. This assertion is based on the observation of different areas that are potentially at different stages in this process, and is by no means confirmed. None the less, if this invasive process is occurring it is a serious concern and warrants further investigation.

Future investigations could extend this work by further examining the spatial extent of colonisation at the confirmed sites, rates of spread and the factors influencing expansion of pearl oyster habitat. Consideration could also be given to possible interactive effects with seagrass in the area.

Introduction

In early 2011, the local upper Spencer Gulf community raised concerns through the Northern and Yorke NRM (Natural Resource Management) Board over the invasive nature of pearl oysters in their region, with particular reference to the colonisation of razorfish (*Pinna bicolor*) beds. Northern and Yorke NRM Board contracted the Department of Environment and Natural Resources (DENR) to determine the spatial extent of pearl oysters in the upper reach of the Spencer Gulf.

Pearl oysters have been noted in the area since the 1980's (S. Shepherd, SARDI, pers. comm. in Wiltshire et al. 2010) and have been identified as the *Pinctada albina sugillata* variety (Wiltshire *et al*. 2010).

Pintada albina sugillata is native to Australia and described as endemic from the Gulf of Carpentaria to the Lower East Coast (http://clade.ansp.org/obis/, "A Biotic Database of Indo-Pacific Marine Mollusks", The Academy of Natural Sciences). This species is a commercially fished and farmed in the East Coast Pearl Fishery (ECPF); however, it is listed as being a less desirable species for pearl farming and there has been a decline in the demand for wild catch pearl oysters for aquaculture (Queensland Department of Primary Industries and Fisheries 2006).

Project Aims

The project aims were to:

- Map and confirm reports from community members of pearl oyster distribution in the upper Spencer Gulf.
- Analyse mapped information against characteristics derived from a variety of sources; both biological (habitat), and physical (depth, aspect and slope) data, and investigate possible correlations between these characteristics and the presence of oysters.

Methods

Study Area

The study area was determined based on information provided through Northern and Yorke NRM by concerned community members. The survey covered the area of upper Spencer Gulf from Orchard Point in the north, to the area between Mangrove Point and Red Cliff Point in the (**Figure 1**).

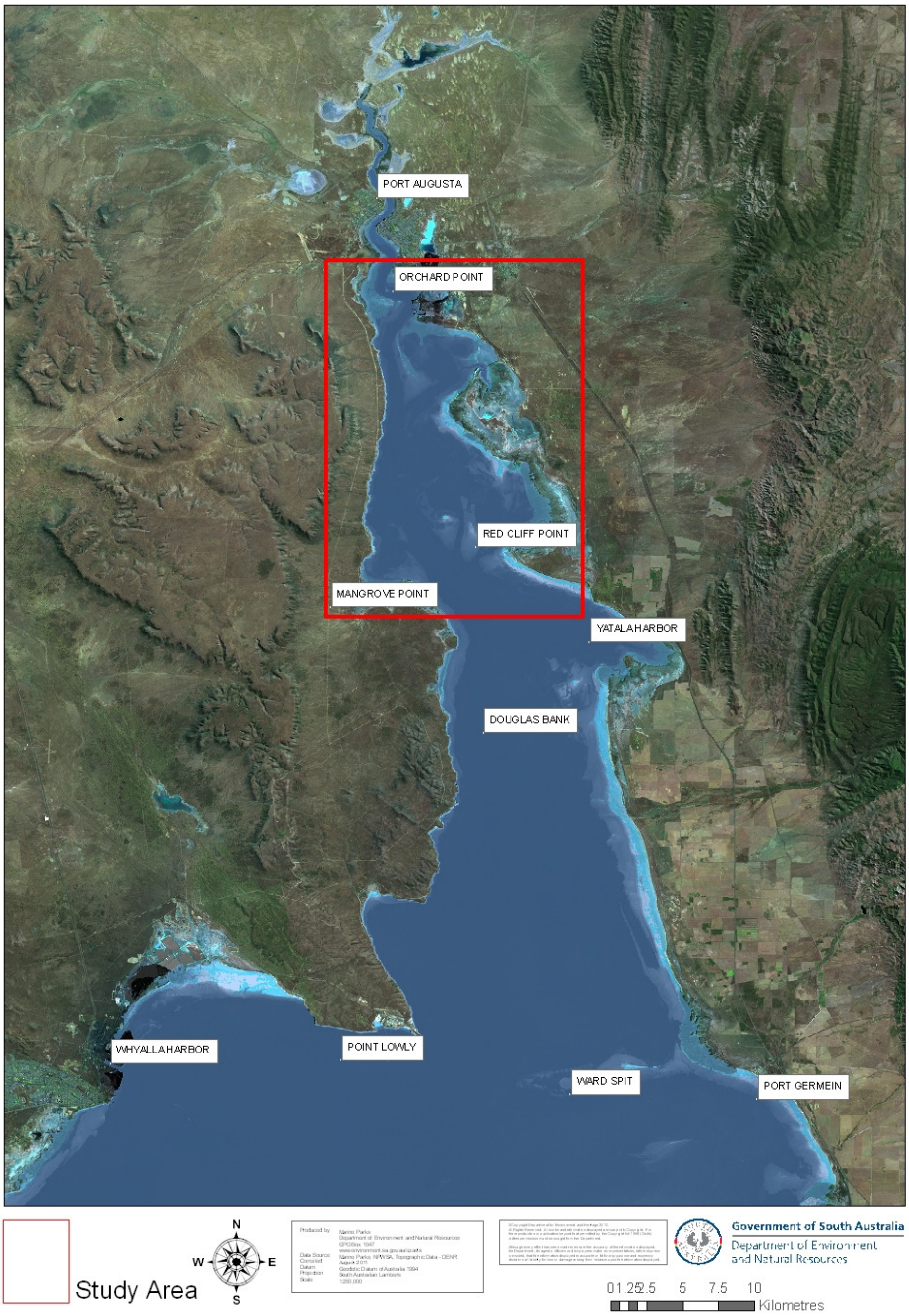


Figure 1. Pearl oyster study area, between Orchard Point and the area between Mangrove Point and Red Cliff Point in upper Spencer Gulf

Field Survey

Two field surveys were conducted, the first from the 21st to 23rd of March, and the second from the 14th to 17th of June 2011.

- The March survey was a pilot to test survey techniques and gain some general insight into the problem. Video data was collected along east / west transects run over wide range of habitats and depths. From this survey it was determined that it would not be possible to fully cover the survey in this manner and a more targeted approach was adopted for the subsequent survey trip.
- The June survey targeted suspected pearl oyster infestations from information provided to the NYNRM through the local community. Sites where pearl oysters had been reported were targeted and all were investigated at some level. In addition, a number of areas with similar physical characteristics (e.g. depth, slope, and aspect) and some physically quite different sites were selected subjectively and included to broaden the findings of the survey. Throughout this survey, wherever possible, 200 – 300m transects were run in two directions across reported locations (at some sites this was restricted by depth).

A towed underwater video camera system was used to capture footage of the sea floor along transects. The system consisted of a Scielex underwater video camera linked to an Archos portable digital hard drive recorder. GPS data was simultaneously encoded on the audio track of the video file to provide position information relative to video footage. In all, over 17 hours of video footage was collected, at an average speed of 1.5 knots, covering over 50 km of transect.

Data Processing

Geo referenced video data was analysed using a combination of VLC media player, and a purpose-built visual basic program for decoding GPS data and classifying habitat type.

Video footage was classified based on three variables:

- Habitat classification was derived from the dominant structure-forming biota. Where no biota was present sediment was classified by grain size (see Table 1 Habitat classifications and descriptions used in the mapping of pearl oysters in the upper Spencer GulfTable 1).
- Pearl oysters were classified as: not sighted; sighted; probable but not confirmed (where visibility was reduced) and dense (>30% of ground cover or >80% surface cover of razorfish).
- Razorfish were classified as: not sighted; probable but not confirmed (where visibility was reduced) and sighted.

Table 1 Habitat classifications and descriptions used in the mapping of pearl oysters in the upper Spencer Gulf

Classification	Description
Algae	Algae dominant habitat
Algae and Invertebrates	Algae and Invertebrate dominant habitat
Amphibolis	Seagrass *Amphibolis* spp. dominant habitat
Amphibolis and Posidonia	Seagrass *Amphibolis* spp / *Posidonia* sp. dominant habitat
Cobble	Bare Substrate, particle size 60 - 250mm
Halophila	Seagrass *Halophila* spp. dominant habitat
Invertebrates	Invertebrate dominant habitat
Mud	Bare Substrate, particle size <63um
Mussels	Mussel dominant habitat
Posidonia and Algae	Seagrass *Posidonia* spp. and Algae dominant habitat
Posidonia: Medium / Sparse	Seagrass *Posidonia* spp. dominant habitat, 15-85% cover
Posidonia; Dense	Seagrass *Posidonia* spp. dominant habitat, >85% cover
Sand	Bare Substrate, particle size <2mm
Zostera	Seagrass *Zostera* sp. dominant habitat

Mapping

A Microsoft Access database was developed to manage and compile data. Data was transferred into ESRI ArcGIS and displayed spatially. Data on pearl oyster incidence was merged into 20 m cells for mapping and further analysis. This merged data was used to produce a map of pearl oyster presence and absence.

Predictive Mapping

Data previously merged to 20 m cells was examined with depth, slope, aspect and benthic habitat type information of the same resolution in order to derive physical parameters that may indicate favourable locations for pearl oyster colonisation.

Classification and regression tree analysis (CART) was used to derive sets or sequences of ‘favourable’ characteristics which could be used to predict areas more likely to be colonised by pearl oysters.

Results

Spatial distribution of pearl oysters in the study area

Pearl oysters were found in a variety of densities from north of the power station to Redcliffe Point (Figure 2). They were often but associated with razorfish; however, some were also found colonising areas with few or no razorfish. They were generally found in intertidal and sub tidal areas to 2 metres depth, and were often found on the edges of *Posidonia* seagrass beds. Infestations tended to be denser in the northern half of the study area and in particular along the edges of the main channels.

The study area was divided into four readily apparent natural divisions for further examination (Figure 2).

- North western area – the main channel from Orchard Point to Commissariat Point.
- North eastern area – the embayment of Port Paterson.
- South western area – the East and West sands, and Flinders Channel.
- South eastern area – the embayment from Point Paterson to Red Cliff Point.

Of the areas covered in this video survey, pearl oysters were confirmed across the study area at 21.0% of the recorded video points in areas where they had been reported (target areas) and 14.5% overall (Table 2).

In the north western area from Orchard Point to Commissariat Point along the course of the main channel, the highest occurrence of pearl oyster was a 42.6% incidence within target areas, and 29.1% overall.

In the north eastern area around the embayment of Port Paterson also had a relatively high occurrence of pearl oysters with a 20.7% incidence in targeted areas, and 15.2% overall.

In contrast, the South western area along the sides of main channel to the channel opening around the East and West Sands saw pearl oysters in smaller numbers. The survey identified pearl oysters in 15.2% of targeted areas and 10.3% overall.

Likewise, in the south eastern area around the embayment reaching from Point Paterson to Red Cliff Point, pearl oysters were identified with a 5.4% result in targeted areas and 3.3% overall.

In some areas visibility was reduced due the presence of the filamentous brown algae *Hincksia sordida*. In video footage affected by the bloom, suspected infestations of pearl oyster were marked as ‘probable but not confirmed’.

Table 2 Incidence of pearl oysters in survey, and target areas (areas identified by community groups as having pearl oysters present.

	%Survey pts InTargetArea	%TargetArea pts Positive	%SurveyInNon TargetArea	%NonTargetArea Positive	%TotalArea Positive
NW	35.5	42.6	64.5	18.7	29.1
NE	53.7	20.7	46.3	7.0	15.2
SW	53.3	15.2	46.7	4.8	10.3
SE	52.4	5.4	47.6	1.6	3.3

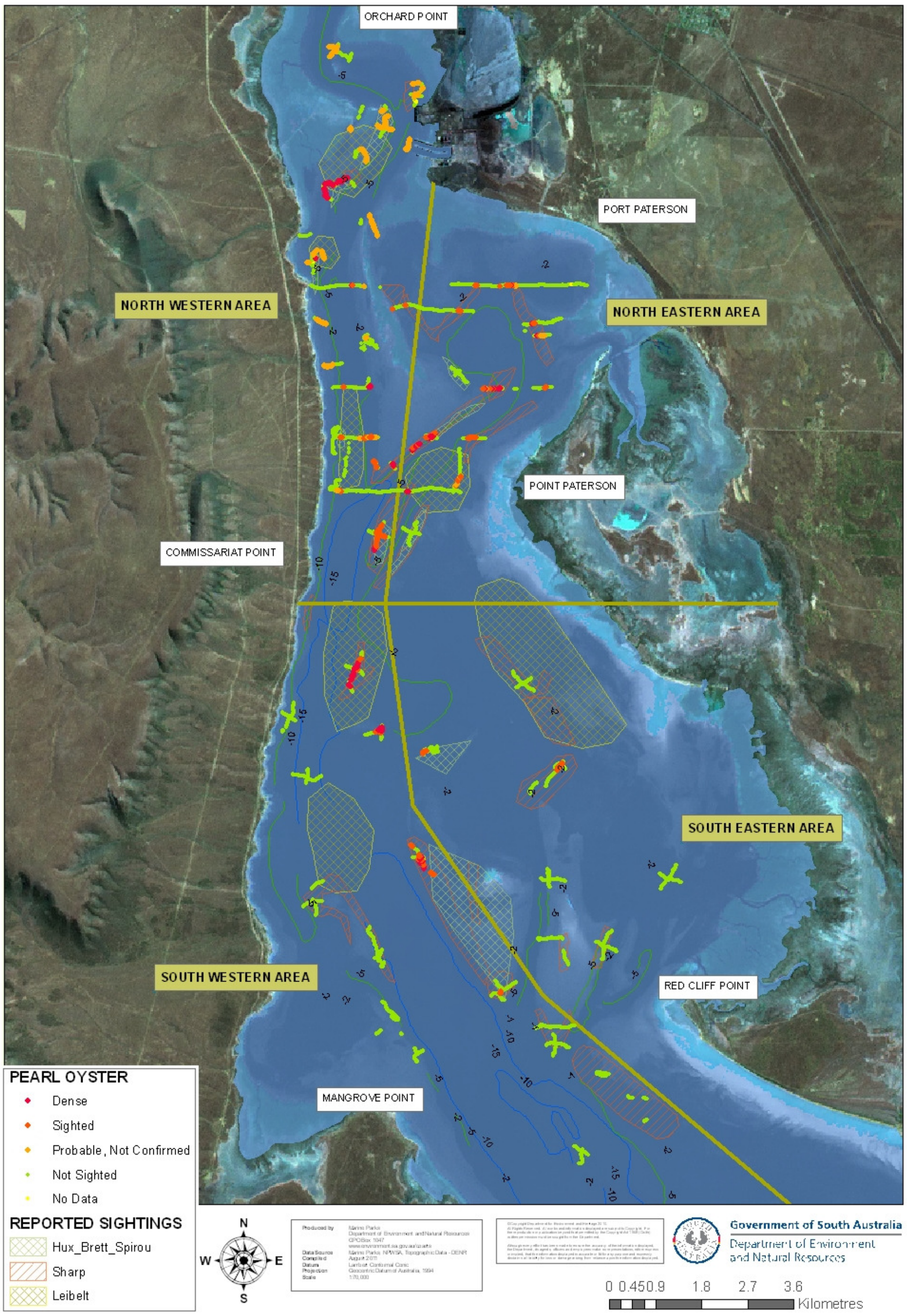


Figure 2 Upper Spencer Gulf pearl oyster study comparison areas, reported infestations, and survey results.

Predictive Mapping

Correlation and regression tree analysis (CART) was performed on a variety ancillary data, including depth, slope, aspect, quadrant (of the survey area, see above) and habitat (using habitat classes from 2006 NRM habitat mapping, DEH 2007). This analysis produced no simple outcomes in terms of predictors (see Appendix B for an example output of splitting variables). However, variable by variable there is the suggestion that several of these factors may interact to provide favourable conditions for pearl oysters with bathymetry, benthic habitat type and quadrant/latitude appearing important (the latter could relate to current, temperature or the point of origin of the pearl oysters).

The lack of any clear predictors may relate to the differences in the scale at which the information used in this analysis was collected. Data from a variety of previous work was used and much of it was collected at a broad scale. For example, benthic habitat information was originally collected with a minimum mapping unit of 1 hectare while bathymetry is from a variety of sources and was originally mapped at a 50 square metre scale. Slope and aspect were also derived from the bathymetry. Information at broader scales may make it difficult to make predictions at the finer scale.

The lack of clear predictors made the final step of producing a predictive map impossible.

Discussion

Overall, 14.5 % of recorded video survey points in this survey produced a positive result for pearl oysters. The majority of these, and the majority of dense infestations, were found in the northern half of the study area (i.e. north of Commissariat Point) and predominantly along the edges of channels and on intertidal flats. This distribution most likely reflects the origin and dispersal characteristics of the species in this area.

Although the origin of *Pinctada albina sugillata* is not known, it has been in the area for at least since the 80’s (Shepherd pers. comm.). It has most likely arrived via shipping ballast. This could be local, however there is also the possibility that it arrived further south (eg Whyalla) and worked its way north to more favourable conditions.

This species is primarily tropical, although it is found in sub tropical waters down the east coast of Australia into New South Wales. The naturally warmer waters of the Spencer Gulf provide an ideal refuge for tropical species such as the pearl oyster (Dittmann *et al.* 2010).

Despite its tropical origins, there are reports of this species from elsewhere in the gulf and beyond. It is well established in the Fitzgerald Bay area (BHP Billiton 2009), and has been reported as far south as the Port Lincoln Marina (Dittmann et al. 2010) and Smokey Bay on the west coast (Shepherd pers. comm.).

P. albina sugillata’s ability to persist and colonise in the upper Spencer Gulf is likely dependent on fluctuations in water temperature which are likely to control its breeding cycle (O’Connor 2001). O’Conner (2001) compared breeding patterns of *P. albina sugillata* in Port Stephens NSW with previous studies on Thursday Island (Tranter 1958) and Orpheus Island (Beer and Southgate 2001) Qld. Conner found that the breading season of this species was significantly truncated (1-2 months) at Port Stephens in NSW relative to Thursday Island (where it bred year round) and Orpheus Island (where breeding was limited to 10 months).

It is likely that summer temperatures in upper Spencer Gulf allow for spawning and oysters are reproductively dormant for the remainder of the year (see appendix B for summer sea surface temperatures for Spencer Gulf). Given relatively long lifespan of pearl oysters, it may also be possible their distribution further south has been made viable by occasional years in which water temperatures have been consistently higher. This observation may be worth considering in the context of local thermal influences from the Pt Augusta power station, and, in the longer term, in the context of climate change.

Much of the concern surrounding the invasive potential of this species in the Port Augusta area is associated with its impact on razorfish (*Pinna bicolor*). Pearl oysters often settle on the exterior of razorfish shells and have the potential to cause stress to the razorfish (Dittmann et al. 2010). Evidence of heavy colonisation of razorfish was plentiful in this survey suggesting that local concern is justified.

A better understanding of the direct effects of pearl oyster colonisation of razorfish is needed to fully understand the likely effects of this species on razorfish more broadly. Biosecurity SA is currently attempting to address this knowledge gap through the initiation of a study examining interactions between the two species.

The potential impact of pearl oysters on other important species and habitats also warrants examination. Observations made during this study suggest pearl oysters may be invading habitat previously dominated by the seagrass *Posidonia* spp. (strapweed). The oysters first colonise the razorfish but as successive generations of oysters die, shells build up on the surrounding seafloor providing substrate for further colonisation. In some areas there is the appearance that aggregations on neighbouring razorfish are expanding and eventually joining to smother out the seagrass and become the dominant habitat-forming species. This assertion is based on the observation of different areas that are potentially at different stages in this process, and is by no means confirmed. Nonetheless, if this invasive process is occurring, it is a serious concern and warrants further investigation.

Future investigations into pearl oysters in this area could expand on this study through investigation of the extent of confirmed pearl oyster sites and further examination of factors that may be predictors for sites that are favourable for pearl oysters. Research into local breeding and dispersal mechanisms and the rate at which these colonies are expanding would also be useful in their management. It is recommended that future mapping exercises be carried out in autumn but winter be avoided, as during winter *Hincksia sordida* (‘brown slime’) tends to dominate the area lowering visibility and reducing survey effectiveness.

References

Beer, A.B. Southgate, P.C. 2001 Collection of pearl oyster (Family Pteriidae) spat at Orpheus Island, Great Barrier Reef (Australia). J. Shellfish Res. 19, 821-826.

BHP Billiton 2009 Olympic Dam Draft Environmental Impact Statement; Appendix O Marine Environment (http://www.bhpbilliton.com/home/aboutus/regulatory/Documents/odxEisAppendixO1MarineEcologicalSurveys.pdf; viewed August 2011)

DEH 2007 Nearshore Marine Benthic Habitat Mapping, Northern Spencer Gulf - South Australia. Department for Environment and Heritage, Adelaide, SA

Dittmann, S. Cameron, S. Conlon, K. 2010. Increasing knowledge of introduced species in the marine environments of the Eyre Peninsula Flinders University, School of Biological Sciences, Bedford Park, South Australia

O'Conner, W.A. 2001 Latitudinal variation in reproductive behaviour in the pearl oyster, *Pinctada albina sugillata*. J. Aquaculture Res. 209, 333-345.

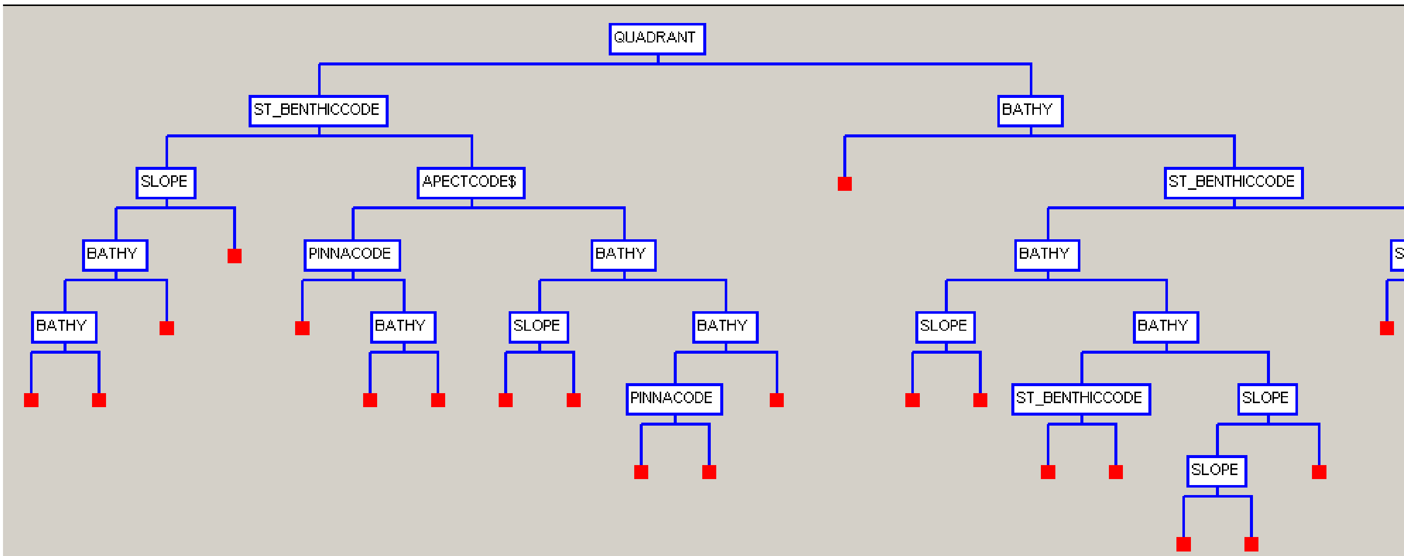
Queensland Department of Primary Industries and Fisheries 2006 Annual Status Report 2006 East Coast Pearl Fishery.

Tranter, D.J. 1958 Reproduction on Australian pearl oysters (lamellibranchia) III. *Pinctada albina* (Lamarck): breeding season and sexuality. Aust. J. Mar. Freshwater Res. 9, 191-216.

Wiltshire, K. Rowling, K. Deveney, M. 2010. Introduced marine species in South Australia: a review of records and distribution mapping. SARDI Aquatic Sciences, Henley Beach, South Australia pp 107-108.

Appendix A – Example regression tree for presence/absence of pearl oysters

(Predictor Variables = Aspect, Bathymetry, Habitat code (ST Benthic Code) Pinna code, quadrant and slope)



Variable Importance

Variable	Score
BATHY	100.00
ST_BENTHICCODE	71.25
QUADRANT	68.32
SLOPE	58.59
APECTCODE$	55.02
PINNACODE	38.26

Appendix B – Average summer sea surface temperatures for Spencer Gulf