Project Plan SP 2009-002

Spatial and temporal patterns in the structure of intertidal reef communities in the marine parks of south-western Australia

Marine Science

Project Core Team

Supervising Scientist	Alan Kendrick
Data Custodian	
Site Custodian	

Project status as of Nov. 15, 2016, 3:40 p.m.

Approved and active

Document endorsements and approvals as of Nov. 15, 2016, 3:40 p.m.

Project Team	granted
Program Leader	granted
Directorate	granted
Biometrician	required
Herbarium Curator	not required
Animal Ethics Committee	not required

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Science and Conservation Division Program

Marine Science

Parks and Wildlife Service

Service 2: Conserving Habitats, Species and Ecological Communities

Project Staff

Role	Person	Time allocation (FTE)
Supervising Scientist	Michael Rule	0.15
Research Scientist	Alan Kendrick	0.15
Research Scientist	John Huisman	0.1

Related Science Projects

Proposed period of the project

None – None

Relevance and Outcomes

Background

1\. The ecology of temperate intertidal reef platforms As the inter-face between marine and terrestrial environments, wave-cut intertidal reefs are a harsh environment, and the distinctive composition of temperate intertidal reef communities reflects both the ability of organisms to tolerate a relatively wide range of physical conditions and the consequences of biological processes such as recruitment, competition and predation (Dakin & Bennett 1987, Edgar 2001). The pronounced vertical distribution of intertidal organisms typically relates to their capacity to tolerate relatively predictable tidal cycles of exposure, inundation and wave action. Hence, species diversity on the high intertidal is low and typically restricted to desiccation-resistant molluscs (such as _Austrolittorina _and _Nodilittorina),_ while organisms of particular abundance on the rarely exposed reef crest (such as _Haliotis roei)_ are more robust to the effects of high wave energy (Edgar 2001, 2008). On the broader reef platform, even small variations in height relative to the tide datum can lead to significant differences in environment conditions caused by varying degrees of tidal exposure. Hence, organisms are commonly also patchily distributed across the seemingly minor depressions, rock-pools and ridges that occur on most reef platforms (Britton et al. 1988). In addition to tidal influences, intertidal reef habitats are also subject to less predictable episodic disturbances from, for example, strong wave action, sand deposition and relatively extreme temperatures (Dayton 1971), which may result in localised or widespread mortality among intertidal organisms (Hodgkin 1959a, Leviten & Kohn 1980, Kohn 1993). Such disturbances can act to maintain community heterogeneity across a range of scales (Lubchenco & Menge 1978). The biological communities of shoreline platform reefs may also be influenced by terrestrial factors, such as freshwater aquifer discharge, particularly if these sources are polluted (Johannes 1980). Complex biological processes such as recruitment, competition, herbivory and predation also strongly influence the structure of intertidal communities (Dayton 1971, Lubchenco & Menge 1978). While larval recruitment to reef platforms may vary depending on life-cycle traits (such as direct or pelagic larval development), the availability of space and competition between organisms for space are major factors that structure intertidal reef communities. Early life stages of many organisms, for example, may require suitable settlement habitat (Raimondi 1990), while some species are competitively dominant over others (Dayton 1971). Intra-specific competition among cohorts may also affect community composition (Boventura et al. 2003). The potential dominance of competitively successful species may in turn be restricted by herbivory, predation or disturbance events. Direct human interactions can also impact on intertidal reef

habitats, which are often easily accessible from the shore. Such impacts may comprise the trampling of organisms by repeated access or their removal by collecting (Robinson 2005). Platform reefs support some important recreational and commercial fishery species, such as Roe's abalone Haliotis roei while other species may be taken for bait or by shell collectors (Keough et al. 1991, Hancock & Caputi 2006). 2\. Intertidal reefs in temperate Western Australia. While wave sculpted intertidal platform reefs are a feature of many temperate Australian rocky shores, their presence and structure depends on the wave exposure and the underlying geology (Dakin & Bennett 1987). Hence, while such platform reefs are relative uncommon along WA's predominantly granitic south coast, they are a common coastal feature of the 'warm' temperate zone extending from Shark Bay to Cape Leeuwin where coastal features are dominated by the softer Tamala limestone. Mainland and island intertidal reefs of this region typically comprise a flat reef platform backed to landward side by an undercut cliff (Figure 1), while isolated patch reefs typically comprise only the reef flat. The platform width varies markedly; those at Rottnest Island commonly exceed 50 m in width and are typically wider than those on the adjacent mainland. The reef platforms vary in structure from being relatively level to very irregular due to the presence of gutters and rock-pools, and their elevation in relation to tide datum may vary considerably. The seaward platform edge is frequently raised into a distinct rim beneath which the reef falls away in a vertical or undercut face to the seabed below. 3\. Intertidal reefs of the Marmion and Shoalwater Islands Marine Parks The Marmion Marine Park (MMP) and Shoalwater Islands Marine Park (SIMP) are located on the north and south Perth metropolitan coast, respectively. Covering coastal waters between Burns Beach and Trigg Island, the ca 9,500 ha MMP was created in 1987, while the ca 6,658 ha SIMP was created in 1990 over coastal waters from South Channel to Becher Point (CALM 1992, DEC 2007). Sanctuary zones were, however, only established in the SIMP as recently as 2007. The MMP and SIMP comprise a similar geomorphology dominated by sub-tidal and emergent limestone reefs and shallow sandy embayments (Searle & Semenuik 1985). Both marine parks support a diverse range of marine conservation values ranging from various marine habitats to threatened marine fauna. These marine parks are subject to high levels of recreational and commercial human activity due to their proximity to the Perth metropolitan area. Occurring along mainland and island shores and as isolated offshore patch reefs, significant areas of intertidal reef platform occur in both the MMP and SIMP. Intertidal reef organisms of the Perth region have been studied since the early 1950s (Smith 1952, Marsh 1955, Hodgkin 1959b, Hodgkin et al. 1959). Since that time, most local research in this field has been concentrated at Rottnest Island, which supports large areas of intertidal reef (see Black & Johnson 1983, Wells et al. 1993a, 1993b). Studies in the 1980s on the intertidal reef fauna of the Perth metropolitan mainland derived from concern regarding exploitation of H. roei and planning for the then proposed Marmion Marine Park (Wells et al. 1987). A recent re-examination of intertidal reef invertebrates at Cottesloe, Waterman and Trigg on the northern Perth metropolitan coast concluded that no major changes in these communities had occurred since the 1980s (Wells et al. 2007). This study however, examined only three mainland reef sites, of which, two (Trigg and Waterman) were located within the MMP. Management of intertidal reefs in the Perth region has increased significantly in recent decades through the creation of marine parks and reserves and enhanced fishery controls (CALM 1992, Hancock & Caputi 2006, DEC 2007). While the above studies provide a significant regional knowledge base, the broad spatial patterns of intertidal biodiversity across both the MMP and SIMP are not adequately understood. Particular gaps exist in knowledge of the intertidal communities of the SIMP and offshore platform reefs. This project will significantly expand on the knowledge generated by Wells et al. (1987, 2007) by increasing the number of sampling sites across both the MMP and SIMP and including offshore platform reefs. This study will determine relationships between the composition of these communities and the physical structure and location of the reefs. This study will focus on assemblages of algae, echinoderms, molluscs and barnacles, as these include major primary producers (ie algae), grazers (ie echinoderms and molluscs) and predators (ie molluscs) in these habitats. It is anticipated that this study will provide a basis for the design and implementation of comparative intertidal research in marine parks and reserves across WA. _4\. Management relevance_ This study will provide knowledge of how intertidal reef communities in the MMP and SIMP are structured in space and time. Such 'inventory' and/or 'baseline' information is required to determine the composition of these ecological values in relation to natural processes, and to benchmark their condition with regard to the impact of current and future anthropogenic impacts (Simpson 2007). This study will address the following management questions: ů What are the patterns of intertidal biodiversity in the MMP and SIMP? ů Do areas of particularly high intertidal biodiversity exist, and where are they located? ů What natural and/or anthropogenic factors best explain the patterns of intertidal biodiversity in the MMP and SIMP? ů Do the current sanctuary zones provide adequate and representative protection for these communities? ů How should these communities be monitored?

Aims

The aims of this study are:

- To determine the spatial and temporal patterns in the composition of intertidal reef communities in the MMP, SIMP and the proposed northern extension to the SIMP (comprising Garden and Carnac Islands);
- To determine if the intertidal reef communities in management zones protected from extractive activities differ from the intertidal reef communities of otherwise comparable reefs; and
- To assist DEC's Marine Monitoring Unit in the development of methods for long-term monitoring of temperate west coast intertidal communities

Expected outcome

This project will:

- Provide a comprehensive understanding of the distribution and abundance of intertidal reef biota of both the MMP and SIMP at a scale commensurate with managing these habitats for biodiversity conservation;
- Provide an understanding of the natural and/or anthropogenic factors that contribute to patterns in the distribution and abundance of intertidal reef biota of the MMP and SIMP;
- Contribute to fulfilling by 2017 Science Division's Key Strategic Goals of:
    - Completing seven targeted surveys of existing or proposed marine protected areas;
    - Implementing research programs on the biology and behaviour of key species and communities that are subject to recreation and tourism impact as a basis for minimising adverse impacts; and
    - Describe marine plants collected in association with research, survey and monitoring. (DEC 2008).
- Inform planning and management of the MMP and SIMP by identifying intertidal reef communities of particular conservation significance. This will enable planners and operational staff to prioritise management controls and effort in relation to intertidal reef communities, and provide quantitative information on MMP and SIMP intertidal reef communities to the MPRA audit process.
- Provide information for the development and implementation of intertidal reef monitoring across DEC's marine parks and reserves, and provide marine research and monitoring training to Swan Coastal District staff.
- Foster collaborations with tertiary institutes by developing and supporting student research projects relating to intertidal reef ecology.
- Contribute to a broader regional study of WA intertidal reef ecology to be implemented by DEC's Marine Science Program.

Knowledge transfer

It is anticipated that: Management Guidelines produced during this study will provide DEC's marine policy, planning and management staff with knowledge of what natural processes and human impacts influence the structure of intertidal reef communities in the MMP and SIMP. Recommendations will be made regarding the adequacy of current management structures for intertidal reefs. Popular articles produced during this study will raise community awareness of the conservation significance of intertidal reef habitats, particularly in high-use areas of the Perth region. Peer-reviewed science journal articles produced during this study will contribute to the broader understanding by the science community of how warm temperate intertidal reef communities are structured, and the impact of human activities on these communities. It is anticipated that this study will contribute to broader regional studies of intertidal reef communities by DEC's Marine Science Program.

Tasks and Milestones

Milestone 1: Project planning completed
Jan-Nov 2009
Task 1: Marine Science Concept Plan (MSCP) written
January 2009
Task 2: MSCP approved by SMT

February 2009
Task 3: Science Project Plan (SPP) written
August 2009
Task 4: SPP approved
August 2009
Task 5: Pilot fieldwork completed
November 2009
Milestone 2: Data collection and collation completed
Nov 2009-Apr 2012
Task 1: Year 1 fieldwork completed
April 2010
Task 2: Year 1 fieldwork samples processed/data collated
April 2010
Task 3: Year 1 fieldwork Data Report completed
April 2010
Task 4: Year 2 fieldwork completed
April 2011
Task 5: Year 2 fieldwork samples processed/data collated
April 2011
Task 6: Year 2 fieldwork Data Report completed
April 2011
Task 7: Year 3 fieldwork completed
April 2012
Task 8: Year 3 fieldwork samples processed/data collated
April 2012
Task 9: Year 3 fieldwork Data Report completed
April 2012
Milestone 3: Analysis and reporting completed
Jun 2010-
Task 1: Annual Research Activity Report completed
June 2010
Task 2: Draft manuscript 1 completed
May 2011
Task 2: Annual Research Activity Report completed
June 2011
Task 3: Landscope article submitted
December 2011
Task 4: Annual Research Activity Report completed
June 2012
Task 5: Project Technical Report
December 2012
Task 6: Draft manuscript 2 completed
June 2013
Task 7: Conference presentation
TBD

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Study design

Methodology

Pilot study

Intertidal reef community studies in the same region as the proposed study have used sampling quadrats of 0.25 and 1.0 m^2 (Wells et al. 2007, R. Black pers com.). Wells et al. (2007) found that ten replicate 0.25 m^2 quadrats sampled 67% and 76% of the echinoderms and molluscs, respectively, recorded in 32 quadrats at a mainland platform reef at Cottesloe, which lies between the SIMP and MMP. Long-term intertidal reef studies at Rottnest Island have used larger quadrats (1.0 m^2) due to the low densities of most organisms (R. Black pers com.).

Preliminary sampling has been carried out to establish the most appropriate sampling units and level of replication for this study (Kingsford & Battershill 1998). Preliminary data derived from using 0.25 and 1.0 m^2 quadrats were subject to precision analysis to determine the most appropriate sampling unit and the optimal number of replicate samples required for the broader study. Precision (p) is high when the standard error is small relative to the mean (ie p=SE/mean) and the optimal sample size (n) may be derived for a given level of precision by $n=[s/p(mean)]^2$, where s=standard deviation (Andrew & Mapstone 1987).

Results of the precision analysis suggest that 9 and 15 0.25 m^2 quadrats per site would provide a high level of precision for species richness and abundance, respectively. In contrast, a minimum of 2 and 7 1.0 m^2 quadrats were required to achieve the same level of precision for species richness and abundance, respectively. Given the expected fine-scale patchiness and low densities of some taxa in these habitats, the 1.0 m^2 quadrat will be used as the sampling unit in this study. To provide an adequate level of spatial coverage a total of 10 replicates will be collected in each tidal zone on each reef.

Sampling design

This study is a broad-scale, descriptive biological survey with a stratified, systematic design. The strata are: (i) marine reserve or proposed marine reserve (MMP, SIMP & proposed SIMP extension); (ii) reefs adjacent to shoreline and isolated patch reefs; and (iii) tidal zones on reefs. The design is unbalanced as not all strata can be consistently replicated. Five shoreline and offshore survey points have been selected in each of the MMP and SIMP, and these sites have been selected to systematically cover the geographic extent of intertidal reef habitat in each reserve. Offshore sites are not represented in the proposed SIMP extension, and a limited number of appropriate shoreline sites are available. The survey design is presented in Fig 2, and the sampling locations are presented in Appendix II.

Park

%7E1/glendaL/LOCALS%7E1/Temp/msohtmlclip1/01/clip_image001.gif%7E1/glendaL/LOCALS%7E1/Temp/msohtmlclip1/01/c

%7E1/glendaL/LOCALS%7E1/Temp/msohtmlclip1/01/clip_image003.gif%7E1/glendaL/LOCALS%7E1/Temp/msohtmlclip1/01/c

%7E1/glendaL/LOCALS%7E1/Temp/msohtmlclip1/01/clip_image005.gifSIMP extension

Position

%7E1/glendaL/LOCALS%7E1/Temp/msohtmlclip1/01/clip_image006.gifShoreline

%7E1/glendaL/LOCALS%7E1/Temp/msohtmlclip1/01/clip_image007.gifOffshore

%7E1/glendaL/LOCALS%7E1/Temp/msohtmlclip1/01/clip_image008.gifShoreline

%7E1/glendaL/LOCALS%7E1/Temp/msohtmlclip1/01/clip_image008.gifOffshore

%7E1/glendaL/LOCALS%7E1/Temp/msohtmlclip1/01/clip_image006.gifShoreline

Platform

5

5

5

5

5
Zones
1-3
1-3
1-3
1-3
1-3
Reps
10
10
10
10
10
Total reps
150
150
150
150
150
Figure 2. Schematic survey design

At each sampling site, transects will be placed parallel to the coast in each of the distinctive reef 'zones' identified by Wells et al. (2007) (ie the low energy inshore zone, the high energy outer 'bare' zone and the middle zone typically dominated by Sargassum or Ecklonia) and quadrats will be sampled along the transect. In each quadrat, the percent cover of algal functional groups (see Bellchambers et al. 2009) will be recorded and the total numbers of each echinoderm, mollusc and barnacle species of >5 mm in length will be counted. The presence of recruits will also be recorded. The number of each species in each quadrat will then be expressed as an abundance m^{-2} for each tidal zone on each reef. Sampling will be conducted during summer months during three consecutive years (2010, 2011 & 2012) to assess the temporal stability of the intertidal reef communities.

Sampling transects will not be permanently marked. The position of each transect will be recorded using GPS and, given the typically small size of the reefs, sampling in consecutive years will occur close to the initial positions.

A range of physical and human use variables will also be measured or estimated in relation to each reef sampling site. These will include the platform location, size, relative exposure and wave energy, relative height in relation to tide datum, and rugosity. Human use data will be derived from MMP and SIMP visitor data and other sources.

Data analyses

Broad spatial and temporal patterns in the composition of intertidal reef communities will be analysed using multivariate analyses (mainly non-metric multidimensional scaling, permutational ANOVA, SIMPER within the PRIMER and PERMANOVA+ software).

The main factors in this analysis will be:

Marine reserve (MMP, SIMP and prospective SIMP extension);

- shoreline and offshore reefs; and
- year (2010, 2011 & 2012).

Relationships between the structure of the biological communities and physical and human use variables will be assessed where possible.

In addition to the broad spatial patterns above, PRIMER will be used to compare the composition of intertidal reef communities in three management zones protected from extractive activities with the composition of intertidal reef communities on adjacent, comparable reefs. The zones are:

- Boyinaboat Sanctuary Zone (MMP) and comparable offshore reefs in the MMP;
- Waterman Recreation Zone (MMP) and comparable shoreline reefs in the MMP; and
- Seal Island Sanctuary Zone (SIMP) and comparable offshore reefs in the SIMP.

Biometrician's Endorsement

required

Data management

No. specimens

Between 100 and 500 voucher specimens are likely to be retained in the Marine Science Program for the duration of this study. Voucher specimens of each species of marine benthic algae will be prepared following the guidelines outlined by Huisman & Parker (2005) in How to collect and document marine plants (available at: http://florabase.dec.wa.gov.au/marineplants/collectguide). Plants will be pressed fresh, which will allow for subsequent DNA analyses should any taxonomic issues arise, and small portions of fragile specimens will be wet-preserved in 5% formalin/seawater for later microscopic examination of structural and reproductive characteristics, if needed. All specimens will subsequently be lodged in the WA Herbarium. Preserved voucher specimens of echinoderms, molluscs and barnacles will be offered to the WA Museum.

Herbarium Curator's Endorsement

not required

Animal Ethics Committee's Endorsement

not required

Data management

The Department of Environment and Conservation will own the data generated by this study. Data sheets will be archived in the DEC corporate records system and an electronic copy will be retained on the Marine Science Program server. Internal data reports will be produced and lodged in the DEC Science Division library.

Budget

Consolidated Funds

Source	Year 1	Year 2	Year 3
FTE Scientist			
FTE Technical			
Equipment			
Vehicle			
Travel			
Other			
Total			

External Funds

Source	Year 1	Year 2	Year 3
Salaries, Wages, OVertime			
Overheads			
Equipment			
Vehicle			
Travel			
Other			
Total			