Marine Park Regional Impact Statements Main Report

A report prepared for

Department of Environment, Water and Natural Resources

Prepared by

econsearch

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Abbreviations

ABS	Australian Bureau of Statistics
C	Council
CBA	Cost Benefit Analysis

DC	District Council
DEH	Department for Environment and Heritage
DENR	Department of Environment and Natural Resources
DEWNR	Department of Environment Water and Natural Resources
DMITRE	Department for Manufacturing, Innovation, Trade, Resources and Energy
ESD	ecologically sustainable development
fte	full-time equivalent
GABMPCC	Great Australian Bight Marine Park Consultative Committee
GDP	Gross Domestic Product
GMUZ	General Managed Use Zone
GRP	gross regional product
GSP	Gross State Product
GVP	Gross Value of Production
HPZ	Habitat Protection Zone
MPLAG	Marine Park Local Advisory Group
MPSIAT	Marine Parks Social Impact Assessment Tool
NL	natural level
NRM	Natural Resource Management
PIRSA	Department of Primary Industries and Regions SA
RAZ	Restricted Access Zone
RIAS	Regional Impact Assessment Statement
RIS	Regional Impact Statement
RISE	Regional Industry Structure and Employment
SA	South Australia
SAMPIT	South Australian Marine Parks Information Tool
SARFAC	South Australian Recreational Fishing Advisory Council
SARDI	South Australian Research and Development Institute
SEIFA	Socio-Economic Indexes for Areas
SIA	social impact assessment
SLA	Statistical Local Area
SPA	Special Purpose Area
SZ	Sanctuary Zone
UNHL	unnaturally high level
UNLL	unnaturally low level

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Executive Summary

In 2009, the SA Government established 19 marine parks covering approximately 44 per cent of the State's waters. The Government has prepared draft management plans for each of South Australia's marine parks. These draft management plans include a number of proposed zones where certain activities will be restricted for biodiversity conservation purposes. Global scientific research is demonstrating that marine parks can conserve coastal and marine biodiversity.

However, it is recognised that the zoning of marine parks will require some restrictions on commercial and recreational activities. The *Marine Parks Act 2007* provides that when the Minister prepares a draft management plan, an impact statement of the expected environmental, economic and social impacts of the management plan must also be prepared. The impact statements are designed to assist the community to understand the projected impacts of the draft management plans[1] during public consultation.

The Department of Environment Water and Natural Resources has contracted EconSearch Pty Ltd and its project partners to provide:

1. Impact statements for each of the 19 marine parks which describe both positive and negative impacts of implementing the draft management plans on the local marine ecosystems, economies and communities. These impact statements are to comply with the SA Government's Regional Impact Assessment Statement Policy and with Section 14(4)(c) of the *Marine Parks Act 2007*.
2. A state level Cost Benefit Analysis (CBA) of the proposed management of the 19 marine parks through zoning regulations. The CBA is to comply with the SA Governments Regulatory Impact Statement (RIS) Policy, but is not a RIS in its own right.

This report is a companion document to the 19 individual marine park impact statements. It provides background and context to and synthesis of the individual impact statements. In addition it describes the CBA results of implementing the draft management plan zoning.

The Impact Statements

The positive and negative impacts of implementing the draft management plan zoning on the local marine ecosystems, economies and communities, together with the results of the cost benefit analysis, are summarised below.

Ecological Impacts

The key positive impact on marine biodiversity from the proposed zoning and management arrangements will be the ability to influence future activities, such as coastal developments and land-based discharges, so as to help mitigate future damage to the marine environment. The maintenance of habitats in good condition is critical for the future of the State's marine environment.

[1] The impact statements were prepared before the draft management plans were finalised.

The current status of habitats within marine parks across the State is generally one of good condition. Localised impacts are apparent in some parks adjacent to the more populated or industrialised regions and in areas where benthic trawling has occurred.

The protection of critical breeding, foraging and aggregation habitats will have a long-term positive impact for protected and threatened species, such as the Australian sea lion and white shark. However, in some cases the proposed zoning and management arrangements are unlikely to have an immediate benefit due to factors beyond the control of marine parks.

It is likely that ecosystems within sanctuary zones will be more resilient and better able to cope with future threats. However, some threatening processes for the marine environment such as climate change, introduction of marine pests, and land-based pollution can only be partially and/or indirectly addressed by zoning.

The main current activity affecting marine ecosystems that will be ceased inside sanctuary zones is fishing. The main current activity affecting marine ecosystems that will be ceased inside habitat protection zones is prawn trawling. Predicting species (and ecosystem) responses to the cessation of fishing is highly complex (see Appendix 1.3) and, compared to other activities, there are generally more data available to inform the assessment. Consequently, the extent and depth of discussion on fishing-related responses may appear to be disproportionate in comparison to other activities, but this is not intended to place any particular emphasis on fishing as a threatening process.

The current status of some fished species is below their natural levels when compared with a pre-European (pre-fishing) baseline. The reduced levels of these fished species are inherent in the exploitation of fisheries and do not necessarily reflect poorly on fisheries management. Fisheries are managed in accordance with the principles of ecologically sustainable development, aiming to maintain populations at a sustainable level while providing significant social and economic benefits to the community. Making predictions of species responses to protection from fishing is intrinsically difficult. Nonetheless, a basic predictive model showed that there is potential for increases in the size and abundance of some fished species, when considered in isolation, inside adequately-sized and adequately-enforced sanctuary zones following protection. In particular, increases in the size and abundance of some of the more resident species such as southern rock lobster, snapper, mud cockle, pipi (Goolwa cockle), and razorfish are possible. Benefits to other more mobile species may also be expected due to the 'network effect' of the sanctuary zones and an overall planned reduction in commercial fishing effort for some sectors. There is potential for negative impacts on some fished species such as blacklip abalone which may be affected by increased numbers of predators such as lobster. Several resident reef fishes of conservation concern such as the western blue groper and harlequin fish will benefit from sanctuary zone protection.

The current status of ecosystems is difficult to assess, but it is apparent that reduced abundances of some fished species (or ecosystem components) may be having an impact on ecosystem structure but not necessarily ecosystem function.

Attempts to predict ecosystem responses were hampered by a general lack of knowledge of South Australia's marine ecosystems. Nonetheless, higher order ecosystem changes are likely to occur following the first order changes that occur in individual species from protection inside sanctuary zones. There will likely be predator-prey interactions that cannot be fully predicted at this stage. It is, however, predicted that some ecosystems will shift towards a more natural state but cannot fully recover to a pre-European baseline due to interactions with the more migratory species outside of the sanctuary zones, as well as other factors such as climate change and the establishment of introduced species. Changes to species and ecosystems are likely to take many years, possibly decades, to occur. Nonetheless, detectable impacts are likely to be apparent for some fished species within five years.

In summary, the planned zoning and management arrangements for the marine parks network are expected to have a net positive impact on biodiversity conservation through protection of ecosystems from some future harmful uses and through the shift of many ecosystems towards a more natural pre-European state.

Economic Impacts

In summary, the proposed draft zoning is expected to have the following economic impacts on the following sectors of the regional economy: potential positive impact in the tourism sector in the medium to long-term; neutral impact in the aquaculture, property, marine infrastructure and operations, mining and coastal development sectors; and short, medium and long-term negative impacts in the commercial fishing sector.

Commercial fishing

In aggregate, it was estimated that the impact of marine park zoning will generate the following loss of regional economic activity on an ongoing annual basis:

- Approximately $12.60 million in gross state product (GSP) which represents 0.02 per cent of the state total ($80.36 billion).
- Approximately 124 fte jobs which represent 0.02 per cent of the state total (774,953 fte jobs).
- Approximately $7.89 million in household income which represents 0.02 per cent of that state total ($45.34 billion).

Impacts are based on SARDI's average annual displaced catches and average annual prices in 2011 dollars. According to industry-derived estimates of displaced catch (which have not yet been reviewed by SARDI), the aggregate state-wide impacts could be as high as 164 fte jobs and $16.1m in GSP.

The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above.

Aquaculture

There are no known current or potential impacts expected from the draft zoning on current or future aquaculture enterprises in marine parks. This is consistent with Government policy commitments.

Any potential future prescribed criteria in aquaculture zone policies derived from Section 11 (3a) of the *Aquaculture Act 2001* could add cost to existing or future aquaculture activities, or have additional regulatory impact (PIRSA, pers. comm., 7 November 2011). However, no such prescribed criteria currently exist and potential impacts have not been assessed.

Property Prices

Given that the overall impact on the regions is not expected to be large in absolute terms, the impact on property values is, similarly, not expected to be significant. States of Australia have introduced marine parks with sanctuary zones in the last decade without any known long-term effects on property values. Residential property prices are unlikely to be affected by the proposed marine park zoning.

Tourism

The actual placement of sanctuary zones is unlikely to place real restriction on recreational fishing with sanctuary zones over highly fished areas limited. However, the perception that recreational fishing opportunities will be restricted by implementing 'no-take' zones is real. So there is potential for a downturn in fishing-based tourism in the short-term until visitors are informed and convinced of the actual situation on the water. In the long-term, managed marine parks will provide certainty that the marine environment within them is being protected and this may support the growth of the ecotourism industry, provided the necessary investment in tourism infrastructure and support services is undertaken. Other, non-extractive tourism, such as diving, is likely to benefit from the implementation of sanctuary zones.

Ports, harbours and shipping

The existing arrangements where shipping, ports and harbour activities are managed pursuant to the *Harbors and Navigation Act 1993* will remain. This includes dredging and channel maintenance, development or improvement of facilities for anchorage, vessel maintenance, loading, unloading and storage of goods, associated commercial and industrial development, sporting and recreational purposes.

All harbours declared under provisions of the *Harbors and Navigation Act 1993* will be zoned special purpose areas. Current and future port, harbour and shipping operations will be accommodated within marine parks and this is reflected in the draft management plan zoning. In addition, due to extensive development expected over the next ten years in the Upper Spencer Gulf, the sanctuary and habitat protection zones of the Upper Spencer Gulf Marine Park will be declared a special purpose area, permitting specified activities.

Concerns from the shipping industry have been addressed through exclusion of all ports from marine parks, special purpose area status applied to all harbours plus appropriate zoning for anchoring grounds, transhipment points and pilot grounds. There is not expected to be any loss of economic activity generated by ports as a result of the implementation of the draft zoning.

Mining

The existing arrangements where DMITRE Minerals and Energy Resources Division oversee activities that support the mineral, petroleum and geothermal resource industries, pursuant to the *Mining Act 1972,* the *Petroleum and Geothermal Energy Act 2000,* the *Offshore Minerals Act 2000* and the *Petroleum (Submerged Lands) Act 1982,* will remain. All existing licences and leases will be accommodated with no change to existing conditions.

Applications for new or renewal of licences and leases within and adjacent to marine parks will require the concurrence of the Minister responsible for marine parks under related amendments to the *Mining Act 1972* and the *Petroleum and Geothermal*

Energy Act 2000. Where the proposed activity is consistent with the zoning regulations, no further approvals or permits will be required, apart from those required under legislation administered by DMITRE Minerals and Energy Resources Division. Section 19 of the *Marine Parks Act 2007* provides for consideration of activities that are inconsistent with marine park zoning regulations on a case-by-case basis with rigorous assessment and approval processes and due consideration of risk to environmental values (e.g. to consider new/emerging lower impact technologies). The Minister responsible for marine parks will be required to issue a special permit in such cases.

There is a petroleum exploration licence partially overlapping this marine park, extending offshore north of Christies Beach, across to Kangaroo Island and into parts of Gulf St Vincent. There are numerous private mines adjacent to the park for sand and limestone between Moana and Rapid Head, and one mineral exploration licence application immediately adjacent to the marine park.

There are mineral exploration licence applications over parts of West Coast Bays, Investigator (off Flinders Island), Franklin Harbor, Upper Spencer Gulf and Eastern Spencer Gulf Marine Parks, one geothermal exploration licence application over parts of Upper Gulf St Vincent Marine Park and one petroleum exploration licence application over parts of Franklin Harbor and Upper Spencer Gulf Marine Parks. As mentioned above, licence applications will be required to go through a joint approval process administered by DMITRE and DEWNR, which may be a potentially lengthier and therefore more costly process to the applicant. Zoning limits the types of activities normally permitted, and could potentially discourage certain types of applications and hence limit exploration and exploitation of resources.

Coastal development

Marine parks will not prevent coastal developments approved under the *Development Act 1993*. Coastal developments and infrastructure are regulated under the provisions of the *Development Act 1993* with developments considered on a case by case basis by the relevant authorities to ensure that the achievement of the objects of the *Marine Parks Act 2007* and the aims of the specific zone where the development is proposed are supported appropriately. As part of the assessment process, advice or direction may be required from the Coast Protection Board and/or the Environment Protection Authority and other authorities, depending on the nature of the development. Development plans and significant projects are informed by the Planning Strategy which now includes the objects of the *Marine Parks Act 2007*.

The proclamation of the marine parks network will not affect access to, or use of, jetties, breakwalls or boat ramps.

It should be noted that aids to navigation and markers are permitted in any waters in any marine park.

Potential future infrastructure has been identified in seven marine parks and minimal impact on their development is envisaged.

Social Impacts

The overall social impacts of the 19 marine parks on communities living in the regions of the marine parks are expected to be low given the magnitude of the economic impacts that have been projected. The main group impacted within these communities will be commercial fishing. Commercial fishing is one of the four top industry sources of regional employment for all but two economic regions (Upper Spencer Gulf and

Fleurieu & Coorong), and contributes significantly fewer jobs than does tourism in all but two economic regions (Lower Eyre Peninsula and Franklin Harbour). Economic impact assessment identifies nine parks where no job losses are anticipated to a high of 28 fte fishing-related job losses estimated for Encounter Marine Park. The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above.

Most of the sanctuary zones are in low use areas for recreational fishing. Consequently, impact on local community identity as a fishing centre, and on fishing as a way of life is also likely to be low to minimal in most instances, with quite localized impact in six marine parks (Far West Coast, West Coast Bays, Upper Spencer Gulf, Eastern Spencer Gulf, Encounter and Lower South East Marine Parks).

It is important to acknowledge that the impact of marine parks on employment and wellbeing is likely to vary significantly across regions and will be mediated by a range of social and economic factors including:

- the age and retirement intentions of fishers;
- the ability of fishers to adapt to changes within the region in which they fish;
- the opportunities available to fishers and those dependent on fishers to work in other industry sectors;
- the impact of buy outs and compensation provided to fishers on their financial circumstances and the local economy;
- the influence of lifestyle attachment and importance of place in the lives of fishers
- the extent to which the existence of marine parks might generate employment in tourism, research, education and other sectors.

No impacts on local government operations, infrastructure and revenue or compliance related activities are expected as a result of the proposed draft zoning.

Experience elsewhere in Australia and internationally, suggests that a range of benefits from the establishment of marine parks become evident over time. These include increased opportunities for education about marine life and conservation, and increased tourism and ecotourism opportunities. This experience indicates that these benefits usually take approximately five years to be evident, and that in the earliest stages of marine protected areas being developed, local communities are more likely to identify possible negative impacts than potential benefits. It takes time to observe how the park's ecological and economic impacts evolve, with social impacts (positive or negative) flowing from these.

Marine parks have broad support in the South Australian community. Market research commissioned by the state government between 2006 and 2012 found strong support for the concept of marine parks among South Australians with approximately 85 per cent in favour of them in 2012 (87 per cent support in metropolitan Adelaide and 82 per cent support in regional areas). Those least likely to support marine parks have been fishing groups (in 2009 55 per cent of respondents who did not support marine parks identified restricted fishing as the reason, this dropped to 39 per cent in 2012). Between 2011 and 2012 the market research findings identify a decline in those who believe they will have limited access to marine parks and an increase in those who associate swimming, boating and snorkelling with marine parks.

A critical factor in determining the ultimate impact of marine parks is how well local communities are able to adapt to change and how cohesive they are in supporting each other through change. Feedback provided for the social impact assessment indicates that communities living near the marine parks will vary in their expected capacity to manage the changes brought by the parks but most are perceived as being sufficiently resilient to manage those changes.

The level of support provided by government to adjust to change is also crucial. One very important factor that affects community attitudes is how informed they are, and feedback from market research and marine park local advisory groups, as well as analysis of media reports indicates a gap in this information. In particular, increasing communities' understanding of the scientific rationale underpinning marine protected areas, and the benefits that these can bring needs to be enhanced. This is one of the functions of impact assessment which is best conceived of as a continuous process informing both the establishment and operation of marine parks.

The Cost Benefit Analysis

The anticipated non-market benefits associated with the protection of marine habitat (resulting from the marine park zoning) have not been valued in the analysis, and the negative outcome can be interpreted as a threshold value. There is an ongoing opportunity cost associated with the establishment and implementation of the zoned marine parks, estimated to have a present value of around $64 million. In the context of the decision regarding marine habitat protection, this opportunity cost can be viewed as the value that the benefits of protecting the marine habitat must exceed for it to be in the best interests of the community overall for the sanctuary zones to be excluded from commercial and recreational fishing and other activities. In terms of a decision rule, only if the benefits of marine habitat protection exceed this "threshold" of opportunity costs should the marine areas be reserved.

To put this in context, in the first year of implementation of the management plans the opportunity cost equates to approximately $7 for the average household in SA.

Study Limitations

A limitation of the analysis was that only the proposed sanctuary zones were publicly available during the information gathering phase[2]). The scope of the project also limited the level of detailed data collection and analysis that could be undertaken.

2 The proposed sanctuary zone locations were publicly released on 27th April 2012. All proposed zoning was publicly released on 10th July 2012, which was after the information gathering phase for the impact statements from non-government organisations.

1. Introduction

In 2009, the SA Government established 19 marine parks covering approximately 44 per cent of the State's waters. The Government has prepared draft management plans for each of South Australia's marine parks. These draft management plans include a number of proposed zones where certain activities will be restricted for biodiversity conservation purposes. Global scientific research is demonstrating that marine parks have the potential to conserve coastal and marine biodiversity (PISCO, 2007).

However, it is recognised that the zoning of marine parks will come with some costs such as restrictions on commercial and recreational activities. The *Marine Parks Act 2007* provides that when the Minister prepares a draft management plan, an impact statement of the expected environmental, economic and social impacts of the management plan must also be prepared. The impact statements are designed to assist the community to understand the projected impacts of the draft management plans[3] during public consultation.

1.1 Project Brief

The Department of Environment Water and Natural Resources (DEWNR) has contracted EconSearch Pty Ltd and its project partners to provide:

1. Impact statements for each of the 19 marine parks which describe both positive and negative impacts of implementing the draft management plans on the local marine ecosystems, economies and communities. These impact statements are to comply with the SA Government's Regional Impact Assessment Statement Policy (RIAS) and with Section 14(4)(c) of the *Marine Parks Act 2007*.
2. A state level Cost Benefit Analysis (CBA) of the proposed management of the 19 marine parks through zoning regulations. The CBA is to comply with the SA Governments Regulatory Impact Statement (RIS) Policy, but is not a RIS in its own right.

1.1.1 Ecological Impact

The ecological component of this report has assessed how marine species, habitats and ecosystems are likely to respond to the proposed management changes. It contributes to the state-wide cost benefit analysis of the overall positive and negative impacts of the draft management plans. It also provides an impact statement for each of the 19 marine parks.

The assessment was required to:

- describe the current status of the marine habitats, plants and animals in each marine park;
- discuss (in qualitative terms) the services that the protected ecosystems provide to South Australians (where not possible to measure their economic value);

[3] The impact statements were prepared before the draft management plans were finalised.

- identify the range of activities that impact on the environment and quantify how the draft management plans will influence the marine environment, against a base case of no management plans;
- assess the implications of the management plans in 5, 10 and 20 years on species diversity and abundance, marine habitats, and ecosystem function;
- include case studies that highlight the potential impacts of the draft management plans on iconic and threatened species and contribute to case studies that effectively communicate the trade-offs between the different environmental, social and economic factors.

The assessment was also required to take into account the environmental objectives outlined in the *Marine Parks Act 2007* and incorporate the work of the Marine Parks Scientific Working Group.

1.1.2 Economic Impact

The economic component of this report has assessed how regional economies and the State economy are likely to respond to the proposed management changes and predicted ecological changes. It undertakes a state-wide cost benefit analysis of the overall positive and negative impacts of the draft management plans and takes into account the non-market benefits and costs. It also provides an impact statement for each of the 19 marine parks.

The assessment was required to:

- profile the economy of each region;
- identify and value the direct impacts on different groups affected by the draft marine park management plans over time. Particular focus is given to commercial fishing, recreational fishing, tourism, jobs, business and capital investment, demographics, average income per capita, local government, and property prices;
- identify and value the flow on effects on employment and economic activity on different groups affected by the draft marine park management plans over time; and
- identify possible cost savings from implementing the draft management plans.

The Department of Primary Industries and Regions SA (PIRSA) contracted the South Australian Research and Development Institute (SARDI) on behalf of DEWNR to estimate the displaced commercial fishing catch and effort that will result from the implementation of the draft management plans. The economic impact assessment used these estimations in its analysis.

1.1.3 Social Impact

The social component of this report has assessed how regional communities are likely to respond to the proposed management changes and estimated economic impacts. It contributes to a state-wide cost benefit analysis of the overall positive and negative impacts of the draft management plans. It also provides an individual impact statement for each of the 19 marine parks, structured to enable comparison across parks as well as detail that is specific to each.

The assessment was required to:

- describe the current demographic and socio-economic characteristics of each of the regions; and
- assess the expected impacts in relation to:
    - Access to education, health, justice and community services;
    - Particular social groups that may benefit or be disadvantaged;
    - Potential changes to communities' ways of life;
    - Recreation and leisure activities; and
    - Scientific, educational and scenic values.

DEWNR conducted a community engagement program as part of developing the draft marine park management plans. Information and results from this program have informed the social impact assessment.

1.2 This Report

This report is a companion document to the 19 individual marine park impact statements. It provides background and context to and synthesis of the individual impact statements. In addition it describes the CBA results and provides three local case studies which describe the environmental, economic and social trade-offs of implementing the draft management plans.

1.3 Marine Park Planning Process

Marine parks in South Australia have been will be zoned for multiple-uses, providing for varying levels of conservation, recreational and commercial use. Zoning provides the basis for the management of marine parks, in accordance with the objects of the *Marine Parks Act 2007*. Figure 1–1 describes the marine park zones.

The Government has developed a table of activities and uses (see Appendix 7) that occur in the marine environment that summarises how these activities are expected to be managed in each marine park zone. The prohibitions and restrictions in the matrix will be included in regulations that will be finalised when marine park management plans are adopted.

Figure 1–1 Marine Park Zones

The management plans will contain the following management zones:	
General managed use	A zone primarily established so that an area may be managed to provide protection for habitats and biodiversity within a marine park, while allowing ecologically sustainable development and use.
Habitat protection	A zone primarily established so that an area may be managed to provide protection for habitats and biodiversity within a marine park, while allowing activities and uses that do not harm habitats or the functioning of ecosystems.
Sanctuary	A zone primarily established so that an area may be managed to provide protection and conservation for habitats and biodiversity within a marine park, especially by prohibiting the removal or harm of plants, animals or marine products.
Restricted access	A zone primarily established so that an area may be managed by limiting access to the area.
To accommodate site specific community needs, within a marine park there may be:	
Special purpose area	An area within a marine park, identified as a special purpose area and with boundaries defined by the management plan for the marine park, in which specified activities, that would otherwise be prohibited or restricted as a consequence of the zoning of the area, will be permitted under the terms of the management plan.

Source: Adapted from sections 4 and 5, *Marine Parks Act 2007*.

The Government dedicated significant resources to gathering environmental, economic and social knowledge and working with community and key stakeholder interests to develop draft park zoning. Key elements of this process are described in Table 1–1.

Table 1–1 Public consultation process to date

Initiative	Timeframe
Statewide consultation on Liberal Government draft policy document *Marine protected areas: a shared vision.* 23 public meetings/information sessions held involving some 1600 people.	2001/02
Labor Government policy *Blueprint for the SA representative system of marine protected areas* developed following the above consultation process, with further consultation undertaken with key stakeholders and across relevant government agencies.	2003/04
The Draft *Encounter Marine Park Zoning Plan* was released for 3 months' public consultation as a pilot process to test key concepts for statewide application. 427 submissions were received. Local consultation was undertaken targeting the Fleurieu Peninsula, Kangaroo Island and Adelaide. 15 public information days and 48 stakeholder group meetings were held.	2005
The Marine Parks Draft Bill (2006) was developed and 3 months' statewide consultation was undertaken on this, involving 16 regional public meetings/information sessions and 112 submissions.	2006-07
On 29 January 2009, the Minister for Environment and Conservation released the outer boundaries of 19 new marine parks, for a public consultation period of three months.	2009
During the comment period, approximately 15,000 copies of the consultation brochure with submission form were distributed through various means. By the end of the three month consultation 2,357 submissions had been received by the Department for Environment and Heritage (DEH) representing a total of 3, 295 individual respondents.	
In addition, 56 public information days were held and 4,800 people were estimated to have been directly engaged in the consultation process.	
Nearly 150 groups provided comment on either the marine parks network or one or more individual marine parks. These included key interest groups, organisations, businesses, associated bodies, local governments, not for profit organisations, community groups and recreational clubs.	
Three regional Pilot Working Groups with multi sectoral representation were established to advise on outer boundary design with minimum three meetings of each.	
Outer boundaries of seven parks were amended as a result of the consultation process.	
Phase 1 - Management planning for South Australia's marine parks network. A Statewide community engagement process was undertaken involving:	Late 2009 onwards
• 13 Marine Park Local Advisory Groups (MPLAGs) established across the state, and the Great Australian Bight Marine Park Consultative Committee (GABMPCC).	
• 67 public MPLAG meetings were facilitated.	
• Peak stakeholders were invited to provide early advice on their preferred zoning for marine parks.	
• A key stakeholder forum was held where broad agreement was reached on the priority areas for conservation	April 2012

Source: Adapted from SA Government Submission to the Marine Parks Select Committee, 2011.

The Scientific Working Group and Marine Parks Council of South Australia are independent advisory bodies providing advice to the Minister for Sustainability, Environment and Conservation. In finalising draft management plans for public consultation, both the SWG and MPC assessed the merits of the draft zoning schemes and strategies for management against the objects of the *Marine Parks Act 2007* and provided the Minister with independent advice.

In finalising draft management plans, discussions were held with members of the Marine Parks Steering Committee as representatives of relevant Government agencies. The Steering Committee considered whether draft management plans took appropriate consideration of all relevant statutory requirements and effectively implemented the Government's policy commitments for marine parks.

Based on the collective advice from MPLAGs, other community members, peak stakeholders and discussions across relevant agencies, the Government developed a draft management plan with zoning for each of the 19 marine parks for formal public consultation. The draft management plans are currently out for public consultation.

1.4 Policy Commitments

The Government has made a range of policy commitments[4] to help ensure South Australian lifestyles and livelihoods are maintained, and to provide more certainty for the industries that use the marine environment. The commitments informed the design of zoning for each marine park, and include:

- access to specific key recreational and commercial fishing sites through appropriate zoning
- access for existing and future aquaculture development through appropriate zoning
- certainty that marine parks will not affect access to, or use of, jetties, break walls or boat ramps
- accommodation of approved coastal development as well as future development and infrastructure needs
- accommodation of approved mining, petroleum and geothermal development activities
- accommodation of shipping and harbor activities
- certainty that marine parks will not create an extra approval process as government agencies will work together to streamline administration.

1.4.1 Displaced Commercial Fishing Policy Framework

The adoption of marine park management plans with zoning will displace some commercial fishing activities. This Policy Framework[5] describes the steps that support this process:

1. Avoid displacement by pragmatic zoning;
2. Redistribute effort only where possible without impacting ecological or economic sustainability of the fishery;
3. Market-based buy back of sufficient effort to avoid impact on the fishery;
4. Compulsory acquisition as a last resort option.

The Government expects that market based buy back of effort and any necessary compulsory acquisition will be undertaken under the authority of the Minister for Agriculture, Food and Fisheries. The Minister for Sustainability, Environment and Conservation will consider any fair and reasonable compensation in accordance with section 21 of the *Marine Parks Act 2007*, and it is envisaged that regulations will be drafted to support this process.

[4] A complete list of the commitments is available at Appendix 2 of the *South Australia's Marine Parks Network Explanatory Document* which accompanies the draft management plans.

[5] The Displaced Commercial Fishing Policy Framework is provided at Appendix 5 of the *South Australia's Marine Parks Network Explanatory Document*

2. Ecological and Socio-economic Profiles of the Marine Parks

A description of each marine park, its ecological attributes and a socio-economic profile of its associated economic region is provided in Section 3 of each individual marine park impact statement. The reader is also referred to Appendix 1 of each impact statement for a detailed description of the socio-economic profile and to DEWNR's *Environmental, Economic and Social Values* statements for a detailed description of the ecological and cultural context of each marine park.

Table 2–1 provides a summary of key socio-economic indicators in the coastal economic regions of South Australia. The regions have been defined so as to best align each marine park with its relevant local community. The main constraints in defining the regional boundaries were: (i) the data required for the economic modelling meant the smallest spatial unit was a statistical local area (SLA); and (ii) the outer boundaries of some marine parks are adjacent to more than one SLA. As a consequence, some of the defined regions were relevant to more than one marine park. The first column of data in Table 2–1 shows which marine parks are relevant to which economic regions.

The population amongst the economic regions (for 2010/11) varies significantly, from as low as 1,364 in Franklin Harbour up to 89,980 in the Fleurieu and Coorong region. The same can also be said regarding the estimated population growth for the period 2006 to 2026, which varies from negative one per cent for the West Coast Bays region, up to 56 per cent for the Fleurieu and Coorong region. All of these regions (excluding the Fleurieu and Coorong) have projected population growth rates below the State's rate of 23 per cent.

The dependency rate is defined as the ratio of individuals who are not of working age (peoples aged under 15 years or 65 years and over) by those who are. The dependency rates for the economic regions are all within the range of 50 to 60 per cent, with the exception of the Upper Spencer Gulf which has a relatively high rate of 73 per cent. Again these rates are all above the State average of 50 per cent (excluding the Upper Gulf St Vincent, which is approximately equal to the State average)

The economic regions have diverse unemployment rates, which fluctuate significantly around the State average of 5.2 per cent. To illustrate, the unemployment rate is high at 8.6 and 8.1 per cent in the Far West Coast and Fleurieu and Coorong regions, respectively; while significantly lower rates of 2.2 and 2.5 per cent can be observed in the Franklin Harbour and the West Coast Bays regions.

A tight band on the median taxable income can be observed across all of the economic regions, ranging from slightly under $44,000 to just over $52,000. This range, however, falls short of the State average of approximately $54,000.

The Gross Regional Product (GRP) figures are equivalent to Gross State Product (GSP) or Gross Domestic Product (GDP), but with specific regional economic focus (e.g. the Far West Coast). Regarding the eleven economic regions, significant variation in the size of the local economies can be found. With the varying magnitudes of the local economies, a strong correlation between GRP and full time equivalent (fte) employment is observed. Depicting these characteristics are regions such as Franklin Harbour which has a GRP of $51 million and employs 564 fte individuals, in contrast to the Fleurieu and Coorong region which generated an estimated $2,464 million in GRP in 2009/10 and almost 29,000 fte jobs.

Table 2–1 Key socio-economic indicators in the coastal economic regions of South Australia

	Marine Parks	Population	Dependency Rate	Population Growth	Unemployment Rate	Mean Taxable Income	Median Dwelling Price	Gross Regional Product	Commercial Fishing GVP	Visitor Expenditure	Recreational Fishing	Employment	Trade Balance
Unit		(no.)	(%)	(%)	(%)	($)	($)	($m)	($m)	($m)	(days)	(fte)	($m)
Data year		2010/11	2009/10	06 - '26	June Qtr '11	2009/10	2010/11	2009/10	10 yr avg	2009/10	2007/08	2009/10	2009/10
Economic Region:													
Far West Coast	1, 2	4,315	51%	5%	8.6%	48,314	250,000	174	6	26	35,656	1,872	-78
West Coast Bays	3,4	3,350	59%	-1%	2.5%	48,983	240,000	148	19	23	38,087	1,671	-49
Lower Eyre Peninsula	5,6,7,8	22,533	56%	13%	4.2%	51,991	287,500	942	45	79	91,314	9,693	-334
Franklin Harbour	9	1,364	63%	4%	2.2%	52,733	278,000	51	7	8	13,872	564	-25
Upper Spencer Gulf	10	59,135	57%	7%	5.5%	52,706	200,000	2,491	8	133	46,735	24,239	-576
Yorke Peninsula	11,12,13	11,795	73%	5%	2.8%	48,870	251,500	386	51	62	266,994	4,340	-125
Upper Gulf St Vincent	14	15,483	50%	21%	3.9%	47,984	200,000	451	5	34	144,631	4,112	-189
Fleurieu & Coorong	15	89,980	60%	56%	8.1%	47,368	326,250	2,464	10	260	130,146	28,789	-980
Kangaroo Island	16,17	4,666	54%	20%	3.9%	43,766	235,000	161	10	121	32,743	2,262	-22
Upper South East	18	3,982	57%	5%	3.3%	48,217	285,000	146	5	29	35,866	1,699	-29
Lower South East	19	43,643	53%	15%	6.5%	50,417	225,250	1,821	92	141	42,508	20,440	-247
South Australia		1,656,299	50%	23%	5.2%	54,349	357,500	80,356	258	4,524	1,054,200	774,953	-9,293

Source: Regional economic profiles compiled by EconSearch.

Commercial fishing is an important component to these regional economies, as the industry contributes significantly to GRP. Measuring the fishing contribution in terms of gross value of product (GVP), gives a range of $5 million in the Upper Gulf St Vincent up to $92 million in the Lower South East region. Proportionally, the contribution of commercial fishing to GRP can range from less than one per cent in the Upper Spencer Gulf, up to almost 13 per cent in the Lower Eyre Peninsula. It appears that the smaller economic regions (GRP wise) rely proportionally more on commercial fishing. That being said, commercial fishing is not the only important industry which contributes economically to these regions. Arguably tourism can be considered as important, after considering that for all regions, gross visitor expenditure exceeded commercial fishing GVP.

3. Impact Analysis Method, Data and Assumptions

This study undertook both an impact analysis and an economic evaluation, in the form of a cost benefit analysis (CBA), of implementing the proposed zoning and management arrangements for marine parks. The CBA method, data and assumptions are described in Section 5.

Impacts of implementing the draft management plans were assessed against a base case scenario of no management plans. This also applies to the CBA. The base case is not static, and requires an understanding of the existing trends in natural resource, economic and social conditions. There are external factors which influence both the 'with management plan' and the base case scenarios that need to be taken into consideration (for example, macro-economic conditions).

3.1 Ecological[6]

3.1.1 General Approach

The process of ecological impact assessment undertaken for the current report can essentially be summarised by three main steps:

1. Activities and uses: determining the range of activities and uses that potentially impact on the marine environment under current management regimes, and then determining how the marine park zoning and management arrangements will influence them.
2. Baseline: determining the current status of the marine habitats, species and ecosystems in the marine parks; what are we comparing future changes against?
3. Predictions: assessing the implications of the marine park zoning and management arrangements in 5, 10 and 20 years on habitats, species and ecosystems against the case of no marine park zoning and management arrangements.

This required an assessment of:

- Current management of the marine environment. Note the assessment does not take into account possible alternative management responses over the next 20 years within the existing management framework.
- Activities that impact on the marine environment (Table 3–1 provides a general summary of impacts on the SA marine environment and the activities that cause them).
- How the proposed zoning arrangements will influence the marine environment
- The scope for making predictions of habitats, species, and ecosystems.

6 For a detailed description of the ecological assessment method, data, assumptions and literature review, see Appendix 1.

Table 3–1 Generic classification of impacts on the SA marine environment

Generic impact	Examples of uses/activities
Extraction of living resources	Fishing activities, water (plankton) extraction (cooling water, desalination), aquaculture (filter feeding)
Modification of fauna behaviour	Berleying, mammal interactions (including noise), provisioning (trawler by-catch discards)
Pollution of water/sediments	Industrial discharges, waste-water, stormwater, coastal and catchment land use, e.g. agriculture by-products, sediment, stormwater, aquaculture, oil spills
Modification or destruction of habitat	Coastal engineering, e.g. marinas, pipelines, dredging, trawling, mining
Introduction of pest species and diseases	Shipping (ballast water and hull fouling), recreational fishing and boating (hull and equipment fouling), imported products, aquaculture
Climate change	A broad range of activities (mainly land-based) that result in the generation of greenhouse gases, acidification, temperature change, sea level rise

To enable meaningful predictions following zoning and management arrangements, it is necessary to assess the current status of habitats, species and ecosystems in relation to some form of baseline. While marine ecosystems are naturally dynamic, it is generally acknowledged that, since European settlement of SA (around 1800), there have been 'unnatural' changes to some components of these ecosystems. Cases of habitat degradation and over-fishing are well documented (see Appendix 1). Even for fisheries managed according to the principles of ecologically sustainable development (ESD), it is well accepted (and indeed a part of fisheries management) that extraction of a species will keep its biomass below a level that would occur more naturally without fishing (see Haddon, 2007). Similarly, even trawling, aquaculture and development in general when managed according to ESD principles will result in some modification to the marine environment. The end result of human-mediated changes to the marine environment is that the current status of the habitats, species, or ecosystems may indeed be different to that when European settlement occurred, i.e., the baseline has shifted (see Appendix 1.1.6). Therefore, we considered it most appropriate to assess the current status of the marine parks relative to a pre-European baseline. This is not intended to cast any aspersions on management of the broader South Australian marine environment according to ESD principles. Furthermore, a recovery to a pre-European condition is not an objective of the *Marine Parks Act 2007*. A pre-European baseline is being used only as a conceptual, qualitative baseline against which to predict future changes. Nonetheless, it is considered by the authors that shifts towards a pre-European state within marine park ecosystems would be of conservation benefit.

The exact date of the pre-European baseline will vary depending on the focus of the assessment. Different components can be assessed as being at an unnaturally low level (UNLL), a natural level (NL) or an unnaturally high level (UNHL) in relation to when impacts from Europeans first commenced. For some habitats the baseline may be when a land-based discharge started damaging the habitat (see Appendix 1.2.4). For some threatened species the impacts of Europeans occurred around the time of first settlement when unsustainable practices, such as whaling, occurred. For some fished species it will be when significant levels of European fishing commenced (see Appendix 1.3.4). As natural variability is inherent in marine ecosystems, such variability is also implicit in the assignment of current status.

3.1.2 Habitats

Habitats may be affected by the zoning and management arrangements in three ways: (1) from protection of current harmful uses within RAZs, SZs and HPZs, (2) from protection of future harmful uses within zones, and (3) from potential third order[7] trophic interactions as a result of species changes in RAZs, SZs and HPZs.

3.1.2.1 Habitats assessed

Ten benthic and one pelagic habitat types were identified for the purpose of habitat assessment:

- saltmarsh
- mangrove
- intertidal sand flat
- subtidal sand
- intertidal seagrass flat
- subtidal seagrass
- intertidal reef
- subtidal high profile reef
- subtidal low profile reef
- beach
- pelagic

When the plants and animals associated with each of the habitats are considered, they can also be treated as discrete ecosystems (see Section 3.1.4).

3.1.2.2 Habitat-use interactions

Human activities that are potentially damaging to the 11 habitat categories are generally well-understood and documented (e.g. Bryars, 2003; Shepherd et al., 2008; and see Appendix 4). This information was used to determine the most threatening processes to habitats on a large-scale, i.e., coastal pollution, coastal development, benthic trawling, and to inform the broad assessment of current status of habitats within marine parks. Small-scale threats and changes to habitats that have occurred adjacent to populated areas were generally not documented.

3.1.2.3 Assessment of current status of habitats

Documented changes in the levels of area and cover of habitats since European settlement were used to assess the current status of habitats. Most habitats were assumed to be at a natural level unless there was evidence available that indicated otherwise.

In the case of potential habitat impacts from prawn trawling, a weight-of-evidence approach was used to identify potential zones that may have been trawled and/or the intensity of that trawling, using the following information:

7 A third order ecological interaction may occur whereby a species (e.g. lobster) increases in abundance due to protection (first order) and this species then causes the decline of another species (e.g. urchin) (second order), which in turn allows an increase of a habitat-forming species (e.g. macroalgae) (third order).

- displaced catch estimates for the proposed SZs and HPZs (Ward and Burch, 2012) and earlier proposals (Currie and Ward, 2011). However, due to artefacts of the estimation method, it is possible that historical catch could be assigned to zones where trawling has not actually occurred.
- other reports on prawn trawling effort, e.g. by Currie et al. (2009).
- an overlay of SZs and HPZs in the park with designated prawn trawl reporting blocks. This approach is not reliable for confirming that trawling occurs, but if a reporting block did not partially overlay a zone, then it was considered safe to assume that trawling had never occurred.
- depth and habitat spatial information. Trawling was assumed not to occur within zones that were shallower than 10 m as prawn trawling is not permitted in these depths, nor within zones that were predominantly reef as trawling typically does not occur over this habitat type.
- local knowledge.

Nonetheless, a high degree of uncertainty still remained with these assessments due to lack of available fine-scale spatial data about previously trawled areas.

3.1.2.4 Predictions of recovery in degraded habitats

Predictions of recovery were made for two situations: (1) areas inside RAZs, SZs and HPZs that had potentially been trawled by the prawn fishery, and (2) areas where habitat degradation due to other activities has been well documented. Predictions of change in area and cover of habitats used the same response model as described for species later.

3.1.2.5 Protection of habitats from future harmful uses

The threats to each of the habitat types defined above are discussed in Appendix 4 (Habitat Profiles). The *Marine Parks Act 2007* will influence future activity in all zones and the zoning plan will afford additional protection from specific activities within HPZs, SZs and RAZs, with respectively increasing protection across this hierarchy of zone types. The activities and uses that are deemed compatible or incompatible with the various zones are provided in Appendix 7.

Habitats that are afforded additional protection through zoning are more likely to be maintained in sufficiently good condition to continue delivering a range of ecosystem services and other benefits as discussed in Appendices 4 (habitat-specific information) and 5 (consolidated discussion). Habitat-specific notes that clarify certain aspects of how protection will provide such benefits are provided in Appendix 1.2.6.

3.1.3 Species

Species may be impacted by the proposed zoning in three ways: (1) protection from current harmful uses within RAZs, SZs and HPZs, (2) protection from future harmful uses within zones, and (3) ecological interactions. The following sections describe how each of these impacts was assessed.

Some of the more mobile species may also show a response within and/or outside zones due to the proposed overall reduction of commercial and charter fishing effort, as per the PIRSA (2011) policy position on redistribution of displaced commercial fishing effort. While it was assumed that the removal of this effort would minimise negative impacts on areas outside SZs, there is potential for the abundance of some fished species to decline outside SZs through displacement of recreational fishing effort, possibly offset to some extent by spill-over.

3.1.3.1 Species assessed

The marine and estuarine waters of South Australia represent some of the most biologically diverse waters, with thousands of marine species. It was not possible to individually assess all of these species for the present study. Therefore, a suite of 205 representative species was chosen to include a range of taxonomic groups, trophic levels, key components of habitat-based ecosystems, representatives of different habitats, common and well-known species, commercial and recreational fishery species, iconic species, and threatened and protected species. The full species list formed the basis for the assessments of species, habitats and ecosystems. This list of species is provided in Appendix 2.

An extensive literature search was conducted to document information on the following parameters for fished species: maximum age (years), maximum length (cm), site fidelity (classed as migrant, resident or temporary resident), predators, prey, and trophic level. For non-fished species, predators, prey, and trophic level only were documented. Maximum age, maximum length and site fidelity information were used in predictions for the fished species assessment component. Predators, prey, and trophic level were used to develop simplified conceptual food webs for the ecosystem assessment component. A database of information was subsequently created that drew on hundreds of literature sources.

3.1.3.2 Species-use interactions

An assessment was made of the current uses that are known to impact marine biodiversity and which would be ceased within zones. This analysis revealed that a range of fishing activities were the main current uses that would be ceased within RAZs and SZs and which have potential for a major impact on biodiversity within these zones; some activities such as jet skis will also be ceased and these may have a minor influence on biodiversity conservation The main current activity that impacts biodiversity and which will be ceased within HPZs was benthic trawling[8]. Thus a major component of the species assessment focussed specifically on fished species and (1) documenting the status of species within each park, and (2) making predictions on the response of fished species to protection from fishing.

Predicting species (and ecosystem) responses to protection from fishing is highly complex (see Appendix 1.3) and, compared to other activities, there are generally more data available to inform the assessment. Consequently, the extent and depth of discussion on fishing-related responses may appear to be disproportionate in comparison to other activities, but this is not intended to place any particular emphasis on fishing as a threatening process.

Another important component of the species assessment focussed on threatened and protected species, and in particular, whether the management changes might affect the recovery of threatened species. A review of existing information was used to inform the

8 Either because activities removed/restricted by zoning are not currently undertaken or because they are licenced under another Act and according to the policy commitments are exempt.

current status of threatened and protected species, and a qualitative assessment was then made of threatening processes and whether the current status might be affected by the proposed zoning and management arrangements (see Species Profiles in Appendix 3). Attempts were also made to qualitatively predict likely ecosystem interactions that might influence threatened, protected, fished, and non-fished species due to the proposed management arrangements (see Appendix 1.4 and Species Profiles of threatened and protected species in Appendix 3).

Future uses that are known to impact marine biodiversity but which will be prevented or influenced by the change in management, were identified. The assessment of these future uses was qualitative only, focusing on the positive impact that the new management may have on the protection of habitats that support the component species and ecosystems (see Appendices 1.3 and 1.4). It can only be a qualitative assessment as there is no way of reliably predicting what, where and when these future uses may occur, e.g. a proposal for a wastewater treatment plant outfall.

3.1.3.3 Method for fished species predictions

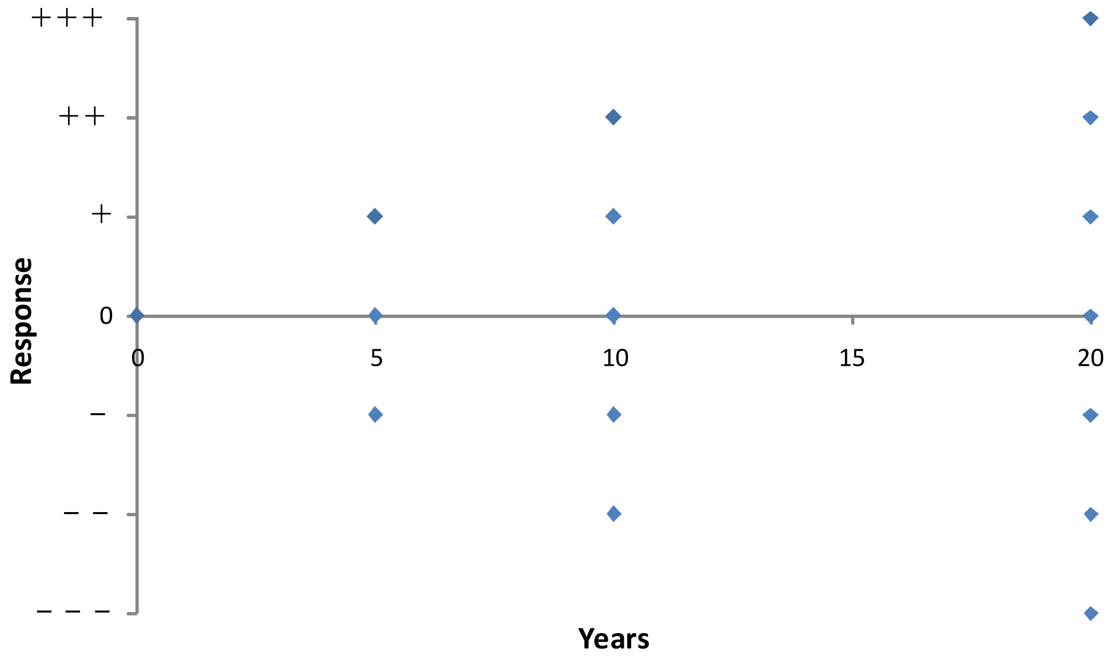
The general sequence of steps for making predictions was to systematically go through each RAZ, SZ and HPZ of each park and determine for a subset of 20 indicator species:

- If the fished life stage of the species (adult and/or sub-adult) occurred in that area and its preferred habitat type was present in a zone (using GIS layers created for the purpose) then the species was assumed to occur in that zone
- Whether the fished life stage was a resident, migrant or temporary resident in the zone (using life history information—see Appendix 3)
- If substantial fishing effort and/or catch (fishing activity) occurred in the region. This step was somewhat subjective given the disparate nature of the data available to determine fishing activity, but it was essentially confined to the highest catch and effort regions of the commercial, recreational and charter sectors (data derived from various sources), as well as for potential recreational fishing activity: accessibility by land (shore-based fishing) and water (boat ramps and boat fishing), and proximity to human population centres. Relevant existing fishing closures were also taken into account.
- If it was felt that sufficient information was available to assess the current status of the species in that region, the species was included in the analysis. If too much uncertainty existed, the species was excluded
- If changes in size and abundance were possible, a prediction was made (see below);
- If an increase in abundance was predicted beyond five years, i.e. an accumulation and not just a temporary increase, and the species was physically capable of moving out of the SZ, spill-over was predicted
- If a species was known to spawn in the general area, larval export from the SZ was predicted.

Given a current status in relation to UNLL or NL (see Section 3.1.1), semi-quantitative predictions can be made as to how the level may change under a specific zoning and management scenario. To enable these predictions, a simple model was developed to demonstrate how a species may respond over the next 5, 10 and 20 years (see Figure

3–1). The model allows only a 1-step or 1-level change across each time period of 0–5 years, 5–10 years, and 10–20 years. For example, in the first 5 years, the response can be either an increase (+), a decrease (-), or no change (0). Following an increase after 5 years to +, the subsequent response from 5–10 years could be either a further increase to ++, a decrease to 0, or no change and remaining at +. Following a decrease after 5 years to -, the subsequent response from 5–10 years could be either a further decrease to - -, an increase to 0, or no change and remaining at -. There could also be no response to zoning and management from 5–10 (and 10–20 years) such that the level continues to remain at 0. Subsequent scenarios from 10–20 years can be readily calculated from Figure 3–1. The maximum level achievable after 20 years is +++ and the minimum is - - -. To assess the net effect of the proposed zoning, predictions with and without the zoning were compared and the net score was assigned by subtracting the response with and without the zoning. Thus, in some cases there may be a net effect that is ++++.

Figure 3–1 Model used to demonstrate possible responses of species and habitats to implementation of proposed management changes



3.1.3.4 Predictions for sessile benthic species in trawled areas

Sessile benthic species that may have been affected by previous prawn trawling were not treated separately (even though they may constitute numerous species, see Currie et al. 2009) but rather were treated as a group in the Habitat section (see Section 3.1.3).

3.1.4 Ecosystems

The habitat types defined above (see Section 3.1.2.1) were used as the basis for the ecosystems assessed. Multiple habitat ecosystems have also been recognized.

Development of ecosystem models for this project was not possible within the time and resources available. Observations from other marine parks and the development of some simplified conceptual food webs have been used as a basis for discussing potential responses of local ecosystems to protection and to illustrate some of the complexity of interactions between species.

3.1.4.1 Ecosystems assessed

Eleven simplified conceptual food webs were developed to illustrate likely ecosystem structure and trophic flows in the eleven ecosystems (see Appendix 6) based upon knowledge of predator-prey relationships and habitat preferences for individual species/groups that were documented earlier (see Section 3.1.3 and Appendix 2). These conceptual models have used (where space permitted) many of the species/groups identified in the species assessment section (see Appendix 2).

In a more descriptive manner multiple-habitat ecosystems were recognized, e.g. saltmarsh-mangrove-intertidal sand/seagrass flats-subtidal sand/seagrass-pelagic; intertidal reef-subtidal high profile reef-subtidal sand-pelagic, and State-wide ecosystems such as the gulfs. The biodiversity conservation benefits of having a network of marine parks and protection zones that provide connectivity at these larger spatial scales are highlighted in some of the Case Studies in the individual impact statements for each park and in the Species Profiles section (Appendix 3).

3.1.4.2 Ecosystem responses to protection

Qualitative assessment was undertaken, based on the simplified conceptual food webs described in the previous section, supported by available literature.

3.2 Economic

The regional economic impact analysis focussed on the following aspects:

- commercial fishing, recreational fishing and tourism
- jobs and job creation
- business and capital investment
- population size/demographics
- average income per capita
- property prices.

As well, implications of the proposed marine park zoning and management arrangements for other industries and regional infrastructure were assessed; for example for mining, aquaculture, port and harbour operations, marine transport, and proposed infrastructure developments.

Government and non-government organisations in these sectors were consulted (see Appendix 10 for the list of persons and organisations consulted).

3.2.1 Economic impact models

The economic impact analysis was based on the input-output method. This method provides a standard approach for the estimation of the economic impact of a particular activity. The input-output model is used to calculate industry multipliers that can then be applied to various change scenarios, as has been done in this study.

For this impact assessment input-output models were constructed for 11 economic regions. The model used is known as a Regional Industry Structure and Employment (RISE) model which is an extension of the standard input-output model that is used within the SA Government for various types of impact assessment (EconSearch 2009). A list of the regions for which RISE models were constructed is provided in Table 3–2 (Impact Region).

Because some of the activities that could potentially be impacted by marine parks are related to the tourism sector, the RISE model includes explicit specification of the regional tourism industry. This was done by following the standard ABS method of constructing tourism satellite accounts.

3.2.2 Indicators of economic impact

The following indicators of economic impact were generated using the economic modelling framework described above:

- value of output
- gross regional product (GRP)
- household income
- employment.

(Value of) Output is a measure of the gross revenue of goods and services produced by commercial organisations (e.g. the value of processed seafood products) and gross expenditure by government agencies. Total output needs to be used with care as it can include elements of double counting when the output of integrated industries is added together (e.g. the value of processed seafood includes the beach value of the fish).

Gross regional product (GRP) is a measure of the net contribution of an activity to the regional economy. GRP is measured as value of output less the cost of goods and services (including imports) used in producing the output. In other words, it can be measured as the sum of household income, 'gross operating surplus and gross mixed income net of payments to owner managers' and 'taxes less subsidies on products and production'. It represents payments to the primary inputs of production (labour, capital and land). Using GRP as a measure of economic impact avoids the problem of double counting that may arise from using value of output for this purpose. **Household income** is a component of GRP and is a measure of wages and salaries paid in cash and in-kind, drawings by owner operators and other payments to labour including overtime payments, employer's superannuation contributions and income tax, but excluding payroll tax.

Employment is a measure of the number of working proprietors, managers, directors and other employees, in terms of the number of full-time equivalent (fte) jobs. Employment is measured by place of remuneration rather than place of residence.

Table 3–2 Regional Economic Models

Marine Park	Impact Region	LGA/SLA
1 Far West Coast	1 Far West Coast	Ceduna (DC)
2 Nuyts Archipelago	1 Far West Coast	Unincorp. West Coast SLA
3 West Coast Bays	2 West Coast Bays	Streaky Bay (DC)
4 Investigator	2 West Coast Bays	Elliston (DC)
5 Thorny Passage	3 Lower Eyre Peninsula	Lower Eyre Peninsula (DC)
6 Sir Joseph Banks Group	3 Lower Eyre Peninsula	Port Lincoln (DC)
7 Neptune Islands Group	3 Lower Eyre Peninsula	Tumby Bay (DC)
8 Gambier Islands Group	3 Lower Eyre Peninsula	
9 Franklin Harbor	4 Franklin Harbour	Franklin Harbour (DC)
10 Upper Spencer Gulf	5 Upper Spencer Gulf	Whyalla (C) Port Augusta (C) Mount Remarkable (DC) Port Pirie - City (M) Port Pirie - Bal (M)
11 Eastern Spencer Gulf	6 Yorke Peninsula	Yorke Peninsula - North (DC)
12 Southern Spencer Gulf	6 Yorke Peninsula	Yorke Peninsula - South (DC)
	9 Kangaroo Island	Kangaroo Island (DC)
13 Lower Yorke Peninsula	6 Yorke Peninsula	Yorke Peninsula - North (DC) Yorke Peninsula - South (DC)
14 Upper Gulf St Vincent	7 Upper Gulf St Vincent	Wakefield (DC)
	6 Yorke Peninsula	Yorke Peninsula - North (DC) Yorke Peninsula - South (DC)
15 Encounter	8 Fleurieu & Coorong	Yankalilla (DC) Victor Harbour (C) Alexandrina - Coastal (SLA) Onkaparinga - South coast (SLA) Onkaparinga - North coast (SLA) The Coorong (DC)
	9 Kangaroo Island	Kangaroo Island (DC)
16 Western Kangaroo Island	9 Kangaroo Island	Kangaroo Island (DC)
17 Southern Kangaroo Island	9 Kangaroo Island	Kangaroo Island (DC)
18 Upper South East	10 Upper South East	Kingston (DC) Robe (DC)
19 Lower South East	11 Lower South East	Wattle Range - West (SLA) Grant (DC) Mount Gambier (C)

Estimates of economic impact are presented in terms of:

- direct impacts
- flow-on impacts
- total impacts.

Direct (or initial) impacts are an estimate of the change in final demand or level of economic activity that is the stimulus for the total impacts.

Flow-on impacts are the sum of production-induced impacts, consumption-induced impacts and offsetting consumption effects.

- **Production-induced impacts** are the sum of first-round impacts (i.e. estimates of the requirement for or purchases of goods and services from other sectors in the economy generated by the initial economic activity) and industrial support impacts (i.e. output and employment resulting from second, third and subsequent rounds of spending by firms). Production-induced impacts are sometimes referred to as 'indirect effects'.
- **Consumption-induced impacts** are additional output and employment resulting from re-spending by households that receive income from employment in direct and indirect activities. Consumption-induced effects are sometimes referred to as 'induced effects'.
  Offsetting consumption effects are 'lost' consumption expenditure by the local unemployed before taking a job or 'new' consumption expenditure of those losing a job as they shift to welfare payments.

Total impacts are the sum of direct and flow-on impacts.

3.2.3 Data and assumptions

At a micro level individual businesses could be impacted by the proposed marine park zoning and management arrangements. To assess the impact on commercial fishing operations representative financial models of fishing businesses were constructed for each of the relevant fishing sectors. These models were based on financial information collected and reported by EconSearch (2010) over the past 13 years. The results of the financial modelling provided input into the regional RISE model to estimate impacts on the regional economy.

The principal driver for change in fishing industry operations and profitability is lost access to the resource. Estimates of displaced catch and effort were provided by the South Australian Research and Development Institute (Ward and Burch 2012). PIRSA Fisheries and Aquaculture provided detailed information on the recreational and commercial fisheries relating to the:

- current condition of the fishery;
- outlook for the fishery without marine parks management plans;
- marine parks impacts on the fishery; and
- measures to mitigate anticipated impacts.

For some fisheries, the relevant fishing industry association has undertaken their own assessment of displaced catch and/or effort. The methods and data used to make these assessments will be reviewed by SARDI (DEWNR pers. comm., 6 July 2012). Analysis of the impact of the displaced catch or effort on commercial fishing based on these industry estimates has also undertaken.

Discussions were also held with representatives of each of the commercial fishing sectors, recreational fishing, mining, various State Government departments and Local Government (see Appendix 10). These discussions provided insights to the likely responses of businesses and organisations associated with or members of the interviewee's organisation. Because of time and resource constraints it was not possible to undertake discussions with or collect data from all potentially impacted parties.

A limitation of the analysis was that only the proposed sanctuary zones were publicly available during the information gathering phase[9]). The scope of the project also limited the level of detailed data collection and analysis that could be undertaken.

3.3 Social

3.3.1 What is social impact assessment

Social impact assessment (SIA) is a process designed to identify, mitigate and manage social impacts over time. More specifically, it is designed to isolate the intended and unintended social consequences, both positive and negative, of planned interventions (such as, marine protected areas) with a view to enabling a more sustainable and equitable biophysical and human environment (International Association for Impact Assessment 2003). SIA is an approach to understanding and assessing the impacts of change on individuals, families, and communities, measuring how these evolve over a period of time.

Likely social impacts will be significantly influenced by short and longer term economic and employment impacts (both positive and negative) of the establishment of a particular marine park. Social impacts also need to be considered in the context of environmental impacts including the medium term impact of zoning on the future sustainability of the marine environment which influences the health of the fishing and tourism industries. Actual impacts will be determined by the extent to which impacts are mitigated by factors such as compensation and the capacity of different population groups to adjust to change. Sound judgement about the interplay between all of these factors in determining the best configuration of a marine park is made possible by viewing impact assessment as a process that both precedes and follows the implementation of decisions.

Perceptions of social impacts at a particular point in time are shaped by experience, expertise and available information. The further information provided in this impact assessment statement on economic and environmental impacts now enables stakeholders to make more informed judgements about likely positive and negative social impacts.

9 The proposed sanctuary zone locations were publicly released on 27th April 2012. All proposed zoning was publicly released on 10th July 2012, which was after the information gathering phase for the impact statements from non-government organisations.

3.3.2 Method

In identifying potential social impacts of the proposed zoning for SA marine parks, this study has used a multi-faceted approach. This involved:

1. A review of relevant literature relating to the various impacts identified to date in established marine parks, both in Australia and internationally, with a focus on social issues (the findings of which are woven throughout this report and the 19 individual Marine Park Social Impact Statements). These included findings of surveys undertaken with recreational fishers affected by marine protected areas.
2. An analysis of key documentation relating to the marine parks establishment process. This analysis has been undertaken with a view to identifying issues that impact on local communities, but has also involved an over-time analysis of trends in the range of issues emerging.

Analysis of key documentation involved:

- An analysis of MPLAG minutes (by individual marine park and across the five meetings for each park, noting trends in attitudes expressed in response to key interventions such as, the SAMPIT[10] survey, feedback on proposed DEWNR zones).
- Analysis of market research findings by McGregor Tan Research and Square Holes. The work by McGregor Tan (2006-2009)[11] was designed to gauge community views on protecting the marine environment and on having marine protected areas and changes in these attitudes and perceptions over time. This research involved SA residents living in regional areas near the coast, specifically in the regions of –
    - West/Eyre Peninsula (Tumby Bay, Coffin Bay, Streaky Bay, Cowell, Port Lincoln and Ceduna);
    - Northern/Yorke Peninsula (Port Augusta, Whyalla, Port Pirie, Port Broughton, Kadina, Wallaroo, Moonta);
    - Central and Kangaroo Island (Victor Harbor, Goolwa, Port Elliot, Middleton, Meningie, Kangaroo Island and Cape Jervois); and
    - South East (Mt Gambier, Kingston, Robe, and Beachport)
    - Metropolitan Adelaide.
- The Social component of all *Environmental Economic and Social Values Statements* produced for the 19 marine parks - the social component of *Values Statements* provides information about recreational activities, and to a lesser extent, the valuing of European and Indigenous heritage. These together provide information about the valuing of a way of life which is closely linked to, but stops short of, identifying the importance of 'sense of

10 The South Australian Marine Parks Information Tool (SAMPIT) is a computer tool designed to gather information from community members about their favourite fishing spots and areas they believe need protection. Data is collected and reported by 'grid cell'. SAMPIT data for 1,739 people is available including 1311 recreational fishers. Quality control by the Department of Environment and Natural Resources in included cross-verification of legitimate naming and activities from the data provided (DENR 2010).

11 Square Holes research (2009-2012) continued the quantitative work of McGregor Tan in measuring changes in attitudes and perceptions as well as a qualitative research in order to obtain a deeper understanding of community views on marine parks in SA. This involved two focus groups in Adelaide and two in Wallaroo.

place' and community identity. It is not known from the information available, whether different groups within communities affected by marine parks regard them as potentially strengthening their identity (for example, as a pristine environment valued for its diversity of plants and animals) or as potentially threatening their identity (for example, as a predominantly fishing environment).

- Analysis of media reports relating to the marine parks, and provided by DEWNR.
- Analysis of SAMPIT survey findings.

These first two steps have informed the third – the design of a *Marine Parks Social Impact Assessment Tool* (MPSIAT) to contribute to the 19 Marine Parks Impact Assessment Statements. The MPSIAT groups social impacts into five domain areas:

- Education and wellbeing
- Culture and heritage
- Recreation and fishing
- Population and housing
- Community.

Finally, social vulnerability of the Impact Region associated with each Marine Park was determined through a combination of Socio-Economic Indexes for Areas (SEIFA) indexes, population (health, family, education, Indigenous status) and economic characteristics (unemployment, job losses).

The SEIFA Indexes presented in each of the individual Marine Park statements provide a measure of the socio-economic disadvantage for the Impact Regions associated with Marine Parks at the time of the 2006 Census[12] . We have included figures from the Index of Relative Socio-economic Disadvantage, the Index of Economic Resources and the Index of Education and Occupation. Each of these provides a slightly different view of the socio-economic profile and potential vulnerability of each region.

SEIFA values have been standardised with Australia (as a whole) having a value of 1000 and a standard deviation of 100, low scores indicate greater disadvantage. South Australia sits below the Australian average with a relative disadvantage level of 979. At the SLA level, South Australian SEIFA relative disadvantage scores range from a low of 527 through to 1107.

A range of SEIFA values at the statistical local areas (SLA) level are associated with the Impact Regions, noting between one and seven SLAs are associated with each Impact Region. These capture information about average socio-economic conditions for the SLA and Impact Region but do not account for variation of individuals within the areas. Areas identified with relative disadvantage may well have individuals and sub-regions that are relatively advantaged. We have also presented individual variables to provide additional information about the potential social vulnerability of SLAs associated with the Impact Regions.

[12] Australian Bureau of Statistics. 2008. *Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), Australia - Data only 2006 (cat. no. 2033.0.55.001)* and *Information Paper: An Introduction to Socio-Economic Indexes for Areas (SEIFA), 2006 (cat. no. 2039.0).* Note SEIFA Indexes for the 2011 Census are not yet available.

Where an Impact Region has an SLA falling within the top decile in South Australia (i.e. most disadvantaged) a ranking of High is provided. A ranking in the second highest decile is ranked as Moderate. Where there are moderate to high ranking SLAs they are rated to as Moderate-High.

The findings from these different sources were analysed separately and in combination to determine overall expected social impacts.

MPSIAT was developed by the Australian Workplace Innovation and Social Research Centre (WISeR, formerly the Australian Institute for Social Research) to identify and compare potential social impacts from the preliminary DENR marine park sanctuary zones (DENR zones) and zones resulting from Marine Park Local Advisory Groups advice (MPLAG zones)[13]. These were the proposed zones that were current at the time of distributing the MPSIAT. MPLAG members provided perspectives on the perceived impacts of zoning proposals based on their local experience and expertise.

Although this report presents impact analysis relating to the draft zones, the MPSIAT findings are included because they represent part of the community consultation process and the draft zones reflect the SA government's response to the findings of that process.

The MPSIAT was designed to shed light on differences in perspectives on social impacts in order to identify the full range of potential social impacts identified by key stakeholders. In the context of the impact assessment process these perspectives can inform our understanding of what the actual social impacts of the final zoning proposal are likely to be. Identification of these involved an examination of the inter-relationship between economic and social considerations in particular. The MPSIAT was provided online to MPLAG members, with participation encouraged by both MPLAG Chairs and DEWNR. Its independence was emphasised as was its confidentiality. MPSIAT was designed to offer balance between positive and negative impacts, and asked respondents to provide separate ratings for DEWNR zones and MPLAG zones, assessing the impact of each against a range of possible outcomes. Scales included in the social impact assessment were rated from 1 (‘very unlikely’) through to 5 (‘very likely’).

All MPLAG members[14] across the State were invited to participate in the social impact assessment with 157 members (59 per cent) contributing overall. Response rates for each park varied from a low of 33 per cent of Neptune Islands Group and Franklin Harbor Marine Parks members through to 73 per cent of members from the Far West Coast Marine Park (see Appendix 9).

13 The draft zoning had to be kept confidential. When consulting organisations on potential impact the MPLAG final advice and the Government’s preliminary zoning maps were used. This limited the accuracy of feedback, particularly where impacts are likely to be site specific.

14 Any MPLAG members who indicated they *did not* wish to participate in the social impact assessment *a priori* were not approached.

4. Results of the Regional Impact Analysis

Synthesis of impacts across all marine parks is provided in Section 4.1. A summary of impacts for each marine park is provided in sections 4.2 to 0. Details corresponding to these summaries can be found in the individual impact statements.

4.1 General

4.1.1 Ecological

The key positive impact on marine biodiversity from the proposed zoning and management arrangements will be the ability to influence future activities, such as coastal developments and land-based discharges, so as to help mitigate future damage to the marine environment. The maintenance of habitats in good condition is critical for the future of the State's marine environment.

The current status of habitats within marine parks across the State is generally one of good condition. Localised impacts are apparent in some parks adjacent to the more populated or industrialised regions and in areas where benthic trawling has occurred.

The protection of critical breeding, foraging and aggregation habitats will have a long-term positive impact for protected and threatened species, such as the Australian sea lion and white shark. However, in some cases the proposed zoning and management arrangements are unlikely to have an immediate benefit due to factors beyond the control of marine parks.

It is likely that ecosystems within sanctuary zones will be more resilient and better able to cope with future threats. However, some threatening processes for the marine environment such as climate change, introduction of marine pests, and land-based pollution can only be partially and/or indirectly addressed by zoning.

The main current activity affecting marine ecosystems that will be ceased inside sanctuary zones is fishing. The main current activity affecting marine ecosystems that will be ceased inside habitat protection zones is prawn trawling.

The current status of some fished species is below their natural levels when compared with a pre-European baseline. The reduced levels of these fished species are inherent in the exploitation of fisheries and do not necessarily reflect poorly on fisheries management. Fisheries are managed in accordance with the principles of ecologically sustainable development (ESD), aiming to maintain populations at a sustainable level while providing significant social and economic benefits to the community.

Making predictions of species responses to the cessation of fishing is intrinsically difficult. Nonetheless, increases in the size and abundance of some fished species, when considered in isolation, are predicted to occur inside adequately-sized and adequately-enforced sanctuary zones following the cessation of fishing. In particular, increases in the size and abundance of some of the more resident species such as southern rock lobster, snapper, mud cockle, pipi (Goolwa cockle), and razorfish are possible. Benefits to other more mobile species may also be expected due to the 'network effect' of the sanctuary zones and an overall planned reduction in commercial fishing effort for some sectors. There is potential for negative impacts on some fished species such as blacklip abalone which may be affected by increased numbers of predators such as lobster. Several resident reef fishes of conservation concern such as the western blue groper and harlequin fish will benefit from sanctuary zone protection.

The current status of ecosystems is difficult to assess, but it is apparent that reduced abundances of some fished species (or ecosystem components) may be having an impact on ecosystem structure but not necessarily ecosystem function.

Attempts to predict ecosystem responses were hampered by a general lack of knowledge of South Australia's marine ecosystems. Nonetheless, higher order ecosystem changes are likely to occur following the first order changes that occur in individual species from protection inside sanctuary zones. There will likely be predator-prey interactions that cannot be fully predicted at this stage. It is, however, predicted that some ecosystems will move towards a more natural state but cannot fully recover to a pre-European baseline due to negative impacts on the more migratory species outside of the sanctuary zones. Changes to species and ecosystems are likely to take many years, possibly decades, to occur. Nonetheless, detectable impacts are likely to be apparent for some fished species within five years.

In summary, the planned zoning and management arrangements for the marine parks network are expected to have a net positive impact on biodiversity conservation through protection of ecosystems from some future harmful uses and through the shift of many ecosystems towards a more natural pre-European state.

4.1.2 Economic

The main economic impact from implementation of marine park management plans will occur in the State's commercial fisheries.

Commercial fishing

The removal of fishing effort from sanctuary zones (and for the prawn fisheries, habitat protection zones) will result in changes in fishing behaviour that will affect both the quantity and, in some cases, the quality of catch as well as the cost of fishing operations.

In most instances, the displaced catch will not equate to a full single licence or, indeed, multiple licences. In the case of quota fisheries, the removal of effort will be achieved by buying out quota which will leave some licence holders with a reduced quota (and income) but unchanged fixed costs which will, in turn, negatively impact profitability. It will reduce the rate of return on investment and thereby devalue the value of licences and quota. Other fishery specific equipment, such as shark cages in the abalone fishery may also be devalued, particularly if there is consolidation of licences.Table 4–1 shows the estimated displaced catch by sector and the value of that catch estimated using average prices (in 2011 dollars). The estimated displaced catch for the sardine fishery, as per PIRSA's policy position on redistribution of displaced commercial fishing, will be able to be redistributed. The estimated displaced catch from the prawn sector is within the 2 per cent displacement limit set by this policy. This quantity and value of catch should not be lost to the sardine and prawn industry.

Excluding sardines the average annual displaced catch would be $5.587 million. The estimated values of displaced catch are based on average catches and average recent year prices, aligned as best as possible to the years for which average displaced catch was calculated. Therefore, there could be significant variation, both up and down, from year to year.

Table 4–1 Estimated Catch and GVP in sanctuary zones by fishery [c] based on SARDI estimates of displaced effort

	Average Annual Displaced Catch (kg)	Average Annual Catch (kg)	% of Average Annual Catch	Average Annual Price[a] ($/kg)	Value of Displaced Catch ($'000)
Sardines	*218,000*	*22,855,273*	*0.95%*	*0.76*	*0*
Prawns WC	649	79,348	0.82%	17.97	*0*
Prawns SG	1,721	1,932,492	0.09%	20.61	*0*
Prawns GSV	4,508	221,884	2.03%	19.02	*1*
Total Prawns	*6,878*	*2,233,724*	*0.31%*	*0.19*	*1*
Abalone WZ-A	7,785	501,742	1.55%	45.22	352
Abalone WZ-B	11,008	39,693	27.73%	45.22	498
Abalone CZ	11,187	178,182	6.28%	48.36	541
Abalone SZ	10	148,266	0.01%	42.76	0
Total Abalone	*29,990*	*867,882*	*3.46%*	*46.39*	*1,391*
NZ Rock lobster	35,149	694,455	5.06%	50.93	1,790
SZ Rock lobster	16,166	1,711,264	0.94%	56.09	907
Total Rock Lobster	*51,315*	*2,405,719*	*2.13%*	*52.56*	*2,697*
Pipi (LCF)	*48,089*	*300,180*	*16.02%*	*10.22*	*491*
Garfish	19,035	289,608	6.57%	7.31	139
KGW	17,355	341,611	5.08%	15.39	267
Snapper	21,924	773,072	2.84%	7.66	168
Sthn Calamary	13,661	311,967	4.38%	10.32	141
Other[b]	-	-	-	-	283
Total MSF	*71,975*	*1,716,258*	*4.19%*	*13.87*	*998*
Blue crab	*1,023*	*527,345*	*0.19%*	*8.25*	*8*
Sub-Total	**427,270**	**30,906,381**	**1.38%**	**13.08**	**5,588**
	Avg Annual Displaced Effort (person days)	Average Annual Effort (person days)	% of Average Annual Effort	Average Price ($/person day)	Value of Displaced Catch ($'000)
Charter Boats	*763*	*21,570*	*3.54%*	*253*	*193*
Total	**-**	**-**	**-**	**-**	**5,781**

[a] In most cases average annual prices were calculated for the same years for which the SARDI catch data were calculated, converted to 2011 dollars. Where SARDI data estimates were based on more than 10 years of catch data, only the most recent 10 years of price data were used.

[b] The four main MSF species comprised approximately 72 per cent of the fishery's GVP over the four years 2006/07 to 2009/10. On that basis the GVP of the average annual displacement of other species in the fishery was estimated.

[c] Estimates for the prawn fisheries include displaced catch in habitat protection zones.

Source Ward and Burch (2012), EconSearch analysis.

Almost 90 per cent of the value of displaced catch would occur in just three sectors, rock lobster (47 per cent of total value), abalone (24 per cent) and marine scalefish (17 per cent).

Estimates of historical catches from sanctuary zones have a high level of uncertainty because of the limited spatially-resolved data available for each of these fisheries (Ward and Burch 2012). For instance, it was assumed that catch of the fishery was evenly distributed in state waters within each MFA. According to Ward and Burch (2012) this assumption introduces considerable potential for bias in the estimates of historical catches for individual sanctuary zones because it may lead to:

- over-estimation of the historical catch from a sanctuary zone if the fishing hotspots (e.g. rock lobster, abalone or marine scalefish) in state waters of that marine fished area were outside the sanctuary zone; and
- under-estimation of the historical catch from that sanctuary zone if the fishing hotspots (e.g.. rock lobster, abalone or marine scalefish) were in a sanctuary zone.

Estimates provided by individual commercial fishing associations suggest that the average annual displaced catch (excluding the sardine and prawn fisheries) would be approximately double that estimated by SARDI. Industry derived estimates indicate a displaced catch of 376 tonnes (excluding sardines and prawns), valued at $8.6m.

Table 4–2 shows the economic impact on the state economy of marine park zoning on all affected fisheries. Impacts are based on SARDI's average annual displaced catches and average annual prices in 2011 dollars. In aggregate, it was estimated that the impact of marine park zoning will generate the following loss of economic activity.

- Approximately $12.60 million in GSP which represents 0.02 per cent of the state total ($80.36 billion).
- Approximately 124 fte jobs which represent 0.02 per cent of the state total (774,953 fte jobs).
- Approximately $7.89 million in household income which represents 0.02 per cent of that state total ($45.34 billion).

According to industry-derived estimates of displaced catch (which have not yet been reviewed by SARDI), the aggregate state-wide impacts could be as high as 164 fte jobs and $16.1m in GSP.

Because the reduced access to the fishery will be permanent, the impacts reported in Table 4–2 are an estimate of the on-going, annual impact.

Table 4–2 State economic impact of marine park zoning on all affected fisheries based on SARDI estimates of displaced effort

Sector	Output		Employment [a]		Household Income		Contribution to GSP	
	($m)	%	(fte jobs)	%	($m)	%	($m)	%
Direct effects								
Abalone	-1.39	6%	0	0%	-1.05	13%	-1.37	11%
NZ Rock Lobster	-1.67	8%	-10	8%	-0.74	9%	-1.09	9%
SZ Rock Lobster	-0.91	4%	-3	3%	-0.51	6%	-0.71	6%
Lakes & Coorong	-0.88	4%	-10	8%	-0.55	7%	-0.68	5%
Marine Scalefish	-1.00	5%	-13	10%	-0.58	7%	-0.76	6%
Charter Boat	-0.19	1%	-2	1%	-0.08	1%	-0.13	1%
Downstream [b]	-3.65	16%	-23	18%	-0.88	11%	-1.42	11%
Total Direct [c]	*-9.69*	*44%*	*-60*	*48%*	*-4.38*	*55%*	*-6.16*	*49%*
Total Flow-on [c]	-12.45	56%	-64	52%	-3.51	45%	-6.45	51%
Total [c]	***-22.14***	**100%**	***-124***	**100%**	***-7.89***	**100%**	***-12.60***	**100%**

Source EconSearch analysis.

Additional costs, which are difficult to quantify, will be incurred by Government to revise the modelling for stock assessments to consider the new area available to the fishery, which excludes the sanctuary zones. Fishery managers will need time and effort to change arrangements so as to account for the consequences of displaced effort on the sustainability of stocks outside of areas closed to fishing (PIRSA pers. comm. 29 September 2011).

Modification to the stock assessment process may result in less certainty regarding interpretation of data in the short-term, since relatively new information will be used (rather than the longer and more reliable time series) to underpin sustainable management of the fishery (PIRSA pers. comm. 29 September 2011). Sanctuary zones may however in the longer term provide an opportunity to accurately measure basic parameters used for modelling stock dynamics of fished species (e.g. rates of natural mortality, growth rates of large individuals, and size at maturity for unfished stocks), and fishing mortality (Buxton et al. 2006, Edgar et al. 2007).

Management costs are unlikely to be reduced at the same rate as declines in the sustainable yield. This could result in an increase in fees per licence or fees per quota unit which are cost recovered from commercial fishery licence holders (PIRSA pers. comm., 29 September 2011).

Table 4–3 shows the distribution of the gross value of displaced catch by marine park. The largest impact in terms of displaced GVP is in the Western Kangaroo Island Marine Park, an impact of almost $1.2 million, almost exclusively rock lobster and abalone.

Table 4–3 Gross value of displaced catch in marine park sanctuary zones [a] ($'000) based on SARDI estimates of displaced effort

Park Name	Sardines	Prawns	Abalone	Rock Lobster	Lakes & Coorong[b]	Marine Scalefish	Blue Crab	Charter Boat	Total
Far West Coast	0	0	0	100	0	1	0	0	**101**
Nuyts Archipelago	0	0	498	114	0	67	0	4	**683**
West Coast Bays	0	0	48	47	0	190	0	2	**287**
Investigator	0	0	223	319	0	2	0	2	**547**
Thorny Passage	0	0	25	224	0	4	0	13	**265**
Sir Joseph Banks Group	0	0	11	4	0	70	0	5	**90**
Neptune Islands Group	0	0	45	75	0	0	0	10	**130**
Gambier Islands Group	0	0	0	0	0	0	0	0	**0**
Franklin Harbor	0	0	4	0	0	22	4	10	**41**
Upper Spencer Gulf	0	0	0	0	0	20	4	15	**39**
Eastern Spencer Gulf	0	0	1	0	0	18	0	7	**27**
Southern Spencer Gulf	0	0	2	78	0	7	0	14	**101**
Lower Yorke Peninsula	0	0	0	39	0	3	0	5	**47**
Upper Gulf St Vincent	0	0	0	0	0	478	1	0	**479**
Encounter	0	1	13	35	491	105	0	81	**726**
Western Kangaroo Island	0	0	512	651	0	2	0	23	**1,188**
Southern Kangaroo Island	0	0	8	103	0	0	0	0	**112**
Upper South East	0	0	0	66	0	10	0	1	**77**
Lower South East	0	0	0	841	0	0	0	0	**841**
Total	**0**	**1**	**1,391**	**2,697**	**491**	**998**	**8**	**193**	**5,781**
GVP	17,384	45,485	39,443	131,363	3,067	23,056	4,353	5,459	**269,610**
Displaced Catch GVP Share	**0.00%**	**0.00%**	**3.53%**	**2.05%**	**16.02%**	**4.33%**	**0.19%**	**3.54%**	**2.14%**

[a] Estimates for the prawn fisheries include displaced catch in habitat protection zones

[b] GVP for the Lakes and Coorong Fishery is for pipis only.

Other marine parks with significant displaced value of catch are Lower South East (rock lobster), Encounter (pipis, marine scalefish, charter boats and rock lobster), Nuyts Archipelago (abalone, rock lobster and marine scalefish), Investigator (rock lobster and abalone) and Upper Gulf St Vincent (marine scalefish). These six marine parks (including Western Kangaroo Island Marine Park) account for around 78 per cent of the total impact.

Because the reduced access to the fishery will be permanent, the impacts reported in Table 4–3 are an estimate of the on-going, annual impact.

Aquaculture

There are no known current or potential impacts expected from the draft zoning on current or future aquaculture enterprises in marine parks. This is consistent with Government policy commitments. Any potential future prescribed criteria in aquaculture zone polices derived from Section 11 (3a) of the *Aquaculture Act 2001* may add cost to existing or future aquaculture activities, or have regulatory impact (PIRSA, pers. comm., 7 November 2011). However, no such prescribed criteria currently exist and potential impacts have not been assessed.

In the Upper South East Marine Park, Lacapede Bay Aquaculture Zone overlaps the entirety of SZ-2, however a special purpose zone will be placed over the sanctuary zone and HPZ-2 to allow for future planned finfish aquaculture activities.

Property prices

Given that the overall impact on the regions is not expected to be large in absolute terms, the impact on property values is, similarly, not expected to be significant. States of Australia have introduced marine parks with sanctuary zones in the last decade without any known long-term effects on property values. Residential property prices are unlikely to be affected by the proposed marine park zoning.

Tourism

The following assessment is based on discussions with the South Australian Tourism Commission, local councils and local offices of Regional Development Australia.

Fishing based tourism has been identified as important to local economies adjacent to 12 marine parks (Nuyts Archipelago, West Coast Bays, Investigator, Thorny Passage, Sir Joseph Banks Group, Franklin Harbor, Eastern Spencer Gulf, Southern Spencer Gulf, Lower Yorke Peninsula, Encounter (Goolwa area), Upper South East and Lower South East Marine Parks). Several organisations have raised the point that towns identified as 'fishing centres' that are comparatively remote are more vulnerable to a downturn in fishing tourism if fishing visitors perceive that there may be restrictions to their activities. This is more likely for local economies along the West Coast and Eyre Peninsula. However, as discussed in section 4.1.3, draft zoning is likely to have very localised impact on recreational fishing in six marine parks (Far West Coast, West Coast Bays, Upper Spencer Gulf, Eastern Spencer Gulf, Encounter and Lower South East) and therefore the actual placement of sanctuary zones is unlikely to place real restriction on recreational fishing. However, the perception that recreational fishing opportunities will be restricted by implementing 'no-take' zones is real (for example, the charter boat industry has identified that they have benefited from an increased number of interstate clients in recent years who come to South Australia to fish because SA waters do not have marine park 'no-take' zones). So there is potential for a downturn in fishing-based tourism in the short-term until visitors are informed and convinced of the actual situation on the water.

Marine ecotourism businesses currently operate in at least seven marine parks (Nuyts Archipelago, West Coast Bays, Thorny Passage, Sir Joseph Banks Group, Neptune Islands Group, Upper Spencer Gulf and Encounter). It is an industry in its infancy and is expected to grow, however is unlikely to grow into a large industry because of the natural limitations of rough seas, cold water and sharks. Several organisations raised the issue of operator permits being a key factor in the ability of the industry to grow. In the past, one-year, renewable permits (issued under the *National Parks and Wildlife Act 1972*) were available which is viewed as a barrier to investment in this area. The permitting policy is being changed, with far greater flexibility on the length of time permits can be held, ranging from temporary permits up to 10 year permits[15] which is seen as likely to boost business investment. There will be situations where eco-tourism operations will occur within sanctuary zones (for example, shark viewing off North Neptune Island) which may benefit from zoning by, for example, not having to share the space with fishers. In the long-term, managed marine parks will provide certainty that the marine environment within them is being protected and this is likely to support the ecotourism industry. So, in summary, it is likely that ecotourism activity will increase over time, although the extent to which such growth can be attributed to marine park zoning is uncertain. Nevertheless, marine-based ecotourism is unlikely to overtake other types of tourism, such as food and wine tourism in size.

Other, non-extractive tourism, such as diving, is likely to benefit from the implementation of sanctuary zones.

Port, harbour and shipping operations

There are nine ports and thirty-one harbours in South Australia, with the majority of harbours located within a marine park. The existing arrangement where shipping, ports and harbour activities are managed pursuant to the *Harbors and Navigation Act 1993* will remain. This includes dredging and channel maintenance, development or improvement of facilities for anchorage, vessel maintenance, loading, unloading and storage of goods, associated commercial and industrial development, sporting and recreational purposes.

Under the Government policy commitment on shipping and harbours, all harbours declared under provisions of the Harbors and Navigation Act 1993 are zoned special purpose areas. Current and future operations in harbours will not be affected and have been accommodated within marine parks as reflected in the draft management plan zoning.

The shipping industry has suggested that marine park zoning may place potential restrictions on port, harbour and shipping facilities through zoning restrictions. These concerns have been addressed through exclusion of ports from marine parks, special purpose area status applied to harbours plus appropriate zoning for anchoring grounds, transhipment points and pilot boarding grounds.

In addition, due to significant economic development expected over the next ten years in the Upper Spencer Gulf, the sanctuary and habitat protection zones of the Upper Spencer Gulf Marine Park has been declared a special purpose area, permitting specified activities.

15 See DEWNR's current *Commercial Tour Operators' Licensing and Permitting Policy* at http://www.environment.sa.gov.au/parks/Get_Involved/Commercial_Tour_Operators

There is not expected to be any loss of economic activity generated by ports as a result of the implementation of the draft zoning, nor any significant impacts on shipping activities. This is consistent with Government policy commitments.

It should be noted that aids to navigation and markers are permitted in any waters in any marine park.

Mining, petroleum and geothermal industries

The existing arrangements where DMITRE Minerals and Energy Resources Division oversee activities that support the mineral, petroleum and geothermal resource industries, pursuant to the *Mining Act 1972,* the *Petroleum and Geothermal Energy Act 2000,* the *Offshore Minerals Act 2000* and the *Petroleum (Submerged Lands) Act 1982,* will remain. All existing licences and leases will be accommodated with no change to existing conditions.

Applications for new or renewal of licences and leases within and adjacent to marine parks will require the concurrence of the Minister responsible for marine parks under related amendments to the *Mining Act 1972* and the *Petroleum and Geothermal Energy Act 2000*. Where the proposed activity is consistent with the zoning regulations, no further approvals or permits will be required, apart from those required under legislation administered by DMITRE Minerals and Energy Resources Division. Section 19 of the *Marine Parks Act 2007* provides for consideration of activities that are inconsistent with marine park zoning regulations on a case-by-case basis with rigorous assessment and approval processes and due consideration of risk to environmental values (e.g. to consider new/emerging lower impact technologies). The Minister responsible for marine parks will be required to issue a special permit in such cases.

There are mineral exploration licence applications over parts of West coast Bays, Investigator (off Flinders Island), Franklin Harbor, Upper Spencer Gulf and Eastern Spencer Gulf Marine Parks, one geothermal exploration licence application over parts of Upper Gulf St Vincent Marine Park and one petroleum exploration licence application over parts of Franklin Harbor and Upper Spencer Gulf Marine Parks. As mentioned above, licence applications will be required to go through a joint approval process administered by DMITRE and DEWNR, which may be a potentially lengthier and therefore more costly process. The mining industry has raised concerns that the joint approval process may increase administrative costs on applicants unless it is integrated within the existing Plan for Environmental Protection and Restoration framework administered by DMITRE, and if such costs increased this may deter investment (SACOME, pers. comm., 18 June 2012). Zoning limits the types of activities normally permitted, and could potentially discourage certain types of applications and hence limit exploration and exploitation of resources. However no examples have been highlighted.

Coastal development and infrastructure

Marine parks will not prevent coastal developments approved under the *Development Act 1993*. Coastal developments and infrastructure are regulated under the provisions of the *Development Act 1993* with developments considered on a case by case basis by the relevant authorities to ensure that the achievement of the objects of the *Marine Parks Act 2007* and the aims of the specific zone where the development is proposed are supported appropriately. As part of the assessment process, advice or direction may be required from the Coast Protection Board and/or the Environment Protection Authority and other authorities, depending on the nature of the development.

Development plans and significant projects are informed by the Planning Strategy which now includes the objects of the *Marine Parks Act 2007*.

The proclamation of the marine parks network will not affect access to, or use of, jetties, breakwalls or boat ramps.

Potential future infrastructure has been identified in seven marine parks and no foreseeable impact on their development is envisaged.

4.1.3 Social

Regional economic impact assessment is closely linked to social impact assessment, with economic effects significantly shaping impacts on communities. Table 4–4 illustrates this, and summarises the expected impact of the marine parks on communities in their vicinity.

An overview of the five main types of social impact follows.

Education and Wellbeing Impacts

There was a trend for MPSIAT views to be divided about the likelihood of marine parks providing increased opportunities for education about marine life and for improved understanding about marine conservation issues. However, international research findings confirm that this is a key outcome and benefit of marine protected areas (Angulo-Valdes & Hatcher 2010). It is evident that more information needs to be provided to communities about the potential benefits, including those relating to marine conservation.

It is difficult at this stage of the parks' development to determine their impact on wellbeing; the impact may well be neutral but will take some time to become apparent. MPSIAT feedback was mixed in expectations about impact on personal, family, and community way of life.

Culture and Heritage Impacts

It was clear from analysis of MPLAG minutes and the MPSIAT survey that more information is needed about the separate consultation that has occurred to manage the interface between Indigenous interests and the marine parks. Most MPLAG members were unable to form an opinion about whether Aboriginal culture and heritage and the interests of Aboriginal communities are likely to be preserved with the implementation of the marine park, nor were they clear about how the parks' effect on helping to preserve local Australian culture and heritage.

Evaluation of the NSW marine parks system found little information forthcoming about the impact of the parks on Indigenous and non-Indigenous culture and heritage, noting a trend for this to occur internationally as well. The researchers recommended that heritage experts be engaged to identify this set of impacts (Fairweather et al. 2009, p.9).

Table 4–4 Summary of socio-economic impacts of marine parks based on SARDI estimates of displaced effort

Marine Park # and Name	Commercial fishing + aquaculture contribution to regional employment (fte)	Tourism contribution to regional employment (fte)	Jobs impact (fte)[a]	Jobs Impact on regional employment (%)	Regional unemployment[b]	Recreational fishing impact	Overall expected social impact
1: Far West Coast			0	0%		Low, localised impact	**Low**
2: Nuyts Archipelago	107 (6%)	164 (9%)	5	0.3%	High (8.6%)	Low	**Moderate**
3: West Coast Bays			5	0.3%		Low	**Low**
4: Investigator	99 (6%)	150 (9%)	4	0.2%	V. low (2.5%)	Low, localised impact	**Low**
5: Thorny Passage			3	<0.1%		Low	**Low**
6: Sir Joseph Banks Group	1,210 (13%)	540 (6%)	2	<0.1%	Low (4.2%)	Low	**Low**
7: Neptune Islands Group			0	0%		Minimal	**Low**
8: Gambier Islands Group			0	0%		Nil	**Low**
9: Franklin Harbor	79 (14%)	39 (7%)	0	0%	V. Low (2%)	Low	**Low**
10: Upper Spencer Gulf	62 (0.2%)	740 (3%)	0	0%	Low (5.6%)	Low , localised impact	**Low**
11: Eastern Spencer Gulf	94 (2%)	460 (11%)	0	0%		Low , localised impact	**Low**
12: Southern Spencer Gulf	168 (2%)	1,420 (18%)	0	0%	V. Low (2.8%)	Low, localised impact	**Low**
13: Lower Yorke Peninsula	94 (2%)	460 (11%)	0	0%		Low	**Low**
14: Upper Gulf St Vincent	113 (0.9%)	690 (5%)	12	0.1%	Low (3.9%)	Low	**Low**
15: Encounter	160 (0.4%)	3,120 (8%)	28	0.1%	High (8.1%)	Low , localised impact	**Low-moderate**
16: Western Kangaroo Island			12	0.5%		Minimal	**Low-moderate**
17: Southern Kangaroo Island	74 (3%)	960 (43%)	1	<0.1%	Low (3.9%)	Minimal	**Low**
18: Upper South East	59 (4%)	200 (12%)	0	0%	V. Low (2.3%)	Low	**Low**
19: Lower South East	330 (2%)	1,000 (5%)	8	<0.1%	Moderate (6.5%)	Low , localised impact	**Low-moderate**

[a] Commercial fishing direct and indirect jobs lost. Jobs impacts outside marine park region is estimated to be 44 fte.
[b] V. Low (<3%), Low (3-5.9%), Moderate (6 to 8%), High (>8%)

Changes expected in relation to commercial fishing and recreational fishing will be low for communities living near most marine parks, with none expected to have significant impacts. However, MPSIAT respondents and the wider community will not have this information until the impact statements are released publicly. Consequently, feedback provided expects maintenance of community identity as a fishing centre to be perceived as threatened by some. While it is too early to determine at this stage, it is unlikely that their negative expectations will be realised, given the low impact expected on recreational fishing, and on commercial fishing in most instances. Furthermore, there will be different groups within the community with varying degrees of attachment to identity as a fishing centre, just as there will be a range of views about being identified as a place of ecological value.

Recreation and Fishing Impacts

In general, a majority of MPSIAT respondents did not expect that the proposed MPLAG zoning to encourage more recreational activity, a greater range of recreational activities and improved recreational facilities.

Recreational Fishing

With regard to recreational fishing, analysis of SAMPIT data corroborated with material from separate interviews with the South Australian Recreational Fishing Advisory Council and the DEWNR project coordinators who facilitated the MPLAG process shows that in all marine parks, most of the protected area is in low use areas for recreational fishing. Consequently, impact on local community identity as a fishing centre, and on fishing as a way of life is also likely to be minimal in most instances, with quite localized impact in six marine parks.

Zoning will have minimal impact on recreational fishing in Neptune Islands Group, Gambier Islands Group, Western Kangaroo Island and Southern Kangaroo Island Marine Parks, which are more challenging to access and therefore less popular fishing spots.

In the following marine parks, where recreational fishing is popular, the proposed zoning is expected to have low impact, with access to popular fished areas near or from the shore maintained:, Nuyts Archipelago, Investigator, Thorny Passage, Sir Joseph Banks Group, Franklin Harbor, Lower Yorke Peninsula, Upper Gulf St Vincent and Upper South East Marine Parks.

The following marine parks are likely to experience some localised impact:

- Far West Coast, the Granites campsite
- West Coast Bays, localized impact within Sceale Bay (boat-based) and Venus Bay
- Upper Spencer Gulf, at Black Point
- Eastern Spencer Gulf, between Cape Elizabeth and the Gap
- Encounter, Carrickalinga (Fleurieu Peninsula), and Lashmar Conservation Park (Kangaroo Island)
- Lower South East, at Canunda Rocks.

Commercial Fishing

The overall social impacts of the 19 marine parks on communities living in the region of are expected to be low given the magnitude of the economic impacts that have been projected. The main group impacted within these communities will be commercial fishing. Commercial fishing is one of the four top industry sources of regional employment for all but two economic regions (Upper Spencer Gulf and Fleurieu & Coorong regions), and contributes significantly fewer jobs than does tourism in all but two economic regions (Lower Eyre Peninsula and Franklin Harbour regions). Economic impact assessment identifies nine parks where no job losses are anticipated to a high of 28 fte fishing-related job losses estimated for Encounter Marine Park. The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above.

Although many of those with fishing involvement, commercial or recreational, tend to be negative in their assessment of expected marine park social impacts, Australian researchers have found that most commercial fishers have adapted their fishing activity and fishing business at least moderately well in the five years following implementation of the 2004 Great Barrier Reef Marine Park rezoning, leading them to conclude that many of the impacts experienced by fishers might be short-term and decline over time as fishers adapt to the change (Ledée et al. 2011: 8). Similarly, research undertaken in New Zealand’s Leigh Marine Reserve has found that almost two decades after it was established in 1975, commercial and recreational fishers reported that fishing outside the boundaries had improved over time (Cocklin et al. 1998).

However, there is a significant gap in the research evidence base relating to the social impacts of marine parks on commercial fishers and their families in particular, and on communities as a whole (Voyer 2011, 2012, Beeton et al 2012, Fairweather et al 2009). The Great Barrier Reef Marine Park Authority is cited as one exception to this trend (Voyer et al 2012, Beeton et al 2012) while social impact research has also been undertaken in relation to Ningaloo Marine Park in Western Australia (Northcote & Macbeth 2008). By contrast, economic impacts of marine parks have been significantly more researched.

More research is needed on the strategies fishers use to adapt, and the social and economic factors that inhibit or facilitate their adaptive capacity. Australian researchers have identified the potential psychological impacts on fishing families arising from uncertainty about fishing business viability, reduced family income, reduced self-esteem arising from the loss of fishing occupation and the difficulty of finding alternative employment in the region (Schirmer et al. 2004: 7-8). Much depends on individual fishers’ capacity to adapt which in turn has been found to depend on their financial situation, ability to work elsewhere, business skills and willingness to accept rather than resist change (Marshall and Marshall 2007). This diversity means that fishers, commercial or recreational, will vary significantly in the way marine parks affect them, and will have differing views on that impact.

Local Government

Through the SA Regional Organisations of Councils, facilitated by the Local Government Association SA, all local government councils which border marine parks in SA were invited to participate in a survey about potential impact of marine park zoning on council operations, council infrastructure and council revenues.

Five local councils responded. Based on the responses from these local councils, no impacts on local government operations, infrastructure and revenue or compliance related activities are expected as a result of the proposed draft zoning.

Population and Housing Impacts

It is considered unlikely that the marine parks will result in significant numbers of local people leaving their communities, although MPSIAT respondents held diverse views on this issue. It is highly unlikely that the parks will cause an increase property prices and make it more difficult for local people to buy houses. Based on the trend in property prices elsewhere in Australia where marine protected areas have been established (Government of South Australia 2011, pp.9-10), it is unlikely that marine parks will cause a decrease in beachfront property prices. The majority of MPSIAT respondents reflected this view.

Community Impacts

Most of the communities living near the marine parks were considered by MPSIAT respondents to be strong enough to manage changes brought by the parks, even if some did not welcome them or feared them as an unknown factor. However, this is an issue requiring specific research that should be conducted over time.

New business opportunities as a result of the marine parks were generally considered to be unlikely by most MPSIAT respondents, although there was some recognition of the need for training programs to assist local people to move into new occupations that may emerge following the park's implementation. It is possible that new employment opportunities will emerge as a result of the marine parks, and it will be important for local people to take advantage of those, with training being critical to their ability to do so.

Most MPSIAT respondents did not expect the marine parks to become a source of pride to local communities or to encourage activities and events that bring the community together. Again, it is too early in the evolution of the parks to determine whether either of these outcomes will emerge. Perceptions were split about whether the marine parks will become a source of division within local communities.

While there is little research evidence about the impacts of marine protected areas on communities as a whole, there are several studies in Australia and overseas that have identified a range of positive impacts, including enhanced tourism opportunities with flow on benefits to other sectors in the local economy. However, as previously stated, these and other benefits are not apparent in the early implementation stages and where positive impacts are reported these tend to be evident after about five years, becoming increasingly evident over the longer term (Cocklin et al. 1998).

Experience with marine parks in New Zealand is illustrative of the potentially positive social and economic impacts of marine protected areas. Research undertaken by Cocklin et al. (1998) involved social impact assessment of the Leigh Marine Reserve which was established in 1975 and the Hahei Reserve which was established in 1992. They found that some twenty years after the Leigh Marine Reserve was established it had achieved almost total support among visitors, local residents (permanent and temporary) and local businesses. In particular, the Reserve was found to have raised the profile of the locality, brought increased tourism with positive flow-on effects for the local economy while raising environmental awareness. Commercial and recreational fishers had come to believe that fishing outside the park's boundaries had improved over time and local fishers were playing a key role in enforcing compliance inside the Reserve (Cocklin et al. 1998: 225-226).

Two years after the establishment of the Hahei Reserve, and following initial opposition due to restrictions on fishing and disagreement with the boundaries, and a perceived lack of consultation, 70 per cent of the community expressed support for the Reserve. Just over one third of those who initially opposed it had changed their opinion, mainly because of boundary compromises. Four years after its establishment, support levels had reached 80 per cent from the local community and more than 90 per cent from visitors and businesses (Cocklin et al. 1998: 228).

Next Steps in Social Impact Assessment

Addressing the information gap

The community's understanding of marine conservation, and why it is important, has been found to directly shape their support for marine parks (Steel et al. 2005a), and generally this understanding is poor compared with knowledge of land based environment protection (Zann 1995; Steel et al. 2005b). Social impact research constantly identifies insufficient information as a cause of concern for communities affected by the establishment of marine parks, and notes how important such information can be for effective participation in the process of designing and implementing these parks. This includes better communication of the underpinning science of marine protected areas and how it has influenced their design and the setting of zones (Fairweather et al. 2009). The most recent review of marine parks in NSW (Beeton et al 2012) also found that insufficient community informing, and an associated lack of resourcing for this purpose, has resulted in marine parks-related decision making and the benefits of marine parks being insufficiently understood the general public. There is also research evidence of the importance of informed participation in marine park decision making and management, and in the enforcement of compliance (McPhee 2011; Cocklin et al. 1998).

A clear message from the market research, media reporting and feedback from MPLAGs is that the scientific arguments in favour of establishing marine parks need to be better understood by the wider community. This is one of the functions of this impact statement which is designed to inform judgements on the impact of the draft zoning proposal. MPSIAT feedback indicates that those members who do not understand the scientific arguments, also tend to disagree that the park's boundaries and proposed zoning are based on sound science.

In their evaluation of NSW marine parks, Fairweather et al. (2009, p.26) recommended to the Marine Parks Advisory Council of NSW that they be *'… more assertive about the science and other research behind the NSW Marine Park system …'* partly to refute misinformation being spread by opponents of the parks but also to ensure levels of understanding were increased. Acknowledging community concerns about possible negative impacts on their lives, the researchers identified the importance of ongoing socio-economic impact assessment as one means of improving understanding of the value of marine protected areas to Indigenous, recreational and commercial users of marine parks, mainly because it can capture the economic and social benefits that develop over time (Fairweather et al. 2009, pp.15-17).

MPSIAT feedback and reports in the local media identify the need for more information about the marine parks and how they will operate. Many of the submissions provided for the proposed zones associated with Encounter Marine Park (DEH: 2008) focused on the need for more information, including about the scientific information (some found it too difficult to comprehend while others found it to be too basic) and about there not being sufficient information to provide effective feedback. It would appear that there is a need to present scientific evidence relating to marine parks in a form that is understandable without reducing important content, and which clearly delineates the reasons for establishing marine parks.

South Australian market research undertaken to assess attitudes to marine parks also identified the need for more information being provided to the wider community and the need for this to be channelled through trusted intermediaries, that is, people considered to not have vested interests in the outcomes of marine protected areas. Examples of trusted intermediaries could be community representatives living in marine parks interstate that have been established for five years or more, or people working in shops with a fishing focus (e.g. bait and tackle shops).

Australian researchers have found that standard consultation methods such as public meetings and submission processes, if used as the only strategies of obtaining community feedback, do not provide access to a representative sample and thus provide biased or misleading information. For example, support for the 2004 rezoning of the Great Barrier Reef Marine Park was higher than anecdotal evidence from media coverage and public meetings suggested when a representative sample was obtained for feedback, and responses were quantified (Sutton and Tobin 2009, p. 250 citing Sutton 2006).

> *Previous research found that recreational fishers with negative opinions about management actions are the ones most likely to express their opinions at public meetings and through the media…. Clearly, negative opinions about the 2004 rezoning plan expressed publicly by some recreational fishers do not represent the diversity of opinions held by the recreational fishing community nor they represent the opinions of the majority of fishers* (Sutton and Tobin 2009, p.250 citing Sutton 2006, 2008).

It is usually the case that those expressing opinions publicly are more likely to be motivated by the need to resist change, than to support it.

> *… opposition is a stronger motivation to get involved than is support; acceptance of a proposal implies to some that they do not need to try to influence a decision* (Cocklin et al. 1998, p.217).

The media have a critical role to play in contributing to public understanding of the reasons for establishing marine parks but their influence can reduce understanding if the information presented is skewed or inaccurate. Researchers have established a trend for environmental news to be portrayed superficially, focusing on immediate and isolated events, such as, natural disasters rather than the less newsworthy provision of public education about environmental issues. Instead, the focus is often on competing views (Beder 2004, Burgess & Harrison 1993). It is likely that a communication strategy will be needed to overcome inaccurate or ill-informed media coverage of marine parks.

Recent research has analysed South Australian media portrayal of marine protection, with specific reference to the Encounter Marine Park (Compas et al. 2007). Examining metropolitan and regional (local to the Encounter Marine Park) newspaper coverage from 1999 to 2006, it found a degree of success in conveying different stakeholder views (77 per cent of content), moderate success in providing information about the public process associated with the marine park's establishment, and very poor provision of essential scientific information that would support informed public debate. There were also significant errors and omissions found and the researchers concluded that the general public would not have received the information needed to understand where and why management zones, including sanctuary zones, would be needed. Of the different types of information provided by newspapers, scientific and ecological content received the least amount of coverage (14 per cent).

Media analysis undertaken by DEWNR monitored all media (radio, TV, print) mentions of marine parks from October 2007 onwards. This analysis showed that print based media dominated reporting (53.5 per cent) followed by radio (39 per cent). Peaks in media coverage followed the release of the marine parks' outer boundaries (February and March 2009), and after the release of the preliminary sanctuary zones to the MPLAGs in late 2010, where an increasing build-up of negative reaction to them was evident, culminating in the February to April 2011 second peak in media mentions. The second peak was characterised by extremely negative reporting, challenging the credibility of scientific justification for the zones, encouraging fear-driven reactions to those zones, and highlighting divisions in the community regarding the zones (commercial against recreational fishers, conservationists against fishers).

It is important to note that a number of information provision strategies were implemented by DEWNR to inform the marine parks decision making process. This impact assessment report can provide the foundation for a further community consultation process.

Ongoing impact assessment

Perceptions of social impacts of change reflect knowledge, experience, values and roles. They provide a guide to possible but not certain impacts. To provide greater certainty about likely impacts we need to subject marine park zones to economic and environmental impact identification processes like those adopted in this impact assessment statement, repeating them over time to measure changes. The results of this process are necessary to inform judgement about the likely magnitude of social impacts, and whether these will be short-term, medium-term, or long-term in nature.

Social impact assessment that is repeated over time, provides a mechanism for informing as well as engaging communities, involving them in decision making, and identifying and assisting with managing intended and unintended social consequences (Vanclay 2005). However coastal zone management is often criticised for a failure to facilitate effective community engagement in what has been termed a 'democratic deficit' (Vanclay 2012).

The opportunity now exists for key stakeholders to re-evaluate their perspectives on social impacts in the light of new knowledge about industry, employment, species and habitat impacts provided by the environmental, economic and social impact statements. All of these factors will have an influence on likely social impacts of marine parks as these evolve over time.

4.2 Far West Coast Marine Park

Situated between the Western Australian border and the Tchalingaby sand hills, the Far West Coast Marine Park covers 1,690km^2 and is located within the Eucla Bioregion. This park encompasses the Great Australian Bight Marine Park and partially overlays the Nullarbor National Park and Wahgunyah Conservation Park up to median high water.

The habitats within the park are considered to be in a condition comparable to the time of European settlement. A number of species within the park were assessed as having lower abundances compared with pre-European levels. The current state of the ecosystems in the park was generally considered to reflect the condition of their component habitats and species.

The proposed management arrangements are predicted to have a net positive long-term impact on South Australia's marine biodiversity. Without the proposed management arrangements there is potential for future activities to occur that could impact on marine habitats, species and ecosystems. The positive ecological impacts inside the Far West Coast Marine Park will include (1) maintenance of habitats and ecosystems in relatively good condition, and (2) changes in some ecosystems towards a more natural and resilient condition. Such changes include possible increases in the size and abundance of at least one fished species (southern rock lobster), which may potentially have socio-economic benefits, and the overall shift towards a more natural ecosystem is also expected to provide a number of management benefits, although these potential benefits have not been quantified.

The proposed zoning restrictions (with habitat protection, sanctuary and restricted access zones covering about 23 per cent, 25 per cent and 42 per cent of the park, respectively) will assist with the future protection of habitats from a range of potentially damaging activities that may otherwise be possible under the existing management framework. Some habitats of particular conservation note include a diversity of intertidal habitats used by sea lions, fur seals, sea birds and resident and migratory wader birds, and also shallow subtidal habitats used by the southern right whale for calving. Maintenance of healthy habitats in general is essential for the functioning of ecosystems and the long-term sustainability of fisheries, aquaculture, and marine-based tourism.

Predictions of responses of fished species (other than rock lobster) to protection within the park were unable to be made. Nonetheless, it is likely that there will be some benefits to some species such as mulloway along the surf beaches.

The estimated economic impacts on commercial fisheries are relatively small for the Far West Coast Marine Park. Impacts are based on SARDI's average annual catches and corresponding average annual prices expressed in 2011 dollars. In aggregate, it was estimated that the impact of marine park zoning will lead to a reduction in the annual value of catch in commercial fishing sectors of $0.10m. This, in turn, will generate the following loss of regional economic activity on an ongoing annual basis.

- Approximately $0.14m in GRP, which represents 0.08 per cent of the regional total ($174m).
- Less than one fte job which represent 0.02 per cent of the regional total (1,872 fte jobs).
- Approximately $0.09m in household income, which represents 0.11 per cent of the regional total ($90m).

The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above.

The economic impacts could be greater as the estimated displaced catch, particularly rock lobster, may understate the actual catch in some sanctuary zones if they are located on important fishing grounds (hot spots). Impacts could also be over-estimated if sanctuary zones avoid hot spots (Currie and Ward 2011; Stevens et al. 2011). The zoning process attempted to avoid impacts on fishing by avoiding important fishing grounds. PIRSA has advised that statewide some draft sanctuary zones are located on important fishing grounds (hotspots), however advice specific to this park has not been provided. Industry derived estimates of displaced Rock Lobster catch (which are yet to be reviewed by SARDI) are consistent with estimates prepared by SARDI. The potential cumulative impact of the proposed extension to and revised zoning of the Commonwealth Great Australian Marine Park and the proposed Western Eyre Commonwealth Marine Reserve may place further pressure on fishing business viability.

Although the aggregate impacts may not appear large in absolute terms, the economy of the West Coast region is a fragile, highly dependent one. Despite the increase in mining activity in recent years the region is still reliant on agriculture and fishing as the core drivers of economic activity. Indeed of the 366 businesses in the region approximately 50 per cent are classified in the agriculture, forestry and fishing sector.

Additionally, unemployment in the Far West Coast region is high (8.6 per cent at June 2011) when compared with the state average (5.2 per cent). This suggests that alternative regional opportunities for unemployed labour will be difficult to find and any job losses will be real and unlikely to be absorbed into the local workforce. However no job losses are anticipated as a result of implementing the draft management plan.

There are currently no aquaculture operations in this marine park and any future development will need to be consistent with policy commitments, marine park and aquaculture related legislation (PIRSA, pers. comm., 27 June 2012).

The Head of Bight Visitor Centre attracts around 30,000 visitors a year (DENR, pers. Comm., 3 August 2011) who come mainly to whale watch. It is expected that the changes to zoning will not have an impact, either positive or negative, on visitation (DENR, pers. comm., 3 August 2011)

There are no ports or harbours in this marine park. No significant impacts on shipping activities arising from the zoning in this park are expected, which is consistent with Government policy commitments.

No mineral, petroleum or geothermal tenements are currently located within this park. Further, there are no major projects or infrastructure planned for this park.

The overall social impacts of the Far West Coast Marine Park on communities living in the Far West Coast region of South Australia are expected to be low given the magnitude of the economic impacts that have been projected (no job losses anticipated). The impact on recreational fishing is also considered to be low. Consequently, any impact on local community identity as a fishing centre and on fishing as a way of life is likely to be low, with some potential impact at the granites composite.

Experience elsewhere in Australia and internationally, suggests that a range of benefits from the establishment of marine parks become evident over time. These include increased opportunities for education about marine life and conservation, and increased tourism and ecotourism opportunities. This experience indicates that these benefits usually take approximately five years to be evident, and that in the earliest stages of marine protected areas being developed, local communities are more likely to identify possible negative impacts than potential benefits. It takes time to observe how

the park's ecological and economic impacts evolve, with social impacts (positive or negative) flowing from these.

4.3 Nuyts Archipelago Marine Park

Nuyts Archipelago Marine Park is the largest single marine park in South Australia's marine parks network. It includes the Nuyts Reef complex, Fowlers Bay, islands of the Nuyts Archipelago and adjacent coastal bays.

In general the habitats within the park can be considered to be in a condition comparable to the time of European settlement, although there are some potential minor threats from agricultural run-off or septic tank overflows in some areas, shellfish aquaculture and port activities, disturbance of sandy habitat by trawling, and potential disturbance of intertidal habitats. A number of species within the park were assessed as having lower abundances compared with pre-European levels. The current state of the ecosystems in the park was generally considered to reflect the condition of their component habitats and species.

The proposed management arrangements are predicted to have a net positive long-term impact on South Australia's marine biodiversity. Without the proposed management arrangements there is potential for future activities to occur that could impact on marine habitats, species and ecosystems. The positive ecological impacts inside the Nuyts Archipelago Marine Park will include (1) maintenance of habitats and ecosystems in relatively good condition, and (2) changes in some ecosystems towards a more natural and resilient condition. Such changes include increases in the size and abundance of some fished species, which may potentially have socio-economic benefits, and the overall shift towards a more natural ecosystem is also expected to provide a number of management benefits, although these potential benefits have not been quantified.

Various zone restrictions (with habitat protection zones and sanctuary zones covering about 51 per cent and 9 per cent of the park, respectively) will assist with the future protection of habitats from a range of potentially damaging activities that may otherwise be possible under the existing management framework however, the proposed zoning alone does not address potential threats listed above, which would require complementary management measures. Some habitats of particular conservation note include seagrass meadows that provide nursery and feeding grounds for a variety of crustaceans, fishes and waterbirds, mangrove communities and Nuyts Reef. Maintenance of healthy habitats in general is essential for the functioning of ecosystems and the long-term sustainability of fisheries, aquaculture, and marine-based tourism.

A number of species when considered in isolation (including southern rock lobster, greenlip and blacklip abalone, snapper, razorfish and mud cockle) have potential to increase in size and abundance inside some of the sanctuary zones. Some of these species also have potential for increased larval export to areas outside the sanctuary zones, as well as potential for spill-over of adults to areas outside the sanctuary zones. These changes may potentially have socio-economic benefits, although not quantified in this report. However, the ecosystems in which these species interact are expected to shift towards a pre-European state, which may result in declines rather than increases of some species such as blacklip abalone. Some species of conservation concern such as the western blue groper and harlequin fish are also likely to benefit from protection inside some of the sanctuary zones.

While the proposed zoning will have a neutral to beneficial impact on species, habitats and ecosystems, the effect on the local economy is generally assessed as negative. Impacts are based on SARDI's average annual catches and corresponding average annual prices expressed in 2011 dollars. In aggregate, it was estimated that the impact of marine park zoning will lead to a reduction in the annual value of catch in commercial fishing sectors of $0.68m. This, in turn, will generate the following loss of economic activity.

Approximately $1.04m in GRP, which represents 0.6 per cent of the regional total ($174m).

- Approximately 5 fte jobs which represent 0.3 per cent of the regional total (1,872 fte jobs).
- Approximately $0.69m in household income, which represents 0.8 per cent of the regional total ($90m).

The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above.

The economic impacts could be greater as the estimated displaced catch, particularly abalone and rock lobster, may understate the actual catch in some sanctuary zones if they are located on important fishing grounds (hot spots). Impacts could also be over-estimated if sanctuary zones avoid hot spots (Ward and Burch 2012; Stevens et al. 2011a and 2011b). The zoning process attempted to avoid impacts on fishing by avoiding important fishing grounds. PIRSA has advised that statewide some draft sanctuary zones are located on important fishing grounds (hotspots), however advice specific to this park has not been provided. According to industry-derived estimates of displaced catch (which have not yet been reviewed by SARDI), the aggregate regional impacts could be as high as 12 fte jobs and $1.39m in GRP.

The potential cumulative impact of the proposed extension to and revised zoning of the Commonwealth Great Australian Marine Park and the proposed Western Eyre Commonwealth Marine Reserve may place further pressure on fishing business viability.

Although the aggregate impacts may not appear large in absolute terms, the economy of the Far West Coast region is a fragile, highly dependent one. Despite the increase in mining activity in recent years the region is still reliant on agriculture and fishing as the core drivers of economic activity. Indeed of the 366 businesses in the region approximately 50 per cent are classified in the agriculture, forestry and fishing sector.

Additionally, unemployment in the Far West Coast region is high (8.6 per cent at June 2011) when compared with the state average (5.2 per cent). This suggests that alternative regional opportunities for unemployed labour will be difficult to find and any job losses will be real and unlikely to be absorbed into the local workforce.

There are no known current or potential impacts expected from the draft zoning in this marine park on current or future aquaculture enterprises. This is consistent with Government policy commitments, provided that any potential future prescribed criteria in aquaculture zone polices derived from Section 11 (3a) of the *Aquaculture Act 2001* do not add cost to existing or future aquaculture activities, or do not have regulatory impact. Because no such prescribed criteria currently exist such potential impacts have not been assessed, (PIRSA, pers. comm., 7 November 2011).

The actual placement of sanctuary zones is unlikely to place real restriction on recreational fishing with sanctuary zones over highly fished areas limited. However, the perception that recreational fishing opportunities will be restricted by implementing 'no-take' zones is real. So there is potential for a downturn in fishing-based tourism in the short-term until visitors are informed and convinced of the actual situation on the water. In the long-term, managed marine parks will provide certainty that the marine environment within them is being protected and this may support the growth of the ecotourism industry, provided the necessary investment in tourism infrastructure and support services is undertaken. Other, non-extractive tourism, such as diving, is likely to benefit from the implementation of sanctuary zones.

Given that the overall impact on the region is not expected to be large in absolute terms, the impact on property values is, similarly, not expected to be significant. States of Australia have introduced marine parks with sanctuary zones in the last decade without any known long-term effects on property values. External factors notwithstanding, the trend in Far West Coast residential property prices, illustrated in the regional socio-economic profile, is unlikely to be affected by the proposed marine park zoning.

The Port of Thevenard is excluded from the marine park. In addition the surrounding harbour of Thevenard has been declared a special purpose area. No significant impacts on shipping activities arising from the zoning in this park are expected, which is consistent with Government policy commitments.

There are no mineral, petroleum or geothermal tenements currently located within the marine park. A mining lease lies adjacent to the park inshore from the park boundary near Port Le Hunte, and extracts gypsum and salt. This operation is not expected to be affected by the zoning as it is not located near a sanctuary zone (where extractions and discharges of seawater are not permitted).

There is a proposal for a commercial and a recreational marina within the Ceduna-Thevenard area. If it goes ahead, this development will be within Thevenard Harbour, which is a SPA, where zoning would not restrict the activity.

The overall social impacts of the Nuyts Archipelago Marine Park on communities living in the Far West Coast region of South Australia are expected to be moderate given the magnitude of the economic impacts that have been projected. Commercial fishing is one of the four top industry sources of employment and is estimated to contribute 107 jobs to employment in the region, compared with tourism which contributes some 164 jobs. Economic impact assessment identifies a loss of five fte commercial fishing-related jobs. The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above. The impact on recreational fishing is considered to be low due to adjustments in zoning to minimise any potential negative impacts. Consequently, any impact on local community identity as a fishing centre and on fishing as a way of life is likely to be moderate.

Experience elsewhere in Australia and internationally, suggests that a range of benefits from the establishment of marine parks become evident over time. These include increased opportunities for education about marine life and conservation, and increased tourism and ecotourism opportunities. This experience indicates that these benefits usually take approximately five years to be evident, and that in the earliest stages of marine protected areas being developed, local communities are more likely to identify possible negative impacts than potential benefits. It takes time to observe how

the park's ecological and economic impacts evolve, with social impacts (positive or negative) flowing from these.

4.4 West Coast Bays Marine Park

The West Coast Bays Marine Park is situated in the Eyre Bioregion. Beginning at the southern end of Rincon Beach it extends to near Point Westall and includes Sceale, Venus and Baird Bays. This marine park encompasses Nicholas Baudin Island, Baird Bay Island and Point Labatt Aquatic Reserve and partially overlays Sceale Bay, Point Labatt and Venus Bay Conservation Parks up to median high water.

In general the habitats within the park can be considered to be in a condition comparable to the time of European settlement, although there are some potential minor threats to water quality from agricultural run-off or septic tank overflows in some areas. A number of species within the park were assessed as having lower abundances compared with pre-European levels. The current state of the ecosystems in the park was generally considered to reflect the condition of their component habitats and species.

The proposed management arrangements are predicted to have a net positive long-term impact on South Australia's marine biodiversity. Without the proposed management arrangements there is potential for future activities to occur that could impact on marine habitats, species and ecosystems. The positive ecological impacts inside the West Coast Bays Marine Park will include (1) maintenance of habitats and ecosystems in relatively good condition, and (2) changes in some ecosystems towards a more natural and resilient condition. Such changes include increases in the size and abundance of some fished species, which may potentially have socio-economic benefits, and the overall shift towards a more natural ecosystem is also expected to provide a number of management benefits, although these potential benefits have not been quantified.

The proposed zoning alone does not address the potential water quality issues listed above, which would require complementary management measures, but various zone restrictions (with habitat protection zones and sanctuary/restricted access zones covering about 89 per cent and 9 per cent of the park, respectively) will assist with the future protection of habitats from a range of potentially damaging activities that may otherwise be possible under the existing management framework. Some habitats of particular conservation note include Baird Bay and Venus Bay (both Wetlands of National Importance) and the Smooth Pool area at the northern end of the marine park. Maintenance of healthy habitats in general is essential for the functioning of ecosystems and the long-term sustainability of fisheries, aquaculture, and marine-based tourism.

It is expected that the designation of areas worthy of zoning as sanctuary protection zones and habitat protection zones would assist in directing future activities appropriately. However, there is some uncertainty about the extent to which zoning will provide future protection within Venus Bay, due to the proposed establishment of a special purpose area (harbor activities) within the Bay.

A small number of species when considered in isolation (namely southern rock lobster, and greenlip and blacklip abalone) have potential to increase in size and abundance inside some of the sanctuary zones. All of these species also have potential for increased larval export to areas outside the sanctuary zones, and southern rock lobster has potential for spill-over of adults to areas outside the sanctuary zones. These changes may potentially have socio-economic benefits, although not quantified in this report. However, the ecosystems in which these species interact are expected to shift towards a pre-European state, which may result in declines rather than increases of some species such as blacklip abalone.

While the proposed zoning will have a neutral to beneficial impact on species, habitats and ecosystems, the effect on the local economy is generally assessed as negative. Impacts are based on SARDI's average annual catches and corresponding average annual prices expressed in 2011 dollars. In aggregate, it was estimated that the impact of marine park zoning will lead to a reduction in the annual value of catch in commercial fishing sectors of $0.29m. This, in turn, will generate the following loss of economic activity.

- Approximately $0.29m in GRP which represents 0.2 per cent of the regional total ($148m).
- Approximately 5 fte jobs which represent 0.3 per cent of the regional total (1,671 fte jobs).
- Approximately $0.17m in household income which represents 0.3 per cent of the regional total ($67m).

The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above.

The economic impacts could be greater as the estimated displaced catch may understate the actual catch in some sanctuary zones if they are located on important fishing grounds (hot spots). Impacts could also be over-estimated if sanctuary zones avoid hot spots (Ward and Burch 2012; Stevens et al. 2011a and 2011b). The zoning process attempted to avoid impacts on fishing by avoiding important fishing grounds. PIRSA has advised that statewide some draft sanctuary zones are located on important fishing grounds (hotspots), however advice specific to this park has not been provided.

The potential cumulative impact of the proposed extension to and revised zoning of the Commonwealth Great Australian Marine Park and the proposed Western Eyre Commonwealth Marine Reserve may place further pressure on fishing business viability.

Although the aggregate impacts appear low, the economy of the West Coast region is a highly dependent one. The region is highly reliant on agriculture and fishing as the core drivers of economic activity. Indeed of the 567 businesses in the region approximately 58 per cent are classified in the agriculture, forestry and fishing sector.

However, unemployment in the West Coast Bays region is relatively low (2.5 per cent at June 2011) when compared with the state average (5.2 per cent). Depending on the skills match, this suggests that alternative regional opportunities for unemployed labour may not be difficult to find.

There are currently no aquaculture operations in this marine park and any future development will need to be consistent with policy commitments, marine park and aquaculture related legislation (PIRSA, pers. comm., 27 June 2012).

In the long-term, managed marine parks will provide certainty that the marine environment within them is being protected and this may support the growth of the ecotourism industry, provided the necessary investment in tourism infrastructure and support services is undertaken. Other, non-extractive tourism, such as diving, is likely to benefit from the implementation of sanctuary zones.

Overall the management plan zoning is expected to have low impact on recreational fishing, with sanctuary zones over highly fished areas limited. The District Council of Streaky Bay highlights that the recreational fishing opportunities in this area are a major draw for both visitors and residents. Travel distances are large (i.e. 700 km from Adelaide) and any perceived limitations in terms for fishing opportunities may detrimentally impact on the desirability of the West coast as a holiday destination.

The Council of Streaky Bay suggests that there may be a proportion of the current homebuyers market or potentially a new segment may enter the market that does value marine parks and specifically restricted access zones and sanctuary zones being in close proximity to their properties. Given that the overall impact on the region is not expected to be large in absolute terms, the impact on property values is, similarly, not expected to be significant. States of Australia have introduced marine parks with sanctuary zones in the last decade without any known long-term effects on property values. External factors notwithstanding, the trend in West Coast Bays residential property prices, illustrated in the regional socio-economic profile, is unlikely to be affected by the proposed marine park zoning.

The harbour of Venus Bay has been declared a special purpose area and there is not expected to be any significant impacts on shipping activities arising from zoning in this park, which is consistent with Government policy commitments.

There are no mineral, petroleum or geothermal tenements currently located within this marine park. An extractive mining lease for sand is located on the coastline along the eastern side of the entrance to Baird Bay, near Jones Island. A mineral exploration licence application is located on the coast near Venus Bay directly adjacent to the marine park boundary and is within the marine park boundary in some locations. There is also a petroleum exploration licence application adjacent to the marine park boundary from Rincon Beach to the southern boundary of the marine park. Licence applications will be required to go through a joint approval process administered by DMITRE and DEWNR, which may be a potentially lengthier and therefore more costly process to the applicant. Zoning limits the types of exploration activities permitted, and could potentially discourage certain types of applications and hence limit exploration and exploitation of resources. However no examples have been highlighted.

The Council of Streaky Bay is keen to manage the access to the coastline to prevent degradation of the fragile ecosystems through numerous uncontrolled access points while also identifying locations that access should be encouraged and formalised. The plans are contained in council's draft District Management Plan. The Plan should be resolved in the next 1-2 years which will provide certainty for landowners and developers. Whether it is a beneficial outcome for these groups will depend on the eventual alignment selected for the Coastal Conservation Zone.

There are no significant projects or infrastructure in or known to be planned for this park.

The overall social impacts of the West Coast Bays Marine Park on communities living in the West Coast Bays region of are expected to be low given the magnitude of the economic impacts that have been projected. Commercial fishing is one of the four top industry sources of employment and is estimated to contribute 99 jobs to employment in the region, compared with tourism which contributes some 150 jobs. Economic impact assessment estimates a loss of five commercial fishing-related jobs. Efforts to mitigate job losses flowing from commercial fishing losses are under consideration by Government. The impact on recreational fishing is considered to be low, with some localised impact within Sceale Bay (boat based) and Venus Bay, with adjustments in zoning designed to reduce any potential negative impacts. Consequently, any impact on local community identity as a fishing centre and on fishing as a way of life is also likely to be low.

Experience elsewhere in Australia and internationally, suggests that a range of benefits from the establishment of marine parks become evident over time. These include increased opportunities for education about marine life and conservation, and increased tourism and ecotourism opportunities. This experience indicates that these benefits usually take approximately five years to be evident, and that in the earliest stages of marine protected areas being developed, local communities are more likely to identify possible negative impacts than potential benefits. It takes time to observe how the park's ecological and economic impacts evolve, with social impacts (positive or negative) flowing from these.

4.5 Investigator Marine Park

The Investigator Marine Park is influenced by both the warmer Leeuwin Current from the west and the cooler Flinders Current from the east, and seasonal, nutrient-rich upwellings.

In general the habitats within the park can be considered to be in a condition comparable to the time of European settlement, although there are some potential minor threats to water quality from agricultural run-off in some areas. A number of species within the park were assessed as having lower abundances compared with pre-European levels. The current state of the ecosystems in the park was generally considered to reflect the condition of their component habitats and species.

The proposed management arrangements are predicted to have a net positive long-term impact on South Australia's marine biodiversity. Without the proposed management arrangements there is potential for future activities to occur that could impact on marine habitats, species and ecosystems. The positive ecological impacts inside the Investigator Marine Park will include (1) maintenance of habitats and ecosystems in relatively good condition, and (2) changes in some ecosystems towards a more natural and resilient condition. Such changes include increases in the size and abundance of some fished species, which may potentially have socio-economic benefits, and the overall shift towards a more natural ecosystem is also expected to provide a number of management benefits, although these potential benefits have not been quantified.

The proposed zoning alone does not address the potential minor water quality issues listed above, which would require complementary management measures, but various zone restrictions (with habitat protection and sanctuary zones covering about 64 per cent and 26 per cent of the park, respectively) will assist with the future protection of habitats from a range of potentially damaging activities that may otherwise be possible under the existing management framework. Some habitats of particular conservation note include seagrass beds at offshore islands, surf beaches of unusually fine sand, supporting a relatively high diversity of invertebrate animals and significant habitats for sea lions, fur seals and birds on the offshore islands. Maintenance of healthy habitats in general is essential for the functioning of ecosystems and the long-term sustainability of fisheries, aquaculture, and marine-based tourism.

A number of species when considered in isolation (namely southern rock lobster, greenlip and blacklip abalone) have potential to increase in size and abundance inside some of the sanctuary zones. All of these species also have potential for increased larval export to areas outside the sanctuary zones, and southern rock lobster has potential for spill-over of adults to areas outside the sanctuary zones. These changes may potentially have socio-economic benefits, although not quantified in this report. However, the ecosystems in which these species interact are expected to shift towards a pre-European state, which may result in declines rather than increases of some species such as blacklip abalone. Some species of conservation concern such as the western blue groper and harlequin fish will likely benefit from protection inside sanctuary zones at the offshore islands.

While the proposed zoning will have a neutral to beneficial impact on species, habitats and ecosystems, the effect on the local economy is generally assessed as negative. Impacts are based on SARDI's average annual catches and corresponding average annual prices expressed in 2011 dollars. In aggregate, it was estimated that the impact of marine park zoning will lead to a reduction in the annual value of catch in commercial fishing sectors of $0.55m. This, in turn, will generate the following loss of economic activity.

- Approximately $0.61m in GRP which represents 0.4 per cent of the regional total ($148m).
- Approximately 4 fte jobs which represent 0.3 per cent of the regional total (1,671 fte jobs).
- Approximately $0.39m in household income which represents 0.6 per cent of the regional total ($67m).

The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above.

The economic impacts could be greater as the estimated displaced catch, particularly abalone and rock lobster, may understate the actual catch in some sanctuary zones if they are located on important fishing grounds (hot spots). Impacts could also be over-estimated if sanctuary zones avoid hot spots (Ward and Burch 2012, Stevens et al. 2011a and 2011b). The zoning process attempted to avoid impacts on fishing by avoiding important fishing grounds. PIRSA has advised that statewide some draft sanctuary zones are located on important fishing grounds (hotspots), however advice specific to this park has not been provided. According to industry-derived estimates of displaced catch (which have not yet been reviewed by SARDI), the aggregate regional impacts are lower at 4 fte jobs and $0.35m in GRP.

The potential cumulative impact of the proposed extension to and revised zoning of the Commonwealth Great Australian Marine Park and the proposed Western Eyre Commonwealth Marine Reserve may place further pressure on fishing business viability.

Although the aggregate impacts may not appear large in absolute terms, the economy of the West Coast Bays region is a highly dependent one. The region is highly reliant on agriculture and fishing as the core drivers of economic activity. Indeed of the 567 businesses in the region approximately 58 per cent are classified in the agriculture, forestry and fishing sector.

However, unemployment in the West Coast Bays region is relatively low (2.5 per cent at June 2011) when compared with the state average (5.2 per cent). Depending on the skills match, this suggests that alternative regional opportunities for unemployed labour may not be difficult to find.

There are currently no aquaculture operations in this marine park and any future development will need to be consistent with policy commitments, marine park and aquaculture related legislation (PIRSA, pers. comm., 27 June 2012).

In the short-term it is unlikely the proposed zoning, in itself, will lead to an increase in tourism and ecotourism or other tourism-related business. Nor, in part due to its remoteness, is it likely to encourage additional recreational activities or associated facilities. By the same token the proposed management plan zoning is unlikely to have a negative impact on recreational fishing, with access to areas fished near or from the shore maintained.

Given that the overall impact on the region is not expected to be large in absolute terms, the impact on property values is, similarly, not expected to be significant. States of Australia have introduced marine parks with sanctuary zones in the last decade without any known long-term effects on property values. External factors notwithstanding, the trend in West Coast Bays residential property prices illustrated in the regional socio-economic profile is unlikely to be affected by the proposed marine park zoning.

There are no ports or harbours in this marine park. No significant impacts on shipping activities arising from the zoning in this park are expected, which is consistent with Government policy commitments.

Two mineral exploration licences cover all of Flinders Island adjacent to the marine park, where diamond indicator rocks have been found. A mineral exploration licence application has been lodged to expand the area of exploration. This application surrounds all of Flinders Island. Conditions attached to existing licences will not change and the operations to which these licences refer to will not be affected by zoning. Licence applications will be required to go through a joint approval process administered by DMITRE and DEWNR, which may be a potentially lengthier and therefore more costly process to the applicant. Zoning limits the types of exploration activities permitted, and could potentially discourage certain types of applications and hence limit exploration and exploitation of resources. However no examples have been highlighted.

A wave energy plant has been given development approval and construction is likely to commence in July 2012. It will be located in the marine park, approximately 800 m offshore from Locks Well Beach in HPZ-4 adjacent to SZ-2. No negative impact on the development and operation of the wave energy plant is expected. A consortium of mining companies is considering locating a desalination plant near Elliston. The proposal is at the prefeasibility stage. It is not clear whether it will be located within the marine park.

The overall social impacts of the Investigator Marine Park on communities living in the West Coast Bays region of South Australia are expected to be low. Commercial fishing is one of the four top industry sources of employment and is estimated to contribute 99 jobs to employment in the region, compared with tourism which contributes some 150 jobs. Economic impact assessment identifies a loss of four commercial fishing-related jobs. The impact on recreational fishing is considered to be low which is of benefit to both locals and those who visit the region for this purpose. Consequently, any impact on local community identity as a fishing centre, and on fishing as a way of life is likely to be low.

Experience elsewhere in Australia and internationally, suggests that a range of benefits from the establishment of marine parks become evident over time. These include increased opportunities for education about marine life and conservation, and increased tourism and ecotourism opportunities. This experience indicates that these benefits usually take approximately five years to be evident, and that in the earliest stages of marine protected areas being developed, local communities are more likely to identify possible negative impacts than potential benefits. It takes time to observe how the park's ecological and economic impacts evolve, with social impacts (positive or negative) flowing from these.

4.6 Thorny Passage Marine Park

Thorny Passage Marine Park is located in the Eyre Bioregion. It includes the waters off lower Eyre Peninsula, extending from Frenchman Bluff on the west to Memory Cove on the east and overlays both Rocky and Greenly Islands.

In general the habitats within the park can be considered to be in a condition comparable to the time of European settlement, although there are some potential threats from shellfish aquaculture and urban or agricultural run-off. There are also isolated occurrences of degradation to seagrass (anchoring), saltmarsh (off-road vehicles), sandy seafloors (trawling) and intertidal reefs (infestations of feral oysters). A number of species within the park were assessed as having lower abundances compared with pre-European levels. The current state of the ecosystems in the park was generally considered to reflect the condition of their component habitats and species.

The proposed management arrangements are predicted to have a net positive long-term impact on South Australia's marine biodiversity. Without the proposed management arrangements there is potential for future activities to occur that could impact on marine habitats, species and ecosystems. The positive ecological impacts inside the Thorny Passage Marine Park will include (1) maintenance of habitats and ecosystems in relatively good condition, and (2) changes in some ecosystems towards a more natural and resilient condition. Such changes include increases in the size and abundance of some fished species, which may potentially have socio-economic benefits, and the overall shift towards a more natural ecosystem is also expected to provide a number of management benefits, although these potential benefits have not been quantified.

The proposed zoning alone does not address other threats listed above, which require complementary management measures, but various zone restrictions (with habitat protection and sanctuary zones covering about 72 per cent and 3 per cent of the park, respectively) will assist with the future protection of habitats from a range of potentially damaging activities that may otherwise be possible under the existing management framework. Some habitats of particular conservation note include Coffin Bay (the largest estuary on Eyre Peninsula and a Wetland of National Importance) and Thorny Passage, with a variety of habitats resulting in high productivity and fish abundances. Maintenance of healthy habitats in general is essential for the functioning of ecosystems and the long-term sustainability of fisheries, aquaculture, and marine-based tourism.

It is expected that the designation of areas worthy of zoning as SZs and HPZs would assist in directing future activities appropriately. However, there is some uncertainty about the extent to which zoning will provide future protection within Coffin Bay, due to the proposed establishment of a special purpose area (harbor activities) within the Bay.

One species when considered in isolation (namely mud cockle) has potential to increase in size and abundance inside some of the sanctuary zones within Coffin Bay.

While the proposed zoning will have a neutral to beneficial impact on species, habitats and ecosystems, the effect on the local economy is generally assessed as negative. Impacts are based on SARDI's average annual catches and corresponding average annual prices expressed in 2011 dollars. In aggregate, it was estimated that the impact of marine park zoning will lead to a reduction in the annual value of catch in commercial fishing sectors of $0.27m. This, in turn, will generate the following loss of regional economic activity on an ongoing annual basis.

- Approximately $0.22m in GRP which represents 0.02 per cent of the regional total ($942m).
- Approximately 3 fte jobs which represent 0.03 per cent of the regional total (9,693 fte jobs).
- Approximately $0.13m in household income which represents 0.03 per cent of the regional total ($487m).

The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above.

The economic impacts could be greater as the estimated displaced catch, particularly abalone and rock lobster, may understate the actual catch in some sanctuary zones if they are located on important fishing grounds (hot spots). Impacts could also be over-estimated if sanctuary zones avoid hot spots (Ward and Burch 2012; Stevens et al. 2011a and 2011b). The zoning process attempted to avoid impacts on fishing by avoiding important fishing grounds. PIRSA has advised that statewide some draft sanctuary zones are located on important fishing grounds (hotspots), however advice specific to this park has not been provided. The potential cumulative impact of the proposed extension to and revised zoning of the Commonwealth Great Australian Marine Park and the proposed Western Eyre Commonwealth Marine Reserve may place further pressure on fishing business viability.

Although the aggregate quantified impacts may not appear large in absolute terms, the economy of the Lower Eye Peninsula region is a fragile, highly dependent one with a high level of reliance on agriculture and fishing as the core drivers of economic activity. Indeed of the 2,559 businesses in the region approximately 31 per cent are classified in the agriculture, forestry and fishing sector.

However, unemployment in the Lower Eye Peninsula region is relatively low (4.2 per cent at June 2011) when compared with the state average (5.2 per cent). This suggests that alternative regional opportunities for unemployed labour may be available over time, depending on the skills of those seeking work and the skills demanded by potential employers.

There are no known current or potential impacts expected from the draft zoning in this marine park on current or future aquaculture enterprises. This is consistent with Government policy commitments.

The actual placement of sanctuary zones is unlikely to place real restriction on recreational fishing with sanctuary zones over highly fished areas limited. However, the perception that recreational fishing opportunities will be restricted by implementing 'no-take' zones is real. So there is potential for a downturn in fishing-based tourism in the short-term until visitors are informed and convinced of the actual situation on the water. In the long-term, managed marine parks will provide certainty that the marine environment within them is being protected and this may support the growth of the ecotourism industry, provided the necessary investment in tourism infrastructure and support services is undertaken. Other, non-extractive tourism, such as diving, is likely to benefit from the implementation of sanctuary zones.

Given that the overall impact on the region is not expected to be large in absolute terms, the impact on property values is, similarly, not expected to be significant. States of Australia have introduced marine parks with sanctuary zones in the last decade without any known long-term effects on property values. External factors notwithstanding, the trend in Lower Eyre Peninsula residential property prices, illustrated in the regional socio-economic profile, is unlikely to be affected by the proposed marine park zoning.

The harbour of Coffin Bay has been declared a special purpose area and no significant impacts on shipping activities arising from zoning in this park are expected, which is consistent with Government policy commitments.

No mineral, petroleum or geothermal licences or leases are currently located within this marine park. There is no immediate impact on mining ventures expected and future opportunities are unknown.

SA Water is at the pre-feasibility stage of planning a water desalination plant to supplement water supplies to Eyre Peninsula. They have narrowed their options to a choice of two possible sites, a location on Sleaford Bay (west of SZ-7) and a site near Shoal Point (located in GMU-2). Both locations are within Thorny Passage Marine Park, but are situated where zoning would not restrict the activity.

The overall social impacts of the Thorny Passage Marine Park on communities living in the region are expected to be low. Commercial fishing is one of the four top industry sources of employment and is estimated to contribute 1,210 jobs to employment in the region, compared with tourism which contributes some 540 jobs. This is one of two regions where fishing provides more jobs than tourism. Economic impact assessment identifies a loss of three commercial fishing-related jobs. The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above. The impact on recreational fishing is considered to be low which is of benefit to both locals and those who visit the region for this purpose. Consequently, any impact on local community identity as a fishing centre and on fishing as a way of life is also likely to be low.

Experience elsewhere in Australia and internationally, suggests that a range of benefits from the establishment of marine parks become evident over time. These include increased opportunities for education about marine life and conservation, and increased tourism and ecotourism opportunities. This experience indicates that these benefits usually take approximately five years to be evident, and that in the earliest stages of marine protected areas being developed, local communities are more likely to identify possible negative impacts than potential benefits. It takes time to observe how

the park's ecological and economic impacts evolve, with social impacts (positive or negative) flowing from these.

4.7 Sir Joseph Banks Group Marine Park

Located in lower western Spencer Gulf, the Sir Joseph Banks Group Marine Park includes parts of the Eyre and Spencer Gulf Bioregions. The park includes Tumby Bay and extends southwards, offshore from Boston Bay. It includes the islands of the Sir Joseph Banks Group and Dangerous Reef.

In general the habitats within the park can be considered to be in a condition comparable to the time of European settlement, although there has been some prawn trawling in deep soft sediments offshore. There are also potential threats to water quality from finfish aquaculture and agricultural run-off in some areas. A number of species within the park were assessed as having lower abundances compared with pre-European levels. The current state of the ecosystems in the park was generally considered to reflect the condition of their component habitats and species.

The proposed management arrangements are predicted to have a net positive long-term impact on South Australia's marine biodiversity. Without the proposed management arrangements there is potential for future activities to occur that could impact on marine habitats, species and ecosystems. The positive ecological impacts inside the Sir Joseph Banks Group Marine Park will include (1) maintenance of habitats and ecosystems in relatively good condition, and (2) changes in some ecosystems towards a more natural and resilient condition. Such changes include increases in the size and abundance of some fished species, which may potentially have socio-economic benefits, and the overall shift towards a more natural ecosystem is also expected to provide a number of management benefits, although these potential benefits have not been quantified.

Recovery of benthic habitats is expected within zones from which trawling is displaced, although this may result in increased degradation elsewhere. The proposed zoning alone does not address the potential water quality issues listed above, which would require complementary management measures, but various zone restrictions (with habitat protection and sanctuary zones covering about 50 per cent and 7 per cent of the park, respectively) will assist with the future protection of habitats from a range of potentially damaging activities that may otherwise be possible under the existing management framework. Some habitats of particular conservation note include the Wetland of National Importance at Tumby Bay, which includes important habitats for various fish, crustaceans and bird species, shallow and deep-water seagrasses, rhodolith beds near Kirkby Island, and significant sites for sea lions and birds. Maintenance of healthy habitats in general is essential for the functioning of ecosystems and the long-term sustainability of fisheries, aquaculture, and marine-based tourism.

A number of species when considered in isolation (namely southern rock lobster, greenlip and blacklip abalone, and snapper) have potential to increase in size and abundance inside some of the sanctuary zones. Some species of conservation concern and/or which are vulnerable to localized depletion (namely the western blue groper, harlequin fish, bluethroat wrasse, and sea sweep) are likely to show particular benefit from protection inside some of the sanctuary zones within the Sir Joseph Banks Group Marine Park. Some of the species assessed also have potential for increased larval export to areas outside the sanctuary zones, as well as potential for spill-over of adults to areas outside the sanctuary zones. These changes may potentially have socio-economic benefits, although not quantified in this report. However, the ecosystems in which these species interact are expected to shift towards a pre-European state, which may result in declines rather than increases of some species such as blacklip abalone.

While the proposed zoning will have a neutral to beneficial impact on species, habitats and ecosystems, the effect on the local economy is generally assessed as neutral to slightly negative. Impacts are based on SARDI's average annual catches and corresponding average annual prices expressed in 2011 dollars. In aggregate, it was estimated that the impact of marine park zoning will lead to a reduction in the annual value of catch in commercial fishing sectors of $89,000. This, in turn, will generate the following loss of regional economic activity on an ongoing annual basis.

- Approximately $0.14m in GRP which represents 0.01 per cent of the regional total ($942m).
- Approximately 2 fte jobs which represent 0.02 per cent of the regional total (9,693 fte jobs).
- Approximately $0.09m in household income which represents 0.02 per cent of the regional total ($487m).

The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above.

The economic impacts could be greater as the estimated displaced catch may understate the actual catch in some sanctuary zones if they are located on important fishing grounds (hot spots). Impacts could also be over-estimated if sanctuary zones avoid hot spots (Ward and Burch 2012; Stevens et al. 2011a and 2011b). The zoning process attempted to avoid impacts on fishing by avoiding important fishing grounds. PIRSA has advised that statewide some draft sanctuary zones are located on important fishing grounds (hotspots), however advice specific to this park has not been provided. However, industry derived estimates of displaced catch (which are yet to be reviewed by SARDI) are similar to the SARDI estimates.

The potential cumulative impact of the proposed extension to and revised zoning of the Commonwealth Great Australian Marine Park and the proposed Western Eyre Commonwealth Marine Reserve may place further pressure on fishing business viability.

Although the aggregate quantified impacts may not appear large in absolute terms, the economy of the Lower Eye Peninsula region is a moderately dependent one with a high level of reliance on agriculture and fishing as the core drivers of economic activity. Indeed of the 2,559 businesses in the region approximately 31 per cent are classified in the agriculture, forestry and fishing sector.

However, unemployment in the Lower Eye Peninsula region is relatively low (4.2 per cent at June 2011) when compared with the state average (5.2 per cent). This suggests that alternative regional opportunities for unemployed labour may be available over time, depending on the skills of those seeking work and the skills demanded by potential employers.

There are no known current or potential impacts expected from the draft zoning in this marine park on current or future aquaculture enterprises. This is consistent with Government policy commitments.

The actual placement of sanctuary zones is unlikely to place real restriction on recreational fishing with sanctuary zones over highly fished areas limited. However, the perception that recreational fishing opportunities will be restricted by implementing 'no-take' zones is real. So there is potential for a downturn in fishing-based tourism in the short-term until visitors are informed and convinced of the actual situation on the water. In the long-term, managed marine parks will provide certainty that the marine environment within them is being protected and this may support the growth of the ecotourism industry, provided the necessary investment in tourism infrastructure and support services is undertaken. Other, non-extractive tourism, such as diving, is likely to benefit from the implementation of sanctuary zones.

Given that the overall impact on the region is not expected to be large in absolute terms, the impact on property values is, similarly, not expected to be significant. States of Australia have introduced marine parks with sanctuary zones in the last decade without any known long-term effects on property values. External factors notwithstanding, the trend in Lower Eyre Peninsula residential property prices, illustrated in the regional socio-economic profile, is unlikely to be affected by the proposed marine park zoning.

There are no ports or harbours in this marine park. No significant impacts on shipping activities arising from the zoning in this park are expected, which is consistent with Government policy commitments.

No mineral, petroleum or geothermal tenements are currently located within this marine park.

Centrex Metals is proposing the development of a deep water port at Lipson Cove, just north of the marine park. No issues are envisaged with the operation of this port on the marine park or vice versa.

The overall social impacts of the Sir Joseph Banks Group Marine Park on communities living in the region are expected to be low. Commercial fishing is one of the four top industry sources of employment and is estimated to contribute 1,210 jobs to employment in the region, compared with tourism which contributes some 540 jobs. This is one of two regions where fishing provides more jobs than tourism. Economic impact assessment estimates a loss of two commercial fishing-related jobs in a region with low unemployment and low levels of relative measured disadvantage. The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above. The impact on recreational fishing is considered to be low which is of benefit to both locals and those who visit the region for this purpose.

Experience elsewhere in Australia and internationally, suggests that a range of benefits from the establishment of marine parks become evident over time. These include increased opportunities for education about marine life and conservation, and increased tourism and ecotourism opportunities. This experience indicates that these benefits usually take approximately five years to be evident, and that in the earliest stages of marine protected areas being developed, local communities are more likely to identify possible negative impacts than potential benefits. It takes time to observe how the park's ecological and economic impacts evolve, with social impacts (positive or negative) flowing from these.

4.8 Neptune Island Group Marine Park

Located in the Eyre bioregion, the Neptune Islands Group Marine Park is situated in offshore waters south of the Thorny Passage Marine Park. The marine park overlays the whole of the Neptune Islands Conservation Park.

The habitats within the park can be considered to be in a condition comparable to the time of European settlement, with the possible exception of anchor damage to seagrass at North Neptune Island. A number of species within the park were assessed as having lower abundances compared with pre-European levels. The current state of the ecosystems in the park was generally considered to reflect the condition of their component habitats and species.

The proposed management arrangements are predicted to have a net positive long-term impact on South Australia's marine biodiversity. Without the proposed management arrangements there is potential for future activities to occur that could impact on marine habitats, species and ecosystems. The positive ecological impacts inside the Neptune Islands Group Marine Park will include (1) maintenance of habitats and ecosystems in relatively good condition, and (2) changes in some ecosystems towards a more natural and resilient condition. Such changes include increases in the size and abundance of some fished species, which may potentially have socio-economic benefits, and the overall shift towards a more natural ecosystem is also expected to provide a number of management benefits, although these potential benefits have not been quantified.

The proposed zoning alone does not address the potential anchor damage issue, which would require complementary management measures, but various zone restrictions (with habitat protection and sanctuary zones each covering about 49 per cent of the park) will assist with the future protection of habitats from a range of potentially damaging activities that may otherwise be possible under the existing management framework. Some habitats of particular conservation note include seagrass meadows in the lee of the islands, and the deep-water pelagic habitat surrounding North Neptune Island. Maintenance of healthy habitats in general is essential for the functioning of ecosystems and the long-term sustainability of fisheries, aquaculture, and marine-based tourism.

Three species (namely southern rock lobster, and greenlip and blacklip abalone), when considered in isolation, have potential to increase in size and abundance inside the single sanctuary zone. All three of these species also have potential for increased larval export to areas outside the sanctuary zone, and southern rock lobster has potential for spill-over of adults to areas outside the sanctuary zone. These changes may potentially have socio-economic benefits, although not quantified in this report. However, the ecosystems in which these species interact are expected to shift towards a pre-European state, which may result in declines rather than increases of some species such as blacklip abalone. Some species of conservation concern such as the western blue groper and harlequin fish will likely benefit from protection inside the sanctuary zone.

The estimated economic impacts on commercial fisheries, based on SARDI's average annual catches and corresponding average annual prices, are relatively small for the Neptune Islands Group Marine Park. The State Government has committed to buy out licences and quota entitlements of displaced effort and catch, although details of the buyout are yet to be finalised. Compensation payments have the potential to at least partially offset the negative impact of the displaced catch, estimated to have an average annual GVP of $0.13m (mainly in the abalone and rock lobster sectors). This, in turn, will generate the following loss of regional economic activity on an ongoing annual basis.

- Approximately $0.11m in GRP which represents 0.01 per cent of the regional total ($942m).
- Approximately less than one fte job which represent 0.004 per cent of the regional total (9,693 fte jobs).
- Approximately $0.07m in household income which represents 0.01 per cent of the regional total ($487m).

The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above.

The economic impacts could be greater as the estimated displaced catch may understate the actual catch in some sanctuary zones if they are located on important fishing grounds (hot spots). Impacts could also be over-estimated if sanctuary zones avoid hot spots (Ward and Burch 2012; Stevens et al. 2011a and 2011b). The zoning process attempted to avoid impacts on fishing by avoiding important fishing grounds. PIRSA has advised that statewide some draft sanctuary zones are located on important fishing grounds (hotspots), however advice specific to this park has not been provided. According to industry-derived estimates of displaced catch (which have not yet been reviewed by SARDI) the aggregate regional impacts could be higher at 2 fte jobs and $0.15m in GRP.

The potential cumulative impact of the proposed extension to and revised zoning of the Commonwealth Great Australian Marine Park and the proposed Western Eyre Commonwealth Marine Reserve may place further pressure on fishing business viability.

Although the aggregate quantified impacts may not appear large in absolute terms, the economy of the Lower Eye Peninsula region is a moderately dependent one with a high level of reliance on agriculture and fishing as the core drivers of economic activity. Indeed of the 2,559 businesses in the region approximately 31 per cent are classified in the agriculture, forestry and fishing sector.

However, unemployment in the Lower Eye Peninsula region is relatively low (4.2 per cent at June 2011) when compared with the state average (5.2 per cent). This suggests that alternative regional opportunities for unemployed labour may be available over time, depending on the skills of those seeking work and the skills demanded by potential employers.

There are currently no aquaculture operations in this marine park and any future development will need to be consistent with policy commitments, marine park and aquaculture related legislation (PIRSA, pers. comm., 27 June 2012).

Existing shark viewing ventures operating around North Neptune Islands are expected to continue under new permitting arrangements.

There are no ports or harbours in this marine park. No significant impacts on shipping activities arising from the zoning in this park are expected, which is consistent with Government policy commitments.

No mineral, petroleum or geothermal tenements are currently located within this marine park.

There are no significant projects or infrastructure in or known to be planned for this marine park and these islands are unlikely to be developed due to their Restricted Access status.

The overall social impacts of the Neptune Islands Group Marine Park on communities living in the region are expected to be minimal. Commercial fishing is one of the two top industry sources of employment and is estimated to contribute 1,210 jobs to employment in the region, compared with tourism which contributes some 540 jobs. This is one of two regions where commercial fishing provides more employment than tourism. Economic impact assessment identifies no loss of commercial fishing jobs. The impact on recreational fishing is considered to be minimal which is of benefit to those who visit the region for this purpose. Regional unemployment is low as are measured levels of relative disadvantage.

Experience elsewhere in Australia and internationally, suggests that a range of benefits from the establishment of marine parks become evident over time. These include increased opportunities for education about marine life and conservation, and increased tourism and ecotourism opportunities. This experience indicates that these benefits usually take approximately five years to be evident, and that in the earliest stages of marine protected areas being developed, local communities are more likely to identify possible negative impacts than potential benefits. It takes time to observe how the park's ecological and economic impacts evolve, with social impacts (positive or negative) flowing from these.

4.9 Gambier Islands Group Marine Park

The habitats within the park can be considered to be in a condition comparable to the time of European settlement. Two fished species (southern rock lobster and greenlip abalone) were assessed as having lower abundances within the park compared with pre-European levels, while a further six reef fish species were considered to be at natural levels. The current state of the ecosystems in the park was generally considered to reflect the condition of their component habitats and species.

The proposed management arrangements are predicted to have a net positive long-term impact on South Australia's marine biodiversity. Without the proposed management arrangements there is potential for future activities to occur that could impact on marine habitats, species and ecosystems. The positive ecological impacts inside the Gambier Islands Group Marine Park will include maintenance of habitats and ecosystems in relatively good condition. However, as there are no sanctuary zones within the park (and no habitat protection zones with a history of prawn trawling), there will be no change in the current status of fished species or associated ecosystems due to the new zoning arrangements. Furthermore, without protection within a sanctuary zone, some fished species of conservation concern such as the western blue groper and harlequin fish may actually decline inside the park.

The entire park is within a habitat protection zone, which will assist with the future protection of habitats from a range of potentially damaging activities that may otherwise be possible under the existing management framework. Some habitats of particular conservation note include the long sandy beaches and seagrass meadows adjacent to Wedge Island, and the adjacent deep-water subtidal reefs. Maintenance of healthy habitats in general is essential for the functioning of ecosystems and the long-term sustainability of fisheries, aquaculture, and marine-based tourism.

The estimated economic impacts on commercial fisheries, based on SARDI's average annual catches and corresponding average annual prices, are nil for the Gambier Islands Group Marine Park.

There are currently no aquaculture operations in this marine park and any future development will need to be consistent with policy commitments, marine park and aquaculture related legislation (PIRSA, pers. comm., 27 June 2012).

In the short-term it is unlikely the proposed zoning, in itself, will lead to an increase in tourism and ecotourism or other tourism-related business. Nor, in part due to its remoteness, is it likely to encourage additional recreational activities or associated facilities. By the same token the proposed management plan zoning will not have a negative impact on recreational fishing.

There are no ports or harbours in this marine park. No significant impacts on shipping activities arising from the zoning in this park are expected, which is consistent with Government policy commitments.

No mineral, petroleum or geothermal tenements are currently located within this marine park. Further, there are no major developments planned for this marine park apart from residential development.

The overall social impacts of the Gambier Islands Group Marine Park on communities living in the Lower Eyre Peninsula region are expected to be minimal. Commercial fishing is one of the two top industry sources of employment and is estimated to contribute 1,210 jobs to employment in the region, compared with tourism which contributes some 540 jobs. This is one of two regions where commercial fishing provides more jobs than tourism in the region. Economic impact assessment identifies no loss of commercial fishing jobs. The impact on recreational fishing is considered to be nil. Levels of regional unemployment are low, as are levels of measured relative disadvantage.

Experience elsewhere in Australia and internationally, suggests that a range of benefits from the establishment of marine parks become evident over time. These include increased opportunities for education about marine life and conservation, and increased tourism and ecotourism opportunities. This experience indicates that these benefits usually take approximately five years to be evident, and that in the earliest stages of marine protected areas being developed, local communities are more likely to identify possible negative impacts than potential benefits. It takes time to observe how the park's ecological and economic impacts evolve, with social impacts (positive or negative) flowing from these.

4.10 Franklin Harbor Marine Park

In general the habitats within the park can be considered to be in a condition comparable to the time of European settlement, although there are some potential threats from aquaculture, boating activity, agricultural run-off and septic tank overflows in some areas. Mangrove and saltmarsh habitats are also potentially subject to a number of threats, and trawling has occurred over sandy seafloors offshore. A number of species within the park were assessed as having lower abundances compared with pre-European levels. The current state of the ecosystems in the park was generally considered to reflect the condition of their component habitats and species.

The proposed management arrangements are predicted to have a net positive long-term impact on South Australia's marine biodiversity. Without the proposed management arrangements there is potential for future activities to occur that could impact on marine biology and ecological processes. Depending on the type and location of zoning, the positive ecological impacts inside the Franklin Harbor Marine Park will include (1) maintenance of habitats and ecosystems in relatively good condition, and (2) changes in some ecosystems towards a more natural and resilient condition. Such changes include increases in the size and abundance of some fished species, which may potentially have socio-economic benefits, and the overall shift towards a more natural ecosystem is also expected to provide a number of management benefits, although these benefits have not been quantified.

Recovery of benthic habitats is expected within zones from which trawling is displaced, although this may result in increased degradation elsewhere. The proposed zoning alone does not address other threats listed above, which would require complementary management measures, but various zone restrictions (with habitat protection and sanctuary zones covering about 66 per cent and 11 per cent of the park, respectively) will assist with the future protection of habitats from a range of potentially damaging activities that may otherwise be possible under the existing management framework. Some habitats of particular conservation note include subtidal reefs offshore from Gibbon Point, and the bay of Franklin Harbor, which is a Wetland of National Importance with links to the extensive network of other wetlands and tidal creeks in the upper Spencer Gulf region. Maintenance of healthy habitats in general is essential for the functioning of ecosystems and the long-term sustainability of fisheries, aquaculture, and marine-based tourism.

There is some uncertainty about the extent to which zoning will provide future protection within Franklin Harbor, due to the proposed establishment of a special purpose area (harbor activities) within the Harbor. However, it is expected that the designation of areas worthy of zoning as habitat protection and sanctuary zones would assist in directing future activities appropriately.

A number of species when considered in isolation (namely greenlip abalone, snapper, and razorfish) have potential to increase in size and abundance inside some of the sanctuary zones. Greenlip abalone and razorfish have potential for increased larval export to areas outside of the sanctuary zones, while snapper has potential for spill-over of adults to areas outside of the sanctuary zones. However, the ecosystems in which these species interact are expected to shift towards a pre-European state, which may result in declines rather than increases of some species.

The estimated economic impacts on commercial fisheries, based on SARDI's average annual displaced catches and corresponding average annual prices, are relatively small for the Franklin Harbor Marine Park. The State Government has committed to buy out licences and quota entitlements of displaced effort and catch, although details of the buyout are yet to be finalised. Compensation payments have the potential to at least partially offset the negative impact of the displaced catch, estimated to have an average annual GVP of $41,000 (mainly in the marine scalefish and charter boat sectors). According to industry-derived estimates of displaced catch (which have not yet been reviewed by SARDI), the aggregate regional impacts could be as high as 2 fte jobs and $0.48m in GRP.

There are no known current or potential impacts expected from the draft zoning in this marine park on current or future aquaculture enterprises. This is consistent with Government policy commitments.

The actual placement of sanctuary zones is unlikely to place real restriction on recreational fishing with sanctuary zones over highly fished areas limited. However, the perception that recreational fishing opportunities will be restricted by implementing 'no-take' zones is real. So there is potential for a downturn in fishing-based tourism in the short-term until visitors are informed and convinced of the actual situation on the water. In the long-term, managed marine parks will provide certainty that the marine environment within them is being protected and this may support the growth of the ecotourism industry, provided the necessary investment in tourism infrastructure and support services is undertaken. Other, non-extractive tourism, such as diving, is likely to benefit from the implementation of sanctuary zones.

Given that the overall impact on the region is not expected to be large in absolute terms, the impact on property values is, similarly, not expected to be significant. States of Australia have introduced marine parks with sanctuary zones in the last decade without any known long-term effects on property values. External factors notwithstanding, the trend in Franklin Harbour residential property prices illustrated in the regional socio-economic profile is unlikely to be affected by the proposed marine park zoning.

The harbour of Cowell (Franklin Harbor) has been declared a special purpose area and no significant impacts on shipping activities arising from zoning in this park are expected, which is consistent with Government policy commitments. Two transhipment points are proposed. They are located in the South-Eastern boundary of the park in HPZ-2 and allow for future transhipment activities out of Lucky Bay. There are no known impacts expected from the zoning in this park on the Lucky Bay ferry operations, which is consistent with Government policy commitments.

No mineral, petroleum or geothermal licences or leases are currently located within this marine park. A petroleum exploration licence application covers much of the northern part of the park. Three mineral exploration licence applications are located offshore covering most of the park from Cowell to the northern boundary, and there is another mineral exploration licence application immediately adjacent to the marine park on its seaward boundary. Licence applications will be required to go through a joint approval process administered by DMITRE and DEWNR, which may be a potentially lengthier and therefore more costly process. Zoning limits the types of exploration and extraction activities permitted, and could discourage certain types of applications and hence limit exploration and exploitation of resources.

There is a proposal to export iron ore, mined from Eyre Peninsula, using the existing ferry infrastructure at Lucky Bay. Lucky Bay will be gazetted as a harbor and port pursuant to the *Harbors and Navigation Act 1993*. Smaller vessels will be loaded at Lucky Bay, which will then load larger vessels at proposed offshore transhipment points. Two transhipment points (SPA-3 and SPA-4) are proposed at the south-eastern boundary of the park, located in HPZ-2.

The overall social impacts of the Franklin Harbor Marine Park on communities living in the Franklin Harbour region are expected to be low given the magnitude of the economic impacts that have been projected. Commercial fishing is one of the four top industry sources of employment and is estimated to contribute 79 jobs to employment in the region, compared with tourism which contributes some 39 jobs. As such, this is one of two regions where commercial fishing provides more employment than tourism.

Economic impacts from displaced commercial fishing were too small to model but in a region of very low unemployment and low levels of measured relative disadvantage, any job losses are likely to have minimal social impact. The impact on recreational fishing is considered to be low which is of benefit to both locals and those who visit the region for this purpose. Consequently, any impact on local community identity as a fishing centre and on fishing as a way of life is also likely to be low.

Experience elsewhere in Australia and internationally, suggests that a range of benefits from the establishment of marine parks become evident over time. These include increased opportunities for education about marine life and conservation, and increased tourism and ecotourism opportunities. This experience indicates that these benefits usually take approximately five years to be evident, and that in the earliest stages of marine protected areas being developed, local communities are more likely to identify possible negative impacts than potential benefits. It takes time to observe how the park's ecological and economic impacts evolve, with social impacts (positive or negative) flowing from these.

4.11 Upper Spencer Gulf Marine Park

The Upper Spencer Gulf Marine Park covers waters north of a line from the southern end of the Whyalla-Cowleds Landing Aquatic Reserve on the western side of Spencer Gulf to Jarrold Point on the eastern shore. The park also includes the uppermost reaches of Spencer Gulf extending north of Port Augusta. The landward boundary of the marine park extends at least to the median high water mark and where possible incorporates coastal Crown Lands including beaches, sand dunes, estuaries and saltmarshes, as shown in the map.

Many habitats within the park can be considered to be in a condition comparable to the time of European settlement, however some habitats have been significantly modified, several introduced pests have become established, and water and/or sediment quality has been impacted by the discharge of industrial or urban pollutants. There is considerable further development proposed within the park. A number of species within the park were assessed as having lower abundances compared with pre-European levels. The current state of the ecosystems in the park was generally considered to reflect the condition of their component habitats and species.

The proposed management arrangements are predicted to have a net positive long-term impact on South Australia's marine biodiversity. Without the proposed management arrangements there is potential for future activities to occur that could impact on marine habitats, species and ecosystems. The positive ecological impacts inside the Upper Spencer Gulf Marine Park will include (1) maintenance of some habitats and ecosystems in relatively good condition, and (2) changes in some ecosystems towards a more natural and resilient condition. Such changes include increases in the size and abundance of some fished species, which may potentially have socio-economic benefits, and the overall shift towards a more natural ecosystem is also expected to provide a number of management benefits, although these potential benefits have not been quantified.

The proposed zoning alone does not address the pollution and introduced pest issues listed above, which would require complementary management measures, but various zone restrictions (with habitat protection and sanctuary zones covering about 32 per cent and 14 per cent of the park, respectively) will assist with the future protection of habitats from a range of potentially damaging activities that may otherwise be possible under the existing management framework. Some habitats of particular conservation note include linked saltmarsh, mangrove, sand flat and seagrass communities which provide nursery habitat and contribute to the productivity of fish throughout Spencer Gulf, internationally important habitat for wader birds and sea birds, and the giant Australian cuttlefish breeding habitat near Black Point. Maintenance of healthy habitats in general is essential for the functioning of ecosystems and the long-term sustainability of fisheries, aquaculture, and marine-based tourism.

There is some uncertainty about the extent to which zoning will provide future protection for the Upper Spencer Gulf Marine Park, due to the proposed establishment of a special purpose area overlaying all sanctuary and habitat protection zones within the park, to provide for significant economic development, and a number of other special purpose areas to provide transitional arrangements for existing and proposed harbour, transport and marine-based infrastructure activities. However, it is expected that the designation of areas worthy of zoning as sanctuary and habitat protection zones would assist in directing future activities appropriately.

Species such as snapper and razorfish are predicted to have long-term increases in size and abundance inside some sanctuary zones. The implementation of a proposed sanctuary zone around a large proportion of the breeding habitat of the giant Australian cuttlefish near Point Lowly should have a positive effect on the future protection of the critical reef habitat, but it is unlikely to arrest the long-term decline in cuttlefish abundance. The causes of this decline are unknown, but legal fishing within the proposed sanctuary zone is unlikely to be contributing because taking cuttlefish is already prohibited.

The estimated economic impacts on commercial fisheries, based on SARDI's average annual displaced catches and corresponding average annual prices, are relatively small for the Upper Spencer Gulf Marine Park. The State Government has committed to buy out licences and quota entitlements of displaced effort and catch, although details of the buyout are yet to be finalised. Compensation payments have the potential to offset, at least in part, the negative impact of the displaced catch, estimated to have an average annual gross value of $39,000 (mainly in the marine scalefish and charter boat sectors).

There are no known current or potential impacts expected from the draft zoning in this marine park on current or future aquaculture enterprises. This is consistent with Government policy commitments.

The actual placement of sanctuary zones is unlikely to place real restriction on recreational fishing with sanctuary zones over highly fished areas limited. However, the perception that recreational fishing opportunities will be restricted by implementing 'no-take' zones is real. So there is potential for a downturn in fishing-based tourism in the short-term until visitors are informed and convinced of the actual situation on the water. In the long-term, managed marine parks will provide certainty that the marine environment within them is being protected and this may support the growth of the ecotourism industry, provided the necessary investment in tourism infrastructure and support services is undertaken. Other, non-extractive tourism, such as diving, is likely to benefit from the implementation of sanctuary zones.

Given that the overall impact on the region is not expected to be large in absolute terms, the impact on property values is, similarly, not expected to be significant. States of Australia have introduced marine parks with sanctuary zones in the last decade without any known long-term effects on property values. External factors notwithstanding, the trend in Upper Spencer Gulf residential property prices illustrated in the regional socio-economic profile is unlikely to be affected by the proposed marine park zoning.

There is considerable shipping and port activity in this park. Whyalla, Port Bonython and Port Pirie are major shipping and industrial hubs. Currently there are about 360 vessel movements per year and this is expected to increase to over 1,000 movements by 2020. In addition there are many barge movements. For example, on average 16 barges (i.e. 32 ship movements) are required to tranship iron ore from Whyalla to one Panamax size vessel. Should the Olympic Dam expansion proceed, BHP proposes to barge equipment from a transhipment point near Point Lowly to a landing facility 12 km south of Port Augusta at Snapper Point. There is potential for congestion in this area if the various planned inland mining developments take place, and access to suitable anchoring grounds and transhipment points is critical. However, no significant impacts on shipping activities arising from the zoning in this park expected, which is consistent with Government policy commitments.

Part of Pipeline Licence 1 (Moomba-Adelaide) is located across the park leading to Whyalla. This pipeline transports natural gas, and is declared a special purpose area. There are two mining leases partially within and two mining leases adjacent to the park near Whyalla. Southeast of Port Augusta, near Port Paterson, there are two mineral retention leases partially within the park for salt extraction. A mining claim exists within the park for metallic minerals offshore from Whyalla. Five mineral exploration licence applications overlap parts of this marine park.

Four geothermal exploration licence application overlaps parts of this marine park, and two geothermal exploration licences are located immediately adjacent to the marine park. A petroleum exploration licence has been applied for. This application covers the expected extent of a coal basin across both the Eyre Peninsula and the Upper Spencer Gulf. (PIRSA MER, pers. comm., 8 September 2011). Conditions attached to existing licences will not change and the operations to which these licences refer to will not be affected by zoning. Licence applications will be required to go through a joint approval process administered by DMITRE and DEWNR, which may be a potentially lengthier and therefore more costly process to the applicant. Zoning limits the types of exploration and extraction activities permitted, and could discourage certain types of applications and hence limit exploration and exploitation of resources.

Due to extensive development expected over the next ten years in the Upper Spencer Gulf, the sanctuary and habitat protection zones of the Upper Spencer Gulf Marine Park will be declared a special purpose area.

The overall social impacts of the Upper Spencer Gulf Marine Park on communities living in the region of are expected to be low given the magnitude of the economic impacts that have been projected. Commercial fishing is not among the four top industry sources of employment but is estimated to contribute 62 jobs to employment in the region, compared with tourism which contributes 740 jobs. Economic impacts from displaced commercial fishing in the region were too small to model and less than one fte job loss can be expected in the region. The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above.

The impact on recreational fishing is considered to be low (except for the sanctuary zone at Black Point), with adjustments in zoning designed to minimise any potential negative impacts. Consequently, any impact on local community identity as a fishing centre, and on fishing as a way of life is also likely to be low.

Experience elsewhere in Australia and internationally, suggests that a range of benefits from the establishment of marine parks become evident over time. These include increased opportunities for education about marine life and conservation, and increased tourism and ecotourism opportunities. This experience indicates that these benefits usually take approximately five years to be evident, and that in the earliest stages of marine protected areas being developed, local communities are more likely to identify possible negative impacts than potential benefits. It takes time to observe how the park's ecological and economic impacts evolve, with social impacts (positive or negative) flowing from these.

4.12 Eastern Spencer Gulf Marine Park

In general the habitats within the park can be considered to be in a condition comparable to the time of European settlement, although there are some potential minor threats to water quality from septic tank overflows in some areas. A number of species within the park were assessed as having lower abundances compared with pre-European levels. The current state of the ecosystems in the park was generally considered to reflect the condition of their component habitats and species.

The proposed management arrangements are predicted to have a net positive long-term impact on South Australia's marine biodiversity. Without the proposed management arrangements there is potential for future activities to occur that could impact on marine habitats, species and ecosystems. The positive ecological impacts inside the Eastern Spencer Gulf Marine Park will include (1) maintenance of habitats and ecosystems in relatively good condition, and (2) changes in some ecosystems towards a more natural and resilient condition. Such changes include increases in the size and abundance of some fished species, which may potentially have socio-economic benefits, and the overall shift towards a more natural ecosystem is also expected to provide a number of management benefits, although these potential benefits have not been quantified.

The proposed zoning alone does not address the water quality issues described above, which would require complementary management measures, but various zone restrictions (with habitat protection and sanctuary zones covering about 54 per cent and 5 per cent of the park, respectively) will assist with the future protection of habitats from a range of potentially damaging activities that may otherwise be possible under the existing management framework. Some habitats of particular conservation note include the limestone reefs in the north of the park, sea bird nesting sites and haul out sites for sea lions. Maintenance of healthy habitats in general is essential for the functioning of ecosystems and the long-term sustainability of fisheries, aquaculture, and marine-based tourism.

A number of species when considered in isolation (namely greenlip abalone, snapper, and razorfish) have potential to increase in size and abundance inside some of the sanctuary zones. Greenlip abalone and razorfish have potential for increased larval export to areas outside the sanctuary zones, while snapper have potential for spill-over of adults to areas outside the sanctuary zones. However, the ecosystems in which these species interact are expected to shift towards a pre-European state, which may result in declines rather than increases of some species such as greenlip abalone.

The estimated economic impacts on commercial fisheries, based on SARDI's average annual displaced catches and corresponding average annual prices, are relatively small for the Eastern Spencer Gulf Marine Park. The State Government has committed to buy out licences and quota entitlements of displaced effort and catch, although details of the buyout are yet to be finalised. Compensation payments have the potential to offset, at least in part, the negative impact of the displaced catch, estimated to have an average annual gross value of $27,000 (mainly in the marine scalefish and charter boat sectors). However, according to industry-derived estimates of displaced catch (which have not yet been reviewed by SARDI), the aggregate regional impacts could be as high as 1 fte job and $0.18m in GRP.

There are no known current or potential impacts expected from the draft zoning in this marine park on current or future aquaculture enterprises. This is consistent with Government policy commitments.

Given that the overall impact on the region is not expected to be large in absolute terms, the impact on property values is, similarly, not expected to be significant. States of Australia have introduced marine parks with sanctuary zones in the last decade without any known long-term effects on property values. External factors notwithstanding, the trend in the Yorke Peninsula residential property prices illustrated in the regional socio-economic profile is unlikely to be affected by the proposed marine park zoning.

The actual placement of sanctuary zones is unlikely to place real restriction on recreational fishing with sanctuary zones over highly fished areas limited. However, the perception that recreational fishing opportunities will be restricted by implementing ‘no-take’ zones is real. So there is potential for a downturn in fishing-based tourism in the short-term until visitors are informed and convinced of the actual situation on the water. In the long-term, managed marine parks will provide certainty that the marine environment within them is being protected and this may support the growth of the ecotourism industry, provided the necessary investment in tourism infrastructure and support services is undertaken. Other, non-extractive tourism, such as diving, is likely to benefit from the implementation of sanctuary zones.

There are no ports or harbours in this marine park. No significant impact on shipping activities arising from the zoning in this park is expected, which is consistent with Government policy commitments.

No mineral, petroleum or geothermal licences or leases are currently located within this marine park. Two mineral exploration licences (for copper and gold) have been applied for covering all of the park and a further mineral exploration licence application is located immediately adjacent to the seaward boundary of the park. There is a petroleum exploration licence application located immediately adjacent to the marine park boundary near Balgowan. Licence applications will be required to go through a joint approval process administered by DMITRE and DEWNR, which may be a potentially lengthier and therefore more costly process to the applicant. Zoning limits the types of exploration and extraction activities permitted, and could discourage certain types of applications and hence limit exploration and exploitation of resources.

There are no major developments planned for this marine park.

The overall social impacts of the Eastern Spencer Gulf Marine Park on communities living in the Yorke Peninsula region are expected to be low given the magnitude of the economic impacts that have been projected and low levels of regional unemployment and measured relative disadvantage. Commercial fishing is an important source of employment and is estimated to contribute 94 jobs to employment in the region, although relatively small when compared with tourism which contributes some 460 jobs. Economic impact from displaced commercial fishing was too small to model and less than one fte job loss is anticipated, but in a region with very low unemployment, and low to moderate measured relative disadvantage, any job losses are likely to have minimal social impact.

The impact on recreational fishing is considered to be low with adjustments in zoning designed to minimise any potential negative impacts. Consequently, any impact on local community identity as a fishing centre and on fishing as a way of life is also likely to be low.

Experience elsewhere in Australia and internationally, suggests that a range of benefits from the establishment of marine parks become evident over time. These include increased opportunities for education about marine life and conservation, and increased tourism and ecotourism opportunities. This experience indicates that these benefits usually take approximately five years to be evident, and that in the earliest stages of marine protected areas being developed, local communities are more likely to identify possible negative impacts than potential benefits. It takes time to observe how the park's ecological and economic impacts evolve, with social impacts (positive or negative) flowing from these.

4.13 Southern Spencer Gulf Marine Park

Spanning across transition zones of three of our bioregions: Spencer Gulf, Eyre and Gulf St Vincent, the Southern Spencer Gulf Marine Park covers 2,972 km^2. This marine park extends around the eastern tip of Yorke Peninsula and across to the central north coast of Kangaroo Island.

In general the habitats within the park can be considered to be in a condition comparable to the time of European settlement, although there are some potential minor threats to water quality from agricultural run-off and some habitat modified by prawn trawling. A number of species within the park were assessed as having lower abundances compared with pre-European levels. The current state of the ecosystems in the park was generally considered to reflect the condition of their component habitats and species.

The proposed management arrangements are predicted to have a net positive long-term impact on South Australia's marine biodiversity. Without the proposed management arrangements there is potential for future activities to occur that could impact on marine habitats, species and ecosystems. The positive ecological impacts inside the Southern Spencer Gulf Marine Park will include (1) maintenance of habitats and ecosystems in relatively good condition, and (2) changes in some ecosystems towards a more natural and resilient condition. Such changes include increases in the size and abundance of some fished species, which may potentially have socio-economic benefits, and the overall shift towards a more natural ecosystem is also expected to provide a number of management benefits, although these potential benefits have not been quantified.

Recovery of benthic habitats is expected within zones from which trawling is displaced, although this may result in increased degradation elsewhere. The proposed zoning alone does not address the potential water quality issues described above, which would require complementary management measures, but various zone restrictions (with habitat protection and sanctuary zones covering about 59 per cent and 5 per cent of the park, respectively) will assist with the future protection of habitats from a range of potentially damaging activities that may otherwise be possible under the existing management framework. Some habitats of particular conservation note include seagrass meadows in Marion Bay and the reef around Chinamans Hat Island. The distinctive high energy Dust Hole Beach south of Daly Head lies within GMUZ-1 and will therefore be afforded less protection. Maintenance of healthy habitats in general is essential for the functioning of ecosystems and the long-term sustainability of fisheries, aquaculture, and marine-based tourism.

There is some uncertainty about the extent to which zoning will provide future protection within the Point Turton area, due to the proposed establishment of a special purpose area (harbor activities). However, it is expected that the designation of this area as a habitat protection zone would assist in directing future activities appropriately.

A number of species when considered in isolation (namely southern rock lobster, greenlip and blacklip abalone, snapper, Bight redfish, swallowtail, sea sweep, western blue groper, harlequin fish, and bluethroat wrasse) have potential for long-term increases in size and abundance inside some of the sanctuary zones. Southern rock lobster and greenlip/blacklip abalone all have potential for increased larval export to areas outside the sanctuary zones. Southern rock lobster, snapper, King George whiting, Bight redfish, swallowtail, and sea sweep have potential for spill-over of adults to areas outside the sanctuary zones. However, the ecosystems in which these species interact are expected to shift towards a pre-European state, which may result in declines rather than increases of some species such as blacklip abalone.

While the proposed zoning will have a neutral to beneficial impact on species, habitats and ecosystems, the effect on the local economy is generally assessed as negative. Impacts are based on SARDI's average annual catches and corresponding average annual prices expressed in 2011 dollars. In aggregate, it was estimated that the impact of marine park zoning will lead to a reduction in the annual value of catch in commercial fishing sectors of $.10m. This, in turn, will generate the following loss of economic activity.

- Approximately $0.10m in GRP which represents 0.03 per cent of the regional total ($386m).
- Less than 1 fte job which represent 0.01 per cent of the regional total (4,340 fte jobs).
- Approximately $0.07m in household income which represents 0.04 per cent of the regional total ($181m).

The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above.

The economic impacts could be greater as the estimated displaced catch, particularly abalone and rock lobster, may understate the actual catch in some sanctuary zones if they are located on important fishing grounds (hot spots). Impacts could also be over-estimated if sanctuary zones avoid hot spots (Currie and Ward 2011, Stevens et al. 2011a and 2011b). The zoning process attempted to avoid impacts on fishing by avoiding important fishing grounds. PIRSA has advised that some draft sanctuary zones are located on important fishing grounds (hot spots). According to industry-derived estimates of displaced catch (which have not yet been reviewed by SARDI), the aggregate regional impacts could be as high as 1 fte job and $0.18m in GRP.

The potential cumulative impact of the proposed extension to and revised zoning of the Commonwealth Great Australian Marine Park and the proposed Western Eyre

Commonwealth Marine Reserve may place further pressure on fishing business viability.

Although the aggregate impacts may not appear large, the economy of the Yorke Peninsula region is a highly dependent one and particularly reliant on agriculture and fishing as the core drivers of economic activity. Indeed of the 1,193 businesses in the region approximately 43 per cent are classified in the agriculture, forestry and fishing sector.

However, unemployment in the Yorke Peninsula region is extremely low (2.8 per cent at June 2011) when compared with the state average (5.2 per cent). This suggests that alternative regional opportunities for unemployed labour may be available over time, depending on the skills of those seeking work and the skills demanded by potential employers.

There are no known current or potential impacts expected from the draft zoning in this marine park on current or future aquaculture enterprises. This is consistent with Government policy commitments, provided that any potential future prescribed criteria in aquaculture zone polices derived from Section 11 (3a) of the *Aquaculture Act 2001* do not add cost to existing or future aquaculture activities, or do not have regulatory impact. Because no such prescribed criteria currently exist such potential impacts have not been assessed, (PIRSA, pers. comm., 7 November 2011).

In the short-term it is unlikely the proposed zoning, in itself, will lead to an increase in tourism and ecotourism or other tourism-related business. Nor is it likely to encourage additional recreational activities or associated facilities. By the same token the proposed management plan zoning is unlikely to have a significant negative impact on recreational fishing, with access to areas fished near or from the shore generally maintained.

Given that the overall impact on the region is not expected to be large in absolute terms, the impact on property values is, similarly, not expected to be significant. States of Australia have introduced marine parks with sanctuary zones in the last decade without any known long-term effects on property values. External factors notwithstanding, the trend in Yorke Peninsula and Kangaroo Island residential property prices illustrated in the regional socio-economic profiles is unlikely to be affected by the proposed marine park zoning.

The harbour of Point Turton has been declared a special purpose area and there is not expected to be any significant impacts on shipping activities arising from zoning in this park, which is consistent with Government policy commitments.

No mineral, petroleum or geothermal licences or leases are currently located within this marine park. Further, there are no major developments planned for this marine park.

The overall social impacts of the Southern Spencer Gulf Marine Park zoning on communities living in the Yorke Peninsula and Kangaroo Island regions are expected to be low given the magnitude of the economic impacts that have been projected and low levels of regional unemployment and measured relative disadvantage. Commercial fishing is an important source of employment and on Yorke Peninsula is estimated to contribute 130 jobs to employment and a further 126 jobs on Kangaroo Island. Economic impact assessment identifies no loss of commercial fishing-related jobs. Efforts to mitigate job losses flowing from commercial fishing losses are under consideration. The impact on recreational fishing is expected to be low. Consequently, any impact on local community identity as a fishing centre, and on fishing as a way of life is also likely to be low.

Experience elsewhere in Australia and internationally, suggests that a range of benefits from the establishment of marine parks become evident over time. These include increased opportunities for education about marine life and conservation, and increased tourism and ecotourism opportunities. This experience indicates that these benefits usually take approximately five years to be evident, and that in the earliest stages of marine protected areas being developed, communities are more likely to identify possible negative impacts than potential benefits. It takes time to observe how the park's ecological and economic impacts evolve, with social impacts (positive or negative) flowing from these.

4.14 Lower Yorke Peninsula Marine Park

Situated in the Gulf St Vincent Bioregion, the Lower Yorke Peninsula Marine Park is located around the heel of Yorke Peninsula, from Point Davenport Conservation Park to near Stansbury, and includes Troubridge Island.

In general the habitats within the park can be considered to be in a condition comparable to the time of European settlement, although there are some potential minor threats from agricultural run-off or septic tank overflows in some areas, and port activities nearby. A number of species within the park were assessed as having lower abundances compared with pre-European levels. The current state of the ecosystems in the park was generally considered to reflect the condition of their component habitats and species.

The proposed management arrangements are predicted to have a net positive long-term impact on South Australia's marine biodiversity. Without the proposed management arrangements there is potential for future activities to occur that could impact on marine habitats, species and ecosystems. Depending on the type and location of zoning, the positive ecological impacts inside the Lower Yorke Peninsula Marine Park will include (1) maintenance of habitats and ecosystems in relatively good condition, and (2) changes in some ecosystems towards a more natural and resilient condition. Such changes include increases in the size and abundance of some fished species, which may potentially have socio-economic benefits, and the overall shift towards a more natural ecosystem is also expected to provide a number of management benefits, although these potential benefits have not been quantified.

The proposed zoning alone does not address all the potential threats listed above, which would require complementary management measures, but various zone restrictions (with habitat protection and sanctuary zones covering about 84 per cent and 8 per cent of the park, respectively) will assist with the future protection of habitats from a range of potentially damaging activities that may otherwise be possible under the existing management framework. Some habitats of particular conservation note include seagrass meadows that are important for overall productivity, fisheries and sediment stability, habitat for threatened and migratory birds and estuarine habitat, including a Wetland of National Importance. Maintenance of healthy habitats in general is essential for the functioning of ecosystems and the long-term sustainability of fisheries, aquaculture, and marine-based tourism.

When considered in isolation, snapper and King George whiting have potential to increase in size and abundance inside one of the sanctuary zones, although the confidence around these particular predictions is low.

The estimated economic impacts on commercial fisheries, based on SARDI's average annual displaced catches and corresponding average annual prices, are relatively small for the Lower Yorke Peninsula Marine Park. The State Government has committed to buy out licences and quota entitlements of displaced effort and catch, although details of the buyout are yet to be finalised. Compensation payments have the potential to offset, at least in part, the negative impact of the displaced catch, estimated to have an average annual gross value of $47,000 (mainly in the rock lobster sector).

There are no known current or potential impacts expected from the draft zoning in this marine park on current or future aquaculture enterprises. This is consistent with Government policy commitments.

The actual placement of sanctuary zones is unlikely to place real restriction on recreational fishing with sanctuary zones over highly fished areas limited. However, the perception that recreational fishing opportunities will be restricted by implementing 'no-take' zones is real. So there is potential for a downturn in fishing-based tourism in the short-term until visitors are informed and convinced of the actual situation on the water. In the long-term, managed marine parks will provide certainty that the marine environment within them is being protected and this may support the growth of the ecotourism industry, provided the necessary investment in tourism infrastructure and support services is undertaken. Other, non-extractive tourism, such as diving, is likely to benefit from the implementation of sanctuary zones.

Given that the overall impact on the region is not expected to be large in absolute terms, the impact on property values is, similarly, not expected to be significant. States of Australia have introduced marine parks with sanctuary zones in the last decade without any known long-term effects on property values. External factors notwithstanding, the trend in the Yorke Peninsula residential property prices illustrated in the regional socio-economic profile is unlikely to be affected by the proposed marine park zoning.

The ports of Klein Point and Port Giles have been excluded from the marine park. In addition, the harbours of Klein Point and Port Giles have been declared special purpose areas. Adelaide Brighton Cement has indicated that they may expand their shipping facilities at Port Giles. No significant impacts on shipping activities arising from the zoning in this park are expected, which is consistent with Government policy commitments.

There are 28 mining leases/miscellaneous purposes licences adjacent to the park relating to limestone mining around Wool Bay to Klein Point. A further six white shale mineral leases are located near Port Giles. There is a petroleum exploration licence overlapping part of this marine park extending from Troubridge Point to near Stansbury but does not include Troubridge Island. Conditions attached to existing licences will not change and the operations to which these licences refer to will not be affected by zoning.

There are no significant projects and infrastructure in this marine park. Adelaide Brighton Cement has expressed that in the future it will need to upgrade its shipping facilities at Klein Point. The details of this potential development are not known yet.

The overall social impacts of the Lower Yorke Peninsula Marine Park on communities living in the Yorke Peninsula region are expected to be low given the magnitude of the economic impacts that have been projected and low levels of regional unemployment and measured relative disadvantage. Commercial fishing is an important source of employment and is estimated to contribute 94 jobs to employment in the region, although relatively small when compared with tourism which contributes some 460 jobs. Economic impacts from displaced commercial fishing in the region were too small to model, but in a region with very low unemployment, and low to moderate measured relative disadvantage, any job losses are likely to have minimal social impact. The impact on recreational fishing is considered to be low with adjustments in zoning designed to minimise any potential negative impacts. Consequently, any impact on local community identity as a fishing centre, and on fishing as a way of life is also likely to be low.

Experience elsewhere in Australia and internationally, suggests that a range of benefits from the establishment of marine parks become evident over time. These include increased opportunities for education about marine life and conservation, and increased tourism and ecotourism opportunities. This experience indicates that these benefits usually take approximately five years to be evident, and that in the earliest stages of marine protected areas being developed, local communities are more likely to identify possible negative impacts than potential benefits. It takes time to observe how the park's ecological and economic impacts evolve, with social impacts (positive or negative) flowing from these.

4.15 Upper Gulf St Vincent Marine Park

Located in the Gulf St Vincent bioregion, the Upper Gulf St Vincent Marine Park lies north of a line from Parara Point to the northern end of Port Gawler Beach. This marine park partially overlays parts of Wills Creek Conservation Park and Clinton Conservation Park.

In general the habitats within the park can be considered to be in a condition comparable to the time of European settlement, although there are some potential threats to water quality from agricultural run-off or septic tank overflows, and modifications to saltmarsh and mangrove habitat in some areas. A number of species within the park were assessed as having lower abundances compared with pre-European levels. The current state of the ecosystems in the park was generally considered to reflect the condition of their component habitats and species.

The proposed management arrangements are predicted to have a net positive long-term impact on South Australia's marine biodiversity. Without the proposed management arrangements there is potential for future activities to occur that could impact on marine habitats, species and ecosystems. The positive ecological impacts inside the Upper Gulf St Vincent Marine Park will include (1) maintenance of habitats and ecosystems in relatively good condition, and (2) changes in some ecosystems towards a more natural and resilient condition. Such changes include increases in the size and abundance of some fished species, which may potentially have socio-economic benefits, and the overall shift towards a more natural ecosystem is also expected to provide a number of management benefits, although these potential benefits have not been quantified yet.

The proposed zoning alone does not address the habitat modification and water quality issues listed above, which would require complementary management measures, but various zone restrictions (with habitat protection, sanctuary and restricted access zones covering about 74 per cent, 14 per cent and 9 per cent of the park, respectively) will assist with the future protection of habitats from a range of potentially damaging activities that may otherwise be possible under the existing management framework. Some habitats of particular conservation note include the significant undisturbed saltmarsh community in the Gulf St Vincent region at Port Clinton and the mangrove forest of the Light River Delta, considered to be one of the most ecologically intact mangrove and saltmarsh systems in South Australia. Maintenance of healthy habitats in general is essential for the functioning of ecosystems and the long-term sustainability of fisheries, aquaculture, and marine-based tourism.

There is some uncertainty about the extent to which zoning will provide future protection in the north and north-east areas of the Gulf due to the proposed establishment of special purpose areas (harbor activities and defence prohibited area). However, it is expected that the designation of areas worthy of zoning as restricted access, sanctuary and habitat protection zones would assist in directing future activities appropriately.

Snapper and razorfish, when considered in isolation, have potential to increase in size and abundance inside some of the sanctuary zones. Snapper and razorfish have potential for increased larval export to areas outside the sanctuary zones, and snapper have potential for spill-over of adults to areas outside the sanctuary zones. There is also potential for some of the more transient species such as King George whiting, yellowfin whiting, blue swimmer crab, southern calamary, and southern garfish to show temporary increases inside some of the sanctuary zones during times when they aggregate. However, the ecosystems in which these species interact may shift towards a pre-European state, which may result in declines rather than increases of some species.

While the proposed zoning will have a neutral to beneficial impact on species, habitats and ecosystems, the effect on the local economy is generally assessed as negative. Impacts are based on SARDI's average annual catches and corresponding average annual prices expressed in 2011 dollars. In aggregate, it was estimated that the impact of marine park zoning will lead to a reduction in the annual value of catch in commercial fishing sectors of $0.48m. This, in turn, will generate the following loss of regional economic activity on an ongoing annual basis.

- Approximately $0.79m in GRP, which represents 0.2 per cent of the regional total ($451m).
- Approximately 12 fte jobs which represent 0.3 per cent of the regional total (4,112 fte jobs).
- Approximately $0.52m in household income, which represents 0.3 per cent of the regional total ($189m).

The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above.

The economic impacts could be greater as the estimated displaced catch may understate the actual catch in some sanctuary zones if they are located on important fishing grounds (hot spots). Impacts could also be over-estimated if sanctuary zones avoid hot spots (Ward and Burch 2012; Stevens et al. 2011a and 2011b). The zoning process attempted to avoid impacts on fishing by avoiding important fishing grounds. PIRSA has advised that statewide some draft sanctuary zones are located on important fishing grounds (hotspots), however advice specific to this park has not been provided. According to industry-derived estimates of displaced catch (which have not yet been reviewed by SARDI), the aggregate regional impacts could be as high as 28 fte jobs and $1.83m in GRP.

Although the aggregate quantified impacts may not appear large in absolute terms, the economy of the Upper Gulf St Vincent region is a dependent one with a high level of reliance on agriculture and fishing as the core drivers of economic activity. Indeed of the 1,372 businesses in the region approximately 44 per cent are classified in the agriculture, forestry and fishing sector.

However, unemployment in the Upper Gulf St Vincent region is relatively low (3.9 per cent at June 2011) when compared with the state average (5.2 per cent). This suggests that alternative regional opportunities for unemployed labour may be available over time, depending on the skills of those seeking work and the skills demanded by potential employers.

Currently there are no aquaculture operations in this marine park, however, an area at the southern end of the marine park has been identified as having potential for future aquaculture activities. There are no known potential impacts expected from the draft zoning in this marine park on future aquaculture enterprises. This is consistent with Government policy commitments.

The actual placement of sanctuary zones is unlikely to place real restriction on recreational fishing with sanctuary zones over highly fished areas limited. However, the perception that recreational fishing opportunities will be restricted by implementing 'no-take' zones is real. So there is potential for a downturn in fishing-based tourism in the short-term until visitors are informed and convinced of the actual situation on the water. In the long-term, managed marine parks will provide certainty that the marine environment within them is being protected and this may support the growth of the ecotourism industry, provided the necessary investment in tourism infrastructure and support services is undertaken. Other, non-extractive tourism, such as diving, is likely to benefit from the implementation of sanctuary zones.

Given that the overall impact on the region is not expected to be large in absolute terms, the impact on property values is, similarly, not expected to be significant. States of Australia have introduced marine parks with sanctuary zones in the last decade without any known long-term effects on property values. External factors notwithstanding, the trend in Upper Gulf St Vincent and Yorke Peninsula residential property prices illustrated in the regional socio-economic profile is unlikely to be affected by the proposed marine park zoning.

The port of Ardrossan is excluded from the marine park. In addition the harbours of Port Wakefield and Ardrossan have been declared special purpose areas, and no significant impacts on shipping activities arising from draft zoning in this park are expected, which is consistent with government policy commitments.

There are numerous mining leases near Price and Dry Creek for salt extraction adjacent to the park. There are five extractive mining leases adjacent to the park near Dry Creek for shell grit extraction. A private mine for construction materials is located adjacent to the park near Port Wakefield. A mineral exploration licence has been applied for adjacent to the park on the Yorke Peninsula. One petroleum exploration licence overlaps part of this marine park, and one is adjacent to the marine park. One geothermal exploration licence applications is partly within the marine park, and one exploration licence is immediately adjacent to the marine park. Conditions attached to existing licences will not change and the operations to which these licences refer to will not be affected by zoning. Licence applications will be required to go through a joint approval process administered by DMITRE and DEWNR, which may be a potentially lengthier and therefore more costly process to the applicant. Zoning limits the types of exploration activities permitted, and could potentially discourage certain types of applications and hence limit exploration and exploitation of resources. However no examples have been highlighted.

There is a formal development application for a residential marina complex proposed for Port Wakefield. It is expected to be located immediately adjacent to the marine park, just north of the southern section of Clinton Conservation Park. The outlet for the proposed marina is on the Port Wakefield River which discharges into the park within HPZ-1. No restriction from marine park zoning is expected.

The overall social impacts of the Upper Gulf St Vincent Marine Park on communities living in the Upper Gulf St Vincent and Yorke Peninsula regions are expected to be low given the magnitude of the economic impacts that have been projected and low levels of regional unemployment and measured relative disadvantage. Economic impact assessment estimates the loss of twelve commercial fishing-related jobs, mainly from the net sector within the Marine Scalefish fishery, bringing an employment impact of -0.1 per cent. The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above. The impact on recreational fishing is considered to be low with adjustments in zoning designed to minimise any potential negative impacts. Consequently, any impact on local community identity as a fishing centre, and on fishing as a way of life is also likely to be low for most sectors but significant for commercial net fishers.

Experience elsewhere in Australia and internationally, suggests that a range of benefits from the establishment of marine parks become evident over time. These include increased opportunities for education about marine life and conservation, and increased tourism and ecotourism opportunities. This experience indicates that these benefits usually take approximately five years to be evident, and that in the earliest stages of marine protected areas being developed, local communities are more likely to identify possible negative impacts than potential benefits. It takes time to observe how the park’s ecological and economic impacts evolve, with social impacts (positive or negative) flowing from these.

4.16 Encounter Marine Park

The Encounter Marine Park straddles the transition between the Gulf St Vincent and Coorong Bioregions. It encompasses waters off southern metropolitan Adelaide and the Fleurieu Peninsula, extending past the Murray Mouth to the Coorong coast. The marine park includes all waters of Backstairs Passage and the eastern shores of Kangaroo Island.

Many habitats within the park can be considered to be at a level comparable to the time of European settlement, although some habitats have been significantly modified, particularly near population centres in the southern suburbs of Adelaide, and near Victor Harbor and Kingscote. Habitat changes have also been documented offshore in Gulf St Vincent and attributed to prawn trawling. A number of species within the park were assessed as having lower abundances compared with pre-European levels. The current state of the ecosystems in the park was generally considered to reflect the condition of their component habitats and species.

The proposed management arrangements are predicted to have a net positive long-term impact on South Australia’s marine biodiversity. Without the proposed management arrangements there is potential for future activities to occur that could impact on marine habitats, species and ecosystems. The positive ecological impacts inside the Encounter Marine Park will include (1) maintenance of habitats and ecosystems in relatively good condition, and (2) changes in some ecosystems towards a more natural and resilient condition. Such changes include increases in the size and abundance of some fished species, which may potentially have socio-economic benefits, and the overall shift towards a more natural ecosystem is also expected to provide a number of management benefits, although these potential benefits have not been quantified.

Areas previously trawled within habitat protection zones (HPZ) and sanctuary zones (SZ) are expected to show an increase in cover of the benthic species that characterise subtidal sand habitat. Restrictions on motorized water sports in SZs on the western Fleurieu Peninsula and in Encounter Bay are expected to reduce noise pollution and other interactions with dolphins and/or whales. The proposed zoning is not predicted to change the current status of the degraded reefs off southern Adelaide nor the degraded seagrass meadows in Western Cove on Kangaroo Island, which require complementary management measures, but the various zone restrictions (with HPZ and SZ covering about 63 per cent and 10 per cent of the park, respectively) will assist with the future protection of habitats from a range of potentially damaging activities that may otherwise be possible under the existing management framework. Some habitats of particular conservation note include deep-sea sponge gardens, the only known bed in South Australia of *Heterozostera tasmanica*, *Posidonia coriacea* beds off Aldinga Beach and Wetlands of National Importance in the Onkaparinga Estuary and Pelican Lagoon. Maintenance of healthy habitats in general is essential for the functioning of ecosystems and the long-term sustainability of fisheries, aquaculture, and marine-based tourism.

There is some uncertainty about the extent to which zoning will provide future protection in areas near Kingscote, Penneshaw, and Victor Harbor and in part of Backstairs Passage due to the proposed establishment of special purpose areas for harbor activities and an underground cable. However, it is expected that the designation of areas worthy of zoning as SZs and HPZs would assist in directing future activities appropriately.

A number of species when considered in isolation (namely southern rock lobster, greenlip and blacklip abalone, snapper, razorfish, mud cockle, Goolwa cockle, Bight redfish, swallowtail, sea sweep, western blue groper, harlequin fish, and bluethroat wrasse) have potential for long-term increases in size and abundance inside some of the sanctuary zones. Southern rock lobster, greenlip/blacklip abalone, southern calamary, razorfish, mud cockle, and Goolwa cockle all have potential for increased larval export to areas outside the sanctuary zones. Southern rock lobster, Goolwa cockle, snapper, Bight redfish, swallowtail, and sea sweep have potential for spill-over of adults to areas outside the sanctuary zones. These changes may potentially have socio-economic benefits, although not quantified in this report. However, some of the ecosystems in which these species interact are expected to shift towards a pre-European state, which may result in declines rather than increases of some species such as blacklip abalone.

While the proposed zoning will have a neutral to beneficial impact on species, habitats and ecosystems, the effect on the local economy is generally assessed as negative. Impacts are based on SARDI’s average annual catches and corresponding average annual prices expressed in 2011 dollars. In aggregate, it was estimated that the impact of marine park zoning will lead to a reduction in the annual value of catch in commercial fishing sectors of $0.73m. This, in turn, will generate the following loss of regional economic activity on an ongoing annual basis.

- Approximately $1.98m in GRP which represents 0.08 per cent of the regional total ($2.46b).

- Approximately 28 fte jobs which represent 0.1 per cent of the regional total (28,789 fte jobs).

- Approximately $1.28m in household income which represents 0.1 per cent of that regional total ($1.33b).

The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above.

The economic impacts could be greater as the estimated displaced catch may understate the actual catch in some sanctuary zones if they are located on important fishing grounds (hot spots). Impacts could also be over-estimated if sanctuary zones avoid hot spots (Ward and Burch 2012; Stevens et al. 2011a and 2011b). The zoning process attempted to avoid impacts on fishing by avoiding important fishing grounds. PIRSA has advised that statewide some draft sanctuary zones are located on important fishing grounds (hotspots), however advice specific to this park has not been provided. According to industry-derived estimates of displaced catch (which are yet to be reviewed by SARDI), the aggregate regional impacts could be as high as 36 fte jobs and $2.48m in GRP.

The potential cumulative impact of the proposed extension to and revised zoning of the Commonwealth Great Australian Marine Park and the proposed Western Eyre Commonwealth Marine Reserve may place further pressure on fishing business viability.

The aggregate quantified impacts are not large for the economy of the Fleurieu and Coorong region, which is a relatively diverse and integrated one. Of the 5,735 businesses operating in the region, approximately 20 per cent were classified in the agriculture, forestry and fishing sector (in some regions the figure is over 50 per cent). To illustrate the diversity, in 2009/10 the top four contributors to fte jobs in the region were estimated to be in the manufacturing (18 per cent), retail trade (16 per cent), health and community services (11 per cent) and building and construction (9 per cent) sectors.

However, unemployment in the Fleurieu and Coorong region is relatively high (8.1 per cent at June 2011) when compared with the state average (5.2 per cent). This suggests that alternative regional opportunities for unemployed labour will be difficult to find and any job losses will be real and unlikely to be absorbed into the local workforce. Furthermore, most fishing operations, such as charter boats, are located in small fishing and tourism orientated settlements (e.g. Cape Jervis) where the relative impacts of reduced economic activity could be quite high.

On Kangaroo Island the dependency of the economy is far greater than the the Fleurieu and Coorong region. Of the 687 businesses operating in the Kangaroo Island region, approximately 52 per cent were classified in the agriculture, forestry and fishing sector. In contrast to the Fleurieu and Coorong region, however, the unemployment rate on Kangaroo Island region (3.9 per cent) is below the state average (5.2 per cent) at June 2011. Although the aggregate quantified impacts are not large for the Encounter Marine Park they will be compounded with the impacts of the Western Kangaroo Island and Southern Kangaroo Island Marine Parks.

There are no known current or potential impacts expected from the draft zoning in this marine park on current or future aquaculture enterprises. This is consistent with Government policy commitments.

The actual placement of sanctuary zones is unlikely to place real restriction on recreational fishing with sanctuary zones over highly fished areas limited. However, the perception that recreational fishing opportunities will be restricted by implementing 'no-take' zones is real. So there is potential for a downturn in fishing-based tourism in the short-term until visitors are informed and convinced of the actual situation on the water. In the long-term, managed marine parks will provide certainty that the marine environment within them is being protected and this may support the growth of the ecotourism industry, provided the necessary investment in tourism infrastructure and support services is undertaken. Other, non-extractive tourism, such as diving, is likely to benefit from the implementation of sanctuary zones.

Given that the overall impact on the region is not expected to be large in absolute terms, the impact on property values is, similarly, not expected to be significant. States of Australia have introduced marine parks with sanctuary zones in the last decade without any known long-term effects on property values. External factors notwithstanding, the trend in Fleurieu and Coorong and Kangaroo Island residential property prices, illustrated in the regional socio-economic profiles, is unlikely to be affected by the proposed marine park zoning.

There are numerous marine infrastructure and operations which are zoned special purpose areas, and their operation is not expected to change. In addition, the Murray Mouth has been zoned as a special purpose area to enable dredging to occur. GMUZ-5 off Kangaroo Island caters for growing cruise ship activity, the Cape Jervis to-Penneshaw ferry operations and potential export activities off Ballast Head. An expansion proposal by Adelaide Brighton Ltd at Rapid Bay has also been accommodated through zoning. No significant impacts on shipping activities arising from the zoning in this park are expected, which is consistent with Government policy commitments

There is a petroleum exploration licence partially overlapping this marine park, extending offshore north of Christies Beach, across to Kangaroo Island and into parts of Gulf St Vincent. There are numerous private mines adjacent to the park for sand and limestone between Moana and Rapid Head, and one mineral exploration licence application immediately adjacent to the marine park. Conditions attached to existing licences will not change and the operations to which these licences refer to will not be affected by zoning. Licence applications will be required to go through a joint approval process administered by DMITRE and DEWNR, which may be a potentially lengthier and therefore more costly process to the applicant. Zoning limits the types of exploration activities permitted, and could potentially discourage certain types of applications and hence limit exploration and exploitation of resources. However no examples have been highlighted.

Transhipment of woodchips from Ballast Head off American River (proposed GMUZ-5) is planned from 2017. No foreseeable impacts are expected.

The overall social impacts of the Encounter Marine Park on communities living in the Fleurieu and Coorong region and on Kangaroo Island are expected to be high for fishing families given the magnitude of the economic impacts that have been projected and low to moderate for the community as a whole. Commercial fishing is estimated to contribute 86 jobs to employment in the Fleurieu and Coorong region and a further 74 jobs on Kangaroo Island. Economic impact assessment identifies a loss of 28 commercial fishing-related jobs, in a region with high levels of unemployment and moderate levels of measured relative disadvantage. The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above. The impact on recreational fishing is considered to be low to moderate with adjustments in zoning designed to minimise any potential negative impacts.

Experience elsewhere in Australia and internationally, suggests that a range of benefits from the establishment of marine parks become evident over time. These include increased opportunities for education about marine life and conservation, and increased tourism and ecotourism opportunities. This experience indicates that these benefits usually take approximately five years to be evident, and that in the earliest stages of marine protected areas being developed, local communities are more likely to identify possible negative impacts than potential benefits. It takes time to observe how the park's ecological and economic impacts evolve, with social impacts (positive or negative) flowing from these.

4.17 Western Kangaroo Island Marine Park

Located in the Eyre Bioregion, the Western Kangaroo Island Marine Park is situated between Cape Forbin and Sanderson Bay, including the Casuarina Islets and Lipson Reef. The marine park includes both the North and South Casuarina Islets as part of Flinders Chase National Park.

In general the habitats within the park can be considered to be in a condition comparable to the time of European settlement. A number of species within the park were assessed as having lower abundances compared with pre-European levels. The current state of the ecosystems in the park was generally considered to reflect the condition of their component habitats and species.

The proposed management arrangements are predicted to have a net positive long-term impact on South Australia's marine biodiversity. Without the proposed management arrangements there is potential for future activities to occur that could impact on marine habitats, species and ecosystems. The positive ecological impacts inside the Western Kangaroo Island Marine Park will include (1) maintenance of habitats and ecosystems in relatively good condition, and (2) changes in some ecosystems towards a more natural and resilient condition. Such changes include increases in the size and abundance of some fished species, which may potentially have socio-economic benefits, and the overall shift towards a more natural ecosystem is also expected to provide a number of management benefits, although these potential benefits have not been quantified.

Various zone restrictions (with habitat protection and sanctuary zones covering about 69 per cent and 31 per cent of the park, respectively) will assist with the future protection of habitats from a range of potentially damaging activities that may otherwise be possible under the existing management framework. Some habitats of particular conservation note include cliffs and reefs around much of the coastline, and the small estuaries which provide habitat for fish nurseries and many other species, and support very high productivity. Maintenance of healthy habitats in general is essential for the functioning of ecosystems and the long-term sustainability of fisheries, aquaculture, and marine-based tourism.

A number of species when considered in isolation (namely southern rock lobster, and greenlip and blacklip abalone) have potential to increase in size and abundance inside the sanctuary zones. All three species have potential for increased larval export to areas outside the sanctuary zones, and southern rock lobster has potential for spill-over of adults to areas outside the sanctuary zones. However, the ecosystems in which these species interact are expected to shift towards a pre-European state, which may result in declines rather than increases of some species such as blacklip abalone. Some species of conservation concern such as the western blue groper and harlequin fish will likely benefit from protection inside the sanctuary zones.

While the proposed zoning will have a neutral to beneficial impact on species, habitats and ecosystems, the effect on the local economy is generally assessed as negative. Impacts are based on SARDI's average annual catches and corresponding average annual prices expressed in 2011 dollars. In aggregate, it was estimated that the impact of marine park zoning will lead to a reduction in the annual value of catch in commercial fishing sectors of $1.19m. This, in turn, will generate the following loss of regional economic activity on an ongoing annual basis.

- Approximately $1.40m in GRP, which represents 0.9 per cent of the regional total ($161m).
- Approximately 12 fte jobs which represent 0.6 per cent of the regional total (2,262 fte jobs).
- Approximately $0.91m in household income, which represents 1 per cent of the regional total ($91m).

The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above.

The economic impacts could be greater as the estimated displaced catch may understate the actual catch in some sanctuary zones if they are located on important fishing grounds (hot spots). Impacts could also be over-estimated if sanctuary zones avoid hot spots (Ward and Burch 2012; Stevens et al. 2011a and 2011b). The zoning process attempted to avoid impacts on fishing by avoiding important fishing grounds. PIRSA has advised that statewide some draft sanctuary zones are located on important fishing grounds (hotspots), however advice specific to this park has not been provided. According to industry-derived estimates of displaced catch (which have not yet been reviewed by SARDI), the aggregate regional impacts could be as high as 24 fte jobs and $2.28m in GRP.

The potential cumulative impact of the proposed extension to and revised zoning of the Commonwealth Great Australian Marine Park and the proposed Western Eyre Commonwealth Marine Reserve may place further pressure on fishing business viability.

Although the aggregate quantified impacts may not appear large in absolute terms, the economy of Kangaroo Island is a very dependent one with a high level of reliance on agriculture and fishing as the core drivers of economic activity. Indeed of the 687 businesses in on Kangaroo Island approximately 52 per cent are classified in the agriculture, forestry and fishing sector.

However, unemployment on Kangaroo Island is relatively low (3.9 per cent at June 2011) when compared with the state average (5.2 per cent). This suggests that alternative regional opportunities for unemployed labour may be available over time, depending on the skills of those seeking work and the skills demanded by potential employers.

Although the aggregate quantified impacts are not large for the Western Kangaroo Island Marine Park they will be compounded with the impacts of the Encounter and Southern Kangaroo Island Marine Parks.

Aquaculture

There are currently no aquaculture operations in this marine park and any future development will need to be consistent with policy commitments, marine park and aquaculture related legislation (PIRSA, pers. comm., 27 June 2012).

Tourism

The actual placement of sanctuary zones is unlikely to place real restriction on recreational fishing with sanctuary zones over highly fished areas limited. However, the perception that recreational fishing opportunities will be restricted by implementing 'no-take' zones is real. So there is potential for a downturn in fishing-based tourism in the short-term until visitors are informed and convinced of the actual situation on the water. In the long-term, managed marine parks will provide certainty that the marine environment within them is being protected and this may support the growth of the ecotourism industry, provided the necessary investment in tourism infrastructure and support services is undertaken. Other, non-extractive tourism, such as diving, is likely to benefit from the implementation of sanctuary zones.

Property prices

Given that the overall impact on the region is not expected to be large in absolute terms, the impact on property values is, similarly, not expected to be significant. States of Australia have introduced marine parks with sanctuary zones in the last decade without any known long-term effects on property values. External factors notwithstanding, the trend in Kangaroo Island residential property prices illustrated in the regional socio-economic profile is unlikely to be affected by the proposed marine park zoning.

There are no ports or harbours in this marine park nor any other major developments planned.

No mineral, petroleum or geothermal applications, leases or licences are currently listed for this marine park.

There are no significant projects or infrastructure in or known to be planned for this marine park.

The overall social impacts of the Western Kangaroo Island Marine Park on communities living on Kangaroo Island are expected to be low to moderate given the magnitude of the economic impacts that have been projected. Possible job losses (11 fte) are expected to have a moderate impact, but offset by overall low unemployment and low measured relative disadvantage. Commercial fishing is an important source of employment and is estimated to contribute 74 jobs to employment in the region, compared with tourism which contributes 960 jobs. The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above. The impact on recreational fishing is considered to be minimal with adjustments in zoning designed to minimise any potential negative impacts. Consequently, any impact on local community identity as a fishing centre and on fishing as a way of life is also likely to be low to moderate.

Experience elsewhere in Australia and internationally, suggests that a range of benefits from the establishment of marine parks become evident over time. These include increased opportunities for education about marine life and conservation, and increased tourism and ecotourism opportunities. This experience indicates that these benefits usually take approximately five years to be evident, and that in the earliest stages of marine protected areas being developed, local communities are more likely to identify possible negative impacts than potential benefits. It takes time to observe how the park’s ecological and economic impacts evolve, with social impacts (positive or negative) flowing from these.

4.18 Southern Kangaroo Island Marine Park

Including parts of the Eyre and Coorong Bioregions, the Southern Kangaroo Island Marine Park abuts the southern coast of Kangaroo Island between D'Estrees Bay and the western end of Seal Bay Conservation Park. It also includes North Rock, Young Rock and South West Rock.

In general the habitats within the park can be considered to be in a condition comparable to the time of European settlement. A number of species within the park were assessed as having lower abundances compared with pre-European levels. The current state of the ecosystems in the park was generally considered to reflect the condition of their component habitats and species.

The proposed management arrangements are predicted to have a net positive long-term impact on South Australia’s marine biodiversity. Without the proposed management arrangements there is potential for future activities to occur that could impact on marine habitats, species and ecosystems. The positive ecological impacts inside the Southern Kangaroo Island Marine Park will include (1) maintenance of habitats and ecosystems in relatively good condition, and (2) changes in some ecosystems towards a more natural and resilient condition. Such changes include increases in the size and abundance of some fished species, which may potentially have socio-economic benefits, and the overall shift towards a more natural ecosystem is also expected to provide a number of management benefits, although these potential benefits have not been quantified.

Various zone restrictions (with habitat protection zones and sanctuary/restricted access zones covering about 88 per cent and 12 per cent of the park, respectively) will assist with the future protection of habitats from a range of potentially damaging activities that may otherwise be possible under the existing management framework. Some habitats of particular conservation note include offshore algal-covered granite knolls, habitat for the Australian sea lion offshore from Seal Bay, the diversity of intertidal reef forms across the park, and seagrass within D’Estrees Bay. Maintenance of healthy habitats in general is essential for the functioning of ecosystems and the long-term sustainability of fisheries, aquaculture, and marine-based tourism.

A number of species when considered in isolation (namely southern rock lobster, and greenlip and blacklip abalone) have potential to increase in size and abundance inside the single sanctuary zone. All three species have potential for increased larval export to areas outside the sanctuary zone, and southern rock lobster has potential for spill-over of adults to areas outside the sanctuary zone. However, the ecosystems in which these species interact are expected to shift towards a pre-European state, which may result in declines rather than increases of some species such as blacklip abalone. Some species of conservation concern such as the western blue groper and harlequin fish will likely benefit from protection inside the sanctuary zone.

While the proposed zoning will have a neutral to beneficial impact on species, habitats and ecosystems, the effect on the local economy is generally assessed as negative. Impacts are based on SARDI's average annual displaced catches and corresponding average annual prices expressed in 2011 dollars. In aggregate, it was estimated that the impact of marine park zoning will lead to a reduction in the annual value in commercial fishing sectors of $0.11m. This, in turn, will generate the following loss of economic activity.

- Approximately $0.14m in GRP which represents 0.1 per cent of the regional total ($161.25m).
- Approximately one fte job which represents 0.02 per cent of the regional total (2,262 fte jobs).
- Approximately $0.10m in household income which represents 0.1 per cent of the regional total ($91.37m).

The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above.

The economic impacts could be greater as the estimated displaced catch may understate the actual catch in some sanctuary zones if they are located on important fishing grounds (hot spots). Impacts could also be over-estimated if sanctuary zones avoid hot spots (Ward and Burch 2012; Stevens et al. 2011a and 2011b). The zoning process attempted to avoid impacts on fishing by avoiding important fishing grounds. PIRSA has advised that statewide some draft sanctuary zones are located on important fishing grounds (hotspots), however advice specific to this park has not been provided. According to industry-derived estimates of displaced catch (which have yet to be reviewed by SARDI), the aggregate regional impacts could be slightly lower at less than 1 fte job and $0.08m in GRP.

The potential cumulative impact of the proposed extension to and revised zoning of the Commonwealth Great Australian Marine Park and the proposed Western Eyre Commonwealth Marine Reserve may place further pressure on fishing business viability.

Although the aggregate quantified impacts may not appear large in absolute terms, the economy of Kangaroo Island is a very dependent one with a high level of reliance on agriculture and fishing as the core drivers of economic activity. Indeed of the 687 businesses in on Kangaroo Island approximately 52 per cent are classified in the agriculture, forestry and fishing sector.

However, unemployment on Kangaroo Island is relatively low (3.9 per cent at June 2011) when compared with the state average (5.2 per cent). This suggests that alternative regional opportunities for unemployed labour may be available over time, depending on the skills of those seeking work and the skills demanded by potential employers.

Although the aggregate quantified impacts are not large for the Southern Kangaroo Island Marine Park they will be compounded with the impacts of the Encounter and Western Kangaroo Island Marine Parks.

There are currently no aquaculture operations in this marine park and any future development will need to be consistent with policy commitments, marine park and aquaculture related legislation (PIRSA, pers. comm., 27 June 2012).

The actual placement of sanctuary zones is unlikely to place real restriction on recreational fishing with sanctuary zones over highly fished areas limited. However, the perception that recreational fishing opportunities will be restricted by implementing 'no-take' zones is real. So there is potential for a downturn in fishing-based tourism in the short-term until visitors are informed and convinced of the actual situation on the water. In the long-term, managed marine parks will provide certainty that the marine environment within them is being protected and this may support the growth of the ecotourism industry, provided the necessary investment in tourism infrastructure and support services is undertaken. Other, non-extractive tourism, such as diving, is likely to benefit from the implementation of sanctuary zones.

Given that the overall impact on the region is not expected to be large in absolute terms, the impact on property values is, similarly, not expected to be significant. States of Australia have introduced marine parks with sanctuary zones in the last decade without any known long-term effects on property values. External factors notwithstanding, the trend in Kangaroo Island residential property prices illustrated in the regional socio-economic profile is unlikely to be affected by the proposed marine park zoning.

There are no ports or harbours in this marine park nor any other major developments planned.

No mineral, petroleum or geothermal licences or leases are currently located within this marine park.

There are no significant projects or infrastructure in or known to be planned for this marine park.

The overall social impacts of the Southern Kangaroo Island Marine Park on communities living on Kangaroo Island are expected to be low given the magnitude of the economic impacts that have been projected. Commercial fishing is an important source of employment and is estimated to contribute 74 jobs to employment in the region, compared with tourism which contributes 960 jobs. Economic impact assessment identifies loss of one commercial fishing-related job in a region of low unemployment and low levels of measured relative disadvantage. The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above. The impact on recreational fishing is considered to be minimal with adjustments in zoning designed to minimise any potential negative impacts. Consequently, any impact on local community identity as a fishing centre, and on fishing as a way of life is also likely to be low.

Experience elsewhere in Australia and internationally, suggests that a range of benefits from the establishment of marine parks become evident over time. These include increased opportunities for education about marine life and conservation, and increased tourism and ecotourism opportunities. This experience indicates that these benefits usually take approximately five years to be evident, and that in the earliest stages of marine protected areas being developed, local communities are more likely to identify possible negative impacts than potential benefits. It takes time to observe how the park's ecological and economic impacts evolve, with social impacts (positive or negative) flowing from these.

4.19 Upper South East Marine Park

The Upper South East Marine Park covers 906km^2 and is divided into two sections: from 11 km north of Tea Tree Crossing to the Maria Creek outlet in Kingston and from Wright Bay to the northern most point of Stinky Bay.

In general the habitats within the park are considered to be in a condition comparable to the time of European settlement although there are some potential, but minor, threats to water quality from agricultural run-off, septic tank overflows or dredging in some areas. A number of species within the park were assessed as having lower abundances compared with pre-European levels. The current state of the ecosystems in the park was generally considered to reflect the condition of their component habitats and species.

The proposed management arrangements are predicted to have a net positive long-term impact on South Australia's marine biodiversity. Without the proposed management arrangements there is potential for future activities to occur that could impact on marine habitats, species and ecosystems. The positive ecological impacts inside the Upper South East Marine Park will include (1) maintenance of habitats and ecosystems in relatively good condition, and (2) changes in some ecosystems towards a more natural and resilient condition. Such changes include increases in the size and abundance of some fished species, which may potentially have socio-economic benefits, and the overall shift towards a more natural ecosystem is also expected to provide a number of management benefits, although these potential benefits have not been quantified.

The proposed zoning alone does not address the potential water quality issues listed above, which would require complementary management measures, but the various zone restrictions (with habitat protection and sanctuary zones covering about 45 per cent and 10 per cent of the park, respectively) will assist with the future protection of habitats from a range of potentially damaging activities that may otherwise be possible under the existing management framework. Some habitats of particular conservation note include the Coorong beach, seagrass and macroalgae beach wrack (which is important for nutrient cycling and food webs), and reefs with a high diversity of macroalgae, including species with limited range. Maintenance of healthy habitats in general is essential for the functioning of ecosystems and the long-term sustainability of fisheries, aquaculture, and marine-based tourism.

There is some uncertainty about the extent to which zoning will provide future protection within Guichen Bay, due to the proposed establishment of a special purpose area (harbor activities), and a special purpose area (aquaculture) over the sanctuary zone north of Kingston. However, it is expected that the designation of areas worthy of zoning as sanctuary and habitat protection zones would assist in directing future activities appropriately.

A number of species when considered in isolation (namely southern rock lobster, blacklip abalone, snapper, and Goolwa cockle) have potential to increase in size and abundance inside some of the sanctuary zones. Southern rock lobster, blacklip abalone and Goolwa cockle have potential for increased larval export to areas outside the sanctuary zones, while southern rock lobster, snapper and Goolwa cockle have potential for spill-over of adults to areas outside the sanctuary zones. However, some of the ecosystems in which these species interact are expected to shift towards a pre-European state, which may result in declines rather than increases of some species such as blacklip abalone. Two resident reef fishes, sea sweep and bluethroat wrasse, that are vulnerable to localized depletions will likely benefit from protection inside one of the sanctuary zones.

While the proposed zoning will have a neutral to beneficial impact on species, habitats and ecosystems, the effect on the local economy is generally assessed as neutral to slightly negative. Impacts are based on SARDI's average annual catches and corresponding average annual prices expressed in 2011 dollars. In aggregate, it was estimated that the impact of marine park zoning will lead to a reduction in the annual value of catch in commercial fishing sectors of $77,000. This, in turn, will generate the following loss of regional economic activity on an ongoing annual basis.

- Approximately $0.08m in GRP, which represents 0.1 per cent of the regional total ($146m).
- Less than 1 fte job which represents less than 0.005 per cent of the regional total (1,699 fte jobs).
- Approximately $0.06m in household income, which represents 0.1 per cent of the regional total ($70m).

The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above.

The economic impacts could be greater as the estimated displaced catch may understate the actual catch in some sanctuary zones if they are located on important fishing grounds (hot spots). Impacts could also be over-estimated if sanctuary zones avoid hot spots (Ward and Burch 2012; Stevens et al. 2011a and 2011b). The zoning process attempted to avoid impacts on fishing by avoiding important fishing grounds. PIRSA has advised that statewide some draft sanctuary zones are located on important fishing grounds (hotspots), however advice specific to this park has not been provided. Industry-derived estimates of displaced catch (which have not yet been reviewed by SARDI) are less than the SARDI estimates. Consequently, the economic impacts would be less than those presented in Table ES1.

Although the aggregate quantified impacts may not appear large in absolute terms, the economy of the Upper South East region is a relatively dependent one. The region is highly reliant on the agriculture, fishing and forestry industries as the core drivers of economic activity. Indeed of the 587 businesses in the region almost 50 per cent are classified in the agriculture, forestry and fishing sector.

However unemployment in the Upper South East region is very low (3.3 per cent at June 2011) when compared with the state average (5.2 per cent). This suggests that alternative regional opportunities for unemployed labour may be available over time, depending on the skills of those seeking work and the skills demanded by potential employers.

Lacapede Bay Aquaculture Zone overlaps the entirety of SZ-2, however a special purpose zone will be placed over the sanctuary zone and HPZ-2 to allow for future planned finfish aquaculture activities. As such, there are no known current or potential impacts expected from the draft zoning in this marine park on current or future aquaculture enterprises. This is consistent with Government policy commitments.

The actual placement of sanctuary zones is unlikely to place real restriction on recreational fishing with sanctuary zones over highly fished areas limited. However, the perception that recreational fishing opportunities will be restricted by implementing 'no-take' zones is real. So there is potential for a downturn in fishing-based tourism in the short-term until visitors are informed and convinced of the actual situation on the water. In the long-term, managed marine parks will provide certainty that the marine environment within them is being protected and this may support the growth of the ecotourism industry, provided the necessary investment in tourism infrastructure and support services is undertaken. Other, non-extractive tourism, such as diving, is likely to benefit from the implementation of sanctuary zones.

Given that the overall impact on the region is not expected to be large in absolute terms, the impact on property values is, similarly, not expected to be significant. States of Australia have introduced marine parks with sanctuary zones in the last decade without any known long-term effects on property values. External factors notwithstanding, the trend in Upper South East residential property prices illustrated in the regional socio-economic profile is unlikely to be affected by the proposed marine park zoning.

The harbour of Robe has been declared a special purpose area and no significant impacts on shipping activities arising from zoning in this park are expected, which is consistent with Government policy commitments.

The coastal and inshore section of Guichen Bay is partially covered by two geothermal exploration licences. Two Petroleum Exploration Licences are adjacent to this marine park at Nora Creina and Guichen Bay. A gazettal of petroleum acreage has been made adjacent to the southern part of the park in Commonwealth waters. Conditions attached to existing licences will not change and the operations to which these licences refer to will not be affected by zoning.

There are no significant projects or infrastructure in this marine park. There is a proposal, at the prefeasibility stage, to develop a barge point at Kingston SE Harbor, just outside the park. No impacts from the proposed draft zoning are expected.

The overall social impacts of the Upper South East Marine Park on communities living in the Upper South East region are expected to be low given the magnitude of the economic impacts that have been projected. Commercial fishing is an important source of employment and is estimated to contribute 59 jobs to employment in the region, compared with tourism which contributes 200 jobs. Economic impact assessment identifies the loss of less than one fte commercial fishing-related jobs in a region of low unemployment and low levels of measured relative disadvantage. The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above. The impact on recreational fishing is considered to be low with adjustments in zoning designed to minimise any potential negative impacts. Consequently, any impact on local community identity as a fishing centre and on fishing as a way of life is also likely to be low.

Experience elsewhere in Australia and internationally, suggests that a range of benefits from the establishment of marine parks become evident over time. These include increased opportunities for education about marine life and conservation, and increased tourism and ecotourism opportunities. This experience indicates that these benefits usually take approximately five years to be evident, and that in the earliest stages of marine protected areas being developed, local communities are more likely to identify possible negative impacts than potential benefits. It takes time to observe how the park's ecological and economic impacts evolve, with social impacts (positive or negative) flowing from these.

4.20 Lower South East Marine Park

Located in the Otway Bioregion, the Lower South East Marine Park covers 360 km^2 and is divided into two sections: the first adjacent to Canunda National Park and the second extending from Port MacDonnell Bay just west of French Point to the Victorian border.

In general the habitats within the park can be considered to be in a condition comparable to the time of European settlement, although there are some potential, but minor, threats to water quality from agricultural run-off or septic tank overflows in some areas. A number of species within the park were assessed as having lower abundances compared with pre-European levels. The current state of the ecosystems in the park was generally considered to reflect the condition of their component habitats and species.

The proposed management arrangements are predicted to have a net positive long-term impact on South Australia's marine biodiversity. Without the proposed management arrangements there is potential for future activities to occur that could impact on marine habitats, species and ecosystems. The positive ecological impacts inside the Lower South East Marine Park will include (1) maintenance of habitats and ecosystems in relatively good condition, and (2) changes in some ecosystems towards a more natural and resilient condition. Such changes include increases in the size and abundance of some fished species, which may potentially have socio-economic benefits, and the overall shift towards a more natural ecosystem is also expected to provide a number of management benefits although these potential benefits have not been quantified.

The proposed zoning alone does not address the potential water quality threats listed above, which would require complementary management measures, but the various zone restrictions (with habitat protection and sanctuary zones covering about 42 per cent and 9 per cent of the park, respectively) will assist with the future protection of habitats from a range of potentially damaging activities that may otherwise be possible under the existing management framework. Some habitats of particular conservation note include giant kelp forests and nearshore coastal fresh water mixing zones. Maintenance of healthy habitats in general is essential for the functioning of ecosystems and the long-term sustainability of fisheries, aquaculture, and marine-based tourism.

There is some uncertainty about the extent to which zoning will provide future protection near Southend, due to the proposed establishment of a special purpose area (harbor activities). However, it is expected that the designation of the area worthy of zoning as an habitat protection zone would assist in directing future activities appropriately.

Southern rock lobster and blacklip abalone, when considered in isolation, have potential to increase in size and abundance inside the two sanctuary zones. Both species have potential for increased larval export to areas outside the sanctuary zones, and southern rock lobster also has potential for spill-over of adults to areas outside the sanctuary zones. However, the ecosystems in which these two species interact are expected to shift towards a pre-European state, which may result in declines rather than increases of blacklip abalone.

While the proposed zoning will have a neutral to beneficial impact on species, habitats and ecosystems, the effect on the local economy is generally assessed as negative. Impacts are based on SARDI's average annual catches and corresponding average annual prices expressed in 2011 dollars. In aggregate, it was estimated that the impact of marine park zoning will leaed to a reduction in the annual value of catch in commercial fishing sectors of $0.84m. This, in turn, will generate the following loss of regional economic activity on an ongoing annual basis.

- Approximately $1.07m in GRP, which represents 0.1 per cent of the regional total ($1,821m).
- Approximately 8 fte jobs which represent 0.04 per cent of the regional total (20,440 fte jobs).
- Approximately $0.67m in household income, which represents 0.1 per cent of the regional total ($1,011m).

The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above.

The economic impacts could be greater as the estimated displaced catch may understate the actual catch in some sanctuary zones if they are located on important fishing grounds (hot spots). Impacts could also be over-estimated if sanctuary zones avoid hot spots (Ward and Burch 2012; Stevens et al. 2011a and 2011b). The zoning process attempted to avoid impacts on fishing by avoiding important fishing grounds. PIRSA has advised that statewide some draft sanctuary zones are located on important fishing grounds (hotspots), however advice specific to this park has not been provided. According to industry-derived estimates of displaced catch (which are yet to be reviewed by SARDI), the aggregate regional impacts could be higher at 13 fte jobs and $1.71m in GRP.

Although the aggregate quantified impacts may not appear large in absolute terms, the economy of the Lower South East region is a relatively dependent one. Although there is diversity in the region's agriculture, fishing and forestry industries, it is still reliant on these sectors as the core drivers of economic activity. Indeed of the 3,946 businesses in the region approximately 31 per cent are classified in the agriculture, forestry and fishing sector.

Additionally, unemployment in the Lower South East region is slightly elevated (6.5 per cent at June 2011) when compared with the state average (5.2 per cent). This suggests that alternative regional opportunities for unemployed labour would be somewhat difficult to find and any job losses would be real and unlikely to be absorbed into the local workforce, in the short-tern at least.

There are currently no aquaculture operations in this marine park and any future development will need to be consistent with policy commitments, marine park and aquaculture related legislation (PIRSA, pers. comm., 27 June 2012).

The actual placement of sanctuary zones is unlikely to place real restriction on recreational fishing with sanctuary zones over highly fished areas limited. However, the perception that recreational fishing opportunities will be restricted by implementing 'no-take' zones is real. So there is potential for a downturn in fishing-based tourism in the short-term until visitors are informed and convinced of the actual situation on the water. In the long-term, managed marine parks will provide certainty that the marine environment within them is being protected and this may support the growth of the ecotourism industry, provided the necessary investment in tourism infrastructure and support services is undertaken. Other, non-extractive tourism, such as diving, is likely to benefit from the implementation of sanctuary zones.

Given that the overall impact on the region is not expected to be large in absolute terms, the impact on property values is, similarly, not expected to be significant. States of Australia have introduced marine parks with sanctuary zones in the last decade without any known long-term effects on property values. External factors notwithstanding, the trend in Lower South East residential property prices illustrated in the regional socio-economic profile is unlikely to be affected by the proposed marine park zoning.

The harbour of Beachport and Southend extends into the marine park and has been declared a special purpose area and no significant impacts on shipping activities arising from the zoning in this park are expected, which is consistent with Government policy commitments.

No mineral, petroleum or geothermal applications, leases or licences are currently located in this marine park. There are two petroleum exploration licences adjacent to this marine park located inshore from the coast while a gazettal of petroleum acreage has been made adjacent to the northern part of the park in Commonwealth waters.

There are no significant projects or infrastructure in or known to be planned for this marine park. Several wave energy projects have made approaches to develop wave energy in state waters north of Cape Douglas to Orwell Rocks, all of which are expected to be outside of the marine park.

The overall social impacts of the Lower South East Marine Park on communities living in the Lower South East region are expected to be low to moderate given the magnitude of the economic impacts that have been projected. Commercial fishing is one of the four top industry sources of employment and is estimated to contribute 330 jobs to employment in the region, compared with tourism which contributes some 1,000 jobs. Economic impact assessment identifies the loss of eight commercial fishing-related jobs in a region of moderate levels of unemployment and low levels of measured relative disadvantage. The State Government has committed to buy out licences and quota entitlements to offset any unsustainable displaced effort and catch. Although details of the buyout are yet to be finalised, any such payments have the potential to at least partially offset the negative impacts outlined above. The impact on recreational fishing is considered to be generally low with localised impact at Canunda Rocks. Consequently, any impact on local community identity as a fishing centre and on fishing as a way of life is also likely to be low.

Experience elsewhere in Australia and internationally, suggests that a range of benefits from the establishment of marine parks become evident over time. These include increased opportunities for education about marine life and conservation, and increased tourism and ecotourism opportunities. This experience indicates that these benefits usually take approximately five years to be evident, and that in the earliest stages of marine protected areas being developed, local communities are more likely to identify possible negative impacts than potential benefits. It takes time to observe how the park's ecological and economic impacts evolve, with social impacts (positive or negative) flowing from these.

5. Cost Benefit Analysis Method, Data and Assumptions

5.1 Method of Analysis

The dominant framework for economic evaluation is based on cost benefit analysis (CBA). Variants of it are cost effectiveness analysis and threshold value analysis. Cost benefit analysis is well suited to aiding decisions about whether a particular initiative or option to deliver an initiative is the better alternative over other options or 'doing nothing'.

Impact assessments are complementary to evaluations, but not substitutable. Statements of impact assess the impacts associated with an initiative and often propose mitigation measures. Unlike evaluations, their role is not to substantiate whether a particular initiative or option to deliver an initiative is the better alternative over other options or 'doing nothing'.

Economic impact statements that are based on analyses such as input-output analysis should not be used as a sole justification for a particular course of action. They do not provide evaluative direction in terms of cost versus benefit, rather they should be used as an input in an evaluation study. Techniques such as cost benefit analysis, which express the relationship between the benefits to society and the costs incurred as a result of the action, are more appropriate for providing information about return on investment, project viability and net benefit to society.

Cost benefit analysis is an economic tool designed to assist resource allocation decision making, particularly in the context of public sector investment. It is used to measure the allocative efficiency of the distribution of resources in a given situation, relative to the status quo, by establishing the point at which the most desirable output is created while utilising the most desirable level of input, at the least possible cost for the amount produced. In other words CBA is used to answer the question "Will the project provide a good return on the investment of public money?"

In contrast to cost benefit analysis, impact analysis provides information on the distribution of benefits and costs rather than providing an assessment of economic benefits required to justify a project. Importantly, techniques to measure economic impact, such as input-output analysis, do not consider explicitly the alternative uses of resources in the project and associated activities. Indeed, a particularly inefficient use of funds may show a greater impact due to its inefficiency.

The benefits and costs flowing from a project are spread over time. In order to compare future costs and benefits flowing from a project to those incurred in the present, it is necessary to convert these streams of costs and benefits to an equivalent amount in today's dollars. This is done by discounting the value of future costs and benefits by a discount rate, and the equivalent amount is known as the present value.

In cost benefit analysis, if the project yields (present value) benefits greater than or equal to the (present value) costs then the return from the project is greater than or equal to the discount rate and the project is potentially worthwhile.

The indicators used in impact analysis typically include employment and gross state/regional product. These indicators can be estimated over the same time period as used in a cost benefit analysis. While it is possible to apply a discount rate to estimates of gross state product, the concept is less easily applied to employment projections.

In principle there can be net economic benefits attributable to employment distribution, flow-on effects and the regional incidence of economic impacts, benefits that would not normally be captured in a standard cost benefit analysis. For these reasons an impact analysis can be worthwhile in providing information that is complementary to a cost benefit analysis and thereby forms a component of a broader economic and social assessment.

There is a clear distinction between economic impact analysis and economic evaluation. Economic impact analysis (see Section 4.1.2) is concerned with measuring the impact or effect of a given stimulus on the economy in economic terms (regional income, employment, etc.). By contrast CBA indicates whether the quantifiable benefits of an investment are greater than the project costs.

General Framework for CBA

The following steps, consistent with the SA Government's *Better Regulation Handbook* were undertaken in order to develop the CBA:

1. describe the 'base case' and set of short-listed policy options for which costs and benefits will be estimated, i.e. the 'without management plan' and 'with management plan' and potentially 'with alternative management plan';
2. establish the time frame over which the proposal is to be assessed, i.e. 20 years;
3. delineate the scope of the assessment of costs and benefits, i.e. within state boundaries;
4. identify the impacts, how they will be measured and any uncertainties surrounding them. Information gathered from the regionally based impact assessments will be used in the CBA model; and will include consideration of extractive and non-extractive use benefits associated with the marine parks foregone as a result of zoning, additional management costs and additional compliance costs;
5. timeline the impacts;
6. monetise, quantify or describe the impacts;
7. undertake the Net Present Value calculation. The discount rates recommended in the Better Regulation Handbook will be used;
8. conduct sensitivity analysis;
9. recommend any other factors for DEWNR's consideration in choosing the optimal option; and
10. rank the policy options if alternative draft management plans are included.

Non-priced Benefits

There are significant non-market benefits of protecting marine ecosystems. If only market-based cost and benefit estimates are included in the CBA it is likely that the quantified net benefits will be negative. To address this would have required a valuation, in monetary terms, of the non-market benefits of implementing the draft management plans to protect marine biodiversity. Unfortunately, this valuation process in the CBA was beyond the scope of the project.

As the non-market benefits were not estimated, the results of the CBA are presented as a threshold value. Presenting the results as a threshold value emphasises that there are significant unpriced values that have been excluded from the analysis

Options

The starting point for the CBA was to develop the 'base case' scenario, that is, the benchmark against which the alternative option was compared. For the purpose of this analysis the 'base case' was defined as 'no management plans' which implies there would be no zoning (sanctuary zones, etc.) within the marine parks.

The alternative option (Option 1) that was compared against the base case was to prepare management plans with zoning and that these would be implemented from 2012/13.

Decision Rule

The cost benefit analysis conducted for this project conforms to South Australian and Commonwealth government guidelines for conducting evaluations of public sector projects (Department of Treasury and Finance (2007) and Department of Finance and Administration (2006)).

Given that costs and benefits were specified in real terms (i.e. constant 2011 dollars), future values were converted to present values by applying a discount rate of 6 per cent for the economic analysis. A sensitivity analysis was conducted using discount rates of 4 and 8 per cent for the economic analysis.

The economic analysis was conducted over a 20 year time period and results were expressed in terms of net benefits, that is, the incremental benefits and costs of the option relative to those generated by the 'base case' scenario. The evaluation criterion employed for this analysis was:

Net present value (NPV) = discounted[16] project benefits less discounted project costs.

Under this decision rule an option was considered to be potentially viable if the NPV was greater than zero. The NPV for option *i* has been calculated as an incremental NPV, using the standard formulation:

NPV_i = (PV (option$_i$ benefits – 'base case' benefits) – (PV (option$_i$ costs– 'base case' costs))

As noted above, the NPV calculation omits significant un-priced benefits and the results are presented as a threshold value. Presenting the results as a threshold value, the evaluation question becomes:

> *To the South Australian economy, are the un-priced net benefits of protecting marine resources via management plans worth the threshold value of priced net costs from implementing the management plans?*

In these circumstances other evaluation criteria, such as benefit cost ratio and internal rate of return, are not relevant.

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16 Discounting refers to the process of adjusting future benefits and costs to their equivalent present-day values (Sinden and Thampapillai 1995).

5.2 Data and Assumptions

The costs and benefits of the project were measured using a ‘with’ and ‘without’ project framework, that is, quantification of the incremental changes associated with the option for management plans prepared and implemented for the marine parks compared with the base case scenario. The method, data sources and assumptions used to quantify these values are described below. Consideration was given to those benefits and costs likely to occur over a 20 year time period.

The major economic costs and benefits of the project are listed in Table 5–1 and Table 5–2, respectively. The estimation of each of the items is detailed below.

Sensitivity analyses were undertaken to reflect the uncertainty associated with these assumptions. Further details of these analyses and results are provided in Section 6.2 of this report.

Table 5–1 Costs of the alternative marine park management options

Option	**Description of Costs**	**Bearer of Cost**	**Valued in Monetary Terms**	**Source of Information**
Base Case (No Management Plan)	Costs of establishing marine parks	SA Government	Yes	SA Government
	Costs of limited management	SA Government	Yes	SA Government
Option 1 (With Management Plan)	Costs of establishing marine parks	SA Government	Yes	SA Government
	Implementation of management plans	SA Government	Yes	SA Government
	Additional resources for priority activities	SA Government	No	
	Regulatory costs for fisheries management	SA Government	No	
	Fishing operations	Industry	Part	EconSearch Analysis

Table 5–2 Benefits of the alternative marine park management options

Option	Description of Benefits	Beneficiary	Valued in Monetary Terms	Source of Information
Base Case (No Management Plan)	Changed profitability for tourism	Industry	No	-
Option 1 (With Management Plan)	Changed profitability for commercial fisheries	Industry	Yes	EconSearch analysis
	Changed profitability for tourism	Industry/ Community	No	-
	Marine ecosystem improvement	Environment/ Community	No	-

Costs

Under the base case it was assumed that the cost of marine park management would be equivalent to 10 per cent of the cost if there were management plans in place (DENR pers. comm., 30 September 2011).

Between 1 July 2007 and 30 June 2011, DEWNR spent approximately $13.9 million on marine parks. The 2011-12 marine parks budget is $3.48 million. (DENR pers. comm., 30 September 2011).

The SA Government has allocated $1.97 million per annum in ongoing funding from 2012/13 to its marine parks program to enable implementation of the management plans with zoning for the 19 marine parks. Management plan implementation activities will include:

- community education and information dissemination;
- compliance and enforcement;
- monitoring, reporting and evaluation of biodiversity outcomes, and
- policy work.

Over time it is likely that demand for more intensive management of marine parks will increase and that funds will be allocated accordingly (DENR pers. comm., 28 September 2011). To reflect this, a real annual increase of 2.5 per cent in the cost of management has been included in the analysis.

Further, the statutory 10 year review will require additional direct funding for the review as well as a need for increased funding as a result of the review. An overall increase in budget of 25 per cent has been factored into the analysis in years 10 and 20.

The 19 management plans will set out the priority management activities required in each park. Once marine park management plans are finalised, any additional resources required to undertake priority management activities will be identified and allocated. Because these management plans are not yet finalised, any additional resources could not be costed and included in the CBA.

The sensitivity analysis considers the a low cost scenario under which there are no real cost increases in park management over the 20 year period of analysis nor any additional costs in years 10 and 20. A high cost scenario was calculated as a 10 per cent increase over projected costs.

In modelling the change in fishing patterns, representative cost models were prepared for each of the commercial sectors, including charter boats. These models were used to estimate the change in variable fishing costs with reduced access to the resource (as per SARDI estimates) as well as changes in fixed costs on a per quantity of fish caught basis.

Sanctuary zones have the potential to disrupt the normal patterns of operation for commercial fishers. This can range from being an inconvenience for fishers to adding significantly to their cost of operation (e.g. fuel, labour, repairs and maintenance). Apart from those costs that can be related directly to catch and effort, these “inconvenience” costs have not been included in the CBA as they were beyond the scope of this study.

There will be situations where fishers may be required to steam further and to more exposed waters to access available fishing grounds and the risk of accidents at sea may increase (PIRSA, pers. comm., 29 September 2011). The potential costs related to safety issues have not been included in the CBA, as they are beyond the scope of this study.

Additional costs, which are difficult to quantify, will be incurred by Government to revise the modelling for stock assessments to consider the new area available to the fishery, which excludes the sanctuary zones. Fishery managers will need time and effort to change arrangements so as to account for the consequences of displaced effort on the sustainability of stocks outside of areas closed to fishing (PIRSA pers. comm., 23 December 2011).

For licence holders in some fisheries there could be cost implications specific to that sector. For example, the economic impact on rock lobster fishers may be higher than the proportion of the catch that will be lost because the small, red lobsters typically taken in State waters (where sanctuary zones are located) are more valuable (reportedly an extra $10 per kg) than the larger, paler lobsters typically taken in Commonwealth waters (PIRSA, pers. comm., 29 September 2011). With the total allowable commercial catch at a historically low level, most licence holders in the fishery have targeted these high value rock lobsters to maximise the value of their catch. For this reason, fishing further offshore or simply having a higher proportion of catch comprised of lower priced fish could adversely affect fishing profitability. These potential costs have not been included in the CBA because of the difficulty of estimation.

In some sectors, particularly rock lobster and abalone, fishers will often fish “stop-over” areas, areas where rock lobster pots, for example, are set on patchy reef en route to more distant fishing grounds. Sanctuary zones located over these fishing routes, even if not located in the most productive fishery areas, may disrupt this pattern leading to less efficient fishing patterns (PIRSA, pers. comm., 29 September 2011), which would mean greater costs per trip. Again, these potential costs have not been included in the CBA because of the difficulty of estimation.

It is likely that most licence holders that currently fish in areas where there are proposed sanctuary zones will be impacted by the zoning either from restricted access or from displaced fishers shifting effort into their patch. This could lead to higher levels of conflict and competition between licence holders, particularly haul netters who already operate in limited areas. It could be expected that this type of conflict would resolve itself over time and not persist into the medium to long-term.

Benefits

Commercial benefits to fishing and tourism businesses can be quantified through the impact on business profitability. Even if profits are negative, the change in profitability is still included in the CBA as a “benefit”. Based on economic indicators for each of the commercial fisheries prepared annually by EconSearch, boat and industry level models were prepared to assess the impact of reduced catches on industry profitability for individual marine parks and aggregated to the fishery level.

This study assessed the potential for spillover of fish stock from protected areas and for larval export of fished species. This long-term benefit was identified in a number of cases, however could not be reasonably quantified and therefore its economic effect could not be estimated. The estimates of lost profitability on the commercial fishing sector have not included this benefit.

As for fishing businesses, the loss in gross revenue for tourism related businesses does not necessarily equate to a net loss for the economy. This is because, although sales may be down it is likely that costs will be down as well (e.g. less labour, less fuel). The relevant measure for a cost benefit analysis is producer surplus, which can be approximated by some measure of profit. However, based on discussions with the South Australian Tourism Commission, local councils and local offices of Regional Development Australia, it is unlikely that the draft zoning, in itself, will lead to an increase in tourism and ecotourism opportunities or other business opportunities in the area. Nor, in part due to the remoteness of many of the marine parks, is it likely to encourage additional recreational activities or associated facilities. Regional and global research evidence identifies increased tourism, including ecotourism arising from marine protected areas, but this outcome is not evident in early implementation stages (Angulo-Valdes and Hatcher 2010, Cocklin et al. 1998). There was no sound basis for quantifying with any confidence future ecotourism industry development that could be attributed to the marine parks and associated zoning.

There are benefits associated with the protection and enhancement of the biodiversity of marine ecosystems. Current markets, however, only shed information about the value of a small subset of ecosystem processes and components that are priced and incorporated in transactions as commodities or services. This poses limits on the ability of markets to provide a comprehensive picture of the ecological values involved in decision processes. These values have not been included in the CBA, as they were beyond the scope of the project.

A discussion of other studies that have valued the non-priced benefits is provided in the following section to give context to the threshold value.

6. Results of the Cost Benefit Analysis

As highlighted in the proceeding section, the non-priced benefits have been excluded from the CBA. Section 6.1 describes these benefits qualitatively, giving the reader a context to the 'value', both in terms of biophysical benefits to ecosystems and benefits to society. Section 6.2.1describes the results of the CBA, presented as a threshold value. The results of the sensitivity analysis are provided in Section 6.2.2.

6.1 Benefits

6.1.1 Biophysical Benefits for Species, Habitats and Ecosystems

Eadie and Hoisington (2011), in a meta-analysis of the benefits of marine protected areas and highly protected zones for ecosystem preservation, list the following biophysical benefits that are very likely to be realised:

- Increased biomass of marine species in and also (to varying degrees) outside the highly protected zones.
- Measured increases in size and age of species, including commercially harvested fish species. This is particularly important because for many species fertility increases far more than proportionally with the age and size of fish – so for example if a female fish is allowed to grow twice as big, it could produce 10 to 100 times as many eggs.
- Increased biological resilience to various environmental threats, from pollution to over-fishing and even to climate change; these effects have been measured repeatedly.
- Many papers also report spill-over effects, meaning increased fish biomass outside the boundaries of the highly protected zones and MPAs. This varies greatly by species as some are more mobile than others. Fisheries management regimes outside the highly protected zone, history of exploitation and other factors will also influence the extent of the spill-over effect.
- Reappearance and/or increased numbers of top predators, better-functioning food webs, functioning and more stable ecosystems.
- Opportunities for research to establish baselines of populations in undisturbed ecosystems. This provides vital information on how to manage entire ecosystems for long-term sustainability.

Beyond these generally accepted benefits, the following discussion identifies some further generalised benefits.

For migratory species or migratory species that show periods of residency in some areas, there may be benefits of a network of SZs that have increased size and abundance of fishes and invertebrates. For example, the white shark feeds on snapper and snapper are predicted to increase in size and abundance in many of the parks. If feeding efficiency for white sharks and other sharks, e.g. whaler sharks, is increased inside these parks it is possible that the sharks will spend longer periods there. These sharks will also not be exposed to fishing mortality while inside the SZs. In the case of the white shark, which is a threatened and protected species, it will not be exposed to fishing practices that may inadvertently result in mortalities, e.g. entanglement in long-lines.

A large number of individuals across many different species is caught as bycatch or released (for various reasons) in the commercial marine scalefish fishery (Fowler et al., 2009), rock lobster fishery (Brock et al., 2007), prawn trawl fishery (Currie et al., 2009; 2011), and the recreational fishery (Jones, 2009). For example, Jones (2009) estimated that 2.6 million individuals from across many different species were released by recreational fishers across SA during 2007/08. Some species such as mulloway and snapper have a much higher release rate (>70 per cent) in the recreational fishery than others (Jones 2009). The post-release survival of these undersized or unwanted fish is unknown. However, some species are known to be susceptible to barotraumas, e.g. southern blue devil, snapper from depth, or are sensitive to handling in general, e.g. southern sea garfish (Saunders et al., 2010, McLeay et al., 2002). Whatever the post-release fate of these fish is (and there must be at least some level of mortality), the potential cumulative impacts of post-release mortality on fish assemblages will be completely eradicated inside sanctuary zones. Furthermore, sub-lethal effects such as the incidence of disease from fisher handling would also be eliminated inside sanctuary zones, e.g. 'tail-fan necrosis' in southern rock lobster (Freeman and MacDiarmid, 2009).

Many fishery species have life-cycles that involve a range of habitats across large spatial scales (see Appendix 3). For example, King George whiting spawn in offshore waters in the southern parts of Spencer Gulf and Gulf St Vincent, and Investigator Strait. The eggs and larvae then drift northwards where the juveniles grow in sheltered intertidal seagrass flats and shallow subtidal seagrass meadows. As they grow and mature they move southwards back to the spawning grounds (see Appendix 3). A network of SZs and HPZs across the State can provide connectivity by protecting individuals and habitat components of complex life-histories for species such as the King George whiting, snapper, western king prawn, and blue swimmer crab.

6.1.2 Benefits to Society

Ecosystems provide many critically important services that people benefit from, many of these benefits are un-priced. Examples of ecosystem services provided by the coastal and marine habitats found within the SA marine park system are described below[17]. At the end of this section an example, taken from the literature, provides an estimate of the monetary value of some marine ecosystem services.

Saltmarsh

Saltmarshes warrant a place amongst all the coastal resources that the human population living along SA estuaries and coasts value and rely upon for their livelihood and quality of life (Dugan, 2005). Saltmarshes provide an ecological service to the human population living on their shores in the form of some protection from storms and coastal erosion.

Saltmarsh ecosystems remove nutrients from runoff as they cover large areas that are occasionally flooded and drained by meandering streams that slowly release water to the sea.

[17] For a list of references see Appendix 4.

Mangrove

A general description of the value of mangrove forests is given by Warne (2011), who discusses the destructive biases of current economic models and points out the real value of mangrove goods and services. Mangroves in estuaries and coastal waters provide ecological services to the human population living on their shores, and protect the coast from wind damage, salt spray and coastal erosion. They also shelter coastal seagrass beds and reefs from excess sedimentation, enhance fisheries production and create self-scoured navigable channels. Mangroves consume carbon dioxide, release oxygen and create carbohydrates through photosynthesis. Mangroves form soil, store and sequester carbon and cycle water and nutrients through the ecosystem. Mangroves provide nursery area and havens for marine organisms and nesting and roosting space for birds. They are a source for nectar and pollen for bees and fodder for browsing herbivores. Mangroves support considerable biodiversity.

Intertidal sand flat

Much of the intertidal area of SA is sand flat and although not readily visible there is a diverse and productive array of invertebrates and diatoms associated with these beds. This biota, from diatoms and any macroalgae that grow on hard surfaces to the larger predators, is a source of organic matter. It is grazed by transitory fish, crabs and molluscs and absorb nutrients and takes up sediment eroded from the land. Blue swimmer crabs (*Portunus armatus*) and some fish are caught on intertidal sand flats making these areas of value to commercial and recreational fishers.

Subtidal sand

The ecological and economic services provided by the intertidal sand habitats of SA are much the same as those provided by the intertidal habitat. Commercial and recreational fishing are a large economic service while biological diversity and primary production offer considerable environmental importance to this habitat. The productivity is provided by an almost invisible source—diatoms or microphytobenthos. The most visible evidence for microphytobenthos is along the lee side of sand ripples seen from aerial photographs.

Intertidal seagrass flat

Seagrasses form some of the most productive ecosystems on earth, rivalling even crops of corn or sugar cane. The beds afford shelter and nursery areas to numerous fish and invertebrates. Seagrass beds filter overlying seawater and prevent erosion and accretion of coastlines. They are a nutrient sink and provide a detrital foodweb for many animals and bacteria. In temperate regions of the world few animals eat live seagrass, however, in SA swans eat *Zostera* and *Halophila*. Economically, seagrass beds provide a nursery ground for commercially and/or recreationally important fish, crabs and prawns. The fish, prawn, and crab yield in southern Australia is valued at US$1,436 per hectare per year (McArthur and Boland 2006). Based on the latter estimate, a loss of 2700 ha of seagrass beds would result in lost fishery production of AU$235,000. They also provide habitat for some adult fish and squid.

Seagrasses are involved in carbon sequestration by using carbon dissolved in the seawater (mostly in the-form of CO_2, but also HCO_3^-) to grow. Once the plants complete their life cycle, a portion of these materials is then buried in the sediment in the form of refractory detritus. It has been estimated that detritus burial from vegetated coastal habitats contributes about half of the total carbon burial in the ocean (Duarte et al. 2005). Therefore, the decline in seagrasses could lead to an important loss in the global CO_2 sequestration capacity, although this effect has yet to be valued.

Subtidal seagrass

The economic goods and services for subtidal seagrass beds are the same as for intertidal seagrass. In SA the denser subtidal seagrass beds have a greater abundance and probably diversity because they offer more surface area for cover and for epiphytes to grow.

Intertidal reefs

Intertidal reefs provide a large surface area for attachment of sessile animals and macroalgae, and shelter for some invertebrates that would otherwise be fed on by fish and other predators. These reefs are excellent areas for education as they are easily accessible and often not dangerous.

Subtidal high profile reef

These environments are important in providing a number of ecosystem services including: primary production; carbon storage and flow; nutrient cycling; disturbance regulation; climate regulation; erosion control; remineralisation; biological control; recreation; tourism; education; indicators of global change; coastal protection; habitat and refuge; food; raw materials; genetic resources; and natural heritage (Turner et al. 2006).

South Australian reefs are a major source of complex organic carbon to coastal ecosystems with productivity comparable to that of a cereal crop or sugar cane stand growing under agricultural mono-culture conditions (Cheshire et al. 1998).

The macroalgae of the subtidal reefs offer cover to many commercially and recreationally important species, including rock lobster and abalone.

The reefs and the plants growing on them reduce the force of waves and swell and protect the exposed coast from erosion and accretion.

Subtidal low profile reef

As with the high profile reefs, many species are fished by recreational and commercial fishers on subtidal low profile reefs. The macroalgae and sessile animals add to the detritus that finds its way to beaches or off the continental shelf.

Beach

Kirkman and Kendrick (1997) provide an overview of the ecological significance of beach-cast seaweed and seagrass describing food webs and the importance of drift. This drift is broken down by invertebrates and bacteria to release nutrients that are returned to offshore reefs and seagrass beds.

Of most importance are the role of birds and their use of drift material. Seabirds, beach waders and terrestrial birds all use drift for food or nest material. The hooded plover *Charadrius rubricollis* has a close association with drift on beaches, feeding on crustaceans, mollusc, insects and polychaetes associated with the drift.

Pelagic

Hoyt (2005) listed three reasons why it is important to consider whales and dolphins when designing marine protected areas: 1) their habitat needs have hitherto been neglected; 2) there is now more information than ever on cetaceans; and 3) cetaceans need large conservation areas so this may be the key to protecting ocean habitats and large new areas. The above reasons can also be connected to other marine megafauna such as pinnipeds and elasmobranchs.

Some large marine mammals form part of a fairly simple food web — Phytoplankton — zooplankton (krill) — baleen whales. Toothed whales form the summit of a longer chain: phytoplankton — zooplankton — fish — squid — sperm whale. These are simplified chains but indicate the services that whales provide in cycling nutrients in the ocean. Marine mammals provide an economic and recreational service in providing pleasure to tourists. The tourism industry in some towns is based on whale watching or diving in cages with great white sharks.

Using the unit benefit transfer technique[18] using a meta-analysis of 582 data points, Eadie and Hoisington (2011) estimated the value of six ecosystem services of the Australian marine environment to the Australian economy. Results of this analysis are provided below, to give an indication of the value society places on the ecosystem services provided by the marine habitats listed below. It should be noted that these figures are total value estimates, and do not represent the marginal values (benefits) of protecting these habitats from degradation, and therefore cannot be transferred directly into a CBA.

Table 6–1 Australian marine ecosystem values (A$/hectare)

	Open Ocean	**Coastal systems**	**Coral reefs**	**Seagrass**
Fresh water supply	0.1	2	5	5
Raw materials		4	1	4
Biological control	4			
Lifecycle maintenance (esp. nursery			134	183
Cultural services		9	9	9
Total	**14**	**42**	**227**	**280**

Source: Eadie and Hoisington (2011).

18 Unit benefit transfer allows the value of ecosystem services to be estimated by multiplying a unit value ($/hectare/year) by the number of hectares of each type of ecosystem. It is frequently used when time and cost prevent detailed ecological and economic studies being undertaken for the specific ecosystems being studied. Instead, it draws on a body of existing studies for similar ecosystems to estimate the value per hectare.

6.2 Analytical Results

6.2.1 Cost benefit analysis

The results of the cost benefit analysis have been expressed in terms of net present value (NPV). The NPV is a measure of the aggregate, annual net benefits (i.e. benefits minus costs) of an option over a 20 year period, discounted (i.e. expressed as a present value[19]) using a discount rate of 6 per cent.[20]

- The net present value for implementing the 19 marine parks with zoning was estimated to be approximately -$63.9 million. This indicates that the investment in marine park management plans would generate lower net benefits to the community than the base case scenario.
- The principal drivers of the estimated negative economic outcome is the net annual cost of implementation (present value of -$26.2 million) as well as the losses incurred by the commercial fishing industry (-$37.7 million).

The anticipated non-market benefits associated with the protection of marine habitat (resulting from the marine park zoning of the sort described in Section 7.1) have not been valued in the analysis, and the negative outcome can be interpreted as a threshold value. There is an ongoing opportunity cost associated with the establishment and implementation of the zoned marine parks, estimated to have a present value of around $64 million. In the context of the decision regarding marine habitat protection, these opportunity costs can be viewed as the value that the benefits of protecting the marine habitat must exceed for it to be in the best interests of the community overall for the sanctuary zones to be excluded from commercial and recreational fishing and other activities. In terms of a decision rule, only if the benefits of marine habitat protection exceed this “threshold” of opportunity costs should the marine areas be reserved.

To put this in context, in the first year of implementation of the management plans the opportunity cost equates to approximately $7 per household in South Australia[21]. Because there is some uncertainty regarding the value of a number of key variables it was prudent to extend the analysis to test the sensitivity of the results to changes in some of the key, uncertain variables.

6.2.2 Sensitivity analysis

The results of the economic analysis were re-estimated using values for key variables that reflect the uncertainty of those variables. The sensitivity analyses included changes in the following:

- discount rate;
- operating and maintenance costs; and

19 The present value is the value now of a sum of money arising in the future. Money now is worth more than money in the future because it could be invested now to produce a greater sum in the future. The present value of money in the future is calculated by discounting it at a rate of interest equivalent to the rate at which it could be invested (Bannock et al. 1979). A discount rate of 6 per cent was used in this economic analysis.

20 For more detailed explanation of each criterion and the method of analysis see Section 5.

21 Based on a Year 1 cost of $5.1 million and 685,699 households. The number of households is derived from the most recently available ABS data on average household size and population for SA.

- impact on the commercial fishing industry.

The range of values used for each uncertain variable and detailed results of the sensitivity analysis is set out in Table 6–2. Note that the sensitivity analysis was undertaken by assuming that all other variables were held constant at their ‘expected’ values.

Table 6–2 CBA sensitivity analysis

	Sensitivity Value		
	Low	Expected	High
Discount Rate:			
Value	4%	6%	8%
NPV ($m)	-76.6	-63.9	-54.2
Management Costs:			
Real rate of increase/an	0.0%	2.5%	5.0%
NPV ($m)	-60.4	-63.9	-68.4
Commercial Fisheries Catch:			
Change on SARDI estimates	-50%	0%	50%
NPV ($m)	-45.1	-63.9	-82.8

The results are quite sensitive to the discount rate, with a lower discount rate (4.0 per cent) giving a larger NPV (in absolute terms), i.e. -$76.6m. The result is relatively sensitive because there are no significant “up front” costs, where both the negative impact on fishing profits and the costs of management are assumed to be relatively steady over time, the latter increasing at a real rate of 2.5 per cent per annum.

Indeed, the sensitivity of the results to the assumed rate of increase of management costs was tested in the second part of the analysis. Under the “expected” value, the real rate of increase in management costs is 2.5 per cent per annum from year 5 with an addition 25 per cent increase in years 10 and 20. Under the “low” value both the annual and the 10-yearly increases are assumed to be zero, which gave an NPV of -$60.4m. Under the “high” rate of increase (5.0 per cent per year) but with no change to the 10 yearly increases, the NPV was calculated to be -$68.4m.

The final broad variable tested in the sensitivity analysis concerned the SARDI estimates of the impact that zoning would have on the catch levels in the commercial fisheries. Assuming the impact on displaced effort in sanctuary zones was 50 per cent greater than SARDI estimated, the NPV would be -$82.8m, other things held equal. If the impact on displaced catch and effort was 50 per cent less than SARDI estimated, the NPV would be -$45.1m.

Estimates provided by individual commercial fishing associations (which have not yet been reviewed by SARDI) suggest that the average annual displaced catch (excluding the sardine and prawn fisheries) would be approximately double that estimated by SARDI. The SARDI analysis indicates an estimated average annual displaced catch of approximately 195 tonnes (excluding sardines and prawns) with a gross value of $5.2m (Table 4–1). Industry derived estimates indicate a displaced catch of 376 tonnes (excluding sardines and prawns), valued at $8.6m. Applying the industry-derived data in the cost benefit analysis yields an expected NPV of -$87.5m.

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Appendix 1 Ecological Assessment Approach

A1.1.1 Process of assessment

The process of ecological assessment undertaken for the current report can essentially be summarised by three main steps:

1. Activities and uses: determining the range of activities and uses that potentially impact on the marine environment under current management regimes, and then determining how the marine park zoning and management arrangements will influence them.
2. Baseline: determining the current status of the marine species, habitats, and ecosystems in the marine parks; what are we comparing future changes against?
3. Predictions: assessing the implications of the marine park zoning and management arrangements in 5, 10 and 20 years on species, habitats, and ecosystems against the case of no marine park zoning and management arrangements.

This required an assessment of:

- Current management of the marine environment
- Activities that impact on the marine environment (Table A1-1 provides a general summary of impacts on the SA marine environment and the activities that cause them).
- How the proposed zoning arrangements will influence the marine environment
- The scope for making predictions of species, habitats and ecosystems.

A1.1.2 Overview of existing (base-case) management

Other than the *Marine Parks Act 2007, c*urrent management of the marine environment occurs under a number of different Acts, including:

- *Aquaculture Act 2001*
- *Coast Protection Act 1972*
- *Development Act 1993*
- *Environment Protection Act 1993*
- *Fisheries Management Act 2007*
- *Harbors and Navigation Act 1993*
- *Historic Shipwrecks Act 1981*
- *Mining Act 1971*
- *National Parks and Wildlife Act 1972*
- *Natural Resources Management Act 2004*

- *Offshore Minerals Act 2000*
- *Petroleum and Geothermal Energy Act 2000*
- *Petroleum (Submerged Lands) Act 1982*

Without any zoning, a park under the *Marine Parks Act 2007* nevertheless serves to ensure that decisions about activities administered under the above Acts (except the *National Parks and Wildlife Act 1972*) have regard to, or seek to further the objects of, marine parks and undertake appropriate consultation with the Minister responsible for marine parks.

Ballast water, biofouling and marine pest risks presented by international vessels are managed in accordance with the Australian ballast water management requirements. Pollution risks presented by international vessels are managed by the International Convention for the Prevention of Pollution from Ships (MARPOL). Ballast water, biofouling, marine pests and pollution risks by domestic vessels are managed through the *Code of Practice for vessel and facility management (marine and inland waters*) issued by the Environment Protection Authority.

Management aspirations under these Acts and other mechanisms are consistent with the ecologically sustainable development (ESD) as defined in the *Marine Parks Act 2007*, i.e. the use, protection, conservation, development and enhancement of the marine environment in a way, and at a rate, that will enable people and communities to provide for their economic, social and physical well-being and for their health and safety while: sustaining the potential of the marine environment to meet the reasonably foreseeable needs of future generations; safeguarding the life-supporting capacities and processes of the marine environment; and avoiding, remedying or mitigating any adverse effects of activities on the marine environment.

Under this framework the marine environment is managed in a state that is quite different from a pre-European settlement environment—partly through management failure, e.g. reef and seagrass degradation on the metropolitan coast (Connell et al. 2008, Shepherd et al., 2008); collapse of the native oyster fishery (Wallace-Carter, 1987), but partly by design. For example, fisheries classed as sustainable (“fully fished”) will fish stocks down to a fraction of their un-fished biomass (Haddon, 2007). This does not necessarily reflect poorly on fisheries management. Fisheries are managed in accordance with the principles of ESD aiming to maintain populations at a sustainable level while providing significant social and economic benefits to the community. Similarly, small-scale changes to coastal processes and habitats have been considered as acceptable trade-offs for the social and economic benefits gained from wastewater outfalls, boat ramps, marinas and other infrastructure. In summary, while management for sustainability within individual sectors reduces threats it does not remove them or consider their cumulative effects (DENR, 2010).

In South Australia, most areas away from population and/or industry centres are considered to be in a relatively good state, but nowhere is ‘pristine’, in the sense of being ‘untouched’ since European settlement. The pre-European state is not, however, well understood, and there is a ‘sliding baseline’ whereby successive human generations may not notice the full cumulative extent of decline (Dayton et al. 1998).

The capacity of South Australia’s marine ecosystems to withstand the cumulative impacts of a variety of human activities is also generally not well understood. DENR (formerly the Department of Environment and Heritage) initiated a marine planning program and produced a Draft Marine Plan to guide development in Spencer Gulf (DEH 2006), but this project has not been pursued further. The Environment Institute at

Adelaide University has recently initiated a scoping study of the carrying capacity of Spencer Gulf (Professor Mike Young, pers. comm. 6 July 2011), but this project represents only a first step in understanding the carrying capacity of the SA marine environment.

The current, modified environment may in many respects be acceptable to the majority of the community, and certain further modifications may similarly be regarded as acceptable. However, observations of significant decline in some marine species in some areas has led to the conclusion that Australia's marine biodiversity and ecosystems are in a state of continuing decline (NRM Ministerial Council, 2008). There are some areas protected primarily for biodiversity conservation, and others which provide some conservation benefit. Although activity restrictions are enforced as part of an overall fisheries compliance program, most protected areas do not have management plans. An exception is the Great Australian Bight Marine Park, and a management plan is being developed for the Pelican Lagoon Aquatic Reserve. Even without management plans, the new marine parks (with outer boundaries already declared) serve some conservation function through links with other Acts.

Apart from the existing protected areas, the existing management regimes are in many cases able to restrict specific harmful activity in the same way that zoning does—but, because of competing management objectives this does not always occur. For example, construction of a marina has significantly modified a mangrove/saltmarsh dominated tidal creek system at Tumby Bay (Minister for Transport and Urban Planning, 1998).

Furthermore, there are limited resources to meet aspirational targets for management on a statewide scale, e.g. aims for zero discharge by 2015 (Cheshire 2006), or coastal rehabilitation by NRM Boards to reduce sedimentation and run-off.

Ecosystem-based management is still an emerging paradigm, with particular advances made in the area of fisheries but there is further progress still required. Fisheries in South Australia are generally regarded to be 'sustainable', and the 'overfished' status of some fisheries (PIRSA 2006) refers more to reduced economic return rather than any possibility of extinction. However, the concept of 'ecological overfishing', whereby species may no longer fulfill their ecological function (Estes et al. 1989), is not addressed by these status reports. All South Australian export fisheries have now undergone assessments of their ecological sustainability under the *EPBC Act 1999*. These assessments take into account the status of target stocks, and the bycatch, ecologically related species, and the ecosystem more generally, broadening the scope of fisheries management. Although all fisheries have been accredited through this process, the assessment reports have recommended further research to properly assess and ensure the long-term ecological sustainability of the fisheries.

A1.1.3 Range of activities that impact on the marine environment

The marine park network has not been proclaimed in response to threats and the aim of the parks design was that comprehensive, adequate and representative examples of habitats would incorporate where possible natural (minimally disturbed) areas, i.e. those that are least subjected to human change (DEH 2009).

Management of these areas, once designed, has a greater focus on managing threats. marine parks have an important role to play in protecting those areas that are still in the most natural condition (where threats and pressures are minimal), but they also integrate and improve marine management in those areas where threats to the marine environment are more apparent (DENR 2010). The current impact study is required to assess the range of activities that impact on the environment and discuss how the draft management plans will influence the marine environment.

The range of activities that impact on the marine environment has been well documented, globally, nationally, e.g. Marine Biodiversity Decline Working Group 2008, and locally, e.g. Brown 2001; Bryars 2003; Baker 2004; EPA 2003, 2008; Shepherd et al. 2008. Table A1-1 provides a generic classification of impacts on the marine environment and examples of activities that can potentially result in such impacts. This summary provides a basis for discussing how the draft management plans will influence the marine environment on an overall network basis. A more detailed summary of the potential impacts is provided for each Marine Park Impact Statement, using the following information sources:

- State of the Marine Environment Report (EPA 2008);
- reef health reports (Turner et al. 2007, Collings et al. 2008);
- historical catch and effort estimates for marine park zones (Currie and Ward, 2011; Ward and Burch, 2012);
- fisheries stock assessment reports;
- the 2008-09 recreational fishing survey (Jones 2009);
- the threat analysis of SA's fisheries habitats (Bryars 2003); and
- information provided by the Marine Parks Scientific Working Group

Table A1-1 Generic classification of impacts on the SA marine environment

Generic impact	Examples of uses/activities
Extraction of living resources	Fishing activities, water (plankton) extraction (cooling water, desalination), aquaculture (filter feeding)
Modification of fauna behaviour	Berleying, mammal interactions (including noise), provisioning (trawler bycatch discards)
Pollution of water/sediments	Industrial discharges, wastewater, stormwater, coastal and catchment land use, e.g. agriculture by-products, sediment, stormwater, aquaculture, oil spills
Modification or destruction of habitat	Coastal engineering, e.g. marinas, pipelines, dredging, trawling, mining
Introduction of pest species and diseases	Shipping (ballast water and hull fouling), recreational fishing and boating (hull and equipment fouling), imported products, aquaculture
Climate change	A broad range of activities (mainly land-based) that result in the generation of greenhouse gases, acidification, temperature change, sea level rise

A1.1.4 Proposed zoning/management arrangements and implications for the environment

The SA Government has recognised that there is currently insufficient protection for our marine habitats, plants and animals from the increasing pressures from population growth, competition for resources and environmental challenges including climate change (DENR, 2010). The Government has declared a system of marine parks and has provided a proposed zoning plan based on the zones described in Figure 1-1 of the Main Document. The activities and uses that are deemed compatible or incompatible with the various zones are provided in Appendix 7.

Zoning and complementary management arrangements can potentially influence the marine environment within the managed area by:

- removing or limiting existing pressures;
- preventing or limiting future pressures;
- building resilience to some pressures by limiting the influence of others;
- highlighting areas of conservation value to inform impact assessment and focus management resources

A key consideration for assessing the impact of the zoning is that the proposed zones are located, primarily by design, to avoid many of the existing uses that would be prevented within the zones. One aspect of this is the inclusion of a number of existing Aquatic Reserves and other closed areas within RAZs and SZs. Only RAZ-1 in the West Coast Bays Marine Park will result in increased restriction in marine waters, with the prevention of access by abalone fishers that is currently allowed, under permit, within the Nicolas Baudin Island Conservation Park (DEH, 2006; DENR pers. comm. 22 May 2012). Ten of the 85 SZs include all or part of existing Aquatic Reserves, although they extend considerably beyond the Aquatic Reserve in four of them and add restrictions for certain gear types in three of them.

Current uses that will be affected include:

- fishing, which occurs in one form or another in most parts of the State's waters, with the exception of areas that are unsuitable for fishing or areas that already exclude all or some fishing activity;
- motorised water sports, which are currently limited to areas 200 m offshore;
- discharge of wastewater from motor vessels, which can occur outside of buffers around aquaculture, marinas, harbours and/or people
- feeding and berleying for animals (the latter has restrictions within 2 nautical miles offshore) ;
- camping, fires and motor vehicle use outside designated areas (not considered further in the current impact assessment).
- domestic animals outside designated areas

In the case of fisheries, studies have been undertaken to assess the impact of fishing effort that would be displaced from the proposed zones. The Department of Primary Industries and Resources SA (PIRSA) contracted the South Australian Research and Development Institute (SARDI) to assess the displaced commercial fishing effort that would result from the draft zoning plans (Ward and Burch, 2012). Further advice, based on earlier zoning proposals but nonetheless relevant, was sought by PIRSA from a panel of experts (Stevens et al., 2011a, 2011b). It is the position of PIRSA (2011) that effort (or more directly, catch, in quota managed fisheries) should be reduced in most fisheries to offset any negative impacts that may arise from the redistribution of effort from SZs (or HPZs in the case of trawling and some miscellaneous fisheries). This could potentially have implications for fished species that are too mobile to gain effective protection from SZs that span only part of their range, but may respond to an overall reduction of effort in the fishery; with potential flow-on effects on ecosystems.

In addition to current uses, the proposed zoning can influence potentially harmful uses, e.g. land-based discharges, dredging, aquaculture, and mining that do not currently occur inside zones, but which could potentially occur in the future. Many such activities, while currently managed in other areas according to the principles of ESD, have been deemed incompatible within RAZs, SZs and/or HPZs.

Importantly, the proposed zoning could reduce the cumulative impact of multiple existing and future pressures, and/or improve resilience to those pressures not directly addressed by zoning. For example, Ling et al. (2009) showed that commercial fishing of large predatory lobsters reduced the resilience of Tasmanian kelp beds against the climate-driven threat of the sea urchin and thus increased the risk of catastrophic shift to widespread sea urchin barrens. Baden et al. (2012) found that human-induced eutrophication in conjunction with overfishing has recently been linked with seagrass losses in Sweden. These examples also serve to illustrate how zoning (in particular RAZs and SZs) can provide reference areas against which the status of outside areas can be assessed (Buxton et al., 2006; Edgar et al., 2007).

There are inherent limitations in the effectiveness of zoning due to the high level of connectivity of the marine environment and the impact of human activity over spatial scales greater than the extent of individual zones. For example: mobile species will interact with fisheries outside the zones; pollution can drift into zones; and despite the increased resilience discussed above, zoning has limited influence on broader-scale impacts including climate change (sea level rise, ocean acidification, global warming) and invasive pests.

Complementary measures are required to more adequately address these issues, and are to some extent already in place with the existing management regime. Additional measures to mitigate some threats may potentially be prescribed in the management plans for the marine parks. For example, measures for responding to an oil spill, establishing mooring buoys or reducing coastal erosion may be implemented, and perhaps be preferentially assigned to areas of high conservation significance (e.g. RAZs, SZs). Furthermore, monitoring programs within parks could improve the detection of invasive species. The present impact study, however, was only able to consider the zoning plan because the full management plan for each park was not available.

A further issue for the present study is the use of special purpose areas (SPAs) which allow specified activities that would otherwise be prohibited or restricted as a consequence of the zoning of the area, to be permitted under the terms of the management plan. Although a number of proposed SPAs have been provided for the present study, the details of permitted activities (that would be specified in the management plans) were not available.

The proposed management measures being assessed by the present study will therefore comprise a zoning plan (but not full management plan), and reductions in fishing effort in most fisheries (hereafter referred to as the ‘zoning plan and effort reductions’).

A1.1.5 Scope for predicting habitat, species and ecosystem responses inside SAs system of marine parks

Much has been written about the potential and real environmental impacts of marine parks (see Nursey-Bray 2011, for a review; Edgar 2011). Real impacts have been determined from monitoring programs around the world, some of which have continued for a decade or more (e.g. Barrett et al. 2007, Russ and Alcala 2010). Other potential impacts that have not necessarily been realised are also cited in the literature and sometimes accompanied by conceptual ecological models (e.g. Yemane et al. 2008, Lozano-Montes et al. 2011).

Responses of marine systems to changes in use through zoning may take many decades to manifest (e.g. Shears and Babcock 2003; Edgar et al., 2009; Babcock et al. 2010). Such delayed responses have occurred in marine parks in New Zealand and Tasmania in temperate ecosystems that are comparable with those of SA. Thus predictions of environmental change following 5, 10 and 20 years (as requested by DEWNR for the current impact assessment) are justified in the case of SA's marine parks. It may well be that changes continue to occur well beyond 20 years.

Predicting environmental changes inside marine parks is inherently complex and therefore difficult. In the few instances where it has been attempted, the actual changes have often been different to the predictions (e.g. Langlois and Ballantine, 2005; Molloy et al., 2009). Nonetheless, attempting to predict changes is still a useful exercise as it informs environmental, economic and social impact assessments of proposed zoning and management scenarios, and it also informs any environmental monitoring and evaluation programs following implementation of the zoning and management plan. Ecological changes inside no-take marine parks can occur through four orders: first order—a species responds to protection and increases in abundance, e.g. lobster; second order—another species is affected by the first order change and decreases in abundance, e.g. urchins are preyed upon by lobsters and decrease in abundance; third order—the second order change results in a change to a habitat-forming species, e.g. with less grazing pressure from a decreased abundance of urchins, the cover of canopy-forming macroalgae increases; and finally fourth order—the third order habitat change results in a change in the abundance of species that use the habitat that has been affecte,d e.g. increased abundance of invertebrates that rely on canopy-forming macroalgae for shelter.

In the case of marine habitats, there are many documented cases of habitat loss and degradation around the State, mostly adjacent to land-based influences from major population centres or industrial areas (Shepherd et al., 1989; Harbison and Wiltshire, 1993; Bryars, 2003, Bryars et al., 2003; Connell et al., 2008; Shepherd et al., 2008). In addition, habitat and/or community changes due to benthic trawling have also been documented in South Australia. Tanner (2005) found a 36 per cent reduction in the number of large epifaunal organisms during experimental trawling in Gulf St Vincent. In Spencer Gulf, Svane et al. (2009) concluded that prawn trawling had a strong influence on the structure of the benthic habitats. Although Currie et al. (2011) suggested that putative trawl-related differences in community structure (comprising mainly fish and mobile invertebrates) were small compared to those associated with environmental gradients, they did find that sessile invertebrates such as sponges and bryozoans were significantly less prevalent on the more heavily trawled areas.

Many of the SZs and HPZs within the 19 marine parks are relatively isolated from land-based influences and were actually selected because they were considered to be in 'good' condition (DEH, 2009). Given this situation, it was not anticipated that major changes would generally occur in habitats following protection, e.g. recovery of a previously degraded habitat, but rather that SZs and HPZs would act to protect already healthy habitats from future harmful uses. Nonetheless, there are still some locations where recovery or changes may occur, and there may also be trophic interactions that result in habitat changes, i.e., third order interactions—see Section A1.4 below.

Predicting the future protection that would be provided by the zoning and management arrangements relative to the base case (existing management) is problematic because it is not possible to predict the full range of future activities and uses and how the available management tools may be used to respond to related environmental issues within an ESD context. Nevertheless, there are key messages to be learned from what has happened in the past and what is likely to occur in the future:

The past:

- Coastal degradation and pollution;
- Habitat loss;
- Over-fishing of some species;
- Shifts in targeted species ('fishing down the food chain'); e.g. human consumption of pipi and mud cockle;
- Introduced pests such as *Caulerpa taxifolia* that threaten fish breeding and feeding grounds, and the Mediterranean fan worm *Sabella spallanzanii* which has become established on some reefs.

The future:

- SA's population will continue to increase with a possible increase in recreational fishing and boat use;
- Trend towards living on the coast may continue;
- Industrial expansion and shipping on the coast will continue, with current proposals including desalination plants at Point Lowly and elsewhere, a barge landing facility near Port Augusta, port facilities at Port Bonython and Sheep Hill, and wave energy proposals;
- Different species may become the focus of targeted fishing as other species become fully-fished or over-fished. It is expected that fishing technology will continue to improve and enable fish to be caught more efficiently, but may also continue to provide ways to mitigate environmental impacts of fishing, e.g. bycatch reduction devices.

A1.1.6 A pre-European baseline

To enable meaningful predictions following zoning and management arrangements, it is necessary to assess the current status of habitats, species and ecosystems in relation to some form of baseline. While marine ecosystems are naturally dynamic, it is generally acknowledged that, since European settlement of SA, there have been 'unnatural' changes to some components of these ecosystems. Cases of habitat degradation and over-fishing are well documented (e.g. Fairweather, 1990; Shepherd et al., 2008). Even for fisheries that are managed according to the principles of ESD, it is well accepted (and indeed a part of fisheries management) that extraction of a species will keep its biomass below a level that would occur more naturally without fishing (see Haddon 2007). Similarly, even trawling, aquaculture and development in general which are managed according to the principles of ESD will result in some modification to the marine environment. The end result of human-mediated changes to the marine environment is that the current status of the habitats, species, or ecosystems may indeed be different to that when European settlement occurred, i.e., the baseline has shifted. The concept of shifting or sliding baselines in the marine environment is well-accepted (Osenberg et al., 1994; Dayton et al., 1998; Underwood, 2000; Lotze and Worm, 2008; Connell et al., 2008). Therefore, we considered it most appropriate to assess the current status of the marine parks relative to a pre-European baseline. This is not intended to cast any aspersions on management of the broader South Australian marine environment according to ESD principles. Furthermore, a recovery to a pre-European condition is not an objective of the *Marine Parks Act 2007*. A pre-European baseline is being used only as a conceptual, qualitative baseline against which to predict future changes. Nonetheless, it is considered by the authors that shifts towards a pre-European state within marine park ecosystems would be of conservation benefit.

The exact date of the pre-European baseline will vary depending on the focus of the assessment. Different components can be assessed as being at an unnaturally low level (UNLL), a natural level (NL) or an unnaturally high level (UNHL) in relation to when impacts from Europeans first commenced. For some habitats the baseline may be when a land-based discharge started damaging the habitat (see Section A1.2.4). For some threatened species the impacts of Europeans occurred around the time of first settlement when unsustainable practices, such as whaling, occurred. For some fished species it will be when significant levels of European fishing commenced (see Section A1.3.4). As natural variability is inherent in marine ecosystems, such variability is also implicit in the assignment of current status.

A1.2 Habitats

Habitats may be affected by the proposed zoning in three ways:

1. from protection of current harmful uses within RAZs, SZs and HPZs;
2. from protection of future harmful uses within zones; and
3. from potential third order trophic interactions as a result of species changes in RAZs, SZs and HPZs.

A1.2.1 Habitats assessed

Assignment of habitat types is an arbitrary process that can be tailored to suit the needs of a task. Given the scope requested by DEWNR to assess habitats and that the DEWNR mapping has numerous (>30) different habitat types, there was a need to rationalize to a number of habitats that could realistically be assessed. Given the locations of the marine parks, knowledge of previous habitat degradation and threats, and the types of species-habitat (ecosystem) responses seen in other marine parks elsewhere, 10 benthic and one pelagic habitat types were used:

- saltmarsh
- mangrove
- intertidal sand flat
- subtidal sand

- intertidal seagrass flat
- subtidal seagrass
- intertidal reef
- subtidal high profile reef
- subtidal low profile reef
- beach
- pelagic

Each of the habitat types (except for pelagic) is essentially defined by the substrate type (soft or hard), the dominant cover of biota (various plant groups or no obvious cover), and the depth (intertidal or subtidal). The beach category is somewhat different as it is defined more by the gradient of the shoreline such that it is separated from intertidal sand flat. The pelagic habitat type is clearly different from the others and it can be argued that the pelagic zone is an integral part of each of the 10 benthic habitats (which it is). So we have used the pelagic habitat category for cases where a proposed zone is far offshore in deep (>50 m) oceanic water where the benthos is unmapped and where organisms that live there have generally escaped consideration in other habitats. The relationship between the habitat classification used by DEWNR for assessing comprehensiveness and representativeness within parks and the classification adopted for the impact assessment can be found in Appendix 4, along with detailed descriptions of each of the classified habitats.

When the plants and animals associated with each of the habitats are considered, they can also be treated as discrete ecosystems (see Section A1.4).

Assessments related to habitats, species and ecosystems are dependant on the precision (scale), accuracy and completeness of the habitat maps available for SA. As only about one-third of SA waters have been mapped, to the scale required for this, there are a number of zones for which only a partial assessment was possible, or for which assumptions had to be made. This was exacerbated for zones with offshore islands, which also generally do not have shoreline habitat data available. Furthermore, it was necessary to assume that habitat polygons, often mapped at a broad scale, represented continuous habitat. In the case of reef, distinctions were not always made between high profile and relatively flat reef; in these cases it was assumed to be the former.

A1.2.2 Habitat-use interactions

Human activities that are potentially damaging to the 11 habitat categories are generally well-understood and documented (Bryars, 2003; and see Appendix 4). This information was used to determine the most threatening processes to habitats on a large-scale, i.e., coastal pollution, coastal development, benthic trawling, and to inform the broad assessment of current status of habitats within marine parks. Small-scale threats and changes to habitats that have occurred adjacent to populated areas were generally not documented.

A1.2.3 Assessment of current status of habitats

Assessing the status of habitats is a non-trivial task and depends on how the habitat is defined. Some assessments such as Reef Health (Turner et al., 2007) have attempted to assess a range of components of subtidal reefs in SA including fishes, invertebrates, and canopy-forming macroalgae. As an attempt was made to assess species separately in the current assessment (see Section A1.3 later), it was decided to assess for changes in the levels of area (spatial area) and cover (cover of habitat-forming, foundation or dominant species; subtidal seagrass bed = seagrasses, subtidal high profile reef = canopy-forming macroalgae, subtidal sand plain = sessile benthic organisms) of habitats since European settlement.

As there are relatively few investigations of the condition of benthic habitats across SA, it was assumed that there was a NL of area and cover in a marine park unless it could be demonstrated otherwise by specific investigations or that the area had experienced benthic trawling in the past. The (good) reality in SA is that nearshore habitats appear (superficially at least) to be in a non-degraded condition, except for specific locations adjacent to human settlements, adjacent to land-based discharges, and in areas where destructive practices have occurred, e.g., coastal developments, land reclamation, prawn trawling, and mining for seagrass fibre; see Appendix 4 for discussions on specific threats to habitats.

In the case of potential habitat impacts from prawn trawling, a weight-of-evidence approach was used to identify potential zones that may have been trawled and/or the intensity of that trawling, using the following information:

- displaced catch estimates for the proposed SZs and HPZs (Ward and Burch, 2012) and earlier proposals (Currie and Ward, 2011). There is some uncertainty associated with these estimates, partly because they were based on a relatively small amount of data (Stevens et al., 2011a) but they are considered to be reliable for confirming that at least some trawling had occurred in a zone.
- other reports on prawn trawling effort, e.g., by Currie et al. (2009)
- an overlay of SZs and HPZs in the park with designated prawn trawl reporting blocks. This approach is not reliable for confirming that trawling occurs, but if a reporting block did not partially overlay a zone, then it was considered safe to assume that trawling had never occurred.
- depth and habitat spatial information. Trawling was assumed not to occur within zones that were shallower than 10 m as prawn trawling is not permitted in these depths, nor within zones that were predominantly reef as trawling typically does not occur over this habitat type.
- local knowledge.

Nonetheless, a high degree of uncertainty still remained with these assessments due to lack of available fine-scale spatial data about previously trawled areas.

A1.2.4 Predictions of recovery in degraded habitats

Predictions of recovery were made for two situations: (1) areas inside SZs and HPZs that had potentially been trawled by the prawn fishery, and (2) areas where habitat degradation due to other activities has been well documented. The latter situation included cases of degradation where the zoning and management arrangements will not necessarily help with the recovery of the habitat, but it was decided that it would be useful to highlight one of the limitations of the marine parks. During the planning process it was often suggested that marine parks should be placed in degraded areas such as off Adelaide, but the reality is that a marine park will not directly address the threatening processes in these areas and recovery of degraded marine habitats is a slow and sometimes irreversible process (e.g. Hamdorf and Kirkman, 1995; Kirkman, 1997; Bryars and Neverauskas, 2004). Marine parks are far better placed in areas with healthy habitats.

Predictions of change in area and cover of habitats used the same response model as described for species later (see Section A1.3.9).

A1.2.5 Predictions of third order habitat effects

It was beyond the capacity of the current assessment to make predictions about third order ecological interactions that may influence the cover of habitat-forming species such as macroalgae and seagrass. Nonetheless, some examples of possible scenarios are highlighted in the habitat profiles (see Appendix 4) and the Ecosystem section below (Section A1.4).

A1.2.6 Protection of habitats from future harmful uses

The threats to each of the habitat types defined above are discussed in Appendix 4 (Habitat Profiles). The *Marine Parks Act 2007* will influence future activity in all zones and the zoning plan will afford additional protection from specific activities within HPZs, SZs and RAZs, with respectively increasing protection across this hierarchy of zone types. The activities and uses that are deemed compatible or incompatible with the various zones are provided in Appendix 7.

Habitats that are afforded additional protection through zoning are more likely to be maintained in sufficiently good condition to continue delivering a range of ecosystem services and other benefits discussed in Appendices 4 (habitat-specific information) and 5 (consolidated discussion). Habitat-specific notes that clarify certain aspects of how protection will provide such benefits are provided below. Some of the 11 habitats defined above have been combined for ease of assessment. Restrictions in a zone type, e.g. HPZ, also apply implicitly to zone types with higher protection (in this case, SZs and RAZs), but are not mentioned below if in practice there are unlikely to be examples in these zones.

The overlay of special purpose areas overrides the protection provided by zoning restrictions for activities and uses broadly defined in Appendix 7. The assessment of future protection that would be provided by zones highlights the uncertainty associated with any of the proposed special purpose areas, with the exception of those that overlay GMUZs or a very small proportion (<1 per cent) of HPZs.

Saltmarsh and mangroves

Saltmarsh and mangroves would be protected from direct physical disturbance as well as changes to hydrology, particularly reduced inundation by seawater, by restrictions on infrastructure development, e.g., marinas, jetties, pontoons and breakwaters, in SZs. Protection from direct physical disturbance and impacts on hydrology by vehicle tyre marks would also be provided in RAZs, and outside designated tracks in SZs. Additional protection from land- and sea-based point sources of nutrients would occur within SZs, and RAZs will provide additional protection from incidental releases of hydrocarbons (which mangroves are sensitive to) from vessels.

Sand

Subtidal sand and intertidal sand and mud flats would be protected from direct physical disturbance by infrastructure development or mining in SZs, and by dredging or the deposition of dredge material in SZs, and HPZs outside existing harbours. Protection of sand from dredging is likely to reduce impacts on other habitats that could potentially arise from the wider dispersion of sediment plumes. Filter feeding invertebrates in sand communities would receive additional protection from smothering in areas where dredged material is not dumped. Protection from vehicles would also be provided in RAZs, and outside designated tracks in SZs, reducing the potential for compaction of sand and disturbance of infauna and microphytobenthos which are important components of the food chain. Trawling is managed state-wide according to ESD principles but does damage or remove habitat forming biota from the seafloor in the areas where it occurs. Subtidal sand habitats would be protected from trawler damage within HPZs and SZs. Additional protection of the sediments and infauna from land- and sea-based point sources of nutrients would occur within SZs.

Seagrass

Seagrass would be protected from direct physical disturbance by infrastructure development, aquaculture cages or mining in SZs, and intertidal seagrass would be protected from bait digging within SZs and RAZs. The absence of marinas and boat ramps within SZs would potentially also reduce damage to shallow or intertidal seagrasses by boat propellers. Seagrass would also have additional protection within SZs from reduced water quality (nutrient levels and turbidity). This in turn would reduce the likelihood of erosion of seagrass beds disturbed at their deeper edge through light reduction and at their shallower edge through excess epiphyte growth in response to elevated nutrients.

By protecting seagrass beds through zoning the natural processes for decline and recovery are allowed to progress. Without human disturbance, seagrass beds are sometimes torn out by unusually intense storms and have a recovery rate of decades. The intense storms may occur once in a hundred years and a dynamic equilibrium is established. However, human disturbances are occurring more often than these intense storms and seagrass cannot recover with the more frequent disturbances. Climate change may bring more intense and more frequent storms that will increase the pressure on this natural equilibrium.

Reef

Reef would be protected from direct physical disturbance by infrastructure development, mining and the dumping of dredge spoil in SZs (and in the latter case outside harbours in HPZs), and intertidal reef would be protected from trampling within RAZs. Reefs would also have additional protection within SZs from reduced water quality (nutrient levels and turbidity), that can affect their habitat forming macroalgal cover and favour less productive turf and mussel bed environments.

A1.3 Species

Species may be impacted by the proposed zoning plan in three ways: (1) protection from current harmful uses within RAZs, SZs and HPZs, (2) protection from future harmful uses within zones, and (3) ecological interactions. The following sections describe how each of these impacts was assessed.

Some of the more mobile species may also show a response within and/or outside zones due to the proposed overall reduction of commercial and charter fishing effort, as per the PIRSA (2011) policy position on redistribution of displaced commercial fishing effort. While it was assumed that the removal of this effort would minimise negative impacts on areas outside SZs, there is potential for the abundance of some fished species to decline outside SZs through displacement of recreational fishing effort, possibly offset to some extent by spill-over.

A1.3.1 Species assessed

The marine and estuarine waters of South Australia represent some of the most biologically diverse waters, with thousands of marine species. It was not possible to individually assess all of these species for the present study. Therefore, a suite of 205 representative species was chosen to include a range of taxonomic groups, trophic levels, key components of habitat-based ecosystems, representatives of different habitats, common and well-known species, commercial and recreational fishery species, iconic species, and threatened and protected species. The full species list formed the basis for the assessments of species, habitats and ecosystems.

An extensive literature search was conducted to document information on the following parameters for fished species: maximum age (years), maximum length (cm), site fidelity (classed as migrant, resident or temporary resident), predators, prey, and trophic level. For non-fished species, predators, prey, and trophic level only were documented. Maximum age, maximum length and site fidelity information was used in predictions for the fished species assessment component. Predators, prey, and trophic level were used to develop simplified conceptual food webs for the ecosystem assessment component. A database of information was subsequently created that drew on hundreds of literature sources.

A1.3.2 Species-use interactions

A number of activities that would be removed or restricted by zoning are not currently undertaken or are exempted according to the policy commitments (using special purpose areas). An assessment was made of the **current** uses that are known to impact marine biodiversity and which would be ceased within zones. This analysis revealed that a range of fishing activities were the main **current** uses that would be ceased within RAZs and SZs and which have potential for a major impact on biodiversity within these zones; some activities such as jet skis will also be ceased and these may have a minor influence on biodiversity conservation The main **current** activity that impacts biodiversity and which will be ceased within HPZs was benthic trawling. Thus a major component of the species assessment focussed specifically on fished species and (1) documenting the status of species within each park, and (2) making predictions on the response of fished species to protection from fishing.

Predicting species (and ecosystem) responses to protection from fishing is highly complex and, compared to other activities, there are generally more data available to inform the assessment. Consequently, the extent and depth of discussion on fishing-related responses may appear to be disproportionate in comparison to other activities, but this is not intended to place any particular emphasis on fishing as a threatening process.

Another important component of the species assessment focussed on threatened and protected species, and in particular, whether the management changes might affect the recovery of threatened species. A review of existing information was used to inform the current status of threatened and protected species, and a qualitative assessment was then made of threatening processes and whether the current status might be affected by the proposed zoning and management arrangements (see Species Profiles in Appendix 3).

Attempts were also made to qualitatively predict likely ecosystem interactions that might influence threatened, protected, fished, and non-fished species due to the proposed management arrangements (see Section A1.4 and Species Profiles of threatened and protected species in Appendix 3).

Future uses that are known to impact marine biodiversity, but which will be prevented or influenced by the change in management, were identified. The assessment of these future uses was qualitative only, focusing on the positive impact that the new management may have on the protection of habitats that support the component species and ecosystems (see Sections A1.3 and A1.4). It can only be a qualitative assessment as there is no way of reliably predicting what, where and when these future uses may occur, e.g., a proposal for a wastewater treatment plant outfall.

A1.3.3 Assessment of current status of species

The majority of species shown in Appendix 2 have not been assessed previously in any formal or recognised manner. Some species have a legislative conservation status (mainly birds and mammals), some fished species have a fishery status (assigned by PIRSA Fisheries), and many of the fishes have a conservation recommendation by Baker (2011). Population trend data are available for some species in some regions of the State, e.g., little penguin at Victor Harbor; Australian sea lion at Seal Bay, The Pages, and Dangerous Reef, while population estimates exist for other species across the State from separate time periods, e.g., white-bellied sea eagle. For the threatened species assessment, the current status usually applies in relation to a European-settlement baseline (see Appendix 3). For fished species a separate assessment of current status was made (see next section).

A1.3.4 Assessment of current status of fished species for use in response predictions

For all the target and byproduct species identified in Appendix 2, an attempt was made to gather the necessary information required to assess their current status and to enable predictions about responses to protection from fishing. Due to a combination of factors related to information limitations (limitations/restrictions with spatial and temporal catch and effort data/information, lack of life history information) and species life-histories (all migrant species were omitted), a short-list of 20 indicator species was used for further assessment (Table A1-2). Migrant species were omitted because they are unlikely to respond inside individual SZs (see Section A1.3.7 later). The response of migrant species will be dependent on a reduction in overall catch (from government buyback) and the cumulative protection of multiple SZs and parks. Descriptions of each of the 20 indicator species are given in Appendix 3. These 20 species comprise a mix of 13 high-value, high-production target species (many of which were assessed in the economic assessment of the current report) and seven non-target species that are intrinsically vulnerable to overfishing and/or are of conservation concern. The 20 species are also associated with a range of different habitat types and have different distributions such that at least one species could likely be assessed in each park. The giant Australian cuttlefish (northern Spencer Gulf population) is restricted to the Upper Spencer Gulf Marine Park and was therefore not considered in other parks.

In addition to the 20 indicator species, there is also a number of other species that would potentially respond to or benefit from protection in zones simply because they have interactions with fishing (see Appendix 2). While the impact of the interaction is largely unknown for most species, the point is that the interaction will be removed through protection of the zoning and is therefore considered as a positive benefit to those species. As an example, the southern blue devil is a long-lived (Saunders et al., 2010), site-attached reef fish (Bryars, 2010) that is incidentally caught as bycatch (e.g. Fowler et al., 2009) but which is susceptible to barotrauma (Saunders et al., 2010) and therefore may have a low rate of post-release survival. The southern blue devil will therefore benefit from protection inside SZs.

Table A1-2 Indicator fished species used for the assessment of current status and predictions of change within sanctuary zones (and habitat protection zones for western king prawn) of the proposed marine park network.

Common name	**Species name**
Bight redfish	*Centroberyx gerrardi*
Blacklip abalone	*Haliotis rubra*
Blue swimmer crab	*Portunus armatus*
Blue throat wrasse	*Notolabrus tetricus*
Giant cuttlefish (northern Spencer Gulf population)	*Sepia apama*
Greenlip abalone	*Haliotis laevigata*
Harlequin fish	*Othos dentex*
King George whiting	*Sillaginodes punctata*
Mud cockle	*Katelysia* spp.
Pipi (Goolwa cockle)	*Donax deltoides*
Razorfish	*Pinna bicolor*
Sea sweep	*Scorpis aequipinnis*
Snapper	*Pagrus auratus*
Southern calamary	*Sepioteuthis australis*
Southern garfish	*Hyporhamphus melanochir*
Southern rock lobster	*Jasus edwardsii*
Swallowtail	*Centroberyx lineatus*
Western blue groper	*Achoerodus gouldii*
Western king prawn	*Melicertus latisulcatus*
Yellowfin whiting	*Sillago schomburgkii*

Predictions of fished species responses cannot be made without having an historical baseline against which to compare change, as the magnitude and direction of the response will be influenced by the prior level of fishing (see Table A1-3). If the current population level is used as the baseline, and the historical level is ignored or unknown, then it is not possible to predict into the future if a species will increase, decrease, or remain at the same level. The notion of using the population level at the time of European settlement as the historical baseline is problematic for fished species because (1) we can never know what the baseline really was, (2) ecosystem changes due to fishing may have occurred since European settlement, and (3) European fishing commenced at different times for different species. For example, it is possible that a fishing-mediated reduction in predatory species such as snapper may have enabled prey species such as calamary (and other cephalopods) to increase in abundance such that calamary are now also targeted in commercial quantities (see Triantafillos, 2008). Nonetheless, for some fished species a great deal is known about population trends since commercial fishing commenced or over at least a period of several recent years.

What is also known is that significant fishing mortality of a species will result in the population status being lower than what it would be without fishing (Haddon, 2007), i.e., it can be considered to be at an UNLL compared to a **baseline of pre-European fishing**. For example, if a fished species is currently at an UNLL and fishing is ceased then there is **potential** for the population to respond. In contrast, if a fished species is currently at a NL and fishing is ceased then it is unlikely that the population will respond directly to protection from fishing (Edgar et al., 2009). Whether or not a species actually does have a response will be influenced by a range of factors (see Table A1-3), including indirect ecosystem interactions (see Section A1.4). The assignment of current status is basically applied based upon historical fishing activity. Thus for the purposes of the coarse predictions being made for the current study, it is largely irrelevant exactly when the fishing commenced or at exactly what level below the pre-fishing baseline the current population. As natural variability is inherent in marine ecosystems, such variability is also implicit in the assignment of current status for each fished species.

It could be argued that wherever fishing removes fish from a population (regardless of the relative amount of catch) the population is UNLL. Using such a methodology would result in every fished species in every location across the State, where it is fished, being classified as UNLL. Clearly this approach is overly simplistic as factors can operate within populations that naturally compensate for a low level of fishing mortality and ecosystem interactions can also influence species populations (Haddon 2007). Furthermore, using the fishery status ratings of PIRSA Fisheries would imply that many of the species are at UNLL across their entire range, which may not necessarily be the case. Given this complexity an attempt was made to identify species and locations where (1) historical fishing activity (catch and effort) is highly likely to have lowered the population since commencement of European fishing in SA, and (2) where historical fishing activity is low but future fishing activity may represent a threat to species that are intrinsically vulnerable to fishing (see Section A1.3.6 later).

A1.3.5 Spatial and temporal patterns of historical fishing

Fishing in SA is widespread; there would be very few productive areas that have not been fished at some stage. Nonetheless, fishing effort is non-uniform being focused in areas of high productivity for different species. It is this spatial distribution of effort (and catch) across time that was used to assess potential prior impacts of fishing on the 20 fished species. Some species are fished across their range by the commercial and recreational sectors, e.g., southern rock lobster, abalone, King George whiting, snapper, while other species experience more spatially-selective pressure because they have restricted distributions, e.g., Goolwa cockles, mud cockles.

For recreational fishers, effort and catch tend to be focused around population centres and regional centres where there is boat ramp access and shore-based access (Stuart-Smith et al., 2008 Jones, 2009 Shepherd et al., 2009). Regions that receive high recreational fishing effort are Adelaide and the Fleurieu Peninsula, Yorke Peninsula, and regional coastal towns on Eyre Peninsula, the west coast, Kangaroo Island, and the southeast. Commercial fishers on the other hand have equipment that enables them to target species throughout State waters. The spatial distribution of effort across the State in the Marine Scalefish Fishery is well documented (Steer, 2009). Effort and catch in commercial fisheries are non-uniform and are related to the spatial distribution of abundance of different species, i.e., fishers will fish where catches are most efficient (within limitations of current regulations).

The charter industry is focused around Fleurieu Peninsula, Kangaroo Island, Yorke Peninsula, and Eyre Peninsula, but some charter activity generally occurs in most of the larger regional population centres. The charter fishing industry is also becoming more advanced and is now capable of accessing the most remote offshore island sites and offshore fishing areas that have not necessarily experienced much fishing activity (Baker, 2011). This is particularly important for site-attached reef fishes that are intrinsically vulnerable to fishing and thus can experience serial depletion over time. The charter sector has expanded considerably in the past 20 years and has potential to further explore new fishing grounds.

A1.3.6 Fished species vulnerability

Saunders et al. (2010) assessed a number of species that were of conservation or management interest and assigned the species a vulnerability index rating based upon their life history characteristics, viz., maximum age and size. Of the species short-listed for consideration in the current assessment, the following species were rated by Saunders et al. (2010) as having a relatively high intrinsic vulnerability to fishing: bluethroat wrasse, sea sweep, harlequin fish, Bight redfish, and swallowtail. All of these species are also resident or at least temporary resident making them vulnerable to localised depletions (see Appendix 3). The western blue groper is also highly vulnerable to fishing and localised depletion (and is still at risk in areas where it is fully protected—see Appendix 3). For these six species, additional consideration was given to possible impacts from fishing activity in traditional areas of high fishing activity and in remote areas that are experiencing increased fishing activity from the charter sector.

A1.3.7 Predictions for indicator fished species

The idea of predicting the response of a fished species to protection from fishing may appear simple: fishing causes additional mortality to the natural mortality that a population normally experiences, so if the ‘fishing mortality’ is removed then the population should return to some ‘normal’ level; unfortunately, the natural situation is not as simple as that.

Table A1-3 shows the types of factors (many of them inter-related) that can influence the first-order response of a fished species to the cessation of fishing following the implementation of a no-take sanctuary zone (see information sources below the table). For species that have been heavily fished there may be a relatively large response following protection from fishing (e.g. Edgar et al., 2009; Lester et al., 2009), i.e., there is a large difference between the level prior to protection and the level that is reached following protection. However, such changes may take many years to occur, so the longer the time since protection, the more likely that the response will be large (e.g. Russ and Alcala, 2010). Species that have a slow intrinsic rate of population increase, e.g., late-maturing, may show a relatively small initial response to protection (e.g. Smith et al., 1998; Jennings, 2001), but the response of such species may increase the longer the zone protection is in place. Species that are permanent residents within a no-take zone will likely show a much larger response to protection than species which are migrants or short-term residents (e.g. Barrett et al., 2007); because as the migrants move in and out of a protected zone they are still vulnerable to fishing outside of the zone. In addition, residents with small home ranges relative to the size of the zone will be more likely to be protected from fishing at the boundaries of no-take zones and thus may have a greater response (e.g. Kramer and Chapman, 1999). In some cases, the home range of a species may be locally restricted by a habitat boundary within the zone, thus reducing boundary interactions (e.g. Barrett, 1995; Bryars et al., 2012). If the level of immigration into a no-take zone is high, then a larger response will be seen compared to if the population relies only on within-reserve recruitment (e.g. Denny et al., 2004). The success of compliance in preventing illegal fishing is a key factor in the level of response (e.g. McCook et al., 2010). Several studies have shown that larger fish (maximum size) respond more to protection than smaller fish (e.g. Barrett et al., 2007), possibly because they were targeted more heavily prior to protection. Note that almost all of the factors shown in Table A1-3 are zone-specific such that observations from one area cannot necessarily be transferred to another area (e.g. Langlois and Ballantine, 2005). For many species in SA there is also limited information on these factors, thus adding to the difficulty in making predictions.

Table A1-3 Factors that may influence a positive first-order response in fished species following the cessation of fishing inside no-take marine reserves, the response of fished species following cessation, and the reliance on zoning.

Factor	Positive response of fished species		Zone reliance
	Small	Large	
Prior level of fishing	Low	High	Specific
Time since protection	Short	Long	Specific
Size of zone	Small	Large	Specific
Intrinsic rate of population increase	Slow	Fast	Specific
Site fidelity	Migrant	Resident	Specific
Home range	Large	Small	Specific
Immigration	Low	High	Specific
Compliance	Low	High	Specific
Size of fish	Small	Large	Generic

Information sources for the above table: Smith et al. (1998), Kramer and Chapman (1999), Mosquera et al. (2000), Jennings (2001), Denny et al. (2004), Langlois and Ballantine (2005), Barrett et al. (2007, 2009), Claudet et al. (2008), Edgar et al. (2009), Lester et al. (2009), Molloy et al. (2009), McCook et al. (2010), Russ and Alcala (2010)

Despite the difficulties in making predictions we have employed a simple first-order model to demonstrate the **potential** for some species to respond to protection from fishing. The first order fished species responses are based on the assumption that the cessation of fishing acts directly on each species in isolation. In reality, this is unlikely to be the case, as demonstrated by several studies (Babcock et al., 2010). However, as discussed in the ecosystem section, making predictions of second–fourth order interactions is extremely difficult. Where the species-specific predictions are likely to be confounded by second order (or higher) interactions that are known to occur elsewhere for particular species or might be expected from our simple food web analysis (see Ecosystem section later), these have been highlighted in the model output tables and are discussed more fully in Section A1.4.

The aim of the predictions was to highlight the **potential** for response of the 20 indicator species to the proposed zoning. Thus, the general approach to assigning current status and making predictions was to deliberately search for cases where a species was either at UNLL or NL and where protection from the zoning and management plans might result in a response, i.e., the assessment was designed to detect a difference between the situations of zoning versus no zoning. There seemed little point in documenting cases where it was felt that the zoning would make little or no change (although a notable exception to this was the giant Australian cuttlefish at Point Lowly). To this end, the rationale for making predictions was not to definitively assign the current status for every species in every zone across all 19 parks (which is an unachievable exercise with the available data and resources), but rather to highlight situations where there was **potential** for population changes of some of the indicator species within each park following protection from fishing. Thus, there may appear to be a bias towards assessing and documenting fished species as UNLL, but in reality the approach used was conservative, i.e., there were many more cases where UNLL could probably have been assigned but wasn't due to a variety of reasons. Furthermore, there were some cases where a species could have been assigned as NL but this wasn't documented because it was felt that no change would occur. For example, some resident reef fishes in remote areas are probably NL and will likely remain that way due to continued low fishing activity into the future. Similarly, where an SZ exactly overlaid an existing no-take Aquatic Reserve such that zoning would not change existing use, then species within this zone were not assessed. The approach used was not intended to make the proposed zoning and management plans appear only positive for biodiversity conservation. There are undoubtedly many cases where the zoning and management plans will not change the current situation; but this works both ways—e.g. for cases where species are UNLL and probably won't respond inside a single zone (e.g. whaler sharks which are highly mobile), and for cases where species are NL and will probably remain that way (e.g. southern blue devil in lightly fished areas). However, in most cases there are insufficient data to make these assessments anyway.

A1.3.8 General methodology for species predictions

The general sequence of steps for making predictions was to systematically go through each RAZ, SZ and HPZ of each park and determine for the 20 indicator species:

- If the fished life stage of the species (adult and/or sub-adult) occurred in that area and its preferred habitat type was present in a zone (using GIS layers created for the purpose) then the species was assumed to occur in that zone;
- Whether the fished life stage was a resident, migrant or temporary resident in the zone (using life history information—see Appendix 3);
- If substantial fishing effort and/or catch (fishing activity) occurred in the region. This step was somewhat subjective given the disparate nature of the data available to determine fishing activity, but it was essentially confined to the highest catch and effort regions of the commercial, recreational and charter sectors (data derived from various sources), as well as for potential recreational fishing activity: accessibility by land (shore-based fishing) and water (boat ramps and boat fishing), and proximity to human population centres. Relevant existing fishing closures were also taken into account;
- If it was felt that sufficient information was available to assess the current status of the species in that region, the species was included in the analysis. If too much uncertainty existed, the species was excluded;
- If changes in size and abundance were possible, a prediction was made (see Section A1.3.9 below);
- If an increase in abundance was predicted beyond five years, i.e., an accumulation and not just a temporary increase, and the species was physically capable of moving out of the SZ, spill-over was predicted (see Section A1.3.12 below);

- If a species was known to spawn in the general area, larval export from the SZ was predicted (see Section A1.3.13 below);

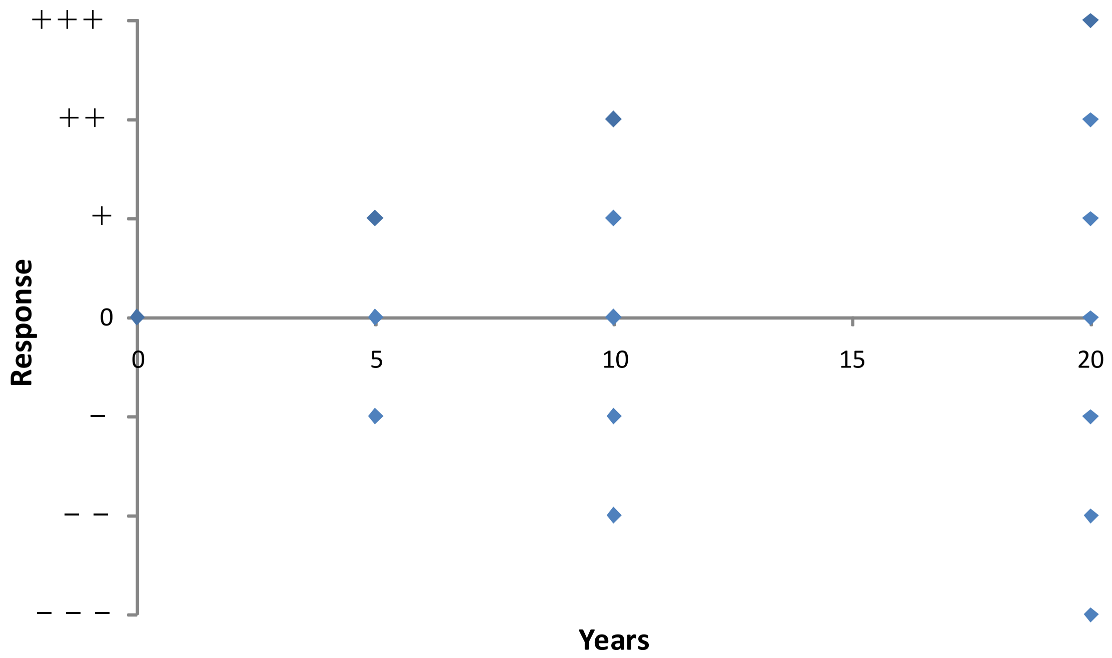
Further details on the rationale for assigning current status and making predictions for individual species are given in Appendix 3.

A1.3.9 Predictions of size and abundance in fished species

A simple model

Given a current status in relation to UNLL or NL, semi-quantitative predictions can be made as to how the level may change under a specific zoning and management scenario. To enable these predictions, a simple model was developed to demonstrate how a species may respond over the next 5, 10 and 20 years (see Figure A1–1). The model allows only a 1-step or 1-level change across each time period of 0–5 years, 5–10 years, and 10–20 years. For example, in the first 5 years, the response can be either an increase (+), a decrease (-), or no change (0). Following an increase after 5 years to +, the subsequent response from 5–10 years could be either a further increase to ++, a decrease to 0, or no change and remaining at +. Following a decrease after 5 years to -, the subsequent response from 5–10 years could be either a further decrease to - -, an increase to 0, or no change and remaining at -. There could also be no response to zoning and management from 5–10 (and 10–20 years) such that the level continues to remain at 0. Subsequent scenarios from 10–20 years can be readily calculated from Figure A1–1. The maximum level achievable after 20 years is +++ and the minimum is - - -. To assess the net effect of the proposed zoning, predictions with and without the zoning were compared and the net score was assigned by subtracting the response with and without the zoning. Thus, in some cases there may be a net effect that is ++++.

Figure A1–1 The simple model used to demonstrate possible responses of species and habitats to the implementation of the proposed management changes.



A1.3.10 Abundance

The general premise behind predictions of changes in abundance was that if fishing mortality is ceased within a SZ where the population is UNLL and recruitment occurs to the SZ (at any life stage from post-larvae through to adult), the abundance of the species will increase over time (after Haddon 2007). This approach obviously has many assumptions (see below) and as shown in Table A1-3, there are many factors that can influence a species' response (see Section A1.3.7). Because we do not have detailed data for all of these factors and because responses of species have often been found to be long-term (decades) in other no-take marine parks, we have adopted a conservative approach and assigned each species that we predict will increase in abundance inside a SZ with a +, ++, and +++ across the 5, 10 and 20 year periods, respectively. This is appropriate given that many of the species are long-lived (>20 years). The response of a species shown by +, ++, or +++ using the simple model does not reflect the magnitude or rate of the increase.

Another situation that can occur is if the fishing mortality of a species is particularly high in an area that contains an SZ, the abundance of that species inside the SZ will be temporarily higher relative to the situation of continued fishing (as long as the species has at least some period of temporary residency inside the SZ and is not a migrant). This is of interest because some species aggregate temporarily (usually for spawning) and in these instances there may be increased reproduction within the SZ. This scenario is possible for species such as southern calamary, giant cuttlefish, blue swimmer crabs, and possibly garfish (although their exact spawning locations remain unknown) (see Appendix 3). Other species that may also have relatively 'elevated' levels in some areas are King George whiting and yellowfin whiting, which may not be spawning in these locations, but their relatively higher abundances may have positive ecosystem affects that are unpredictable at this stage. Predictions for these situations were made in some areas of the State where commercial or recreational catches are greatest and were generally indicated by a + at each of 5, 10 and 20 years.

Predictions were also made for some situations whereby the size and abundance of resident species would be unlikely to respond to the proposed zones but could potentially decline in those same areas if left unzoned over the next 20 years due to a combination of increased fishing activity, the species intrinsic vulnerability to fishing, and/or a lack of current fisheries regulations. For such species, a minus (-) was arbitrarily assigned at 20 years to reflect the potential risk of current or anticipated future fishing activity. However, this assessment does not take into account possible alternative management responses over the next 20 years within the existing management framework.

A1.3.11 Size

Fishing often results in a truncation of the age/size distribution of a species because the older/larger individuals are selectively removed from the population; this is particularly so for longer-lived species (e.g. mulloway, see Ferguson et al., 2010). If fishing is ceased it is expected that individuals within a population will be able to reach their natural maximum age/size and the age/size distribution in turn will return to a more natural or non-fished distribution (Haddon, 2007). For fast-growing/short-lived species the shift will occur more rapidly than for slow-growing/long-lived species. Other factors will also influence this change, including recruitment frequency (Haddon 2007). To correspond with the need for predictions at 5, 10 and 20 years in the current impact assessment, we have predicted that populations that are at UNLL will return to a more normal size distribution based upon their maximum age (Table A1-4).

TableA1-4 Predicted times and likelihoods for population size distributions to return.

Maximum age of species (years)	Time period of prediction		
	5 years	10 years	20 years
<5	+	+	+
5-10	+	++	++
>10	+	++	+++

These predictions assume that juvenile recruitment into the overall population occurs within the timeframe specified. Without recruitment of young/small individuals into the population the distribution will simply shift from one that is skewed to younger/smaller organisms (as a result of fishing) to one which is skewed to larger/older organisms. If the species is short-lived and no recruitment occurs then the species would become locally extinct, e.g., cuttlefish, calamary, which only live for 1–2 years. An example of a short-lived species that will see a relatively rapid change in size/age distribution with the cessation of fishing is the Goolwa cockle. As the Goolwa cockle lives for only 3–4 years, there will be complete turn-over of the population in <4 years and if juvenile recruitment occurs during this time (combined with a lack of fishing mortality on the larger cockles), the population would return to its natural age/size distribution in <5 years. For a longer-lived species such as the blue groper (maximum age = 70 years), it would be predicted that even with regular recruitment of sub-adults into a local population, it would take at least 20 years for the size/age distribution to begin resembling a non-fished distribution. Of the 20 species short-listed for assessment, only five had a maximum age of <5 years (southern calamary, giant cuttlefish, western king prawn, blue swimmer crab, Goolwa cockle). The remaining 15 species have a maximum age of >10 years (see Appendix 3 for further details).

A1.3.12 Predictions of spill-over and larval export in fished species

Spill-over

Increased abundance of a species inside a SZ may be observed for several reasons related to fishing, including: (1) the fishing mortality outside the zone is higher than inside the zone (but the actual numbers of individuals have not increased relative to when the SZ was implemented), (2) there is a temporary increase in the number of individuals inside the SZ during aggregation times, and (3) there is accumulation of individuals over time inside the SZ compared to when the SZ was implemented, i.e., the number of individuals has actually increased. It is the latter scenario that the concept of 'spill-over' really applies. Many marine species experience intra-specific interactions or density-dependence that will limit the number of individuals that can live in a given area, e.g. competition for food, shelter, mates (see Connell and Gillanders, 2007). Thus if the number of individuals increases sufficiently inside a SZ it may reach the 'carrying capacity' of the area and this may lead to 'spill-over' whereby individuals are forced to move outside the SZ. This phenomenon has been witnessed in no-take marine parks around the world (e.g. Stobart et al., 2009; Russ and Alcala, 2011). However, spill-over should not be expected for all species and all SZs in SA's network of marine parks. Whether or not spill-over occurs will depend on many factors including whether there is a positive response by the species to the establishment of the SZ (Table A1-3), and whether the species is physically capable of moving outside the SZ (some species are highly sedentary and will not travel far). In the context of local species found within SA there are several species (mainly temporary resident) that are heavily fished that may appear to temporarily have increased numbers inside SZs compared to outside (or a scenario of no-fishing) but these species are not actually increasing in numbers and so movement of these fish outside the SZ boundaries does not represent real spill-over. On the other hand, there are several species (mainly resident) that are predicted to increase in abundance inside appropriately-sized SZs and it is from these SZs that spill-over might occur. However, while we do make predictions of potential for spill-over from SZs for some species, we do not make predictions of how this may contribute to the overall population of a species.

Larval export

Many marine species have a planktonic larval phase in their life cycle. The larval stages can be carried large distances (km's) before they 'settle' as a post-larval fish or invertebrate, usually depending on their larval duration or time spent in the water column. If SZs result in an increased abundance and/or size of breeding individuals that have a planktonic larval phase with potential for larval dispersal, it may be expected that, due to increased reproductive output, 'larval export' from the SZ will occur, e.g. Diaz et al. (2011). Even for species such as blacklip abalone that may have limited larval dispersal (see Species Profile in Appendix 3), the potential still exists for larval export from an SZ. Whether or not exported larvae survive and reach an age where they can recruit to the general population or breed themselves remains a contentious issue (Haddon, 2007; Christie et al., 2010). However, a recent study of two commercially and recreationally targeted fish species on the Great Barrier Reef has now demonstrated that no-take marine reserves can make a significant contribution to the replenishment of populations in fished areas outside reserves (Harrison et al., 2012). At this stage, it is unknown whether such scenarios will occur in SA. Thus, while we do make predictions of potential larval export from SZs for some species, we do not make predictions of how this may contribute to the overall population of a species.

A1.3.13 Assumptions and limitations of the approach

- It was assumed that fisheries management will continue as it currently exists; which no doubt is untrue as fisheries management in SA is adaptive and ever-changing/improving (including some advances in the area of ecosystem-based management).
- Predictions of fished species responses necessarily had a level of subjectivity associated with them. However, where there was great uncertainty about a species current status, level of fishing mortality, and/or life history within a proposed SZ, the species was omitted from the assessment. In this regard the predictions are considered to be conservative, i.e., there are possibly a greater number of species that will respond to SZ protection than what is presented.
- Assessments of current status for target fished species were hampered by a lack of high resolution spatial data on historical catch and effort. Much of the unavailability was related to confidentiality issues with commercial fishers, while some was due to the resolution of reporting by commercial fishers. Some fisheries record GPS data, e.g., sardine, while others report only at the fisheries block level, e.g., marine scalefish—which in any case are larger than the size of proposed sanctuary zones.
- Consultation with local experts, fishers, scientists and others who could have greatly assisted the assessment process was limited by the requirement to keep the proposed zonings confidential for much (SZs) or all (other zones) of the time available for writing this report.
- Apart from high-value fishery species, there are few data available on species population sizes and trends over time. In such instances we relied upon anecdotal information on species changes, data on fishing activity, and intrinsic vulnerability of individual species to fishing activity.
- Assessments of the current status of fished species were not based solely on the level of catch. Some species have high levels of catch but are naturally abundant anyway. In contrast some species are naturally less abundant and/or intrinsically vulnerable to fishing such that a low level of catch may be significant for local populations of that species. Some species that fall into the latter category are Bight redfish, western blue groper and harlequin fish.
- Ultimately the accumulation of individuals may result in spill-over outside a SZ for a species, but the assignment of a species with a spill-over prediction does not indicate when it might occur nor does it imply that it will occur at or before 20 years.
- Predictions of larval export and spill-over are indicative only. There may be specific instances where spill-over is not possible if adjacent suitable habitat is not present, e.g. a small reef surrounded by sand may restrict movement of southern rock lobster to other reefs. There may also be specific cases where larval export does not actually occur due to local hydrodynamic processes. Incorporating such site-specific detail into the predictions was beyond the capacity of the current assessment.
- Around some islands, e.g., The Pages, Lipson Reef, there was no mapped habitat. However, the shoreline around these outcrop islands is known to be rocky and thus there must be at least some subtidal reef. It is highly likely that these rocky outcrops located in deep waters are surrounded offshore by subtidal sand habitat.

- The intrinsic rate of population increase for a species within a zone will be determined by a complex interaction of a number of factors including (but not limited to), the basic biology of the species (natural growth rate, age at maturity, etc.), stock-recruitment relationships, metapopulation structure, variations in the success of recruitment events, and whether the zone is a source or sink of recruits. Incorporating all of these factors into predictions was beyond the capacity of the current assessment.
- Any future abundance increases of previously fished species inside SZs such as abalone and razorfish, will also depend on the remaining density of reproductively mature individuals (see Species Profiles in Appendix 3). For these species the success of fertilisation, i.e., the chance of a sperm meeting an egg, is highly dependent on the males and females being close enough to one another. In low density populations recovery could potentially be slower (unless recruitment occurs from outside the SZ). If densities of adults are too low, successful reproduction may not occur at all.
- Future predictions of an increase in size and abundance for some species such as abalone and mud cockle may be affected by density-dependent factors that limit the population growth (see Species Profiles in Appendix 3). For example, blacklip abalone populations could eventually become stunted in some areas due to high levels of intra-specific competition. Incorporating such site-specific detail into the predictions was beyond the capacity of the current assessment.
- It was assumed that current fishing regulations are adhered to and that compliance within RAZs and SZs will be 100 per cent effective.
- It was assumed that current fishing management will result in no change in size and abundance of fished species over the next 5, 10 and 20 years. In reality, some species may show increases as they are in a rebuilding phase, e.g., southern rock lobster stock in the Northern Zone, others may fluctuate greatly due to natural variability, e.g., natural fluctuations in recruitment of snapper, while others may decline due to a failure of management, e.g. lack of regulations for reef fishes that are intrinsically vulnerable to fishing.
- Natural variability is inherent in all marine systems. For example, many species have high recruitment variability and this will affect long-term population trends, e.g., snapper (see Species Profile in Appendix 3). Explicitly accounting for this variability in the predictions was beyond the capacity of the current assessment.
- It was assumed that Indigenous communities had not already had an impact on the marine environment prior to European settlement; some Indigenous fishing is known to have occurred in SA and in some areas there may have been localised impacts, e.g., pipi harvesting in The Coorong (based upon the size of shell middens in the area, see Ferguson and Mayfield, 2006). Nonetheless, populations of Indigenous people were relatively low and thus the level of impact would likely have reflected this

A1.3.14 Predictions for sessile benthic species in trawled areas

Sessile benthic species that may have been affected by previous prawn trawling were not treated separately (even though they may constitute numerous species, see Currie et al., 2009) but rather were treated as a group in the Habitat section (see Section A1.2).

A1.3.15 Predictions for non-fished species

Detailed predictions of responses of non-fished species were beyond the capacity of the current assessment. Nonetheless, some discussions on possible second–fourth order ecological interactions are provided in the habitat profiles (see Appendix 4), the Ecosystems section of this report, and the individual case studies in each of the 19 Marine Park Impact Statements.

A1.3.16 Predictions for species diversity

Detailed predictions of the response of species diversity were beyond the capacity of the current assessment. Nonetheless, some discussion on species diversity is provided here.

- There have been only a dozen well-documented marine extinctions with another 18 possible, depending on taxonomic analysis. However, at least 133 species have been identified as regionally or locally extinct (Dulvy et al., 2003).
- Species may also become depleted to the point of 'ecological extinction', whereby they no longer fulfil a previous ecological function (Estes et al., 1989) (see ecosystems, below).
- The main causes for extinction are considered to be exploitation and habitat loss, with pollution, introduced marine pests and climate change also considered as threats (Dulvy et al., 2003).
- The life history characteristics of many marine species (including the wide dispersal of many offspring) reduce their likelihood of extinction, but there are others with less favourable life history characteristics (see species vulnerability section).
- Many exploited species may not be fished to extinction but may persist at the reduced level at which continued fishing becomes economically unviable. This partial safeguard does not, however, apply to bycatch species, or species that may be recreationally fished, irrespective of the economic cost of extraction.

Areas which remove or reduce impacts that would otherwise cause local extinctions would have a greater richness of species. Lester et al. (2009) documented 39 studies that measured the effect of SZs on species richness (with inside-outside, before-after, or both comparisons), including 21 in temperate waters. Species richness in SZs was found to be significantly higher (21 per cent mean), but the mean increase was smaller and not significant (14 per cent) when considering only temperate waters, with almost half of the SZs actually showing a reduced species richness (Lester et al., 2009).

It should also be noted that many of the results came from field studies that sampled a relatively small area and therefore underestimated total species richness (Lester et al., 2009). In this respect, the studies show more about the evenness of species abundance, than about species richness. Nevertheless, evenness is important for some measures of species diversity, e.g., the Shannon biodiversity index.

The different levels at which biodiversity is often considered (ecosystem, species and genetic) are interrelated, and SZs can enhance ecosystem diversity (see below) and conserve genetic diversity.

Genetic diversity

Fishing places selection pressure on populations causing them to undergo physiological or behavioural adaptations that reduce the probability of capture (Edgar et al., 2007). For example, fishing of species managed by a minimum size limit will favour fish that are genetically disposed to maturity at a short body length, and potentially reduce the genetic pool for fast growing fish (Conover and Munch, 2002, Conover et al., 2005, cited by Edgar et al., 2007; FAO, 2011). Local examples of possible size evolution include:

- a reduction in annual growth rate of abalone in Waterloo Bay by 12 mm and size of maturity by 27 mm over four generations (28 years) (Dr S. Shepherd, pers comm)
- The median size at maturity of garfish is smaller than for fish in Victoria and Western Australia, and there is some evidence that the size and age of first maturity in SA has decreased over time, possibly in response to the high rate of exploitation of this species (McGarvey et al., 2009).
- A reduction in size of maturity of King George whiting by 5 cm over 30 years (Cockrum & Jones, 1992).

A1.4 Ecosystems

As with defining a habitat, defining an ecosystem is arbitrary. Ecosystems could operate on the scale of microscopic benthic infauna in a sand hole within a seagrass meadow through to pelagic fauna in the water column across an entire ocean. Given the scope requested by DEWNR to assess ecosystems, we needed to rationalize the number and type of ecosystems that could be realistically assessed in some manner. Given the locations of the marine parks and the types of species-habitat (ecosystem) responses seen in other marine parks elsewhere (especially reefs), the habitat types defined above were used as the basis for the ecosystems. We have also recognized multiple-habitat ecosystems (see later).

Relatively little is really known about SAs marine ecosystems and how they may be potentially influenced by human activities. Possibly the best understood ecosystem in SA (and its interaction with a fishery) is the eastern Great Australian Bight and the sardine fishery (Goldsworthy et al., 2011). Nonetheless, a good deal is known about some species (in particular some fished species) and their reliance on particular habitats and associated food sources (see Shepherd et al., 2008) and this information can be used to make some informed discussions about the structure and function of local ecosystems.

Ecosystem modelling is a resource and data hungry exercise, e.g., Goldsworthy et al., 2011, Lozano-Montes et al., 2011. A detailed investigation of SA's ecosystems and the potential impacts of the marine park zoning and management arrangements is a massive task that was well beyond the capacity of the current impact assessment. Nonetheless, some useful observations from other marine parks and the development of some simplified conceptual food webs have been used as a basis for discussing potential responses of local ecosystems to protection.

A1.4.1 Ecosystems assessed

Eleven simplified conceptual food webs were developed to illustrate likely ecosystem structure and trophic flows in the eleven ecosystems (see Appendix 6) based upon knowledge of predator-prey relationships and habitat preferences for individual species/groups that were documented in Section A1.3.1. These conceptual models have used (where space permitted) many of the species/groups identified in the species assessment section (see Appendix 2). The conceptual models are designed to illustrate some of the complexity of interactions between species, and to highlight how changes to their abundance might have flow-on effects to other parts of the food chain. It is important to note, however, that predator-prey relationships are not the only ecological interactions between species; others include competition for food and space, and provision of habitat, e.g., 'reef' biota attached to razorfish in sand or hermit crabs in discarded shells.

It is apparent from the food webs in Appendix 6 that there are no fishery-interactions in saltmarsh (no species harvested) or intertidal reef (intertidal reef fauna are protected in SA), and very few species are harvested from mangrove habitats (usually captured at the edge or in mangrove tidal creeks due to the difficulty of penetrating mangrove forests). In contrast, there are numerous species that are harvested from across a number of trophic levels in the other eight habitat-ecosystems.

In a more descriptive manner, multiple-habitat ecosystems were recognised, e.g., saltmarsh-mangrove-intertidal sand/seagrass flats-subtidal sand/seagrass-pelagic; intertidal reef-subtidal high profile reef-subtidal sand-pelagic, and State-wide ecosystems such as the gulfs. The biodiversity conservation benefits of having a network of marine parks and protection zones that provide connectivity at these larger spatial scales are highlighted in some of the Case Studies in the individual impact statements for each park and in the Species Profiles section (Appendix 3).

A1.4.2 Ecosystem responses to protection

As fishing is the main activity that will be ceased inside SZs by the zoning and management arrangements, and quantitative predictions were not possible, the response of different ecosystems could only be examined in a qualitative sense.

Commercial, recreational, and (to a lesser extent) charter catches in SA are substantial (Table A1–5). For example, Jones (2009) estimated that a total of 6.3 million marine finfish and shellfish were harvested in a one year period (2007/08) from SA waters. In 2009/10, the top 25 commercial marine species by value (excluding sardine) had a total weight of 9,585 tonnes (Knight and Tsolos, 2011). The harvest of sardine for 2009/10 was 36,573 tonnes (Knight and Tsolos, 2011). It was estimated that almost 150,000 marine organisms were harvested by the charter industry in 2008/09 (Knight, 2010). These catch figures are from single years and do not portray the cumulative impacts of harvest (especially on species that are intrinsically vulnerable to fishing and have a longevity) and do not indicate from what trophic level they are harvested.

As stated earlier, commercial fisheries, by their very nature, maintain populations of species at some level below their un-fished biomass (Haddon, 2007; see Table A1–5). The commercial, recreational and charter fishery harvest of biomass (or fishing mortality) occurs across a number of habitat-ecosystems and from a range of trophic levels (Appendix 2, Appendix 6). Thus the components of these ecosystems (or relative abundances of the fished species) must be altered to some degree by fishing in some areas and therefore there is potential for ecosystem impacts.

Despite the level of fishing mortality, there is very little evidence of ecosystem impacts from fishing in SA. Recent ESD risk assessments on most of the major fisheries in SA have recognised that removal of large quantities of the target species will likely influence the components of ecosystems (or the structure), but that the ecosystems are still functioning as they would be without fishing. Nonetheless, these qualitative assessments are based on a lack of data and a generally poor understanding of the ecosystem effects of fishing in SA (exceptions being the sardine and prawn fisheries: Goldsworthy et al., 2011; Svane et al., 2008). Even for the sardine fishery, which extracts by far the largest biomass of a single species in SA (albeit at a relatively low trophic level), a major study by Goldsworthy et al. (2011) concluded that the current levels of fishing effort (~30,000 tonnes per annum, and exploitation rates of 10–20 per cent) were not impacting negatively on the ecosystem function. Thus it would appear that some changes to ecosystem structure may be expected following protection from fishing inside SZs within SA, but that changes to ecosystem function may not necessarily occur.

Table A1–5 Harvest biomass and numbers for some of the key ecosystem species that are also fished.

Common name	Main habitat type from which harvested	Commercial harvest (tonnes)	Recreational harvest (tonnes)	Total harvest (tonnes)	Recreational harvest (numbers)*
King George whiting	Subtidal low profile reef, Intertidal and subtidal seagrass	330	324	654	1,249,079
Southern garfish	Intertidal and subtidal seagrass	290	75	365	807,743
Snapper	Subtidal low profile reef, Subtidal sand	742	178	920	97,010
Yellowfin whiting	Intertidal and subtidal sand	82	23	105	71,120
Flathead	Intertidal and subtidal sand, Intertidal and subtidal seagrass	3	18	21	38,873
Blue swimmer crab	Intertidal and subtidal sand, Intertidal and subtidal seagrass	668	284	952	1,144,837
Southern calamary	Subtidal low profile reef, Subtidal seagrass	303	206	509	484,456
Goolwa cockle	Beach	607	5	612	306,107
Razorfish	Intertidal sand, Intertidal seagrass	9	149	158	148,593
Mud cockle	Intertidal sand	320	1	321	91,994
Southern rock lobster	Subtidal high profile reef	2,309	60	2,369	47,875
Sand crab	Subtidal sand	63	11	74	28,634
Greenlip abalone	Subtidal low and high profile reef	409	2	411	3,462
Blacklip abalone	Subtidal high profile reef	475	1	476	1,685

Data are mainly taken from Jones (2009) for the year 2007/08 (harvest values have been rounded to the nearest tonne).

NB. The values shown are not intended to portray these fisheries as unsustainable but merely to show that substantial amounts of biomass (>20 tonnes per species for those shown) are removed each year from South Australian marine ecosystems through fishing mortality.

Harvest numbers are unavailable for the commercial sector

A1.4.3 Possible higher order ecosystem effects from protection

Some of the possible responses in size and abundance of fished species to protection were discussed in Section A1.3. However, those predictions ignore any possible higher order ecosystem interactions.

Making predictions of single species responses to SZ protection is difficult; making predictions about second, third, and fourth order changes to ecosystems is even more difficult. Given the current lack of ecosystem models for SA (except Goldsworthy et al., 2011, see below) and the high level of uncertainty surrounding single-species first order changes, we were unable to predict with any certainty changes to species arising from ecosystem interactions that may occur over the next 5, 10 and 20 years. Nonetheless, it is apparent from the conceptual food webs that major changes (positive or negative) in the abundance of some species could lead to changes (positive or negative) in abundance of other species. With a high level of protection inside an SZ, a previously-disturbed ecosystem may shift towards a pre-European state, with the extent of this shift dependant on a number of factors including:

- the first order species-specific responses to protection (see Table A1-3 earlier)
- the species and habitat assemblages that comprise the ecosystem
- the spatial scale of ecosystem processes and threats.

Some of the ecosystem responses that have been observed in studies of marine parks elsewhere are discussed below in the context of their relevance to SA. As with single-species responses, it is likely that larger SZs will generate larger ecosystem effects and/or provide better ecosystem protection from future threats. For example, a larger SZ will encompass a larger suite of species with a greater variety of home range sizes. However, even within the largest SZs proposed for SA, e.g., the 8 SZs larger than 100 km^2, a complete return to a pre-European state is unlikely to occur due to impacts that may originate beyond the SZ or even the marine environment, including: establishment of introduced species, shifts in species and habitat distributions due to climate change (Hobday, 2011), and fishing of highly mobile species while they are outside the SZs, e.g., whaler sharks.

However, some of these more mobile scalefish species are expected to increase in abundance as a result of the proposed overall reduction of commercial and charter fishing effort (see Section A1.1.4), and there may be localised flow-on effects for food webs inside marine parks. Similarly, increased abundances of some species during temporary residency within an SZ, e.g., spawning aggregations (see Section A.1.3.10), may also result in increased predation and competition.

Experience from some no-take marine parks suggests that the numbers of small-bodied fish will decrease as larger piscivores (fish that eat other fish), which had been historically targeted by fishing, increase in size and abundance (e.g. Micheli et al., 2004). However, these studies are less relevant to SA as the types of larger fishes that are targeted in SA (excluding sharks), and which are likely to increase in abundance inside zones (such as snapper, and blue groper) are not primarily piscivores but feed mainly on invertebrates; an example of such predator-prey relationships is an increase in cephalopods in response to reductions in predatory fish such as snapper and gummy sharks (Triantafillos, 2008). Therefore increases in larger non-piscivorous fishes are considered more likely to cause a decline in invertebrate prey species such as abalone, urchins, crabs, and cephalopods. This effect has been observed in marine reserves in New Zealand whereby snapper abundance increased inside no-take zones and the abundance of urchins declined due to predation by snapper (and also by lobster which increased in abundance as well). This and other studies on reef ecosystems are discussed below.

A1.4.4 Reef ecosystem interactions

Introduction

There have been some important studies on the response of temperate reef ecosystems to protection from fishing, with first through to fourth order changes demonstrated., including North America and the Mediterranean (Tegner and Dayton, 1999, 2000), and two particularly relevant studies in New Zealand and Tasmania (see below).

New Zealand

One classic example of ecological interactions showing a major shift following the implementation of a sanctuary zone comes from the Leigh Marine Reserve in New Zealand (Shears and Babcock, 2003). Prior to protection the area was characterised by high abundances of urchins and a low coverage of kelp and other macroalgae on the rocky reef (areas called urchin barrens). Protection resulted in increased abundances of rock lobster (four-fold) and snapper (14-fold), decreased abundance (seven-fold) of urchins (a prey species of lobster and snapper), increased cover of kelp (which is grazed by urchins), increased abundance of gastropods associated with the kelp and decreases of limpets (which favour the barren habitat). These responses occurred over a period of 25 years. The snapper *Pagrus auratus*, lobster *Jasus edwardsii* and kelp *Ecklonia radiata* are the same species as found in South Australia.

Tasmania

Similarly to the New Zealand example, first and second order responses have been demonstrated in SZs within Tasmania over 10–15 years of monitoring (Barrett et al., 2007, 2009; Edgar et al., 2009, 2007; Buxton et al., 2006; Edgar and Barrett, 1999), for a suite of species found also in South Australia. The abundance of lobsters, particular large (legal size) individuals, increased by more than three-fold within the Maria Island Marine Reserve (seven kilometre coastline), and the mean (carapace) length increased by 3 cm. The overall biomass increased ten-fold. Smaller increases were found in the Tinderbox Marine Reserve (spanning two kilometres), and there were no significant differences within smaller reserves spanning only one kilometre. Boundary effects demonstrated by an increase in lobster size with distance into the reserve implied that full protection of rock lobsters requires an SZ spanning more than seven kilometres (Edgar et al., 2005). Some spill-over of large individuals outside the reserve was also demonstrated. Large reef fish, including the bluethroat wrasse *Notolabrus tetricus* (found in SA), showed variable responses to protection, with an increase of large individuals in a small reserve previously subjected to fishing pressure (Tinderbox), but no long-term change in the larger Maria Island Reserve, which was considered to have been less exposed to line fishing prior to protection.

Blacklip abalone showed a mixture of first and second order responses at Maria Island, with a 1 cm increase in the mean size of legal size abalone, but a ten-fold decrease in the number of sub-legal size abalone over the first ten years. A similar effect may have occurred at Tinderbox, but there was no effect at the two smallest Tasmanian reserves (Barrett et al., 2009). After 15 years of protection, the density of gastropods (mainly abalone and the turban shell, *Turbo undulatus*) had declined by approximately 60 per cent, relative to unfished populations.

The purple urchin, *Heliocidaris erythrogramma* (found in SA), also showed a second order decline in relative abundance of approximately 60 per cent over eight years (due to predation by large lobsters), after no change in the first seven years of protection (Edgar et al., 2009). The pencil urchin, *Goniocidaris tubaria* (also found in SA), experienced a ten-fold decline over ten years, and the long-spine urchin, *Centrostephanus rodgersi,* (similar to *C. tenuispinus* found in SA) also showed an isolated response.

No third order effect (on macroalgae) was demonstrated during the first ten years of protection (Edgar et al., 2007), but increases in macroalgae were observed over the subsequent five years (Babcock et al., 2010).

Predictions for South Australia

There were 1,553 tonnes of rock lobster and 453 tonnes of blacklip abalone harvested from South Australia in 2009–10 (Knight and Tsolos, 2011). The Tasmanian fisheries have the same species as in South Australia, similar levels of catch for rock lobster (Gardner and Ziegler, 2010), and an abalone catch approximately five times higher (Tarbath and Gardner, 2009). It is considered that similar first and second order responses to those observed in Tasmania could be expected in proposed SZs of an adequate size in SA. To get the full range of protection and ensure maintenance of ecological processes such as urchin predation, such zones should span more than 7 km. South Australia already has a number of Aquatic Reserves (and SZs in the Great Australian Bight Marine Park) that are closed to both lobster and abalone fishing, and four Lobster Sanctuaries (which exclude lobster fishing). No known surveys of these areas have been undertaken prior to protection. There have been only four areas for which any surveys are known to have been undertaken to compare communities inside and outside the unfished area:

- Surveys of fish, mobile invertebrates and macroalgae inside and outside the Point Labatt Aquatic Reserve (Currie and Sorokin, 2005, 2009). There were no significant differences between the blacklip abalone populations inside and outside the fished area. There were too few lobster (two outside, none inside) and greenlip abalone (nine inside, 14 outside) to make any statistically valid comparison. The area surrounding this Aquatic Reserve is a significant fishing ground for blacklip abalone and rock lobster but a less important ground for greenlip abalone. It is possible that the Aquatic Reserve was too small to protect lobsters which moved beyond the unfished area. The Aquatic Reserve also contains a breeding colony of Australian sea lions, so some localised level of lobster predation may be expected. It is also possible that illegal fishing has occurred inside the reserve which is in a very isolated location.
- Counts of lobster inside and outside Gleesons Landing and Margaret Brock Reef Lobster Sanctuaries (approximately 9.6 and 3.3 km^2, respectively) found no significant difference between abundances inside or outside the Lobster Sanctuaries (McGarvey, 2003). This may be due to movement from the relatively small unfished area.
- Surveys inside and outside Aldinga Aquatic Reserve (Edgar et al., 2009).

The food web diagrams for high and low profile subtidal reef (Appendix 6) show that a number of other species from a range of trophic levels are also extracted from South

Australian reef ecosystems. For example, additional second order effects on urchins and/or abalone may arise from higher abundances of snapper (PIRSA, 2010; Coleman and Mobley, 1984; Russell, 1983; Godfriaux, 1974), blue groper (Shepherd, 2006) or bluethroat wrasse (Shepherd and Clarkson, 2001) within SZs (refer Section 4.2.2—species responses in individual park impact statements), although lobsters have been found to be more important predators of urchins than demersal fishes (Pederson and Johnson, 2006).

First and second order responses can also be expected from the cessation of octopus fishing. Approximately 100 tonnes of octopus were caught in 2009–10, of which approximately 8 per cent was by the Marine Scalefish fishery (using traps), and the rest as byproduct of the lobster fisheries (Knight and Tsolos, 2011). The main octopus species associated with the lobster fisheries is the Maori octopus, *Octopus maorum,* which predates on lobsters in pots (Brock and Ward, 2004). Octopus catch rates have declined in recent years in both the northern and southern lobster fishing zones (Linnane et al., 2011a; 2011b). It is expected that Maori octopus abundances would have a positive first order response to the cessation of fishing in SZs. Assuming that some level of predation of lobsters also occurs in the wild, second order effects can be expected on lobster that would offset the first and second order responses (on abalone and urchins) associated with lobster in the absence of octopus predation.

Third order effects related to reduced urchin grazing are less likely to occur in South Australia. It has been shown that the purple urchin, *Heliocidaris erythrogramma,* normally feeds on drift algae but switches to bottom scraping at high densities, which tend to occur in sheltered, nutrient rich waters such as in eastern Australia (Livore, 2009). Barrens (resulting from bottom scraping) can occur at densities less than 10/m^2 (Valentine and Johnson, 2005), but this is twice the density recorded in sheltered waters in South Australia (Livore, 2009). Densities high enough to trigger a switch in feeding behaviour are not likely to occur in South Australia under the current conditions, and are less likely to occur in the future in areas where urchin predators are not fished.

Nevertheless, third order effects observed in Tasmania may have also been related to other grazers, e.g., blacklip abalone (Barrett et al., 2009), or the turban shell *Turbo undulatus*; and such effects would also be possible in South Australia.

Experience so far suggests that other, unforeseen, direct or higher order interactions may occur, highlighting the value that SZs provide as reference areas for understanding the ecological effects of fishing (Freeman and MacDiarmid, 2009; Edgar et al., 2007; Buxton et al., 2006; Langlois and Ballentine, 2005).

A1.4.5 Interactions in other ecosystems

The studies in Tasmania and New Zealand on the effects of no-take marine reserves on temperate reef ecosystems have provided insights as to what may occur in reef ecosystems inside SZs in SA. However, there are no equivalent studies to inform predictions of ecosystem response in seagrass and sand habitats. An apparently unique study of the effect of a no-take marine reserve on temperate surf-zone fish assemblages in South Africa found stock recoveries of exploited fish species following protection (Bennett and Attwood, 1991). However, similar studies have not been conducted for the types of fish assemblages found in SA waters.

In HPZs where benthic trawling is ceased on sand habitats, the abundance of prawns and bycatch organisms (crabs, bugs, small fish, etc.) may increase. This may in turn attract predators, e.g., snapper, which may then increase in abundance. The cessation of prawn trawling will also allow the regeneration of sessile invertebrates that are susceptible to trawl damage, e.g., razorfish, sponges, hammer oysters (see Tanner, 2005). While some of these taxa are very slow-growing and recovery may take many years, their return may result in flow-on ecosystem effects.

It is likely that the effects of fishing in other ecosystems will also involve ‘top-down’ predator-prey (second order) interactions where the removal of predators by fishing has led to changes in the abundance of prey species, with subsequent third and fourth order changes also possible. There is some evidence elsewhere (southern United States of America) that a top-down trophic cascade can occur in seagrass ecosystems in response to a decline in top level predators. The consequent increase in small fish predators (prey of the top level predators) can deplete populations of mollusc and crustacean grazers that suppress epiphyte loads (Williams and Heck, 2001; Heck and Valentine 2007). The consequent increase in epiphytic algae cover can reduce photosynthesis of the seagrass blades, eventually smothering the seagrass (Cambridge et al. 1986; Bryars et al., 2011). A similar scenario that involves human-induced eutrophication in conjunction with overfishing has recently been linked with seagrass losses in Sweden (Baden et al., 2012). In other parts of the world, notably the South China Sea and Yellow Sea, overfishing by fishing down the food chain and eutrophication have been blamed for enormous jellyfish blooms (Burchett, 1996; Richardson, 2009).

‘Bottom-up’ relationships appear less likely. Bottom-up relationships assume that food is a limiting factor for some species which may be less likely than predation (top-down effect) influencing population abundance. Goldsworthy et al. (2011) found that current sardine harvest levels are having an undetectable impact on higher order predators, whereas effects on birds were noted as a consequence of the mass sardine kills i.e., far greater mortality than current fishing level, that occurred in SA during March 1995 and October 1998, and which eventually affected the entire southern Australian sardine population (Fletcher et al., 1997; Gaughane et al., 2000; Griffin et al., 1997; Jones et al., 1997; Ward et al., 2001a; Ward et al., 2001b; Ward et al., 2001c). In addition, a modeling study found that temperate ecosystems within Jurien Bay Marine Park were characterized by bottom-up rather than top-down processes, with benthic primary production being a major limiting factor (Lozano-Montes et al., 2011).

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Appendix 2 List of Species Considered

A total of 205 species or species groups were selected as representative species for the impact assessment. The rationale for the selections is provided in Appendix 1.3.1.

Species/taxon	Common name	Subtidal habitat[1]	Trophic level[2]	Commercial fishing interaction?[3]	Recreational fishing interaction?[4]	Conservation concern[5]
Mammals						
Arctocephalus forsteri	New Zealand fur seal	R	4			P
Delphinus delphis	Common dolphin	SP	4	y		P
Eubalaena australis	Southern right whale	P	3			EA,W,VS,P
Neophoca cinerea	Australian sea lion	RS	4	y		VA,VS
Tursiops aduncus	Bottlenose dolphin	SP	4			W,P
Birds						
Chroicocephalus novaehollandiae	Silver gull		3			Ma
Cormorants	Cormorants		4			
Egrets	Egrets		3			Ma,Mi*
Eudyptula minor	Little penguin		4			Ma
Greenshanks	Greenshanks		3			Ma,Mi*
Haematopus fuliginosus	Sooty oystercatcher		4			
Haliaeetus leucogaster	White-bellied sea-eagle		5			Ma,Mi,VS
Herons	Herons		3			Ma*
Ibises	Ibises		3			Ma
Morus serrator	Australasian gannet		4			Ma
Pandion cristatus	Eastern osprey		5			Ma,Mi,R
Pelagodroma marina	White-faced storm petrel		4			Ma
Pelecanus conspicillatus	Australian pelican		4			Ma
Plovers	Plovers		3			Ma*,Mi*
Puffinus tenuirostris	Short-tailed shearwater		4			Ma,Mi
Sandpipers	Sandpipers		3			Ma,Mi
Snipes	Snipes		3			Ma,Mi
Spoonbills	Spoonbills		3			
Sterna bergii	Crested tern		4			Ma

Species/taxon	Common name	Subtidal habitat[1]	Trophic level[2]	Commercial fishing interaction?[3]	Recreational fishing interaction?[4]	Conservation concern[5]
Stints	Stints		3			Ma,Mi
Fishes, sharks and rays						
Acanthaluteres brownii	Spinytail leatherjacket	RG	3	y	g	
Acanthaluteres spilomelanurus	Bridled leatherjacket	RG	3	y	g	
Acanthopagrus butcheri	Black bream	SMGE	3	S2	y	
Achoerodus gouldii	Western blue groper	R	4	y	y	B(V)
Aldrichetta forsteri	Yelloweye mullet	SG	3	S3	y	
Ammotretis rostratus	Longsnout flounder	SM	3	y	y	
Argyrosomus japonicus	Mulloway	RSM	4	S2	y	
Arripis georgianus	Australian herring	P	3	S2	y	
Arripis truttaceus	Western Australian salmon	P	4	S2	y	
Carcharhinus brachyurus	Bronze whaler	RSP	5	S2	y	
Carcharhinus obscurus	Dusky whaler	RSP	5	S2	y	
Carcharodon carcharias	White shark	P	5	y		VA,Mi,P
Centroberyx gerrardi	Bight redfish	R	3	y	y	
Centroberyx lineatus	Swallowtail	R	3	y	y	
Cheilodactylus nigripes	Magpie perch	R		y	y	
Chrysophrys auratus	Snapper	R	3	S1	y	
Cnidoglanis macrocephalus	Estuary catfish	RSG		y	y	
Dactylophora nigricans	Dusky morwong	RSG	3	y	y	
Dasyatis brevicaudata	Smooth stingray	RS	4	y	g	
Engraulis australis	Anchovy	P	3	D2		
Favonigobius lateralis	Long-finned goby	SM	3			
Filicampus tigris	Tiger pipefish	RS	3	y		
Galeorhinus galeus	School shark	P	4	S2	y	
Genypterus tigerinus	Rock ling	RG	3	y	y	B(NT)
Geotria australis	Pouched lamprey	S				B(V)
Girella zebra	Zebrafish	R	2	y	y	
Gymnapistes marmoratus	Cobbler	SG	3	y	y	
Heterodontus portusjacksoni	Port Jackson shark	RG	3	y	y	
Hyporhamphus melanochir	Southern garfish	P	2	S1	y	
Isurus oxyrinchus	Shortfin mako	P	5	S2	y	

Species/taxon	Common name	Subtidal habitat[1]	Trophic level[2]	Commercial fishing interaction?[3]	Recreational fishing interaction?[4]	Conservation concern[5]
Kyphosus sydneyanus	Silver drummer	R	2		y	
Macquaria colonorum	Estuary perch	SE		y		B(E)
Meuschenia hippocrepis	Horseshoe leatherjacket	R	3	y	y	
Mordacia mordax	Short-headed lamprey	SE				B(V)
Mustelus antarcticus	Gummy shark	RS	4	S2	y	
Myliobatis australis	Eagle ray	RSG	3	y	g	
Nemadactylus valenciennesi	Blue morwong	R	3	y	y	
Neoodax balteatus	Weedy whiting	RG	3	y	y	
Notolabrus tetricus	Bluethroat wrasse	R	3	y	y	B(NT)
Odax cyanomelas	Herring cale	R	2			
Orectolobus maculatus	Spotted wobbegong	R	4	y	g	
Othos dentex	Harlequin fish	R	4	y	y	B(NT)
Parapercis haackei	Wavy grubfish	RS				
Paraplesiops meleagris	Southern blue devil	R	3	y		B(NT)
Parequula melbournensis	Southern silverbelly	SM	3	y		
Pelates octolineatus	Striped trumpeter	SG	3	y	y	
Pempheris multiradiata	Common bullseye	R				
Pentaceropsis recurvirostris	Longsnout boarfish	R	3	y	y	B(NT)
Phycodurus eques	Leafy seadragon	RG	3	y		Ma,P
Phyllopteryx taeniolatus	Weedy seadragon	R	3	y		Ma,P
Platycephalus bassensis	Sand flathead	SM	3	S3	y	
Polyprion oxygeneios	Harpuka	P		y	y	B(V)
Pseudaphritis urvillii	Congolli	SME		y		
Pseudocaranx georgianus	Silver trevally	P	3	y	y	
Pseudocaranx wrighti	Skipjack trevally	P	3	y	y	
Pseudorhombus jenynsii	Smalltooth flounder	S	3	y	y	
Rhombosolea tapirina	Greenback flounder	S	3	y	y	B(NT)
Sardinops sagax	Sardine	P	3	T		
Scobinichthys granulatus	Rough leatherjacket	G	3	y	g	
Scomber australasicus	Blue mackerel	P	3	y	y	
Scorpis aequipinnis	Sea sweep	R	3	S3	y	
Seriola lalandi	Yellowtail kingfish	P	4	S3	y	

Species/taxon	Common name	Subtidal habitat[1]	Trophic level[2]	Commercial fishing interaction?[3]	Recreational fishing interaction?[4]	Conservation concern[5]
Sillaginodes punctata	King George whiting	SMG	3	S1	y	
Sillago bassensis	School whiting	S	3	y	y	
Sillago schomburgkii	Yellowfin whiting	S	3	S2	y	
Siphamia cephalotes	Wood's siphonfish	RG	3			
Sphyraena novaehollandiae	Snook	RSGP	4	S2	y	
Stigmatopora argus	Spotted pipefish	RG	3	y		Ma,P
Stigmatopora narinosa	Southern gulf pipefish	RG	3	y		Ma,P,B(V)
Thamnaconus degeni	Degen's leatherjacket	RM	3	y		
Thunnus maccoyii	Southern bluefin tuna	P	4	y	Y	
Tilodon sexfasciatus	Moonlighter	R		y	Y	
Torquigener pleurogramma	Toadfish	S	3	y	y	
Trachinops noarlungae	Noarlunga hulafish	R				
Trygonorrhina dumerilii	Southern fiddler ray	RSG	4	y	g	
Upeneichthys vlamingii	Red mullet	RS	3	y	y	
Urolophus cruciatus	Banded stingaree	RS		y	g	
Urolophus orarius	Coastal stingaree	S	3	y		
Invertebrates						
Actinia tenebrosa	Waratah anemone	R	3			
Amoria undulata	Wavy volute	S	3	y		
Amphipods	Amphipods	RS	2			
Australostichopus mollis	Southern sea cucumber	RSMG	2			
Austrocochlea	Winkles	R	2			
Barnacles	Barnacles	R	2			
Bellidilia laevis	Smooth pebble crab	SMG	2			
Brittlestars	Brittlestars	R	2			
Cenolia trichoptera	Featherstar	R	3			
Centrostephinus tenuispinus	Long spine urchin	R	2			
Ceratosoma brevicaudata	Short-tail nudibranch	R	3			
Chitons	Chitons	R	2			
Comb jellies	Comb jellies	P	3			
Coscinasterias muricata	Eleven-armed seastar	RSM	3			
Dicathais orbita	Cartrut shell	R	3			

Species/taxon	Common name	Subtidal habitat[1]	Trophic level[2]	Commercial fishing interaction?[3]	Recreational fishing interaction?[4]	Conservation concern[5]
Donax deltoides	Pipi (Goolwa cockle)	S	2	T	y	
Equichlamys bifrons	Queen scallop	SG	2	y	y	
Galeolaria caespitosa	Coral worm	R	2			
Haliotis laevigata	Greenlip abalone	R	2	T	y	
Haliotis roei	Roe's abalone	R				
Haliotis rubra	Blacklip abalone	R	2	T	y	
Hapalochlaena maculosa	Blue-ringed octopus	RS	3			
Heliocidaris erythrogramma	Purple urchin	R	2	y		
Helograpsus haswellianus	Haswell's shore crab	M	2			
Herdmania grandis	Redthroat ascidian	R	2			
Isopods	Isopods	RSG	2			
Jasus edwardsii	Southern rock lobster	R	3	T	y	
Jellyfish	Jellyfish	P	3			
Katelysia spp.	Mud cockle	SM	2	S2	y	
Lepsiella vinosa	Veined rock shell	R	3			
Leptomithrax gaimardii	Spider crab	RS	3	y		
Limnoperna pulex	Flea mussel	R	2			
Limpets	Limpets	R	2			
Malleus meridianus	Hammer oyster	RS	2	y		
Marinula xanthosoma	Air breathing gastropod	RM	2			
Melicertus latisulcatus	Western king prawn	SM	2	T	y	
Mopsella klunzingeri	Gorgonian	R	2			
Mytilus galloprovincialis	Blue mussel	R	2			
Naxia aurita	Decorator crab	RG	3			
Nectocarcinus integrifrons	Seagrass swimmer crab	G	3	y		
Nerita atramentosa	Western black crow	R	2			
Nototodarus gouldii	Gould's squid	P	4	y	y	
Nyctiphanes australis	Southern krill	P	2			
Octopus berrima	Speckled octopus	RSG	3	y	y	
Octopus maorum	Maori octopus	RS	3	y	y	
Ovalipes australiensis	Sand crab	S	3	S2	y	
Ozius truncatus	Reef crab	R	3			

Species/taxon	Common name	Subtidal habitat[1]	Trophic level[2]	Commercial fishing interaction?[3]	Recreational fishing interaction?[4]	Conservation concern[5]
Paphies elongata	Surf clams	S	2			
Pecten fumatus	King scallop	S	2	y	y	
Phasianotrochus eximius	Giant kelp shell	R	2			
Phasianotrochus irisodontes	Maireener	RG	2			
Pinna bicolor	Razorfish	S	2	S3	y	
Plagusia chabrus	Red bait crab	R	3			
Plesiastrea versipora	Green coral	R	2			
Pleuroploca australasia	Tulip shell	RS	3			
Polinices conicus	Moon snail	S	3			
Polychaete worms	Polychaete worms	RSM	2	S3	y	
Portunus armatus	Blue swimmer crab	SG	3	T	y	
Pyura	Sea tulips	RG	2			
Salinator fragilis	Fragile air-breather	SM	2			
Salps	Salps	P	2			
Sea pens	Sea pens	SM				
Sepia apama	Giant cuttlefish	RG	3	S2	y	
Sepioloidea lineolata	Striped pyjama squid	SG	3			
Sepioteuthis australis	Southern calamary	RS	4	S1	y	
Sponges	Sponges	RSMG	2	y		
Thalotia conica	Conical top shell	RS	2			
Turbo undulatus	Turbo shell	R	2	y		
Zoila friendii thersites	Black cowry	RSG	3	y	y	
Macroalgae						
Caulerpa	*Caulerpa*	R	1	y		
Cystophora	*Cystophora*	R	1	y		
Durvillaea potatorum	*Durvillaea potatorum*	R	1	y		
Ecklonia radiata	*Ecklonia radiata*	R	1	y		
Enrusting coralline algae	Enrusting coralline algae	R	1	y		
Enteromorpha	*Enteromorpha*	R	1	y		
Epiphytic algae	Epiphytic algae	RG	1	y		
Hormosira banksii	*Hormosira banksii*	R	1	y		
Macrocystis	*Macrocystis*	R	1	y		

Species/taxon	Common name	Subtidal habitat[1]	Trophic level[2]	Commercial fishing interaction?[3]	Recreational fishing interaction?[4]	Conservation concern[5]
Microphytobenthos	Microphytobenthos	SM	1	y		
Red macroalgae	Red macroalgae	RSM	1	y		
Rhodoliths	Rhodoliths	R				
Sargassum	*Sargassum*	R	1	y		
Scaberia agardhii	*Scaberia agardhii*	R	1	y		
Turfing algae	Turfing algae	R	1			
Ulva	*Ulva*	RSG	1	y		
Seagrasses						
Amphibolis	*Amphibolis*	G	1	y		
Halophila	*Halophila*	G	1	y		
Heterozostera	*Heterozostera*	G	1	y		
Posidonia	*Posidonia*	G	1	y		
Ruppia	*Ruppia*	G	1	y		
Zostera muelleri	*Zostera muelleri*	G	1	y		R
Mangrove/saltmarsh						
Avicennia marina	Grey mangrove	M	1			
Halosarcia	*Halosarcia*	M	1			
Sarcocornia quinqueflora	*Sarcocornia quinqueflora*	M	1			
Sclerostegia arbuscula	*Sclerostegia arbuscula*	M	1			
Suaeda australis	*Suaeda australis*	M	1			
Other biota						
Bacteria	Bacteria					
Protozoa	Protozoa	P		y		
Phytoplankton	Phytoplankton	P	1			
Zooplankton	Zooplankton	P	2			
Infauna	Infauna	SMG	2			
Epifauna	Epifauna	SM	2			

[1] R = reef; S = sand; G = seagrass; M = mud

[2] Approximate trophic level as applied in Appendix 6

[3] S(1-3) = Marine scalefish primary, secondary, tertiary species; T = specific target fisheries (prawn, abalone, rock lobster, sardine); y = byproduct, bycatch or other interaction with the above fisheries, Lakes and Coorong Fishery or Miscellaneous fisheries (oyster, scallop, urchin, worms, giant crab, specimen shells and beach-cast seagrass/macroalgae)

[4] EA = Endangered, VA = Vulnerable, Mi = Migratory, Ma = Listed Marine, W = Cetaceans (all under the *EPBC Act 1999*); VS = Vulnerable, R = Rare (both under the *National Parks and Wildlife Act 1973*); P = protected under the *Fisheries Management Act 2007*; B() = Species of conservation concern documented by Baker (2009)—for species in or 'possibly in' categories of E = Endangered, V = Vulnerable, NT = Near Threatened); * indicates that not all species within a group have the respective status

Appendix 3 Species Profiles

Profiles of some protected and threatened species

A large number of marine species are protected in SA under either State legislation (*National Parks and Wildlife Act 1972, Fisheries Management Act 2007*) and/or Federal legislation (*Environment Protection and Biodiversity Conservation Act 1999*), including all syngnathids (seahorses, seadragons, pipefishes, and pipehorses), all marine mammals and most seabirds. Some of these species are also listed as threatened species under either State (*National Parks and Wildlife Act 1972*) and/or Federal legislation (*Environment Protection and Biodiversity Conservation Act 1999*). Listed threatened species may be in decline and/or at an unnaturally low level (UNLL) to the extent that they may be threatened with extinction. For threatened species there are often individual recovery plans that identify objectives/actions required to mitigate against threatening processes that will ultimately allow recovery of the species.

It was beyond the scope of the current project to assess all protected and threatened species, but the following nine species/species groups that were identified in the ecosystem food webs (see Appendix 6) and/or that are a key feature of many of the marine parks were selected for the impact assessment:

- Australian sea lion (threatened and protected species)
- Little penguin (protected species)
- New Zealand fur seal (protected species)
- White shark (threatened and protected species)
- Syngnathids including the leafy and weedy seadragon (protected species)
- Bottlenose dolphin (protected species)
- Common dolphin (protected species)
- Southern right whale (threatened and protected species)
- White-bellied sea eagle (threatened and protected species)

Brief discussions about each of these species/groups are made below, including their current status, biology, key threatening processes (if any), and how they may respond to the proposed zoning and management arrangements. Western blue groper, which is protected in parts of SA, is discussed in the fished species section later.

Australian sea lion (*Neophoca cinerea*)

Current status: Listed as a protected species under State (National Parks and Wildlife Act 1972, Fisheries Management Act 2007) and Federal legislation (Environment Protection and Biodiversity Conservation Act 1999). Listed as a threatened species under State (Vulnerable under the National Parks and Wildlife Act 1972) and Federal legislation (Vulnerable under the Environment Protection and Biodiversity Conservation Act 1999). A draft National recovery plan exists (DEWHA 2010a). Colony numbers were dramatically reduced by sealing which occurred mainly during the early 1800s. Despite being fully protected in SA for many years, most colonies are likely to still be at an unnaturally low level compared to a pre-European baseline. Pup production and population estimates are available for many of the colonies in SA. However, reliable population trend data are available for just a few colonies including Dangerous Reef (Sir Joseph Banks Group Marine Park), Seal Bay (Southern Kangaroo Island Marine Park), and the North and South Pages Islands (Encounter Marine Park) (see Goldsworthy et al. 2009). The population at Dangerous Reef is increasing (Goldsworthy et al. 2010), the population at Seal Bay is in a long-term decline (Goldsworthy et al. 2011a), and the Pages colonies appear stable (Goldsworthy et al. 2009).

Biology relevant to discussion: Each breeding colony or geographically-clustered group of colonies may constitute a genetically separate sub-population (Lowther et al. 2011). Each of the breeding colonies appears to operate in isolation and has different foraging grounds; even for colonies that are adjacent to one another such as at the Franklin Islands (Goldsworthy et al. 2010). Australian sea lions are benthic foragers, i.e., they hunt for food on the seabed. Adult foraging grounds often extend great distances (many tens of km's) from the land-based colonies and haul out sites (Goldsworthy et al. 2010).

Current threatening processes: Despite being fully protected in SA for many years, many colonies are not recovering and some are in decline. The main threatening process for many colonies is believed to be bycatch in the Commonwealth-managed shark demersal gillnet fishery (Goldsworthy et al., 2010). Negative interactions between the Australian sea lion and the gill nets can occur many kilometres away from colonies. Other threats also exist including human disturbance.

Impact of proposed zoning and management arrangements: Protection of important breeding, haul out and foraging areas is identified as important for the recovery of the Australian sea lion (DEWHA 2010a). RAZs, HPZs and SZs that include these areas will assist with future protection from damaging activities and uses. The implementation of RAZs that further restrict access to colonies (over and above existing restricted areas) may provide benefits to colonies by preventing disturbance (e.g. Kent and Crabtree 2008), which is particularly important during the pupping season (n.b. many colonies are already afforded this protection due to their locations within restricted access conservation parks, e.g. Neptune Islands, and new State government legislation for marine mammals will also limit approach distances).

The impact of zoning on the threat of shark gillnet bycatch will vary greatly on the locations of the different colonies and parks. Recent management changes and spatial closures have greatly restricted the amount of shark gillnet fishing within nearshore State waters. Thus most of the current negative interactions will occur offshore outside the marine park boundaries and some colonies may continue to decline regardless of the proposed zoning (n.b. very recent events have seen a dramatic reduction in shark gillnet fishing in adjacent Commonwealth waters and this will likely have a positive effect on many sea lion colonies). The implementation of RAZs and SZs around colonies will not change current fishing practices as spatial gillnet closures are already in place around all colonies. There is currently no evidence that fishing of species that are preyed upon by the Australian sea lion has a limiting role on population viability in the Australian sea lion (e.g. Goldsworthy et al., 2011b). However, two potential benefits could occur but cannot be predicted at this stage with any certainty due to a lack of ecosystem models:\

- If abundances of prey for the Australian sea lion, e.g. benthic fishes and invertebrates, increase inside the various zones once current fishing is ceased (see Fished Species section below), then this may assist in the survival of adults. (n.b. this would be most likely to occur in regular foraging grounds in zones away from the colony as adults do not generally feed close to the colony, see Goldsworthy et al. 2010), and

- As juveniles forage close to colonies (Goldsworthy et al. 2010), if abundances of prey increase inside the various zones around colonies, this may assist with the survival of juveniles and the learning of juveniles in capturing prey.

Little penguin (*Eudyptula minor*)

Current status: Listed as a protected species under State (*National Parks and Wildlife Act 1972*) and Federal legislation (*Environment Protection and Biodiversity Conservation Act 1999*). Not listed as a threatened species. Coarse population estimates for the entire State were compiled by Copley (1996). Recent population estimates and population trend data are available for only a few colonies. Little penguin numbers are declining in some regions (e.g. Victor Harbor, Bool et al. 2007) and there is some conservation concern for the species in these areas.

Biology relevant to discussion: Feeding grounds are away from land-based colonies but usually <40 km (Goldsworthy and Page 2010). Little penguins are pelagic foragers with anchovy an important component of their diet (Goldsworthy et al. 2011b).

Current potentially threatening processes: The abundance of little penguins in the Victor Harbor region has declined dramatically over the past decade (Bool et al. 2007, Natalie Gilbert, unpublished data for Granite Island). While there are several potential causes of this decline (including feral animals), an increase in abundance of the New Zealand fur seal and associated increase in predation on the little penguin is likely to be a contributing factor (see Page et al. 2005). The New Zealand fur seal was hunted historically but has been protected for many decades now. Its numbers are now thought to be returning to more ‘natural’ levels, i.e., pre-European settlement. It is possible that little penguin numbers actually increased during the past 200 years when New Zealand fur seal numbers and associated predation and competition were reduced (Page et al. 2005). If the decline in little penguins is actually due to New Zealand fur seal numbers returning to more natural levels then it must be considered as a natural process.

Impact of proposed zoning and management arrangements: The implementation of RAZs and SZs may not have any discernible impact on populations of little penguins. The little penguin is a pelagic forager and its diet (and thus survivorship) is not predicted to be affected by fishing restrictions within SZs. The pelagic prey species of little penguins (viz. anchovies) are one of the least likely groups of species to show a response to relatively small static SZs in the coastal zone. In addition there is no evidence to indicate that fishing of their prey species by the sardine fishery is limiting to populations of little penguins (see Goldsworthy et al. 2011b). There is also no evidence to suggest that an increase in other prey species due to the proposed management changes would cause the New Zealand fur seal to shift its diet away from little penguins; the New Zealand fur seal is also a pelagic forager and again the abundance of these mobile pelagic prey species may not be affected by static SZs (see Appendix 1).

The implementation of RAZs that further restrict access to colonies (over and above existing restricted areas, e.g., Neptune Islands) may provide benefits by preventing disturbance. RAZs and SZs (to a lesser extent) will also place restrictions on domestic animals which potentially represent a land-based threat to little penguins.

New Zealand fur seal (*Arctocephalus forsteri*)

Current status: Listed as a protected species under State (*National Parks and Wildlife Act 1972, Fisheries Management Act 2007*) and Federal legislation (*Environment Protection and Biodiversity Conservation Act 1999*). Not listed as a threatened species. Colony numbers were dramatically reduced by sealing which occurred mainly during the early 1800s. Population trend data are available for many colonies and population numbers are currently increasing across most of SA (Goldsworthy et al. 2007).

Biology relevant to discussion: Adult feeding grounds are generally many kilometres offshore from land-based breeding colonies (Goldsworthy et al. 2007). New Zealand fur seals are pelagic foragers with squids and little penguin forming important components of their diet (Goldsworthy et al. 2011b).

Current potentially threatening processes: There are no major current threats, and there is a strong recovery across SA. Negative interactions with some types of fishing gear can still occur (see Goldsworthy et al. 2007).

Impact of proposed zoning and management arrangements: Although there is currently no evidence that fishing of prey species limits New Zealand fur seal populations (e.g. Goldsworthy et al. 2011b), there is potential for greater availability of some fish prey species inside RAZs and SZs (see Fished Species section below). However, the pelagic species that New Zealand fur seals prey upon in offshore waters are some of the least likely to increase in abundance inside relatively small static sanctuary zones in the coastal zone.

White shark (*Carcharodon carcharias*)

Current status: Listed as a protected species under State (*Fisheries Management Act 2007*) and Federal legislation (*Environment Protection and Biodiversity Conservation Act 1999*). Listed as a threatened species under Federal legislation (Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999*). A National recovery plan and issues paper exist (DEWHA 2009, 2010b). There are few data available on current population sizes or population trends to inform whether or not the species is recovering.

Biology relevant to discussion: Highly migratory and capable of trans-oceanic migrations. However, many individuals have some pattern to their movements and regularly return to aggregation sites such as the Neptune Islands (DEWHA 2009).

Current threatening processes: Various threats have been identified including entanglement in fishing gear such as nets and long-lines, and in aquaculture nets (DEWHA 2009).

Impact of proposed zoning and management arrangements: Protection of aggregation sites from future damaging activities and uses may be important for the long-term recovery of the white shark (see DEWHA 2010b). RAZs and SZs that encompass aggregation sites and migration routes have potential to reduce bycatch mortality. There is potential for greater availability of some prey fish species inside RAZs and SZs (see Fished Species section below) but there is currently no evidence that fishing of prey species has any limiting role on white shark populations.

Syngnathids – seahorses, pipefishes, pipehorses, and the leafy seadragon (*Phycodurus eques*) and weedy seadragon (*Phyllopteryx taeniolatus*)

Current status: All syngnathid species are listed as protected species under State (*Fisheries Management Act 2007*) and Federal legislation (*Environment Protection and Biodiversity Conservation Act 1999*). No syngnathids are listed as threatened species. There are no published data available on current population sizes or population trends in SA, and no evidence to suggest that any of the species are immediately threatened. There is some anecdotal evidence of localized population declines of the leafy seadragon.

Biology relevant to discussion: Browne et al. (2008) provide a review of the biology of many syngnathids in SA. There are too many species to discuss in detail here other than to say that many have limited mobility and may be considered to be site-attached. Syngnathids also inhabit a range of habitats including seagrass beds, subtidal reefs, and subtidal sandy plains. Leafy and weedy seadragons have been shown to be site-attached with small home ranges (Connolly et al. 2002 Sanchez-Camara and Booth, 2004).

Current potentially threatening processes: The main threatening processes are probably habitat loss and habitat degradation. Illegal collection of leafy seadragons for the aquarium trade is perceived to be a threat by some groups at the more accessible dive locations, e.g. Rapid Bay, Wool Bay. Leafy and weedy seadragons, the big-belly seahorse *Hippocampus abdominalis* and Tiger pipefish *Filicampus tigris* are among the species recorded during bycatch surveys for the Spencer Gulf prawn trawl fishery (Currie et al. 2009).

Impact of proposed zoning and management arrangements: Future protection of habitats from damaging activities and uses in RAZs, SZs, and HPZs where syngnathids occur will assist with their long-term protection. The proposed zoning and any associated increase in compliance resources may provide a disincentive for illegal take (if it currently occurs). Prevention of current and future prawn trawling inside some SZs and HPZs will assist with the protection of species that are caught as bycatch.

Bottlenose dolphin (*Tursiops aduncus*)

There are actually two species of bottlenose dolphin in SA: the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) and the common bottlenose dolphin (*Tursiops truncatus*) (Kemper et al. 2008). *Tursiops aduncus* appears to favour sheltered bays and gulfs, while *T. truncatus* inhabits more oceanic waters (Kemper et al. 2008). Only *T. aduncus* is discussed here.

Current status: Listed as a protected species under State (*National Parks and Wildlife Act 1972, Fisheries Management Act 2007*) and Federal legislation (*Environment Protection and Biodiversity Conservation Act 1999*). Not listed as a threatened species. There are few published data available on current population sizes or population trends, and no evidence to suggest that the species is threatened.

Biology relevant to discussion: Occurs in social groups that are attached to areas, e.g., bays and inlets like the Port River area (Kemper et al. 2008). Feeds on a range of prey species including octopus, cuttlefish, squid, and various fish species (Goldsworthy et al. 2011b).

Current potentially threatening processes: Pollution, entanglement with aquaculture operations, and habitat degradation have been identified as potential threats in some areas (de Jong and Tanner 2004 Kemper et al., 2008). Rates of entanglement in finfish aquaculture cages have been dramatically reduced with changes in management practices (de Jong and Tanner 2004).

Impact of proposed zoning and management arrangements: Future protection of habitats from damaging activities and uses in RAZs, SZs, and HPZs where bottlenose dolphins occur will assist with their long-term protection. Although there is currently no evidence that fishing of prey species limits bottlenose dolphin populations, there is potential for greater availability of some fish prey species inside RAZs and SZs (see Fished Species section below).

Common dolphin (*Delphinus delphis*)

Current status: Listed as a protected species under State (*National Parks and Wildlife Act 1972, Fisheries Management Act 2007*) and Federal legislation (*Environment Protection and Biodiversity Conservation Act 1999*). Not listed as a threatened species. There are no published data available on current population sizes or population trends, and no evidence to suggest that the species is threatened.

Biology relevant to discussion: Highly mobile, and occurs in large pods. Feeds on a range of pelagic prey species including sardines and anchovies (Goldsworthy et al. 2011b).

Current potentially threatening processes: There is currently a very low level of bycatch mortality in the sardine purse-seine fishery (Ward et al. 2010). Removal of large quantities of sardine biomass by the sardine fishery is not thought to be having a measurable impact on the ecosystem (Goldsworthy et al. 2011b) and thus on the common dolphin.

Impact of proposed zoning and management arrangements: Sardine effort will be displaced by the SZs where it overlaps. As the common dolphins follow the sardine schools which are also highly mobile, it is envisaged that the current low level of interaction between the common dolphin and the sardine fishery will remain unchanged by the SZs due to the relatively small size of the zones and no removal of displaced effort from the sardine fishery. As sardines are highly mobile and there will be no reduction in total commercial catch, the SZs will be unlikely to have increased abundances of sardines. Thus it is expected that the SZs will have little or no influence on populations of the common dolphin.

Southern right whale (*Eubalaena australis*)

Current status: Listed as a protected species under State (*National Parks and Wildlife Act 1972, Fisheries Management Act 2007*) and Federal legislation (*Environment Protection and Biodiversity Conservation Act 1999*). Listed as a threatened species under State (Vulnerable under the *National Parks and Wildlife Act 1972*) and Federal legislation (Endangered under the *Environment Protection and Biodiversity Conservation Act 1999*). A National recovery plan exists (DEH 2005). Recent population estimates indicate that the southern Australian population that visits SA waters is recovering (Bannister 2006, Burnell 2007).

Biology relevant to discussion: Highly migratory, covering huge distances along migration paths. Aggregates in some locations in SA waters for several months each winter to give birth, viz. the head of the Great Australian Bight, Encounter Bay, and Fowlers Bay (DEH 2005).

Current threatening processes: Historically whaling was the key threatening process. Since whaling was banned, current threats include ship strikes, noise pollution, and entanglement in fishing gear (DEH 2005).

Impact of proposed zoning and management arrangements: Zoning that protects the important calving habitats from future harmful developments and uses will assist recovery of the species (see DEH 2005). RAZs and SZs can potentially reduce the chance of accidental entanglement in fishing gear in aggregation areas. Shipping activity and routes will not be changed by the zoning and management plans and thus the potential threat of a ship strike (which is probably relatively small within State waters) remains the same. RAZs and SZs will also prevent the use of motorized water sports that may cause noise pollution and disturb calving whales, which may add to the protection provided by existing regulations that limit the approach distance of vessels.

White-bellied sea eagle (*Haliaeetus leucogaster*) and Eastern osprey (*Pandion cristatus*)

Current status: Both species are listed as protected species under State (*National Parks and Wildlife Act 1972*) and Federal legislation (*Environment Protection and Biodiversity Conservation Act 1999*). Both species are listed as threatened species under State legislation (Endangered under the *National Parks and Wildlife Act 1972*). Recent population estimates are available for SA, with 70 to 80 pairs of sea eagle and 55 to 65 pairs of osprey (Dennis et al. 2011a). Both species have declined on the mainland (Dennis et al. 2008) and should be considered as being at UNLL.

Biology relevant to discussion: Sea eagles and ospreys probably have naturally low numbers due to density-dependent factors, i.e., adults have territories and the total population is limited by the amount of suitable coastline habitat for individual territories. Breeding in the sea eagle occurs over a protracted period and involves courting/nest lining, egg laying/incubation, and tending chicks (Dennis et al., 2011a).

Current threatening processes: The main threat to both species is from land-based human disturbance of nest sites, including rural land-use change leading to increased human activity, unregulated off-road vehicle access to remote locations on the mainland, and poorly conceived tourism developments (Dennis et al. 2011a, b). The white-bellied sea eagle appears to be more sensitive to human disturbance than the eastern osprey (Dennis et al. 2011a). Disturbance is a particular problem for the sea eagle during the breeding season when nesting pairs may abandon their nest, eggs and/or chicks (Dennis et al. 2011b). Noise pollution and disturbance from motorised jet-skis could also be a concern (Dennis 2008).

Impact of proposed zoning and management arrangements: The implementation of RAZs that further restrict access to nesting sites (over and above existing restricted areas, e.g., Neptune Islands) may provide benefits by preventing disturbance, which is particularly important during the breeding season. However, many nesting sites lie on the margins of marine parks often being located atop cliffs, especially for the sea eagle. In these instances, land-based access will not be influenced by the zoning and will require a separate management strategy. Nonetheless, if shore-based fishing is no longer allowed in an SZ that overlaps with breeding sites then potentially the amount of human traffic (associated with fishing) would decrease and this would be beneficial for sea eagles and ospreys. Restriction of motorised water sports inside RAZs and SZs could also be beneficial to sea eagles and ospreys. Although there is currently no evidence that fishing of prey species has any limiting role on sea eagle or osprey populations, there is potential for greater availability of some fish prey species inside RAZs and SZs (see Fished Species section below).

Profiles of indicator fished species

This section should be read in conjunction with Appendix 1.

South Australia's proposed system of marine parks was designed for biodiversity conservation purposes rather than as a fisheries management tool. Nevertheless, the impact assessment identified that fishing is a key current use which will be ceased inside some zone types. Consequently a total of 20 species were selected for further assessment (see Appendix 1.3.4). These 20 species comprise a mix of 13 high-value, high-production target species (many of which were assessed in the economic assessment of the current report) and seven non-target species that are intrinsically vulnerable to overfishing and/or are of conservation concern. This section presents brief profiles of the 20 species with the following sections: fishing activity, current level of protection, biology relevant to discussion, rationale for assigning current status, potential effect of zoning, and predictions of first order response. This information is presented to highlight what (if any) response these fished species may have to protection from fishing inside sanctuary zones (SZs). Some species may also have a specific response to protection within habitat protection zones (HPZs) where current prawn trawling ceases and these cases are also highlighted. Current levels of protection for each species under the *Fisheries Management Act 2007* (through catch limits and no-take Aquatic Reserves) are presented (see www.pir.sa.gov.au/fisheries for further information); no protection is currently afforded to any species of fish, crustacean or mollusc under the *National Parks and Wildlife Act 1972.* Additional information to that detailed in Appendix 1.3.3 is provided to explain the rationale for assigning the current status level of each species.

Some presentation of historical catch information is given below for each species, but is in no way intended as a commentary on the sustainability of the fishery. Rather, it is presented to argue that if fishing mortality is substantial, then there is **potential** for a positive first order (direct) response to the removal of fishing mortality of many species (see Haddon, 2007). Nonetheless, some first order species responses that are considered in isolation must be viewed with caution as they may be altered by higher order ecosystem interactions that are not fully understood (see Appendices 1.4.3, 1.4.4, and 1.4.5). For the species profiles presented below it is worth noting that: (1) Commercial catch data date back many years, or even decades, depending on the species, (2) Recreational catch data are available for 2000/01 (Jones and Doonan, 2005) and 2007/08 (Jones, 2009), and (3) Detailed records of charter fishing catch date back to 2005/06 (Knight et al., 2007).

In all of the discussions below on potential effects of no-take zones, it is assumed that the average size and abundance of the population in areas subjected to high fishing activity will be lowered compared to what would occur without fishing. This is an intrinsic effect of fishing and is not a negative reflection on fisheries management (see A1.3.3). In addition to individual fished species responses, there may be flow-on effects to the ecosystem (as highlighted by the food webs in Appendix 6, and discussed in sections A1.4.3, A1.4.4, and A1.4.5).

The table below indicates how the fished stage (usually adult) of each of the 20 species can potentially be protected from fishing within a sanctuary zone of a size that is typical of those proposed in the management plans, based upon their behaviour and site fidelity (see individual species profiles below for further detail). Further discussion on the various factors that influence the response of a fished species to protection within a no-take zone is provided in Appendix 1.3.7 and Table A1.3.

MAXIMUM		← Level of protection within sanctuary zone →		MINIMUM
Resident with sessile habit	**Resident with sedentary habit**	**Resident with home ranging habit**	**Resident at some locations**	**Temporary resident at some locations**
Razorfish	Blacklip abalone	Bluethroat wrasse	Snapper	Southern calamary
	Greenlip abalone	Harlequin fish	King George whiting*	Southern garfish
	Goolwa cockle	Western blue groper	Swallowtail*	Yellowfin whiting
	Mud cockle	Southern rock lobster	Bight redfish*	Western king prawn
			Sea sweep*	Blue swimmer crab
				Giant Australian cuttlefish
				Snapper

Note: the level of protection is indicative only and will be dependent on many factors including size of the sanctuary zone and variations in behaviour between locations. Patterns of behaviour are well known for some species but less so for others; the latter are indicated by *. Note that snapper and King George whiting are listed twice as individuals within populations can display different behaviours and the sub-adult stage of King George whiting may be more transient than the adult stage. Resident = the fished stage lives more or less permanently within a defined spatial area; with sessile species being attached to the seabed, sedentary species having limited ability to move around, and home ranging species having a home base(s) from where they roam. Temporary resident = the fished stage lives within a defined spatial area for a period that would allow some level of increased protection above having a migrant habit, e.g., in an adult spawning aggregation area, or in a sub-adult nursery area before moving away.

Razorfish (*Pinna bicolor*)

Fishing activity: Targeted by commercial and recreational fishers. Razorfish are harvested for use as bait and for human consumption. Commercial production was 10 tonnes in 2009/10 (Knight and Tsolos, 2011). Recreational harvest was estimated at almost 150,000 individuals or 149 tonnes for 2007/08 (Jones, 2009). Harvesting occurs mainly in intertidal sand/seagrass flats in locations that are accessible at low tide by shore or by boat.

Current level of protection: Stocks are managed by PIRSA Fisheries and some aspects of management that relate to protection are mentioned here; readers are directed to www.pir.sa.gov.au/fisheries for more detailed information on management arrangements. A recreational bag limit exists. Commercial limits exist. Some existing no-take Aquatic Reserves contain razorfish where their take is prohibited, e.g. Whyalla-Cowleds Landing and Yatala Harbour..

Biology relevant to discussion: Razorfish are sessile and relatively long-lived (up to 16 years), often occur in dense patches, and have high recruitment variability (Butler, 2008). Razorfish have a larval stage that allows dispersal. Their life history strategy is a ‘storage effect’ whereby adults are long-lived and successful recruitment does not need to occur each year. Due to this strategy, razorfish are particularly vulnerable to fishing as they will not respond to fishing by increasing recruitment levels as occurs in some other species (Butler, 2008). Spawning of razorfish is probably similar to scallops and abalone in that fertilization success is greatly enhanced with higher densities of individuals (Butler, 2008 Shepherd, 2008).

Current status and rationale: Stock assessments have not been undertaken and no known current population estimates exist. There is anecdotal evidence of localised depletions in some intertidal areas where fishing activity is high (Butler, 2008). An unpublished Honours study conducted in Smoky Bay showed that razorfish abundance was higher inside oyster leases compared to outside; with the difference attributed to lower levels of harvesting inside the leases where public access is restricted (Krastev, 2001). Subtidal razorfish populations can be affected by prawn trawling (Tanner, 2005). Using a precautionary approach based upon their vulnerability to overfishing and the recorded recreational and commercial catches, razorfish were assigned a status of UNLL in intertidal areas where recreational fishing effort is greatest (using spatial data derived from Jones, 2009, and local knowledge) and where shore-based access is possible. Spatial data on commercial catches were unavailable to contribute to the assessment.

Potential effect of zoning: Due to the sessile nature of razorfish, SZs would offer a high level of protection from fishing for patches of this species. Existing populations would be protected from future harvesting and could provide a long-term storage bank to supply recruits to areas both inside and outside an SZ. Nonetheless, long-term maintenance of razorfish inside an SZ would be dependent on periodic recruitment from either within the SZ or from outside. SZs would also provide an area for post-larval settlement to occur such that cohorts can grow to adult-hood undisturbed. As recruitment is patchy in space (Butler, 2008), large SZs and a network of nearby SZs (with larval connectivity) would assist in providing for protected areas where cohorts of post-larvae could settle and grow. HPZs will be of benefit for subtidal populations of razorfish in areas where prawn trawling is ceased, such that recovery may occur or by protecting intact populations from future trawling. As spawning occurs in all areas where adults occur, additional larval export is possible where there is potential for an increase in abundance. Due to the sessile nature of razorfish, spill-over of adults into areas outside SZs is not possible. It is more likely that density-dependent factors such as competition would limit the abundance of razorfish in areas without fishing mortality.

Predictions of first order response: It was assumed that wherever suitable habitat inside an SZ overlapped with the regions of the State where razorfish are known to occur and the current status was UNLL, then the population inside the SZ was predicted to have potential to increase in average size and abundance. As most harvesting of razorfish occurs in intertidal or shallow subtidal seagrass/sand habitats, predictions were restricted to zones that included these habitats. In addition, because razorfish are sessile, an SZ of any size has potential for a response to protection. As spawning occurs in all areas where adults occur, predictions of additional larval export were made where there was potential for an increase in abundance. As adults are sessile, spill-over of razorfish outside of SZs was not predicted.

Greenlip abalone (*Haliotis laevigata*) and blacklip abalone (*Haliotis rubra*)

Fishing activity: Targeted by commercial and recreational fishers. Commercial fishing occurs across most of the State waters (where regulations and depths allow dive fishing on suitable reef habitat), even in the most remote and exposed locations. Historical commercial fishing dates back to the 1960s (Mayfield et al., 2008), presumably when the advent of diving gear allowed access to subtidal waters. Commercial production for both species combined was 855 tonnes in 2009/10 (Knight and Tsolos, 2011). Recreational fishing catch is much lower; in 2007/08 it was estimated at around 3 tonnes for both species combined (Jones, 2009). Fishing occurs on subtidal low profile reef (mainly for greenlip) and subtidal high profile reef (mainly for blacklip).

Current level of protection: Stocks are managed by PIRSA Fisheries and some aspects of management that relate to protection are mentioned here; readers are directed to www.pir.sa.gov.au/fisheries for more detailed information on management arrangements. Commercial limits exist. Recreational size and bag limits exist. Some existing no-take Aquatic Reserves contain greenlip and blacklip abalone, e.g. Point Labatt.

Biology relevant to discussion: Both species are relatively long-lived (>10 years, but growth rates vary greatly between locations); they occur in meta-populations that are largely isolated from one another; and they occur in aggregations that make localised depletions possible (Shepherd et al., 2001). Abalone have a larval stage that allows dispersal but it appears that in many cases larval dispersal is limited and individual reefs are self-sustaining (Shepherd, 2008; Miller et al., 2009). Nonetheless, larval dispersal between reefs does occur (Shepherd, 2008; Miller et al., 2009). Post-larvae, juveniles and adults are found in the same reef habitat, i.e., after post-larval settlement the abalone do not move far.

Current status and rationale: Regular stock assessments and stock status reports are available at a relatively fine spatial scale (e.g. Mayfield and Hogg, 2011; Stobart et al., 2011). While the overall stocks are managed sustainably (e.g. Mayfield and Hogg, 2011; Mayfield et al., 2011), it was assumed that wherever substantial harvesting occurs then abalone size and abundance will be at a lowered level than would occur without fishing. In addition, serial depletion of reefs can occur (Shepherd et al., 2001; Shepherd, 2008). Based upon historical fishing activity and catches, and spatial patterns of displaced commercial catch over the past 20 years (as estimated by SARDI, 2011 and Ward and Burch, 2012), a current status of UNLL was generally assigned for an SZ where the displaced catch within an area was greater than a set threshold value and in SZs where suitable reef habitat occurred. The threshold value, while somewhat arbitrary (and which cannot be stated here because of confidentiality issues), was designed to eliminate areas with considerable uncertainty about where some of the relatively small catches are actually taken within a park and whether they are having a measurable impact on the populations within a proposed SZ. It is acknowledged that if the low catches are the result of abalone being naturally rare within an area then even small catches could have a significant impact on the local population, but it was considered that there was too much uncertainty to assess such areas. In a few cases, additional information on commercial fishing activity, which was not evident from the Ward and Burch (2012) data, and/or recreational fishing activity were used to assign a status of UNLL.

Potential effect of zoning: As greenlip/blacklip abalones are sedentary, SZs would offer a high level of protection from fishing for populations of abalone. In a previously fished population, simple first order predictions would indicate that an increase in size and abundance of the population would occur. However, it is possible that second order interactions with higher order predators such as southern rock lobster and snapper may influence such predictions (see Appendix 1.1.4). Any future increases in abundance of previously fished populations will also depend on the existing density of reproductively mature individuals, as the success of fertilisation, i.e. the chance of a sperm meeting an egg, is highly dependent on the males and females being close enough to one another (Shepherd, 2008). In low density populations responses could potentially be slower (unless recruitment occurs from outside an SZ) or if densities of adults are too low, then successful reproduction may not occur at all. In addition, some populations are reliant on larval recruits from other populations, i.e. they are 'sinks' rather than 'sources', (Shepherd, 2008) so in these cases a response may not occur if the source population is depleted and recruits do not arrive. Conversely, an accelerated response may be observed in populations with a density already near the threshold required for successful reproduction or which are sinks for larval recruitment. Even though dispersal distances can sometimes be relatively small (Shepherd, 2008), a protected population could potentially provide larval export that assists populations outside an SZ. If abalone numbers are enhanced inside an SZ then spill-over of adults into areas outside the SZ is unlikely due to the sedentary nature of the species. If an increase does occur then at some time density-dependent factors will likely place limits on the population density and size structure; for example in some areas of the South East abalone are naturally stunted (Mayfield and Hogg, 2011) probably due to competition between individuals for limited food resources.

Predictions of first order response: For the purposes of predictions in the present study, it was assumed that wherever suitable habitat inside an SZ overlapped with the regions of the State where abalone are known to occur and the current status was UNLL, then the population inside the SZ was predicted to have potential to increase in average size and abundance. In addition, because abalone is very sedentary, an SZ of any size has potential for a response to protection. As spawning occurs in all areas where adults occur, predictions of additional larval export were made where there was potential for an increase in abundance (even though it is acknowledged that actual larval dispersal can be spatially limited). As adults are very sedentary, spill-over of abalone outside of SZs is unlikely and was not predicted.

Goolwa cockle or pipi (*Donax deltoides*)

Fishing activity: Targeted by commercial and recreational fishers. Traditional harvesting was for use as bait but recent increases in commercial harvesting have been for human consumption. Commercial catch data date back to the 1980s (see Ferguson and Mayfield, 2006). Commercial production was 301 tonnes in 2009/10 (Knight and Tsolos, 2011). Recreational harvest was estimated at 5 tonnes for 2007/08 (Jones, 2009). Fishing occurs at a limited number of high-energy beaches where the species is found in SA, viz. Coorong beaches and Gunyah Beach.

Current level of protection: Stocks are managed by PIRSA Fisheries and some aspects of management that relate to protection are mentioned here; readers are directed to www.pir.sa.gov.au/fisheries for more detailed information on management arrangements. Recreational size and bag limits exist. Commercial limits exist.

Biology relevant to discussion: Short-lived (<5 years) and fast-growing species (Ferguson and Mayfield, 2006). Pipi have a larval stage that allows dispersal. Juveniles and adults are found in the same beach habitat, but they can move along beaches using prevailing currents. Occur in high density aggregations that are amenable to efficient harvesting.

Current status and rationale: Stock assessments and stock status reports are available (e.g. Ferguson and Mayfield, 2006; Fowler et al., 2010a; Ferguson, 2011). Overharvesting has previously occurred in the two locations where Goolwa cockles are mainly found in SA; The Coorong beaches within the Encounter and Upper South East Marine Parks (Ferguson and Mayfield, 2006), and Gunyah Beach within Thorny Passage Marine Park (anecdotal evidence). Management measures have been implemented to reduce commercial and recreational catches along The Coorong beaches and Gunyah Beach. The most recent stock status report for pipi in the Lakes and Coorong Fishery indicates there is still some cause for concern along The Coorong beaches (Ferguson, 2012). As overharvesting may have occurred in the locations along The Coorong beaches that overlap with proposed SZs (see Ward and Burch, 2012), a current status of UNLL was assigned (note that no SZs are proposed for Gunyah Beach).

Potential effect of zoning: While Goolwa cockles are sedentary in habit, they can be moved considerable distances along beaches by water currents. Nonetheless, if an SZ is sufficiently large then a high level of protection from fishing is possible. The Goolwa cockle is a relatively fast-growing and early-maturing species (Ferguson and Mayfield, 2006) that is likely to respond quickly to the cessation of fishing mortality in areas where high levels of harvesting have occurred. In the absence of fishing mortality, abundance is predicted to increase rapidly and may reach a point where density-dependence and intra-specific competition becomes a factor. If this is the case then individuals are likely to move along the beach, and spill-over into areas outside SZs may occur. Larval export is also likely to occur from within a SZ as reproductive output will be enhanced by the increased abundance of adults. As there is likely to be self-replenishment of local populations, the abundance of cockles within a zone can potentially continue to accumulate for many years. As recruitment can be highly variable, predictions have assumed that abundance has the potential to continue to increase to 20 years post-protection, notwithstanding possible density-dependent limitations.

Predictions of first order response: It was assumed that wherever suitable habitat inside an SZ overlapped with the regions of the State where cockles are known to occur and the current status was UNLL, then the population inside the SZ was predicted to have potential to increase in average size and abundance. As spawning occurs in all areas where adults live, predictions of additional larval export were made where there was potential for an increase in abundance. As adults can be moved by currents, spill-over of cockles outside of SZs was also predicted.

Southern rock lobster (*Jasus edwardsii*)

Fishing activity: Targeted by commercial and recreational fishers. Commercial fishing has occurred historically across almost all State waters (where regulations allow and where suitable reef habitat and lobsters are found) but catch rates and catches are non-uniform (McGarvey and Linnane, 2009). Historical fishing dates back to the 1890s but the commercial fishery did not develop until the late 1940s/early 1950s (Linnane et al., 2011a). Commercial production was 1,553 tonnes in 2009/10 (Knight and Tsolos, 2011). Recreational harvest was estimated at 60 tonnes for 2007/08 (Jones, 2009).

Current level of protection: Stocks are managed by PIRSA Fisheries and some aspects of management that relate to protection are mentioned here; readers are directed to www.pir.sa.gov.au/fisheries for more detailed information on management arrangements. Recreational size and bag limits exist. Commercial limits exist. Some existing no-take Aquatic Reserves and Rock Lobster Sanctuaries contain southern rock lobster, e.g. Point Labatt.

Biology relevant to discussion: Relatively long-lived (20 years), usually site-attached with sedentary nature, and high annual recruitment variability in some areas (Edgar, 2008, Linnane et al., 2011a, b). Southern rock lobsters have an extended larval stage that allows long range dispersal. Post-larvae, juveniles and adults are found in the same types of reef habitats.

Current status and rationale: Regular stock assessments and stock status reports are available which document the status of the fishery (e.g. Linnane et al., 2011a, b).

The Northern Zone stock is considered to be over-fished and the Southern Zone stock has shown signs of decline (Linnane et al., 2011a, b). Based upon the known widespread historical fishing activity and spatial patterns of displaced commercial catch (as estimated by Ward and Burch, 2012), a current status of UNLL was generally assigned for an individual SZ where the displaced catch across SZs collectively within each park was >500 kg as a 17 year average and the SZ contained suitable reef habitat. The threshold value, while somewhat arbitrary, was designed to eliminate areas with considerable uncertainty about where the relatively small catches are actually taken within a park and whether they are having a measurable impact on the populations within a proposed SZ. It is acknowledged that if the low catches are the result of lobster being naturally rare within an area, e.g., Franklin Harbor Marine Park, then even small catches could have a significant impact on the local population, but it was considered that there was too much uncertainty to assess such areas. In addition, the commercial threshold value does not account for recreational catch which may be significant in some parks such as the Encounter Marine Park, Upper South East Marine Park, and Lower South East Marine Park (Currie et al., 2006); in cases where recreational catch was believed to be a factor (and commercial displacement was <500 kg) a status of UNLL was also applied.

Potential effect of zoning: Southern rock lobster are generally site-attached, although they can sometimes make long distance migrations. Thus in most cases RAZs and SZs can provide a high level of protection from fishing. Studies from New Zealand and Tasmania have clearly shown that southern rock lobsters are likely to show a positive response to protection from fishing inside appropriately-sized no-take zones (see Appendix 1.4.4). Several kilometres of coastline appear to be necessary to provide a high level of protection for populations of southern rock lobster (see Appendix 1.4.4).

Predictions of first order response: It was assumed that wherever suitable habitat inside an SZ overlapped with the regions of the State where lobsters are known to occur and the current status was UNLL, then the population inside the SZ was predicted to have potential to increase in average size and abundance. Nonetheless, it is well known that settlement of post-larval southern rock lobster is highly variable from year to year and across different parts of the State; thus an increase in abundance may not always eventuate or it may take much longer in some locations than others. As spawning probably occurs in all areas where adults occur, predictions of additional larval export were made where there was potential for an increase in abundance. It was assumed that once a population reaches a certain level, spill-over of adults into adjacent areas outside of a SZ would be possible. In reality this may not always occur; for example where an isolated section of reef is surrounded by unsuitable habitat such as sand, lobsters may not move away from the reef (Freeman et al., 2009).

Mud cockle (*Katelysia* spp.)

Fishing activity: Targeted by commercial and recreational fishers. Traditional harvesting was for use as bait but recent increases in commercial harvesting have been for human consumption (Gorman et al., 2011). Historical commercial fishing dates back to the 1960s (Gorman et al., 2010). Commercial production was 99 tonnes in 2009/10 (Knight and Tsolos, 2011). Recreational harvest was estimated at 1 tonne or ~92,000 individuals for 2007/08 (Jones, 2009). Commercial harvest has historically focused on a few areas: Port River, Coffin Bay, and some of the west coast bays (Gorman et al., 2010, 2011).

Current level of protection: Stocks are managed by PIRSA Fisheries and some aspects of management that relate to protection are mentioned here; readers are directed to www.pir.sa.gov.au/fisheries for more detailed information on management arrangements. Recreational size and bag limits exist. Commercial limits exist. Some existing no-take Aquatic Reserves probably contain mud cockles, e.g. Whyalla-Cowleds Landing and Yatala Harbour.

Biology relevant to discussion: There are actually three species of mud cockle that are harvested: *Katelysia peroni*, *K. scalarina* and *K. rhytiphora* (Gorman et al., 2010). Mud cockles are relatively long-lived (at least 10 years for *K. scalarina*), slow-growing, and late-maturing (Cantin, 2010). Juvenile recruitment events are also infrequent. Mud cockles have a larval stage that allows dispersal. Post-larvae, juveniles and adults are found in the same types of habitat, i.e., after post-larval settlement the cockles do not move far. The species appears to employ a life-history strategy known as the 'storage effect' (see Butler, 2008) whereby long-term persistence of the species is reliant upon storage banks of long-lived adults that only need to successfully recruit on an infrequent basis. If the storage bank of these adults is lost then the capacity to reproduce may also be lost.

Current status and rationale: Stock assessments and stock status reports are available (e.g. Gorman et al., 2010, Fowler et al., 2010a). Over-harvesting has occurred previously in some areas, e.g., Coffin Bay, Port River, but now that it is recognised that the biology of the species makes it vulnerable to over-exploitation, the commercial catch is managed more conservatively. The most recent biomass assessment discusses the need for a continued conservative approach to fisheries management of mud cockles (Dent et al., 2012). Based upon the limited number of locations where mud cockles can be harvested in significant quantities and their vulnerability to over-harvesting, a current status of UNLL was assigned wherever there was an overlap of mud cockle habitat in areas of highest commercial catch (Gorman et al., 2011) and/or recreational fishing activity (data derived from Jones, 2009, and local knowledge).

Potential effect of zoning: As mud cockles are sedentary, SZs would offer a high level of protection from fishing. The protection of mud cockles inside SZs where fishing has occurred previously is predicted to result in an increase in the size and abundance of mud cockles towards a more natural population level. Even if mud cockle populations are not enhanced (because fishing has not occurred there previously) the SZs will provide refuges for the maintenance of natural populations. The protection of mud cockles from fishing within SZs could have benefits to harvested areas outside the SZs if larval export results in successful recruitment to those areas.

Predictions of first order response: It was assumed that wherever suitable habitat inside an SZ overlapped with the regions of the State where cockles are known to occur and the current status was UNLL, then the population inside the SZ was predicted to have potential to increase in average size and abundance. As harvesting of mud cockle occurs in intertidal sand habitat, predictions were restricted to zones that included this habitat type. In addition, because mud cockle is very sedentary, it was considered that an SZ of any size has potential for a response to protection. As spawning occurs in all areas where adults occur, predictions of additional larval export were made where there was potential for an increase in abundance. As adults are very sedentary, spill-over of cockles outside of SZs is unlikely and was not predicted.

Western blue groper (*Achoerodus gouldii*) and harlequin fish (*Othos dentex*)

Fishing activity: Both species are captured by commercial, recreational and charter fishers, but are rarely targeted (Fowler et al., 2009; Bryars et al., 2011). During the 1960–70s recreational spearfishers and commercial fishers did target blue groper (Johnson, 1982). Recreational harvest for 2007/08 was estimated at 714 and 240 individuals of western blue groper and harlequin fish, respectively (Jones, 2009). Charter harvest in 2008/09 for western blue groper was 49 fish (Knight, 2010). Separate charter harvest data for harlequin fish were not presented by Knight, (2010). Separate commercial production data for western blue groper and harlequin fish were not presented by Knight and Tsolos (2011). Fishing for both species occurs over subtidal high profile reef.

Current level of protection: Stocks are managed by PIRSA Fisheries and some aspects of management that relate to protection are mentioned here; readers are directed to www.pir.sa.gov.au/fisheries for more detailed information on management arrangements. A high level of protection exists for western blue groper (fully protected in central part of SA, and restrictive recreational size and bag limits elsewhere). No recreational catch limits exist for harlequin fish but a few commercial restrictions exist (some minor restrictions on take by some commercial sectors, e.g. it is not on rock lobster list of permitted species). Commercial harvest of western blue groper is currently restricted to a 50 kg trip limit for fishers in the Commonwealth-managed Southern and Eastern Scalefish and Shark Fishery. Some existing no-take Aquatic Reserves contain western blue groper, e.g. Point Labatt, and harlequin fish, e.g. Aldinga Reef.

Biology relevant to discussion: Both species are long-lived (>40 years), adults are site-attached with small home ranges, and susceptible to serial depletion of reefs over time (Coulson et al., 2009; Bryars, 2010, 2011; Bryars et al., 2011, 2012a,b; Saunders et al., 2010; Baker, 2011). Blue groper is a sex-changing species which further increases its susceptibility to fishing through selective removal of the larger males (Coulson et al., 2009). Both species suffer from barotrauma when captured from depth and their rates of post-release survival may be low (McLeay et al., 2002, Bryars et al., 2011). Both species are near the eastern extent of their range and appear to be naturally uncommon in the SE of SA. Both species have been identified as being of conservation concern in SA (Baker, 2011). Adult blue groper recruit to the deeper more exposed locations as sub-adults having originated from sheltered reef locations that act as nurseries (Shepherd and Brook, 2007), i.e., the adult habitat can be spatially separated from the juvenile habitat. Locations of juvenile habitat for harlequin fish are unknown. Both species have a larval phase which allows dispersal.

Current status and rationale: Stock assessments have not been made and no known current population estimates exist. Anecdotal information on abundances of blue groper indicates that numbers declined in the central parts of SA during the 1960–70's due to spearfishing activity (Johnson, 1982). Survey data shows an absence of large adult blue gropers in central parts of the State possibly partly due to historical fishing (Shepherd and Brook, 2007) and continued issues with barotrauma of released protected fish. Blue gropers are captured at offshore islands and reefs by charter fishers but are not necessarily targeted. However, when charter fishers (and commercial fishers) are targeting other species, e.g. Bight redfish, snapper, it may be difficult to avoid hooking blue gropers. Harlequin fish is a prized catch for recreational/charter fishers when targeting other reef species and is rarely released. Harlequin fish populations appear to be naturally low in SA, with only some hotspots of abundance (Bryars, 2010; Bryars et al., 2011). Anecdotal evidence exists for localised depletions of harlequin fish in some areas (Bryars, 2010; Bryars et al., 2011, Bryars unpublished data).

Based upon anecdotal reports of declines and recorded catches, both species were assigned a status of UNLL in reef areas where recreational and charter fishing effort is greatest (using spatial data derived from Jones, 2009, and data in Knight, 2010) and where shore-based access is possible. While there is some uncertainty about assigning them with UNLL, it was felt that their vulnerability to fishing required a precautionary approach to assigning current status. Spatial data on commercial catches were unavailable to contribute to the assessment. In lightly-fished or inaccessible areas a status of NL was assigned.

Potential effect of zoning: SZs would provide a high level of protection for populations of adult western blue groper and harlequin fish. Due to barotrauma issues, neither species is able to be fully protected through catch restrictions; no-take SZs can reduce fishing mortality to zero. To be effective, SZs must be of an adequate size to encompass the home ranges of a population of individuals. For adult blue groper and harlequin fish several km's of coastline appears to be adequate in coastal reef situations (Bryars et al., 2011, 2012a,b; Bryars unpublished data).

Predictions of first order response: It was assumed that wherever suitable reef habitat inside an SZ overlapped with the regions of the State where adult fish are known to occur and the current status was UNLL, the population inside the SZ was predicted to have potential to increase in average size and abundance. As spawning is assumed to occur in all areas where adults live, predictions of additional larval export were made where there was potential for an increase in abundance. It was assumed that once a population reaches a certain level, spill-over of adults into adjacent areas outside of a SZ would be possible. In cases where the population was at NL a prediction of maintaining the current status was made, but it is possible that fishing activity over the next 20 years may increase or be sustained..

Bluethroat wrasse (*Notolabrus tetricus*)

Fishing activity: Traditionally has not been a target species and considered to be an unwanted catch. However, recent recreational catch data indicates significant harvest, and the commercial fishery is possibly expanding with a live export fishery. It is possible that harvest of bluethroat wrasse may increase as demand and markets change (as has happened with other species in the past, e.g., southern calamary, pipi). Commercial catch data are unavailable for bluethroat wrasse but are available for 'parrotfish' which includes bluethroat wrasse. Commercial production of parrotfish was 20 tonnes in 2009/10 (Knight and Tsolos, 2011). Recreational harvest of bluethroat wrasse was estimated at ~5,000 individuals for 2007/08, although the catch was much higher at ~24,000 fish (Jones, 2009) and the post-release survival rate of the ~19,000 fish is unknown. Fishing occurs over subtidal high profile reef.

Current level of protection: Stocks are managed by PIRSA Fisheries and some aspects of management that relate to protection are mentioned here; readers are directed to www.pir.sa.gov.au/fisheries for more detailed information on management arrangements. No regulations on recreational take exist. Commercial limits exist. Some existing no-take Aquatic Reserves contain bluethroat wrasse, e.g. Point Labatt.

Biology relevant to discussion: Abundances are naturally high and it is one of the dominant reef fishes in many locations across SA. However, it is relatively long-lived

(>20 years), is site-attached, has a small home range, and is therefore susceptible to serial depletion of reefs over time (Bryars et al., 2011, Saunders et al., 2010, Baker, 2011). Bluethroat wrasse is a sex changing species which increases its susceptibility to fishing through selective removal of the larger males (Shepherd et al., 2009). Adults and sub-adults are found in the same locations. The species has a larval phase which allows dispersal.

Current status and rationale: Stock assessments have not been undertaken and no known current population estimates exist. Parrotfish (*Notolabrus* spp.) are included in stock status reports (e.g. Fowler et al. 2010a). The most recent stock status report indicates that harvesting of parrotfish is occurring within sustainable limits (Fowler et al., 2011b). Nonetheless, data from extensive diver surveys and fish counts are available and they indicate that localised impacts on populations have occurred in areas exposed to increased fishing activity (Shepherd et al., 2009). Using a precautionary approach based upon their vulnerability to overfishing, published data on localised depletions and recorded recreational and commercial catches, bluethroat wrasse were assigned a status of UNLL in reef areas where recreational fishing effort is greatest (using spatial data derived from Jones, 2009) and where shore-based access is possible. While there is some uncertainty about assigning them with UNLL, it was felt that their vulnerability to fishing required a precautionary approach to assigning current status. Spatial data on commercial catches were unavailable to contribute to the assessment. In lightly-fished or inaccessible areas a status of NL was assigned.

Potential effect of zoning: SZs would provide a high level of protection for populations of adult bluethroat wrasse. To be effective, SZs must be of an adequate size to encompass the home ranges of a population of individuals; even small SZs of a few hundred metres in width would offer high protection levels for adults (Bryars et al., 2011).

Predictions of first order response: It was assumed that wherever suitable reef habitat inside an SZ overlapped with the regions of the State where adult fish are known to occur and the current status was UNLL, the population inside the SZ was predicted to have potential to increase in average size and abundance. As spawning occurs in all areas where adults occur, predictions of additional larval export were made where there was potential for an increase in abundance. It was assumed that once a population reaches a certain level, spill-over of adults into adjacent areas outside a SZ would be possible. In cases where the population was at NL, but it is possible that fishing activity over the next 20 years may increase or be sustained, a prediction of maintaining the current status was made

Snapper (*Pagrus auratus*)

Fishing activity: Targeted by commercial, recreational and charter fishers. Commercial production was 919 tonnes in 2009/10 (Knight and Tsolos, 2011). Commercial catch data date back to the 1980s (see Fowler et al., 2011). Recreational harvest was estimated at ~97,000 fish or 178 tonnes for 2007/08 (Jones, 2009). Charter harvest was 30,830 fish in 2008/09 (Knight, 2010). Fishing occurs mainly over subtidal sand plains (especially with rubble or some structural feature) and subtidal low profile reef. Fishing activity from commercial and recreational sectors on this species is widespread but the heaviest recreational activity is closest to Adelaide and regional centres (Jones, 2009). Greatest recent historical targeted commercial effort has occurred in Spencer Gulf, Investigator Strait and Backstairs Passage (Steer, 2009).

Current level of protection: Stocks are managed by PIRSA Fisheries and some aspects of management that relate to protection are mentioned here; readers are directed to www.pir.sa.gov.au/fisheries for more detailed information on management arrangements. Recreational and charter size, bag and boat limits exist. Commercial limits exist. A seasonal closure currently occurs each year. Some existing no-take Aquatic Reserves probably contain adult snapper, e.g. Point Labatt and Aldinga Reef.

Biology relevant to discussion: Fowler (2008) and Fowler et al. (2010b) provide detailed summaries of the biology. There is some taxonomic uncertainty and some referenced literature that use *Chrysophrys auratus*, but the key point is that the species found in SA is the same as the species found in New Zealand and thus valid comparisons across the two regions can be made. Snapper is a long-lived (>30 years) species with sporadic juvenile recruitment (Fowler, 2008; Fowler et al., 2010b). Recognised spawning areas occur in upper Spencer Gulf and upper Gulf St Vincent, but spawning is probably widespread. The species has a larval phase which allows dispersal. The subtidal sand habitats of upper Spencer Gulf and upper Gulf St Vincent are nursery areas for the juveniles (Fowler, 2008; Fowler et al.; 2010b). Adult/sub-adult populations comprise a mix of resident and migrant fish. Patterns of fish movement are complex. For example, young adults move out of the northern gulfs and become residents along the continental shelf in areas such as Investigator Strait, lower Gulf St Vincent, lower Spencer Gulf, the west coast, and the South East. Some of these fish then regularly move back to the upper gulfs to spawn and some eventually become residents there also (Fowler, 2008).

Current status and rationale: Regular stock assessments and stock status reports are available which document the status of the fishery (e.g. Fowler et al. 2010a, b). The most recent stock assessment indicates that harvesting is occurring within sustainable limits (Fowler et al., 2010b). Nonetheless, in areas where fishing activity is greatest there are likely to be lower abundances than would occur without fishing. Thus the current status was assigned as UNLL in areas of suitable habitat with the greatest commercial effort (see Steer, 2009), charter displaced catch (Ward and Burch 2012), and recreational catch/effort (data derived from Jones 2009), and/or where the displaced commercial catch across the park by the proposed SZs was >500 kg as a 4-year average (data derived from Ward and Burch 2012); and where it was felt that specific SZs overlapped with the greatest effort (using local knowledge because fine-scale spatial data are unavailable).

Potential effect of zoning: Appropriately-sized SZs will offer a high level of protection from fishing for **resident** snapper. Tagging of snapper in SA indicates that populations are comprised of both resident and migrant fish (Fowler 2008). At this stage research has not been conducted to determine the home ranges of resident snapper in SA, but long-term acoustic tagging of the same species in New Zealand has shown that some members of the populations on reef systems are residents with relatively small home ranges of <1 km^2 (Parsons et al., 2003, 2010). Parsons et al. (2010) also found that fish behaved differently inside SZs compared with outside, and that this was due to the SZ restrictions. Anecdotal evidence in SA indicates that snapper can aggregate around physical structures during times when fishing activity is restricted, such as the seasonal snapper closure during November each year (although this behaviour could be related to other factors such as spawning). The New Zealand studies suggest that the size of some of the SZs proposed in SA might provide total protection from fishing for some resident fish. Thus for locations in SA where adult snapper move into and then become resident, SZs in those locations could potentially accumulate fish over time. For many of the larger proposed SZs, it is not unreasonable to predict that resident fish could be totally protected inside them. No-take marine reserves in New Zealand have seen rapid increases in snapper abundance following protection (Denny et al. 2004).

Predictions of first order response: It was assumed that wherever suitable habitat (sand/reef) inside an SZ overlapped with the regions of the State where adult snapper are known to show some residency (i.e. Investigator Strait, lower GSV, lower SG, the South East, upper Spencer Gulf, upper Gulf St Vincent, the West Coast) and the current status was UNLL, then the population inside the SZ was predicted to have potential to increase in average size and abundance. As some spawning areas are known, predictions of additional larval export were made where there was potential for an increase in abundance. It was assumed that once a population reaches a certain level, spill-over of adults into adjacent areas outside of a SZ would be possible.

King George whiting (*Sillaginodes punctata*)

Fishing activity: Targeted by commercial, recreational and charter fishers. Commercial fishing for King George whiting dates back to the time of European settlement (Bryars et al., 2008). Commercial catch data date back to the 1980s (see Fowler et al. 2011). Commercial production was 343 tonnes in 2009/10 (Knight and Tsolos 2011). Recreational harvest was estimated at 1.2 million fish or 324 tonnes for 2007/08 (Jones, 2009), i.e., almost the same as the commercial catch. Charter harvest was 54,563 fish in 2008/09 (Knight, 2010). Fishing activity from commercial and recreational sectors on this species is currently widespread, but is not uniform (Jones, 2009, Steer, 2009). Fishing occurs over a variety of habitats including seagrass beds and subtidal low profile reef. The highest recreational activity is closest to Adelaide and regional fishing destinations (Jones, 2009). Greatest recent historical targeted commercial effort has occurred in the far west coast bays and Spencer Gulf (Steer, 2009).

Current level of protection: Stocks are managed by PIRSA Fisheries and some aspects of management that relate to protection are mentioned here; readers are directed to www.pir.sa.gov.au/fisheries for more detailed information on management arrangements. Recreational and charter size, bag and boat limits exist. Commercial limits exist. Some existing no-take Aquatic Reserves probably contain adult King George whiting, e.g. Point Labatt and Aldinga Reef.

Biology relevant to discussion: Fowler and Jones (2008) and Fowler et al. (2011) provide detailed summaries of the biology. King George whiting have a complex life history which involves a number of habitat types across large spatial scales. Spawning appears to occur in just a few areas such as Investigator Strait and lower Spencer Gulf, while nursery areas for post-larval juvenile fish are in shallow, sheltered bays across the State that are characterised by intertidal seagrass flats and subtidal seagrass beds. The species has a larval phase which allows dispersal. As the juveniles grow they tend to move into deeper water. Sub-adults may migrate to other areas, but movement patterns of sub-adults (and adults) are highly complex. Adult King George whiting prefer habitats such as low profile reef, sand with broken rubble, and subtidal seagrass meadows.

Current status and rationale: Regular stock assessments and stock status reports are available which document the status of the fishery (e.g. Fowler et al., 2010a, 2011). The most recent stock assessment indicates that harvesting is occurring within sustainable limits (Fowler et al., 2011a). Nonetheless, in areas where fishing activity is greatest there are likely to be lower abundances than would occur without fishing. Thus the current status was assigned as UNLL in areas of suitable habitat with the greatest commercial effort (see Steer, 2009), charter displaced catch (data derived from Ward and Burch, 2012), and recreational catch/effort (data derived from Jones 2009); and/or where the displaced commercial catch across the park by the proposed SZs was >1000 kg as a 4-year average (data derived from Ward and Burch, 2012); and where it was felt that specific SZs overlapped with the greatest effort (using local knowledge because fine-scale spatial data are unavailable).

Potential effect of zoning: In general it would appear that the transitory nature of King George whiting would result in only limited protection from fishing inside SZs. This certainly appears to be the case for areas such as upper Spencer Gulf and Gulf St Vincent where juveniles and sub-adults occupy nursery areas from where they eventually migrate to other areas. However, there is enough evidence to suggest that some adult fish may receive high levels of protection inside appropriately-sized SZs in some locations.

Tagging studies have indicated that some fish are resident, especially around Kangaroo Island and in lower Spencer Gulf (Fowler and Jones, 2008, Fowler et al., 2011). If SZs are sufficiently large, these **resident** fish would be predicted to increase in size in the absence of fishing. It is apparent that adult fish also move into some areas to spawn, such as Investigator Strait and lower Spencer Gulf. Abundance may increase in these areas if the fish move into and then become resident within the SZs. Without comparable examples for King George whiting from no-take marine parks in other areas, at this stage all of the predictions are hypothetical. Appropriate monitoring programs can test such predictions.

Predictions of first order response: It was assumed that wherever suitable habitat inside an SZ overlapped with the regions of the State where adult fish are known to occur and the current status was estimated to be UNLL, then the population inside the SZ was predicted to have potential to increase in average size and abundance. As some spawning areas are known, predictions of additional larval export were made where there was potential for an increase in abundance. It was assumed that once a population reaches a certain level, spill-over of resident adults into adjacent areas outside of an SZ would be possible. It must be reiterated that there is a high level of uncertainty around the predictions for adult King George whiting. Nonetheless, it was felt that there was sufficient evidence to warrant their inclusion in the present study.

In addition to adult fish that potentially become resident, there could be a short-term response from sub-adult fish in some locations. If the level of fishing mortality is high in an area where the sub-adults temporarily aggregate, e.g. in inshore nursery areas, then the abundance of fish may be temporarily higher inside an SZ compared to the situation if fishing continued at the current level. However, due to the mobility and eventual migration of these sub-adult fish to other areas (see above) this situation will not result in a long-term increase in abundance.

Bight redfish (*Centroberyx gerrardi*) and swallowtail (*Centroberyx lineatus*)

Fishing activity: Bight redfish are targeted by commercial, recreational and charter fishers. Swallowtail is taken incidentally while fishing for Bight redfish and other reef fishes. Commercial catch of Bight redfish was 9 tonnes in 2009/10 (Knight and Tsolos, 2011, separate figures are not available for swallowtail). Recreational catch for Bight redfish/nannygai (which probably includes swallowtail in that category) was estimated at 25,050 fish in 2007/08 (Jones, 2009). Charter catch in 2008/09 was 15,624 and 6,509 for Bight redfish and swallowtail, respectively (Knight, 2010). Fishing activity from the charter sector has increased over the past decade or so with larger boats now reaching more remote locations. Bight redfish and swallowtail are captured mainly in deeper waters over reefs by boat fishers.

Current level of protection: Stocks are managed by Federal and State agencies and some aspects of management that relate to protection within SA are mentioned here; readers are directed to www.pir.sa.gov.au/fisheries for more detailed information on management arrangements. Recreational and charter size, bag and boat limits exist. Commercial limits exist. Some existing no-take Aquatic Reserves possibly contain adult Bight redfish and swallowtail, e.g. Aldinga Reef and Point Labatt.

Biology relevant to discussion: Both species are long-lived (>30 years, Saunders et al., 2010), probably site-attached for extended periods, definitely reef-associated, and susceptible to serial depletion over time (Baker, 2011). Limited tagging data on Bight redfish have recorded recaptures on exactly the same reefs (Bryars, unpublished data). Some charter fishers suspect that larger Bight redfish may move between reefs, but this hypothesis is untested. Schools of swallowtail may also move between reefs (Edgar, 2008). It is unknown where spawning occurs or from where the sub-adults/adults recruit to the reefs within State waters.

Current status and rationale: Stock assessments have not been made and no known current population estimates exist. Overall fishing activity in some regions is relatively high and anecdotal evidence suggests that numbers have diminished on some reefs; charter fishers are aware of this possibility and rotate their fishing efforts amongst reefs to minimise impacts. Using a precautionary approach based upon their vulnerability to overfishing and the recorded catches, both species were assigned a status of UNLL in deep reef areas where fishing catch and effort is greatest (using spatial data derived from Jones, 2009—recreational catch/effort, Steer, 2009—commercial effort, Knight 2010—charter catch, Ward and Burch, 2012—displaced charter effort). Spatial data on commercial catches were unavailable to contribute to the assessment.

Potential effect of zoning: As the adults are thought to be site-attached, SZs may offer a high level of protection from fishing. If adults recruit to reefs inside SZs then average size and abundance will increase.

Predictions of first order response: It was assumed that, wherever suitable, habitat inside an SZ overlapped with the regions of the State where adult fish are known to occur and the current status was UNLL, then the population inside the SZ was predicted to have potential to increase in average size and abundance. As spawning areas are unknown, no predictions of additional larval export can be made. It was assumed that once a population reaches a certain level, spill-over of adults into adjacent areas outside a SZ would be possible. In cases where the population was at NL, but it is possible that fishing activity over the next 20 years may increase or be sustained, a prediction of maintaining the current status was made.

Sea sweep (*Scorpis aequipinnis*)

Fishing activity: Targeted mainly by commercial and recreational fishers, with some take by charter fishers. Catches are recorded as sweep and potentially include both sea sweep (*Scorpis aequipinnis*) and banded sweep (*Scorpis georgiana*); however, most records are probably for sea sweep as they are far more common than banded sweep in SA (e.g., Shepherd and Baker, 2008). Commercial production of sweep was 2 tonnes in 2009/10 (Knight and Tsolos, 2011). Recreational harvest of sweep was estimated at ~33,000 fish or 8.7 tonnes for 2007/08 (Jones, 2009). Charter harvest was 3,449 fish in 2008/09 (Knight, 2010). Fishing occurs over subtidal high profile reef.

Current level of protection: Stocks are managed by PIRSA Fisheries and some aspects of management that relate to protection are mentioned here; readers are directed to www.pir.sa.gov.au/fisheries for more detailed information on management arrangements. Recreational and charter size, bag and boat limits exist. Commercial limits exist. Some existing no-take Aquatic Reserves contain sea sweep, e.g. Point Labatt.

Biology relevant to discussion: The biology of sea sweep is poorly understood. They are long-lived (at least 68 years), late-maturing, and probably site-attached (Coulson et al., 2012), although specific tracking studies on movement have not been conducted. For the present assessment it was assumed that sea sweep is site-attached.

Current status and rationale: Stock assessments have not been undertaken and no known current population estimates exist. Anecdotal evidence indicates that localised impacts on populations have occurred in areas exposed to increased fishing activity with a lack of larger individuals. Using a precautionary approach based upon their vulnerability to overfishing and the recorded recreational and commercial catches, sea sweep were assigned a status of UNLL in reef areas where commercial and charter effort is greatest, and where recreational fishing effort is greatest (using spatial data derived from Jones, 2009) and where shore-based access is possible. Spatial data on commercial catches were unavailable to contribute to the assessment.

Potential effect of zoning: Assuming that adult sea sweep are site-attached then adequately-sized SZs will offer a high level of protection from fishing. In the absence of fishing mortality there is potential for average size and abundance to increase inside SZs where the population is UNLL.

Predictions of first order response: It was assumed that wherever suitable habitat inside an SZ overlapped with the regions of the State where adult fish are known to occur and the current status was UNLL, then the population inside the SZ was predicted to have potential to increase in average size and abundance. As spawning areas are unknown (although they are likely to be wherever the adults reside), no predictions of additional larval export were made. It was assumed that once a population reaches a certain level, spill-over of adults into adjacent areas outside an SZ would be possible. In cases where the population was at NL and it is possible that fishing activity over the next 20 years may increase or be sustained, a prediction of maintaining the current status was made.

Southern calamary (*Sepioteuthis australis*)

Fishing activity: Targeted mainly by commercial and recreational fishers, with some take by charter fishers. Commercial catches have increased since the mid 1980s due to demand for human consumption rather than use as bait (Triantafillos, 2008). Commercial catch in 2009/10 was 399 tonnes (Knight and Tsolos, 2011), and an estimated 206 tonnes (representing almost 500,000 individuals) was taken in 2007/08 by recreational fishers (Jones, 2009). Charter harvest is relatively minor at 2,244 individuals for 2008/09 (Knight, 2010). Greatest recent historical targeted commercial effort has occurred in Spencer Gulf, Gulf St Vincent, and Backstairs Passage (Steer, 2009). Fishing occurs to varying degrees wherever aggregations are found in shallow inshore waters over subtidal seagrass beds and subtidal low profile reef.

Current level of protection: Stocks are managed by PIRSA Fisheries and some aspects of management that relate to protection are mentioned here; readers are directed to www.pir.sa.gov.au/fisheries for more detailed information on management arrangements. Recreational and charter bag and boat limits exist. A commercial limit on effort exists. Some existing no-take Aquatic Reserves contain southern calamary during their breeding aggregations, e.g., Aldinga Reef.

Biology relevant to discussion: The southern calamary has a complex, but short, life history that involves a number of habitat types across large spatial scales (see Triantafillos, 2008 for a review). Adults move inshore to mate and attach eggs to shallow subtidal seagrass beds (viz. *Amphibolis antarctica*) and shallow subtidal macroalgal-covered reefs (viz. *Cystophora* spp.). They remain on the spawning grounds for several months and may move substantial distances within them; but they can be considered to be temporary residents within an area during the breeding period (Triantafillos, 2008, Pecl et al., 2006). Following mating and egg laying the adults die (they live for <1 year). Once the eggs hatch the juveniles or hatchlings are thought to remain inshore for some time before moving offshore to deeper sandy habitats. They remain offshore until they are ready to return inshore as adults where they then mate and die. It is unknown whether adults return to the same site as where they were born. As calamary live for just one year, if there is widespread recruitment failure it may have serious implications for the entire population.

Current status and rationale: Stock assessments and stock status reports are available which document the status of the fishery (e.g. Steer et al., 2007, Fowler et al., 2010a). The most recent stock status report indicates that harvesting is occurring within sustainable limits (Fowler et al., 2011b). Nonetheless, in areas where fishing activity is greatest there are likely to be lowered abundances than would occur without fishing. Localised depletions of breeding aggregations are possible (Triantafillos, 2008). Indeed, Triantafillos (2008) suggested the use of spatial closures during times of spawning aggregations as a fisheries management tool for the species and this strategy is employed in Tasmania (Pecl et al., 2006). Thus in areas of suitable habitat with the greatest commercial effort (see Steer, 2009) and recreational catch/effort (data derived from Jones, 2009); and/or where the displaced commercial catch across the park by the proposed SZs was >3000 kg as a 4-year average (data derived from Ward and Burch, 2012); and where it was felt that specific SZs overlapped with the greatest effort (using local knowledge because fine-scale spatial data are unavailable), then the current status was assigned as UNLL.

Potential effect of zoning: SZs can provide protection for inshore breeding aggregations of southern calamary. The level of fishing mortality within some areas may be sufficiently high for both the abundance and size (the species grows rapidly and an increase in body size will be seen over just a few months) to be elevated inside the SZs compared to the situation if fishing continued at the current level. This apparent 'increase' in biomass would only be temporary while the calamary are on the breeding ground after which time they will die of natural causes. There will be no long-term increase in abundance within the SZs as, once the eggs hatch, the juveniles (hatchlings) move offshore where they mix together with other juveniles from other breeding grounds and grow until a new cohort of adults moves inshore again the next year to breed, .i.e. the adults in a SZ may have been derived from breeding grounds in many different areas and not just the SZ where they were hatched. Thus, while there will not be spill-over from an SZ, there is potential for increased larval export (in this case via hatchlings).

Predictions of first order response: It was assumed that wherever suitable habitat inside an SZ overlapped with the regions of the State where southern calamary are known to aggregate and the current status was UNLL, then the population inside the SZ was predicted to have potential to increase in average size during the aggregation and to have larval export.

Giant Australian cuttlefish (*Sepia apama*—northern Spencer Gulf sub-population)

This discussion relates only to the Northern Spencer Gulf sub-population that contributes to the breeding aggregation in the Point Lowly region. Thus the giant Australian cuttlefish was assessed only in the Upper Spencer Gulf Marine Park.

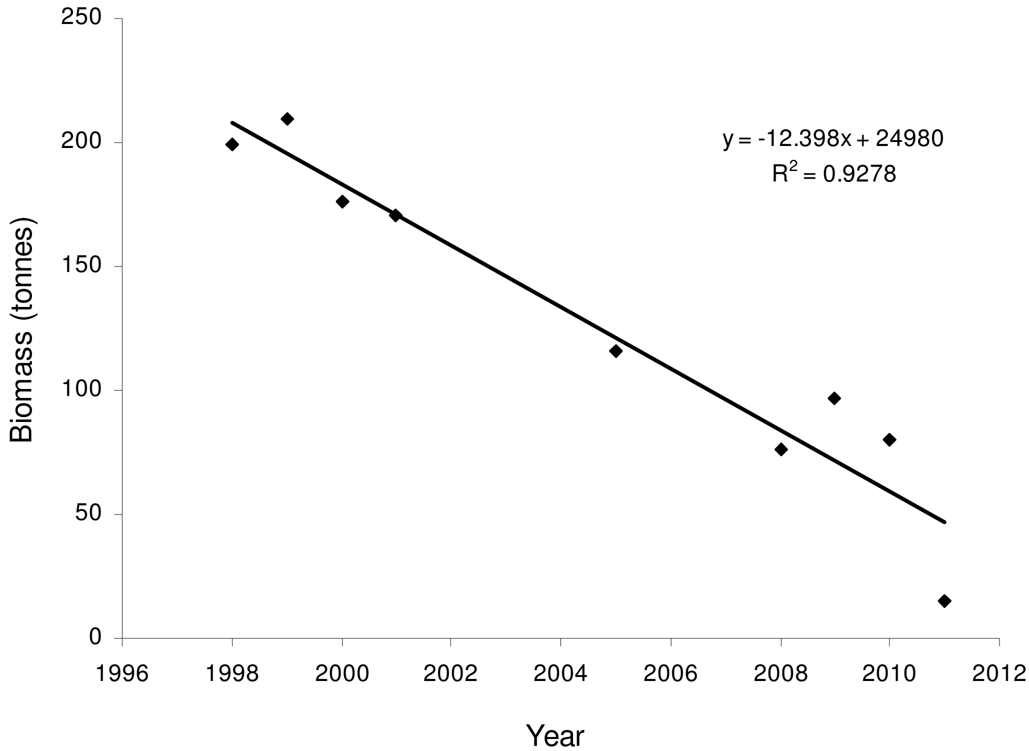
Fishing activity: Historically the cuttlefish aggregation at Point Lowly supported a small commercial bait fishery with annual catches rarely exceeding four tonnes, but this rapidly increased to approximately 250 tonnes in 1997 in an attempt to develop a niche fishery (Steer and Hall, 2005). Due to concerns of overharvesting, a spatial closure for the take of all cephalopods (cuttlefish, southern calamary, and octopus) was introduced across False Bay in 1998 under the *Fisheries Management Act 2007* (at the time under the *SA Fisheries Act 1982*).

Current level of protection: Stocks are managed by PIRSA Fisheries and some aspects of management that relate to protection are mentioned here; readers are directed to www.pir.sa.gov.au/fisheries for more detailed information on management arrangements. The breeding aggregation currently has a high level of protection from fishing. A spatial closure at Point Lowly has remained in place since 1998 and encompasses most of the reef that is utilised for breeding in the region; it was recently extended to include even more reef around Point Lowly. The closure prevents targeted jigging and the take of cephalopods but does not prevent some other forms of fishing for other species. Outside of the closed zone there are recreational bag and boat limits, and commercial limits for cuttlefish.

Biology relevant to discussion: Each winter tens of thousands of giant Australian cuttlefish aggregate at the inshore reefs in the Point Lowly region to mate and lay their eggs. Recent studies have indicated that these cuttlefish originate only from across northern Spencer Gulf and that they may be a separate sub-population to the other giant Australian cuttlefish populations across southern Australia (Gillanders and Donnellan, unpublished data, B. Gillanders, pers. comm., November 2011). The reason that they aggregate at Point Lowly is because they require hard substrate (reef) to attach their eggs and there is very little of this habitat type in other parts of northern Spencer Gulf. Many of the cuttlefish die following mating, but there is a proportion of the population that returns again the following year to repeat the process before dying (no cuttlefish live beyond two years) (Hall et al., 2007). If there is recruitment failure in successive years the entire population could be at risk.

Current status and rationale: Published estimates of the breeding aggregation numbers and biomass are available from eight surveys since 1998 (e.g. Hall, 2012, see figure below). Despite the closure being in place for many years and thus fishing mortality being effectively eliminated at the aggregation sites, the giant Australian cuttlefish breeding aggregation at Point Lowly has been in decline for some years (Hall, 2012, see figure below). For this reason the Northern Spencer Gulf population was considered to be at UNLL. A number of possible anthropogenic threats have been linked with the decline, but the cause remains unknown. The reef habitat lies within a region that is heavily industrialised with several known sources of pollution. Commercial and recreational fishing also occurs for cephalopods and other species in the region outside the cuttlefish closure. Negative ecosystem interactions, e.g. with snapper, or dolphins, also cannot be discounted.

Potential effect of zoning: The proposed SZ at Point Lowly (SZ_F) encompasses a significant amount (but not all) of the cuttlefish breeding reef in the area. The sanctuary zone should assist with protection of this critical reef habitat from damaging activities that might be proposed in the future. The proposed SZ will not allow fishing (of any form) throughout most of the zone but will allow shore based fishing at the western end of the zone (~2.5 km of coastline). It is assumed that the current level of protection (under the *Fisheries Management Act 2007*) that prevents take of cephalopods in False Bay will be maintained in conjunction with the proposed park zoning and management arrangements. Thus the proposed SZ would sit inside the False Bay closed area. While the proposed SZ does provide an additional level of protection from all forms of fishing, it is unlikely to provide an additional level of protection for cuttlefish from fishing (unless there is mortality from interactions of cuttlefish with fishing techniques other than jigging, e.g. line and hook, which is doubtful. In other areas where a fishing closure does not exist and cuttlefish aggregate, e.g. Backy Point, an SZ would offer a high level of protection from fishing.



Plot of giant Australian cuttlefish biomass (tonnes) versus years for the Point Lowly aggregation area (data taken from total aggregation numbers presented in Table 4 of Hall, 2012; n.b. error values associated with these biomass values were not provided in Hall, 2012).

Blue swimmer crab (*Portunus armatus*)

Fishing activity: Targeted mainly by commercial and recreational fishers, with some take by charter fishers. Commercial production was 592 tonnes in 2009/10 (Knight and Tsolos, 2011). Recreational harvest was estimated at ~1.1 million crabs or 284 tonnes for 2007/08 (Jones, 2009). Charter harvest is relatively minor at 1,497 crabs in 2008/09 (Knight, 2010). Fishing occurs in west coast bays, mid-upper Spencer Gulf, and mid-upper Gulf St Vincent across a range of habitats including seagrass/sand tidal flats, subtidal seagrass beds, and subtidal sand plains. Greatest commercial effort occurs in Spencer Gulf and Gulf St Vincent.

Current level of protection: Stocks are managed by PIRSA Fisheries and some aspects of management that relate to protection are mentioned here; readers are directed to www.pir.sa.gov.au/fisheries for more detailed information on management arrangements. Recreational and charter size, bag and boat limits exist. Commercial limits exist. Some existing no-take Aquatic Reserves contain blue swimmer crab, e.g. Whyalla-Cowleds Landing (protected in most of the reserve) and Yatala Harbour.

Biology relevant to discussion: Recent taxonomic revision has changed the scientific name of the species found in SA from *Portunus pelagicus* to *Portunus armatus* (Lai et al., 2010). The blue swimmer crab has a complex, but short, life history that involves a number of habitat types across large spatial scales (for reviews see Svane and Bryars, 2005, and Bryars and Svane, 2008). The species has a larval phase which allows dispersal. Following post-larval settlement, juveniles grow in shallow inshore nursery areas, particularly on intertidal seagrass flats. As they grow they use deeper subtidal seagrass beds and sand plains, but also still use intertidal habitats. During the warmer months, adults move inshore where males and females pair up, copulate, and the females later produce an external egg mass. Females with eggs ('berried' females) stay inshore during the warmer months while the eggs develop over a few weeks. When the eggs are ready to hatch it appears that the females make a rapid migration offshore where the eggs hatch and the free-swimming larvae are released. Maximum age is three years.

Current status and rationale: Stock assessments and stock status reports are available which document the status of the fishery (e.g. Dixon and Hooper, 2011). The most recent stock assessment indicates that stocks are being harvested within sustainable limits but that some caution is required (Dixon et al., 2012a). Nonetheless, in areas where fishing activity is greatest there are likely to be lower abundances than would occur without fishing. Thus in areas of suitable habitat with greatest recreational catch/effort (data derived from Jones, 2009); and/or where displaced commercial catch occurs (confidential data derived from SARDI, 2011 and Ward and Burch, 2012); and where it was felt that specific SZs overlapped with the greatest effort (using local knowledge because fine-scale spatial data are unavailable), the current status was assigned as UNLL.

Potential effect of zoning: Blue swimmer crab adults are highly mobile but do become temporarily resident in some areas at different times. If the level of fishing mortality is high in an area where the adults temporarily aggregate, the abundance of crabs may be temporarily higher inside an SZ compared to the scenario where fishing continued at the current level. Such a situation could be expected where recreational 'crab-raking' is popular or where commercial potting is conducted. Such occurrences are unlikely to lead to a long-term increase in crab abundance within an SZ as the adults are too mobile and will move out of the SZ. However, it is quite plausible that an SZ could lead to increased larval export. Under current fisheries regulations berried females are fully protected and must be returned to the water if caught. However, it is possible that inside an SZ, where both males and non-berried females will be protected from fishing, there will be an increase in male-female encounters (relative to outside if fishing activity is high). Thus there could be an increase in successful copulation and a subsequent increase in the abundance of berried females. If these berried females leave the protection of the SZ to move offshore and hatch the eggs, they will still be protected by fisheries regulations, so it is possible that SZs could lead to an increase in larval export for the blue swimmer crab.

Predictions of first order response: It was assumed that wherever suitable habitat inside an SZ overlapped with the regions of the State where adult crabs are known to aggregate and the current status was UNLL, then the population inside the SZ was predicted to have potential for temporary increased abundance (relative to outside the SZ) and for larval export.

Southern garfish (*Hyporhamphus melanochir*)

Fishing activity: Targeted mainly by commercial and recreational fishers, with some take by charter fishers. Commercial production was 261 tonnes in 2009/10 (Knight and Tsolos, 2011). Recreational harvest was estimated at ~808,000 fish or 75 tonnes for 2007/08 (Jones, 2009). Charter harvest is relatively minor at 6,259 fish in 2008/09 (Knight, 2010). Fishing occurs at varying levels wherever the species is aggregated, often in shallow inshore waters over seagrass beds. Greatest recent historical targeted commercial effort has occurred in upper Spencer Gulf and upper Gulf St Vincent (Steer, 2009).

Current level of protection: Stocks are managed by PIRSA Fisheries and some aspects of management that relate to protection are mentioned here; readers are directed to www.pir.sa.gov.au/fisheries for more detailed information on management arrangements. Recreational and charter size, bag and boat limits exist. Commercial limits exist. In recent years there has been a major reduction in commercial effort and an increased number of spatial netting closures for garfish. Some existing no-take Aquatic Reserves contain southern garfish, e.g. Whyalla-Cowleds Landing.

Biology relevant to discussion: Garfish are highly mobile but do aggregate in some areas at different times. At these times they are vulnerable to higher catch rates. There is evidence of population sub-structuring within different regions across the State (see McGarvey et al., 2009). The species has a larval phase which allows dispersal. Exact spawning locations are unknown.

Current status and rationale: Stock assessments and stock status reports are available which document the status of the fishery (e.g. McGarvey et al., 2009, Fowler et al., 2010a). Concerns of overfishing in recent years have seen a marked reduction in commercial fishing effort and subsequent catch, and this trend is reflected in the latest stock status report (Fowler et al., 2011b). Nonetheless, in areas where fishing activity is greatest there are likely to be lowered abundances than would occur without fishing. Thus in areas of suitable habitat with greatest commercial effort (see Steer, 2009), and recreational catch/effort (data derived from Jones, 2009); and/or where the displaced commercial catch across the park by the proposed SZs was >2500 kg as a 4-year average (data derived from Ward and Burch, 2012); and where it was felt that specific SZs overlapped with the greatest effort (using local knowledge because fine-scale spatial data are unavailable), then the current status was assigned as UNLL.

Potential effect of zoning: In general it would appear that due to the transitory nature of southern garfish they would only receive limited protection from fishing inside SZs. Nonetheless, if the level of fishing mortality is high in an area where the adults temporarily aggregate, then the abundance of fish may be temporarily higher inside an SZ compared to the situation if fishing continued at the current level. Due to the mobility of southern garfish this will probably not result in a long-term increase in abundance inside an SZ of the general size proposed for SAs network of marine parks. In these instances the temporary increase will also not result in spill-over or larval export. However, due to the population sub-structuring that is evident in SA and the current status of the fishery, the response of southern garfish to SZs may be stronger than unexpected.

Predictions of first order response: It was assumed that wherever suitable habitat inside an SZ overlapped with the regions of the State where adult fish are known to aggregate and the current status was UNLL, then the population inside the SZ was predicted to have potential for temporary increased abundance (relative to outside the SZ).

Yellowfin whiting (*Sillago schomburgkii*)

Fishing activity: Targeted by commercial and recreational fishers. Commercial production was 104 tonnes in 2009/10 (Knight and Tsolos, 2011). Recreational harvest was estimated at ~71,000 fish or 23 tonnes for 2007/08 (Jones, 2009). Charter harvest was low in 2008/09 (1,130 fish in the aggregated species group which includes yellowfin whiting, Knight, 2010). Fishing occurs in shallow inshore areas of mid-upper Spencer Gulf and mid-upper Gulf St Vincent on intertidal and subtidal sand habitats and beaches. Greatest recent historical targeted commercial effort has occurred in upper Spencer Gulf and upper Gulf St Vincent (Steer, 2009). Yellowfin whiting are not found in SA outside Spencer Gulf and Gulf St Vincent.

Current level of protection: Stocks are managed by PIRSA Fisheries and some aspects of management that relate to protection are mentioned here; readers are directed to www.pir.sa.gov.au/fisheries for more detailed information on management arrangements. Recreational and charter size, bag and boat limits exist. Commercial limits exist. Some existing no-take Aquatic Reserves contain yellowfin whiting, e.g. Whyalla-Cowleds Landing.

Biology relevant to discussion: Yellowfin whiting are quite mobile but do aggregate in some areas at different times. For instance they move onto tidal flats at high tide and then back into deeper water as the tide recedes (Ferguson, 1999). At these times they are vulnerable to higher catch rates.

Current status and rationale: Stock assessments and stock status reports are available which document the status of the fishery (e.g., Ferguson, 1999; Fowler et al., 2010a). The most recent stock status report indicates that harvesting is occurring within sustainable limits (Fowler et al., 2011b). Nonetheless, in areas where fishing activity is greatest there are likely to be lowered abundances than would occur without fishing. Thus in areas of suitable habitat with greatest commercial effort (see Steer, 2009) and catch (Knight and Tsolos, 2011); and/or recreational catch/effort (data derived from Jones, 2009); and where it was felt that specific SZs overlapped with the greatest effort (using local knowledge because fine-scale spatial data are unavailable), then the current status was assigned as UNLL.

Potential effect of zoning: In general it would appear that due to the transitory nature of yellowfin whiting they would only receive limited protection from fishing inside SZs. Nonetheless, if the level of fishing mortality is high in an area where the adults temporarily aggregate, then the abundance of fish may be temporarily higher inside an SZ compared to the situation if fishing continued at the current level. However, due to the mobility of yellowfin whiting this will not result in a long-term increase in abundance inside an SZ. In these instances the temporary increase will also not result in spill-over or larval export.

Predictions of first order response: It was assumed that wherever suitable habitat inside an SZ overlapped with the regions of the State where adult fish are known to aggregate and the current status was UNLL, the population inside the SZ was predicted to have potential for temporary increased abundance (relative to outside the SZ).

Western king prawn (*Melicertus latisulcatus*)

Fishing activity: Targeted by commercial prawn fishery. Commercial fishing for larger adult prawns in SA began in 1968 (Kangas and Dixon, 2008) and the fisheries have been operating for several decades in three main areas: Spencer Gulf, Gulf St Vincent, and some bays of western Eyre Peninsula (intermittently). Commercial production was 2,669 tonnes in 2009/10 (Knight and Tsolos, 2011). Prawns are captured by benthic trawling from subtidal sand habitat.

Current level of protection: Stocks are managed by PIRSA Fisheries and some aspects of management that relate to protection are mentioned here; readers are directed to www.pir.sa.gov.au/fisheries for more detailed information on management arrangements. Commercial and recreational limits exist. Some existing no-take Aquatic Reserves contain juvenile western king prawn, e.g. Whyalla-Cowleds Landing.

Biology relevant to discussion: The western king prawn has a complex, but short, life history that involves a number of habitat types across large spatial scales (see Kangas and Dixon, 2008 for a review). The species has a larval phase which allows dispersal. Following post-larval settlement, juveniles grow in shallow inshore nursery areas, particularly on intertidal sand flats. Once mature, the adults move offshore to deeper subtidal sand plains where they continue to grow and eventually spawn. Maximum age is four years.

Current status and rationale: Stock assessments and stock status reports are available which document the status of the fishery (e.g. Hooper et al., 2010, 2011; Dixon et al., 2011; Gorman et al. 2012). The most recent stock assessments indicate that the Spencer Gulf fishery is being fished within sustainable limits, while the Gulf St Vincent fishery is continuing to recover from historical overfishing (Dixon et al., 2012b, c). Nonetheless, in areas where fishing activity is greatest there are likely to be lower abundances than would occur without fishing. In the absence of fine-scale spatial data on prawn trawling, in all areas of suitable habitat where there was any historical commercial catch across the park by the proposed SZs and/or HPZs (data derived from Currie and Ward, 2011; SARDI, 2011; and Ward and Burch, 2012, the current status was assigned as UNLL. It could be argued that prawn abundances are actually higher today than pre-European times due to the habitat, modified by trawling, which may be more conducive to prawns. Even if this is the case, the UNLL still applies; if trawling was ceased today it is considered likely that there would be more prawns in the future regardless of any habitat modifications.

Potential effect of zoning: Adult prawns are mobile and would only be totally protected from prawn trawling in SZs and HPZs that were large enough to encapsulate the adult movements. It is unknown what large-scale movements the adults make once they are on the deeper spawning grounds. If it is assumed that the adults don't move great distances, there is potential for the average size and abundance of adults to increase inside no-take zones. An increase in abundance would rely upon the continued arrival of new adult recruits from the inshore nursery areas. Even if this did occur, the abundance of these populations inside no-take zones would not accumulate beyond five years as their life span is <5 years and thus the population would experience complete turnover during this time.

Predictions of first order response: It was assumed that wherever suitable habitat inside an SZ or HPZ overlapped with the regions of the State where adult prawns are known to occur and the current status was UNLL, then the population inside the zone was predicted to have potential for increased size and abundance. Predictions of additional larval export were made where there was potential for an increase in abundance. Spill-over was not predicted.

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Appendix 4 Habitat Profiles

Assignment of habitat types is an arbitrary process that can be tailored to suit the needs of a task. Given the scope requested by DEWNR to assess habitats and that the DEWNR habitat maps use numerous (>30) different habitat types, we needed to rationalize the number of habitats that we could realistically assess. Given the locations of the marine parks, knowledge of previous habitat degradation and threats, and the types of responses species-habitat (ecosystem) responses seen in other marine parks elsewhere, we decided to create 10 benthic and one pelagic habitat types:

- saltmarsh
- mangrove
- intertidal sand flat
- subtidal sand
- intertidal seagrass flat
- subtidal seagrass
- intertidal reef
- subtidal high profile reef
- subtidal low profile reef
- beach
- pelagic

The DEWNR habitat categories that were merged into these categories are shown in Table A4-1. The following decisions should be noted:

- deep sea sponge habitats, e.g. in Backstairs Passage and invertebrate communities, e.g. in Streaky Bay, or central Gulf St Vincent, are generally associated with subtidal sand substrates
- macroalgae on sand was considered to have structure and function most closely aligned with subtidal low profile reef.
- where the profile was not specified within a DEWNR habitat reef category, it was assumed to be subtidal high profile reef.

Descriptions of each habitat, including their distribution, species assemblage, ecosystem services and threatening processes are provided below. Further detail on ecosystem processes is provided in Appendix 5.

Table A4-1 Impact Assessment Habitat classifications compared with DEWNR classifications

Impact study habitat classification	DEWNR shoreline/benthic habitat classification
Beach	Sand Dunes
	Coarse Sand Beach
	Fine-medium Sand Beach
	Mixed Beach
	Pebble and Cobble Beach
Intertidal reef	Boulder Beach
	Cliff
	Bedrock Platform
Intertidal sand	Mudflats & Sandflats
Intertidal seagrass	Seagrass Intertidal
Mangrove	Mangrove
Saltmarsh	Saltmarsh
Subtidal high profile reef	Heavy Limestone or Calcarenite Reef (>-50m)
	Reef (-10 to -30m)
	Reef (0 to -10m)
	Reef (>-50m)
	Granite Reef (-30 to -50m)
	Granite Reef (-10 to -30m)
	Granite Reef (0 to -10m)
	Heavy Limestone or Calcarenite Reef (0 to -10m)
	Heavy Limestone or Calcarenite Reef (-10 to -30m)
	Heavy Limestone or Calcarenite Reef (-30 to -50m)
	Reef (-30 to -50m)
Subtidal low profile reef	Macroalgae on Sand (-10 to -30m)
	Low Profile Platform Reef (>-50m)
	Cobble (-10 to -30m)
	Cobble (0 to -10m)
	Low Profile Platform Reef (-10 to -30m)
	Macroalgae on Sand (0 to -10m)
	Macroalgae on Sand (-30 to -50m)
	Low Profile Platform Reef (-30 to -50m)
	Low Profile Platform Reef (0 to -10m)
Subtidal sand	Soft-bottom Habitat (>-50m)
	Soft-bottom Habitat (-30 to -50m)
	Soft-bottom Habitat (-10 to -30m)
	Deep Sea Sponges (>-50m)
	Deep Sea Sponges (-30 to -50m)
	Soft-bottom Habitat (0 to -10m)
	Invertebrate Community (0 to -10m)
	Invertebrate Community (-10 to -30m)
Subtidal seagrass	Seagrass (-10 to -30m)
	Dense Seagrass Patches (0 to -10m)
	Seagrass (0 to -10m)
	Seagrass (-30 to -50m)
Unmapped	Unmapped (-30 to -50m)
	Unmapped (>-50m)
	Unmapped (0 to -10m)
	Unmapped (-10 to -30m)

Habitat type: Saltmarsh:

Much of this section comes from Fairweather "Saltmarshes" (in press) Vulnerability of coastal and marine habitats in South Australia. Fairweather (1990) identified saltmarshes (along with sandy beaches) as the least studied or understood of the major coastal habitats. A multi-authored work covering most taxonomic groups of biota found in saltmarshes as well as pure and applied scientific questions about them in Australia (Saintilan 2009a) describes how SA lags behind other states in how much is known about its local saltmarshes—there was no contribution from SA.

Distribution: In SA, saltmarshes are composed of several different plant associations including species from the grasses, shrubs, herbs and sedges. There are few estuaries in SA but saltmarshes are not confined to estuaries; instead they occupy large areas behind the open coastlines of sheltered waters, such as in the Gulfs. They are not often associated with the grey mangrove, *Avicennia marina*, as most of the largest marshes extend well beyond where mangroves can grow.

SA is in many ways the centre for saltmarshes in Australia (Fairweather 2011). Typically, saltmarsh habitats are only periodically inundated by the highest tides, they grow in sediments or soils that are often waterlogged and extremely saline (with salt concentrations often well above seawater, due to evaporation).

Species assemblages: There are at least 25 families of saltmarsh plants. The major plant associations found in SA saltmarshes include the samphires or chenopod shrublands (typified by the samphire *Sarcocornia quinqueflora* and other succulents), salt-tolerant grasses, e.g. *Sporobolus virginicus*, sedges, e.g. the genus *Gahnia*, and herbfields, e.g. *Selleria radicans*. These vegetation formations are often separated vertically by only a few centimetres and may represent differences in soil porosity or salinity, to form complex mosaics of plant associations. At their lower points they may abut either mudflats (including those with intertidal seagrasses) or mangroves, whereas at their upper boundaries they may grade into coastal forest or shrublands (including arid saltbushes in the Chenopodiacae family).

Saltmarshes are also home to some quite specialised species of animals and other life forms. Animals with interesting adaptations include molluscs (especially pulmonate gastropods), crustaceans (especially burrowing crabs), insects and other arthropods more associated with terrestrial habitats. Occasional visitors include fishes (for feeding at high tide), birds (especially for roosting but also feeding opportunities) and bats. Algae and microbes are common in saltmarshes, and unvegetated or bare sediment areas known as "salt pans" or "rotten spots" can be common and extensive in semi-arid areas.

Ecosystem services: Saltmarshes warrant a place amongst all the coastal resources that the human population living along SA estuaries and coasts value and rely upon for their livelihood and quality of life (Dugan, 2005). Saltmarshes provide an ecological service to the human population living on their shores in the form of some protection from storms and coastal erosion.

Saltmarsh ecosystems remove nutrients from runoff as they cover large areas that are occasionally flooded and drained by meandering streams that slowly release water to the sea.

Threatening processes: As coastal development and use by the expanding population continues, saltmarshes are more likely to be impacted. The most widespread destruction of saltmarshes has resulted from filling to create dryland sites for coastal land uses by humans. The human impacts on saltmarshes (often in conjunction with adjacent mangroves) are well discussed in Coleman (1998), Adam (2002), Connolly & Lee (2007), Adam et al. (2008), Fotheringham & Coleman (2008) and Saintilan (2009a). Here we list them with some discussion but these references add much further detail to this discussion.

Thousands of hectares were thus converted to pasture, buried under rubbish tips or used for roads, industrial sites, playing fields, housing, carparks and other developments. This landfill can modify the local tidal range and change levels of inundation in any remnants that persist. Of particular note is land reclamation from saltmarshes and mangroves in the Port River-Barker Inlet area near Adelaide.

In areas like the Port River much of the remaining saltmarshes are poorly connected to the sea or otherwise suffering from disturbed hydrology. Once the landfilled area is in use, other environmental problems usually follow. Stormwater runoff, accidental spills of pollutants and discharge of treated or untreated effluent cause environmental problems in remnant saltmarshes.

Elevated nutrient levels, from sewage and stormwater discharges, could also affect saltmarsh ecosystems adjacent to outfalls or urbanised centres. Saltmarshes to the north of Adelaide have been used for the production of salt and are often impacted with bund walls to limit tidal inundation. Many of these saltmarshes do not receive the natural infrequent interchange of seawater at high tides. Through a lack of inundation, saltmarsh sediments may become acid sulphate soils.

Straightening of meandering tidal channels causes changed tidal levels and reduced inundation and hence nutrient uptake for the remaining saltmarshes. Bund walls are useful for flood mitigation but their environmental impacts include limiting the upward rise of flooding king tides and so result in disconnection and destruction of habitat in the area beyond the bunds. Hydrodynamic changes to saltmarsh habitats thus have multi-faceted and extreme impacts.

In many areas saltmarshes are grazed by kangaroos at levels beyond their natural use. Stock moving along pathways alters drainage lines that act as shallow channels that often remove water very quickly from flooded areas. Similar subtle changes to topography resulting in altered drainage also come from use of off-road vehicles or attempts at mosquito control via runnelling. Even a single vehicle pass can produce changes that can last decades, either removing (crushing) vegetation or creating lower paths that alter drainage lines and rates. Such damage can be readily seen across any saltmarsh surface so impacted.

A number of weedy species of plants are found in saltmarshes close to urban land or otherwise impacted, e.g. from nutrient-rich runoff. These are few in number of species, however, because most land plants cannot tolerate saturated soils and many aquatic species cannot tolerate hypersaline soils. Invasive grass species e.g. *Spartina anglica* and *Juncus acutus* are also of concern in some areas of the state. In the eastern states, invasion by mangroves can be an issue, especially in relation to altered sediment budgets from the catchment. In the future, interactions with any mangrove stands that expand under climate change could be a growing threat to saltmarshes.

Climate change can affect saltmarsh physiology by the complex ways that carbon dioxide is assimilated. Given that saltmarsh plants are already “on the edge” in regards to their water relations, increases in water-use efficiency may not be possible. The general trade off between water use and CO_2 acquisition means the saltmarsh response to high atmospheric CO_2 may not be easy to predict. Also saltmarshes naturally reach their zenith at mid-latitudes (Saintilan 2009b) and so a general rise in temperatures may not favour many species and probably not over the grey mangrove. The most likely effects of sea level rise will be to further squeeze saltmarshes into a narrowing space between the sea and human habitation and other structures. Reports of this "coastal squeeze" phenomenon are already coming from the eastern states (Saintilan, 2009b).

Habitat type: Mangrove

Some of this section is taken from Kirkman "Mangroves" (in press) Vulnerability of coastal and marine habitats in South Australia. DENR, 30–32.

Distribution: In SA mangrove forests are composed of only one species—the grey mangrove, *Avicennia marina*. *A. marina* grows to about 3.5 to five metres high and has aerial roots (pneumatophores) which project vertically from the sediment surface.

Mangroves in SA grow from Tourville Bay in the west to Barker inlet in Gulf St Vincent. They next appear at Barwon Heads in Victoria approximately 660 km east. Mangrove forests covering about 156 km^2 grow in the northern part of the two gulfs and in the bays near Ceduna in SA (Fotheringham pers. comm.).

Typically, mangrove habitats are periodically inundated by tides and they grow in waterlogged soil with salinity fluctuating between hypersaline and almost fresh. The aerial roots are an adaptation to obtain oxygen for root growth and metabolism.

Species assemblages: Although there is only one species of mangrove growing in SA, its forests are home to many animals and plants. Birds, mammals, reptiles and insects enter the mangrove forest from the land. Mangrove harbours midges and mosquitoes, however fungal gnats, march flies and dragonflies are common. Other herbivorous insects live in the mangrove canopy, such as bees, ants, isopods, Lepidoptera and Arachnids.

Birds are the most visible fauna in mangrove forests and mostly use them as visitors or vagrants. White faced heron, white egret, white ibis, and cormorants feed on fish in the forest or mudflats. Swans, many species of duck and waders including migratory species are common.

The tide brings in fish, e.g. yellow eyed mullet and black bream, which feed on amphipods, barnacles, shrimps, prawns and crabs, worms and molluscs**.** Crustacea, e.g. *Helograspsus haswellianus*, *Macrophthalmus latrifrons*, *Eriocheir spinosus* and *Philyra laevis*, molluscs and polychaetes are the most abundant fauna of the mangroves, grazing on algae (*Cladophora*, *Enteromorpha*, *Oscillatoria* and diatoms), detritus and organic matter and hunting smaller prey (Edyvane, 1995).

Ecosystem services: A general description of the value of mangrove forests is given by Warne (2011), who discusses the destructive biases of current economic models and points out the real value of mangrove goods and services. Mangroves in estuaries and coastal waters provide ecological services to the human population living on their shores, and protect the coast from wind damage, salt spray and coastal erosion. They also shelter coastal seagrass beds and reefs from excess sedimentation, enhance fisheries production and create self-scoured navigable channels. Mangroves consume carbon dioxide, release oxygen and create carbohydrates through photosynthesis. Mangroves form soil, store and sequester carbon and cycle water and nutrients through the ecosystem. Mangroves provide nursery area and havens for marine organisms and nesting and roosting space for birds. They are a source for nectar and pollen for bees and fodder for browsing herbivores. Mangroves support great biodiversity.

Threatening processes

The human impacts on mangroves are well discussed in Bird and Barson (1982). Here we list them with some discussion but the Bird and Barson chapter adds much to this discussion. Mangroves were cleared by early settlers for farming land or for access to the sea. Later, large areas of mangrove were cleared for rubbish dumps because people did not realise the value of mangroves. Cleared mangrove areas have also been used for recreational purpose by recreational and four wheel drive vehicles. These scours left by the wheels often form into rills and later erosion runnels. This clearing of mangrove for pastures, other farming or land use will usually cause environmental problems to follow. Acid sulphate soils often appear once inundation is stopped. Acid sulphate soils will cause fish kills, crop and aquaculture failure and, once the land is abandoned, the acid remains to cause problems after flooding. The acidic soils come from the aeration of iron sulphide compounds to form sulphuric acid which is then washed out by flooding or tidal inundation causing fish kills and vegetation to die.

Stormwater runoff, accidental spills of pollutants and discharge of treated or untreated effluent cause environmental problems in remnant saltmarshes and areas cleared of mangrove. Straitening the meandering channels within mangrove forests causes problems with allowing the tide or terrestrial runoff to flow quickly to the sea and not allowing saltmarsh or mangrove plants to slow the water, trap sediments and use the nutrients coming off the higher reaches. The sediment and nutrients then go out to sea and cause problems on seagrass beds or reefs.

Habitat type: Intertidal Sand

Distribution: Intertidal sandy substratum exists in all bioregions in SA. It may have small or large wave and swell driven ripples and is usually covered by a layer of diatoms known as microphytobenthos. The shallow sand flats of the gulfs, sometimes leading into mangrove stands, cover the largest areas.

Species assemblages: The habitat of intertidal sand usually consists of subsurface suspension feeders, such as polychaetes and ascidians, and deposit feeders such as molluscs and some crustaceans (amphipods and isopods). The majority of these benthic fauna do not appear to be eaten by predators but die from a variety of causes and are then consumed by scavengers, such as heart urchins, or recycled through the food web by bacteria and other decomposers. Some starfish are carnivorous invertebrates grazing on smaller prey (Edgar, 2001). Fish in the intertidal sandy habitats of SA move in as the tide comes in and include flounder, flathead, sharks and whiting.

Intertidal sand flats have birds associated with them particularly when the tide is out, these include white faced heron, white egret, cormorants and white ibis and spoonbills. Gannets and terns feed in the water column when the tide is in.

Although the large macroalgae of sandy substratum offer little permanent space for biota, they may hold transitory fauna such as amphipods and isopods while the hard substrate on which macroalgae are attached may attract sponges and ascidians. When small rocks, shell particles or large dead shells lie on this substrate for any time macroalgal propagules begin to grow on them. These macroalgae grow to a size where they become so buoyant that they float or move along the bottom to the beach or out to sea. The macroalgae are very diverse and vary from *Sargassum*, *Ecklonia, Osmundaria, Hypnea, Polysiphonia, Laurencia*, *Codium, Ulva* and many others.

The razorfish *Pinna bicolor*, a large bivalve, may also develop small communities around it. This bivalve becomes well established in the sand and may have sponges and associated sessile fauna around it. Propagules attach themselves to solid pieces of molluscs or rock on an opportunistic basis. Razorfish can grow in dense beds and have sessile invertebrates and macroalgae attached to them.

Ecosystem services: Much of the intertidal area of SA is sand flat and although not readily visible there is a diverse and productive array of invertebrates and diatoms associated with these beds. This biota, from diatoms and any macroalgae that grow on hard surfaces to the larger predators, is a source of organic matter. It is grazed by transitory fish, crabs and molluscs and absorb nutrients and takes up sediment eroded from the land. Blue swimmer crabs (*Portunus armatus*) and some fish are caught on intertidal sand flats making these areas of value to commercial and recreational fishers.

Threatening processes: Dredging for channel deepening or laying pipeline also damages sand bottom and macroalgae. It should also be mentioned that where dredging takes place the sediment plume at the dredging site or the disposal site may carry for many kilometres causing problems with light to benthic plants.

At low tide mechanical vehicles may cause great damage to sand flats by the wheel tracks leaving grooves that become permanent as drainage runnels. Oyster and mussel culture can cause damage due to trampling and physical changes in the bottom.

Climate change may cause more desiccation to infauna, such as worms and burrowing snails and crabs. The extent of the sand flats may increase with sealevel rise and acidification of seawater will reduce the strength of animal exoskeletons.

Habitat type: Subtidal Sand

Distribution: Most of the details on intertidal sand flats are similar to subtidal sand. The sand flats of the gulfs, sometimes leading into seagrass beds, cover the largest areas. There are probably large areas of deeper water sand substratum that are unmapped in SA. In Lacepede Bay, where wave energy has restricted seagrass beds to east of Kingston, lies large areas of sand shoreward of flat platform calcarenite reef.

Caulerpa cactoides may grow on some sheltered areas in the gulfs (see Species Assemblages below). Beds of *C. cactoides* are noted in 10 m on the edge of the channel on the western side of Spencer Gulf by Shepherd (1983).

Species assemblages: The general species assemblages as described in the intertidal sand section above, are similar. The subtidal sand substratum may lead into seagrass beds either on the shallower intertidal areas or on edges depending on the suitability for seagrass growth.

Obviously only diving and swimming birds can use the subtidal sand flats and they include shearwaters, gannets, gulls, cormorants and terns. Dolphins, pelagic sharks and the fish mentioned in the intertidal sand section also pass through or live in this habitat.

Caulerpa spp. may also grow in sheltered areas on subtidal sandy substratum in much the same way as seagrass. *Caulerpa*, however, does not have strong underground stems that take up nutrients from the substratum as does seagrass. It has specially adapted holdfasts that attach it to the sand and by which it spreads. *Caulerpa* does not have such a diverse assemblage of epiphytes as seagrass nor are there as many or diverse an array of invertebrates associated with this genus. *Caulerpa cactoides* may have toxic caulerpins that discourage herbivores and some epiphytes.

Ecosystem services: The ecological and economic services provided by the intertidal sand habitats of SA are much the same as those provided by the intertidal habitat. Commercial and recreational fishing are a large economic service while biological diversity and primary production offer considerable environmental importance to this habitat. The productivity is provided by an almost invisible source—diatoms or microphytobenthos. The most visible evidence for microphytobenthos is along the lee side of sand ripples seen from aerial photographs.

Threatening processes: The main threats to subtidal sand habitats are trawling (Curie and Parry, 1996) and pollution from such land-based sources as sediment and nutrient runoff. Mechanical damage can occur from propeller scouring and large ships disturbing the sediment in shallow water. Aquaculture cages can also potentially cause considerable damage to sandy habitats, at least within the vicinity of the cages (de Jong and Tanner 2004). Faeces, waste and unused food from cultured animals can sink, be decomposed by bacteria thus using up dissolved oxygen and, in its worst case, causing the substratum to become anoxic with the resultant death of benthic invertebrates (Feng et al., 2004). Within SA, management dictates that the impact (if any) on benthic habitats from finfish aquaculture cages must be limited to the areas inside designated lease sites; these impacts are regularly assessed with monitoring programs. Nonetheless, the expansion of aquaculture into new areas does represent a potential threat to subtidal sand habitats that have not previously experienced anthropogenic impacts.

Prawn trawling in Gulf St Vincent for more than 30 years has affected bottom communities and changed this habitat (Tanner 2005). Little is known about recovery rate or whether recovery to the pre-European time will occur at all.

Climate change may cause warmer water, but little is known about the effects of this on sandy substratum infauna. The acidification of seawater will reduce the strength of animal exoskeletons.

Habitat type: Intertidal Seagrass

Some of this section is taken from Kirkman “Seagrasses” (in press) Vulnerability of coastal and marine habitats in South Australia. DENR, 59–64.

Distribution: Seagrass habitats are much better known scientifically and taxonomically than sandy habitats. In SA the dominant seagrass in the intertidal is *Zostera* found most abundantly in the flat sandy intertidal areas of the gulfs and estuaries. *Zostera mucronata* grows around the coast of SA associated with *Lepilaena marina* and *Ruppia tuberosa*. It has been found at Port Lincoln, Barker Rocks, Yorke Peninsula, Goldsmith Beach, Edithburgh, Port Clinton and American River inlet on Kangaroo Island (Robertson, 1984). *Zostera muelleri* grows east of Port Gawler in SA (Kuo, 2011)

Halophila australis grows throughout sheltered bays and estuaries in SA. It is usually associated with other seagrasses. Robertson (1984) found it in Waterloo Bay, East Cove, Pearson Island, Coffin Bay, Wallaroo, Tiparra Reef, Brighton and Encounter Bay.

Species assemblages: There are 21 species in nine genera of seagrasses in SA if the genera *Ruppia* and *Lepilaena* are included. They grow in shallow sheltered bays from Port McDonnell near the Victorian border to Fowlers Bay in the west. Not all of these are intertidal, in fact, *Posidonia, Heterozostera* and *Amphibolis* do not tolerate exposure and there have been reports of seagrass death due to exposure to sun and atmosphere (Seddon et al., 2001). *Posidonia australis* is often reported as being exposed at low tide, however, because of the density of its rhizomes and the way the wide leaves lie on the surface it retains water during the low tide period.

Ecosystem services: Seagrasses form some of the most productive ecosystems on earth, rivalling even crops of corn or sugar cane. The beds afford shelter and nursery areas to numerous fish and invertebrates. Seagrass beds filter overlying seawater and prevent erosion and accretion of coastlines. They are a nutrient sink and provide a detrital foodweb for many animals and bacteria. In temperate regions of the world few animals eat live seagrass, however, in SA swans eat *Zostera* and *Halophila*. Economically, seagrass beds provide a nursery ground for commercially and/or recreationally important fish, crabs and prawns. The fish, prawn, and crab yield in southern Australia is valued at US$1436 ha^{-1} yr^{-1} (McArthur and Boland 2006). Based on the latter estimate, a loss of 2700 ha of seagrass beds would result in lost fishery production of AU$235 000. They also provide habitat for some adult fish and squid.

Seagrasses are involved in carbon sequestration by using carbon dissolved in the seawater (mostly in the-form of CO_2, but also HCO_3^-) to grow. Once the plants complete their life cycle, a portion of these materials is then buried in the sediment in the form of refractory detritus. It has been estimated that detritus burial from vegetated coastal habitats contributes about half of the total carbon burial in the ocean (Duarte et al., 2005). Therefore, the decline in seagrasses could lead to an important loss in the global CO_2 sequestration capacity, although this effect has yet to be valued.

Threatening processes: The human impacts on seagrasses are well discussed in Ralph et al. (2007). Here we list them with some discussion, but Ralph et al. (2007) adds much to this discussion.

Development of the coast by building causeways and shoreline armouring may divert water and generally destabilize beaches and shorelines. Physical damage to seagrass beds can occur when marinas, jetties and boat ramps are built on or adjacent to seagrass beds or these structures may change the hydrology (water circulation patterns) of the area, reducing on-shore drift and water flow. Mining or oil and gas extraction from under seagrass beds are potentially damaging to seagrass beds. In the early part of last century fibre from the sediment under *Posidonia australis* in Gulf St Vincent was mined for cellulose use in clothing and explosives (Winterbottom, 1917). The dredging marks are still evident and little *Posidonia* has returned to this region.

Human occupation of the coastal zone is accompanied by the dangers of pollution. Industrial chemicals from factories, including heavy metals, petrochemicals and toxic compounds are a danger to seagrass ecosystems. Heavy metals, petrochemicals and nutrients enter the sea from runoff and stormwater drains. Agricultural runoff containing herbicides and insecticides can damage seagrass beds and its associated fauna. Runoff from land clearing in preparation for housing construction may be the largest impact on offshore seagrass meadows. The problem is that the land is cleared for building and sometimes heavy rains wash off the topsoil because it is no longer held by vegetation. New roads and cuttings for roads are another source of sediment run-off.

Another way that seagrass plants are prevented from photosynthesising is by increasing the turbidity of the surrounding water. As mentioned above, this occurs when runoff containing sediment flows across the seagrass bed. Dredging near seagrass beds increases turbidity and there may be a smothering effect as well if silt screens are not used. If the sediment load is very high, the effect of seagrass leaves slowing the surrounding water will cause the sediment to drop out of the water column and smother plants.

Sheltered waters, besides being the optimal habitat for seagrasses, make preferable sites for aquaculture, including oyster farms and fish cages. The oyster farms may be on seagrass beds that become damaged by trampling and, as with fish cages or other structures, shading of seagrass plants will cause some decline (Tanner and Bryars, 2006).

Although not scientifically proven in SA, there is evidence that a top-down trophic cascade can occur when the top level predators are removed. The decline in large predators brought about by fishing causes an increase in small fish predators which deplete populations of mollusc and crustacean grazers that keep down epiphyte loads. Increasing epiphytes leads to a gradual loss of seagrass as explained above (Williams and Heck, 2001).

Disease in seagrass in Australia has not been identified as a major threat. However, loss of seagrass due to exposure to strong sunlight or heat has been shown to damage seagrass beds in SA (Seddon et al., 2000).

Invasive species are a problem in seagrass meadows in other parts of the world and of particular note in seagrass beds is the damage done by *Caulerpa taxifolia* in *Posidonia oceanica* beds in the Mediterranean (Meinesz et al., 1993). *C. taxifolia* was found in West Lakes but removed by lowering the salinity in the waterways. There was no success in removing it from the Port River. Some consideration should be given, to other invasive species that may arrive, when considering the vulnerability of seagrass to marine pests (Glasby and Creese, 2007).

The full extent of climate change has not yet been demonstrated or predicted in SA nor have the forecast extremes eventuated yet. However, temperature rises, greatly exceeding average rates of change over the last 20,000 years, are predicted. Climate change affects ocean temperature, salinity, acidification and aragonite saturation, sea level, circulation, productivity and exposure to damaging UV light (Fine and Franklin, 2007).

Storms stir up sediment in shallow seas and hence reduce light to seagrass. The light required by seagrass to live in winter is often very low and plants are at a compensation level. Increased storm frequency means that there will be increased turbidity and this may reduce light to lower than compensation levels for marginal meadows at the deeper edge. Increased frequency of storms may also disturb seed beds that normally lie in the sediment, e.g. *Halophila australis* and *H. ovalis* were lost from Hervey Bay, Queensland when two very large storms followed each other, the first destroying the seagrass and the second destroying newly germinated seedlings (Preen et al., 1995). They also mention that excessive prawn trawling may have exacerbated the storm effect.

The problem with climate change is that, if development has used the shallower edges and the seagrass can move no further up the shore, large areas will be lost. The building of sea walls, coastal roads, housing to the edge of the sea and other development must be carefully managed with sea level rise in mind.

Little is known about the effect of seawater temperature rising, but shifts in distribution are expected. Seagrass plants cannot move as can some invertebrates and fish as the water temperature increases. The success of a slow distributional shift will depend upon the suitability of a new habitat being available.

As carbon dioxide rises in the atmosphere more is dissolved in seawater leading to ocean acidification. In seagrass ecosystems, calcareous epiphytes will be the main victims. The response of calcareous epibionts to a raise in pH to 7.7 in aquaria was a loss of all calcareous algae and the only calcifers were bryozoans at pH 7.7 (Martin et al., 2008). This result may have dramatic effects on biogeochemical cycling of carbon and carbonate in coastal ecosystems dominated by seagrass beds.

Habitat type: Subtidal Seagrass

Distribution: In SA the predominant genus of seagrass growing in the subtidal is *Posidonia*, which grows in the gulfs, large sheltered bays like Lacepede Bay and in sheltered bays and lagoons at Kangaroo Island, of particular note there is Antechamber Bay. After *Posidonia*, *Amphibolis* is the next most abundant genus in SA. It grows in sheltered bays in the gulfs but also along the more open coast and islands, sometimes forming its own substratum by initiating its growth on limestone reefs. It does this by way of its seedling which contains a small fibrous anchoring device.

In Gulf St Vincent *Posidonia coriacea* there is a developing, continuous bed from Aldinga to Sellicks Beach. This is seen from aerial photographs as patches of seagrass about four metres across and four metres apart. Further north in Gulf St Vincent *P. sinuosa* and *angustifolia* may have covered the sand to about 15 m depth but because of sediment and nutrients from outfalls from Adelaide much of this seagrass is lost but the dominant genus remains *Posidonia*. Further north still the swell is less and *P. australis* becomes the dominant seagrass. This is similar in Spencer Gulf where *P. australis* is the dominant species in the northern reaches.

Two possibly unique, for SA, seagrass habitats are worthy of note. The first is at Horseshoe Bay near Victor Harbour where this small bay contains *Heterozostera tasmanica* as distinct from many other areas where *H. nigricaulis* grows in patches in *Posidonia* beds. The other area of note is Marion Bay where *Posidonia kirkmanii* grows. These species may grow elsewhere in SA but have not, so far, been recorded. They are not in any proposed zoning.

Species assemblages: The seagrasses that dominate the subtidal regions of the coast are *Posidonia* and *Amphibolis*. *Posidonia* has eight species in SA but the most abundant are *P. australis* in sheltered areas like the northern ends of the gulfs and *P. sinuosa* and *P. angustifolia* that grow in less sheltered bays like Lacepede Bay and Antechamber Bay while *P. coriacea* grows in vigorous water movement and can tolerate ocean swell.

At Kangaroo Island the animals that live in *P. australis* in Pelican Lagoon, *P.* sinuosa and *P. australis* in Nepean Bay and those that live in a mixture of *P.sinuosa* and *P. angustifolia* in Antechamber Bay were collected at night by beam trawl and demonstrated the diversity that live in these seagrasses. There were 157 species of animals collected and about 26,500 individuals in 52 trawls of 50 m each. (Kinloch et al., 2007). Some of the more common species are the pipefish (*Vanacampus poecilolaemus*), decorator crab (*Naxia aurita*) and the pistol shrimp (*Alpheus novaezealandiae*). The pygmy squid (*Idiosepius notoides*) and many gastropods were also caught.

Far fewer animals were caught from each square metre by McDonald (2007) during beam trawls at Port Gawler in Upper Gulf St Vincent in *Posidonia australis* beds. Fewer taxa were also caught but this is probably because he trawled during the day whereas Kinloch et al. (2007) trawled at night. *Macrobrachium* spp were found in large numbers at Port Gawler and Kangaroo Island but MacDonald collected many more Asterinidae than were collected at Kangaroo Island.

Ecosystem services: The economic goods and services for subtidal seagrass beds are the same as for intertidal seagrass. In SA the denser subtidal seagrass beds have a greater abundance and probably diversity because they offer more surface area for cover and for epiphytes to grow.

Threatening processes: The threats to subtidal seagrass beds are the same as those for intertidal seagrass (see above) except that exposure to heat and sunlight is more likely in intertidal seagrass. Subtidal seagrass is probably less vulnerable to many pollution effects because of the dilution effect in deeper water.

By far the most damaging pollutant in seagrass beds is nutrients. The Adelaide Coastal Waters study showed a loss of about 5,000 ha of seagrass attributed to small amounts of nutrients released into the area from sewage treatment plants (Fox et al, 2007). These nutrients promoted epiphyte growth that smothered seagrass. The study demonstrated the vulnerability of *Amphibolis* and *P. sinuosa* to low levels of increased nitrogen. Eutrophication occurs when high nutrient loads, particularly inorganic nitrogen, are taken up by opportunistic macroalgae growing on seagrass leaves. Growth of epiphytic algae blocks light to the seagrass blades, preventing photosynthesis, and eventually smothers the seagrass. The epiphytes and dead seagrass leaves which fall to the substrate beneath are broken down by bacteria that use up oxygen, and this anoxic sediment gives off hydrogen sulphide that kills the benthic flora and the whole seagrass ecosystem may be lost.

Climate change will have similar effects on subtidal seagrass as for intertidal. Storm intensity may increase the disturbance to seagrass meadows. It has been estimated that a one in a hundred year storm can remove seagrass from its substrate. Kirkman and Kuo (1990) report on the formation of blowouts in a *Posidonia sinuosa* bed near Perth, they estimate that a one in 60 year storm caused blowouts in this bed. Later a one in a hundred year storm removed *Posidonia coriacea* in Two Peoples Bay near Albany in WA in 1984. There is a photo of the drift rhizomes on the beach after this storm in Kirkman and Kuo (1990). Those beds are not yet completely recovered. It is thought that the *P. coriacea* patches at Aldinga are due to the seagrass bed recovering after a storm many years ago. Storms, of the intensity that occur once in a hundred years, may increase in frequency to one in forty or fifty years giving *Posidonia* beds, in particular, no chance of recovering.

Warmer temperatures and ice cap melting are expected to raise sea levels. For seagrasses this will bring their habitats shoreward. Those seagrasses growing at the deeper edge of their habitat may be lost while the shallower margins will gain coverage. Furthermore, those slow growing genera, like *Posidonia*, may not be able to “catch up” in the shallower sites now suitable for their growth.

Habitat type: Intertidal Reef

Much of this section comes from Fairweather “Intertidal Seashores” (in press) Vulnerability of coastal and marine habitats in South Australia. DENR, 16–22.

Distribution: The intertidal rocky reef that fringes our seas and lies between the extremes of tides constitutes an important coastal environment that is accessible to many people and therefore well-studied. Covered by high tides but exposed during low tides, these intertidal reefs are often the main part of the sea that the widest range of the public interacts with for recreational or other pursuits. Indeed many people's interaction with the sea starts with them dabbling in rockpools as a child.

Comparatively very little work has been done in SA, but some of that is older and descriptive in nature for either all SA coasts or specific locations near Adelaide or on Kangaroo Island (e.g. Womersley & Edmonds, 1958, 1979; Womersley & Thomas, 1976; Thomas & Edmonds, 1979; Benkendorff et al., 2008). Other, more remote locations have received some attention more recently, e.g. Benkendorff, 2005. Relatively little experimental work has been done in SA compared with elsewhere (but see Chilton & Bull, 1984; 1986 for a not-so-recent example). The rock types vary enormously along the State's coastline, from soft to friable calcarenite (aeolinite) in the South East (the so-called 'Limestone Coast') to hard granites and gneiss of some offshore islands and mainland outcrops. This affects the slope of the shore, hardness of the substratum and the sorts of microhabitats, e.g. rockpools, crevices, boulderfields, found on the shore and hence their biodiversity (Benkendorff et al., 2008).

In SA intertidal reefs are found along most coastlines, even under the cliffs of the Great Australian Bight. They are not as common in the gulfs or where beaches spread along the coast. Very often they lie at each end of the beaches at the rocky capes or points that protect the beach.

Species assemblages: As with subtidal reefs there are many macroalgae and invertebrate fauna that live in the rockpools and exposed rock of the intertidal reefs. These animals and plants must be able to tolerate large temperature ranges whether permanently covered in water or not because rock pools are shallow and warm and cool quickly. The exposure to air of some of the invertebrates means they must also tolerate desiccation. At the higher intertidal region foliose algae are excluded because of the grazing of limpets (*Siphonaria* species) and gastropods (Edgar, 2001). The locally important grazing gastropods are *Turbo*, *Austrocochlea*, *Bembicium* and *Nerita* and star fish and sea urchins in the rock pools also graze macroalgae. Mussel beds also form in the low intertidal but are probably restricted by a paucity of phytoplankton.

Ecosystem services: Intertidal reefs provide a large surface area for attachment of sessile animals and macroalgae, and shelter for some invertebrates that would otherwise be fed on by fish and other predators. These reefs are excellent areas for education as they are easily accessible and often not dangerous.

Threatening processes: Intertidal reefs are more susceptible to pollution than their deeper neighbours. An oil spill at low tide or point sources of nutrient effluent can do much damage to plants and sessile invertebrates that live on these reefs. It is common to see bright green seaweed, usually *Enteromorpha* and *Ulva* on the reef tops when nutrients have flown onto them. These macroalgae are opportunistic for nutrients and may smother other seaweed less able to take advantage of the inflowing nutrients. Because of their shallow nature and that they are exposed at low tide pollutants have longer to poison or smother reef tops before being diluted when the tide comes in. Other effects can include more damage from waves than from swell, the likelihood of physical damage from floating debris, contaminants that are lighter than seawater and damage from boats or ships.

Trampling by interested people trying to learn about these intertidal reefs may also be a threat to fragile plants and animals.

Climate change may also have a greater effect at the margin of sea and shore. Storms are predicted to be more frequent and stronger while changes in sealevel can shift the areas at which the biota live. The threats generated by climate change described in the section below on subtidal high profile reefs applies to these intertidal reefs.

Habitat type: Subtidal High Profile Reef

Distribution: In SA, high profile rocky reef usually describes limestone or calcarenite reef that may be rugged and have overhangs, caves and cliff edges. This description also applies to the infrequent granite reef that outcrops around some of the islands near Cape Catastrophe. The high profile reefs lie off most islands, capes and points along the ocean coastline but are not as common in the gulfs. These reefs have very diverse macroalgal growth and these macroalgal forest habitats occur on all rocky coasts, except those in the upper Gulfs, where algae are much less abundant. The SE coasts of SA are especially rich, with the large macroalgae *Phyllospora*, *Durvillea potatorum* and *Macrocystis pyrifera* growing in colder waters east of Margaret Brock Reef. *Durvillea* grows only in very rough water conditions along the edge of coastal reefs in shallow water. All the high profile reefs contain *Ecklonia radiata* while *Cystophora platylobium* and other *Cystophora* species are less prolific.

Species assemblages On SA reefs algal forests are habitats dominated by macro-algae. They comprise up to five different layers or strata. The uppermost stratum is the giant kelp, found only in the South East (SE) of the State (see separate account of *Macrocystis* forests), and below this is the layer of canopy species up to 1 m high, comprising the kelp, *Ecklonia,* and the fucoids, with many species of *Cystophora* and *Sargassum*—all species that are widespread throughout the State.

The kelp *Ecklonia* tends to dominate exposed coasts, while the fucoids dominate moderately exposed to very sheltered reefs. The fucoids themselves (Order Fucales) are extremely rich in species, with some 67 species in southern Australia, the centre of their diversity globally. Their vertical distribution reaches 10 –20 m in depth on coastal reefs, but much deeper (to >50 m) on offshore reefs in the clear waters of the eastern Great Australian Bight (GAB).

Below the canopy is the algal understorey of (plants to ~40 cm high), which is extraordinarily rich in number of species, with more than 1,000 species recorded from SA alone. Some species are widespread throughout southern Australia and others rare or with very restricted distributions. Below the lower depth limit of the canopy species, red algae extend throughout the deeper photic (light) zone to a depth of 20–30 m on most coastal reefs, but to depths of ~70 m in oceanic waters, as in the SE of SA or the eastern GAB. Below the main understorey are algal turfs 1–2 cm high, and encrusting algae; comprising mainly calcified corallines. Algal turfs go to 20 m depth or more, and encrusting algae to >100 m.

The high diversity of canopy and understorey species means that algal forest habitats are heterogeneous to the extreme, and change continuously with shifts in temperature, exposure and other factors along the coast.

Nearly half of all animal phyla are found on most coastal reefs. The most obvious phyla are sponges, ascidians, bryozoans, soft corals, gorgonians, bivalves, polychaete worms, echinoderms, crustacean and fishes. Many are sessile while mobile fauna search for food and can actively disperse their progeny. Dispersal by sessile animals is not well understood but colonization to other reefs emphasizes the need to have nearby available reefs for more certain conservation (Edgar, 2001).

Although macroalgae are the dominant plants, *Amphibolis griffithii* and particularly *antarctica* grow well because of their ability to attach and anchor to the uneven rock surfaces. They do not grow on the granite surfaces of some of the island reefs and southern Eyre Peninsula.

Little is known about seasonality or inter-annual variation in assemblages for much of the coastline. In SA large storms occur at any time of year and their effects can persist for very long periods because large disturbances are not followed by clear and predictable patterns of succession. Instead different species can become abundant in different cleared patches and persist for long periods, or can change in different ways at different times (Underwood and Chapman, 2007).

Ecosystem services: These environments are important in providing a number of ecosystem services including: primary production; carbon storage and flow; nutrient cycling; disturbance regulation; climate regulation; erosion control; remineralisation; biological control; recreation; tourism; education; indicators of global change; coastal protection; habitat and refuge; food; raw materials; genetic resources; and natural heritage (Turner et al., 2006).

South Australian reefs are a major source of complex organic carbon to coastal ecosystems.with a productivity comparable to that of a cereal crop or sugar cane stand growing under agricultural mono-culture conditions (Cheshire et al., 1998).

The macroalgae of the subtidal reefs offer cover to many commercially and recreationally important species, including rock lobster and abalone.

The reefs and the plants growing on them reduce the force of waves and swell and protect the exposed coast from erosion and accretion.

Threatening processes:

Much of this section comes from the “Threats” section in Shepherd and Cheshire “Algal forest habitats” (in press) Vulnerability of coastal and marine habitats in South Australia. DENR, 6–7.

The major threats to subtidal high profile reefs dominated by kelp or fucoid algae are excess nutrients and sedimentation. These tend to increase in densely populated coastal areas, where land use has intensified, and storm-water run-off and effluent discharges from industry and sewage treatment plants have increased. Offshore dredging and coastal construction also cause increased sedimentation.

On the open coast pollutants entering the sea from point or non-point sources are diluted rapidly. This is not the case in more sheltered areas and damage has occurred off Adelaide in Gulf St Vincent, because of sediment and nutrients. Outfalls from stormwater drains, desalination plants and sewage outfalls are all capable of damaging reef habitats.

The effects of excess nutrients are the decline and disappearance of algal forests and their replacement by algal turfing species 1–2 cm high (Connell 2008; Connell et al., 2008). The combination of nutrients and sedimentation are synergistic, and can dramatically increase low, algal turfs (by 77 per cent in a study by Gorgula and Connell 2004).

Sedimentation alone is a stress on algal forests and can eliminate most species in an assemblage, to be replaced by low algal turfs, which themselves accumulate sediment, and prevent a return to the former forest habitat. Hence the final 'alternative state' becomes stabilised. Notorious examples of the above switch from algal forest to a degraded alternative state are the numerous reefs in eastern Gulf St Vincent from Port Noarlunga north to Outer Harbour (Turner et al., 2007; Connell, 2008; Gorman and Connell, 2009). In some cases, the algal forest has been replaced by mussels, which are favoured by the increased nutrients, and again become stabilised.

Boating and diving can also cause damage to subtidal reefs. Anchors from boats can dislodge boulders and detach large seaweeds. Divers can damage fragile gorgonians and sponges with their fins or even by collecting. In shallow water, boat propellers cause direct damage to reef communities.

Development on the coast, such as marinas, jetties, pontoons and breakwaters all have the potential to damage reef habitats by changing the hydrology around them or direct mechanical damage. Dredging also causes sediment plumes which may directly smother plants or reduce light to plants. Dredge spoil deposits will destroy reef habitats.

Aquaculture cages can also potentially cause considerable damage to sandy habitats, at least within the vicinity of the cages, either by shading or by adding nutrients from faeces or unused food. (de Jong and Tanner 2004). Faeces, waste and unused food from cultured animals can sink, be decomposed by bacteria thus using up dissolved oxygen and, in its worst case, causing the substratum to become anoxic with the resultant death of benthic invertebrates (Feng et al., 2004). Within SA, management dictates that the impact (if any) on benthic habitats from finfish aquaculture cages must be limited to the areas inside designated lease sites; these impacts are regularly assessed with monitoring programs.

Another threat to the integrity of algal communities is climate change, notably acidification of coastal waters. Little is as yet known about the effects, except that some algae e.g. calcified species, such as crustose corallines, will be deleteriously affected (Hall-Spencer et al. 2008), and that synergisms will occur, as in the accelerated expansion of turfing algae in the presence of nutrients (Russell et al. 2009). Other effects are the disappearance of calcifying animals, such as grazing sea urchins or molluscs, with consequent cascading effects on algae.

Seawater temperature increases due to climate change are also likely to result in a suite of cold-adapted large brown algae retreating out of SA state waters over the next few years to decades. These include *Durvillaea* and *Phyllospora* mentioned above as well as the giant kelp *Macrocystis pyrifera*. All of those are presently confined to the SE of the State, where they benefit from cold, nutrient-rich waters in summer from the Bonney Coast upwelling. If the intensity of upwelling increases then they may stay in SA but it is also likely that the passage of high-pressure systems will move south of their present path and so miss SA. In that case their climate-change driven retreat would be hastened (Shepherd and Cheshire, 2011).

Habitat type: Subtidal Low Profile Reef

Distribution: On the low profile platform reefs the macroalgae do not attain great size because of their exposure and they are often scoured by sand. These reefs are defined as having a vertical profile of less than 1 m. Although macroalgae are the dominant plants, *Amphibolis griffithii* and particularly *A. antarctica* grow well because of their ability to attach and anchor to the uneven rock surfaces. This reef habitat is found in each of the bioregions of SA, however, reefs in the gulfs are not as common as the offshore reefs of the rest of the coast nor are they as well endowed with biological diversity. The low profile reefs are more susceptible to sediment flow which affects the sessile filter feeders and plants while water movement is less in these more sheltered areas. Their total distribution is not clear because mapping efforts have usually been to diver depths or what can be seen from remote sensing. These reefs are often old shorelines and are found offshore of most of the western SA coast including to the northwest of the Coorong coast (Haig et al., 2006). Notably, the deeper reefs in the southeast of SA off Cape Northumberland are flat platform reef with more than 200 species of red algae at a single site (Shepherd, 1979). Backstairs Passage between the Fleurieu Peninsula and Kangaroo Island has low profile reef from 10–25 m to about ten kilometres east southeast of Troubridge Island in the lower Gulf St Vincent. These reefs were subjected to very strong currents. Other places with low profile calcarenite reef are in Anxious Bay from 15–20 m deep and running for 25 km north to Venus Bay, off Ward Island, and running from the isles of the Nuyts Archipelago in the east Great Australian Bight. Some of these reefs are covered with algae to 40–70 m deep (Shepherd, pers.comm.)

Species assemblages: The deeper reefs of flat calcarenite have *Scabaria agardhii, Cystophora retorta* and *C. gracilis* and *Osmundaria prolifera* growing on them, occasionally the seagrass *Amphibolis antarctica* grows in loose sand or porous rock (Edyvane, 1999). Small *Ecklonia radiata* and other browns including *Hormosira, Scytothallia* and *Cystophora* andgreen macroalgae such as *Caulerpa* spp. grow on the reefs or on coarse sediment 1–2 cm thick overlying the reef. Sponges and ascidians with molluscs are the most obvious invertebrates. A mixed red understorey, e.g. *Areschougia, Dictymenia tridens* and encrusting red coralline algae, e.g. *Metagoniolithon* grows on these reefs. Occasionally beds of rhodoliths are found or make up their own habitats.

Ecosystem services: As with the high profile reefs, many species are fished by recreational and commercial fishers on subtidal low profile reefs. The macroalgae and sessile animals add to the detritus that finds its way to beaches or off the continental shelf.

Threatening processes: The same threats as for high profile reefs exist in the reefs, too. There is more energy generated from swell than from waves in deeper water and less light at this depth but less likelihood of physical damage from floating debris, contaminants that are lighter than seawater and damage from boats or ships.

Climate change will have the same threats as for high profile reefs in SA.

Habitat type: Beach

Distribution: The long and variable coastline of SA has beaches exposed to high energy wave and winds in the south and west and tide-modified and some tide-dominated beaches in the gulfs and northern Kangaroo Island. The Coorong is Australia's longest continuous beach and one of the world's highest energy beaches. The central Fleurieu and Yorke peninsulas, Kangaroo Island and St Vincent and Spencer gulfs provide a wide range of beaches, from exposed high-energy to very sheltered, tide-dominated beaches in the upper gulfs. The western Eyre Peninsula from Cape Catastrophe is a highly exposed and predominantly high-energy coast. It features rip-dominated beaches backed by massive dune systems and interspersed with sheltered bays (Short and Woodroffe, 2009).

Species assemblages: The plants and animals living on SA beaches inhabit one of the harshest environments in Australia. They must tolerate drying, extreme temperatures, wave disturbance that rearranges and buries them and strong winds that prevent settling. Air-breathing amphipods and isopods are present at the highest levels on most beaches and feed on the lucrative drift that washes up at each high tide. Polychaetes, crabs, bivalves also live in the sand or in the swash at the wave edge of the beach. The diversity and abundance of animals that live on or in beaches depend upon the sediment size distribution and the exposure to rough conditions experienced by the beach.

Ecosystem services: Kirkman and Kendrick (1997) provide an overview of the ecological significance of beach-cast seaweed and seagrass describing food webs and the importance of drift. This drift is broken down by invertebrates and bacteria to release nutrients that are returned to offshore reefs and seagrass beds.

Of most importance are the role of birds and their use of drift material. Seabirds, beach waders and terrestrial birds all use drift for food or nest material. The hooded plover C*haradrius rubricollis* has a close association with drift on beaches, feeding on crustaceans, mollusc, insects and polychaetes associated with the drift.

Threatening processes: Beaches are the most readily accessible of coastal habitats and can be easily abused by humans. Walking on the beach and trampling half buried in-fauna or driving vehicles on the beach and compounding the sand and destroying the sparse vegetation can also damage beaches. Structures built into the sea such as seawalls, marinas and breakwaters will change the hydrology and, with longshore drift, change the aspect and size of a beach. Diatoms on the sea/beach interface have a close relationship with the sand size particles, nutrients and water movement. Disturbance of drift or upper reaches of the beach may threaten breeding birds. The hooded plover nest on the upper-most sections of beaches and this brings them into conflict with people (Buick and Paton, 1989).

Habitat type: Pelagic

Much of this section comes from “Pelagic Habitats” Kemper, C. and Huveneers, C. (in press) Vulnerability of SA Marine and Coastal Habitats.

Distribution: Pelagic habitats and the physical processes that ultimately define them are represented in SA gulf and inshore continental shelf ecosystems. Many species of the migratory megafauna traverse and use these spatially and temporally dynamic habitats on their way to and from SA waters, so it is important to have a clear understanding of the oceanography and pelagic ecology of this region.

This overview covers the megafauna that inhabit the pelagic habitat because they are high-profile species, they are generally near the top of the food web, and are often more susceptible to the major anthropogenic threat, e.g., fishing, than most teleost species. For a comprehensive general description of the plankton that live in SA temperate waters refer to Edgar (2001).

Marine megafauna are here defined as Chondrichthyes (sharks, rays, skates and chimaeras), pinnipeds (seals and sea lions), cetaceans (whales and dolphins), seabirds, e.g., albatrosses and petrels, and turtles. These groups are ecologically important, are high profile and therefore valued by the human community.

Oceanic waters are generally less productive and contain less biomass and less diversity than coastal waters. Nevertheless, there are also ‘hotspots’ of relatively high productivity and biodiversity in the open ocean, generally associated with nearby bathymetric structures, such as seamounts and mid-ocean ridges, and oceanographic features including, eddies and sea-surface temperature defined frontal zones (Worm et al., 2003). Pelagic waters can also be influenced by the interaction between landmasses, wind regimes and currents, which can result in upwelling. Areas of high productivity can vary seasonally, or shift with oceanographic conditions, so it can be necessary for pelagic organisms to migrate long distances (Block et al., 2001).

SA marine waters fall within the temperate to warm temperate zone where sea surface temperatures are about 10–20ºC. For the most part, water temperatures range 14–23ºC, with 10ºC being rare at the surface. Oceanographic features, such as currents and upwelling affect coastal and southern gulf conditions. The Leeuwin Current is a warm water mass that flows southward along the Western Australian coast and into the Great Australian Bight during early winter. It is of variable strength and the eastward extent to which it flows varies from year to year (Feng et al. 2003) and this may influence how far east it penetrates the SA region. In some years, the Leeuwin Current can reach as far east as Tasmania. It is likely that some vagrant tropical and subtropical marine fauna, e.g. turtles, Bryde's whale, pygmy killer whale, make their way into SA waters in this current (Maxwell and Cresswell, 1981, Segawa, 2009). During the summer, the Flinders Current flows along the continental slope at around 600 m depth from the west coast of Tasmania. This deep-water current drives cold water onto the shelf where it can be brought to the surface via wind driven upwelling. One of the major drivers of the ocean systems to the south of Australia is the Westwind Drift (Tomczak and Godfrey, 1994). However, during winter, an easterly flowing counter-current appears over the flow of the Flinders current and pushes it deeper.

The upwelling systems that are found on the continental shelf off SA may be the most important in Australia (Kampf et al., 2004).

Species assemblages: The Bonney Upwelling occurs off the Limestone Coast in southeast SA from about November to April and may have a major influence on the vertebrate fauna of the region (Middleton and Bye, 2007). This upwelling represents the most biologically significant seasonal oceanographic feature in the SA marine region and occurs over a narrower part of the shelf than those that occur in the GAB. The upwelling region is used by a suite of large migratory species both during the peaks of the upwelling and in the periods directly following the events. For example, pygmy blue whales are present and feed on krill in the upwelling system (Gill, 2002) and there is evidence that some other baleen whales (pygmy right whales, Gill et al., 2008) may also take advantage of the zooplankton blooms. Other highly migratory species that use this pelagic foraging area include small pelagic, e.g., sardine (*Sardinops sagax*), anchovy (*Engraulis australis*), and large pelagic fish species, e.g., southern bluefin tuna, albacore, sharks (white sharks, shortfin mako), pinnipeds, e.g., New Zealand fur seals, Australian sea lions, and birds, e.g., wandering albatross, Australasian gannets, little penguins, (Goldsworthy et al., 2011).

Flow-on effects of increased productivity as a result of upwelling are likely to be advantageous for other marine vertebrates. For example, 86 per cent of the Australian sea-lion population is found in SA waters (Goldsworthy et al., 2009). Two smaller regions of upwelling are found west of Kangaroo Island and west of southern Eyre Peninsula (McClatchie et al., 2006; van Ruth, 2009). Productivity there is inter-annually variable (van Ruth et al., 2009) and may influence the presence/abundance of marine vertebrates using this region as a pelagic foraging area. (Kemper and Ling, 1991; Shaughnessy et al., 1994).

The Subtropical Front (Convergence) lies between 39 and 49°S (Belkin and Gordon, 1996) and is also an important nutrient-rich zone. Some species of whales are known to feed in this region (Kawamura, 1974) and there is evidence that New Zealand fur seals forage across this broad area (Baylis et al,. 2008; Page et al., 2006). The position of the front is variable in its latitudinal position and in some years may be responsible for the irregular appearance of subantarctic species along the SA coast.

The continental slope, Murray Canyons and Ceduna Canyons, are features of steep gradients in water depth. Deep sea fish and squid that inhabit these areas are the prey of sperm whales and beaked whales that are sometimes recorded (alive or dead) in coastal waters (Kemper and Link, 1991).

There are far fewer species of elasmobranchs (sharks and rays) in the open ocean than in coastal waters, these species are wide-ranging and play an important role in the food webs of the high seas. School sharks (*Galeorhinus galeus*) and gummy sharks (*Mustelus* antarcticus) are fished in South Australia but young school sharks come from Bass Strait and eastern Tasmania (Kailola et al., 1993).

Ecosystem services: Hoyt (2005) listed three reasons why it is important to consider whales and dolphins when designing marine protected areas: 1) their habitat needs have hitherto been neglected, 2) there is now more information than ever on cetaceans and 3) cetaceans need large conservation areas so this may be the key to protecting ocean habitats and large new areas. The above reasons can also be connected to other marine megafauna such as pinnipeds and elasmobranchs.

Some large marine mammals form part of a fairly simple food web—Phytoplankton—zooplankton(krill)—baleen whales. Toothed whales form the summit of a longer chain: phytoplankton—zooplankton—fish—squid—sperm whale. These are simplified chains but indicate the services that whales provide in cycling nutrients in the ocean. Marine mammals provide an economic and recreational service in providing pleasure to tourists. The tourism industry in some towns is based on whale watching or diving in cages with great white sharks.

Threatening processes:

Pelagic ecosystems face a multitude of threats including overfishing, climate change, eutrophication, chemical and industrial pollutants, noise pollution, mining and oil and gas exploration (Game et al., 2009) and species introductions. Mechanisms that threaten the conservation of the pelagic habitat and associated organisms are poorly understood because of the often remote nature of this environment. Many of the examples listed below apply to sharks and marine mammals but can equally be relevant for other fauna, including other vertebrate megafauna. An in-depth discussion of the threats to Australian cetaceans is found in Bannister et al. (1996), to pinnipeds in Shaughnessy (1999) and Goldsworthy et al. (2009), and to chondrichthyans in Camhi et al. (2007, 2008).

Immediate threats involve processes that result in mortality and serious injury. Pelagic shark species exhibit a wide range of life-history characteristics, but many have relatively low productivity and consequently relatively high intrinsic vulnerability to threats such as over-exploitation (Dulvy et al., 2008).

Commercial fishing, including longline, purse seines and gillnets, has been identified as the single most important threat to pelagic chondrichthyans wherever they occur. Oceanic shark and ray species taken regularly in high-seas fisheries, e.g., shortfin mako, are more likely to be threatened (52 per cent) than are pelagic elasmobranchs in general (Camhi et al., 2009). Pelagic sharks occur in international waters and most migrate across national borders. Because they move regularly between the EEZ's of different countries and into the high seas, they do not fully benefit from regulations that apply only to the waters or fleets of a single country.

Immediate threats to marine mammals include illegal killing (all marine mammals are protected in Australian waters under the *Environmental Protection and Biodiversity Conservation Act 1999*), incidental catch, vessel collisions, pollution in the form of plastic and other debris, and entanglement. Illegal killing of dolphins (Kemper et al. 2005) and pinnipeds has been recorded in several regions in the state (SA Museum, unpublished data), including Gulf St Vincent, lower Spencer Gulf and south of Kangaroo Island. Incidental catch (bycatch) is a documented and serious concern for Australian sea-lions in the demersal shark fishery in four areas: off Ceduna, off Port Lincoln, south of Kangaroo Island and south of the Fleurieu Peninsula (Goldsworthy et al., 2009; Goldsworthy et al., 2010) and for short-beaked common dolphins in the SA Sardine Fishery in lower Spencer Gulf and Investigator Strait (Hamer et al., 2008). Bycatch of bottlenose dolphins has also been also recorded in the sardine fishery but the degree of threat is not known. If offshore finfish aquaculture is established in SA, there is potential for entanglement of cetaceans and pinnipeds since this has been documented in coastal areas (Kemper and Gibbs, 2001). Entanglement of large cetaceans in SA is documented for southern right whales (Kemper et al., 2008) and sperm whales (Shaughnessy et al., 2003) and there is one case of a humpback whale trapped in a tuna cage near Port Lincoln (Kemper, 2005). In the pelagic environment, longlines are probably the most common form of recorded entanglement of large whales. Monitoring fatal entanglements in SA (both in the coastal and pelagic environment) is difficult because, although there is a requirement to report incidents, there is no co-ordinated approach by government agencies. Mortality of Australian sea-lions has been reported in rock lobster pots and there is potential for considerable interaction in three areas of the State: off Streaky Bay, south of Eyre Peninsula and south of Kangaroo Island (Goldsworthy et al., 2009).

Fatal vessel collisions are documented in SA for the southern right whale (Kemper et al., 2008), dolphins (Kemper et al., 2005), sperm whale, fin whale, Antarctic minke whale and pygmy right whale (SA Museum, unpublished data). Collisions involving large vessels are more likely to occur in the ship corridors between Melbourne and Adelaide and Adelaide/Melbourne to Perth. At present these routes are not as heavily used as along the eastern seaboard of Australia and therefore not considered a serious threat to large cetaceans but many collisions are likely to go unreported.

Intermediate threats to vertebrate megafauna include competition from commercial fisheries, the less immediate effects of oil spills, disturbance and harassment, degradation of habitat, and exposure to human and domestic animal diseases.

There is now a reasonable knowledge of the diet, feeding locations and population size of the Australian sea-lion and a concern for overlap with the demersal gillnet fishery for sharks (Goldsworthy et al., 2009). For all species of cetacean living in SA, there is inadequate data on diet, feeding areas and population size to comment on these threats except to say there is some overlap in species harvested by humans and consumed by toothed whales and dolphins (Kemper and Gibbs, 2001). There is potential that harvesting sardines may impact short-beaked common dolphins through resource competition.

Exploration for petroleum and gas are being undertaken in the SE of SA, the Great Australian Bight and to the west of Kangaroo Island. Oil exploration usually involves seismic surveys which may affect some marine mammal species (Richardson et al., 1995). If adequate reserves are found and mining commences, the benthic zone and other layers of the water column will be affected in localised areas. Oil spills are a substantial risk in the pelagic environment and marine mammals (Geraci and St Aubin, 1990), even with tight controls on mining processes. There are no documented cases of oil spills in pelagic waters of SA but there is potential for serious consequences to the Australian sea-lion and New Zealand fur-seal if oil washes up in the vicinity of many breeding colonies around Kangaroo Island and the south and west coast of Eyre Peninsula (Shaughnessy, 1999). In the event of a substantial oil spill, the effects on calving grounds of southern right whales, e.g. Head of Bight, Sleaford Bay, Encounter Bay, are likely to be serious.

Exposure to infectious human and domestic animal diseases is likely to be more concern in the coastal habitats and associated fauna. However, pathogens could spread to pelagic habitats. No outbreaks of morbillivirus have been reported in Australian waters and there have been no mass mortalities as a result of disease. The potential exists for a variety of diseases to be spread by ‘rescued’ and released pinnipeds, a practise that is currently being carried out in the State. Although the SA Museum performs necropsies on marine mammals opportunistically collected during grant-funded research, there is no recognition by the SA Government that routine sampling should be carried out in order to monitor disease outbreaks.

Except in cases of acute toxicity, chemical pollution and marine debris are long-term threats for marine megafauna. For example, heavy metal pollution from the Port Pirie smelter is a known threat to Spencer Gulf and possibly beyond (through water circulation and movement of organisms) and there are documented cases of high levels of zinc, lead and cadmium in sediments, fauna and flora, particularly from upper Spencer Gulf (Lavery et al., 2008). Heavy metals accumulate in the tissues of long-lived vertebrates and can cause a range of deleterious effects, including bone disease in dolphins from Spencer Gulf (Lavery et al., 2009). Much of the pelagic environment of SA is remote from industrial pollution, e.g. Great Australian Bight, and this threat is not generally considered a concern. However, there may be far-ranging effects from pollutants due to surface and deeper layer water currents. For example, it is known that heavy, salt-laden (and presumably contaminated with heavy metals) water takes about one year to travel from the head of Spencer Gulf to Investigator Strait (Nunes and Lennon, 1986).

There is little information on the extent of floating debris in SA. A project is currently underway to document marine debris in Gulf St Vincent bioregion and Kangaroo Island (Caring for Your Country Grant to Adelaide Mount Lofty NRM) and there are published data on the west coast of Eyre Peninsula. Entanglement rates for Australian sea-lions and New Zealand fur-seals in SA are reported as amongst the highest in the world for pinniped species (Page et al., 2004).

Other long-term threats include the reduced genetic variation in depleted populations. Such a scenario may apply to Australian sea lions, New Zealand fur seals, southern right whales and other ‘great whales’ because these species were substantially reduced by hunting in the 19th and 20th centuries.

The effects of climate change on the marine megafauna are not known. The likely scenarios include altered distributions of species as a result of higher sea levels, warmer water and changes in upwelling patterns. There may be deleterious effects on species already vulnerable or endangered, e.g. Australian sea lion, blue whale.

For some species, long-term threats may include resource competition from other marine megafauna. For example, the New Zealand fur seal is increasing at rates of about 11.2 per cent per annum (Shaughnessy et al., 2009). The overall trend for the Australian sea lion is not known: numbers are increasing at Dangerous Reef, stable at The Pages and decreasing at Seal Bay (Goldsworthy et al., 2009).

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Appendix 5 Ecosystem Services

Goods and Services Offered by Coastal and Marine Habitats

To defend the need for protection of SA marine habitats some form of monetary value can be put on them. This economic value is very difficult to determine but to illustrate the importance of valuing coastal marine habitats in SA a description of the necessary goods and services that need to be taken into account is provided. Coastal marine habitats in SA were divided into the following types:

- Saltmarsh,
- Mangrove,
- Intertidal sand flat,
- Subtidal sand,
- Intertidal seagrass flat,
- Subtidal seagrass,
- Intertidal reef,
- Subtidal high profile reef,
- Subtidal low profile reef,
- Beach and
- Pelagic.

These eleven habitats, and others not considered as important as these, offer goods and services that are of economic, social and environmental value to SA. The goods and services provided by coastal, marine and estuarine habitats were classified under four headings by McLeod and Leslie (2009). These headings were:

- Life supporting services,
- Resources and products,
- Maintenance of Earth’s living space and
- Recreational and cultural services.

The first three of these headings was divided into categories that could be more easily valued, either directly or as a service, and are discussed below. Recreational and cultural services have not been addressed here.

Life supporting services

All the listed coastal and estuarine habitat types have life supporting services that sustain them and provide other services to other habitats including our own. Our economy relies on services performed by Nature described as 'natural capital' or natural resources and ecological systems that provide vital life-support services. Globally, human activities are breaking down the life-support services (known as ecosystem services) provided by natural ecosystems. Without these services, our civilizations will decline as they have done in the past when natural resources were over committed. This time though, the breakdown threatens global and smaller-scale processes.

Biogeochemical processes

The chemical balance of the ocean and the atmosphere, and the habitability of Earth, is largely maintained by the activities of microorganisms, the chemical engines of the biosphere. Without micro-organisms, essential processes that maintain the habitability of the Earth—organic matter degradation, recycling of CO_2 and other greenhouse gasses, nitrogen fixation from the atmosphere—would cease.

Microorganisms form microbial ecosystems whose functional complexity is mirrored by their evolutionary diversity. Despite our ignorance of the roles and responses of specific organisms as part of microbial communities, these communities are largely responsible for determining the gross environmental boundaries within which we exist. Human impact on the natural environment via land-use, changes in water balances, and nutrient additions, all affect microbial communities, whose responses can impact human health, recreation, and agriculture (Velmirov, 1981).

Ecosystem functions such as nutrient retention and transformation often entail biogeochemical processes mediated by microbial communities. There is considerable interest in how declines in biodiversity might affect ecosystem services, and in many cases the linkage involves the species-specific influences of plants and animals on biogeochemical processes.

The benefits of removing mangrove and saltmarsh should be balanced against the cost of having biogeochemical problems of acid sulphate soils (Russell et al., 2010).

Biophysical processes

The interactions between biodiversity and the physical environment affect water quality, nutrient cycling, sediment retention, micro-climates, atmospheric circulation, marine currents and other global climate patterns. Nutrients move between the physical and biological spheres as they are taken up from the sediment, water or atmosphere, pass through the food web (sometimes being concentrated), and are eventually released again with decomposition (Lourey and Kirkman, 2009). Organic pollutants and heavy metals follow a similar cycle and may persist through many biophysical processes before being broken down or trapped in sediment (Ward and Young, 1982).

Changes in the biophysical carbon cycle have attracted much attention in recent years as a probable cause of global warming. Carbon is removed from the atmosphere by plants and bound in wood and is also removed by marine organisms and bound in calcium carbonate shells and skeletons. It is released again when wood is burnt or decomposed and when calcium carbonate is dissolved in ocean waters rather than being deposited as sediment. Ocean acidification is rapidly changing the carbonate system of the world oceans. The current rate of change in seawater chemistry is unprecedented. Evidence suggests that these changes will have significant consequences for marine taxa, particularly those that build skeletons, shells, and tests of biogenic calcium carbonate. Potential changes in species distributions and abundances could propagate through multiple trophic levels of marine food webs, though research into the long-term ecosystem impacts of ocean acidification is in its infancy. (Guinottea and Fabry, 2008).

Biodiversity

Internationally and nationally, the term biodiversity—or biological diversity—is used to describe the variety of all life forms. Biodiversity is considered at three levels: the different plants, animals and microorganisms (species diversity), the genes they contain (genetic diversity), and the ecosystems of which they form a part (ecosystem diversity).

Biodiversity is constantly changing; it is increased by genetic change and evolutionary processes and reduced by habitat degradation, population decline and extinction. It emphasizes the interrelatedness of the biological world, and covers terrestrial, marine and other aquatic environments.

The biodiversity of each of the listed habitats above provides stability to the habitats and forms complex food webs about which we have little knowledge. Upsetting these food webs may have catastrophic consequences on the habitats and a flow over effect on others. Valuing biodiversity is a key challenge to environmental economics, put into focus by policy developments everywhere, and now increasingly focusing on habitat preservation. Jacobsen et al. (2009) indicated that the value of the habitat can be captured reasonably well in a specific attribute representing size of the habitat, and the parameter estimate of this attribute was little affected by changes in the biodiversity protection attribute. By simply naming and hence 'iconising' only a few species they received dramatically higher value estimates than when using a quantitative description. They concluded that using 'iconised' species for valuing biodiversity at habitat level may lead to a very high, potentially overestimated, value of species preservation.

Nutrient cycling

An adequate and balanced supply of elements necessary for life, provided through the ecological processes of nutrient cycling, underpins all other ecosystem services. The cycles of several key elements—phosphorus, nitrogen, sulphur, carbon, and possibly iron and silicon—have been substantially altered by human activities over the past two centuries, with important positive and negative consequences for a range of other ecosystem services and for human well-being (Raven et al., 2005).

Nitrogen accumulation on land and in waters has permitted a large increase in food production, but at the cost of increased emissions of greenhouse gases and a frequent deterioration in freshwater and coastal ecosystem services, including water quality, fisheries, and amenity value (Duarte, 2009).

Human-induced alteration of the iron and silicon cycles is less well understood, but it is believed, with medium certainty, to be a significant factor in altering the productivity of the ocean. This may be a significant benefit to the service of carbon sequestration.

Resources and products

Food

Marine habitats of all eleven types indirectly or directly provide food for human consumption. Seagrass and mangroves provide shelter for juvenile commercial and recreational fish that may be caught where they grew or where they migrate to after maturity. Sandy habitats make bottom trawling for prawns possible whereas trawling on seagrass beds would be destructive to the seagrass. Rocky reefs and mangrove are impossible to trawl on. Line fishing, in seagrass meadows for squid and fish, diving for abalone and pot fishing for rock lobster on reefs and crab netting on sand or seagrass can be carried out. There are useful, edible animals in mangroves but Australians do not usually eat sipunculid worms, sea cucumbers or mangrove crustacean like mantid shrimps.

Fibre, fuel, shells etc.

One hundred years ago seagrass fibre and leaves were used for clothing and insulation, respectively Winterbottom, 1917. This mining operation has ceased but the potential for collecting cellulose is still there. Seaweed and seagrass drift is collected in SA from the beach for garden fertilizer and mulch. In some places this is of no concern as the excess nutrients from runoff from farms is being removed, however each enterprise to use large quantities of drift should be investigated and regulated (Kirkman and Kendrick, 1997). Shells are collected for ornaments from all of the habitats. These shells may be alive, dead or be the current homes of hermit crabs. Collection of the more attractive shells could have lasting effects on marine habitats.

Non-biological materials, e.g. minerals.

Limestone sand and rock for the manufacture of cement can be extracted from most of the habitat types, e.g. mining limestone from under a seagrass bed in Cockburn Sound, WA. Sand and gravel can be dredged for concrete, road and rail ballast or for landscaping. Attractive rock including granite may be used for building decoration or gardens. Exploration and exploitation for gas, oil and minerals can cause damage to underwater habitats or to pelagic animals. Desalination plants remove seawater but return warmer more salt concentrated water that may affect marine habitats.

Pharmaceuticals and nutriceuticals.

Biological diversity in all marine and coastal waters offer potential pharmaceutical chemicals for medicine. The potential for sponge chemicals, for example (Andavan and Lemmens-Gruber, 2010) to hold a cure for a yet incurable disease or add pain relief is quite unknown. Another example is for brown seaweeds (Ale et al., 2010). All the habitats on which large animals and plants live are potentially crucial for providing life giving or life sustaining chemicals.

Maintenance of earth's living space

Climate regulation.

All the habitats with growing plants take up CO_2 from the atmosphere. Phytoplankton in the pelagic realm, mangroves and seagrasses from their areas, diatoms on sandy areas and seaweed from the reefs all sequester CO_2. The fewer plants there are and the less area of surface covered by plants the weaker this sequestration. Increased carbon dioxide in the atmosphere increases climate change and resultant sea level rise (Fry, 2008).

Waste processing.

All the habitats considered here have mechanisms for some waste processing. The problem is when that waste exceeds the capacity of the habitat to use it. Mangroves, saltmarshes and seagrass beds are well known for taking up nutrients and collecting sediment from water running over or through them. Macroalgal forests absorb nutrients but, as with the other vegetations, when the nutrient load is exceeded opportunistic epiphytes may grow to such an extent that light cannot reach the underlying plants and they die. The meanders of mangrove forest and saltmarsh creeks help with nutrient uptake by the mangroves and saltmarsh plants.

Flood/storm protection.

Mangroves are renowned for preventing storm damage on coasts (Badola and Hussain,2 005), however, the other habitats with large vegetation cover can also prevent flood and storm damage. The vegetation slows overlying water and storm surges. Saltmarsh and mangrove creek meanders slow the water movement from floods and reduce loss of sediment directly to the sea during floods.

Erosion control.

Mangrove forests, offshore reefs, seagrass beds and saltmarshes can all prevent erosion of coasts. Their vegetation slows the water passing over them reducing the impact on fragile areas. The meanders of creeks in mangrove and saltmarsh reduce water flow rates allowing entrained sediment to drop out rather than flow to the coast and cause problems in shipping or boating channels or smother vulnerable seagrass or reef macroalgae.

Water quality.

The large plants of seagrass and macroalgae are able to slow the water passing over them causing sediment and organic matter to drop to the bottom to replace lost sediment and provide food for filter feeding invertebrates Ward et al., 1984). This action improves water quality in nearshore areas. In mangrove and saltmarsh creek meanders slow water movement and improve water quality as suspended matter drops to the bottom on both tides.

Sediment quality.

Any habitat with plants growing on them is improved by the aerobic action of the plants. Even microphytobenthos can use nutrients and prevent a bloom of aerobic bacteria using bottom oxygen giving rise to death of infauna and a bloom of anaerobic bacteria and a deterioration in quality of bottom sediments. Sediments are usually sorted by the strength of movement of overlying water and this sediment size distribution can effect what is growing on them.

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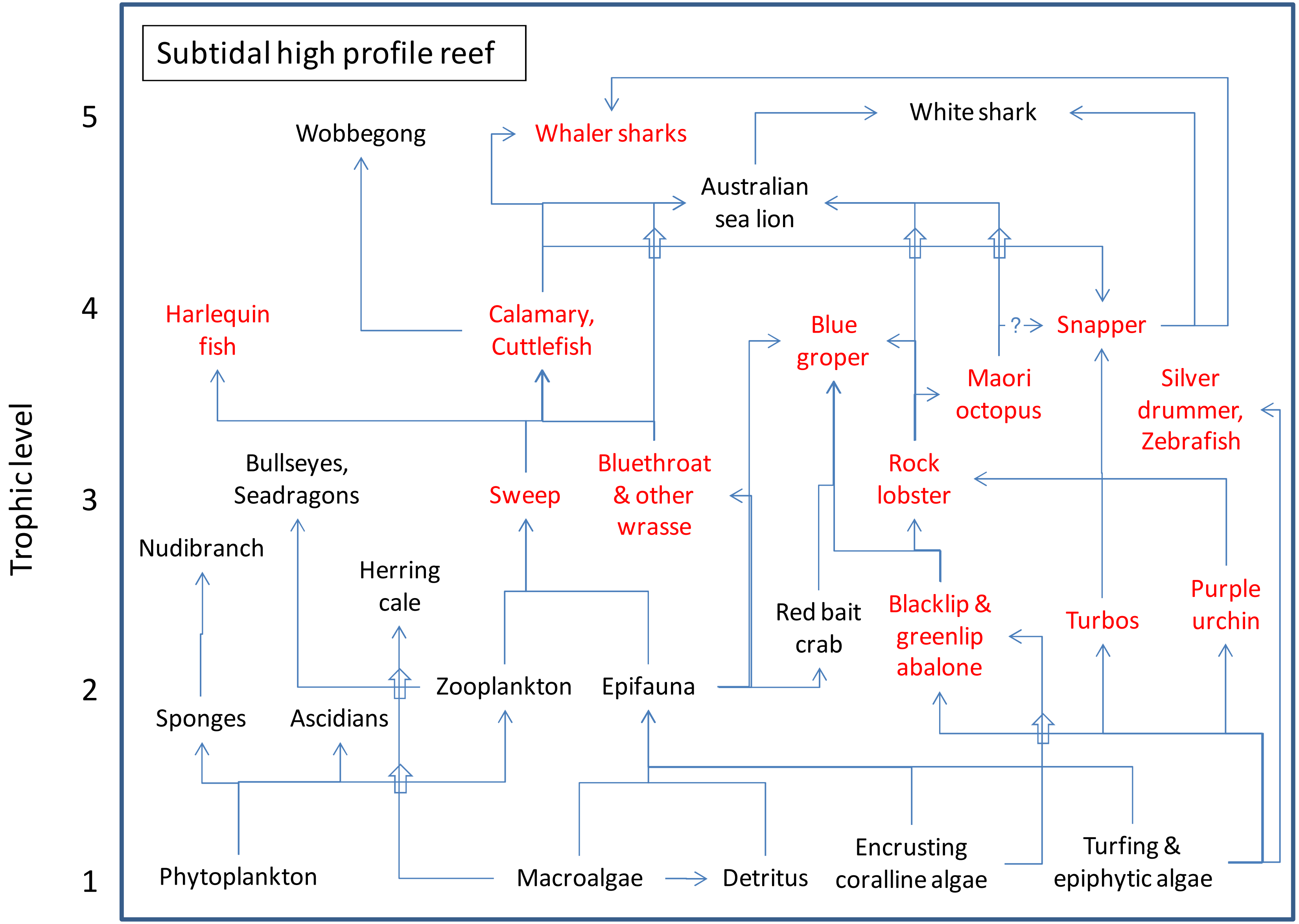
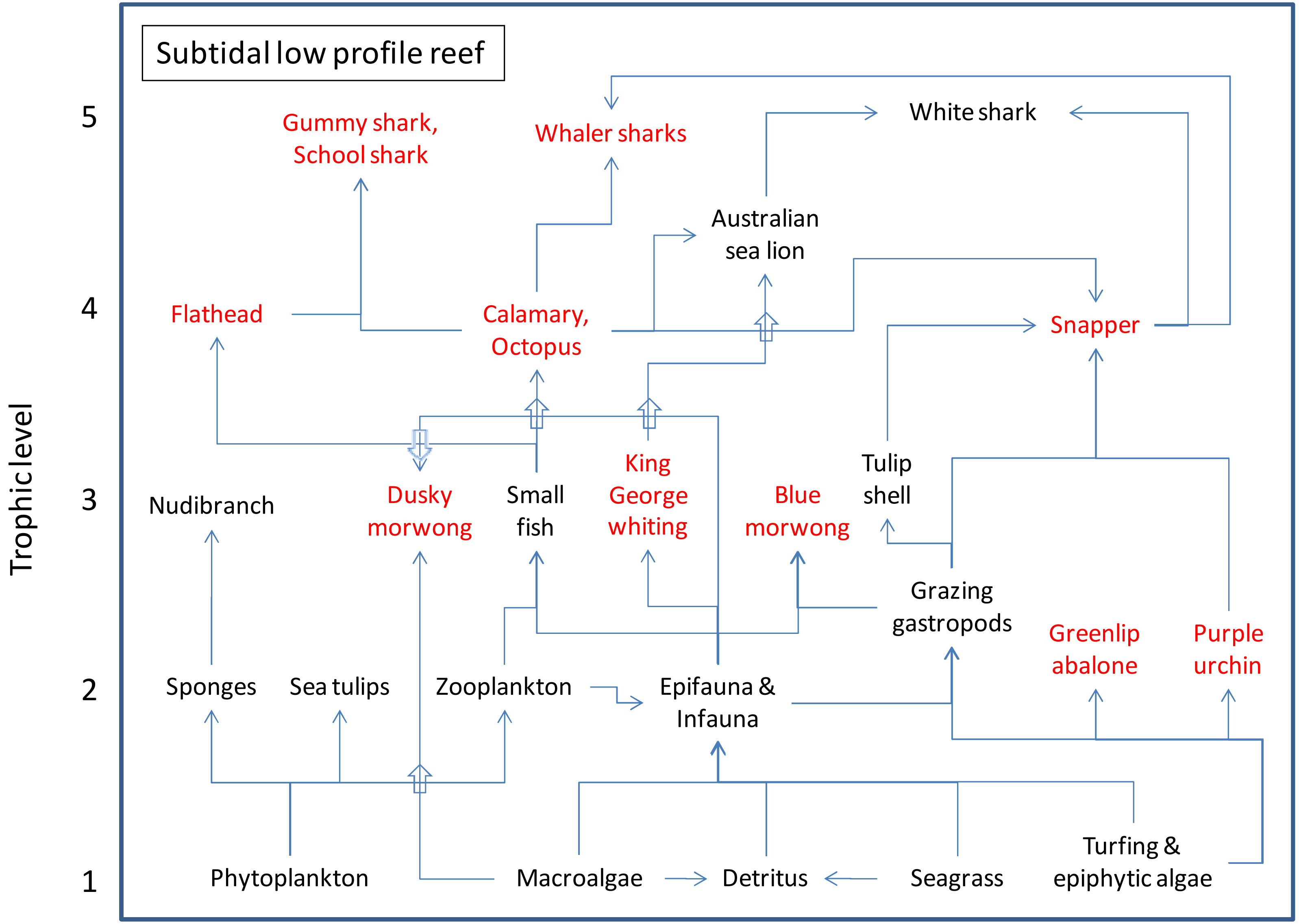
Appendix 6 Food Webs

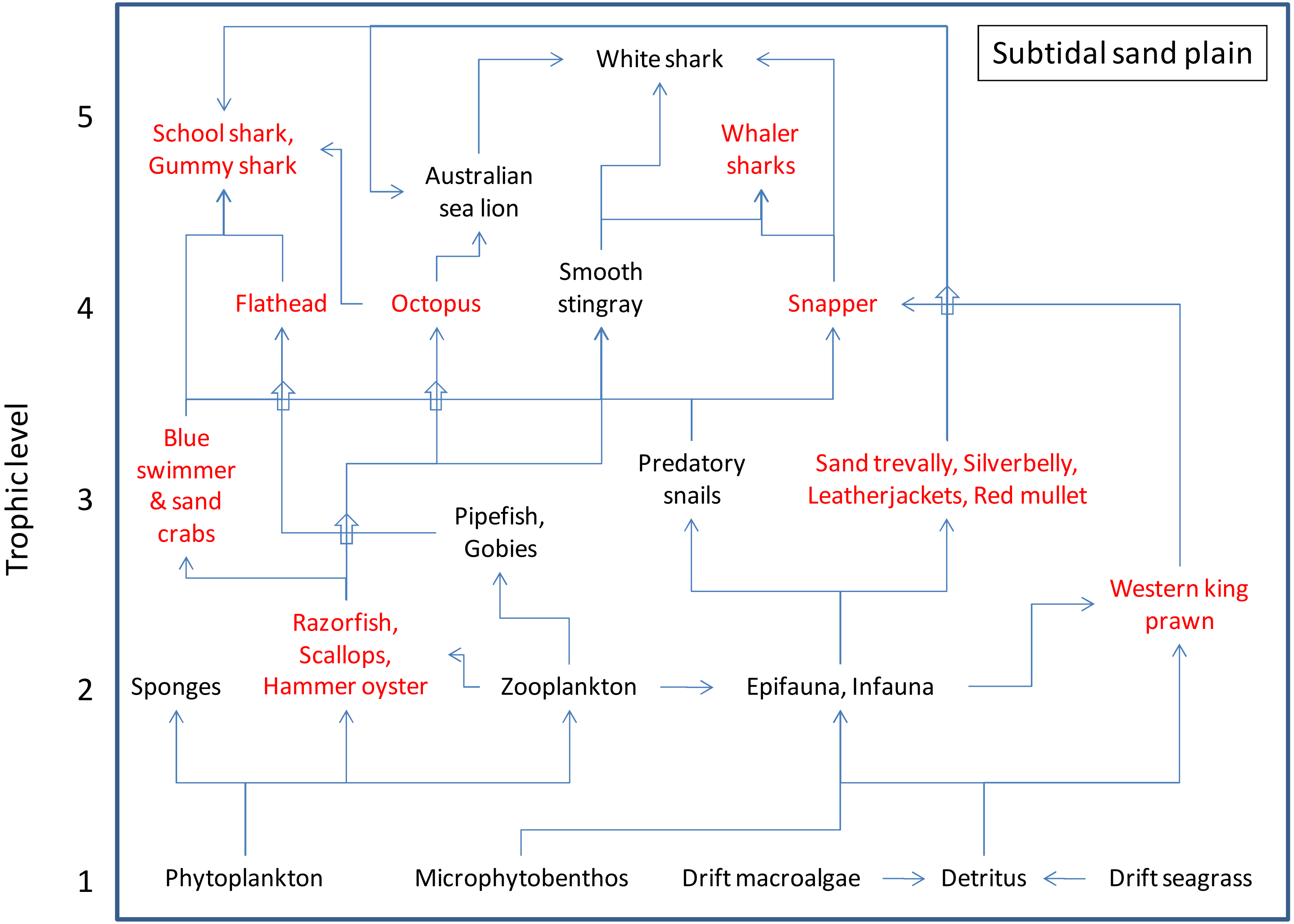
Eleven simplified conceptual ecosystem food webs are presented in this section.

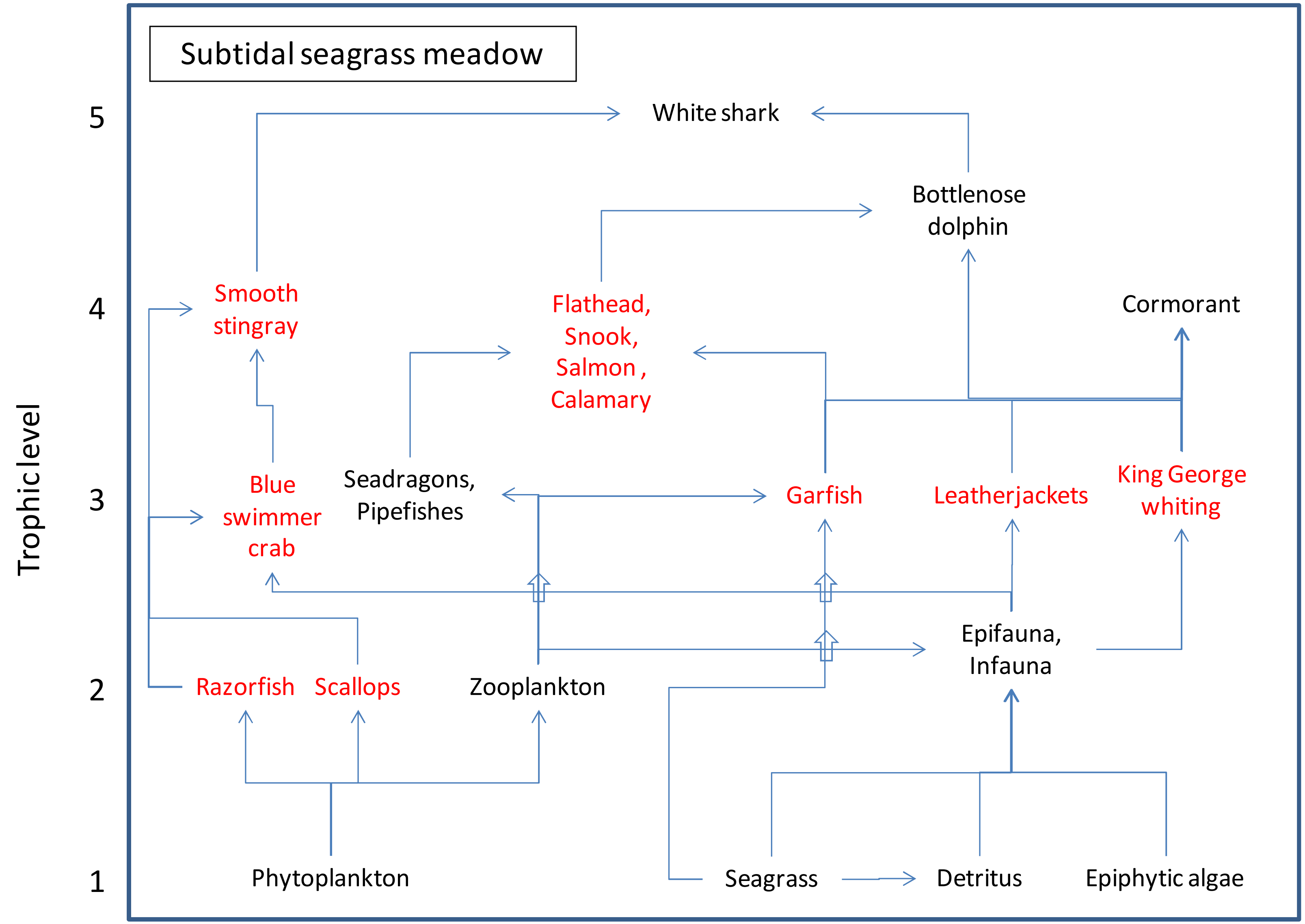
Notes for ecosystem food webs:

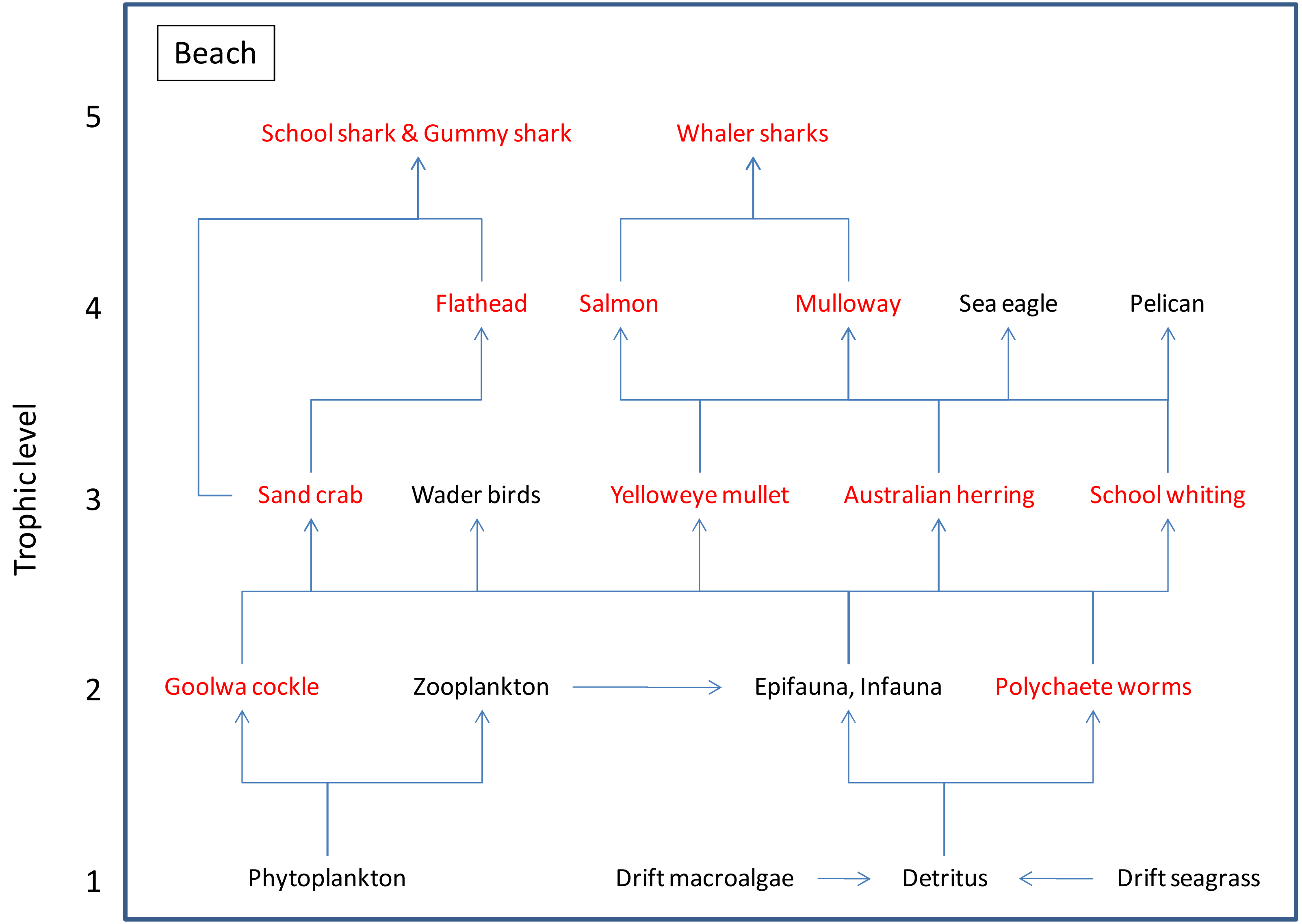
- The species used in the food webs are not exhaustive. They are simplified and designed to illustrate a range of species at a range of trophic levels and feeding guilds, and hopefully demonstrate the complexities of marine ecosystems. Some species are fished, some are iconic, some protected, etc (see Appendix 2). The species highlighted in red have an interaction with fishing.
- The trophic levels of species shown are indicative only and may vary from what is shown in Appendix 2. Allocation of more precise trophic levels (e.g. 2.5 for a species that lies between 2 and 3) was beyond the capacity of the present project. Trophic levels were assigned based upon what is known about each species/species group in terms of where it derives most of its energy requirements (using the information collated in an internal database – see A1.3.1).
- Energy flow is depicted by the lines and arrows commencing at the bottom of the food web (trophic level 1). For example, in the subtidal high profile reef food web, phytoplankton is consumed by sponges, ascidians and zooplankton. The zooplankton is eaten by bullseyes, seadragons, and sweep. The sweep are then consumed by a range of species (harlequin fish, calamary, cuttlefish, and Australian sea lion). The Australian sea lion is finally eaten by the white shark which is the top predator in the food web at trophic level 5. A hollow vertical arrow indicates that the flow moves vertically only and that a horizontal flow line does not join into the vertical flow. For example, in the subtidal high profile reef food web, macroalgae is consumed only by herring cale and not by sponges, ascidians, zooplankton, bullseyes or seadragons.
- Some species depicted in the food webs are not found in those habitats in all locations across the State. For examples: western blue groper and harlequin fish are rare in the South East and so would not form an important part of the reef ecosystems in that region; yellowfin whiting are restricted to the waters of Spencer Gulf and Gulf St Vincent where they are an important component of the intertidal flats.
- A number of information sources were used to construct the food webs. These included general fish and other marine life books (e.g. Edgar, 2001, 2008; Gomon et al., 2008; Kuiter, 2000; Last and Stevens, 1994; Scott et al., 1974; Shepherd et al., 2008); Fishbase (Froese and Pauly, 2012) and other websites (e.g. Australian Museum, 2012); SARDI stock assessments (e.g., Fowler et al. 2011); ecosystem model studies (e.g., Goldsworthy et al., 2011); other references provided in the reference list below; unpublished data and personal observations by the authors.

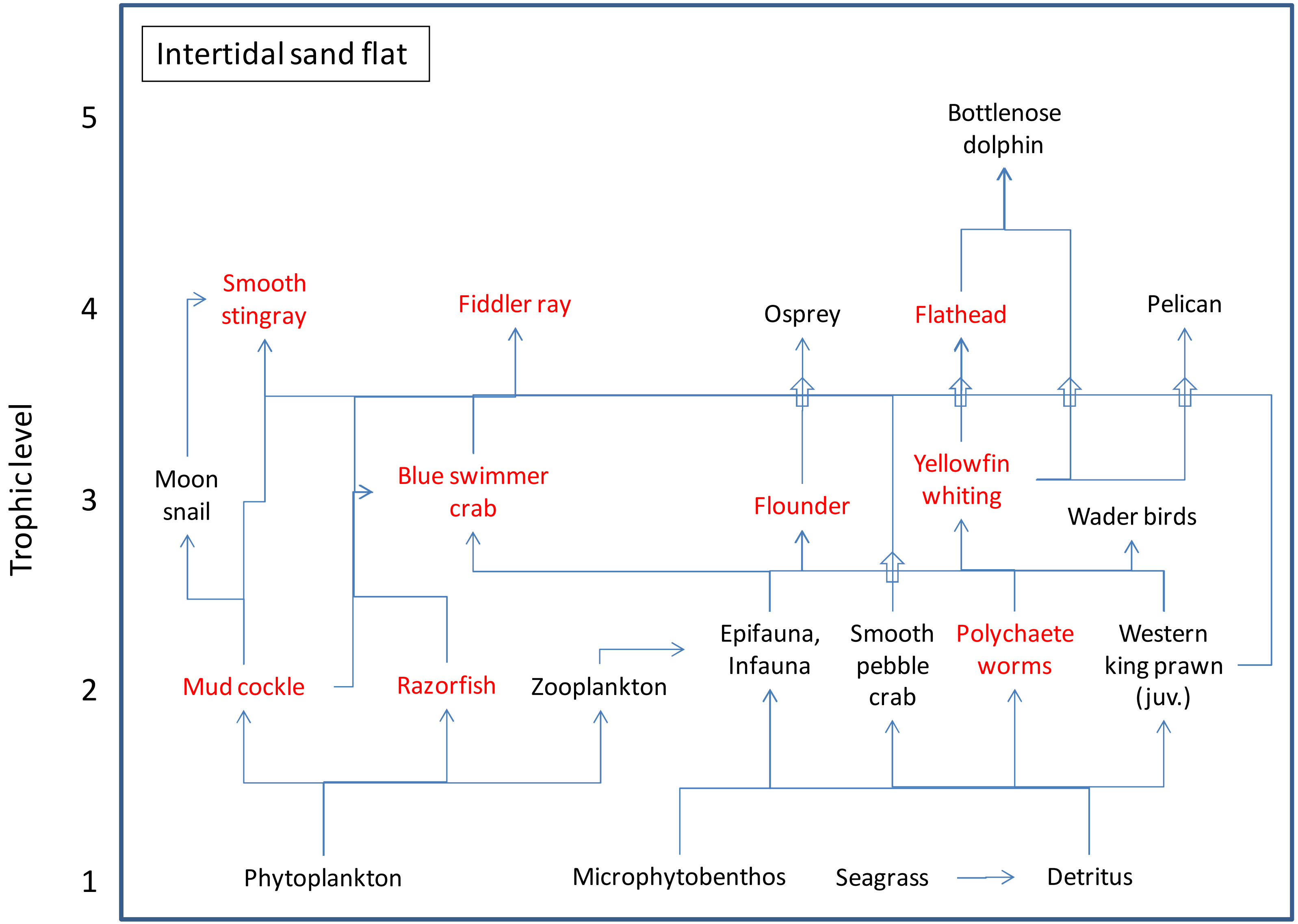

Subtidal high profile reef
Trophic level
5
4
3
2
1
Wobbegong
Whaler sharks
White shark
Australian sea lion
Harlequin fish
Calamary, Cuttlefish
Blue groper
?
Snapper
Maori octopus
Silver drummer, Zebrafish
Bullseyes, Seadragons
Sweep
Bluethroat & other wrasse
Rock lobster
Nudibranch
Herring cale
Red bait crab
Blacklip & greenlip abalone
Turbos
Purple urchin
Zooplankton
Epifauna
Sponges
Ascidians
Phytoplankton
Macroalgae
Detritus
Encrusting coralline algae
Turfing & epiphytic algae

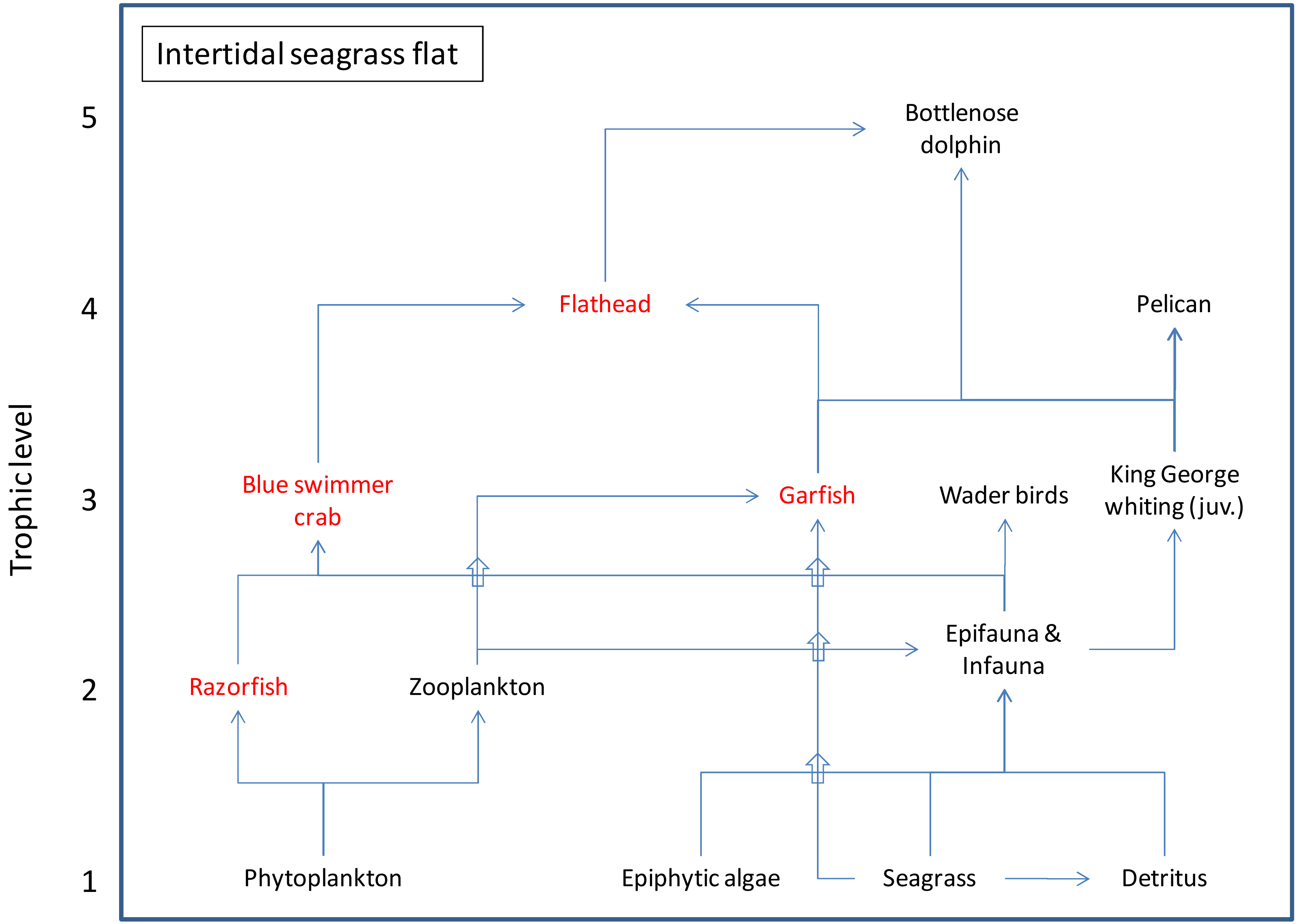

Subtidal low profile reef
Trophic level
5
4
3
2
1
Gummy shark,
School shark
Whaler sharks
White shark
Australian
sea lion
Flathead
Calamary,
Octopus
Snapper
Nudibranch
Dusky
morwong
Small
fish
King
George
whiting
Blue
morwong
Tulip
shell
Grazing
gastropods
Greenlip
abalone
Purple
urchin
Sponges
Sea tulips
Zooplankton
Epifauna &
Infauna
Phytoplankton
Macroalgae
Detritus
Seagrass
Turfing &
epiphytic algae

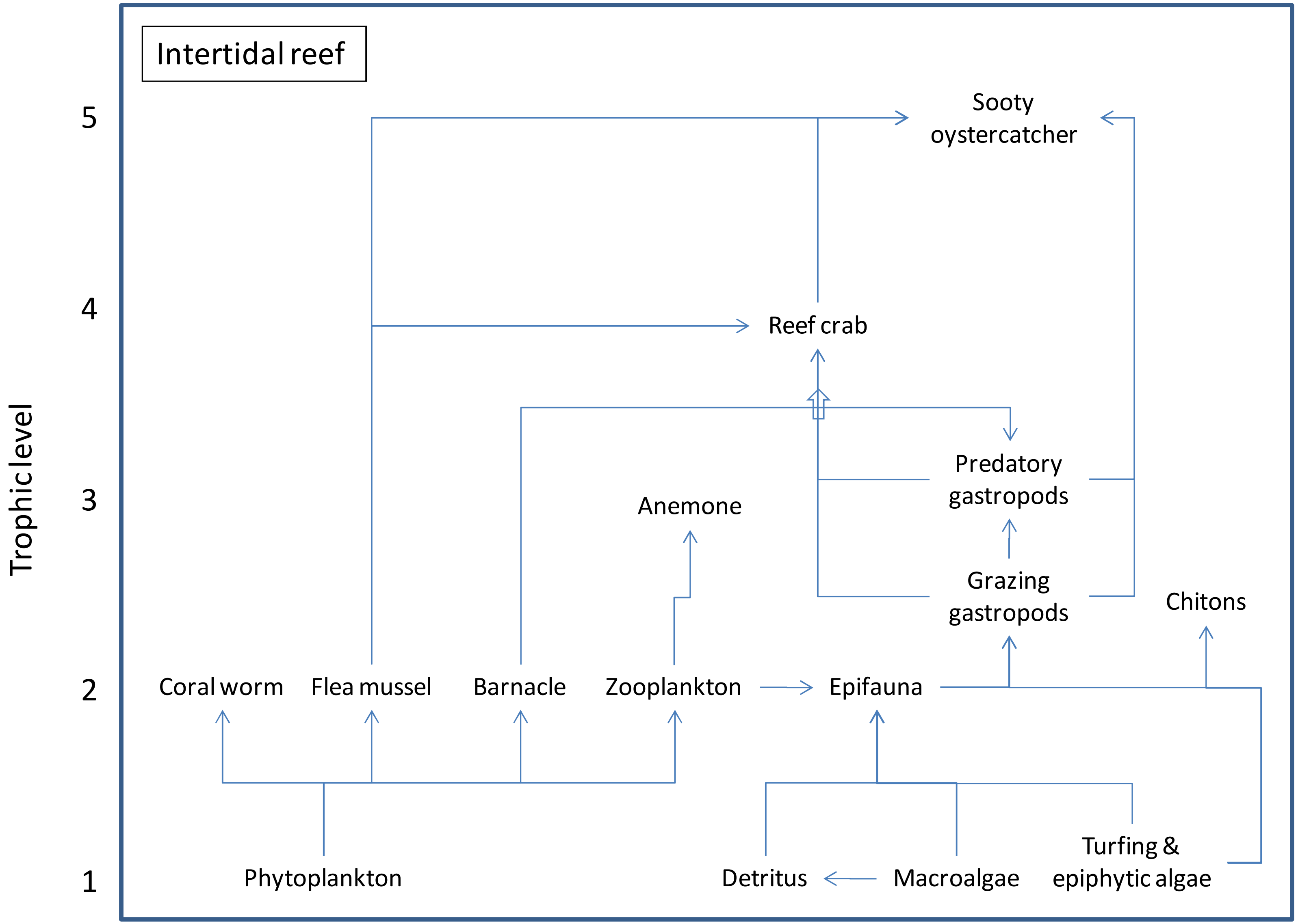

Subtidal sand plain
Trophic level
5
4
3
2
1
White shark
School shark, Gummy shark
Whaler sharks
Australian sea lion
Smooth stingray
Flathead
Octopus
Snapper
Blue swimmer & sand crabs
Predatory snails
Sand trevally, Silverbelly, Leatherjackets, Red mullet
Pipefish, Gobies
Western king prawn
Razorfish, Scallops, Hammer oyster
Sponges
Zooplankton
Epifauna, Infauna
Phytoplankton
Microphytobenthos
Drift macroalgae
Detritus
Drift seagrass

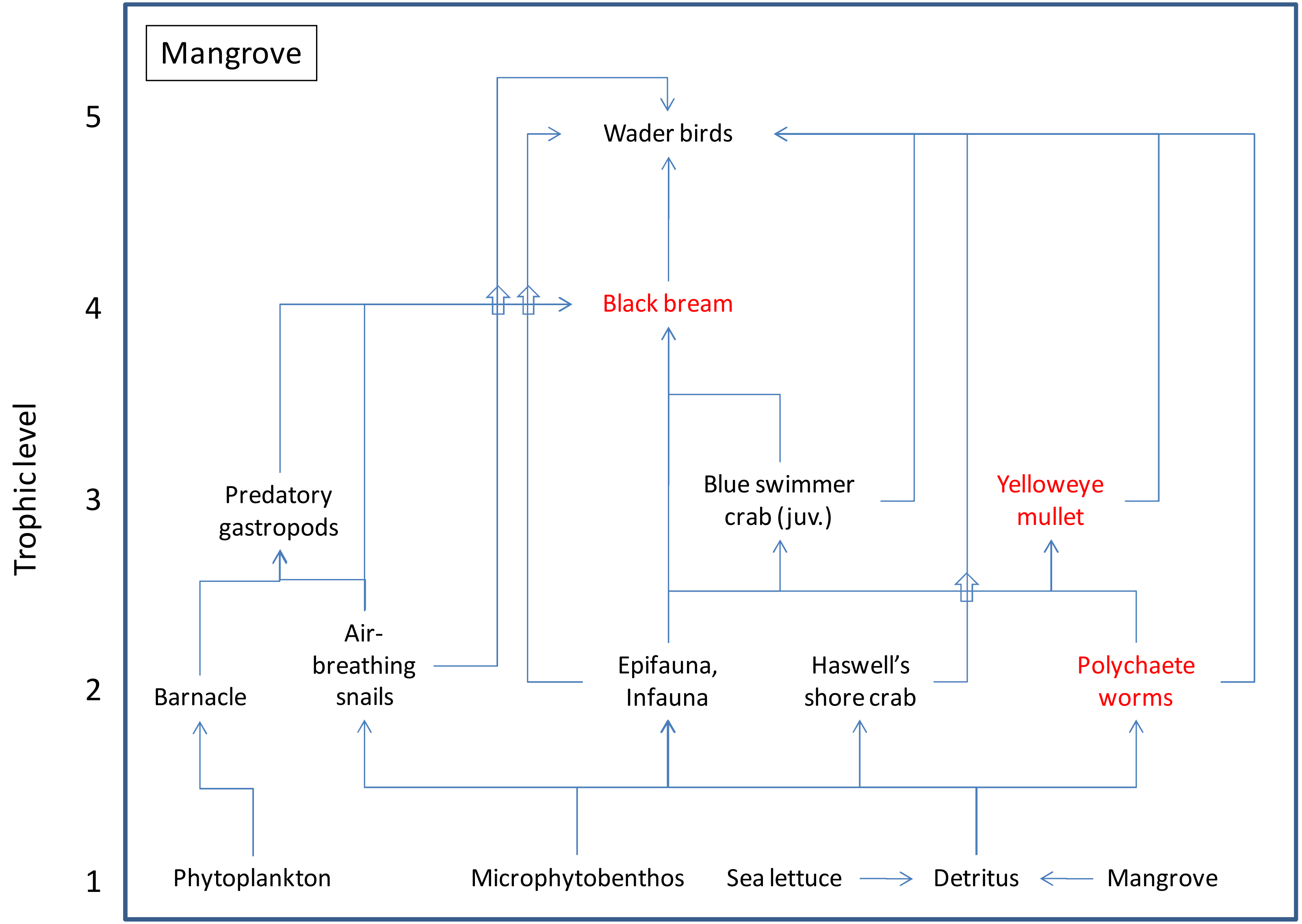

Subtidal seagrass meadow
Trophic level
5
4
3
2
1
White shark
Bottlenose dolphin
Smooth stingray
Flathead, Snook, Salmon , Calamary
Cormorant
Blue swimmer crab
Seadragons, Pipefishes
Garfish
Leatherjackets
King George whiting
Epifauna, Infauna
Razorfish
Scallops
Zooplankton
Phytoplankton
Seagrass
Detritus
Epiphytic algae

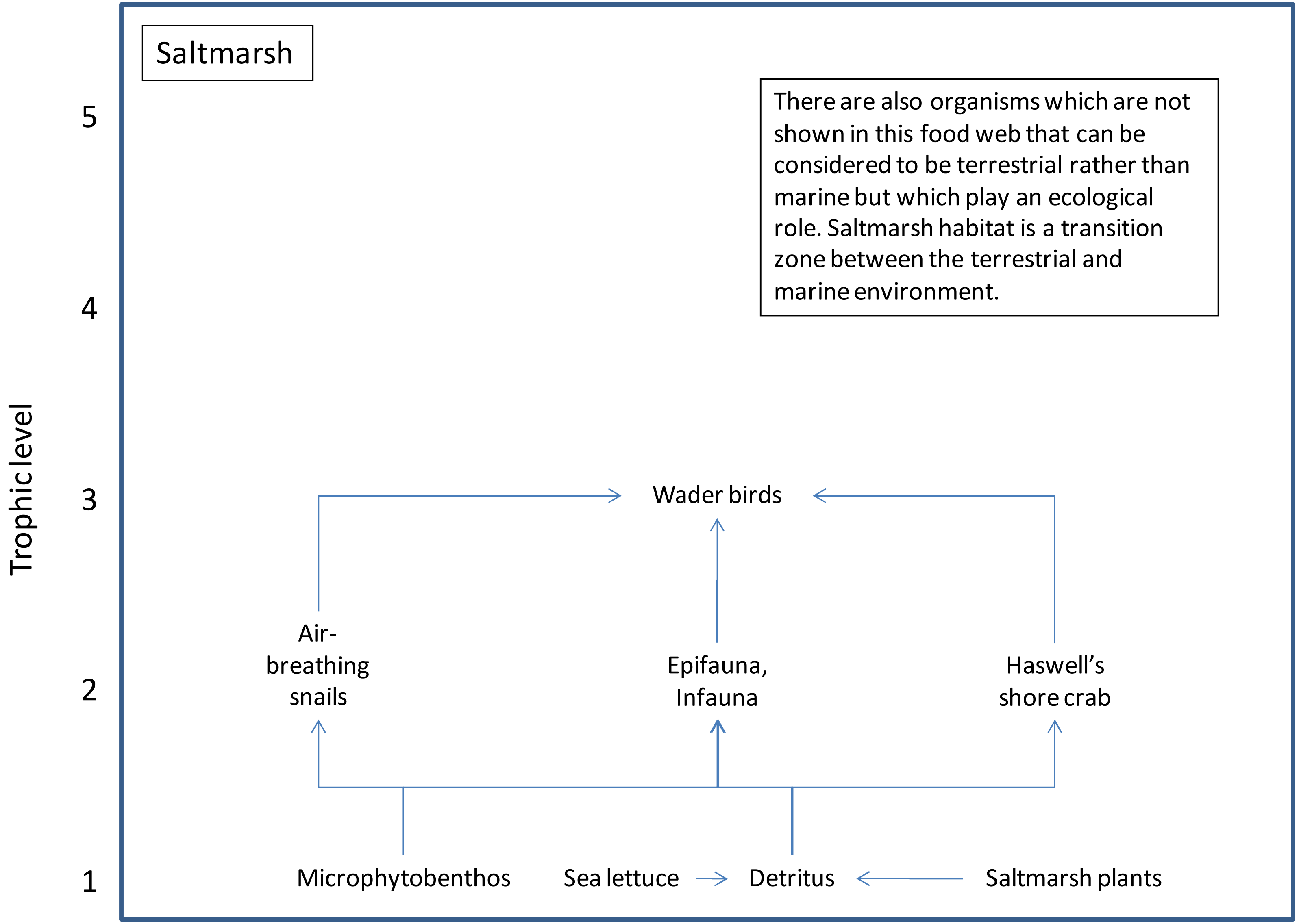

Beach
Trophic level
5
4
3
2
1
School shark & Gummy shark
Whaler sharks
Flathead
Salmon
Mulloway
Sea eagle
Pelican
Sand crab
Wader birds
Yelloweye mullet
Australian herring
School whiting
Goolwa cockle
Zooplankton
Epifauna, Infauna
Polychaete worms
Phytoplankton
Drift macroalgae
Detritus
Drift seagrass

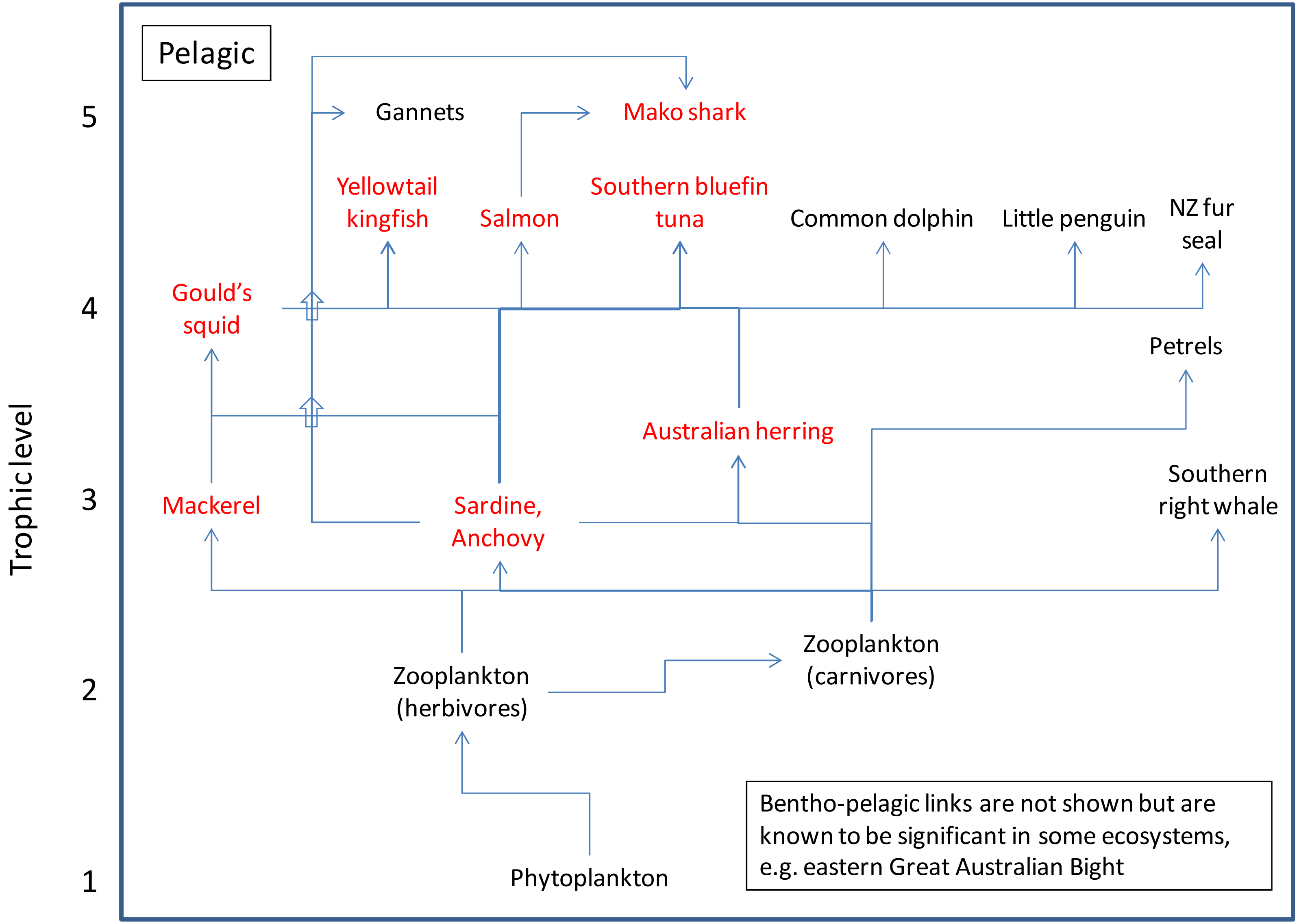

Intertidal sand flat
Trophic level
5
4
3
2
1
Bottlenose dolphin
Smooth stingray
Fiddler ray
Osprey
Flathead
Pelican
Moon snail
Blue swimmer crab
Flounder
Yellowfin whiting
Wader birds
Mud cockle
Razorfish
Zooplankton
Epifauna, Infauna
Smooth pebble crab
Polychaete worms
Western king prawn (juv.)
Phytoplankton
Microphytobenthos
Seagrass
Detritus


Intertidal seagrass flat
Trophic level
5
4
3
2
1
Bottlenose dolphin
Flathead
Pelican
Blue swimmer crab
Garfish
Wader birds
King George whiting (juv.)
Epifauna & Infauna
Razorfish
Zooplankton
Phytoplankton
Epiphytic algae
Seagrass
Detritus


Intertidal reef
Trophic level
5
4
3
2
1
Sooty oystercatcher
Reef crab
Predatory gastropods
Anemone
Grazing gastropods
Chitons
Coral worm
Flea mussel
Barnacle
Zooplankton
Epifauna
Phytoplankton
Detritus
Macroalgae
Turfing & epiphytic algae


Mangrove
Trophic level
5
4
3
2
1
Wader birds
Black bream
Predatory gastropods
Blue swimmer crab (juv.)
Yelloweye mullet
Barnacle
Air-breathing snails
Epifauna, Infauna
Haswell's shore crab
Polychaete worms
Phytoplankton
Microphytobenthos
Sea lettuce
Detritus
Mangrove


Saltmarsh
There are also organisms which are not shown in this food web that can be considered to be terrestrial rather than marine but which play an ecological role. Saltmarsh habitat is a transition zone between the terrestrial and marine environment.
Trophic level
5
4
3
2
1
Wader birds
Air-breathing snails
Epifauna, Infauna
Haswell's shore crab
Microphytobenthos
Sea lettuce
Detritus
Saltmarsh plants


Pelagic
Trophic level
5
4
3
2
1
Gannets
Mako shark
Yellowtail kingfish
Salmon
Southern bluefin tuna
Common dolphin
Little penguin
NZ fur seal
Gould's squid
Petrels
Australian herring
Southern right whale
Mackerel
Sardine, Anchovy
Zooplankton (carnivores)
Zooplankton (herbivores)
Phytoplankton
Bentho-pelagic links are not shown but are known to be significant in some ecosystems, e.g. eastern Great Australian Bight

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Appendix 7 Activities and Uses Tables

The following tables summarise how activities and uses are expected to be managed once marine park management plans are adopted. The prohibitions and restrictions described in the tables (grey shaded boxes) will be represented in the *Marine Park (Zoning) Variation Regulations 2012*.

Section 4 of the *Marine Parks Act 2007* establishes four types of marine park zones. These are General Managed Use, Habitat Protection, Sanctuary and Restricted Access Zones.

Section 5 of the *Marine Parks Act 2007* provides for Special Purpose Areas. These are areas within a marine park, defined by management plans, in which specified activities will be allowed that would otherwise be prohibited or restricted by zoning.

No additional permits under the *Marine Parks Act 2007* will be required if the activity is already permitted or licensed under another Act.

Exemptions
• The Minister responsible for marine parks may provide a permit for any activity to take place that would not ordinarily be allowed in a specific zone in accordance with section 19 of the *Marine Parks Act 2007*.
• The Regulations also provide an exemption for any person acting in the course of an emergency.
• The Regulations will not apply to a person exercising official powers or functions under a State or Commonwealth Act or an Aboriginal person acting in accordance with an ILUA or Aboriginal tradition..

Existing activities and uses
When management plans are developed, existing and reasonably foreseeable activities and uses will be accommodated, (as outlined by the policy commitments endorsed by Government) by appropriate zoning, the application of Special Purpose Areas or the provision of permits. Apart from fishing activities, any permits, licences or leases that are current at the time of the adoption of management plans, will not be affected by these restrictions.

KEY

GMUZ	General Managed Use Zone - being a zone primarily established so that an area may be managed to provide protection for habitats and biodiversity within a marine park, while allowing ecologically sustainable development and use
HPZ	Habitat Protection Zone - being a zone primarily established so that an area may be managed to provide protection for habitats and biodiversity within a marine park, while allowing activities and uses that do not harm habitats or the functioning of ecosystems
SZ	Sanctuary Zone - being a zone primarily established so that an area may be managed to provide protection and conservation for habitats and biodiversity within a marine park, especially by prohibiting the removal or harm of plants, animals or marine products
RAZ	Restricted Access Zone - being a zone primarily established so that an area may be managed by limiting access to the area

KEY

	Activity is deemed to be consistent with the definition of the zone (i.e. no change to current activity/use).
limit	Activity is deemed to be consistent with the definition of the zone when conducted in accordance with stated limits under the Regulations.
permit	Activity is deemed to be consistent with the definition of the zone when conducted in accordance with a permit under the Regulations.
	Activity is deemed to be inconsistent with the definition of the zone and will not be allowed. However, the Minister for Sustainability, Environment and Conservation may grant a permit for an activity that would otherwise be prohibited or restricted in a zone on a case by case basis.

RECREATION, EDUCATION AND OTHER

	GMUZ	HPZ	SZ	RAZ	Limits / Permits / Exceptions
Operating aircraft				limit	Limit: Aircraft cannot fly within 300m of the ground or sea level, and helicopters not within 500m of the ground or sea level.
Diving e.g. scuba/snorkel					
Pedestrian access					
Recreational boating/yachting					
Surfing/swimming					
Domestic animals			limit		Limit: Dogs on leads (up to 2m long); or animals confined to vessels/vehicles; or animals under effective control and behaving in accordance with relevant local Council by-laws.
Research			permit	permit	Permit[3]: A permit is not required for research authorised under another Act.
Commercial photography / film making			permit		Permit[3]: A permit is not required for commercial photography/film making authorised under another Act.
Competitions / organised events (non-fishing)			permit		Permit[3]: A permit is not required for non-fishing competitions/organised events authorised under another Act.
Tourism operations			permit		Permit[3]: A permit is not required for tourism operations authorised under another Act.

RECREATION, EDUCATION AND OTHER	GMUZ	HPZ	SZ	RAZ	Limits / Permits / Exceptions
Animal feeding/baiting/berleying [1]					
Motorised water sports[2]					
Lighting and supervision of fires		limit	limit		Limit: Lighting and supervision of fires is confined to designated areas.
Camping		limit	limit		Limit: Camping is confined to designated areas.
Collection of naturally occurring materials for burning in fires					

Notes:
[1] Feeding/baiting/berleying animals is not recommended in marine parks, except as required for fishing, aquaculture, research or tourism purposes.

[2] A person may transit through a sanctuary zone in a motorised vessel, but gear such as water skis or a wake board must be stowed.
[3] Standard permits (and conditions) may be issued for activities that are deemed to be low impact. All other activities will be subject to case-by-case assessments and non-standard permits (and conditions) may be issued. DEWNR will develop a permit policy to provide clear guidance to users about activities that require permits.

KEY

	Activity is deemed to be consistent with the definition of the zone (i.e. no change to current activity/use).
limit	Activity is deemed to be consistent with the definition of the zone when conducted in accordance with stated limits under the Regulations.
permit	Activity is deemed to be consistent with the definition of the zone when conducted in accordance with a permit under the Regulations.
	Activity is deemed to be inconsistent with the definition of the zone and will not be allowed. However, the Minister for Sustainability, Environment and Conservation may grant a permit for an activity that would otherwise be prohibited or restricted in a zone on a case by case basis.

FISHING AND COLLECTING (commercial, recreational and traditional)

Fishing activities are regulated under provisions of the *Fisheries Management Act 2007*.

	GMUZ	HPZ	SZ	RAZ	Limits / Permits / Exceptions
Bait digging/pumping					
Berleying for fishing					
Cockling (pipi and mud cockles)					
Collecting fish by hand (abalone, urchin, scallop, etc)					
Line fishing (including long lining)					
Netting (e.g. dab, haul, swing, gill, beach or power)					
Pot and trap fishing (including drop/hoop nets)					
Purse seine netting (including sardine)					
Raking (crab)					
Spear fishing					
Competitions / organised events (fishing)					

FISHING AND COLLECTING (commercial, recreational and traditional) Fishing activities are regulated under provisions of the *Fisheries Management Act 2007*.					
	GMUZ	HPZ	SZ	RAZ	Limits / Permits / Exceptions
Traditional fishing and collecting (Aboriginal)					Limit: Activity is limited to persons who are exercising their rights in accordance with an ILUA or Aboriginal tradition.
Collecting seagrass/algae (including beach cast)					
Collecting sessile assemblages, stromatolites, fossils and archaeological remains					
Trawling					

KEY

	Activity is deemed to be consistent with the definition of the zone (i.e. no change to current activity/use).
limit	Activity is deemed to be consistent with the definition of the zone when conducted in accordance with stated limits under the Regulations.
permit	Activity is deemed to be consistent with the definition of the zone when conducted in accordance with a permit under the Regulations.
	Activity is deemed to be inconsistent with the definition of the zone and will not be allowed. However, the Minister for Sustainability, Environment and Conservation may grant a permit for an activity that would otherwise be prohibited or restricted in a zone on a case by case basis.

HARBOR, NAVIGATION & TRANSPORT ACTIVITIES [1]

Harbor, navigation and transport activities are regulated under provisions of the *Harbors and Navigation Act 1993*.

	GMUZ	HPZ	SZ	RAZ	Limits / Permits / Exceptions
Navigation markers/aids					
General navigation and operation of vessels (other than anchoring)					
Anchoring of vessels – less than 80 metres (overall length)					
Anchoring of vessels – 80 metres and over (overall length)					Special Purpose Areas will provide for anchoring of vessels 80 metres and over in all harbors and in designated transhipment and anchoring locations and pilot boarding grounds
Permanent vessel moorings			permit		Permit: A permit will be required, which includes assessment by DEWNR and DPTI.
Dredging		limit			Limit: Activity is confined to harbors established under the *Harbors and Navigation Act 1993*.
Depositing dredged materials		limit			

Notes:

[1] Activities undertaken to support the ongoing operation of ports and harbors will be provided for in all zones. Also, given the extensive development expected to occur over the next 5-10 years in Upper Spencer Gulf, transitional arrangements will be required. For this purpose all HPZ, SZ and RAZ in Upper Spencer Gulf Marine Park will be declared Special Purpose Areas. This will provide for (a) developments comprising a development or project, or that part of a development or project, within the ambit of a declaration under section 46 of the *Development Act 1993*; and (b) activities comprising development approved under section 49 (crown development and public infrastructure) or section 49A (Electricity infrastructure development) of the *Development Act 1993*. This arrangement will be assessed at the time the first management plan is reviewed.

KEY

	Activity is deemed to be consistent with the definition of the zone (i.e. no change to current activity/use).
limit	Activity is deemed to be consistent with the definition of the zone when conducted in accordance with stated limits under the Regulations.
permit	Activity is deemed to be consistent with the definition of the zone when conducted in accordance with a permit under the Regulations.
	Activity is deemed to be inconsistent with the definition of the zone and will not be allowed. However, the Minister for Sustainability, Environment and Conservation may grant a permit for an activity that would otherwise be prohibited or restricted in a zone on a case by case basis.

COASTAL DEVELOPMENTS AND INFRASTRUCTURE [1]

Coastal developments and infrastructure are regulated under provisions of the *Development Act 1993*.

	GMUZ	HPZ	SZ	RAZ	Limits / Permits / Exceptions
Infrastructure (marinas, jetties, pontoons, breakwalls)					
Outfall and pipelines					
Renewable energy infrastructure (wind, wave, tidal)					

Notes:
[1] Coastal developments and infrastructure in HPZ will be managed under the *Development Act 1993* to achieve the definition of the zone (i.e. no harm to habitats or the functioning of ecosystems). Developments will be considered on a case by case basis to ensure that the achievement of the objects of the *Act* and the zone are supported appropriately. Development Plans and significant rojects are informed by the Planning Strategy which now includes the objects of the *Marine Parks Act 2007* so consideration of these will inform the assessment process. In addition, as part of the assessment process, advice or direction may be required from the Coast Protection Board and/or the Environment Protection Authority and other authorities, depending on the nature of the development. These agencies also have the requirement to take into account the objects of the *Marine Parks Act 2007*.

KEY

	Activity is deemed to be consistent with the definition of the zone (i.e. no change to current activity/use).
limit	Activity is deemed to be consistent with the definition of the zone when conducted in accordance with stated limits under the Regulations.
permit	Activity is deemed to be consistent with the definition of the zone when conducted in accordance with a permit under the Regulations.
	Activity is deemed to be inconsistent with the definition of the zone and will not be allowed. However, the Minister for Sustainability, Environment and Conservation may grant a permit for an activity that would otherwise be prohibited or restricted in a zone on a case by case basis.

AQUACULTURE

Aquaculture activities are regulated under provisions of the *Aquaculture Act 2001*.

	GMUZ	HPZ	SZ	RAZ	Limits / Permits / Exceptions
Farming of bivalve molluscs					
Farming of aquatic animals (other than prescribed wild-caught tuna) with regular feeding					
Farming of prescribed wild-caught tuna					
Farming of algae					
Pilot leases					

Notes: Aquaculture in HPZ will be managed under the *Aquaculture Act 2001* to ensure that all reasonable and practicable measures are taken to achieve the definition of the zone (i.e. no harm to habitats or the functioning of ecosystems). The *Aquaculture Act 2001* operates in addition to the *Marine Parks Act 2007* and requires aquaculture policies to seek to further the objects of the *Marine Parks Act 2007* where they apply within a marine park.

KEY

	Activity is deemed to be consistent with the definition of the zone (i.e. no change to current activity/use).
limit	Activity is deemed to be consistent with the definition of the zone when conducted in accordance with stated limits under the Regulations.
permit	Activity is deemed to be consistent with the definition of the zone when conducted in accordance with a permit under the Regulations.
	Activity is deemed to be inconsistent with the definition of the zone and will not be allowed. However, the Minister for Sustainability, Environment and Conservation may grant a permit for an activity that would otherwise be prohibited or restricted in a zone on a case by case basis.

WASTEWATER DISPOSAL/ DISCHARGES

Discharges are generally regulated under provisions of the *Environment Protection Act 1993* and the *Environment Protection (Water Quality) Policy 2003*.

	GMUZ	HPZ	SZ	RAZ	Limits / Permits / Exceptions
Discharge [1]					Discharges regulated under sections 3(2) or 8(7) of Schedule 1 of the *Environment Protection Act 1993* are prohibited
Extraction and disposal for a desalination plant[1]					
Vessel discharge of wastewater [2]					Specifically regulated by Clause 36 of the E*nvironment Protection (Water Quality) Policy 2003*

Notes:

[1] Discharges in HPZ will be managed under the *Environment Protection (Water Quality) Policy 2003* to ensure that all reasonable and practicable measures are taken to achieve the definition of the zone (i.e. no harm to habitats or the functioning of ecosystems).

[2] Wastewater includes black water, concentrated black water and grey water as defined by the *Environment Protection (Water Quality) Policy 2003*.

KEY	
	Activity is deemed to be consistent with the definition of the zone (i.e. no change to current activity/use).
limit	Activity is consistent with the definition of the zone when conducted in accordance with stated limits.
*	Activity is deemed to be inconsistent with the definition of the zone and will not be considered until such time as it can be demonstrated otherwise.
	Activity is deemed to be inconsistent with the definition of the zone and will not be permitted.

RESOURCE EXPLORATION AND PRODUCTION

These activities are regulated under provisions of the *Mining Act 1971*, the *Petroleum and Geothermal Act 2000, the Offshore Minerals Act 2000 and the Petroleum (Submerged Lands) Act 1982* to achieve the objectives of the marine park zones described under the *Marine Parks Act 2007*.

	GMUZ	HPZ	SZ	RAZ	Limits / Permits / Exceptions
Exploration (passive)	□	□	□	□	
– satellite/high level airborne					
– airborne surveys				*	*Will depend on the nature and timing of the proposed survey in relation to key environmental considerations (e.g. breeding and migration cycles of protected species).
– geophysical/geochemical surveys			limit		Limit: Will depend on the nature and timing of the proposed survey in relation to key environmental considerations (e.g. breeding and migration cycles of protected species).
Exploration (active)	□	□	□	□	
– geological sampling			*		* Will depend on nature of proposed surveying
– geophysical/geochemical surveys			*		* Will depend on nature of proposed surveying
– drilling (drill rig within zone)		*			* Will depend on nature of proposal and its location
– deviated drilling (drill rig outside zone)			limit	*	Limit: Activity will need to be conducted in accordance with approved conditions * Deviated drilling from outside zone may be considered if consistent with the zone
– trenching/bulk sampling	*	*			* Will depend on nature of proposal and its location

RESOURCE EXPLORATION AND PRODUCTION

These activities are regulated under provisions of the *Mining Act 1971*, the *Petroleum and Geothermal Act 2000, the Offshore Minerals Act 2000 and the Petroleum (Submerged Lands) Act 1982* to achieve the objectives of the marine park zones described under the *Marine Parks Act 2007*.

	GMUZ	HPZ	SZ	RAZ	Limits / Permits / Exceptions
Gas storage					
– carbon sequestration (surface facilities within zone)		*	×	×	* Will depend on nature of proposal and its location
– carbon sequestration (surface facilities outside zone)			*	*	* Deviated drilling from outside zone may be considered if consistent with the zone
Production/ Extraction	□	□	□	□	
– seawater (for extraction of resources such as salt)					
– through drillhole (surface facilities within zone)		*			* Will depend on nature of proposal and its location
– through drillhole (surface facilities outside zone)			limit	*	Limit: Activity will need to be conducted in accordance with approved conditions * Extraction from deviated drillhole from outside zone may be considered if consistent with the zone
– underground mining with surface facility	*				* Will depend on nature of proposal and its location
– underground mining with no surface facility		limit	*	*	Limit: Activity will need to be conducted in accordance with approved conditions. May be considered if activity does not compromise habitats or the functioning of ecosystems. * Will depend on nature of proposal and its location.
– pipeline on/above ground/seabed/trenched		*			* Will depend on nature of proposal and its location
– pipeline underground			*	*	* Will depend on nature of proposal and its location
– seabed dredging	*				* Will depend on nature of proposal and its location
– pit-type extraction	*				* Will depend on nature of proposal and its location

RESOURCE EXPLORATION AND PRODUCTION

These activities are regulated under provisions of the *Mining Act 1971,* the *Petroleum and Geothermal Act 2000, the Offshore Minerals Act 2000 and the Petroleum (Submerged Lands) Act 1982* to achieve the objectives of the marine park zones described under the *Marine Parks Act 2007*.

	GMUZ	HPZ	SZ	RAZ	Limits / Permits / Exceptions
Processing	□	□	□	□	
– mineral facility (mobile e.g. vessel based)	*				* Will depend on nature of proposal and its location
– mineral facility (permanent)					
– petroleum/geothermal facility					

Notes: All licence applications under the *Mining Act 1971* and the *Petroleum and Geothermal Act 2000* within and adjacent to marine parks are referred by the Minister for Mineral Resources and Development to the Minister for Sustainability, Environment and Conservation for concurrence. A referral process is required for the approval of on-ground exploration, and production activities, as part of the relevant mining regulation protocols between DMITRE and DEWNR. This provides for case-by-case assessment of each proposed activity. This includes activities deemed consistent with with the definition of the zone. The table indicates which activities are likely to be restricted when leases, licences and permits are considered by the Ministers. Activity proposals are considered by assessing risk. Activities likely to compromise the values of any zone would not be approved. A similar process is expected to be undertaken for activities authorised under the *Offshore Minerals Act 2000* and the *Petroleum (Submerged Lands) Act 1982*.

This table may be revised over time as new technologies and techniques are developed, to ensure that new technologies are appropriately considered, consistent with marine park zone objectives.

The following types of special purpose area may be identified in accordance with section 13(1)(c) of the *Marine Parks Act 2007*. Notwithstanding the zoning of the area, the following activities will be permitted in the special purpose areas.

Special Purpose Areas (significant economic development)
Activities comprising a development or project, or that part of a development or project, within the ambit of a declaration under section 46 of the *Development Act 1993*; and
Activities comprising development approved under section 49 (Crown development and public infrastructure) or section 49A (Electricity infrastructure development) of the *Development Act 1993*.

Special Purpose Areas (harbor activities)
Activities undertaken by or on behalf of the Minister responsible for the administration of the *Harbors and Navigation Act 1993*, or a port operator, for the purposes of maintaining or improving a harbor or port. (Harbor, port and port operator have the same meanings as in the *Harbors and Navigation Act 1993*.)

Special Purpose Areas (submarine cables and pipelines)
Activities undertaken for the purposes of maintaining or improving submarine cables or pipelines comprising public infrastructure (within the meaning of section 49 of the *Development Act 1993*).

Special Purpose Areas (transhipment)
Activities comprising the establishment, maintenance or improvement of facilities for a transhipment point prescribed or to be prescribed under the *Harbors and Navigation Regulations 2009*; and
Activities comprising or connected with loading or unloading a vessel at a transhipment point prescribed under the Harbors and Navigation Regulations 2009.

Special Purpose Areas (anchoring)
Activities comprising anchoring a commercial vessel (within the meaning of the *Harbors and Navigation Act 1993*) in an area recommended for that purpose by way of a Notice to Mariners by the Minister responsible for the administration of the *Harbors and Navigation Act 1993*.

Special Purpose Areas (shore-based recreational line fishing)
Recreational fishing from the shore by use of a hand line or rod and line. (Hand line, recreational fishing and rod and line have the same respective meanings as in the *Fisheries Management Act 2007*.)

Special Purpose Areas (Murray Mouth dredging)
Activities associated with dredging undertaken for the purposes of maintaining or improving water flows through the mouth of the River Murray.

Special Purpose Areas (Defence Prohibited Area)
Activities undertaken by the Department of Defence in relation to the Proof and Experimental Establishment (Port Wakefield).

Special Purpose Areas (Aquaculture)
Activities authorised under the *Aquaculture Act 2001*.

Appendix 8 Marine Parks Social Impact Assessment Tool

Marine Parks Social Impact Assessment Survey - Marine Park 1

Marine Parks Social Impact Assessment Survey

The *Australian Institute for Social Research* at The University of Adelaide has been commissioned by the South Australian Government Department of Environment and Natural Resources (DENR) to identify **potential social impacts of the proposed Marine Parks in SA** and prepare independent impact statements as part of the Marine Parks impact assessment process.

We recognise that you have expertise and experience that enables you to provide informed commentary on potential social impacts of the proposed Marine Parks. **We would very much appreciate your perspective**, whether positive or negative.

Your survey responses will be *confidential*, and your participation or non-participation will not affect you in any way. Any reports of the results from this survey will *not* identify individuals.

For further information about this survey, please contact Ms Cecilia Moretti at the Australian Institute for Social Research (cecilia.moretti@adelaide.edu.au or 8313 3392). Note that Cecelia is available Mondays to Thursdays only.

To begin the survey, please click on the "*Next*" button below.

Marine Parks Social Impact Assessment Survey - cont.

The establishment of Marine Parks can have a range of positive and negative impacts. We are interested in your views on the full range of these impacts.

We would like to ask for your views about **the Marine Park referred to in the email you received**, i.e. the email that linked you to this survey. Please confirm below which Marine Park you will be answering about.

Marine Parks Social Impact Assessment Survey - Marine Park 1

Marine Park ***(please select one)***

- Far West Coast
- Nuyts Archipelago
- West Coast Bays
- Investigator
- Thorny Passage
- Sir Joseph Banks Group
- Neptune Islands Group
- Gambier Islands Group
- Franklin Harbour
- Upper Spencer Gulf
- Eastern Spencer Gulf
- Southern Spencer Gulf
- Lower Yorke Peninsula
- Upper Gulf St Vincent
- Encounter
- Western Kangaroo Island
- Southern Kangaroo Island
- Upper South East
- Lower South East

Marine Parks Social Impact Assessment Survey - cont.

Please answer this questionnaire with reference to the **[Q1]** Marine Park. The questionnaire has several parts, as outlined below.

Part A will ask for **your general views** about this Marine Park.

Part B will ask you to rate the potential social impacts of the **DENR Preliminary Marine Park Sanctuary Zones** for this Marine Park.

Part C will ask you to rate the potential social impacts of the **MPLAG (Marine Park Local Advisory Group) Zone advice** for this Marine Park.

Part D will ask for your **final comments** about this Marine Park.

And finally in **Part E** you will be asked to provide some basic information about yourself.

We very much appreciate you taking the time to participate in this survey. **If you are unable to complete this questionnaire in one sitting**, you may access it again later using the link supplied in the email you received. All of your answers up to and including the page where you last clicked the 'Next' button will be stored.

Marine Parks Social Impact Assessment Survey - Marine Park 1

Part A - Your general views about this Marine Park

Please rate your agreement with the following statements about the [Q1] Marine Park:

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	*Don't know*
I fully understand the scientific arguments in favour of this Marine Park	◯	◯	◯	◯	◯	◯
The establishment of this Marine Park is based on sound scientific evidence	◯	◯	◯	◯	◯	◯
The DENR Preliminary Marine Park zone for this Marine Park is about right	◯	◯	◯	◯	◯	◯
The MPLAG zone advice for this Marine Park is about right	◯	◯	◯	◯	◯	◯
More information is needed about this Marine Park and how it will operate	◯	◯	◯	◯	◯	◯

Part B - DENR Preliminary Marine Park Sanctuary Zones

Tourism, Education and Wellbeing impacts of the DENR Preliminary Marine Park Sanctuary Zones

Please rate the likelihood that the DENR Preliminary Marine Park Sanctuary Zones for the [Q1] Marine Park will impact the following aspects of tourism, education and wellbeing.

	Very unlikely	Unlikely	Neither likely nor unlikely	Likely	Very likely	*Don't know*
The Marine Park is likely to increase tourism in our area – e.g. ecotourism, education related tourism	◯	◯	◯	◯	◯	◯
There will be more opportunity for charter boats to exploit ecotourism opportunities	◯	◯	◯	◯	◯	◯
The Marine Park will have no impact (positive or negative) on me or my family	◯	◯	◯	◯	◯	◯
The Marine Park will improve the quality of life of people in my community	◯	◯	◯	◯	◯	◯
The Marine Park will improve my personal quality of life	◯	◯	◯	◯	◯	◯
The Marine Park will provide increased opportunities for education about marine life	◯	◯	◯	◯	◯	◯
The Marine Park will provide increased opportunities for our understanding of marine conservation issues	◯	◯	◯	◯	◯	◯
The Marine Park will negatively change our way of life	◯	◯	◯	◯	◯	◯
The Marine Park will create new employment opportunities for local people	◯	◯	◯	◯	◯	◯

Marine Parks Social Impact Assessment Survey - Marine Park 1

Culture and Heritage Impacts of DENR Preliminary Marine Park Sanctuary Zones

Please rate the likelihood that the DENR Preliminary Marine Park Sanctuary Zones for the [Q1] Marine Park will impact the following aspects of the community's culture and heritage.

	Very unlikely	Unlikely	Neither likely nor unlikely	Likely	Very likely	*Don't know*
The Marine Park will respect the interests of Aboriginal communities	○	○	○	○	○	○
The Marine Park will help preserve Aboriginal culture and heritage	○	○	○	○	○	○
The Marine Park will help preserve local Australian culture and heritage	○	○	○	○	○	○
The Marine Park will help maintain our community's identity as a fishing centre	○	○	○	○	○	○

Part B - DENR Preliminary Marine Park Sanctuary Zones - cont.

Recreation and Fishing Impacts of DENR Preliminary Marine Park Sanctuary Zones

Please rate the likelihood that the DENR Preliminary Marine Park Sanctuary Zones for the [Q1] Marine Park will impact the following aspects of recreation and fishing.

	Very unlikely	Unlikely	Neither likely nor unlikely	Likely	Very likely	*Don't know*
The Marine Park will help to encourage recreational activities	○	○	○	○	○	○
The Marine Park will discourage recreational fishing	○	○	○	○	○	○
The Marine Park will bring better local facilities e.g. for recreation and fishing	○	○	○	○	○	○
The Marine Park will bring a wider range of activities for local people to participate in	○	○	○	○	○	○
Any significant losses in commercial fishing would be very damaging for my family	○	○	○	○	○	○
Any significant losses in commercial fishing would be very damaging for the community as a whole	○	○	○	○	○	○

Marine Parks Social Impact Assessment Survey - Marine Park 1

Population and Housing Impacts of DENR Preliminary Marine Park Sanctuary Zones

Please rate the likelihood that the DENR Preliminary Marine Park Sanctuary Zones for the [Q1] Marine Park will impact the following aspects of population and housing.

	Very unlikely	Unlikely	Neither likely nor unlikely	Likely	Very likely	*Don't know*
The Marine Park will bring too many tourists here and change the quality of our life	○	○	○	○	○	○
The Marine Park will see too many locals leaving the area	○	○	○	○	○	○
The Marine Park and the tourism it brings will generally increase property prices making it more difficult for locals to buy houses in this area	○	○	○	○	○	○
The Marine Park will lead to a lowering of beachfront property prices	○	○	○	○	○	○

Part B - DENR Preliminary Marine Park Sanctuary Zones - cont.

Managing change - DENR Preliminary Marine Park Sanctuary Zones

Please rate the likelihood of the following community responses to the DENR Preliminary Marine Park Sanctuary Zones for the [Q1] Marine Park.

	Very unlikely	Unlikely	Neither likely nor unlikely	Likely	Very likely	*Don't know*
Our community will adapt well to having the Marine Park	○	○	○	○	○	○
Our community is strong enough to manage the changes that will be brought by the Marine Park	○	○	○	○	○	○
There are a number of potential business opportunities that will be brought by the Marine Park	○	○	○	○	○	○
There will be a need for training programs to help people adapt to new occupations associated with the Marine Park	○	○	○	○	○	○
The Marine Park will divide our community into those for and against it	○	○	○	○	○	○
The Marine Park will be a source of pride to this community	○	○	○	○	○	○
The Marine Park will increase the number of events and other activities that help bring the community together	○	○	○	○	○	○

Part C - MPLAG Zone advice about Sanctuary Zones

Marine Parks Social Impact Assessment Survey - Marine Park 1

Tourism, Education and Wellbeing Impacts of MPLAG Zone advice

Please rate the likelihood that the MPLAG Zone advice for the [Q1] Marine Park will impact the following aspects of tourism, education and wellbeing.

	Very unlikely	Unlikely	Neither likely nor unlikely	Likely	Very likely	*Don't know*
The Marine Park is likely to increase tourism in our area – e.g. ecotourism, education related tourism	○	○	○	○	○	○
There will be more opportunity for charter boats to exploit ecotourism opportunities	○	○	○	○	○	○
The Marine Park will have no impact (positive or negative) on me or my family	○	○	○	○	○	○
The Marine Park will improve the quality of life of people in my community	○	○	○	○	○	○
The Marine Park will improve my personal quality of life	○	○	○	○	○	○
The Marine Park will provide increased opportunities for education about marine life	○	○	○	○	○	○
The Marine Park will provide increased opportunities for our understanding of marine conservation issues	○	○	○	○	○	○
The Marine Park will negatively change our way of life	○	○	○	○	○	○
The Marine Park will create new employment opportunities for local people	○	○	○	○	○	○

Culture and Heritage Impacts of MPLAG Zone advice

Please rate the likelihood that the MPLAG Zone advice for the [Q1] Marine Park will impact the following aspects of the community's culture and heritage.

	Very unlikely	Unlikely	Neither likely nor unlikely	Likely	Very likely	*Don't know*
The Marine Park will respect the interests of Aboriginal communities	○	○	○	○	○	○
The Marine Park will help preserve Aboriginal culture and heritage	○	○	○	○	○	○
The Marine Park will help preserve local Australian culture and heritage	○	○	○	○	○	○
The Marine Park will help maintain our community's identity as a fishing centre	○	○	○	○	○	○

Marine Parks Social Impact Assessment Survey - Marine Park 1

Part C - MPLAG Zone advice about Sanctuary Zones - cont.

Recreation and Fishing Impacts of MPLAG Zone advice

Please rate the likelihood that the MPLAG Zone advice for the [Q1] Marine Park will impact the following aspects of recreation and fishing.

	Very unlikely	Unlikely	Neither likely nor unlikely	Likely	Very likely	*Don't know*
The Marine Park will help to encourage recreational activities	○	○	○	○	○	○
The Marine Park will discourage recreational fishing	○	○	○	○	○	○
The Marine Park will bring better local facilities e.g. recreation and fishing	○	○	○	○	○	○
The Marine Park will bring a wider range of activities for local people to participate in	○	○	○	○	○	○
Any significant losses in commercial fishing would be very damaging for my family	○	○	○	○	○	○
Any significant losses in commercial fishing would be very damaging for the community as a whole	○	○	○	○	○	○

Population and Housing Impacts of MPLAG Zone advice

Please rate the likelihood that the MPLAG Zone advice for the [Q1] Marine Park will impact the following aspects of population and housing.

	Very unlikely	Unlikely	Neither likely nor unlikely	Likely	Very likely	*Don't know*
The Marine Park will bring too many tourists here and change the quality of our life	○	○	○	○	○	○
The Marine Park will see too many locals leaving the area	○	○	○	○	○	○
The Marine Park and the tourism it brings will generally increase property prices making it more difficult for locals to buy houses in this area	○	○	○	○	○	○
The Marine Park will lead to a lowering of beachfront property prices	○	○	○	○	○	○

Part C - MPLAG Zone advice about Sanctuary Zones - cont.

Managing change - MPLAG Zone advice

Marine Parks Social Impact Assessment Survey - Marine Park 1

Please rate the likelihood of the following community responses to the MPLAG Zone advice for the [Q1] Marine Park.

	Very unlikely	Unlikely	Neither likely nor unlikely	Likely	Very likely	*Don't know*
Our community will adapt well to having the Marine Park	○	○	○	○	○	○
Our community is strong enough to manage the changes that will be brought by the Marine Park	○	○	○	○	○	○
There are a number of potential business opportunities that will be brought by the Marine Park	○	○	○	○	○	○
There will be a need for training programs to help people adapt to new occupations associated with the Marine Park	○	○	○	○	○	○
The Marine Park will divide our community into those for and against it	○	○	○	○	○	○
The Marine Park will be a source of pride to this community	○	○	○	○	○	○
The Marine Park will increase the number of events and other activities that help bring the community together	○	○	○	○	○	○

Part D - Final comments about this Marine Park

In the spaces provided below, please list the impacts you are **most** concerned about for the [Q1] Marine Park, and how:

- potential negative impacts might be avoided or minimised, or

- how positive impacts might be maximised.

IMPACT 1

Likely impact (positive or negative)

Please suggest ways of minimising the negative impact or maximising the positive impact

Marine Parks Social Impact Assessment Survey - Marine Park 1

IMPACT 2

Likely impact (positive or negative)

Please suggest ways of minimising the negative impact or maximising the positive impact

IMPACT 3

Likely impact (positive or negative)

Please suggest ways of minimising the negative impact or maximising the positive impact

Part D - Final comments about this Marine Park - cont.

In the space below, please provide any further comments that you wish to make on the likely social impacts of the [Q1] Marine Park:

Part E - About you

Marine Parks Social Impact Assessment Survey - Marine Park 1

Which of these statements best describes your residential status? ***(select as many as apply)***

- ☐ I live full time in an area near the [Q1] Marine Park
- ☐ I own a shack/holiday home in an area near the [Q1] Marine Park and visit at least once a month
- ☐ I own a shack/holiday home in an area near the [Q1] Marine Park and visit less than once a month
- ☐ Other (*please specify*)

Do you own/operate a business in this area? ***(select as many as apply)***

- ☐ No, I do not own or operate any business in this area
- ☐ Yes - a Tourism related business
- ☐ Yes - a Hospitality related business
- ☐ Yes - a Fishing related business (e.g. tackle and bait shop, fishing charter boat)
- ☐ Yes - a Service business (e.g. deli, hotel, kiosk, cleaning business, aged care service)
- ☐ Yes - an other type of business (*please describe*)

My home postcode is:

I am: ***(select one)***

- ○ Male
- ○ Female

My age is:

My occupation is:

Appendix 9 MPLAG Member Response Rate

There were 168 MPLAG members with valid email addresses or contactable by phone, as some members worked with more than one park a total of 265 survey participation requests were sent:

- 111 members were invited to complete a survey about one park;
- 30 were invited to complete surveys about 2 parks (ie appeared on MPLAGs for 2 parks, equating to 60 responses);
- 14 were invited to complete surveys about 3 parks (equating to 42 responses); and
- 13 were invited to complete surveys about 4 parks (equating to 52 responses)

From the 265 invitations there were 157 responses which included 103 unique responses (and 54 responses to either 1, 2 or 3 additional parks).

- Therefore, 103 (61.3 per cent) of 168 MPLAG members with valid emails or willing to engage in a phone survey responded.
- Note response rate does not include any MPLAG members who:
    - were not contactable by email or phone
    - those who indicated they did not wish to participate in the social impact assessment (when DEWNR sent letter/email or when AISR phoned those with missing email addresses).

The park distribution is:

Number	Park	Invited	Response (n)	Response (%)
1	Far West Coast	11	8	73%
2	Nuyts Archipelago	11	6	55%
3	West Coast Bays	14	10	71%
4	Investigator	14	10	71%
5	Thorny Passage	12	8	67%
6	Sir Joseph Banks Group	14	8	57%
7	Neptune Islands Group	12	4	33%
8	Gambier Islands Group	12	5	42%
9	Franklin Harbor	9	3	33%
10	Upper Spencer Gulf	15	9	60%
11	Eastern Spencer Gulf	12	7	58%
12	Southern Spencer Gulf	26	16	62%
13	Lower Yorke Peninsula	12	6	50%
14	Upper Gulf St Vincent	10	7	70%
15	Encounter	28	18	64%
16	Western Kangaroo Island	14	9	64%
17	Southern Kangaroo Island	14	9	64%
18	Upper South East	13	7	54%
19	Lower South East	12	7	58%
Total		**265**	**157**	**59%**

Appendix 10 List of Parties consulted

Name		Affiliation	Organisation
Natalie	Ban	Research Fellow	James Cook University
Ruth	Beach	Member	Lower South East Marine Parks Local Advisory Group
James	Bennett	Fishery Management Officer	Department for Primary Industries and Resources SA
Michelle	Besley	Fishery Manager	Department for Primary Industries and Resources SA
Rex	Bichard	Abalone Fisher	Abalone Fisheries, Western Zone
Peter	Boulton		Department for Transport, Energy and Infrastructure
Amanda	Bridge	Economic Development Manager	Regional Development Australia, Eyre Peninsula
Andrew	Burnell	Principal Advisor	Department of Environment and Natural Resources
Mark	Cant	Chief Executive Officer	Regional Development Australia, Whyalla
Lionel	Carrison	Member	Lower South East Marine Parks Local Advisory Group
Ross	Carter	Project Manager	SA Water
Jenny	Cassidy	Senior Project Officer	Department for Transport, Energy and Infrastructure
Maureen	Christie	Member	Lower South East Marine Parks Local Advisory Group
Simon	Clark	Executive Officer	Spencer Gulf & West Coast Prawn Fishermen's Association
Dave	Cockshell	Chief Petroleum Geophysicist	Department for Primary Industries and Resources SA
Harvey	Cook	Director	Spencer Metals Pty Ltd
Steven	Cooper	Director	Orogenic Exploration Pty Ltd
Shaun	de Bruyn	Manager	South Australian Tourism Commission
Peter	Dunnicliffe	Member	Lower South East Marine Parks Local Advisory Group
Graham	Edgar	Senior Research Fellow	University of Tasmania
Roger	Edward	Independent Chair	Goolwa Pipi Harvesters Assoc. Inc.
Jon	Emmett	Project Coordinator, Marine Parks Project	Department of Environment and Natural Resources
Barry	Evans	Prawn fisher	Prawn Fisheries
Alice	Fistr	Manager, Fisheries Policy	Department for Primary Industries and Resources SA
Ian	Fitzgerald	Secretary	South Australian Recreational Fishing Advisory Council

Name		Affiliation	Organisation
Rob	Forgan		South East Local Government Association
Jim	Godden	Abalone Fisher	Southern Zone Abalone Fishery
David	Hitchcock	Director, Environment & Infrastructure	The Local Government Association of SA
Peter	Hollister	Director, Marine Transport and Policy	Department for Transport, Energy and Infrastructure
Phil	Hollow	Project Coordinator, Marine Parks Project	Department of Environment and Natural Resources
Vera	Hughes	Team Leader, Legislation and Governance	Department of Environment and Natural Resources
Ian	Janzow	Member	Metropolitan Fishers Alliance
Ken	Jones	Member	Lower South East Marine Parks Local Advisory Group
Sean	Kalling		Tony's Tuna International Pty Ltd
Carl	Kavina	General Manager Marine Operations	Flinders Ports Pty Ltd
Grant	King	Chairman	Lower South East Marine Parks Local Advisory Group
Keld	Knudsen	Senior Policy Adviser	Australian Petroleum Production and Exploration Association
Barry	Kuhl		District Council of Grant
Saras	Kumar	Marine Park Manager, Great Australian Bight	Department of Environment and Natural Resources
David	Lake	Manager	South Australian Tourism Commission
Peter	Lauer	Manager Aquaculture Policy, Planning and Environment Unit	Primary Industries and Regions South Australia
Chris	Lim	Case Manager	Department for Transport, Energy and Infrastructure
Ian	Llewellyn	Senior Project Officer	Department for Transport, Energy and Infrastructure
Nigel	Long	Director Corporate and Social Responsibility	South Australian Chamber of Mines and Energy
Neil	MacDonald	Executive Officer	Surveyed Charter Boat Owners and Operators Association, Gulf St Vincent Prawn Fishery
Arthur	Martel	Secretary	Southern Zone Abalone Management
Martin	McCarthy	Chief Executive Officer	Kingston District Council
Tim	McConachy	Director	Spencer Metals Pty Ltd
	Members		Marine Park Council
	Members		South Australian Regional Organisations of Councils

Name		Affiliation	Organisation
	Members	The Scientific Working Group	Department of Environment and Natural Resources
Samara	Miller	Executive officer	Abalone Industry Association of SA Inc.
Lachlan	Miller	Chief Executive Officer	District Council of Streaky Bay
Angus	Mitchell	Principal Policy Officer	Department of Environment and Natural Resources
Gary	Morgan	Chairman	Wildcatch Fisheries SA
Steve	Moriarty	Rocklobster Fisher	Rock lobster fisheries
Paul	Mullen	Former Exceutive Officer	South Australian Tourism Commission
Merilyn	Nobes	Policy Manager, Fisheries and Aquaculture	Department for Primary Industries and Resources SA
Peter	Noble	Secretary	Surveyed Charter Boat Owners and Operators Association
Craig	Noell	Fishery Manager	Department for Primary Industries and Resources SA
Bob	Oliver	Member	Lower South East Marine Parks Advisory Group
Greg	Palmer	Prawn fisher	Prawn Fisheries
David	Pearce	Project Coordinator, Marine Parks Project	Department of Environment and Natural Resources
Russell	Peate		District Council of Grant
Justin	Phillips	Executive Officer	Blue Crab Pot Fishers Association
Justin	Phillips	Executive Officer & Industry Liaison Officer (PIFS)	South Australian Rock Lobster Advisory Council, South East Professional Fishermen's Association, Northern Zone Rock Lobster Fishing Association
Phillip	Reddy	Environmental Sustainability Officer	Alexandrina Council
Joel	Redman	Member	Lower South East Marine Parks Local Advisory Group
Keith	Rowling	Fishery Manager	Department for Primary Industries and Resources SA
Richard	Sage	Mayor	District Council of Grant
Brenton	Schahinger	Chairman	South Australian Recreational Fishing Advisory Council
Rob	Shaw		Department for Primary Industries and Resources SA
Scoresby	Shepherd	Senior Research Fellow	South Australian Research and Development Institute
Peter	Short	Project Director	Department for Transport, Energy and Infrastructure
Emmanualle	Sloan	Manager, Aquaculture Planning Unit	Department for Primary Industries and Resources SA

Name		Affiliation	Organisation
Sean	Sloan	Director of Fisheries and Aquaculture Policy	Department of Primary Industries and Resources SA
Mark	Spencer	Fishery Manager	Department for Primary Industries and Resources SA
Adam	Stanford	Commercial Analyst	South Australian Tourism Commission
Graham	Tapley	President	South Australian Sardine Industry Association
Chris	Thomas	Branch Manager	Department of Environment and Natural Resources
Michael	Tokley	Executive officer	Central Zone Abalone Fishery
Lianos	Triantafillos	Fishery Manager	Department for Primary Industries and Resources SA
Hank	van der Wijngaart	President	Scuba Divers Federation of SA
Tim	Ward	Program Leader, Wild Fisheries	South Australian Research and Development Institute
Paul	Watson	Executive Officer	South Australian Sardine Industry Association
Dion	Watson	Deputy Chief Executive Officer	District Council of Tumby Bay
Scott	Weaver	President	Charter Boat Association of SA
Peter	Welch	Executive Officer	Marine Fishers Association
Peter	Whitehead	Member	Lower South East Marine Parks Local Advisory Group
Ian	Winton	Deputy Chairman	South Australian Recreational Fishing Advisory Council
Jonas	Woolford	SA Director	Abalone Council Australia Ltd
Alison	Wright	Project Coordinator, Marine Parks	Department of Environment and Natural Resources
Qifeng	Ye	Acting Chief Scientist	South Australian Research and Development Institute

Appendix 11 State-wide Economic Impacts by Individual Fishery

Estimates of the economic impact of marine park zoning in South Australia on affected fisheries are shown below. The direct impact measures fishing and downstream activities (i.e. processing, transport, retail/food services and capital expenditure). The flow-on impact measures the economic effects in other sectors of the economy (trade, manufacturing, etc.) generated by the fishing industry activities, that is, the multiplier effects.

Abalone

The value of output lost directly in SA by Abalone fishing enterprises is estimated to be \$1.39m and \$0.74m is estimated to be lost to associated downstream activities (processing, transport and retail/food services). Flow-on output lost to other sectors of the state economy is estimated to be \$2.70m. The total loss in output in SA (direct plus indirect) is estimated to be \$4.83m (Table A11–1).The loss in direct employment in the Abalone fishery in SA is estimated to be less than 1 fte job, while downstream activities are estimated to lose around 4 fte jobs state-wide. Flow-on business activity was estimated to lose a further 14 fte jobs, while the total loss in employment is to be approximately 17 fte jobs.

Contribution to GSP is measured as value of output less the cost of goods and services (including imports) used in producing the output. The loss in total Abalone fishing industry related contribution to GSP in South Australia is \$3.03m, \$1.37m lost by fishing directly, \$0.25m in downstream activities and \$1.41m lost in other sectors of the state economy.

Table A11–1 State economic impact of marine park zoning on the Abalone fishery based on SARDI estimates of displaced effort

Sector	Output		Employment [a]		Household Income		Contribution to GSP	
	($m)	%	(fte jobs)	%	($m)	%	($m)	%
Direct effects								
Fishing	-1.39	29%	0	0%	-1.05	54%	-1.37	45%
Downstream [b]	-0.74	15%	-4	20%	-0.15	8%	-0.25	8%
Total Direct [c]	*-2.13*	*44%*	*-4*	*20%*	*-1.20*	*62%*	*-1.62*	*54%*
Flow-on effects								
Trade	-0.44	9%	-4	23%	-0.15	8%	-0.21	7%
Manufacturing	-0.43	9%	-2	9%	-0.08	4%	-0.13	4%
Accom, Cafe, Rest	-0.14	3%	-1	5%	-0.04	2%	-0.06	2%
Transport	-0.16	3%	-1	4%	-0.03	2%	-0.07	2%
Other Sectors	-1.53	32%	-7	39%	-0.44	23%	-0.95	31%
Total Flow-on [c]	*-2.70*	56%	*-14*	80%	*-0.74*	38%	*-1.41*	46%
Total [c]	**-4.83**	**100%**	**-17**	**100%**	**-1.94**	**100%**	**-3.03**	**100%**

[a] Full-time equivalent jobs.
[b] Downstream activities consist of seafood processing, transport, retail trade and food services.
[c] Totals may not sum due to rounding.
Source: EconSearch analysis

Northern Zone Rock Lobster

The value of output lost directly in SA by Northern Zone Rock Lobster fishing enterprises is estimated to be $1.67m and $0.58m is estimated to be lost to associated downstream activities (processing, transport and retail/food services). Flow-on output lost to other sectors of the state economy is estimated to be $2.77m. The total loss in output in SA (direct plus indirect) is estimated to be $5.02m (Table A11–2).

The loss in direct employment in the Northern Zone Rock Lobster fishery in SA is estimated to be 10 fte jobs, while downstream activities are estimated to lose around 3 fte jobs state-wide. Flow-on business activity was estimated to lose a further 14 fte jobs, while the total loss in employment is to be approximately 28 fte jobs.

Contribution to GSP is measured as value of output less the cost of goods and services (including imports) used in producing the output. The loss in total Northern Zone Rock Lobster fishing industry related contribution to GSP in South Australia is $2.76m, $1.09m lost by fishing directly, $0.23m in downstream activities and $1.45m lost in other sectors of the state economy.

Table A11–2 State economic impact of marine park zoning on the Northern Zone Rock Lobster fishery based on SARDI estimates of displaced effort

Sector	Output		Employment [a]		Household Income		Contribution to GSP	
	($m)	%	(fte jobs)	%	($m)	%	($m)	%
Direct effects								
Fishing	-1.67	33%	-10	37%	-0.74	44%	-1.09	39%
Downstream [b]	-0.58	12%	-3	12%	-0.14	8%	-0.23	8%
Total Direct [c]	*-2.25*	*45%*	*-13*	*48%*	*-0.87*	*52%*	*-1.32*	*48%*
Flow-on effects								
Trade	-0.41	8%	-4	14%	-0.14	8%	-0.19	7%
Manufacturing	-0.37	7%	-1	5%	-0.07	4%	-0.11	4%
Accom, Cafe, Rest	-0.19	4%	-1	5%	-0.06	3%	-0.08	3%
Transport	-0.16	3%	-1	2%	-0.03	2%	-0.07	2%
Other Sectors	-1.64	33%	-7	26%	-0.51	30%	-0.99	36%
Total Flow-on [c]	*-2.77*	55%	*-14*	52%	*-0.81*	48%	*-1.45*	52%
Total [c]	**-5.02**	**100%**	**-28**	**100%**	**-1.68**	**100%**	**-2.76**	**100%**

[a] Full-time equivalent jobs.
[b] Downstream activities consist of seafood processing, transport, retail trade and food services.
[c] Totals may not sum due to rounding.
Source: EconSearch analysis

Southern Zone Rock Lobster

The value of output lost directly in SA by Southern Zone Rock Lobster fishing enterprises is estimated to be $0.91m and $0.32m is estimated to be lost to associated downstream activities (processing, transport and retail/food services). Flow-on output lost to other sectors of the state economy is estimated to be $1.49m. The total loss in output in SA (direct plus indirect) is estimated to be $2.71m (Table A11–3).

The loss in direct employment in the Southern Zone Rock Lobster fishery in SA is estimated to be 3 fte jobs, while downstream activities are estimated to lose around 2 fte jobs state-wide. Flow-on business activity was estimated to lose a further 8 fte jobs, while the total loss in employment is to be approximately 13 fte jobs.

Contribution to GSP is measured as value of output less the cost of goods and services (including imports) used in producing the output. The loss in total Southern Zone Rock Lobster fishing industry related contribution to GSP in South Australia is $1.61m, $0.71m lost by fishing directly, $0.12m in downstream activities and $0.78m lost in other sectors of the state economy.

Table A11–3 State economic impact of marine park zoning on the Southern Zone Rock Lobster fishery based on SARDI estimates of displaced effort

Sector	Output		Employment [a]		Household Income		Contribution to GSP	
	($m)	%	(fte jobs)	%	($m)	%	($m)	%
Direct effects								
Fishing	-0.91	33%	-3	26%	-0.51	51%	-0.71	44%
Downstream [b]	-0.32	12%	-2	14%	-0.07	7%	-0.12	8%
Total Direct [c]	*-1.22*	*45%*	*-5*	*40%*	*-0.58*	*58%*	*-0.84*	*52%*
Flow-on effects								
Trade	-0.24	9%	-2	18%	-0.08	8%	-0.11	7%
Manufacturing	-0.22	8%	-1	6%	-0.04	4%	-0.07	4%
Accom, Cafe, Rest	-0.10	4%	-1	5%	-0.03	3%	-0.04	3%
Transport	-0.09	3%	0	3%	-0.02	2%	-0.04	2%
Other Sectors	-0.84	31%	-4	28%	-0.25	25%	-0.52	32%
Total Flow-on [c]	*-1.49*	55%	*-8*	60%	*-0.42*	42%	*-0.78*	48%
Total [c]	**-2.71**	**100%**	**-13**	**100%**	**-1.01**	**100%**	**-1.61**	**100%**

[a] Full-time equivalent jobs.
[b] Downstream activities consist of seafood processing, transport, retail trade and food services.
[c] Totals may not sum due to rounding.
Source: EconSearch analysis

Lakes and Coorong

The value of output lost directly in SA by Lakes and Coorong fishing enterprises is estimated to be $0.88m and $0.88m is estimated to be lost to associated downstream activities (processing, transport and retail/food services). Flow-on output lost to other sectors of the state economy is estimated to be $2.42m. The total loss in output in SA (direct plus indirect) is estimated to be $4.18m (Table A11–4).

The loss in direct employment in the Lakes and Coorong fishery in SA is estimated to be 10 fte jobs, while downstream activities are estimated to lose around 6 fte jobs state-wide. Flow-on business activity was estimated to lose a further 12 fte jobs, while the total loss in employment is to be approximately 28 fte jobs.

Contribution to GSP is measured as value of output less the cost of goods and services (including imports) used in producing the output. The loss in total Lakes and Coorong fishing industry related contribution to GSP in South Australia is $0.61m, $0.19m lost by fishing directly, $0.09m in downstream activities and $0.32m lost in other sectors of the state economy.

Table A11–4 State economic impact of marine park zoning on the Lakes and Coorong fishery based on SARDI estimates of displaced effort

Sector	Output		Employment [a]		Household Income		Contribution to GSP	
	($m)	%	(fte jobs)	%	($m)	%	($m)	%
Direct effects								
Fishing	-0.88	21%	-10	34%	-0.55	38%	-0.68	30%
Downstream [b]	-0.88	21%	-6	22%	-0.23	16%	-0.35	16%
Total Direct [c]	*-1.77*	*42%*	*-16*	*56%*	*-0.77*	*53%*	*-1.03*	*45%*
Flow-on effects								
Trade	-0.37	9%	-3	12%	-0.13	9%	-0.17	8%
Manufacturing	-0.37	9%	-1	5%	-0.07	5%	-0.11	5%
Accom, Cafe, Rest	-0.20	5%	-1	5%	-0.06	4%	-0.08	4%
Transport	-0.14	3%	-1	2%	-0.03	2%	-0.06	3%
Other Sectors	-1.33	32%	-6	20%	-0.40	27%	-0.81	36%
Total Flow-on [c]	*-2.42*	58%	*-12*	44%	*-0.68*	47%	*-1.24*	55%
Total [c]	**-4.18**	**100%**	**-28**	**100%**	**-1.45**	**100%**	**-2.27**	**100%**

[a] Full-time equivalent jobs.
[b] Downstream activities consist of seafood processing, transport, retail trade and food services.
[c] Totals may not sum due to rounding.
Source: EconSearch analysis

Blue Crab

SARDI estimates indicate that historically there has been an average annual catch of 1,023 kg of blue crabs in the draft sanctuary zones in South Australia. This represents 0.19 per cent of all South Australian Gulf Crab Fisheries' average annual catch. The value of the catch displaced from these sancturary zones is approximately $8,000.

Marine Scalefish

The value of output lost directly in SA by Marine Scalefish fishing enterprises is estimated to be $1.00m and $1.00m is estimated to be lost to associated downstream activities (processing, transport and retail/food services). Flow-on output lost to other sectors of the state economy is estimated to be $2.70m. The total loss in output in SA (direct plus indirect) is estimated to be $4.70m (Table A11–5).

The loss in direct employment in the Marine Scalefish fishery in SA is estimated to be 13 fte jobs, while downstream activities are estimated to lose 7 fte jobs state-wide. Flow-on business activity was estimated to lose a further 20 fte jobs, while the total loss in employment is 34 fte jobs.

Contribution to GSP is measured as value of output less the cost of goods and services (including imports) used in producing the output. The loss in total Marine Scalefish fishing industry related contribution to GSP in South Australia is $2.54m, $0.76m lost by fishing directly, $0.40m in downstream activities and $1.38m lost in other sectors of the state economy.

Table A11–5 State economic impact of marine park zoning on the Marine Scalefish fishery based on SARDI estimates of displaced effort

Sector	Output		Employment [a]		Household Income		Contribution to GSP	
	($m)	%	(fte jobs)	%	($m)	%	($m)	%
Direct effects								
Fishing	-1.00	21%	-13	38%	-0.58	36%	-0.76	30%
Downstream [b]	-1.00	21%	-7	21%	-0.26	16%	-0.40	16%
Total Direct [c]	*-2.00*	*42%*	*-20*	*59%*	*-0.83*	*52%*	*-1.16*	*46%*
Flow-on effects								
Trade	-0.42	9%	-4	12%	-0.14	9%	-0.20	8%
Manufacturing	-0.43	9%	-2	5%	-0.08	5%	-0.13	5%
Accom, Cafe, Rest	-0.22	5%	-1	4%	-0.07	4%	-0.09	4%
Transport	-0.17	4%	-1	2%	-0.03	2%	-0.07	3%
Other Sectors	-1.47	31%	-6	19%	-0.44	27%	-0.89	35%
Total Flow-on [c]	*-2.70*	58%	*-14*	41%	*-0.76*	48%	*-1.38*	54%
Total [c]	**-4.70**	**100%**	**-34**	**100%**	**-1.59**	**100%**	**-2.54**	**100%**

[a] Full-time equivalent jobs.
[b] Downstream activities consist of seafood processing, transport, retail trade and food services.
[c] Totals may not sum due to rounding.
Source: EconSearch analysis

Charter Boat

The value of output lost directly in SA by Charter Boat fishing enterprises is estimated to be $0.19m and $0.10m is estimated to be lost to associated downstream activities (accommodation, transport and retail/food services). Flow-on output lost to other sectors of the state economy is estimated to be $0.38m. The total loss in output in SA (direct plus indirect) is estimated to be $0.70m (Table A11–6).

The loss in direct employment in the Charter Boat fishery in SA is estimated to be 2 fte jobs, while downstream activities are estimated to lose 1 fte job state-wide. Flow-on business activity was estimated to lose a further 2 fte jobs, while the total loss in employment is 5 fte jobs.

Contribution to GSP is measured as value of output less the cost of goods and services (including imports) used in producing the output. The loss in total Charter Boat fishing industry related contribution to GSP in South Australia is $0.39m, $0.13m lost by fishing directly, $0.06m in downstream activities and $0.19m lost in other sectors of the state economy.

Table A11–6 State economic impact of marine park zoning on the Charter Boat fishery based on SARDI estimates of displaced effort

Sector	Output		Employment [a]		Household Income		Contribution to GSP	
	($m)	%	(fte jobs)	%	($m)	%	($m)	%
Direct effects								
Fishing	-0.19	28%	-2	34%	-0.08	35%	-0.13	35%
Downstream [b]	-0.12	18%	-1	23%	-0.04	17%	-0.06	15%
Total Direct [c]	*-0.32*	*46%*	*-3*	*57%*	*-0.12*	*53%*	*-0.19*	*50%*
Flow-on effects								
Trade	-0.06	9%	-1	13%	-0.02	9%	-0.03	8%
Manufacturing	-0.06	8%	0	5%	-0.01	5%	-0.02	5%
Accom, Cafe, Rest	-0.07	10%	0	10%	-0.02	10%	-0.03	8%
Transport	-0.02	3%	0	2%	0.00	2%	-0.01	2%
Other Sectors	-0.16	23%	-1	13%	-0.05	22%	-0.11	27%
Total Flow-on [c]	*-0.38*	54%	*-2*	43%	*-0.11*	47%	*-0.19*	50%
Total [c]	**-0.70**	**100%**	**-5**	**100%**	**-0.23**	**100%**	**-0.39**	**100%**

[a] Full-time equivalent jobs.
[b] Downstream activities consist of seafood processing, transport, retail trade and food services.
[c] Totals may not sum due to rounding.
Source: EconSearch analysis