Report on the Scientific Basis for and the Role of Marine Sanctuaries in Marine Planning

Marine Scientific Panel

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For the Inter Departmental Committee for the Management of the States Marine Protected Areas

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A. Executive Summary

Introduction

In September 2006, the Western Australian (WA) Cabinet decided to establish a Marine Scientific Panel to address scientific issues arising from the regional marine planning process and to provide advice to the Government in the development of marine parks and reserves policy. The Panel was appointed by the then Minister for the Environment in January 2008. The Panel members were Mr Simon Woodley (Chair), Professor Neil Loneragan, Murdoch University and Dr Russ Babcock from CSIRO, Brisbane and Perth.

The Panel's terms of reference are to:

(a) Contribute through provision of scientific advice to the development of Government policy on marine parks and reserves through dialogue with the Expanded Interdepartmental Committee of Agency CEOs; and

(b) Respond to requests from the expanded Interdepartmental Committee of Agency CEOs and the State Marine Policy Stakeholder Group for independent scientific advice on other matters pertaining to regional marine planning.

Marine Sanctuaries Task

The first task set for the Panel was to develop a report on the scientific basis for and the role of marine sanctuaries in marine planning, for consideration by Government.

This report addresses this task and was commissioned by the Expanded Inter-Departmental Committee of Agency CEOs (EIDC) (Section B). The main aims of the report were to:

i. examine the context of marine protected areas and marine sanctuaries in marine planning (Section C),

ii. evaluate the scientific evidence for the effectiveness of marine sanctuaries for conserving biodiversity and in fisheries management from both a global perspective (Section D, Appendix 1) but in particular for Western Australia (Section E, Appendix 2), and

iii. make policy recommendations on the scientific basis for and the role of marine sanctuaries in marine planning in Western Australia.

The Panel has examined the scientific information on the basis for and role of marine sanctuaries and similar 'no-take' areas from Australia and other countries, and for WA, including sanctuary zones as defined in the *Conservation and Land Management Act 1984* (CALM Act), and Fish Habitat Protection Areas (FHPAs) and closures to fishing under the *Fish Resources Management Act 1994* (FRM Act). The effectiveness of marine sanctuaries in achieving their purpose has also been examined. The Panel has then drawn general conclusions from this evidence and specific conclusions in relation to WA marine planning (Section G). Finally the Panel has developed policy recommendations on the role of marine sanctuaries in WA marine planning (Section H).

In compiling this report, the Panel has also attempted to address questions of the scale of marine sanctuaries (temporal and spatial) in relation to biodiversity conservation and fisheries management. Evidence from Ningaloo Marine Park has been used to examine these questions (Section E).

The Panel consulted with key stakeholder groups with an interest in marine parks and reserves and marine planning (see Appendix 3) and provided a draft report to the EIDC for comment and feedback in May 2008. This report incorporates the feedback and comments received from members of the EIDC at that time.

Note 1: The term 'marine sanctuaries' used in this report refers to 'no-take' zones generally. "Effectiveness" means the degree to which the objectives and outcomes for which marine sanctuaries have been established have been achieved.

Note 2: This report was completed in July 2008 and information relating to marine protected areas, marine sanctuaries and other forms of marine protection referred to in the report is current at that time

General overview

Marine sanctuaries are areas of the marine environment that are primarily established for the purpose of conserving biodiversity. Marine protected areas cover approximately 2.35 million km^2, equivalent to 0.65% of the world's oceans and 1.6% of the area within Exclusive Economic Zones. The area of marine protected areas has been growing at a rate of 4.6% p.a. since 1984, mainly in coastal waters. 20-40% of the global area is within small and isolated areas, which may not be effective in conserving marine populations, or may not contribute to a wider network. A large proportion of the total global protected area (64%) lies within the 10 largest marine protected areas that range in size from 46.7 km^2 to 340,000 km^2.

Conservation of marine biodiversity

The empirical evidence for the use of marine sanctuaries for biodiversity conservation is now substantial. The Panel has drawn the following broad conclusions from the evidence:

(a) Marine sanctuaries can have a positive effect on conserving marine biodiversity.

(b) Ecological responses to marine sanctuaries may vary greatly from one area to another, and depend on many factors

(c) Marine sanctuaries have potential to provide increased resilience for marine ecosystems and their ability to resist or recover from disturbances such as climate change.

(d) Marine sanctuaries can provide benefits for ecosystem based management (both for conservation and fisheries applications) by acting as reference areas to assess the scale of human impacts on the environment, and as locations for the collection of data that cannot be gained from fished systems.

(e) The effectiveness of marine sanctuaries for conservation purposes will vary markedly depending on the match between the size and location of the sanctuary, the life history characteristics of the species in question and the length of time the marine sanctuary is in place.

Fisheries Management

The evidence for the effects of marine sanctuaries on fisheries, either positive or negative, is less clear. The attribution of the benefits of marine sanctuaries for fisheries is controversial, and most of the empirical data on the benefits of marine sanctuaries to fisheries come from severely over-exploited tropical reef systems in developing countries. The Panel has drawn the following broad conclusions from the evidence:

(a) Conservation benefits for fisheries are mainly evident through the increased abundance and size of previously targeted species of fish and invertebrates within the boundaries of the marine sanctuaries.

(b) Marine sanctuaries may be valuable tools for ecosystem based fisheries management, providing reference areas against which to assess the status of fished areas.

(c) Marine sanctuaries may reverse the indirect ecological effects resulting from fishing such as major changes in food webs or trophic cascades (i.e. where the removal of significant proportions of predators can result in profound re-arrangements of ecosystems, such as changes from kelp forest to barren rocks in temperate systems).

(d) Sanctuary areas may provide a level of insurance in the face of the difficulties of managing fisheries and preventing stock collapse, potentially increasing the production of eggs and larvae, and potentially adding directly to fisheries through the dispersal of eggs and larvae or through the migration of juveniles and adults across the boundary of the sanctuary into adjacent areas.

(e) Marine sanctuaries are a promising tool for fisheries management but they are not a solution for fisheries management when used in isolation.

(f) Marine sanctuaries are likely to have few benefits compared with conventional fisheries management tools for highly mobile single species with little bycatch or habitat impact. The potential benefits of marine sanctuaries compared with traditional fisheries management are likely to be greater for multi-species fisheries or for more sedentary stocks, or where fishing has broader ecological impacts e.g. trawling.

(g) Marine sanctuaries may impose costs through displaced fishing effort and short-term reductions in catches, although the empirical evidence of these effects is scant.

In summary, marine sanctuaries, together with other fisheries management tools, may help achieve broad fisheries and biodiversity objectives, but their use requires careful planning and evaluation. To minimise the loss of yield to fisheries and to achieve the desired conservation benefits, sanctuaries need to be evaluated in the context of:

1. clear biodiversity, ecosystem and fisheries objectives;
2. the social and institutional ability to maintain and enforce the closures,
3. existing fisheries management actions that marine sanctuaries could complement under certain conditions, and
4. the ability to monitor and evaluate success.

The rigorous assessment of the effects of marine sanctuaries (both positive and negative) on fisheries in developed countries is, in general, a major information gap that requires further investigation.

The effectiveness of any particular marine sanctuary or network of marine sanctuaries can only be assessed if the objectives of the sanctuary are clear. Well designed and resourced research and monitoring programs are necessary to evaluate whether planning objectives have been reached. This is a major shortcoming in the implementation of marine protected areas worldwide, particularly in assessing the potential affects of sanctuary zones (or no-take zones) on fisheries.

Other Purposes for Marine Sanctuaries

Marine sanctuaries are also valuable tools for research and have benefits for non-extractive uses such as tourism, recreation, education and for aesthetic reasons. However they exist in a socio-political context and understanding the human dimension of marine planning is essential for the effective design of marine sanctuaries to protect biodiversity and for fisheries management.

Western Australia

In WA, marine sanctuaries have been established as sanctuary zones under the CALM Act (for biodiversity conservation purposes) or for fisheries management purposes under the FRM Act e.g. the Reef Observation Areas in some FHPAs; areas permanently or seasonally closed to fishing, particularly trawling.

At the time of publication, there are 13 CALM Act marine parks and reserves in Western Australia covering a total area of approximately 1.48 million ha (14,801 km^2) with approximately 302,564 ha (3,026 km^2) in no-take marine nature reserves, sanctuary zones, or conservation areas. Approximately 2.4% of WA state waters are included in CALM Act no-take areas, or about 20% of the total area of marine parks and reserves. The area of sanctuary zones or conservation zones in the existing marine parks and reserves system ranges from none in the Walpole and Nornalup Inlets Marine Park to the entire area of the 112,300 ha Hamelin Pool Marine Nature Reserve. The largest area of sanctuary zone within a marine park is in the Ningaloo Marine Park with 87,216 ha or 33% of the marine park designated sanctuary zone. Shark Bay Marine Park is the largest marine park in the State and includes 41,913 ha or 5.4% of its area in sanctuary zone.

The largest FHPA is in the waters of the Abrolhos Islands covering about 240,000 ha, with about 6,859 ha in the four Reef Observation Areas that exclude all fishing, except potting for lobster. The Miaboolya FHPA, near Carnarvon, covers an area of about 11,460 ha and excludes commercial and recreational fishing but allows spearfishing. All other FHPAs are less than 400 ha in area. Much larger areas of marine waters are closed to trawling, particularly in the North West Shelf and the Gascoyne and West Coast bioregions. The FRM Act has the ability to establish closures (including no-take areas) for the purpose of creating FHPAs, in areas of the aquatic environment considered to be of high significance (e.g. Abrolhos Islands). This process is independent of the marine parks and reserves process under the CALM Act.

There is little or no systematic information relating to whether the sanctuary zones (or other protected zones) created by WA legislation have had any effect on biodiversity in a broad sense. The data that do exist relate mainly, but not exclusively, to the influence of sanctuary zones and other forms of closure on a restricted subset of biodiversity i.e. fish and invertebrates that are caught by commercial and recreational fishers. With the exception of Ningaloo Marine Park, where the initial sanctuary zones were established in 1990, and the Abrolhos Islands FHPA that was established in 1994, little scientific information is available to evaluate the effectiveness of these closures. However, current and recently completed research in Jurien Bay, the Capes region and Ningaloo will provide a rigorous baseline for the evaluation of sanctuary zones in the future, providing current monitoring and evaluation programs are continued.

While WA has many sanctuaries of different types, (CALM Act marine nature reserve, sanctuary zones in marine parks, and no-take conservation areas in marine management areas; FHPAs; and areas fully closed to all fisheries or closed to some fisheries e.g. trawling), little is known about the effectiveness of most of these closures in meeting their objectives. Clear objectives coupled with robust research and monitoring programs are needed over 5-10 year time spans in order to assess whether objectives are being achieved.

For many of the sanctuary zones under the CALM Act, baseline studies have started, have been completed or are in progress. For fisheries closures there is much less evidence of baseline studies or post closure assessment of effectiveness. A uniform approach to research and monitoring is needed for the assessment of the effectiveness of all marine sanctuaries in WA regardless of their legislative origins.

Ningaloo Marine Park

The Ningaloo Marine Park was evaluated as an example of how size and location of a sanctuary zone may influence the effectiveness of the zone in protecting particular species. The Ningaloo Marine Park now has 18 sanctuary zones and the Muiron Islands Marine Management Area has three no-take conservation areas as outlined in the management plan covering both reserve areas. Scientific studies are currently being carried out to address questions about size, location and effectiveness (see Conclusions below).

Conclusions

The Panel has drawn the following specific conclusions about the role and benefits of marine sanctuaries, primarily for conservation of biodiversity purposes and for fisheries management purposes (Section G)

General

1. Marine sanctuaries are an important tool for marine resource management. They should complement existing management tools and be used as part of an integrated approach to marine planning and implementation. The primary purpose for marine sanctuaries is to exclude human extractive and polluting activities. They are useful for other purposes such as tourism and (non-extractive) recreation, research and monitoring, as reference areas for comparison with other areas open to fishing and as refugia for fished or vulnerable species. They are also important psychologically for their intrinsic value and for aesthetic reasons.

2. Marine sanctuaries offer potential benefits for the conservation of biodiversity at all scales i.e. from ecosystem to genotype provided they are established at appropriate spatial and temporal scales and locations. There is a wide range of scientific studies which show that such closures may have positive effects for conserving marine biodiversity through re-establishing the balance of food webs (trophic structure, increasing the size and abundance of key species, increases in top level predators and reductions in prey species including grazers; and increases in key structuring species e.g. kelp, sponges, corals).

3. Marine sanctuaries are a promising tool for fisheries management but are likely to have few benefits compared with conventional fisheries management tools for highly mobile species with little bycatch and habitat impact. For previously fished species, many cases of positive changes have been recorded within marine sanctuaries – increases in biomass, abundance and size are commonly found after closures of

previously fished areas. The rate and nature of the recovery are not easily predicted and depend on many factors (e.g. fishing pressure prior to closure, density-dependent factors and the age, growth and reproductive biology of the species).

4. The scientific evidence for the flow of positive effects from marine sanctuaries on fished species to areas outside sanctuaries (e.g. through spillover, the migration of adults and juveniles from marine sanctuaries to adjacent areas, or recruitment subsidy from marine sanctuaries to adjacent areas) is relatively poor and largely restricted to over-exploited tropical reefs.

5. There is some evidence from overseas studies that fishing the margins of marine sanctuaries can result in significantly enhanced catches of larger fish.

6. Marine sanctuaries may also have detrimental effects on fished species through the displacement of fishing effort e.g. increases in fishing pressure in areas adjacent to the marine sanctuaries. However, the Panel could find little or no empirical evidence for such effects. Furthermore, although other negative socio-economic effects on fisheries, fisheries dependent communities and service industries are well known anecdotally, the Panel could find little empirical evidence for such effects.

7. Marine sanctuaries of an appropriate size and in appropriate locations can be useful for protecting sedentary organisms and demersal or territorial species, whose life history phases are largely confined to the marine sanctuary. They can also be important for protecting vulnerable life history phases of migratory or wide-ranging species from human influences and activities that may specifically target these vulnerable phases. For these species, marine sanctuaries must be used in combination with other management tools to protect the species throughout its life cycle, and in areas beyond the immediate jurisdiction of the management agency.

8. Because the specific response of marine organisms and communities to any particular marine sanctuary is difficult to predict, it is important to implement scientific programs of study to detect trends in key condition indicators. Many marine sanctuaries have been established without information on their condition prior to their establishment i.e. establishing baseline conditions. Nevertheless, the lack of baseline measurements should not preclude the establishment of marine sanctuaries and the subsequent monitoring of trends and conditions after closure, provided monitoring is carried out in multiple sanctuaries and adjacent non-sanctuary areas.

9. The establishment of marine sanctuaries alone does not deal with the broader issue of the sustainable use of marine resources outside the marine sanctuary, nor does it deal with the need for integrated planning and management for the use of the marine environment. Marine sanctuaries are therefore not an alternative, but a complement to conventional fisheries management strategies and should be an integral part of regional marine planning strategies.

10. Marine sanctuaries have a potentially vital role to play in providing reference points against which to gauge the success of broader scale marine resource management (Ecologically Sustainable Development, Ecosystem Based Fisheries Management). They may provide insights into potential resource condition levels as well as unique insights into ecosystem function that may not be possible in other areas where important functional groups of organisms may be absent or present but in greatly reduced numbers.

11. Strong public support for marine planning and marine sanctuaries, in particular, is essential for the effective compliance and enforcement of sanctuary zones. Strong public support should lead to high voluntary compliance, and allow targeted

enforcement against systematic infringement. The evidence suggests that in sanctuaries that allow some form of fishing, the effectiveness of the sanctuary may be compromised.

12. It is important to ensure that compliance with sanctuary zone prohibitions on fishing or collecting is high so that the results from research and monitoring are not confounded by illegal activities (such as poaching) within the zones.

13. Much of the biological and physical science that has addressed the effects of marine sanctuaries has been carried out in tropical marine and coastal environments in developing countries, except for the sustained research and monitoring of the Great Barrier Reef Marine Park over the past 25 years. Scientific research into the effects of marine sanctuaries in temperate marine environments of relevance to this report has been conducted around New Zealand and in the waters of south-eastern waters Australia. Nevertheless, the results of this scientific effort provide valuable insights into the responses of some marine organisms and communities to closures and exclusion of fishing.

14. In general, the evidence for the effectiveness of specific marine sanctuaries in achieving their objectives is much less clear, because of the lack of historical, comprehensive research and monitoring studies to accompany the declaration of the sanctuaries. In more recent years the development of research and monitoring programs as part of the declaration process has improved.

15. If the policy objectives for marine sanctuaries are to be properly evaluated their objectives must be clearly defined, baseline studies carried out and well designed, peer-reviewed programs of scientific research implemented that are sustained for significant periods of time both prior to and after the declaration of the sanctuary.

16. Marine sanctuaries are not isolated from the surrounding waters in which they are placed. Bio-physical processes outside sanctuaries, and human activities adjacent to them, can affect the integrity of the sanctuaries. The location, size and duration of marine sanctuaries should follow the principles of Comprehensiveness, Adequacy and Representativeness (CAR) and be embedded in regional marine planning strategies.

17. Marine sanctuaries are predominantly established for biodiversity conservation purposes, but exist in a complex and dynamic socio-political environment. Understanding the social, economic and political dimensions will largely determine the success or not, of conservation strategies. Research into these dimensions is as important as into the bio-physical dimensions.

Western Australia

18. No-take marine nature reserves, sanctuary zones within marine parks, and conservation areas within marine management areas have been established under the CALM Act and are areas that are closed to all extractive activity, including fishing. Some or all forms of full or partial fishing closures have also been established under the FRM Act. These closed areas have different purposes - sanctuary zones within marine parks established under the CALM Act have a primary purpose of protecting and conserving marine biodiversity but provide for other non-extractive uses such as nature-based recreation, tourism, research and education. Permanent closures to fishing and other closures in Fish Habitat Protection Areas are designed to conserve fish stocks and/or their habitats. At the time of publication, there is approximately 302,564 ha (3,026 km^2) of sanctuary zones or no-take conservation areas in 13 marine parks and reserves established

under the CALM Act and 11 FHPAs covering approximately 2,916 km^2 established under the FRM Act. Of these, the Abrolhos FHPA comprises 96% of all FHPAs and has 68 km^2 of its FHPA closed to all forms of fishing, except lobster potting. In addition, there is a marine reserve established by the Rottnest Island Authority that contains 5 sanctuary zones covering approximately 663 ha or 17% of the Rottnest Island marine reserve.

19. The extensive network of marine sanctuaries in WA provides an opportunity for an evaluation of the combined coverage of both sanctuary zones and other areas closed to fishing that have similar effects for biodiversity, within the Interim Marine and Coastal Regionalisation of Australia (IMCRA) bioregional framework. This comparison may allow some evaluation of the representativeness, comprehensiveness and adequacy of protection within the WA marine environment.

20. For the effective adaptive management of sanctuary zones, the objectives of the zones must be clearly defined and monitoring programs carefully designed to assess their performance. Adaptive management also requires a commitment to evaluating the results of the program and revising the management arrangements accordingly.

21. There is little overlap between the processes of the Department of Environment and Conservation and the Department of Fisheries in terms of the location of marine sanctuary areas or areas closed to fishing. This appears to continue, despite a growing convergence of management objectives, particularly through fisheries management requirements for Ecologically Sustainable Development and Ecosystem Based Fisheries Management.

22. Scientific studies of marine sanctuaries and other closed areas in WA have been *ad hoc* to date and reliable evidence for their ecological effectiveness is only available from Ningaloo, Abrolhos Islands and Rottnest Island. Research in these areas has shown that sanctuaries are effective for protecting some fished species within the sanctuary. Little or no data are available on the socioeconomic implications/impacts of sanctuary areas. However evidence from some sanctuary areas shows that they can be effective for conserving species and ecosystem processes.

23. Baseline data have been collected from other more recently declared protected areas such as the Jurien Bay Marine Park and Ningaloo Marine Park.

24. The Department of Environment and Conservation (DEC) management plans for marine parks include sanctuary zones to provide highly protected representative examples of marine habitat and communities. These plans now have clearly specified objectives and performance indicators (e.g. Ningaloo) which is commendable. However, it is less clear how these objectives will be assessed and evaluated under a framework of adaptive management.

25. There does not seem to be a process through which closures declared under the FRM Act are monitored and evaluated for their effectiveness, nor does there appear to be a review process for these closures.

26. The primary focus for the research and monitoring that is being undertaken for WA marine sanctuaries is bio-physical; research into socio-economic factors will be important for understanding any changes in values, perceptions and attitudes as well the impacts on stakeholder groups, regional economies and social systems.

<u>Ningaloo Marine Park</u>

The following conclusions about the effectiveness of sanctuary zones in Ningaloo Marine Park for species with different life cycle strategies are drawn from Section E:

(www.Sanctuary zones in Ningaloo Marine Park:

- are inadequate to achieve conservation outcomes of major significance for oceanic fish such as the Whale Shark (*Rhincodon typus*);
- may represent <1% of the total range of coastal pelagic fish species such as Spanish Mackerel *(Scomberomorus commerson)*, and would thus provide little in the way of effective protection;
- may provide a high level of potential protection to mobile target fish such as Spangled Emperor (*Lethrinus nebulosus*);
- may provide an extra level of protection for fished species that aggregate to spawn if spawning aggregation sites for those species are included in sanctuary zones;
- appear to offer a reasonable level of protection to Nursery Area species located at the well known nursery areas (Mangrove Bay, Skeleton Bay, Pelican Point);
- are more than adequate to protect local populations of low mobility species; and
- provide good protection for sessile organisms such as clams and corals from direct harvesting by the current zoning.

Note: A major research program at Ningaloo Marine Park through the Western Australia Marine Sciences Institution in collaboration with CSIRO is expected to conclude in 2010 (www.wamsi.org.au) .

Policy Recommendations

At the time of submission of this report, it was understood by the Panel that the basic policy and legislative framework for the establishment of sanctuary zones under the CALM Act, and as set out in the 1998 framework document *"New Horizons: the way ahead in marine conservation management"* ,would be likely to be retained.

The following recommendations are made within that context.

We recommend that the following recommendations be incorporated into the policy framework for marine planning:

1 The process of selecting marine sanctuaries or designing networks of sanctuaries should be based on a clear set of agreed design/planning criteria based on both bio-physical and socio-economic principles (e.g. Comprehensiveness, Adequacy and Representativeness). The process should be part of a broader regional planning process and should use all available data; however the lack of data should not prevent the planning process from being concluded.

2 The objectives of marine sanctuaries and closures to fisheries, whether established under marine conservation or fisheries legislation, should be clearly stated to allow their effectiveness within short to medium timeframes to be evaluated (1-5-10-15 years). Wherever possible overlap/commonality

in objectives between different jurisdictions should be sought to avoid duplication, redundancy or conflict in management objectives.

3 Baseline conditions for areas proposed as marine sanctuaries and adjacent areas should be established prior to declaration; research and monitoring should commence immediately prior to the point of establishment with the intention of providing reliable evidence on the effects of the sanctuaries i.e. did they achieve the objectives, were the underlying assumptions valid?

4 Robust experimental designs (e.g. Before-After-Control-Impact - BACI) should be used for all research and monitoring of marine sanctuaries.

5 Both bio-physical and socio-economic effects should be monitored for each marine sanctuary.

6 Research priorities and programs should be established as part of the management planning approach for each marine sanctuary. There should be explicit feedback between these programs and broader scale marine resource management.

7 A common approach should be followed for the establishment of marine sanctuaries, regardless of the legislative basis for the establishment i.e.

   a) they should be set in a regional planning framework

   b) there should be a clear primary purpose that can be measured and reported on at periodic intervals

   c) a research and monitoring program should be developed, funded and implemented as part of each marine sanctuary to determine the effectiveness of the sanctuary; reporting should be regular and transparent

   d) an adaptive management approach should be taken to apply knowledge gained from individual sanctuaries and from the overall network of sanctuary areas to inform decision making at both levels.

   e) an independent expertise based scientific reference group should be established to provide advice on the experimental design and implementation of research and monitoring programs for marine sanctuaries, and to provide peer review of the results of such programs.

   f) adequate resources should be provided to enable effective research and monitoring programs to be implemented and evaluated.

B. Terms of Reference and Other Guidance

Background

In September 2006, Cabinet made a decision to establish a Scientific Panel to address scientific issues arising from the regional marine planning process and to provide advice to the Government in the development of marine parks and reserves policy. It was agreed the Scientific Panel would be appointed by the then Minister for the Environment on recommendation of the Western Australian Marine Science Institution, with advice from the then Minister for Fisheries and the then Minister for Resources.

Terms of Reference

Contribute through provision of scientific advice to the development of Government policy on marine parks and reserves through dialogue with the expanded Interdepartmental Committee of Agency CEOs; and

Respond to requests from the expanded Interdepartmental Committee of Agency CEOs and the State Marine Policy Stakeholder Group for independent scientific advice on other matters pertaining to regional marine planning.

Operating Rules

The Scientific Panel will:

1. Comprise three independent, high-level scientists who are not employees of Western Australian State Government agencies;

2. Meet at least quarterly;

3. Provide timely, consensus advice to the expanded Interdepartmental Committee on matters relating to the terms of reference; and

4. Receive and respond to requests for advice on matters relating to the terms of reference from the State Marine Policy Stakeholder Group through the expanded Interdepartmental Committee.

Marine Sanctuaries Task

The first task set for the Scientific Panel has been to develop a report on the scientific basis for and the role of marine sanctuaries in marine planning, for consideration by Government. The Scientific Panel's advice to the Expanded IDC on the Management of the State's Marine Protected Area is to be timely and consensus based. The Scientific Panel is to consult with other key individuals and bodies in the preparation of the report.

The Panel has firstly examined the scientific information on the basis for and role of marine sanctuaries and similar 'no-take' zones from Australia and other countries, where that information is relevant to the task. The Panel has also specifically examined the scientific information that is available about the basis for and role of marine sanctuaries in WA, including sanctuary zones as defined in the Conservation and Land Management Act (CALM Act), and spatial closures to fishing, including Fish Habitat Protection Areas (FHPAs), under the Fish Resources Management Act (FRM Act). References to sanctuary zones are to those established under the CALM Act. The term 'marine sanctuaries' used in this report refers to 'no-take' zones generally. Secondly the Panel has drawn general conclusions from this evidence and specific conclusions in relation to

WA marine planning. Finally the Panel has developed policy recommendations on the role of marine sanctuaries in WA marine planning.

This report has examined the scientific basis for and role of marine sanctuaries, for two main purposes – biodiversity conservation and fisheries management. Where possible the scientific basis and role of marine sanctuaries for other purposes (e.g. tourism and recreation, scientific research and intrinsic/aesthetic reasons) has also been examined. The Panel has also attempted to address the evidence for the effectiveness of marine sanctuaries generally and sanctuary zones and FHPAs in WA in particular. Questions of scale (temporal and spatial) in relation to biodiversity conservation and fisheries management have also been investigated. In this context "effectiveness" means the degree to which the objectives and outcomes for which marine sanctuaries have been established were achieved. The effectiveness of these areas needs to be evaluated through focussed scientific research and monitoring.

The Panel undertook limited consultations of key stakeholder groups and individuals in the compilation of this report. A list of stakeholders and individuals consulted is provided in Appendix 3.

C. Context

1. Marine Protected Areas and Marine Sanctuaries – definitions and objectives

The purposes for which marine protected areas (MPAs) and marine sanctuaries have been established are many and varied and the term 'marine sanctuary' has many different meanings (e.g. Jones, 1994; Alder, 1996; Agardy, 1997; Lubchenco et al. 2003). The principle goals for marine sanctuaries are usually for biodiversity conservation or for habitat protection for fisheries management purposes. Secondary purposes of MPAs and marine sanctuaries can include recreation, education, research, and meeting aesthetic needs (Roberts et al. 2003). Important economic activities such as tourism and fishing can continue in multiple-use MPAs subject to the overriding requirement that they are ecologically sustainable. Marine Protected Areas can vary widely in size and location, ranging from large multiple use marine parks (such as the Great Barrier Reef Marine Park, in which 'no-take" zones comprise over one-third of the area) to single use reserves (e.g. Maria Island Reserve in Tasmania, Leigh Marine Reserve in New Zealand). In recent years, the concept of networks of small highly protected "no-take" areas has been advocated to reduce the risk of vulnerability of single reserves to catastrophic events and to improve the protection of key parts of the ecosystem that are biologically connected (Cabeza 2003, Game et al. in press)

Marine Protected Areas can contain within them selected areas where no extractive activity may take place; other MPAs may be solely "no-take". A profusion of specific terms to describe various sorts of MPAs have been adopted, including: coastal or marine or national park, marine reserve, fisheries reserve, closed area, marine sanctuary, marine and coastal protected areas (MACPAs/ MCPAs), nature or ecological or replenishment reserve, marine management area, coastal or marine preserve, area of conservation concern, sensitive sea area, biosphere reserve, no-take or closed area, coastal park, national marine park, marine conservation area and marine wilderness area. The term "marine sanctuary" is similarly confusing. Often it means an area established primarily for conservation purposes and is generally "no-take", but in the USA the term "sanctuary" is applied to multiple use MPAs designated under the jurisdiction of NOAA's National Marine Sanctuary Program, e.g. Florida Keys National Marine Sanctuary (Agardy et al. 2007). Most marine sanctuaries are within the jurisdiction of a single nation state but at least one has been established as a trans-national marine sanctuary - the Pelagos Marine Sanctuary in the Mediterranean Sea, which has been established collaboratively by three nations for the specific purpose of protecting marine mammals in an area of significant coastal development, shipping, tourism and recreation (Notobartolo di Sciara 2007)

Other areas may have a similar protective effect to that of a specific 'no-take' zone even if the purpose for which they were established was not for biological conservation reasons e.g. some defence areas, historic shipwrecks, oil drilling platforms. Perhaps the best known of these examples is the Wildlife Refuge around the Cape Canaveral space launch facility in Florida. Waters adjacent to this extensive estuarine and wetland "no-go" area contribute a disproportionately large proportion of recreational angling line-class records for key species in Florida and the Gulf of Mexico (Roberts et al. 2001).

For the purpose of this report the term "marine sanctuary" is a part of the marine environment, protected by law, to be used by humans only for non-extractive purposes i.e. a "no-take" area. Globally MPAs and marine sanctuaries have been designated in most nations with coastal or marine jurisdiction (Table D1). Recent global figures on the extent of these areas are summarised in Table D1.

2. WA Policy and Practice in relation to marine sanctuaries

In Western Australia, marine sanctuaries have been established primarily for biodiversity conservation purposes e.g. Ningaloo Marine Park or for fisheries management purposes e.g. the Reef Observation Areas in some Fish Habitat Protection Areas.

The 1998 framework document *"New Horizons: the way ahead in marine conservation management* is a key policy framework that evolved from an earlier policy document "New Horizons in Marine Management" released in 1994 (Government of Western Australia 1994) and followed key amendments to the CALM Act related to marine parks and reserves. A major component of the New Horizons framework was the establishment of a comprehensive and state-wide system of multiple-use marine conservation reserves under the Conservation and Land Management (CALM) Act. The marine conservation network comprises five main types of Western Australian marine protected areas (MPAs) CALM Act Marine Nature Reserves, Marine Parks, and Marine Management Areas; FRM Act Fish Habitat Protection Areas; and the Rottnest Island marine reserve.

2.1 Marine Parks and Reserves

The Marine Parks and Reserves Authority (MPRA) is the vesting authority for MPAs reserved under the provisions of the Conservation and Land Management (CALM) Act 1984. The key functions of the MPRA are:

- Be the vesting authority with responsibility for the care, control and management of marine parks, marine nature reserves and marine management areas that are reserved under the provisions of the CALM Act.
- Advise the Minister for the Environment on proposals for marine parks and reserves and their management.
- Develop policies for the preservation of the natural marine and estuarine environments of the State and the provision of facilities for the enjoyment of those environments by the community and promote appreciation of marine and estuarine plants and animals and natural environments.
- Submit management plans for marine parks and reserves to the Minister.
- Develop guidelines for monitoring the implementation of management plans.
- Set performance criteria and conduct periodic assessments on the implementation of management plans.
- Promote necessary study or research.

In WA marine parks, four statutory management zones can be created:

1. Sanctuary Zones – are 'look but don't take' areas managed solely for nature conservation and low-impact recreation and tourism.

2. Recreation Zones – provide for conservation and recreation including recreational fishing (subject to bag limits and other conservation measures).

3. General Use Zones – are areas of marine parks not included in sanctuary, recreation or special purpose zones. Conservation of natural resources in general use zones is the priority but activities such as sustainable commercial fishing, aquaculture, pearling and petroleum exploration and production are permissible provided they do not compromise conservation values.

4. Special Purpose Zones – are managed for a particular priority use or issue. This could be protection of habitat, a seasonal event such as wildlife breeding

or whale-watching or a particular type of commercial fishing. Uses compatible with the priority use or seasonal event are allowed in these zones.

The following description of sanctuary zones for the purpose of the CALM Act has been taken from the Ningaloo Marine Park Management Plan (Government of Western Australia 2004)

"Sanctuary zones

Sanctuary zones in marine parks provide for the maintenance of environmental values and are managed for nature conservation by excluding human activities that are likely to affect the environment adversely. The primary purpose of sanctuary zones is for the protection and conservation of marine biodiversity. They are used to provide the highest level of protection for vulnerable or specially protected species, and to protect representative habitats from human disturbance so that marine life can be seen and studied in an undisturbed state. These zones also provide the opportunity to improve understanding of the key ecological processes of the Marine Park and to obtain critical comparative data with areas of the Park where extractive activities are permitted and/or where environmental impacts may be occurring. These zones will also provide other ecological benefits such as refugia for exploited species, replenishment areas, education and nature appreciation sites (via passive recreation and tourism opportunities), ecological 'insurance' and resilience against the failure of the adaptive management approach adopted for the rest of the Park, and enhanced resilience to natural and human- induced disturbance.

Specified passive recreational activities consistent with maintaining environmental values may be permitted, but extractive activities, including fishing and traditional fishing and hunting are not. Commercial tourism operations (such as for nature-based tours) will be considered where they do not conflict with other uses and are regulated under the CALM Act.

All extractive activities are excluded from sanctuary zones. Passive nature-based tourism, some recreational activities, boating and approved scientific research are permitted."

2.2 Fisheries Management

In Western Australia, fisheries within 3 nautical miles of the coast ("State" waters) are managed under the WA Fisheries Resources Management Act 1994 (FRM Act), while those from 3 nm to the 200 nm limit of the Exclusive Economic Zone are managed under co-operative arrangements under both the Commonwealth Fisheries Management Act 1991 and the WA FRM Act 1994, under the arrangements of the Offshore Constitutional Settlement agreements (Brayford and Lyon, 1995). This allows a single fishery to be managed in both State and Commonwealth waters out to 200 nm by the WA Department of Fisheries, which manages most fisheries in the State out to this limit (Fletcher and Penn, 2005). In contrast, most other government departments in WA only have jurisdiction to the three nautical mile boundary.

The Department of Fisheries has the statutory responsibility for managing the 'fish' resources (including their habitat) of WA, which includes, but is not restricted to, managing recreational and commercial fishing activity. There are a number of mechanisms and legislative instruments under the provisions of the FRM Act to close or restrict fishing out to the 200 nm limit. These include general and fishery-specific closures and controls, which are achieved by regulation or order. Usually, each closure has a set of specific objectives or a rationale, which relate to the objectives, processes, fish species and/or human activities being managed. These management arrangements may control total exploitation, the method of exploitation of specific fish stocks, or the access to areas of significance to individual stocks/habitats. (Fletcher and Penn, 2005)

The FRM Act also has the ability to establish closures (including no-take areas) for the purpose of creating Fish Habitat Protection Areas (FHPAs), in areas of the aquatic environment considered to be of high significance (e.g. Abrolhos Islands). This process is independent of the marine parks process (Fletcher and Penn, 2005).

Fish Habitat Protection Areas

The guidelines for the establishment of FHPAs have been described in a Management Paper by the Department of Fisheries (2001a). FHPAs can be established when a need has been identified to control the impact of human activities (both fishing and other) on an area that is considered appropriate for protection. They can be established by the Minister of Fisheries for three purposes:

1. the conservation and protection of fish, fish breeding areas, fish fossils or the aquatic ecosystem;

2. the culture and propagation of fish and experimental purposes related to that culture and propagation; and

3. the management of fish and activities related to the appreciation and observation of fish.

The focus of a FHPA is generally either to a) protect a specific localised feature e.g. a fish breeding area or fish habitat; or b) protect a large representative area of recognised conservation value.

Although some FHPAs may fulfil a similar function to marine sanctuaries, they have a number of major differences from sanctuary zones and marine parks. Firstly, FHPAs do not protect sea birds, turtles and marine mammals. Secondly, they are not permanent reserves and can be revoked by the Minister for Fisheries and lastly, the management of a FHPA may be vested in a community group, which is a body corporate.

Other fisheries management measures

The FHPA is only one of a number of management measures that the Department of Fisheries uses to manage fish and their environment. The guidelines for the use of FHPA suggest that it may be used when other regulations (see Department of Fisheries, 2001b) are unlikely to achieve the goals of management. These other regulations include:

- area protection
- gear restrictions
- effort restrictions
- temporal/time closures
- catch limits

These other measures also provide some measure of protection to biodiversity and habitats covering very large areas (see also Section E, Figs E1, and E2). For example, large areas of the Western Australian coast are permanently closed to trawl fishing (e.g. from Lancelin to north of Kalbarri, extensive areas of Exmouth Gulf and Shark Bay, the North West Shelf), which provides some protection to habitats and species caught in trawls. In fact, only about 15% of the North West Shelf area is open to trawling (see Newman et al. 2003, Fletcher and Head 2006, Fletcher and Penn 2005). The largest FHPA is in the Abrolhos Islands. Within the Abrolhos, some areas have a higher level of protection with four areas designated as Reef Observation Areas, where only lobster fishing with pots is allowed. These areas have been in place since 1994 and constitute about 5% of the total area of state territorial waters of the Islands and 17% of the shallow water lagoonal reef habitat in the Abrolhos (Nardi et al. 2004).

3. Regional Marine Planning in WA – the Role of Marine Sanctuaries

The WA Government has committed to the development of comprehensive and integrated approach to the conservation and sustainable use of the marine environment through Regional Marine Planning (RMP). The first RMP process is currently being conducted for the south coast marine environment; a draft strategic plan has been developed for an initial consideration by government agencies.

The goals of the draft strategic plan include the goal:

1. utilize the best available information as the basis for marine planning and management while constantly gathering new information

Guiding Principles in the plan include:

2. gathering, disseminating and utilizing scientific, economic, social and cultural information about the marine environment and its uses

When completed and approved, the South Coast Regional Marine Strategic Plan (SCRMSP) should provide the basis for specific integrated and coordinated decisions about marine management actions, the creation of marine reserves (including marine sanctuaries or other no-take areas), resource allocation decisions and development approvals.

The provision of high quality and timely marine science information is essential in the development of policies and operational decisions for planning and the implementation of the SCRMSP and any other regional marine plan. The Panel's view is that marine science is a critical input to integrated sustainable regional planning, selection of candidate sites for marine conservation, understanding values, status and trends for key environmental assets, scenario modelling for future management and development options and for evaluating the effectiveness of policy and management decisions.

The value of marine science in these processes is enhanced if the RMP process has clear objectives, identifies the specific management information needs at the outset of the planning process, is sufficiently resourced to gather data in a timely manner for policy makers and has a clear pathway for bringing scientific data and information and scientific opinion to bear on the policy making process.

The overall process of RMP is broader than the task given to the Panel of assessing the effectiveness of marine sanctuaries. The Panel nevertheless feels that in designing a network of marine sanctuaries and integrating such a network within the broader regional processes, the application of the principles of Comprehensive Adequacy and Representativeness (CAR) is essential. The application of the CAR principles for prioritizing decision making has been a core component of marine planning in Australia since 1998 (ANZECC TFMPA 1998). Essentially, these principles are meant to ensure that any sanctuary area or network is large enough to protect the species it is meant to protect, that all the types of biodiversity (i.e. genotype, species, and ecosystem) are represented, and that they are represented in a proportional manner. The CAR principles have been defined as:

- *Comprehensive:* examples of all types of regional-scale ecosystems in each of Australia's Bioregions should be included in the National Reserve System
- *Adequate*: sufficient levels of each ecosystem should be included within the protected area network to provide ecological viability and to maintain the integrity of populations, species and communities

- *Representative:* the inclusion of areas at a finer scale, to encompass the variability of habitat within ecosystems (http://www.environment.gov.au/parks/nrs/science/scientific-framework.html)

These three CAR principles have been further elaborated into so-called "bio-physical" and 'socio-economic" design principles that have been used in the re-zoning of several large multiple-use marine parks such as the Great Barrier Reef Marine Park (Day et al. 2003) and the Moreton Bay Marine Park in Queensland:

http://www.epa.qld.gov.au/parks_and_forests/marine_parks/moreton_bay_marine park_zoning_plan_review/

These principles not only facilitate the zoning process, but also help to focus the formulation of objectives for marine sanctuary areas and their subsequent monitoring and assessment as part of an adaptive management process. Finally, agreeing on a formal set of principles allows them to be incorporated in a computer/GIS based environment where decision support tools (such as MARXAN and TRADER) can be used to separate a set of optimal potential solutions from the large number of potential solutions to achieve the best marine planning outcome for all stakeholders while ensuring high level conservation outcomes (Pressey et al. 1995, Pressey and Cowling 2001). While some planning processes in WA have used bio-physical and socio-economic design principles with success e.g. the Rottnest Island Marine Management Strategy 2007 (Rottnest Island Authority 2007), it is understood that computer based decision support has so far not been used. The use of such tools is now becoming essential in order to fully consider the broader range of options required as part of regional marine planning.

D. The Scientific Basis for and Role of Marine Sanctuaries in Marine Planning – General Overview

Introduction

In this section, we examine the scientific evidence from around the world and in other regions of Australia, for the role of marine sanctuaries established to conserve biodiversity and ecosystem processes. We also examine the evidence for the effects of marine sanctuaries on fish stocks and fisheries management. Many benefits from marine sanctuaries are attributed to fisheries and this topic is an area of considerable controversy and debate (see Hilborn et al. 2004). Much greater detail on this topic is presented in Appendix 1, based largely on a recent review by Edgar et al. (2007), who examined the global evidence for the costs and benefits of marine sanctuaries. The review of scientific evidence in relation to biodiversity conservation and fisheries management covers the topics of the conservation of species, ecosystems and genotypes, the costs of no-take marine protected areas for biodiversity conservation and the scientific benefits of marine protected areas. Evidence relating to the use of marine sanctuaries in the area of fisheries management is also reviewed, including changes in key population parameters (density, average size and biomass, larval production), recruitment subsidy and spillover (Edgar et al. 2007, Appendix 1). Much of this evidence on the effects of marine sanctuaries on fisheries is drawn from developing countries where fishing pressure is very high and/or in areas where fisheries management has been ineffective (Hilborn et al. 2004). The potential for marine sanctuaries to be used for insurance against management failure and unpredictable stochastic events, and to provide information on important parameters for stock assessment are explored and the costs of no-take marine protected areas as fisheries management tools are summarised (Hilborn et al. 2004). We also briefly address the uses of marine sanctuaries for education and tourism, as well as other aspects of marine sanctuaries, although these latter topics are somewhat outside the central brief of the Panel.

General overview

Marine sanctuaries are spatially-defined areas of the marine environment that are primarily established for the purpose of conserving biodiversity. The number of marine sanctuary areas worldwide is growing exponentially, and although these areas are known by a variety of names, and are established for a wide range of specific purposes, all have the principle of some kind of spatial management at their core (Edgar et al. 2007, Wood et al. in press). Marine protected areas cover approximately 2.35 million km^2, equivalent to 0.65% of the world's oceans and 1.6% of the area within Exclusive Economic Zones (Wood et al. in press). The spatial extent of marine protected areas has been growing at an annual rate of 4.6% since 1984. The distribution of the worlds protected areas is highly biased towards both coastal waters and the 10 largest marine protected areas (Table D1, Wood et al. in press). A significant portion of the global area protected (between 20 and 40%) is within small and isolated areas, which may not be effective in conserving marine populations, or may not contribute to part of a coherent network (Wood et al. in press). Conversely, a large proportion of the total protected area (64%) lies within the 10 largest marine protected areas globally that range in size from 46,700 km^2 (Wrangel Island Zapovednik, Russia) to 410,500 km^2 (Phoenix Islands Protected Area, Kiribati). The Papahanaumokuakea Marine National Monument, Hawaii USA and the Great Barrier Reef Marine Park are 362,000 km^2 and 344,400 km^2 respectively) (Wood et al. in press).

Table D1 Summary Statistics for Marine Protected Areas from around the world (Wood et al. in press). Note that (a) the total area of ‘no-take’ or sanctuary zones is about 12.8% of the total area of MPAs and (b) the marked difference between mean and median areas is due to small number of very large MPAs that contribute 75% of the total global MPA area.

Attribute	Value
Number of Designated MPAs	4,435
Total Area	2.35 Million km^2
% of ocean in MPAs	0.65%
% of MPA area within EEZs	1.6%
% of global MPAs in ‘no-take’ zones	12.8%
Mean area of MPAs	544 km^2
Median area of MPAs	4.6 km^2
% of MPAs in tropics (30^0N-30^0S)	65%

In order for management agencies to assess the success of any particular marine sanctuary or network of marine sanctuaries, they must clearly specify the objectives of the protected area, since without this it will be virtually impossible to design effective research and monitoring activities. This has been seen as a major shortcoming in the implementation of marine protected areas worldwide, particularly in assessing the potential affects of sanctuary zones (or no-take zones) on fisheries (Hilborn et al. 2004). Because of the diverse objectives of marine sanctuaries, as well as the complexity of processes within marine ecosystems, ecological responses to marine sanctuaries may vary greatly from one area to another. Important factors that affect the way plants and animals respond to marine sanctuaries include the distribution of habitat types, level of connectivity to nearby fished habitats, wave exposure, depth distribution, prior level of fishing, the regulations in place, and the level of compliance with regulations. For example, the responses of fish and invertebrate communities differed among sanctuary areas of different sizes and in different parts of Tasmania (Barrett et al. 2007). The responses of New Zealand marine communities to the implementation of marine sanctuaries were similar for some species but differed for others, despite relatively similar groups of species on either side of the Tasman (Babcock, 2003). Nevertheless, there is a general overall consensus from a wide range of studies that marine sanctuaries have a positive affect on conserving biodiversity (for further details see Appendix 1). It is important to note that some protected areas allow some forms of fishing while excluding others. Available evidence suggests that these protected areas are less effective for protecting targeted species or general biodiversity (Denny and Babcock 2004, Shears et al. 2006).

In addition to their value for conserving biodiversity, marine sanctuaries have been seen as valuable tools for research and management and they also have benefits for non-extractive uses such as recreation, education and aesthetics (Edgar et al. 2007, Wood et al. in press). The evidence for their effects on fisheries, either positive or negative, has been the topic of major debate (see below and summary of potential effects, Table D2). Conservation benefits are mainly evident through the increased abundance and size of targeted species of fish and invertebrates in marine sanctuaries. For example, lobsters in the Maria Island reserve are more than 10 times more abundant, and much larger, inside the reserve than outside it (Edgar and Barrett 1999). On the Great Barrier Reef, coral trout are 2 to 4 times more abundant inside no-take areas than outside them (Williamson et al. 2004). After only four years of protection, snapper (*Pagrus auratus*) were more than 7 times more abundant inside the Poor Knights Islands marine reserve (New Zealand) than outside it (Denny et al. 2004). If sanctuary areas can reverse the indirect effects from fishing then these responses may lead to the maintenance of a full range of genetic diversity and greater habitat diversity.

The indirect effects of fishing following the removal of predators have been termed "trophic cascades", which can result in profound re-arrangements of ecosystems, such as changes from kelp forest to barren rocks (Babcock et al. 1999). Trophic cascades can be caused by the removal of high numbers of predatory fish or lobsters, which may allow the populations of herbivorous animals like sea urchins to increase beyond normal levels, leading to overgrazing and the removal of kelp forests (Shears and Babcock 2002). In coral reef systems, trophic cascades leading to an increased abundance of herbivorous urchins can also lead to accelerated reef bioerosion (McClanahan 1999). Because primary producers such as kelp are the foundation of food webs on temperate reefs, the impact of fishing may then continue to propagate back up through food webs by altering the type and availability of food (Salomon et al. in press). Sanctuary areas also have potential to provide increased resilience for marine ecosystems, where protected ecosystems with a full range of functional trophic groups are less vulnerable to disease and better able to recover from disturbances.

Sanctuary areas may provide a level of insurance in the face of the difficulties of managing fisheries and preventing stock collapse, potentially increasing the production of eggs and larvae (recruitment subsidy), and potentially adding directly to fisheries through the dispersal of juvenile and adult fish across the boundary of the sanctuary into open areas, (also known as spillover, Table D2). The large body of literature that predicts both benefits and costs for fisheries of marine sanctuaries, is based largely on numerical simulation models (e.g. Hastings and Botsford 1999, White and Kendall 2007, White et al. 2008). The attribution of the benefits of sanctuary areas for fisheries is controversial, and most of the empirical data on the benefits of sanctuaries to fisheries come from severely over-exploited tropical reef systems in developing countries (Alcala et al. 2005). Some data are available on the benefits of marine sanctuaries to fisheries in developed countries (e.g. Roberts et al. 2001) and these show benefits or the lack of negative effect (Kelly et al. 2002). However, the rigorous assessment of the effects of marine sanctuaries (both positive and negative) on fisheries in developed countries is, in general, a major information gap that requires further investigation (Willis et al. 2003b).

Table D2 The potential benefits and costs of no-take marine reserves on fished species, (a) inside and (b) outside reserves (modified from Russ, 2002 and Hilborn et al. 2004). The table below is a summary of the current state of knowledge, but does not attempt to reflect the specific evidence, or lack of it, that may apply to any particular effect listed in the table.

Summary of potential effects of marine sanctuaries	
Benefits	**Costs**
(a) Inside reserves	
Lower Fishing Mortality	unpredicted effects on other commercial species e.g. lobster predation on abalone
Higher density	Concentration of activities and damage to sessile fauna and habitats
Higher mean size/age	
Higher biomass	
Higher production of propagules (eggs/larvae) per unit area	
Reduced ecological impacts	
Increased stocks of “sedentary” species	
Multispecies fisheries	
Improved knowledge	
(b) Outside reserves	
Net export of adult (post-settlement) fish (the “Spillover” Effect)	Displaced fishing effort reduces stock size outside the sanctuary
Net export of eggs/larvae (“Recruitment Subsidy”).	Stocks of highly mobile species (economic inefficiencies)
	Better management options may be available
	Hardship to fishing communities

Hilborn et al. (2004) reviewed the evidence for the influence of marine reserves on fisheries and assessed when they can improve fisheries management. They found that marine reserves are a promising tool for fisheries management and the conservation of biodiversity but they are not a solution for fisheries management when used in isolation i.e. they are not a “panacea” for fisheries. Furthermore, they found that marine reserves are likely to have few benefits compared with conventional fisheries management tools for highly mobile single species with little bycatch or habitat impact (see also Section E on Western Australia, Newman et al. 2003). The potential benefits of marine sanctuaries compared with traditional fisheries management are likely to be greater for multi-species fisheries or for more sedentary stocks, or where fishing has broader ecological impacts e.g. trawling (Table D2, Hilborn et al. 2004).

Marine sanctuaries provide benefits for ecosystem based management (both for conservation and fisheries applications) since sanctuaries can act as reference areas to assess the scale of human impacts on the environment, and as locations for the collection of data that cannot be gained from fished systems (Buxton et al. 2005, Edgar et al. 2007). Marine sanctuaries can impose costs through displaced fishing effort, short-term reductions in catches, and even through undesirable (from a fisheries economic view) interactions within the biota (Table D2, Hilborn et al. 2004). Hilborn et al. (2004) conclude that marine reserves, together with other fishery management tools, can help achieve broad fishery and biodiversity objectives, but their use requires careful planning and evaluation. To minimise the loss of yield to fisheries and to achieve the desired conservation benefits, Hilborn et al. (2004) specified that reserves need to be evaluated in the context of:

1. “clear biodiversity, ecosystem and fisheries objectives;
2. the social and institutional ability to maintain and enforce the closures,
3. existing fisheries management actions they could complement under certain conditions, and
4. the ability to monitor and evaluate success.” (Hilborn et al. 2004).

They stress the need for planning, evaluation and monitoring to learn from the implementation of marine reserves – what worked, what did not work and what were the reasons for the successes and failures of reserves.

While marine sanctuaries are an important part of the marine management toolbox, there is a danger that they may create a false sense of security, since we must also be aware of managing the majority of areas that are not within marine sanctuaries. In the overall context of marine management, marine sanctuaries do not exist in isolation, which is particularly true in fisheries management where the fished populations often extend well beyond the boundaries of the sanctuaries and may be highly mobile (e.g. Newman et al. 2003; Hilborn et al. 2004; Fletcher and Penn 2005, see also Section E). Marine sanctuaries are necessary for the successful management of both biodiversity and probably fisheries, but they are not sufficient in themselves (Allison et al. 1998). Successful management of marine resources in the future must find ways to better integrate the use of marine sanctuaries within the broader marine management context.

Establishing the scale of the marine sanctuary relative to the life history scales of the organisms they are intended to protect is critical for the effectiveness of the sanctuary. The effectiveness, or lack of effectiveness of no-take areas for conservation purposes, will vary markedly depending on the level of concordance between the spatial dimensions of the protected area and the life history characteristics of the species in question (see Table D3). Assuming that some level of exploitation of marine resources is desirable, there will always be an interest in making no-take areas as small as possible to minimise economic effects and allow continued access for different groups. However, because the life history characteristics of marine organisms are so different among groups of organisms (Tables D3, E1), and even within some groups, it will always be difficult to optimise the size (and adequacy) of no-take areas for marine conservation across the entire range of species that comprise an ecosystem. For this reason, it is probably most profitable to further optimise the size of no-take areas with respect to key threatening processes, the species that are most affected by them, and the capacity of spatial management measures to reduce the level of threat.

Table D3 Scale of the effects of marine sanctuaries for generic types of organisms with different larval and adult phases (adapted from Kenchington 1990).

	Generic Life Cycle	Effectiveness of marine sanctuaries for protection of life cycle
A	Juvenile phase fixed or non-planktonic species; adult phase fixed or territorial e.g. seagrasses	Site specific protection for all phases
B	One phase fixed or site dependent and associated with distinctive benthic structure or community e.g. coral reef, turtle nesting site, fish spawning site; other phase planktonic or migratory e.g. green turtles	Site specific protection may protect critical breeding ground or spawning site, but not all phases
C	Limited or periodic adult territoriality and planktonic larvae OR specific nursery areas for larval or juvenile phases e.g. territorial reef fishes such as Red Emperor, marine mammals such as whales	Site specific protection of adult territory or nursery site
D	Pelagic or planktonic adult phase with pelagic or planktonic larval/juvenile phase e.g. most oceanic species such as plankton, tuna	Little or no site specific protection

4. Other Purposes for Marine Sanctuaries

In addition to their value for conserving biodiversity, marine sanctuaries have been seen as valuable tools for research and management and they also have benefits for non-extractive uses such as recreation, education (Taylor and Buckenham 2003) and aesthetics (Edgar et al. 2007, Wood et al. in press). Although it is common to find claims that marine sanctuaries are beneficial for these purposes, quantitative studies of the benefits or costs of marine sanctuaries for such purposes seem to be scant. However there are some studies that support these views. For example, surveys of scuba divers have shown that they are increasingly more willing to accept restrictions if they can expect to see more marine life, for example in a marine reserve (Sorice et al. 2007), and that non-use values may be more highly valued by visitors to marine protected areas than use values (Togridou et al. 2006). Given a high willingness to pay for non-use values from marine reserves, this means that marine reserves could add significantly to the economy. Even in the case of small single marine reserves, tourism can be important to the local economy. Tourism based on the marine reserve at the Leigh (New Zealand) Marine Reserve alone is estimated to bring 100,000 visitors per year, contributing substantially to the local economy (Cocklin et al. 1998). Where large regions such as the Great Barrier Reef are underpinned by tourism this means that marine conservation and marine parks can be a key component of the economy. In the GBR in 2002, tourism was worth $4 billion per year and is a far larger component (27%) of GVP than fishing (1%) (Hand 2003), therefore in terms of competing uses of the park, it makes economic sense to carefully evaluate the balance between these alternate uses. Interestingly a large majority of the general population appears to favour significant levels (>30%) of no-take protection for iconic marine areas such as the GBR (Hand 2003), despite what appears to be a consistent media bias in favor of presenting views opposing marine protected areas (Compas et al. 2007). An exception is in the

Great Barrier Reef Marine Park where extensive studies have been made around the use of marine sanctuaries for tourism and recreation. Examples of such studies are the economic value of tourism (Productivity Commission 2003), the inclusion of visitor experiences in dwarf minke whale tourism (Birtles et al. 2002) and changing visitor perceptions (Moscardo et al. 2002). Many other examples may be found on the CRC Reef website:

http://www.reef.crc.org.au/publications/techreport/index.html.

Related to these studies are others that address the important issues of socio-economic/cultural aspects of marine planning. Innes et al. 2004 succinctly capture the importance of understanding the human dimension of marine planning – "*the effective design of Marine Protected Areas to protect biodiversity is as dependent upon understanding the biodiversity and associated ecological processes of a region, as it is upon knowing its human dimensions. Achieving a biodiversity protection outcome in the multiple-use Great Barrier Reef Marine Park is a complex social and political issue. Whilst it is critical to know to understand the dynamics of the complex marine system, it is ultimately the social and political dimension that will largely determine the success, or not, of conservation strategies"* (Innes et al. 2004). Techniques such as Social Impact Assessment and TRC-Analysis[1] may also be used to understand the social and economic consequences of planning decisions made for biological conservation reasons (Fenton and Marshall 2001, Sutton 2006).

[1] Town-Resource-Cluster Analysis

E. The Scientific Basis for and Role of Marine Sanctuaries in Marine Planning in Western Australia – General Overview

Introduction

This section provides an overview of the information available from both biodiversity conservation and fisheries management perspectives of marine parks and reserves and fisheries closures in Western Australia. For a detailed description of the science on the effects of sanctuary zones in Western Australia, see Appendix 2.

General overview

The primary purpose of sanctuary zones established under the Conservation and Land Management Act (CALM Act) is for the protection and conservation of marine biodiversity. At the time of publication, there are 13 CALM Act marine parks and reserves in Western Australia covering a total area of approximately 1.48 million ha (14,801 km^2) with approximately 302,564 ha (3,026 km^2) in no-take marine nature reserves, sanctuary zones, or conservation areas. Approximately 2.4% of WA state waters are included in CALM Act no-take areas, or about 20% of the total area of marine parks and reserves. The area of sanctuary zones or conservation zones in the existing marine parks and reserves system ranges from none in the Walpole and Nornalup Inlets Marine Park to the entire area of the 112,300 ha Hamelin Pool Marine Nature Reserve. The largest area of sanctuary zone within a marine park is in the Ningaloo Marine Park with 87,216 ha or 33% of the marine park designated sanctuary zone. Shark Bay Marine Park is the largest marine park in the State and includes 41,913 ha or 5.4% of its area in sanctuary zone.

Areas can also be established under the Fisheries Resources Management Act (FRM Act) that limit fishing activities and, as a consequence, may have a similar function to sanctuary zones for conserving biodiversity. These zones include: the Reef Observation Areas within some Fish Habitat Protection Areas (FHPAs) and areas permanently or seasonally closed to fishing, particularly trawling. Fletcher and Penn (2005) assessed the use of sanctuary areas for the management of fish stocks and biodiversity in Western Australian waters. The largest FHPA is in the waters of the Abrolhos Islands which covers about 240,000 ha, with about 6,859 ha in the four Reef Observation Areas that exclude all fishing, except potting for lobster (see Appendix 2, Nardi et al. 2004; Watson et al. 2007). The Miaboolya FHPA, near Carnarvon, covers an area of about 11,460 ha and excludes commercial and recreational fishing but allows spearfishing (Appendix 2). All other FHPAs are less than 400 ha in area. Much larger areas of marine waters are closed to trawling, particularly in the North West Shelf and the Gascoyne and West Coast bioregions, as defined by the Department of Fisheries for fisheries management (Figs E1, E2, Newman et al. 2003, Fletcher and Head 2006, Fletcher and Penn 2005, Appendix 2).

Table E1. Summary of the size of existing marine reserves and their sanctuary zones (SZ) in Western Australian waters. MCR = Marine Conservation Area. Information provided by the Department of Environment and Conservation. Note: Areas should be regarded as approximate. * = Areas are calculated to High Water Mark because of poor definition of Low Water Mark. Area of WA waters taken as 12,633,297 ha, defined as extending from Mean High Water mark to the 3 nautical mile limit of state waters.

Reserve	Area (hectares)	Total MCR as % of WA waters	Total SZ & Cons. Area	% SZ of MCR	% SZ of WA waters
Existing Marine reserves					
Barrow Island Marine Management Area	114,693	0.9%	1,642	1.4%	0.0%
Barrow Island Marine Park	4,169	0.0%	4,169	100.0%	0.0%
Hamelin Pool Marine Nature Reserve	112,301	0.9%	112,301	100.0%	0.9%
Jurien Bay Marine Park	82,376	0.7%	3,061	3.7%	0.0%
Marmion Marine Park	9,495	0.1%	41	0.4%	0.0%
Montebello Islands Marine Park*	58,333	0.5%	28,626	49.1%	0.2%
Muiron Islands Marine Management Area	28,616	0.2%	1,929	6.7%	0.0%
Ningaloo Marine Park	261,036	2.1%	87,216	33.4%	0.7%
Rowley Shoals Marine Park	87,632	0.7%	21,279	24.3%	0.2%
Shark Bay Marine Park	714,426	5.7%	41,913	5.9%	0.3%
Shoalwater Islands Marine Park (proposed zones)	6,658	0.1%	387	5.8%	0.0%
Swan Estuary Marine Park	343	0.0%	0	0.0%	0.0%
Total existing reserves	1,480,075	11.7%	302,564	18.8%	2.4%

Source: WA Department of Environment and Conservation

The closed areas around Rottnest Island in Thompson Bay (126 ha) and at Parker Point (5 ha) are a third category of closure. These sanctuary zones were established by the Rottnest Island Authority in a Marine Management Strategy but the zones were declared under the FRM Act. Although these closed areas were declared in 1986, no studies were carried out on comparing their effectiveness with the open waters around Rottnest (except to spearfishing) until 2003. Several studies on the island's sanctuary zones were conducted starting in 2003, mainly focused around the Thompson Bay reserve and adjacent waters on the eastern end of the island. In 2007 a new Marine Management Strategy was declared for the Rottnest Island Reserve under the RIA Act, with expanded sanctuary zones at Thompson Bay and Parker Point and new zones at West End, Armstrong Bay and Green Island. Once again these zones are to be declared under the FRM Act and supported by research and monitoring programs to test their effectiveness

There is little or no systematic information relating to whether the sanctuary zones (or other protected zones) created under WA legislation have had any effect on biodiversity in a broad sense. The data that do exist relate mainly, but not exclusively, to the influence of sanctuary zones and other forms of closure on a restricted subset of biodiversity i.e. fish and invertebrates that are caught by commercial and recreational fishers. Note that with the exception of Ningaloo, where sanctuary zones were established in 1990, and the Abrolhos Islands FHPA that was established in 1994, little scientific information is available to evaluate the effectiveness of these zones (see also Table E2). However, current and recently completed research in Jurien Bay, the Capes region and Ningaloo (see Appendix 2) will provide a rigorous baseline for the evaluation of sanctuary zones in the future, providing a commitment is made to monitoring and evaluating the effects of sanctuary zones beyond the current programs of research funded through the Western Australian Marine Science Institution and the CSIRO Collaboration Fund. The following discussion summarises the current information found to date for various marine protected areas in WA (for detail see Appendix 2).

Figure E1 Areas open to Trawling (light blue) and closed to trawling (white) in WA waters. The dark blue areas are the boundaries of where trawling has occurred in the past 2 years. The solid line is the 200m depth contour. Figure provided by the Department of Fisheries.

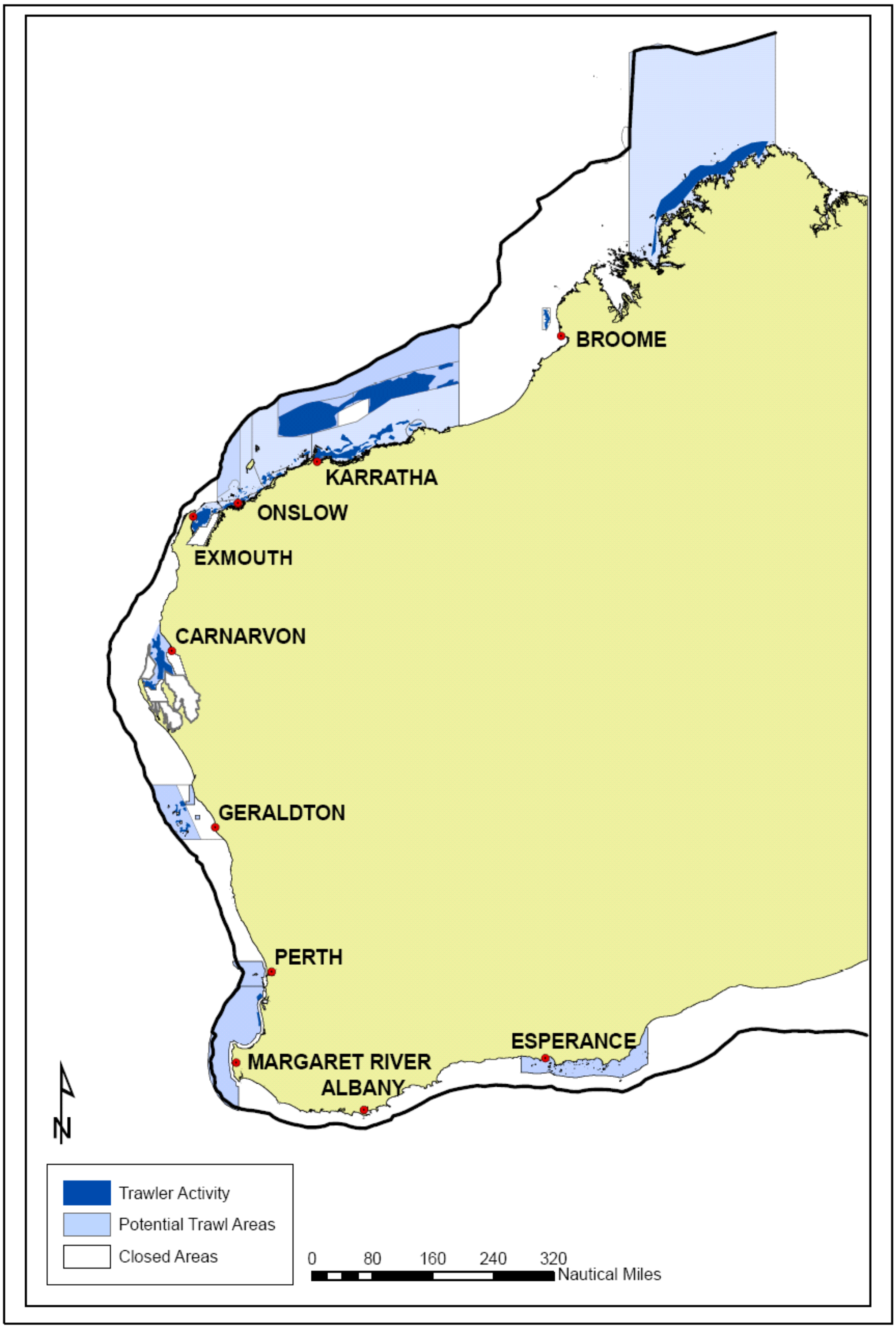
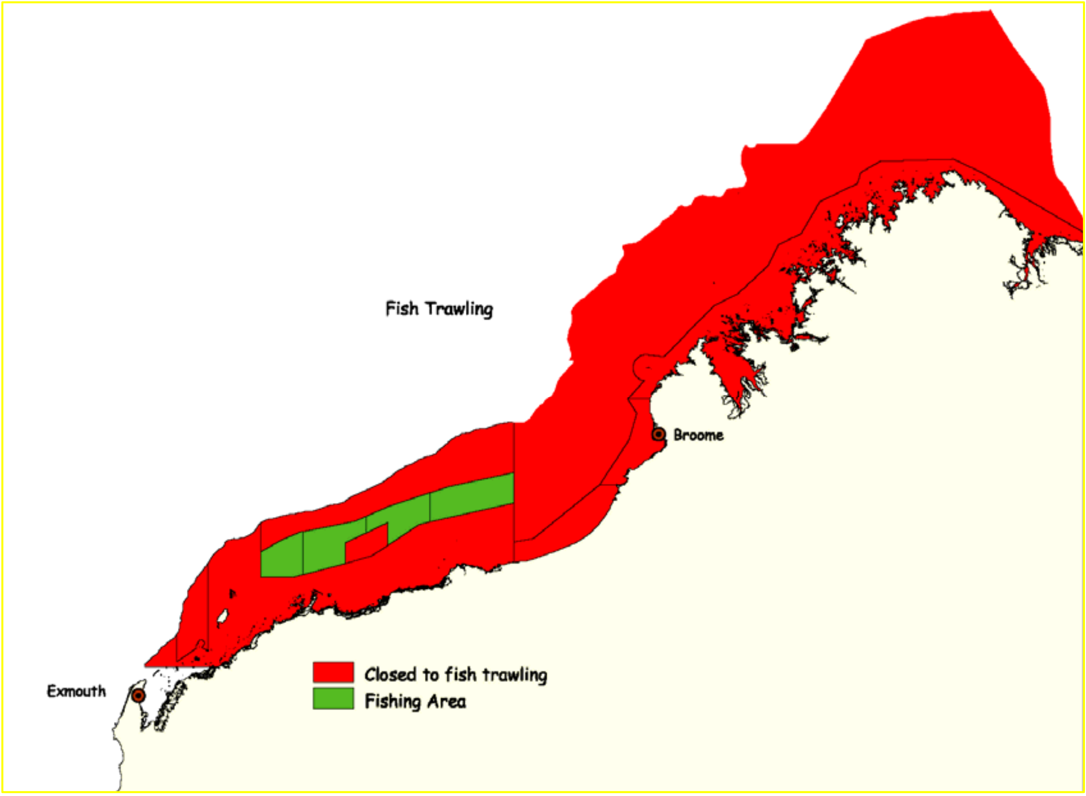


Figure E2 An example of the closures to fish (not prawn) trawling within WA waters from Northern Western Australia. - modified from Newman et al. 2003. Figure provided by the Department of Fisheries.



The evidence from WA with respect to the effectiveness of sanctuary zones or other areas where fishing is restricted (i.e. those areas declared under the FRM Act and managed by the Department of Fisheries), is consistent with findings in other parts of Australia and the rest of the world. Inside sanctuary zones or areas with restricted access to fishing, large increases in the abundance and size of some fished species have been reported, as well as some more modest effects.

Probably the most detailed and long term information on the potential effects of closed areas in Western Australia comes from the Reef Observation Areas of the Abrolhos Islands, where before and after data have been collected on fished species in areas with restricted fishing (lobster potting only) and those open to fishing since 1993. Studies have been carried out using a variety of techniques including visual census by divers (Nardi et al. 2004), baited remote under water video and diver operated video (Shedrawi, 2007; Watson et al. 2007). The population densities and body sizes of the coral trout (*Plectropomus leopardus*) were monitored six times between 1993 and 2002 before and after the implementation of closed areas (Nardi et al. 2004). After eight years of protection, populations of the Coral Trout were significantly higher in the closed than open areas, with densities between 3x (Easter group) and 17x higher (Wallabi group) in the closed than open areas (Nardi et al. 2004). No significant differences were found for the first three years of protection for Coral Trout but after a further three years of protection densities were 1.2 and 2.8 x higher in the protected areas (Watson et al. 2007). Subsequent monitoring of the Reef Observation Areas in the Abrolhos found that the numbers of fished species such as Coral Trout had dropped to 1.2 to 2.8 times higher in closed areas but that the densities of Emperors (*Lethrinus miniatus* and *L. nebulosus).* Pink Snapper (*Pagrus auratus*) and Dhufish (*Glaucosoma hebraicum*) were higher by 1.1 to 8 times in closed than in fished areas (Watson et al 2007). In contrast, the numbers of many unfished species (*Coris auricularis*, *Thalassoma lunare, Thalassoma lutescens, Dascyllus trimaculatus)* were higher in the fished areas. In addition to the direct effect of the closures on the fished species, the closures may have had indirect effects on species that are not fished i.e. the results suggest that the abundance of unfished species has increased in areas open to fishing because of the removal of abundant fished species and that the trophic structure of the food web has been altered with an increased dominance of species lower in the food web. Studies on the rates of predation of the prey species are needed to increase the level of confidence around any suggestion of indirect fishing effects (e.g. Shears and Babcock 2002). Other information gaps relate to results for numbers of Coral Trout which have recently been lower (Watson et al. 2007) than those reported in previous studies (Nardi 2004), and anecdotal reports indicate that this drop in relative abundance is due to poaching within the ROAs.

In the Ningaloo Marine Park, the density and biomass of some key fished species e.g. spangled emperor *Lethrinus nebulosus,* have been shown to be higher in sanctuary zones than areas open to fishing, but this effect was not consistent across sites (Westera et al. 2003). At Rottnest Island, the density of rock lobster in closed areas is 30 times higher than in open areas, and significantly greater numbers of fished species, including dhufish, have been recorded in the closed area (Babcock et al. 2007a, Kleczkowski et al. 2008).

Other smaller closed areas at Rottnest and Marmion show little or no effect in comparison to open areas (Babcock et al. 2007b, Ryan 2008). It is not clear whether this difference in the effectiveness of closures is due simply to the size of the closed area, a lack of compliance with regulations or lack of appropriate habitat. Potentially all three factors may contribute to these differences in the effects of closures in different areas.

The FHPAs at Cottesloe and Watermans (a Reef Observation Area) appear to have been effective in conserving abalone populations that are heavily fished by recreational fishers during a very short season (currently 6 hours, spread over 6 days during summer). Surveys in 2007 indicated that the biomass in some closed areas remained at similar levels to that in the 1980s, while in open areas, it had declined by about 50% compared with over 20 years ago (Wells et al. 2007, Appendix 2). Populations in the habitat protection zones have remained at similar levels to those in the early 1980's, although there is some variation among these sites (Wells et al. 2007). At Cottesloe, population densities were almost three times higher in 2007 than in the 1980s, while at Watermans south, where poaching is suspected, the densities have declined. However, there was considerable variation between sites and the survey from 1983 to 1986 also found significant variation in abundance between years. It would be valuable to continue these surveys of abalone in closed and open areas to determine the current status of their populations with greater confidence.

These results demonstrate the complexity of investigating the effects of sanctuary zones or other forms of closure in the marine environment and highlight the need for carefully designed research programs that extend over many years (see also Hilborn et al. 2004, Section D). One of the key factors affecting the design of marine sanctuaries is the life history characteristics of the animal(s) to be conserved, particularly their distribution, habitat use and extent of movement. Newman et al. (2003) examined the potential effectiveness of sanctuary zones compared with Targeted Fishery Closures for six tropical fish species (Spanish mackerel *Scoberomorus commerson*, goldband snapper *Prestipomoides multidens*, red emperor *Lutjanus sebae*, Rankin cod *Epinephelus multinotatus*, blue-spot emperor *Lethrinus hutchinsi* and spangled emperor (*Lethrinus nebulosus* – inshore-offshore demersal species) in the marine waters of the North West Shelf (see also Appendix 2). These species comprised about half of the total annual landings of 3,000 tonnes in 2000 by commercial fleets in the region. They concluded that five of the six species were too widely distributed for the sanctuary zones in the area to be effective and that the fisheries management regimes provided much for more effective conservation of the fish stocks of these species (Appendix 2). A further illustration of the importance of understanding the life history of marine species and clearly defining the objectives of the sanctuary zone(s) is provided by examining some of the species with different life history strategies in the Ningaloo Marine Park and comparing their life history strategies with the areas of sanctuary zones in Ningaloo.

Table E2. Summary of literature relevant to assessing sanctuary zones and other forms of closures in Western Australian Marine waters

Area, level of protection and Study	Author(s)	Source	Approach
Sanctuary Zones under the CALM Act			
Capes Region, Proposed Marine Protected Area			
Numbers, biomass and fishery of 3 species of abalone	Hesp et al. (2007)	Report (reviewed)	Data from fishers, log books, counts of abalone in closed areas only
Reef fish assemblages	Watson et al. (2006)	Journal	3 types of underwater stereo-video, Hamelin Bay before proposed areas designated
Jurien Bay Marine Park			
Fish assemblages, benthic invertebrates, benthic habitats	Edgar et al. 2008	Report	Underwater visual census Video of open and closed areas, benthic invertebrate census, benthic habitat characterization
Fish Assemblages	Bivoltsis 2008, Fairclough and Potter 2007	Hons Thesis, Report	Underwater visual census and Baited Underwater Video of open and closed areas
Rock Lobster and benthic assemblages	McArthur et al. in press	Journal	Underwater visual census of open and closed areas, benthic habitat characterization, acoustic tracking of lobsters
Benthic assemblages	Babcock et al. 2007b	Report	benthic invertebrate census, benthic habitat characterization

Table E2 continued

Area, level of protection and Study	Author(s)	Source	Approach
Marmion Marine Park			
Benthic assemblages	Babcock et al. 2007b	Report (Reviewed)	benthic invertebrate census, benthic habitat characterization
Fish assemblages, benthic invertebrates, benthic habitats	Ryan 2008	PhD thesis	Underwater visual census Video and Baited Underwater Video of open and closed areas, benthic invertebrate census, benthic habitat characterization
Intertidal invertebrates, abalone	Wells et al. 2007	Report	Intertidal surveys of open and closed areas including historical comparisons
Ningaloo Marine Park			
Fish assemblages, habitat	Ayling & Ayling 1987	Report	Underwater visual census of open and closed areas, some benthic habitat characterization
Fish assemblages, benthic invertebrates, benthic habitats	Westera 2003	PhD thesis	Underwater visual census and Baited Underwater Video of open and closed areas, benthic invertebrate census, benthic habitat characterization
Fish assemblages	Westera et al. 2003	Journal	Underwater visual census and Baited Underwater Video of open and closed areas
Grazing fish, benthic invertebrates, benthic habitat and processes	Webster 2007	PhD thesis	Underwater video of grazing fish, benthic invertebrate census, benthic habitat quantification in open and closed areas
Fish assemblages	Fitzpatrick and Harvey 2008	Report	Baited Remote Underwater Video in open and closed areas, including deep water
Fish assemblages, benthic invertebrates, benthic habitats and processes	Babcock et al. 2008	Report	Underwater visual census of open and closed areas from Muirons to Gnarraloo, benthic invertebrate census, benthic habitat characterization of open and closed areas

Table E2 continued

Area, level of protection and Study	Author(s)	Source	Approach
Fish Habitat Protection Areas under the FRMA and Rottnest Island			
Abrolhos, Fish Habitat Protected Area (ROA)			
Two species of exploited fish (bald-chin grouper, coral trout)	Nardi et al. (2003)	Journal	Underwater visual census of open and closed areas
Fish assemblages	Watson et al. (2007)	Journal	Baited remote underwater video in open and closed areas at depths of 8-12 m and 22-26 m
Fish assemblages inside and outside multiple protected areas	Shedrawi (2007)	Hons Thesis	Comparison of reef fish assemblages using diver operated stereo-video in open and closed areas for four Reef Observation Areas. Counts, biomass estimates and lengths of fish
Cottesloe			
Intertidal molluscs	Wells et al. (2007)	Report	Intertidal surveys
Rottnest Island			
Rock lobster	Babcock et al. 2007	Journal	benthic invertebrate census, benthic habitat characterization
Fish assemblages	Kleczkowski et al. 2008	Journal	Baited Underwater Video of open and closed areas
Benthic habitat, ecological processes	Babcock et al. 2007	Report (Reviewed)	benthic invertebrate census, benthic habitat characterization, predation experiments
Fish assemblages	Cook 2006	Hons. Thesis	Underwater visual census Video and Baited Underwater Video of open and closed areas, benthic invertebrate census

Table E2 continued

Area, level of protection and Study	Author(s)	Source	Approach
Watermans (ROA)			
Intertidal molluscs	Wells et al. (2007)	Report	Intertidal surveys
Fishery Closures under the FRMA Act			
North West Shelf, Fishery Closure (Trawl)			
Fish	Sainsbury and Sumaila (1988)	Book Chapter	Trawl sampling of fish and invertebrates, video of habitats, fishery catch per unit effort data
Exmouth Gulf, Fishery Closure (Trawl)			
Fish and invertebrates	Kangas et al. (2007)	Report (reviewed)	Trawl and video sampling of fish and invertebrates in areas open and closed to trawl fishing (all open to recreational fishing)
Shark Bay, Fishery Closure (Trawl)			
Fish and invertebrates	Kangas et al. (2007)	Report (reviewed)	Trawl and video sampling of fish and invertebrates in areas open and closed to trawl fishing (all open to recreational fishing)

Ningaloo Case Study

The Ningaloo Marine Park can be used as an example of how the size of a sanctuary area may influence the effectiveness of sanctuary zones for particular species. The Ningaloo Marine Park now has 18 sanctuary zones and the Muiron Islands Marine Management Area has three no-take conservation areas as outlined in the management plan covering both reserve areas . Scientific studies are currently being carried out to address questions about size, location and effectiveness through research sponsored by the Western Australian Marine Science Institution and the CSIRO Collaboration Fund. The following discussion compares life history characteristics of selected organisms and the spatial and temporal scales at which sanctuary zones might be effective. The discussion below is current at the time of submission (July 2008) and is not intended in any way to pre-empt the results of the WAMSI Node 3 research program which will provide additional rigorous data and information to address these questions.

Table E3 Major groups of marine organisms, categorized by Life History Mobility Category.

Life History Mobility Category	LH Characteristics	Example	Spatial Scales (km)	Temporal Scales
Oceanic fish	Long-lived, large size, live birth	Whale sharks (other large sharks?)	10^3	Months to years
Coastal pelagic fish	Short lived, planktonic larval phase	Spanish Mackerel	10^2	Weeks to months
Mobile target fish	Long lived or short lived	Spangled emperor, trevally	10^0-10^1	Days to weeks
Spawning aggregating fish	Long lived, planktonic larval phase, return to specific spawning sites	Coral trout,	10^0-10^1	Days to weeks
Nursery area species	Long lived, live birth/nesting	black tip reef sharks	10^1-10^2	Months to years
Low mobility fish	Long or short lived, long to very long planktonic larval phase	Rock lobsters, smaller serranids (Charlie Court/Chinaman cod)	10^{-2} 10^{-1}	Months to years
Sessile organisms	Diverse life cycles	Corals, gorgonians, large sponges	10^{-3}-10^{-2}	Years to decades

With these general criteria in mind, the effectiveness of no-take zones as a conservation measure for following broad life history groups are assessed, using the current zoning of the Ningaloo Marine Park as an example.

Oceanic fish

Species in this group travel large distances across ocean basins with movements ranging into the thousands of kilometers that may take place over periods of a year or more. Whale Sharks are a species that falls within this category; the movements of this shark are large relative to the size of sanctuary zones at Ningaloo and they spend only a minor portion of their time in Ningaloo waters, even less within sanctuary zones. The major threats to this animal come not from Ningaloo but from fisheries in the general area of southeast Asia and south Asia where they are caught. At Ningaloo human interactions with Whale Sharks may pose a nuisance to the sharks, but are unlikely to be fatal or compromise any key life history processes at their current level. These interactions are managed through a code of practice and are not affected by zoning provisions. Other large predatory sharks may be taken incidentally or even targeted deliberately in the area, and would be afforded some protection by sanctuary zones while present in them. In conclusion then, *sanctuary zones in Ningaloo Marine Park are inadequate to achieve conservation outcomes of major significance for the Whale Shark,* apart from raising public awareness of them, and of threats to their existence. Global or regional initiatives are required for the conservation of this species. For large predatory sharks, some small degree of protection may be afforded by existing sanctuary zones.

For such large sharks, we know little about the details of movement, which are likely to be highly species specific.

Coastal pelagic fish

Mackerel and coastal tunas are likely to be typical of pelagic fishes associated with coastal seas. Such species are thought to make seasonal movements of hundreds of kilometers, possibly following seasonal peaks in production and schools of baitfish species. Threatening processes to these species come mainly from commercial and recreational fishing based in Australian waters; therefore spatial management measures within Australia may have the potential to achieve positive conservation/management outcomes for this category of species. While sanctuary zones at Ningaloo are of the scale of up to tens of kilometers, they are nevertheless small relative to the scale of movements made by such coastal pelagic fishes (see also Newman et al. 2003, Appendix 2). *Sanctuary zones at Ningaloo may represent <1% of the total range of a species such as Spanish Mackerel, and would thus provide little in the way of effective protection.* This conclusion is based on assumptions about current knowledge of life history, scales of movement, and more importantly, the use of habitat and how this may vary along the coast.

Mobile target fish

Possibly the greatest number of targeted species fall into this category, and one of the iconic target fishing species from Ningaloo, the Spangled Emperor, is a representative of this group. Popular conception of the behaviour of this species is that individuals move over distances of tens of kilometers, perhaps moving in and out of certain habitats seasonally or in accordance with particular weather conditions. Tagging studies (Moran 1993) are consistent with these findings showing that over 1 year, the majority of movements were less than 7 kilometers, however a significant proportion (~20%) moved 25 km or more over this time. The 7 km movement range is similar to the lengths of coast protected by no-take areas at Ningaloo. There is therefore a reasonably high degree of concordance between the typical scale of movement exhibited by Spangled Emperor and the size of protected areas and a *high level of potential protection may be afforded to mobile target fish such as Spangled Emperor by sanctuaryzZones*. At the same time however, a substantial proportion of the population moves more widely and is consequently available for exploitation by various forms of fishing.

Spawning aggregating fish

Certain species of coral reef fish are known to aggregate to spawn, with the annual spawning aggregations being restricted to particular locations on a reef, usually taking place at particular lunar phases. Many species of groupers (Serranidae) are known to spawn in such aggregations, the most notable example from Australian waters being the Coral Trout. Emperors (Lethrinidae) are also known to spawn in aggregations and both groupers and emperors are favoured angling species. Typically, individuals move from their usual place of residence on the reef to spawning aggregation sites where they may spend periods from days to weeks. Potentially, individuals may make more than one annual trip to spawn. If spawning sites are outside protected areas, aggregating species may be particularly vulnerable to fishing. We know little about which species may take part in spawning aggregations at Ningaloo, or the position of any aggregation sites. However, if the species and the locations of the sites are similar to those observed in other parts of the Indo-Pacific, the main species involved will be groupers and emperors, and the spawning sites will be located around large passages through the reef. *If no-take areas include spawning aggregation sites they will provide an extra level of protection for target species. If no-take areas do not include aggregation sites, species may be far more vulnerable than might otherwise be assumed since at one time or* *another, virtually all members of the population will be exposed to fishing at highly predictable junctures in time and space. The current zoning may under-represent spawning aggregation sites as reef passages are frequently outside existing sanctuary zones at Ningaloo.* Species spawning at aggregation sites all have planktonic larvae and although many of the larvae produced at the site will return to the same general area, they will not be vulnerable to fishing for some time – theoretically until they reach legal size. There may be little if any detectable feedback from the spawning site to the sanctuary zone due to variations in larval and juvenile mortality.

<u>Nursery Area species</u>

Species that use nursery or nesting areas differ from species aggregating for spawning in that juveniles are born live and may remain in the nursery area for some time before moving on. During this time they may be particularly vulnerable to threatening processes such as fishing or habitat destruction. One species that appears to use nursery areas extensively is the Black Tip Reef Shark which may move from considerable distances to nursery areas where it is thought pups are born. Other elasmobranch species may display similar behaviour but for all species, including the Black Tip Reef Shark, little or no detailed information is available. Although adult Black Tip Reef Sharks may be vulnerable to fishing when they are outside the nursery areas, they are likely to be sparsely distributed during this time, and not particularly vulnerable. When they move to nursery areas, similar considerations to those expressed above for spawning aggregation species apply. It should be noted however that the well known nursery areas at Ningaloo *(Mangrove Bay, Skeleton Bay, and Pelican Point*) are located within no-take areas*; therefore the current zoning does appear to offer a reasonable level of protection to Nursery Area species*. Sea turtles nesting at Ningaloo may be analogous to nursery area species in some ways but since they are no longer directly exploited by any extractive activities no enhanced protection will be afforded to them by the presence of sanctuary zones.

<u>Low mobility species</u>

Low mobility species are mostly those that are not targeted by fishing. Notable exceptions are principally among the groupers, and particularly the small groupers such as the Charlie Court (*Epinephelus rivulatus, E. fasciatus*). Spiny lobster (*Panulirus ornatus*), may also be included in this group. Individuals of these species may move only tens to 100s of meters over their entire life, though greater distances are also possible. They are under threat from fishing either as target or bycatch species and thus are likely to be afforded significant protection by no-take areas. *The size of sanctuary zones at Ningaloo is more than adequate to protect local populations of low mobility species.*

<u>Sessile organisms</u>

Sessile organisms such as corals, giant clams (Tridacna spp.) and algae by definition do not move, and in theory any no-take area, however small, will provide protection from direct effects of exploitation. While there is a small amount of commercial coral collection in the Ningaloo region, the level of direct threat to this class of organisms is low. It has to be concluded that *sessile organisms are well protected from direct exploitation by the current zoning.* Other threats to sessile organisms such as ocean acidification and sea temperature rise occur at a global scale, and local zoning will not directly lessen their effects. There is the potential, however, for no-take areas to increase the overall resilience of ecosystems, indirectly making them less vulnerable to climate stressors. For example, the recovery of coral communities from bleaching can be slowed or even stopped, if algal grazing species are removed from the ecosystem, by fishing for example (Mumby et al. 2006). In the absence of grazing pressure, algae can over-run reefs preventing re-colonization by corals as they inhibit coral settlement and the growth of juvenile corals (Webster, 2008). Algal grazing fish are generally not target fish and their scales of movement are probably best characterized as similar to those of mobile target fish or low mobility species; therefore if zoning is adequate for these species then indirectly it will also be adequate to ensure the recovery of corals and other sessile organisms. This protection of key structuring species should also enhance the overall resilience of the ecosystem.

Implications

The conclusions reached here are similar to those of Newman et al. (2003) for pelagic species such as mackerel but not for mobile target species of demersal fish. Newman et al. (2003) reached their conclusions from the fisheries perspective of an overall stock, while we have approached this question from the view of assessing the effectiveness of a particular sanctuary zone for conservation. This is an important distinction related to the differing scales of management being undertaken at the level of fisheries and of marine parks and has probably been responsible for some of the disagreement and controversy about the effectiveness or otherwise of no-take areas.

One small reserve may be quite effective for the conservation of a species or community within a marine park, yet it may be quite ineffective in addressing the requirements of fisheries management at scales that may be orders of magnitude larger. This has strong implications for the design of marine sanctuaries and for the assessment of their effectiveness: 1) Assessment must be based on clear objectives that are appropriate to the scale of the management action 2) in order to address conservation at scales relevant to stocks, rather than just local populations, a very large reserve or more likely, a network of smaller reserves, will be needed and these will not be effective unless other measures to control the fishing effort or catch are in place (Hilborn et al. 2004).

Conclusions for Ningaloo Marine Park

There are clear benefits for local populations of targeted species and biodiversity conservation and protection that can be shown to have resulted from sanctuary zones, Fish Habitat Protection Areas and other spatial closures in Western Australia. In order to maximise these localized benefits, marine sanctuaries and marine parks need to be considered with the broader management goals. Clear objectives need to be specified for management, which can be objectively evaluated, particularly with respect to larger scale issues including fisheries management, but also factors such as climate change. Finally it will be necessary to be realistic about the resources required to implement the entire process of adaptive management from planning to declaration, compliance, monitoring assessment and review.

It is important to ensure that compliance with sanctuary zone prohibitions on fishing or collecting is high so that the results from research and monitoring are not confounded by illegal activities (such as poaching) within the sanctuary zones.

With growing populations in the southwest corner of Western Australia, and increasing concerns about managing iconic fish species, calls from some quarters for the use of no-take areas in a more direct management context is likely to grow. Any such step would require very clearly specified objectives, as well as a well designed and highly targeted assessment program, with a far more systematic approach to the implementation of MPAs than has been seen in WA to date.

There are some clear benefits for fisheries management to implementing spatial closures either through conventional fisheries management measures or through Fish Habitat Protection Areas in WA. The closure of NW shelf to fish trawling has allowed the trap fishery for demersal finfish to develop and enabled an Australian trawl fishery on high value species to develop (see Appendix 2). These closures also ensure the supply of habitat and shell for pearl oyster. Information from closed areas/sanctuary zones can also increase the understanding of the dynamics and biology of fished species. For example, acoustic tagging and tracking studies to understand the movement patterns of immature rock lobster has been facilitated by locating the research in sanctuary zones at Jurien Bay, where animals will remain undisturbed (MacArthur et al. in press). Other work using closed areas has provided reassurance to fisheries managers, as well as help maintain "green" accreditation, for the rock lobster industry by showing that there seems to be no sign of trophic cascades (e.g. urchin barrens) as a result of fishing in WA (Babcock et al. 2007b).

While WA has many areas declared as sanctuary zones (Table E1), a number of areas declared as FHPAs and large areas that are closed to trawling (Table E1, Appendix 2), we know little about the effectiveness of most of these zones. For example, the results discussed above for sanctuary zones relate to just 6 of the 45 sanctuary zones under the CALM Act. Many of these areas are too new to be able to evaluate their effectiveness. However in many cases, baseline studies, that will provide the information for evaluation in the future, have been completed or are in progress. It is clear, however, that the implementation of a long term monitoring and evaluation program for the conservation estate under a framework of adaptive management is a major task for DEC. The effectiveness of closures under the Fisheries Resources Management Act for biodiversity conservation is not apparently monitored and evaluated.

F. Marine Science and Planning for MPAs and Marine Sanctuaries

F.1 Marine Environments and Scientific Method

The nature of the marine environment makes the conduct of marine science more difficult and expensive than in terrestrial systems. Characteristics such as the opacity of water, exposure to weather, depth limitations and the inherent complexity of the system have limited human access to and understanding of fundamental functions. Until recently knowledge of the marine environment below depths accessible by SCUBA, was very limited. The scales at which marine systems operate (from microbial to oceanic) further complicate the ability to sample sufficient data at the right spatial and temporal scales in order to differentiate natural variation from the effects of human activities and interventions. Science proceeds on the basis of hypothesis testing, peer review and challenge. The understanding of the functioning of marine organisms and systems is current until further research and interpretation brings new insights. Science is never complete or exact and proceeds on the basis of rigorous peer review and debate within and outside the many disciplines that are applied to the problems of marine resource management. There are further challenges of communicating the results of science to non-experts who are often required to make policy and operational decisions in time frames that do not match those needed to generate scientific data. Scientific information is one input to the policy decision making process.

Scientific disciplines that need to be applied to the issues surrounding marine sanctuaries are very diverse. The biological and physical sciences are essential to the understanding of natural systems; however the conceptual ideas, political responses and management decisions are driven by human values, perceptions and needs. Accordingly the application of the social sciences is also necessary in order to understand the drivers behind the establishment of MPAs and marine sanctuaries, and especially to effectively manage human impacts. The degree to which marine sanctuaries achieve their purpose will depend on many factors, but particularly the degree of public acceptance and voluntary compliance.

Ecological monitoring of subtidal marine ecosystems to evaluate their status and the direction of their responses cannot be achieved by casual observation. To a much greater extent than their terrestrial equivalents, marine sanctuaries require special sampling programs to assess even the abundance of common marine algae, plants or invertebrates such as corals. Specialised sampling protocols are particularly required for mobile organisms such as fishes and larger invertebrates. Management agencies also commonly need to understand the socio-economic and cultural implications of their decisions, in which case monitoring should include assessment of human interactions with the ecosystem. Effective research and monitoring, either to achieve management goals or to assess MPAs as large scale ecosystem-level experiments, is dependent on the application of scientific method. This is often compromised by the MPA creation process.

The importance of sound scientific methodology cannot be underestimated when it comes to designing research or monitoring intended to further the understanding of ecosystems, to inform management or assist interactions between stakeholder groups. In this regard the Before-After-Control-Impact (BACI) experimental design philosophy is central to the application of evidence based approaches to management. This philosophy requires that in order to assess the effects of an experimental treatment (for example different management zones) there must be adequate controls or reference points for comparison. The ideal is that there are comparisons not only in space (Control vs Impact) but also in time (Before vs After). This is because it is possible that, even in an ideal world, control and impact areas may differ intrinsically in many ways. For example an area chosen for a marine sanctuary may always have had higher levels of fish or other fauna than the only logical control areas (Edgar et al. 2004b). If there are samples from before and after the marine sanctuary is implemented, it is possible to compare the trends over time between the areas, which would more truly reflect the consequences of management than any set of observations from a single point in time. When we consider that populations vary naturally over time, and that these variations can differ from one place to another, it is also clear that it is important to have several Before and After observations, as well as multiple Control and Impact sites. The scientific principle that no hypothesis is ever absolutely proven frequently conflicts with the manager's need for clear and conclusive results with which to justify his or her actions (Woodley 2006). Scientists and managers tend to work at different confidence levels: scientists require a confidence level of 95-99% whereas 70-80 % may be perfectly adequate for managers, given time and financial constraints (Wells 1995). Not only can there be a conflict of purpose, misunderstanding can arise about the nature of science and what it can deliver. However there are many ways in which scientists can contribute to natural resource management problems. The following areas of scientific support for marine planning and management are derived from Cullen (1997):

a. *Description.* Inventory of what exists in the system and identification of the key processes

b. *Diagnosis.* Analysis of past environmental damage and the present condition of the resource. Identification of the problems including causes and consequences of ecological disturbance.

c. *Prediction.* Assessment of the capability of the resource to support various functions. Identification of possible hazards, special values and probable ecological effects of specific resource uses. Interpretation of ecological patterns and processes.

d. *Prescription.* Recommendations on the requirements to maintain the resource within acceptable limits of change; provision of opinions and consensus statements that bring together the state of knowledge on a particular problem.

e. *Implementation.* Advice in formulating management actions and monitoring parameters.

f. *Monitoring and review*; routine measurements or monitoring to provide a feedback loop for management on the efficacy of management actions and whether management assumptions and objectives are realised or not. Monitoring should be tailored to detect key changes and to test management predictions, within an uncertain environment (Langlois and Ballantine 2005)

High quality science is an important input to the design of MPAs and marine sanctuaries – e.g. for determining optimal locations of marine sanctuaries, to maximise protection of larval sources, spawning sites and key habitats; to help choose the optimum location of networks of MPAs; in the development of models to generate 'candidate sites' for marine sanctuaries. The experience of the recent Great Barrier Reef Marine Park rezoning in 2003 is an excellent illustration of the use of science from the provision of data sets to map key habitats and choose bioregion boundaries, to the use of MARXAN (a decision support tool) for generating candidate sites, and the development of science based policy principles to guide the final decisions about the choice of no-take zones. Equally, high quality social science is needed to understand the perceptions, values and behaviour of people dependent on and affected by policy decisions, including the economic and social effects of protection of marine areas and subsequent displacement of users.

F.2 Factors Affecting the Effectiveness of Marine Sanctuaries

A number of factors are potentially important influences on whether any given marine sanctuary is effective for protecting either a marine community or any particular species within it. Most of the examination of such factors has focused on the effectiveness of marine sanctuaries for protecting exploited species. The size and age of the marine sanctuary, and how these characteristics interact with biological attributes of the species within the sanctuary are the most commonly cited influences on effectiveness, however there are a number of anthropogenic and natural factors that can interact with management practices to determine zoning effectiveness, or **apparent** zoning effectiveness.

Spatial and Temporal Factors

Tasmanian studies have suggested that the size of the marine sanctuary and its age were key factors in explaining whether or not differences existed between fished and unfished populations. Smaller marine sanctuaries showed little or no increase in density or biomass of exploited species and differences in fish assemblages diverged in fished and unfished areas over time (Barrett et al. 2007). These conclusions are consistent with theoretical expectations as well as with recent meta-analyses from the Mediterranean that conclude both reserve size and age are important factors influencing relative differences in abundance and biomass of exploited species. (Claudet et al. 2008). The time taken for “full recovery” of populations in reserves can vary among different systems, however. It is estimated that recovery of large predatory fish may take 3-4 decades in the Philippines (Russ & Alcala 2004, Russ et al. 2005) and probably decades in East Africa (McClanahan 2000). However in New Zealand the biomass of snapper in a no-take zone at the Poor Knights Islands increased 818% in just 3 years (Denny et al. 2004). This trend was due to immigration of adult snapper, rather than being driven by recruitment of juveniles. The recovery process will inevitably take longer for long-lived species dependent on larval recruitment, especially where recruitment is infrequent or highly variable (Barrett et al. 2007).

The effect of size and age of no-take areas on population recovery are due to the influence both these factors can have on the amount of time individuals spend in protected areas safe from fishing mortality. Similarly, the mobility of individuals, which may be a characteristic of particular species, may well determine whether populations respond to the establishment of marine sanctuaries (Gerber et al. 2002). Therefore, the size of reserve that would be adequate to protect a species which had very low mobility would be smaller than that required for a highly mobile species that frequently crossed sanctuary zone boundaries and spent more of its time vulnerable to fishing. It has been advocated that reserve boundaries can be drawn in such a way that mobility across boundaries is minimized, at least for some species, if natural habitat boundaries are considered when drawing up marine sanctuaries. For example reef associated species may be reluctant to cross large areas of sand, a behaviour that could be used to help reduce the vulnerability of protected populations. Such decisions would however reduce any spillover effect that might occur.

Species that are not overfished, or not fished at all, may show no difference between fished and unfished areas. A further factor to consider is the potential for recovering species to interact negatively with other species through competition or predation (Edgar and Barrett 1999, Willis & Anderson 2003). Finally, recovery depends on adherence to or effective enforcement of no-take principals – poaching can greatly compromise the success of MPAs for conservation outcomes (Kritzer 2004, Little et al. 2005). Public perception and understanding of MPAs and marine sanctuaries vary widely. For some people it is sufficient to have a general understanding that an area of sea is protected for future generations; for others it is for the protection of a particular species (usually charismatic megafauna such as whales). For some stakeholder groups marine protected areas (MPAs) and marine sanctuaries are the response to the actual, perceived or expected failure of other natural resource management mechanisms to protect and maintain parts of the marine environment in a state that is regarded as "natural". If the sites are degraded or compromised, then sanctuary zones are seen as a way of allowing the natural restorative processes to rejuvenate the site to a "natural" state. For some people it is important to have protected areas to allow important fish stocks to build up and ensure a future supply of fish and other species for consumption or for recreation. Finally the knowledge that there are places that have an intrinsic value of their own, are free from human exploitation and degradation, and are able to function in "natural" conditions is sufficient reason for their establishment.

MPAs that use a spatial zoning scheme to allocate resource uses and designate no-take areas are essentially static systems that are the 'best fit' for the competing objectives at the time of declaration. Both the ecological systems, and the human systems that the MPA is intended to regulate, are dynamic, variable and unpredictable[1]. The consequences of this are that plans need to be reviewed periodically to determine whether firstly they are achieving the objectives of management and secondly whether the ecological and social assumptions that underpinned the objectives in the plan were correct, or have changed

[1] Note that MPAs are three-dimensional but are typically described as 'areas' i.e. surface features. In fact they not only have length and breadth but also depth and often height above the sea surface.

G. Conclusions

General

1. Marine sanctuaries are an important tool for marine resource management. They should complement existing management tools and be used as part of an integrated approach to marine planning and implementation. The primary purpose for marine sanctuaries is to exclude human extractive and polluting activities. They are useful for other purposes such as tourism and (non-extractive) recreation, research and monitoring, as reference areas for comparison with other areas open to fishing and as refugia for fished or vulnerable species. They are also important psychologically for their intrinsic value and for aesthetic reasons.

2. Marine sanctuaries offer potential benefits for the conservation of biodiversity at all scales i.e. from ecosystem to genotype provided they are established at appropriate spatial and temporal scales and locations. There is a wide range of scientific studies that such closures may have positive effects for conserving marine biodiversity through re-establishing the balance of food webs (trophic structure, increasing the size and abundance of key species, increases in primary predators and reductions in secondary predators; increases in key structuring species e.g. kelp, sponges, corals).

3. Marine sanctuaries are a promising tool for fisheries management but are likely to have few benefits compared with conventional fisheries management tools for highly mobile species with little bycatch and habitat impact. For previously fished species, many cases of positive changes have been recorded within marine sanctuaries – increases in biomass, abundance and size are commonly found after closures of previously fished areas. The rate and nature of the recovery are not simply predictable and depends on many factors (e.g. fishing pressure prior to closure, density-dependent factors and the age, growth and reproductive biology of the species).

4. The scientific evidence for the flow of positive effects from marine sanctuaries on fished species to areas outside sanctuaries (e.g. through spillover, the migration of adults and juveniles from marine sanctuaries to adjacent areas, or recruitment subsidy from marine sanctuaries to adjacent area) is relatively poor and largely restricted to over-exploited tropical reefs.

5. There is some evidence from overseas studies that fishing the margins of marine sanctuaries can result in significantly enhanced catches of larger fish.

6. Marine sanctuaries may also have detrimental effects on fished species through displacement of fishing effort e.g. increases in fishing pressure in areas adjacent to the marine sanctuaries. However the Panel could find little or no empirical evidence for such effects. Furthermore, although other negative socio-economic effects on fisheries, fisheries dependent communities and service industries are well known anecdotally, but the Panel could find little empirical evidence for such effects.

7. Marine sanctuaries of an appropriate size and in appropriate locations can be useful for protecting sedentary organisms and demersal or territorial species, whose life history phases are largely confined to the marine sanctuary. They can also be important for protecting vulnerable life history phases of migratory or wide-ranging species from human influences and activities that may specifically target these vulnerable phases. For these species, marine sanctuaries must be used in combination with other management tools to protect the species

throughout its life cycle, and in areas beyond the immediate jurisdiction of the management agency

8. Because the specific response of marine organisms and communities to any particular marine sanctuary is difficult to predict, it is important to implement scientific programs of study to detect trends in key condition indicators. Many marine sanctuaries have been established without information on their condition, prior to their establishment i.e. establishing baseline conditions. Nevertheless, the lack of baseline measurements should not preclude the establishment of marine sanctuaries and the subsequent monitoring of trends and conditions after closure, provided monitoring is carried out in multiple sanctuaries and adjacent non-sanctuary areas.

9. The establishment of marine sanctuaries alone does not deal with the broader issue of the sustainable use of marine resources outside the marine sanctuary, nor does it deal with the need for integrated planning and management for the use of the marine environment. Marine sanctuaries are therefore not an alternative, but a complement to conventional fisheries management strategies and should be an integral part of regional marine planning strategies.

10. Marine sanctuaries have a potentially vital role to play in providing reference points against which to gauge the success of broader scale marine resource management (Ecologically Sustainable Development, Ecosystem Based Fisheries Management). They may provide insights into potential resource condition levels as well as unique insights into ecosystem function that may not be possible in other areas where important functional groups of organisms may be absent, or present in greatly reduced numbers

11. Strong public support for marine planning and marine sanctuaries, in particular, is essential for effective compliance and enforcement. Strong public support should lead to high voluntary compliance, and allow targeted enforcement against systematic infringement. Evidence suggests that in sanctuaries that allow some form of fishing, effectiveness may be compromised.

12. It is important to ensure that compliance with sanctuary zone prohibitions on fishing or collecting is high so that the results from research and monitoring are not confounded by illegal activities (such as poaching) within the zones.

13. Much of the biological and physical science that has addressed the effects of marine sanctuaries has been carried out in tropical marine and coastal environments in developing countries, except for the sustained research and monitoring of the Great Barrier Reef Marine Park over the past 25 years. Scientific research into the effects of marine sanctuaries in temperate marine environments of relevance to this report has been conducted around New Zealand and in south-eastern waters of Australia. Nevertheless, the results of this scientific effort provide valuable insights into the responses of some marine organisms and communities to closures and exclusion of fishing.

14. In general, the evidence for the effectiveness of specific marine sanctuaries in achieving their objectives is much less clear, because of the historical lack of comprehensive research and monitoring studies to accompany the declaration of the sanctuaries. In more recent years the development of research and monitoring programs as part of the declaration process has improved.

15. If the policy objectives for marine sanctuaries are to be properly evaluated there needs to be clear objectives, baseline studies and well designed, peer-reviewed

programs of scientific research that are sustained for significant periods of time prior to and after the declaration of the sanctuary.

16. Marine sanctuaries are not isolated from the surrounding waters in which they are placed. Bio-physical processes outside sanctuaries, and human activities adjacent to them, can affect the integrity of the sanctuaries. The location, size and duration of marine sanctuaries should follow the principles of Comprehensiveness, Adequacy and Representativeness (CAR) and be embedded in regional marine planning strategies.

17. Marine sanctuaries are predominantly established for biodiversity conservation purposes, but exist in a complex and dynamic socio-political environment. Understanding the social, economic and political dimensions will largely determine the success or not, of conservation strategies. Research into these dimensions is as important as into the bio-physical dimensions.

Western Australia

1. No-take marine nature reserves, sanctuary zones within marine parks, and conservation areas within marine management areas have been established under the CALM Act and are areas that are closed to all extractive activity, including fishing. Some or all forms of full or partial fishing closures have also been established under the FRM Act. These closed areas have different purposes - sanctuary zones within marine parks established under the CALM Act have a primary purpose of protecting and conserving marine biodiversity but provide for other non-extractive uses such as nature-based recreation, tourism, research and education. Permanent closures to fishing and other closures in FHPAs are designed to conserve fish stocks and/or their habitats. At the time of publication, there is approximately 302,564 ha (3,026 km^2) of sanctuary zones or no-take conservation areas in 13 marine parks and reserves established under the CALM Act and 11 FHPAs covering approximately 2,916 km^2 established under the FRM Act. Of these, the Abrolhos FHPA comprises 96% of all FHPAs and has 68 km^2 of its FHPA closed to all forms of fishing, except lobster potting. In addition, there is a marine reserve established by the Rottnest Island Authority that contains 5 sanctuary zones covering approximately 663 ha or 17% of the Rottnest Island marine reserve.

2. The extensive network of marine sanctuaries in WA provides an opportunity for an evaluation of the combined coverage of both sanctuary zones and other areas closed to fishing that have similar effects for biodiversity, within the Interim Marine and Coastal Regionalisation of Australia (IMCRA) bioregional framework. This comparison may allow some evaluation of the representativeness, comprehensiveness and adequacy of protection within the WA marine environment.

3. For effective adaptive management of sanctuary zones, the objectives of the zones must be clearly defined and monitoring programs carefully designed to assess their performance. Adaptive management also requires a commitment to evaluating the results of the program and revising the management arrangements accordingly.

4. There is little overlap between the processes of the Department of Environment and Conservation and the Department of Fisheries in terms of the location of marine sanctuary areas or areas closed to fishing. This appears to continue, despite a growing convergence of management objectives, particularly through

fisheries management requirements for ecologically sustainable development and ecosystem based fisheries management.

5. Scientific studies of marine sanctuaries and other closed areas in WA have been *ad hoc* to date and reliable evidence for their ecological effectiveness is only available from Ningaloo, Abrolhos Islands and Rottnest Island. Research in these areas has shown that sanctuaries are effective for protecting some fished species. Little or no data are available on the socioeconomic implications/impacts of sanctuary areas. However evidence from some sanctuary areas shows that they can be effective for conserving species and ecosystem processes.

6. Baseline data have been collected from other more recently declared protected areas such as the Jurien Bay Marine Park and Ningaloo Marine Park.

7. The Department of Environment and Conservation (DEC) management plans for marine parks include sanctuary zones to provide highly protected representative examples of marine habitat and communities. These plans now have clearly specified objectives and performance indicators (e.g. Ningaloo) which is commendable. However, it is less clear how these objectives will be assessed and evaluated under a framework of adaptive management.

8. There does not seem to be a process through which closures declared under the FRM Act are monitored and evaluated for their effectiveness, nor does there appear to be a review process for these closures.

9. The primary focus for the research and monitoring that is being undertaken for WA marine sanctuaries is bio-physical; research into socio-economic factors will be important for understanding any changes in values, perceptions and attitudes as well the impacts on stakeholder groups, regional economies and social systems.

<u>Ningaloo Marine Park</u>

The following conclusions about the effectiveness of sanctuary zones in Ningaloo Marine Park for species with different life cycle strategies are drawn from Section E:

Sanctuary zones in Ningaloo Marine Park:

- are inadequate to achieve conservation outcomes of major significance for oceanic fish such as the Whale Shark (*Rhincodon typus*);

- may represent <1% of the total range of coastal pelagic fish species such as Spanish Mackerel *(Scomberomorus commerson)*, and would thus provide little in the way of effective protection;

- may provide a high level of potential protection to mobile target fish such as Spangled Emperor (*Lethrinus nebulosus*);

- may provide an extra level of protection for fished species that aggregate to spawn if spawning aggregation sites for those species are included in sanctuary zones;

- appear to offer a reasonable level of protection to Nursery Area species located at the well known nursery areas (Mangrove Bay, Skeleton Bay, Pelican Point);

- are more than adequate to protect local populations of low mobility species e.g. : and
- provide good protection for sessile organisms such as clams and corals from direct harvesting by the current zoning.

Note: A major research program at Ningaloo Marine Park through the Western Australia Marine Sciences Institution in collaboration with CSIRO is expected to conclude in 2010 (www.wamsi.org.au)

H. Policy Recommendations

At the time of submission of this report, it was understood by the Marine Scientific Panel that the basic policy and legislative framework for the establishment of sanctuary zones under the CALM Act, and as set out in the 1998 framework document *"New Horizons: the way ahead in marine conservation management"*, would be likely to be retained.

The following recommendations are made within that context.

We recommend that the following recommendations be incorporated into the policy framework for marine planning:

1. The process of selecting marine sanctuaries or designing networks of sanctuaries should be based on a clear set of agreed design/planning criteria based on both bio-physical and socio-economic principles (e.g. Comprehensiveness, Adequacy and Representativeness). The process should be part of a broader regional planning process and should use all available data; however the lack of data should not prevent the planning process from being concluded.

2. The objectives of marine sanctuaries and closures to fisheries, whether established under marine conservation or fisheries legislation, should be clearly stated to allow their effectiveness within short to medium timeframes to be evaluated (1-5-10-15 years). Wherever possible overlap/commonality in objectives between different jurisdictions should be sought to avoid duplication, redundancy or conflict in management objectives.

3. Baseline conditions for areas proposed as marine sanctuaries and adjacent areas should be established prior to declaration; research and monitoring should commence immediately prior to the point of establishment with the intention of providing reliable evidence on the effects of the sanctuaries i.e. did they achieve the objectives, were the underlying assumptions valid?

4. Robust experimental designs (e.g. Before-After-Control-Impact - BACI) should be used for all research and monitoring of marine sanctuaries.

5. Both bio-physical and socio-economic effects should be monitored for each marine sanctuary.

6. Research priorities and programs should be established as part of the management planning approach for each marine sanctuary. There should be explicit feedback between these programs and broader scale marine resource management.

7. A common approach should be followed for the establishment of marine sanctuaries, regardless of the legislative basis for the establishment i.e.

   (a) they should be set in a regional planning framework;

   (b) there should be a clear primary purpose that can be measured and reported on at periodic intervals; and

   (c) a research and monitoring program should be developed, funded and implemented as part of each marine sanctuary to determine the effectiveness of the sanctuary; reporting should be regular and transparent.

(d) an adaptive management approach should be taken to apply knowledge gained from individual sanctuaries and from the overall network of sanctuary areas to inform decision making at all levels.

(e) an independent expertise based scientific reference group should be established to provide advice on the experimental design and implementation of research and monitoring programs for marine sanctuaries, and to provide peer review of the results of such programs.

(f) adequate resources should be provided to enable effective research and monitoring programs to be implemented and evaluated.

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Appendix 1

Detail in Support of Section D: Scientific Basis for and Role of Marine Sanctuaries in Marine Planning

Two of the main purposes for the establishment of marine sanctuaries are for biodiversity conservation and fisheries management. This section discusses available evidence from global reports for the achievement of these purposes and the effects, costs and benefits of marine sanctuaries. Results from Australia and New Zealand are used where available to give as high a level of regional relevance as possible. The structure and content of this section is based on the recent publication by Edgar et al. (2007).

1. Biodiversity protection

The variety of life on earth or "biodiversity" is a broad term, encompassing organisms at genetic, species and ecosystem levels. In principle, MPAs should protect biodiversity each of these levels and a primary objective of most MPAs declared to date is the conservation of biological diversity. This may be expressed in terms of the protection of threatened species, the preservation of important species, communities or habitats, or the conservation of representative ecosystems or ecological processes. Most marine protected areas in the world are established to conserve species, ecosystems, habitats, bioregions and biodiversity (Roberts et al. 2005). State, Territory and National governments of Australia and New Zealand, for example, have jointly agreed to establish a National Representative System of Marine Protected Areas with the primary goal "To contribute to the long-term ecological viability of marine and estuarine systems, to maintain ecological processes and systems, and to protect Australia's biological diversity at all levels" (ANZECC 1998, 1999). Biodiversity and its protection can be considered at a number of scales: species, ecosystems and genotypes.

a. Conservation of species

For the majority of exploited species, the most obvious conservation benefit of MPAs is the protection of exploited animals, which translates to increased local abundance inside MPAs relative to outside. Even though populations of exploited species can generally continue to persist at low levels even when a fishery is no longer economically viable ("commercial extinction"), the extinction of local populations and even species is possible in circumstances where the target is highly-valuable and lacks a refuge from hunting, as in the case of Steller's sea cow, or where an animal concentrates in a small area to breed. Therefore in extreme circumstances MPAs can play a significant role in conserving species and for this reason, boundaries of MPAs are often delineated to include and protect spawning aggregations of fishes, such as Nassau grouper (Chiappone & Sealey 2000, Sala et al. 2001, Zeller et al. 1999).

A further benefit of marine sanctuaries relates to protection of bycatch, or non-target species caught incidentally during fishing operations. In many cases this incidental catch does not decline as target populations decline, providing the economics of the fishery allow it to remain commercially viable. For example populations of albatross caught incidentally in the tuna longline fishery could be driven to very low levels, even to extinction, providing that the tuna populations remained economically viable (Brothers 1991). Trawl fisheries are also notable for their potential to impact bycatch species.

While catches in the NSW trawl fishery declined by around 70% over a period of 20 yrs, the catch of Sharks and rays, including slow growing species such as the dog shark (*Centrophorus* spp) declined by 99.6% (Graham et al. 2001). Populations of dogshark continue to decline towards extinction because the NSW trawl fishery remains commercially viable for other species.

Species can also be indirectly affected by marine sanctuaries with both positive and negative changes in abundance having been observed. Some algae such as kelp (*Ecklonia*) and other brown algae (*Sargassum* sp) have benefited from marine sanctuaries in NZ because of reductions in sea urchin grazing pressure that came about through increased predation by larger populations of lobsters and snapper (Babcock et al. 1999, Shears and Babcock 2002). However these indirect effects can only come into effect because of declines in abundance of intermediate species, in this case the sea urchin *Evechinus chloroticus*. Increases in lobster density in the Maria Island Marine Reserve in Tasmania, while beneficial to local lobster populations, may have indirectly lead to increased predation on juvenile abalone populations there, and long term reductions in density of abalone in the reserve (Edgar and Barrett 1999). Consequently, the aggregate response of a community to protection in terms of species richness or diversity is not simply predictable, other than the small increases in abundance of exploited species. The unpredictability of the specific nature of indirect effects is one reason why it is important to conduct ongoing monitoring in marine sanctuaries.

b. Conservation of ecosystems

Because of the ubiquity of fishing, which occurs in almost all accessible coastal and pelagic regions of the world's oceans, as well as the increasing intensity of fishing, large fish and invertebrates from high trophic levels ("top of the food chain") are increasingly rare or even functionally absent from many of these habitats. The removal of large predatory species by fishing can in turn cause indirect flow-on effects through the rest of the food web (Pauly et al. 1998, Pauly et al. 2000, Okey et al. 2004). Marine sanctuaries can allow populations of these higher trophic level species to recover, and for food webs and ecosystems in protected regions to develop not only a greater range and more even balance of species, but also to regain missing functionality.

Many types of fishing directly damage or destroy marine habitats with direct effects on the biodiversity of non-target epifaunal and by catch species as well as the species such as prawns and demersal fish that are directly targeted. Clearly marine sanctuaries will do much to protect ecosystems from the effects of trawling and dredging as well as from less intensive activities such as trapping and potting. There is increasing awareness that these activities affect huge areas of the sea floor (Jenkins et al. 2001, Hall-Spencer et al. 2002, Thrush & Dayton 2002). In some cases these activities have targeted biodiversity hot-spots such as in the case of the orange roughy fishery on seamounts around the world, including those off southern Australia. This fishery has significantly affected not only the orange roughy populations but also the delicate coral communities that cover the seamounts (Koslow & Gowlett-Holmes 1998, Koslow et al. 2001). Some of these seamounts are now protected from trawling within the Tasmanian Seamounts MPA.

The effect of fishing on non-targeted species is clearly one of the major mechanisms through which fishing affects marine ecosystems. While some species are unintentionally depleted by fishing, others such as scavengers, can benefit from the supply of dead or injured prey items, leading to increases in undesirable species such as crabs or lizard fish (Wassenberg & Hill 1987, Bradshaw et al. 2002, Catchpole et al. 2006).

By reducing fishing pressure, at least in some areas, marine sanctuaries should allow the full range of species and ecosystem functions to become established, thereby increasing the stability or "resilience" of marine ecosystems. This is important because anthropogenic (and natural) stresses often impact communities in a synergistic manner, such that effects of factors such as increased nutrient or sediment runoff, disease, invasive species, or more recently, the effects of climate change can be exacerbated by fishing. While the resilience concept and the importance of biodiversity in enhancing it has substantial theoretical support (Case 1990, Stachowicz et al. 1999, Stachowicz et al. 2002, Occhipinti-Ambrogi & Savini 2003), there are relatively few empirical examples of this effect in the context of MPAs.

Some convincing examples of increased resilience of ecosystems in marine sanctuaries do exist nevertheless. For instance the incidence of disease epidemics among sea urchins is much higher outside marine reserves in the Channel Islands of southern California than inside the marine sanctuaries (Behrens & Lafferty 2004). Urchin populations in fished areas are very dense and exert heavy grazing pressure on the local kelp forests but when the urchins are affected by epidemics, the kelp recovers until the urchin populations can once more build up. The resulting fluctuations in ecosystem structure and function are far smaller in the marine sanctuaries where predators never allow the urchin populations to build up to a high level. Marine sanctuaries may confer similar levels of resilience in Tasmania where the urchin *Centrostephanus rogersii* is spreading southward from NSW in response to a combination of climate change (Crawford et al. 2000, Ling et al. 2008) and low predator abundance (Buxton et al. 2005, .Pederson and Johnson 2006). The marine reserve at Maria Island has resisted the incursions of the urchin, and has retained a high level of kelp coverage. The dominance of native kelps also helps prevent the establishment of the exotic species *Undaria pinnatifida* which has covered large areas of Tasmania's east coast (Valentine & Johnson 2003, Edgar et al. 2004a).

c. Conservation of genotypes

Fishing exerts a very strong selective pressure on populations. When fishing is intense, those individuals that mature and reproduce earlier or at smaller sizes are advantaged and their genes may become more common in the population. These traits are passed on to their offspring, resulting in populations that diverge more and more from the species' original characteristics. These changes have been measured in fished populations and it has been shown that mean size at maturity can decline significantly in less than four generations (Conover & Munch 2002, Conover et al. 2005). There are significant characteristics that may also change due to such selection e.g. egg production, growth rates and rates of mortality. While some management actions such as maximum and/or minimum size limits for individual species may be put in place to try to counteract these pressures, they may not be effective or practical to apply across the entire spectrum of species affected by fisheries. MPAs may play a significant role in minimizing the effects of fisheries selection by allowing a pool of individuals to survive in environments not subject to this selection. Through larval dispersal these individuals will contribute to maintaining the diversity of the overall gene pool.

d. Costs of no-take marine protected areas for biodiversity conservation

The establishment of marine sanctuaries can have negative and potentially undesirable effects on target species, such as the decline in abalone mentioned above. Other potential risks include the potential for fishing effort displaced from marine sanctuaries to be concentrated in areas outside the reserve, protecting the reserve but resulting in even more intense fishing pressure outside it. This is clearly an undesirable result both from a general resource management perspective and from the conservation perspective since the populations within the reserve are part of the wider ecosystem and ultimately rely on it for their continued existence (Buxton, et al. 2005). Given the cumulative area of reserve networks in most of the world the volume of displaced fishing is likely to be small and spread over quite large areas such that the environmental effects of displaced effort may be limited. There is also the potential for fishing effort to be concentrated in marine sanctuaries before they are formally declared, in a race to extract fish that may later be inaccessible. The effects of this effort may be severe in locations such as spawning aggregation sites.

Marine parks can attract large numbers of visitors, divers, snorkelers and other users, particularly where there are large numbers of fish and invertebrates that are rare elsewhere. If concentrated in particular areas these activities can result in localized damage to benthic organisms, and clearly management has to take into account the potential for damage and take steps to minimize such impacts. The perception that simply because a sanctuary area has been created conservation outcomes will be achieved fails to recognize the difficult and long-term task of implementation through management actions (environmental impact management, resource allocation, education, compliance, enforcement and ongoing monitoring of ecosystem status and human usage patterns).

e. Scientific benefits of marine protected areas

Sanctuary zones have been implemented in many parts of the world, and for many purposes, such as for conservation, tourism, enhanced bioeconomic outcomes and as insurance against management failures. One of the most important potential uses of marine sanctuaries is as a tool for understanding of ecosystem processes and human impacts to underpin better management across all these areas. Scientific studies can be undertaken to observe and study rare species that are not accessible elsewhere, and experiments can be conducted without the confounding effects of human impacts (Buxton et al. 2005). This was in fact the primary purpose for creating reserves under New Zealand's original marine reserve legislation

> "(1) It is hereby declared that the provisions of this Act shall have effect for the purpose of preserving, as marine reserves for the scientific study of marine life, areas of New Zealand that contain underwater scenery, natural features, or marine life, of such distinctive quality, or so typical, or beautiful, or unique, that their continued preservation is in the national interest." (NZ Marine Reserves Act 1971)

Marine sanctuaries can act as reference points against which the status of other areas can be measured. In Australia this is especially critical in the context of the imperative for Ecosystem Based Management, which has the goal of managing for the overall health of the ecosystem rather than a single species or species-by-species approach. As described above, the interactions among components of marine ecosystems are complex and often unpredictable, and it is not a simple matter to predict the response of the system to management actions.

Even more importantly, because of the pervasiveness of fishing in marine environments, it is very difficult to know what an unimpacted or "healthy" ecosystem might look like and how it might function when many of the important components are reduced in abundance or commercially and potentially ecologically "extinct". This is the "sliding-baseline" syndrome whereby small changes accumulate over generations resulting in significant environmental changes. These changes can go unnoticed because each generation starts off from a different, slightly worse concept of the natural state of the environment (Dayton et al. 1998). Marine sanctuaries can short circuit this perception by allowing long absent functional groups to return to higher levels of abundance and achieve their potential roles in the ecosystem. This in turn gives managers the ability to consider alternative management approaches that may previously not have been conceived.

An example of this sort of realization comes from northeastern New Zealand, where until the late 1990s, urchin barrens were thought to be the standard state of the ecosystem in most areas. Instead, marine reserves established there have enabled the discovery of so called "trophic cascades" in which the removal or replacement of predators at the top of the food web alters the abundance of their prey, "cascading" down through the food web. In this case urchin populations exploded as a consequence of fishing on predators such as lobsters and snapper. The urchins overgrazed the kelp forests, leaving bare rock and coralline algae. This in turn has had a number of other consequences throughout the food web (Babcock 2003). The transition of habitats from urchin barrens to kelp forests in marine reserves brought with it the realization that the effects of fishing were far more widespread and potentially significant in terms of the structure and productivity of the system than could possibly have been imagined without the benefit of the insights gained from the marine sanctuaries (Babcock et al, 1999, Salomon et al. in press).

Increasing numbers of rock lobsters and fish predators within the Maria Island MPA have probably caused a general decline in densities of large herbivorous invertebrates. Algal vegetation has not changed significantly following restrictions on fishing; nevertheless, a longer time series of data is necessary to assess whether declining levels of herbivorous invertebrates within the MPA ultimately generates a cascading habitat effect involving plants. Such an interactive effect involving increased lobster and fish predator numbers, decreased urchin and herbivorous invertebrate numbers, and increased macroalgae canopy cover, known as a "trophic cascade" was observed after 20 years protection in the Leigh Marine Reserve, New Zealand (Shears and Babcock 2002, Shears and Babcock 2003).

In this context, it is important to recognise that the study of MPAs not only provides information on how fishing affects the environment, but can also alleviate concerns about fishing where this activity has little effect. Without MPAs as reference areas, the contributing factors can only be speculated on, and fishing blamed in some cases when it is not a major contributing factor, (see below for WA example).

From an ecological perspective, MPAs represent a large-scale manipulative experiment where predation by humans is excluded from particular plots (Walters and Holling 1990).

If appropriately monitored, results can provide profound insights into structural connections within food webs at regional, continental and global scales. These spatial scales differ markedly from those traditionally studied in ecological investigations, such as when plant and animal densities are modified at the scale of metres on patches of shore. Processes operating at small scales often differ from those operating at larger scales (Andrew and Choat 1982, Andrew and MacDiarmid 1991, Babcock, et al. 1999), so conclusions reached cannot be extrapolated to the more interesting larger domains without validation (Eberhardt and Thomas 1991, Menge 1992). MPAs provide prime opportunities to validate experiments at scales relevant to management intervention. In this respect marine sanctuaries can play a vital role in the adaptive management cycle and evidence based management. It would not be going too far to say that without the opportunities for contrasting management manipulations provided by marine reserves it may be impossible to apply genuine adaptive management criteria.

Similarly, without MPAs it is often impossible to accurately measure basic parameters used for modelling stock dynamics of fished species, such as rates of natural mortality, growth rates of large individuals, and size at maturity for unfished stocks (see Fisheries section).

2. Fisheries management

This section considers the role of marine sanctuaries for fisheries management purposes (see Ward et al 2001 for an early summary of concepts, evidence and international experience).

Although the vast majority or MPAs are set up for conservation purposes most discussion about MPAs relates to fisheries issues, even though they are not declared with fisheries enhancement as a primary goal. Nevertheless this paradox is understandable since the main activity that is restricted within MPAs, especially marine sanctuaries, is fishing.

Possibly the world's best-known MPA is Australia's Great Barrier Reef Marine Park (GBRMP) in Queensland (Day et al. 2003). Although it was established in the 1970s with multiple use zoning including numerous marine sanctuaries, the reef was rezoned in 2004 under the Representative Areas Program (RAP). The objective of RAP was to protect representative sections of each of 70 major bioregions in the marine park (Day, et al. 2003). The outcome of the rezoning was that the area of the GBRMP under no-take zoning increased from 4.5% to 33.4%, a total area of 115,000 km^2 and the largest group of fishing closures in the world. While the original marine sanctuaries were mainly located on the reef proper and some distance offshore, the RAP process also created many new marine sanctuaries near the coast and population centres. These closures affected large numbers of recreational fishers. Consequently the RAP process was contentious and much of the debate around its implementation focused on fishing issues rather that biodiversity conservation issues. The potential benefits and costs of marine sanctuaries for fisheries and fisheries management on the GBR and their use as management tools in general, was brought to the fore in the public debate during the rezoning. Interestingly there is strong support in the general population in favour of significant levels (>30%) of no-take protection for iconic marine areas such as the GBR (Hand 2003), while in other places, there can be media bias in favor of presenting views opposing marine protected areas (Compas et al. 2007).

The Effects of Line Fishing experiment (ELF) in the Great Barrier Reef Marine Park anticipated the need to understand the interactions of fisheries management and conservation in the context of multiple-use marine park zoning. ELF was an extensive research program that actually used marine park zoning as a tool to understand more about the dynamics of fish populations and the effects of fishing in a controlled set of manipulations that involved closing some reefs to fishing, while simultaneously opening other reefs to fishing in order to measure rates of population growth as well as rates of depletion, while also comparing individual growth rates, population structures, and reproduction (Mapstone et al. 2004). The program was pioneering in its scope and while it serves as a model of the potential use of no-take areas as experimental fisheries management tools, it has yet to be repeated in Australia or around the world. One of the results of the study was to show that the effects of fishing were probably smaller in magnitude than previously expected, and that the effects were also reversible.

Marine sanctuaries are advocated by many as one solution to help slow or reverse the worldwide decline of marine capture fisheries which are generally considered to be overexploited (Pauly et al. 2002). Most of the opposition to their implementation comes from fishers who feel that their right to fish will be denied and that resources are being locked up by marine sanctuaries. The competing arguments are between the views that (a) managing fishing using traditional means rather than spatial closures would be more successful in protecting stocks and less damaging to the economy of fishery, and (b) that exclusion of fishing from important areas is necessary to ensure sustainability of stocks and ecosystems. However the frequent failure of fisheries management in developed countries and the virtual lack of any fisheries management in many developing nations means that marine sanctuaries continue to be viewed as a viable alternative management strategy. This popularity is boosted by the interest in and legal imperatives to implement more holistic management practices such as Ecosystem Based Management (EBM) or Ecosystem Based Fisheries Management (EBFM), preserving ecosystems on which fishery resources depend. Much of the debate around MPAs and marine sanctuaries acknowledges that MPAs on their own are not the answer to all the problems of overexploitation of marine resources; rather they need to be used as one part of the “tool-box” and combined with other management practices. Understanding the best way to combine the MPAs and other types of management is a task that has occupied the minds of experts in fields of fisheries science, conservation ecology, economics, environmental science, fisheries management, mathematical modelling and social sciences. EBFM is still a concept in the process of implementation and which still requires time and data to demonstrate whether it can achieve both sustainable fisheries and conservation of marine resources.

2.1 Expectations of no-take marine protected areas as fisheries management tools

Russ (2002) identifies seven expectations of the effects of no-take marine reserves on organisms targeted by fisheries, inside and outside reserves.

Table A1.1

Effects Inside Reserves	**Effects Outside Reserves**
1. Lower Fishing Mortality.	6. Net export of adult (post-settlement) fish (the “Spillover” Effect)
2. Higher density.	7. Net export of eggs/larvae (“Recruitment Subsidy”).
3. Higher mean size/age.	
4. Higher biomass.	
5. Higher production of propagules (eggs/larvae) per unit area.	

While good evidence exists to show that marine sanctuaries can achieve their conservation goals, the use of marine sanctuaries for fisheries management remains controversial since in order for them to be useful for fisheries there must be a net export of recruits or adult biomass from the marine sanctuary to the fishery. These processes are difficult to quantify even on small scales, and to show that they take place at relevant levels on the scale of a fishery is a significant logistical and technical challenge.

a. Higher density, average size and biomass

Studies from many parts of Australia, and around the world, have shown increases in density, size and biomass of exploited populations in marine sanctuaries. Inshore reefs on the Great Barrier Reef (GBR) showed 2-4 fold increases in density and biomass of coral trout (the major target species on the GBR) after the implementation of marine sanctuaries (Williamson et al. 2004). Coral trout were also much larger in marine sanctuaries. There is a high level of certainty that these changes were the result of exclusion of fishing through zoning, and not some other random set of factors, because of comparison with data from 1984, before the zoning came into effect. A ten-year study of four marine reserves in Tasmania has shown increases in the density of large fish (Barrett et al. 2008) however these increases were not uniform across all of the marine sanctuaries, and were likely to be influenced by a range of factors (see below). Rock lobster increased 10-fold in the largest reserve at Maria Island (Edgar and Barrett 1999) during this period.

b. Higher propagule production and recruitment subsidy

In order for marine sanctuaries to be net exporters of propagules (eggs and larvae) to other areas, the absolute level of egg production per unit area for populations in marine sanctuaries must be higher than for other populations. Since both size and density of exploited species are known to increase in response to protection from fishing it follows that estimates of egg production from marine sanctuaries should be far higher than for fished areas. Such estimates are relatively rare however. In reserves in northeast New Zealand it has been estimated that on average the egg production per unit area inside marine sanctuaries is 18 times higher than in fished areas (Willis et al. 2003), and for lobsters it is 4.4 times higher (Kelly et al. 2000). In California, a study of rockfish found that egg production was 2-3 times higher in marine sanctuaries than outside (Paddack and Estes 2000). While these differences are substantial, there is a profound gap between differences in egg production and the subsequent settlement of juveniles and recruitment into adult populations. Larval mortality and dispersal may obscure any potential increase in recruitment that may result from increased egg production however and it is far from clear whether increases in egg production in individual reserves make a measurable impact on the wider stock. Recent discoveries relating to the level of self seeding within fish populations suggest that there is the potential for such effects to occur in and around marine sanctuaries.

Evidence for recruitment subsidy (net export of propagules from no-take marine reserves to adjacent areas) is still extremely limited. The main reasons for this are that propagules (eggs, larvae) are extremely difficult to sample, tag and track. Marine ecologists still have very limited knowledge of the "dispersal kernels" (Kinlan and Gaines 2003) of most marine larvae. Furthermore, recruitment of marine organisms is notoriously variable, making both the identification and statistical testing of trends in recruitment difficult. A case in point is the example of the Georges Bank scallop fishery, where the highest ever recorded recruitments were measured after an extensive fishery closure, yet because of high recruitment variability it is not clear whether this was due to chance or some form of recruitment subsidy (Hart and Rago 2006).

c. Spillover

As originally defined, spillover is the movement of individuals from marine sanctuaries to fished areas and is driven by density dependent effects, whereby individuals move outwards to avoid competition or seek more abundant resources. The usage of the term has now broadened to include movements out of sanctuaries that may not necessarily driven by density dependent effects. The export of adult biomass from marine sanctuaries is critical to the argument that marine sanctuaries can sustain fisheries as well as conserve exploited species. Whether spillover occurs, and the level of spillover, will be dependent on the size of the sanctuary zone, the level of recovery, and the mobility of the species in question. Modelling studies have suggested that if spillover does occur, its contribution to the overall fishery will be relatively minor (Russ 2002) and that it will rarely if ever compensate for the loss of fishery catch in the sanctuary zone. A number of studies have however shown that the abundance and/or catch rates of targeted species has increased in areas adjacent to reserves over time (McClanahan & Mangi 2000, Roberts et al. 2001, Russ et al. 2003, Abesamis & Russ 2005), and have suggested that these trends are a product of spillover. However not all of these studies have adequate control areas, leaving the interpretation of trends open to debate. A study utilizing replicated marine sanctuaries in New Zealand showed that while catch rates of lobsters in adjacent areas were no higher than in reference areas, neither was there an adverse effect on overall catch rates in areas with marine sanctuaries (Kelly et al. 2002), demonstrating that the "locking up" of some parts of the coast did not adversely effect the lobster fishery, nor did it "enhance" the fishery. It may not be coincidental that the areas which have reported significant spillover effects are all in very heavily fished developing countries, while the neutral effect was reported from a developed country with reasonably effective fisheries management (NZ). Numerical models predict that spillover effects are much more likely to be found in heavily exploited populations (Pezzy et al. 2000).

d. Insurance against management failure and unpredictable stochastic events

The precautionary use of marine sanctuaries to insure against environmental catastrophes and/or the failure of other fisheries management approaches has been advocated as one of the strongest argument for their implementation in the light of the poor record of fisheries management around the world (Pauly, et al. 2002). In Australia out of 97 Commonwealth managed fisheries, 19 are officially overfished and 27 are not (Larcombe and McLouglin 2007). The status of the remaining stocks is uncertain, which suggests that some additional degree of caution may be needed. Essentially no-take areas provide insurance against the many sources of uncertainty, such as recruitment variability or even recruitment failure that arise when trying to estimate the abundance of fish populations. Notably there are other sources of uncertainty in fisheries management that are managed well by sanctuary zones, such as bycatch, lack of effectiveness of size limits (incidental or accidentally mortality of undersized fish), ineffectiveness of bag limits (size of fishing population outstrips ability of bag limits to control total catch), and ineffectiveness of seasonal closures (temporal displacement of fishing effort and consequent race to fish). All of these sources of uncertainly are currently being faced by fisheries managers in the southwest of WA.

As with many aspects of marine sanctuaries there are different arguments with some groups claiming that the only way to ensure that sufficient spawning stocks remain is to set aside significant areas free from fishing, while others argue that the cost of this type of insurance is too high. While the latter argument seems to prevail currently it must be evaluated in relation to the costs of the potential collapse of a fishery and in terms of short term costs vs. long term gains. Furthermore it should be noted that while there are several documented studies showing either neutral or beneficial effects of closures on fisheries yields, we are not aware of any similar empirical studies documenting negative impacts of marine sanctuaries on fisheries. Therefore the short term costs may in fact be minimal since closures usually represent only a small proportion of the overall area available for fishing.

e. Information on important parameters for stock assessment

A very clear benefit of no-take reserves, protected properly in the long-term, is that they provide sites for scientific study of unexploited populations, communities, and ecosystems. They are some of the few places where scientific studies can be applied directly to make reasonable estimates of such key parameters as natural mortality rates or growth rates (Buxton et al. 2005). They are also places that show us what natural marine communities and ecosystems actually look like, and how they function. No-take reserves can also provide novel means of independently estimating parameters, such as fishing mortality, that are vital for the effective management of fisheries. For example, by comparing seasonal fluctuations in abundance of snapper in reserves and fished areas on coastal reefs it has been estimated that between 70 and 96% of legal-sized snapper are being taken, mostly by recreational fishers (Willis & Millar 2005).

f. Costs of no-take marine protected areas as fisheries management tools

<u>Displaced effort</u>

If large areas of the sea are closed off from fishing and if no steps are taken to reduce the overall fisheries effort, the resulting displacement of effort may result in even higher levels of over-fishing outside marine sanctuaries. The prospects of such effects are real, particularly if fisheries are fully exploited or over exploited. But the measured effects are not as great as would be predicted purely on an areal basis (De La Mare pers. comm.). Modelling studies in Tasmania have suggested that marine sanctuaries will enhance overall stock recovery, and fisheries catches, in some areas, while in others the effects of displaced effort mean that overall recovery will be delayed (Hobday et al. 2005. Buxton et al. 2005).

Many of the large-scale implementations of marine sanctuaries in Australia have involved the reduction of overall effort through “structural adjustment” packages that offered financial support to fishers to leave the fishery. Such readjustments were offered as a consequence of the increased no-take zones in the GBR RAP process and the expected economic effects on the commercial and recreational fishing industries.

<u>“Locked-up” resources</u>

A common argument against the use of marine sanctuaries as fisheries management tools is that that they simply lock up biomass and make it unavailable to the fishery. However this ignores the potential for “spillover” and recruitment subsidy that may compensate for “locked up” resources as well as the insurance policy value of marine sanctuaries against future fisheries management failures.

<u>False sense of security</u>

The term “paper parks” refers to protected areas that may be legally protected but where understanding, public support, compliance and enforcement is low or non-existent. This phenomenon can apply to marine sanctuaries as well as other parks. It is essential that MPAs and marine sanctuaries have strong voluntary public compliance, enforcement of non-compliance and monitoring of effectiveness of management i.e. are the objectives for which the MPA was established being achieved, and what is the status and trends of key indicators in the MPA. It is also important to note that protected areas are sometimes established that allow some forms of fishing while excluding others. Available evidence suggests that these forms of zoning are ineffective for protecting targeted species or biodiversity more generally (Denny and Babcock 2004, Shears et al 2006, Cook 2006). For example, in zones where commercial fishing is excluded, but recreational fishing is allowed, there is frequently no measurable effect of protection.

3. Other Purposes for Marine Sanctuaries

In addition to their value for conserving biodiversity, marine sanctuaries have been seen as valuable tools for research and management and they also have benefits for non-extractive uses such as recreation, education (Taylor and Buckenham 2003) and aesthetics (Edgar et al. 2007, Wood et al. in press). Although it is common to find claims that marine sanctuaries are beneficial for these purposes, quantitative studies of the benefits or costs of marine sanctuaries for such purposes seem to be scant. However there are some studies that support these views. For example, surveys of scuba divers have shown that they are increasingly more willing to accept restrictions if they can expect to see more marine life, for example in a marine reserve (Sorice et al. 2007), and that non-use values were more highly valued by visitors to marine protected areas than

(Togridou et al. 2006). Given the high willingness to pay for non-use values and marine reserves, this means that marine reserves can add significantly to the economy. Even in the case of small single marine reserves, tourism can be important to the local economy. Tourism based on the marine reserve at the Leigh (New Zealand) Marine Reserve alone is estimated to bring 100,000 visitors per year, contributing substantially to the local economy (Cocklin et al. 1998). In large regions such as the Great Barrier Reef Marine Park tourism is the main industry and this means that marine conservation and marine parks can be a key component of the economy. In the GBR, tourism is worth $4 billion per year and is a far larger component (27%) of GVP than fishing (1%) (Hand 2003). It therefore makes economic sense to carefully evaluate the balance between these different uses. In the Great Barrier Reef Marine Park extensive studies have been undertaken around the use of marine sanctuaries for tourism and recreation. Examples of such studies are the economic value of tourism (Productivity Commission 2003), the inclusion of visitor experiences in dwarf minke whale tourism (Birtles et al. 2002) and changing visitor perceptions (Moscardo et al. 2002). Many other examples may be found on the CRC Reef website:

http://www.reef.crc.org.au/publications/techreport/index.html.

Related to these studies are others that address the important issues of socio-economic/cultural aspects of marine planning. Innes et al. (2004) succinctly capture the importance of understanding the human dimension of marine planning – "*the effective design of Marine Protected Areas to protect biodiversity is as dependent upon understanding the biodiversity and associated ecological processes of a region, as it is upon knowing its human dimensions. Achieving a biodiversity protection outcome in the multiple-use Great Barrier Reef Marine Park is a complex social and political issue. Whilst it is critical to know to understand the dynamics of the complex marine system, it is ultimately the social and political dimension that will largely determine the success, or not, of conservation strategies"* (Innes et al. 2004). Techniques such as Social Impact Assessment and TRC-Analysis[3] may also be used to understand the social and economic consequences of planning decisions made for biological conservation reasons (Fenton and Marshall 2001, Sutton 2006).

[3] Town-Resource-Cluster Analysis

Appendix 2. Detail in Support of Section E: Scientific Basis for and Role of Marine Sanctuaries in Marine Planning – Western Australia.

Introduction

This section examines the information available from both a biodiversity conservation perspective and a fisheries management perspective for marine parks and reserves and fisheries closures in WA. Spatial management of marine resources falls under two main jurisdictions within Western Australia; sanctuary zones and Fish Habitat Protection Areas (FHPAs) of various descriptions. The primary purpose of no-take sanctuary zones and other no-take areas established under the CALM Act is for the protection and conservation of marine biodiversity. There is little or no systematic information relating to whether the sanctuary zones (or other protected zones) created by the WA legislation or agencies of various kinds that have the powers to take this action, have had any effect on biodiversity in a broad sense. The data that do exist relate mainly, but not exclusively, to directly exploited taxa. The following discussion summarises the information found to date for various marine protected areas in WA. The purposes for which FHPAs under the Fish Resources Management Act (FRM Act) have been established vary from area to area and range from protecting fauna on wrecks (Swan), to vast areas where trawling is prohibited (Northwest shelf) to small no take areas (Quobba), with a range of commercial, recreational gear and vessel restrictions in between.

The evidence from WA with respect to the effectiveness of sanctuary zones or other no-take areas is consistent with findings in other parts of Australia and the rest of the world. There have been large increases in the abundance of some exploited species reported, as well as some more modest effects. At Rottnest Island, the density of rock lobster has been reported to be more than 30 times higher in the sanctuary zone at Thompson Bay, and significantly greater numbers of targeted fish species, including dhufish, have been recorded (Babcock et al. 2007a, Kleczkowski et al. 2008). At Ningaloo the density and biomass of some key target species has also been shown to be higher in sanctuary zones (Westera et al. 2003). Other smaller sanctuary zones at Rottnest and at Marmion show little or no effect in comparison (Ryan 2008, Babcock et al. 2007b). It is not clear whether this difference is due simply to size, a lack of compliance with regulations, or lack of appropriate habitat. Potentially all three factors may contribute.

Areas closed to fisheries

The FRM Act 1994 requires the Department of Fisheries in WA to "conserve fish and protect their environment" by ensuring that these resources in all WA waters are used sustainably. Note that under the FRM Act, "fish" include all marine species such as bony fish, invertebrates, molluscs, algae and corals but excludes reptiles, amphibians, birds and mammals (Fletcher and Penn, 2005). As discussed in Section C (above), a number of mechanisms can be used to control fishing under the FRM Act including: Fish Habitat Protection Areas, area protection, gear restrictions, effort restrictions, temporal closures, catch limits (Department of Fisheries 2001a, b). The guidelines for the use of FHPAs suggest that these may be established when other regulations are unlikely to achieve the goal of management. Some of our knowledge of FHPAs and other fisheries management measures is discussed below.

a) Fish Habitat Protection areas

FHPAs have been established for a very diverse range of purposes, from total no-take closures (Lancelin Island Lagoon) to habitat protection (Quobba Point), to protection of fossil fish (Cottesloe), to prohibition of certain types of vessels (Kalbarri Blue Holes) (Table 2.1). These areas also vary greatly in size and most have been established relatively recently, except for the Abrolhos Islands, which was established in 1994 and has an area of about 2,400 km^2 (Table 2.1). All other FHPAs are smaller than 115 km^2 in area and most are less than 10 km^2. Fish Habitat Protection Areas which restrict fishing include:

- Abrolhos Islands – recreational and commercial fishing (except rock lobster pot fishing in season) are both excluded in some areas.
- Lancelin Island Lagoon – no recreational or commercial fishing is permitted.
- Cottesloe Reef – commercial fishing and spear fishing are both not permitted (but angling for migratory species is permitted).
- Miaboolya Beach – commercial fishing is not permitted.

With a couple of notable exceptions, there is little known about the effectiveness of these areas for habitat protection or for the protection of the various species whose capture is prohibited within them.

Abrolhos Islands

Some marine and estuarine areas are provided with different levels of protection under the FRM Act through the declaration of FHPAs, areas closed to trawling and those closed to fishing (Fletcher and Head 2006, Figure E1). The most notable FHPA is the State waters of the Houtman Abrolhos Islands, which has four areas designated as Reef Observation Areas, where only lobster fishing (with pots) is allowed. These areas have been in place since 1994 and constitute about 5% of the total area of State territorial waters of the Islands and 17% of the shallow water lagoonal reef habitat (Nardi et al. 2004).

The population densities and body sizes of bald-chin groper, a sub-tropical wrasse (*Choerodon rubescens*) and the coral trout (*Plectropomus leopardus*) were monitored before the implementation of the closed areas (1993 and 1994) and then at four more times between 1995 and 2002 in the Easter and Wallabi group (Nardi et al. 2004). Populations of the wrasse fluctuated and did not differ significantly between open and closed areas. In contrast, after eight years of protection, populations of the Coral Trout were significantly higher in the closed than open areas, with densities between 3x (Easter group) and 17x higher (Wallabi group) in the closed than open areas (Nardi et al. 2004). No significant differences were found for the first three years of protection for Coral Trout.

Baited remote underwater stereo-video cameras were used to investigate the fish assemblages in Reef Observation Areas and open areas and in shallow (8 to 12 m) and deep (22 to 26 m) reef sites in each of three island groups (Watson et al. 2007). The areas of the Reef Observation Areas were 13.72 km^2 in the Pelsaert group, 22.3 km^2 in the Easter group and 27.4 km^2 in the Wallabi group. The numbers of targeted fish species such as Coral Trout, Emperors (*Lethrinus miniatus* and *L. nebulosus)*, Pink Snapper (*Pagrus auratus*) and Dhufish (*Glaucosoma hebraicum*) were higher by 1.1 to 8 times in closed than in fished areas. In contrast, the numbers of many non-targeted fish species (*Coris auricularis*, *Thalassoma lunare, Thalassoma lutescens, Dascyllus trimaculatus)* were higher in the fished areas. However, this was not the case for all non-targeted fish species. These results suggest that the removal of abundant fished species may indirectly impact non-targeted species and alter the trophic structure of fish assemblages.

In an honours thesis at the University of Western Australia, Shedrawi (2007) used diver operated stereo underwater video to investigate fish assemblages inside and outside four Reef Observation Areas of the Abrolhos Islands. The numbers of species, and numbers and biomass of two fished species (bald chin groper and coral trout) were higher inside than outside the closed areas. The numbers of small unfished pomacentrids (*Pomacentrus milleri*) were lower inside the closed than fished areas and were inversely correlated with the numbers of the coral trout. Predation by coral trout on the pomacentrids may explain this result and hence the increased abundance of predators such as coral trout may lead to a change in fish assemblage structure in closed areas. These results and those of Watson et al. (2007), indicate that fishing may affect the assemblage structure of fishes in reef systems and hence may also affect ecosystem processes. Many of the fish that may be indirectly affected are prey and/or competitor species of the fished species. Because there were no historical studies of this nature (i.e. “before” data), we cannot be certain that these differences are not due to some other factor of spatial variation among the sites rather than their level of protection from fishing. Studies on the rates of predation of the prey species are needed to increase the level of confidence around any suggestion of indirect fishing effects (e.g. Shears and Babcock 2002). Other information gaps relate to results for numbers of Coral Trout which have recently been lower (Watson et al. 2007) than those reported in previous studies (Nardi 2004), and anecdotal reports indicate that this drop in relative abundance is due to poaching within the ROAs.

Table 2.1. Summary of the attributes of selected Fish Habitat Protection Areas (FHPA) in Western Australia. Year of establishment is shown in parentheses where known. Data on Area provided by Eve Bunbury, Department of Fisheries, WA

FHPA/Closure (establishment)	Area (km^2)	Commercial fishing	Recreational fishing	Spear fishing	Vessel restrictions	Shell fish collection	Gear restrictions	Special condition
Fish Habitat Protection Areas								
Abrolhos, (Reef Observation Area) (1994)	2,793.8	Crayfish only	No	No	No	No	Lobster potting only	
Cottesloe (2001)	3.58	No	yes	No	No jet skis, No anchoring	No	No nets	No sharks or rays
Cowaramup		No	yes	yes	No	No except abalone, squid, crabs, octopus, rock lobster	No pots	-
Kalbarri Blue Holes	0.5	No	No		No motorised vessels	No		
Lancelin (2001)	0.125	No	No	No	No vessels on beach	No	-	-

Table 2.1 Summary of FHPA attributes continued.

FHPA/Closure (establishment)	Area (km^2)	Commercial fishing	Recreational fishing	Spear fishing	Vessel restrictions	Shell fish collection	Gear restrictions	Special condition
Miaboolya (2004)	114.6	no	no	yes	no	no		Encourage responsible fishing
Point Quobba (2003)	3.58	yes	yes	yes	No jet skis, no anchoring	yes	no	Small no-take area in coral lagoon
South Muiron Island		No	No	No		No		
Swan wreck, (also Sanko Harvest, Gudrun, Kunmunya, Samson II) (1997)		No	No		No anchoring	No		
Watermans Reef Observation Area		No	No		-	No		
Yallingup		No	Yes, finfish only	no	no	No abalone or other shellfish	No lobster pots	

Other FHPAs

Some additional information is also available from the FHPAs at Cottesloe and Watermans (a Reef Observation Area). Intertidal gastropod and echinoderm assemblages, including abalone, were surveyed in these areas between 1983 and 1986, and have recently been re-surveyed using the same methods (Wells et al. 2007). The main species targeted by shore-based harvesters in the Perth metropolitan area is the abalone *Haliotis roei*, which has decreased by approximately 50% at three sites open to seasonal harvesting. Populations in the habitat protection zones have remained more or less at the same levels as those in the early 1980's, although there is some variation among these sites (Wells et al. 2007). At Cottesloe, population densities are almost three times as high in 2007 as in the 1980s, while at Watermans south, where poaching is suspected, the densities have declined. In 2007, Waterman's north population estimates have varied around the same levels as those in the 1980s. The time series of data from the 1980s shows that the abalone populations can fluctuate greatly between years and therefore the single year of observations from 2007 must be interpreted with caution. It would be valuable to continue these surveys of abalone in closed and open areas to determine the current status of their populations with greater confidence.

b) other fisheries closures

Fishery Research Closure Areas at Garden Island and particularly Dongara were used extensively in the past as areas free of disturbance from fishing in which fisheries research could be carried out. Such work led to important advances in the understanding of rock lobster biology and ecology (Joll and Phillips 1984, Howard 1988, Jernakoff et al, 1993). However, it is understood that these zones were allowed to lapse and are again open to all forms of fishing.

In addition to Fish Habitat Protection Areas, extensive areas in the fisheries management "Bioregions" of the West Coast, Gascoyne and North Coast are permanently closed to trawl fishing e.g. north of Kalbarri, areas of Exmouth Gulf and Shark Bay, extensive areas of the North-West Shelf (Fletcher and Penn 2005; Fletcher and Head, 2006), which provides some protection to habitats and species caught in trawls. In fact, only about 15% of the North West Shelf area is open to trawling. The smallest area of permanent closure to fishing is found in the South Coast bioregion.

Shark Bay and Exmouth Gulf

Spatial closures are an important component of fisheries management and are used as an integral part of fisheries management to conserve sensitive stages of the life cycle and sensitive habitats (Fletcher and Penn, 2005; Kangas et al. 2007). Spatial closures may be permanent, vary in time, or vary in both time and space. The spatial closures in the Shark Bay and Exmouth Gulf prawn trawl fisheries (Fletcher and Head, 2006; Kangas et al. 2007) demonstrate some of the measures that can be taken for fisheries management. The following range of spatial management measures are in place in Shark Bay (similar measures are in place in Exmouth Gulf):

- Large areas are permanently closed to trawling
- Fixed seasonal closure of the area to trawling from November to March
- Temporary closures of spawning and recruitment grounds (with the opening of the fishing season determined by monitoring the catch rates and sizes of prawns)
- Time closures to trawling on the full moon and a restriction of trawling to the night.

Kangas et al. (2007) examined the variation in species composition and biodiversity (total numbers, number of species, evenness and Shannon-Weaver diversity) of fish and invertebrates caught in prawn trawls in Shark Bay and Exmouth Gulf in areas with different levels of trawling, including no trawling i.e. permanently closed areas. These analyses were completed at the family level of classification because of the diversity of fish and invertebrate taxa caught in the study. In both systems, the major groupings of sites were based on geographic separation and included samples from both trawled and untrawled grounds in these major groupings (Kangas et al. 2007). For example, in Shark Bay; southern, western and northern groups of sites were identified that included sites in both trawled and untrawled grounds. Differences were found in species richness, evenness and diversity between trawled and untrawled grounds in one area but not the others i.e. the area x trawling interaction was significant. Similar results were found for Exmouth Gulf and Onslow i.e. the composition of fish and invertebrate assemblages and diversity was influenced more by geographic location than level of trawling.

North West Shelf

The North West Shelf covers an area of about 95,000 km^2 of broad shelf under a tropical hydrographic regime (e.g. Fulton et al. 2006). The area from 50 m to 200 m in depth is marked by a sharp break between naturally turbid inshore waters and clearer offshore waters. The seabed is primarily calcareous sands and fine muds with patchy coverage of reef and sponge beds. This region has had a varied history of fishery management because of changes in jurisdiction with the declaration of the 200 nautical mile Exclusive Economic Zone and has gone from including areas classified under international waters to those managed by the Australian government. Since 1998, the trawl and trap fisheries in the region have been managed by Western Australia. The history of commercial fishing operations started with Japanese stern trawlers in the early 1950s and was dominated by foreign fleets in the waters outside 12 nautical miles, until the late 1980s (Table 2.2). An Australian trap fishery was established in 1980 and a trawl fishery in 1987 (Althaus et al. 2006).

Table 2.2. Summary of commercial fishing operations in the North West Shelf (based on information in Althaus et al. 2006).

Commercial fishing operation	**Years of operation**	**Depth of operation**
Japanese stern trawlers	1959 to 1963	30 to 120 m
Taiwanese pair trawlers	1972 to 1989	30 to 120 m
South Korean and Chinese stern trawlers	1979 to 1989	30 to 120 m
Australian trap fishers	1980 –	50 to 80 m
Australian stern trawlers	1987 -	30 to 120 m

Initially, the trawl fishery was based mainly on high-value species of emperors (*Lethrinus spp*, *Lutjanus spp*) that have a strong association with benthic habitat such as sponges and gorgonian corals. During the Taiwanese pair trawling era, total catches increased to a peak of about 40,000 tonnes per year, and the catch rates of emperors declined, while those of lower value species, nemipterids (*Nemipterus spp*) and lizard fish (*Saurida spp*), with no association with structured benthic habitat, increased (Sainsbury, 1988). International fishing was phased out towards the end of the 1980s. Several Australian fisheries were developed in the region following this time, with Western Australian jurisdiction.

An experimental management regime was introduced in the mid-1980s to test the cause of the decline and attempt to recover the habitats and stocks of these species. This included closing very large areas to trawling in the northern areas of the North West Shelf (Sainsbury, 1988). The results from both fishery independent monitoring and catches in the Australian finfish trawl fishery have shown that the emperors and benthic habitats have recovered (Sainsbury et al. 1997).

Large areas of the North West Shelf remain closed to trawling. Since 1998, when the Department of Fisheries WA took over the management of the fishery, a closed area (to both trap and trawl fishing) has been in place in the open fishing grounds to protect the spawning grounds of Rankin Cod (*Epinephelus multinotatus)* and red emperor (*Lutjanus sebae*) (Newman et al. 2003). Pearling is allowed in this closed area. The offshore zone of the Fish Trawl Fishery from 100 to 200 m depth is closed to protect a portion of the spawning stock of gold-band snapper. In addition, no fish trawling or fish trapping is allowed along the inshore region of the coast to prevent conflict with other user groups (Newman et al. 2003).

Newman et al. (2003) reviewed generic no-take (sanctuary) areas in the region and compared their potential effectiveness for conserving and sustaining the stocks of six fished species with different life history characteristics and levels of mobility. The species they examined were: Spanish mackerel (*Scoberomorus commerson* – pelagic species), goldband snapper (*Prestipomoides multidens* – deepwater demersal species), red emperor (*Lutjanus sebae* – offshore demersal species), Rankin cod (*Epinephelus multinotatus* – offshore demersal species), blue-spot emperor (*Lethrinus hutchinsi* – inshore-offshore demersal species) and spangled emperor (*Lethrinus nebulosus* – inshore-offshore demersal species) and comprised about half of the total annual landings of 3,000 tonnes by commercial fleets in 2000. The recreational catch for the Pilbara and West Kimberley regions was about 320 tonnes, mostly from near-shore waters (Newman et al. 2003). Spanish mackerel are caught in line fisheries (trolling), while the other species are caught in the fish trawl and trap fisheries in the region.

All species, except spangled emperor, are distributed widely across the North West Shelf and have dispersed living and spawning habitats (Newman et al. 2003). In contrast, the red emperor is more limited to coral reef habitats such as those associated with the Ningaloo Marine Park. Newman et al. (2003) concluded that at a fisheries level, sanctuary zones are too small (10^1 km) to be effective for managing stocks of the five widely distributed species, relative to TFCs (10^3 km). They concluded that no-take areas may be effective for spangled emperor because for this species the area of sanctuary zones is significant in comparison to the potential habitat spawning areas in the region which are largely restricted to coral reefs.

There are some clear benefits for fisheries management of the existing sanctuary zones or FHPAs in WA. The closure of NW shelf to trawling has allowed the trap fishery for demersal finfish to persist, and also ensures the supply of habitat and shell for pearl oyster. In other areas benefits are currently mainly in the form of research that benefits fisheries through improved understanding of fisheries target species and the habitats that support them. For example acoustic tagging and tracking studies to understand the movement patterns of immature rock lobster has been facilitated by locating the research in no-take areas at Jurien Bay where animals will remain undisturbed (MacArthur et al. in press). Other work using sanctuary zones has provided reassurance to fisheries managers as well as help maintain “green” accreditation for the rock lobster industry by showing that there seems to be no sign of trophic cascades as a result of fishing in WA (Babcock et al. 2007b).

While WA has a wealth of areas declared as sanctuary zones (Table 2.3) or FHPAs, we know little about the effectiveness of most of these zones. For example, the results discussed above for sanctuary zones relate to just 6 of the 45 DEC sanctuary areas. Many of these sanctuary areas are too new to have developed measurable effects; however in many cases baselines are in place to make this possible in the longer term. It is clear however that there is a substantial task ahead of DEC to implement long term monitoring of the conservation estate, if it is to achieve some form of adaptive management for these areas. In the case of FHPAs there is a similar situation, but further complicated by the wide array of objectives for which these areas have been created. Increased uniformity among these areas would greatly simplify the task of assessing their effectiveness, and potentially the level of compliance with FHPA regulations.

Marine Parks and Reserves

Table 2.3 Summary of characteristics of Marine Reserves under the CALM Act

Attribute	Value
Total area of marine parks and reserves under CALM Act	1,480,075 ha
Total CALM Act marine parks and reserves as % of WA waters	11.7%
Total no-take areas (Sanctuary Zones) within marine parks and reserves	302,564 ha
Total no-take areas as % of marine parks and reserves	20%
Total no-take areas as % of WA waters	2.4%

Rottnest Island.

The waters around Rottnest Island are included in a multiple-use marine protected area. Two sanctuary zones were created under the protection of the Rottnest Island Authority (RIA) in 1986, one at Thompson Bay (126 ha) and a much smaller one at Parker Point (5 ha). The Parker Point reserve is notable for the abundant large coral heads that are found in the lagoon there. From the time of their declaration, no studies were conducted formally or published in relation to the effectiveness of these sanctuary zones relative to the relatively unprotected waters surrounding them (commercial fishing and spearfishing are banned in near shore island waters but other forms of recreational fishing are allowed). Several studies on the island's sanctuary zones were conducted starting in 2003, mainly focused around the Thompson Bay reserve and adjacent waters on the eastern end of the island.

Surveys of the western rock lobster populations in the Thompson Bay Marine Reserve found significant differences between the reserve and adjacent fished areas, with 34 times more lobster, more than 300 times greater biomass and 100 times greater egg production in the reserve (Babcock et al. 2007). Fishes were also surveyed and again there were significant differences recorded, with significantly more dhufish and breaksea cod inside the sanctuary than outside (Kleczkowski et al. 2008). Iconic species such as Blue Grouper and Kingfish were rare but were only seen inside the sanctuary. Other species, mainly wrasses likely to be caught as bycatch (but increasingly targeted by a new generation of recreational fishers) showed differences in the size of males or the proportion of males in populations from fished and unfished areas (Kleczklowski et al. 20008). Most wrasses undergo sex changes as they grow, starting out as females and then changing to males. This transition is controlled by social factors such as suppression by other dominant males (Francis 1992).

At the community level of analysis, overall species diversity and biomass of fishes was higher in the reserve (Babcock et al. 2007b), and given the large differences in abundance and size of predators such as lobster and fishes, and the age of the sanctuary, the overall benthic community composition was also examined inside and outside the Thompson Bay sanctuary zone. There were no differences in algal community structure detectable between fished and unfished areas (Babcock et al. 2007b) indicating that trophic cascades similar to those observed in New Zealand and other temperate ecosystems were not occurring at Rottnest. Further studies undertaken subsequent to the original work support the original findings, and suggest that of the three levels of fishing implemented in Rottnest waters (no-take, recreational only, both commercial and recreational fishing) the recreational only areas had the lowest abundances of fish (Cook 2006).

Experimental studies at Thompson Bay showed that there were measurable differences between fished and unfished areas in the predation rates suffered by important grazing sea urchin species. The relative abundance of these species did vary for some groups (*Heliocidaris* urchins and trochid snails) across different levels of fishing pressure, but not for other species (*Centrostephanus* urchins) known to be responsible for the creation of urchin barrens in other parts of Australia. These patterns of density were consistent with the lack of cascading effects to the benthic algal community.

Similar surveys of the small Parker point sanctuary found no significant differences in the abundance of lobsters or exploited fish species (Babcock et al. 2007b). Corals were not specifically surveyed as part of this work; however anecdotal reports (G. Clapin unpublished observations) suggest many of the corals had suffered damage due to trampling during the period following their inclusion in a sanctuary zone. The area is roped off to prevent anchoring and anchor damage but there is no comparative data between sanctuary zones and other regions with which to assess the effectiveness of this measure.

In 2007, the RIA re-zoned the waters around the island creating several new sanctuary zones and expanding existing zones at Parker Point and Thompson Bay. Work to establish baseline data on fish and lobster abundances in these areas is being undertaken by WA Fisheries and CSIRO Marine and Atmospheric Research. No results are available as yet from the fish and lobster surveys but surveys of intertidal abalone populations show that the populations of *Haliotis roei* in Rottnest Island marine reserve waters have been stable since that time.

Studies of Rock lobster populations in the sanctuary zone at Thompson Bay found approximately 100 times greater egg production inside the sanctuary zone than outside it (Babcock et al. 2007a). Clearly there is potential here for significant larval export. However because of the long larval phase of the western rock lobster, high larval mortality and the small size of the sanctuary zone relative to the overall fishery there is likely to be no measurable effect of this. Nevertheless it does suggest that significant increases in egg production can be achieved in marine sanctuaries for this very important fishery species, and that a relatively small area of sanctuary zone protection may be needed to boost overall spawner biomass and egg production. For example, setting aside 1% of the fisheries area as a spawning reserve could double the total egg production of the stock. Effort reductions of more than 1% have been undertaken a number of times over the history of the fishery.

The spatial pattern of lobster distribution around the Thompson Bay sanctuary zone suggests a significant amount of movement across the sanctuary zone boundary by lobsters. Densities are highest in the central area of the reserve and decrease steadily as distance from the centre of the reserve increases (Babcock et al. 2007a). Whether this is a result of “spillover” of lobsters into the adjacent fishery, or the effect of illegal fishing on the population inside the reserve is an unknown. Clearly the rates of movement and the centres of activity are sufficiently low that the lobster population increases within the reserve, yet they are not so low that the area is completely isolated from the surrounding areas and their fishery activity. Some of the lobsters in the sanctuary are quite large, and it has to be assumed that they have lived there for some considerable time.

Aside from the RIA's mandate to protect the biodiversity of Rottnest Island and surrounding waters, it also has the task of preserving the social values of the island, which relate principally to the public's ability to enjoy an unspoilt natural environment. The RIA may well have achieved this to a large extent, however it is not clear how much of a role if any marine sanctuaries may have played in this success in the past, or whether the new zones will change this equation. Some tour groups do however make extensive use of the no-take zone in Thompson Bay, mainly the glass bottom boat tours that run through the summer. Most visitors to the island come for a range of reasons, with fishing usually secondary at best, (Smallwood et al. 2006). This suggests that the potential for negative impact of marine sanctuaries on recreation may be small. Because the new sanctuary zones around the island actually extend to the shore there is a greater potential for them to interact with shore-based activities. In the case of fishing the impacts may be negative, but other activities such as snorkelling may be enhanced.

Marmion Marine Park

Within the multiple use Marmion Marine Park there are four small marine sanctuaries, similar in size to Parker point, with the largest being located around the north lumps. The sanctuary zones differ significantly in their biophysical settings, ranging from semi-exposed outer reefs, to near shore reefs, to coastal limestone fringing reef. Differences in the density of rock lobsters between fished and unfished areas have been described for Marmion Marine Park sanctuary zones (Ryan 2008). Overall, lobsters were around 4 times more abundant in sanctuary zones with legal sized lobsters around 4 times and sublegal sized lobsters 1.5 times more abundant. While the differences between fished and unfished areas were consistent over time for legal sized animals, overall density effects and effects on sublegal sized lobsters varied over time, apparently being influenced by the strength of recruiting year classes. Differences in abundance of both legal sized and sublegal sized lobsters may both be attributable to fishing. Potentially the effect could be attributed directly to sanctuary zone protection or to fishing, but only if a high illegal retention rate of undersized lobsters is occurring. Alternatively there may be behavioural explanations for the build-up of undersize lobsters in the sanctuary zones (e.g. Parsons and Eggleston 2005) relating to disturbance by fishing, lobster mobility and pheromonal aggregation cues emitted by spiny lobsters (Parsons and Eggleston 2005). Therefore it is possible that the density differences are a genuine effect of the sanctuary zones, albeit mediated by behavioural processes, rather than by a reduction in direct fishing mortality.

Among the fish assemblages in the Marmion sanctuary zones, a number of differences are reported relative to fished areas in the Marine Park. Similar to Rottnest Island, the most abundant wrasse species (Western King Wrasse) showed differences in mean size being smaller in fished areas. Fish assemblage structure, as well as invertebrate and algal assemblage structure was found to vary between fished and unfished areas, and several new trophic and behavioural mechanisms have been suggested as potential explanations (Ryan 2008). Apart from *Heliocidaris* urchins, patterns in the abundance of benthic invertebrate and algal communities were not consistent across all sanctuaries and are difficult to explain in terms of any previously described trophic interactions. Without a clear understanding of causal processes underlying these patterns it is difficult to confidently attribute these patterns to zoning effects rather than random variation, especially in the absence of targeted studies conducted before and after the introduction of the zoning (BACI experimental design).

In contrast to most of the sanctuary zones in Marmion and generally in WA, the coastal reef sanctuary zone was surveyed soon after its implementation in 1983-4. The sanctuary was created principally to protect abalone (*Haliotis roei*) which occurs in high abundances on these reefs. Recent surveys in 2007 indicate that abalone populations remain at similar levels on the reef now to those found in the 1980's (Keesing and Wells 2007)

Ningaloo Marine Park

The multiple-use Ningaloo Marine Park came into effect in 1987 with numerous marine sanctuaries as well as a restriction on commercial fishing throughout the park. Within the park therefore, the effects of fishing since that time are assumed to be solely from recreational fishing. In addition to the normal fisheries management restrictions that apply to recreational fishing, there is a ban on spearing of groupers (Serranidae) and tusk fish (Cheilinidae) throughout the park and a total spearfishing ban between Tantabiddi and Winderabandi. Similar to the zoning of Jurien Bay, the marine sanctuaries at Ningaloo included shallow lagoonal areas almost exclusively, though some did extend far enough beyond the reef crest that some protection would be afforded to fish populations on the fore-reef slopes of marine sanctuaries. The Ningaloo Marine Park was re-zoned in 2006 to increase the total protected area to 34% of the overall area. This was mainly achieved by extending the protected zones further offshore to include the fore-reef and deep water areas offshore. Some additional new shallow water sanctuary zones were also created (CALM 2005).

While the principle management focus within the park is the control of fishing, most of the monitoring activity that has been undertaken at Ningaloo since its creation has been in relation to coral cover and factors that have caused it to fluctuate such as anoxic events, bleaching, and coral eating *Drupella* infestations. Two surveys of fish communities stand out as exceptions to this generalization. Firstly a baseline study was carried out prior to the park's creation near what is now the Osprey Sanctuary Zone (Ayling 1987); secondly a study of three sanctuary zones and adjacent reference sites was undertaken in the mid 1990s to test whether significant changes had occurred in the sanctuary zones as a consequence of protection from fishing (Westera, 2003). Westera found significantly more fish from the Emperor family (Lethrinidae) in the sanctuary zones, with approximately 3 times higher densities there on average. Ongoing studies commenced in 2006 immediately prior to the implementation of the new zoning have also found a 2-3 fold difference in the abundance of both spangled emperor (*Lethrinus nebulosus*) and the yellow tailed emperor (*L. atkinsoni*) in the zones established in 1990 (Babcock et al. 2008). A re-survey of the sites censused by Ayling in 1987 suggested that the overall abundance of spangled emperor in 2006 was about one-third what it was in 1987. However, the drop was smaller in the sanctuary zone (46%) than it was in the recreational fishing zone (92%). While this evidence is consistent with the sanctuary zone providing some protection for the spangled emperor population in the face of an overall decline in abundance over the past 20 years, it suffers from a lack of replication in space and time. In other words despite the fact that over 80 sites were sampled on each occasion, there is a possibility that the apparent differences were due to chance and that if either survey had been repeated at a slightly different time or place along the reef, quite different conclusions may have resulted.

An important part of more recent studies at Ningaloo has been to examine whether a reduction of large predatory fish in the region might have had a cascading effect on the reef such that numbers of invertebrates (urchins, *Drupella* snails) and the abundances of coral and algae on the reef were affected. These cascades can increase the vulnerability of reefs to disturbances such as cyclones, coral bleaching sedimentation etc, reducing their "resilience" or the ability to bounce back from or resist degradation or damage. The results of initial studies to assess the indirect effects of varying predator numbers on the reef gave inconsistent results that were consistent with trophic cascades at some areas but not others. There was also no significant trend in the abundance of *Drupella* across the different zones.

Other more recent surveys designed to detect this type of trophic cascade at Ningaloo have concluded that based on differences between fished and unfished zones, no such indirect effects of fishing were present (Webster 2007). Experimental studies there have however demonstrated that, if there were reductions in key grazing species leading to trophic cascades, it would be the grazing fish that would be the most important groups, rather than grazing sea urchins (Webster 2007). Ongoing studies have also concluded that based on relative abundances of invertebrates, algae and corals, there is no evidence of trophic cascades, and that relative grazing rates as well as predation rates are very similar across zones. This offers managers some confidence that resilience in this system has not been significantly eroded, as it has been on the majority of the world's coral reefs.

Jurien Bay Marine Park

The Jurien Bay Marine Park was created as a multiple use marine park under the Department of Environment and Conservation with the zoning implemented in December 2005. The park contains multiple marine sanctuaries plus scientific reference zones which allow commercial and recreational fishing for rock lobster, but in which the taking of finfish is not allowed. Most of these protected zones are within the coastal lagoon area and in depths of less than 10m. There was a vigorous debate around the zoning that resulted in zoning placements which minimised the impact of the zoning on fishing activities. In terms of assessing sanctuary zone effectiveness, the consequences of placing protected zones in areas where there was little fishing in any case have yet to be fully assessed. The consequences for some of the other potential uses of the zones are discussed below, under Fisheries Management.

There have been strong efforts to establish a baseline of data describing the condition of populations of exploited species from within marine sanctuaries, SRZs and from reference areas in fished zones within the park. The Tasmanian Aquaculture and Fisheries Institute (TAFI), supported in part by DEC, have surveyed the park on a roughly biennial basis since 1999, with three surveys having taken place since the park zoning has been in effect (Edgar et al. 2008). Results from this latest survey are not available; however it appears that abundances of baldchin grouper are beginning to be seen. This change is relatively rapid and was not anticipated that significant differences in abundance of fish would have developed over the short period of protection. The TAFI surveys also included measurements of benthic habitat composition (algae and invertebrates), but did not suggest any change in lobster abundance at this point in time.

In addition to the TAFI work, a range of more detailed projects undertaken by CSIRO and Universities under the SRFME[4] program. Much of this work was conducted before the park zoning was enforced and was focused on broad understanding of ecosystem interactions, and will form a valuable long term reference point in the event that zoning may influence overall ecosystem structure and function. There were, however, studies funded by the SRFME collaborative funding arrangements that concentrated on exploited groups, specifically rock lobsters, and finfish, and some components of the

[4] Strategic Research for the Marine Environment; a joint initiative of the WA Government and the Commonwealth Scientific and Industrial Research Organisation.

work did extend into the period immediately after zoning regulations came into effect. In contrast to the TAFI studies, the conclusions from this work in relation to rock lobster and the effectiveness of zoning show that while there were higher densities of legal sized lobster in the marine sanctuaries, this pattern appeared to have been present even before the zones were declared (McArthur et al. 2008). This study was relatively intensive and focused on a handful of reefs in the immediate Jurien area, while the TAFI work has involved sampling throughout the park and consequently sampling any particular area less intensively. The magnitude of the differences observed between the two studies is not great and may be due to a combination of the differing sampling intensities, or site specific effects. This observation reinforces the need for BACI type experimental designs when testing for sanctuary zone effects. Most of the variation in lobster density and population structure was related to habitat factors, an observation also highlighted by studies of the fish populations at Jurien Bay (Fairclough and Potter 2008). No significant trends in the abundance of fish in different management zones have yet been detected in the SRFME collaborative studies (Bivoltsis 2008).

Fisheries related ecological research at Jurien Bay, particularly in relation to marine sanctuaries, has become prominent in the past few years. This is because of the creation of the marine sanctuaries themselves, and because the marine sanctuaries provide opportunities to better understand wider issues surrounding the ecosystem effects of fishing. The incentives driving this need for wider understanding include not only EBFM legislation, but also non-governmental imperatives in the form of the Western Rock Lobster Industry's accreditation by the Marine Stewardship Council (MSC). The MSC has been set up to provide assurance to consumers that a particular product is being harvested in an ecologically sustainable way, presumably resulting in the return of a premium price for the product in the market.

As part of the compromises made between conservation goals (mainly ensuring Representativeness and Adequacy of zones) and fisheries interests (continued access by commercial and recreational fishers) there was an undertaking by the WA government to assess the effects of rock lobster fishing on the Jurien Bay Marine Park. This promise has been partly fulfilled in the form of research undertaken by TAFI and SRFME. However it is incomplete insofar as that research was not specifically designed to measure the affects of the fishery. Another doubt is whether the fishery's effect can in fact be assessed without the inclusion of a full range of habitats, including those that were excluded from marine sanctuaries because there were centres of fishing activity. These areas (reefs in waters greater than 15m depth) are just the places that should be the site of experimental closures to test the ecological effect of the fishery. This issue, which is still unresolved, is central to whether the marine sanctuaries can be effectively used for research underpinning EBFM, and for MSC accreditation.

An alternative approach to understanding the effects of fishing on coastal ecosystems has been implemented at Jurien Bay with the development of an ecosystem model (Ecopath with Ecosim, or EwE) that can be used to simulate the responses of key ecosystem components to different management approaches (FRDC project 2006/038). The model can be used to examine the consequences or effectiveness of both traditional catch/effort reductions as well as the implementation of marine sanctuaries. The integration of this model with newly implemented marine sanctuaries presents a unique opportunity to validate or test the model predictions by comparing its results with trends observed in fished and unfished areas. Preliminary output from the model shows that the system is characterised by a large number of relatively weak ecological linkages, reducing the likelihood that fishing will produce any wholesale changes in ecosystem structure (Lozano et al. 2008). This is broadly consistent with the observation at Rottnest Island that apart from direct effects on target or bycatch species there were no changes to habitat structure such as those seen in other temperate ecosystems in which lobsters are important components (Babcock et al, 1999).

Finally, one sanctuary zone at Jurien has been established as the site of an acoustic receiver array that has been used to track the movements of rock lobster, trevally and snapper. The protected status of the area is important because the equipment and tags are valuable and if tagged individuals are caught or interfered with this can affect the results of the study as well as potentially remove the animal from the study. These studies have provided new insights into the habitat use and behaviour of exploited species. For example it was found that less than half of the white-phase rock lobster that were tagged on this inshore coastal reef site migrated further offshore during the study which was conducted at the time of the whites migration (McArthur et al. in press). This was a very clear result which would potentially have been badly compromised if most of these animals were caught before they left the area. Similarly, many of the trevally tagged during the study were found to remain resident in the area over a period of 12 months (Fairclough and Potter 2008). This outcome was unexpected considering that trevally are a pelagic species that was assumed to roam over wide areas of coastline. In the case of both species, the high levels of site fidelity have important implications for assumptions regarding stock structure, estimates of populations size based on mark-recapture, and for the potential effectiveness of marine sanctuaries as a more direct fisheries tool.

Proposed Ngari Capes Marine Park

The proposed Ngari Capes Marine Park was proposed in 2005 and a draft zoning for the Marine Park released for public comment in 2007. There are a number of sanctuary zones proposed for the marine park.

In 2006, the Departments of Fisheries and Environment and Conservation in Western Australia approached Murdoch University to investigate the biomass of abalone in the Capes region. A study with Professor Neil Loneragan and Drs Alex Hesp and Halina Kobryn was completed in collaboration with the Department of Fisheries (Dr Anthony Hart) and Biospherics (Dr Jeremy Prince) to estimate the biomasses, biologically sustainable catches and current average annual commercial catches of three fished species of abalone, *Haliotis roei* (Roei), *Haliotis laevigata* (Greenlip) and *Haliotis conicopora* (Brownlip) in the proposed sanctuaries of the Capes Marine Park, south-western Australia. The current annual catch estimates represent the catches that would be foregone by commercial fishers if the sanctuaries are implemented and will be used to evaluate the potential compensation to fishers (not part of the study). The biomass and catch estimates for each species in the proposed sanctuaries were estimated from a combination of scientific survey data and commercial catch information (provided by fishers) in the proposed sanctuaries. The data held by the Department of Fisheries are recorded in 10 nautical mile blocks that cross sanctuary zone and open areas so could not be used. No surveys were carried out in the open areas.

Commercial abalone fishers who operate in the Capes area were consulted to identify areas where commercial quantities of abalone were known within the proposed sanctuary zones. Of the 12 proposed sanctuary zones, three were identified as containing commercial stocks of Roei and four sanctuaries were identified with commercial stocks of both Greenlip and Brownlip. Roei, which occur over intertidal and shallow, subtidal reefs, were sampled using 0.5 m^2 quadrats along transect lines set perpendicular to the shore. Greenlip and Brownlip, which are found in deeper waters over reefs, were sampled using 30 m^2 transects at randomly selected sites within the areas identified by commercial fishers. The data from the surveys were used to produce biomass estimates for each species which were subsequently adjusted for the catches reported by fishers from the proposed sanctuaries during the 2006/07 fishing season.

The current annual commercial catch for each species in the sanctuary zones was estimated by applying values of fishing mortality and natural mortality to the estimates of harvest biomass. These values were provided as the basis for discussions of compensation between the fishers and Government.

Some initial conclusions from these studies are that

- Level of protection varies between species
- Effects of closures may not be observed for some time
- Compensation for loss of income will be needed in some cases and this requires defendable estimates of biomass and harvest rates of the fished species when the livelihood is derived from fishing.

Appendix 4. Consultations held in Preparation of Report

The following individuals and organisations were consulted in the preparation of this report:

- Expanded IDC on Management of the State's Marine Protected Areas

  Mr Peter Millington DoF (Chair), Mr Jim Sharp, A/DDG, DEC; Mr Peter Dans, DEC; Mr Ray Bucholz, DPI; Mr Ian Briggs DOIR; Mr Steve Crawford, Tourism; Ms Eve Bunbury DoF and Dr Rick Fletcher DoF.

- State Marine Policy Stakeholder Group – Mr Barry Carbon (Chairman)
- Department of Fisheries – Mr Peter Millington, Dr Rick Fletcher, Ms Eve Bunbury
- Department of Environment and Conservation – Mr Keiran McNamara, Mr Peter Dans, Dr Chris Simpson
- Marine Parks and Reserves Authority

  Mr Eric Streitberg (Chair), Mr Chris Doepel (Deputy Chair), Mr Kim Colero, Mr Angus Horwood, Emeritus Professor John Penrose, Professor Diana Walker and Dr Trevor Ward.

- Recreational Fishing Council of WA – Mr Frank Prokop, Mr Kane Moyle
- West Australian Fishing Industry Council – Mr Guy Leyland, Ms Felicity Horn
- WWF – Mr Paul Gamblin