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The efficacy of sanctuary areas for the management of fish stocks and biodiversity in WA waters

J. W. Penn and W. J. Fletcher

Government of **Western Australia**
Department of **Fisheries**

Fisheries Research Division
Western Australian Fisheries and Marine Research Laboratories
PO Box 20 NORTH BEACH, Western Australia 6920

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Enquiries:

WA Fisheries and Marine Research Laboratories, PO Box 20, North Beach, WA 6920
Tel: +61 8 9203 0111
Email: library@fish.wa.gov.au
Website: www.fish.wa.gov.au
ABN: 55 689 794 771

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J. W. Penn and W. J. Fletcher
Department of Fisheries – Research Division
PO Box 20, North Beach WA 6920

Abstract

Debate concerning the relative benefits of marine protected areas (MPAs) for the management of marine resources can often reflect unrecognized differences in the scope, scale and definitions of the objectives being sought by various Government or community bodies. There can also be different opinions on the level of protection required for an area to be considered an 'MPA' and functional definitions for both the biological diversity and ecosystems within these areas are often lacking. This paper seeks to outline the relative efficiency and effectiveness of MPAs, especially no-take sanctuary areas, compared to other strategies currently employed to help achieve the main objective of the Western Australian (WA) Fish Resources Management Act (FRMA) 1994, which is "to conserve fish* and protect their environment". This objective covers the conservation of most of the marine resources of the WA coast, including fish stock management; habitat protection and biodiversity generally out to the 200 m depth contour.

The review considers the current range of threats to fish stocks and biodiversity in WA continental shelf waters under existing management arrangements and assesses the relative efficiency of the various marine management strategies available to achieve the broad objective of protecting the State's fish stocks and biodiversity. The report highlights that sanctuary areas implemented under Marine Park legislation or fish habitat protection areas under the FRMA, are just one of a large number of possible strategies that can be used to meet the State's management objectives for the marine environment. The report notes that in WA coastal waters there is already more than a forty year history of marine management using targeted large and small-scale spatial closures to various fishing activities to ensure sustainable harvesting of fish stocks and the protection of their environment. Most of WA coastal waters have had significant levels of protection, either by closures or controls on the fishing methods that can directly affect marine habitats, to a degree that elsewhere have been described as being an 'MPA'.

The habitat areas protected include large sections of WA's continental shelf waters where all trawl fishing is prohibited which provides comprehensive protection to all sensitive habitats, eliminating any fishing gear disturbance to approximately 35% of continental shelf waters. In addition, management controls within the other areas effectively restrict trawl fishing to even smaller areas, such that about 90% of the continental shelf habitats are actually protected in practical terms. In addition to these protected habitats, the comprehensive set of species-specific controls on all harvested species are designed to ensure the biomass levels are maintained at appropriate levels and provide further protection at the whole of stock level. Strict limits on the use of fishing gear that can result in by-catch provide similar protection for non-target species

* As defined under the *Fish Resources Management Act 1994*, 'fish' represents all marine species including finfish, crustaceans, molluscs, algae, corals etc (i.e. not just commercially or recreationally important species) but excludes reptiles, birds, amphibians and mammals.

and therefore biodiversity generally. As a result of this comprehensive range of historical controls, marine species, marine habitats and therefore biodiversity in WA are already highly protected from negative fishery impacts compared to nearly all other locations elsewhere in the world. In effect, most of WAs continental shelf waters could already meet the IUCN criteria IV, V, VI to be designated as MPAs in the international context.

In assessing the potential benefits of sanctuaries to add further protection to the State's marine fish stocks and biodiversity, the review illustrates that public support for the use of this strategy for fisheries management purposes could be based on a number of misconceptions about the dynamics of fished stocks and a lack of appreciation of the dispersal and recruitment processes for marine species generally. In terms of benefits, whilst there is no doubt that sanctuaries often result in an increase in the local densities and sizes of some species (i.e. those that are not highly migratory), this does not automatically equate with improved fish production potential at the whole of stock level or even increased biodiversity. In WA there are few species with breeding stock levels that are reduced to a point where the increased egg production generated from a general sanctuary zone is likely to measurably improve their recruitment. Consequently, these areas will probably not improve the quality of fishing within other areas of the WA coast and, if not managed appropriately, the re-direction of fishing effort removed from new sanctuary areas could in some cases reduce the local abundance of species in nearby areas.

Sanctuary areas and the equivalent no-take fish habitat protection areas will, nonetheless, play a valuable part within an overall scheme of marine management where they (1) ensure that particular areas are specifically reserved for non-fishing/eco-tourism purposes ('no-take' uses), preferably developed as part of the overall planning process for a bioregion; (2) protect particularly vulnerable sedentary species; and (3) establish areas of the marine landscape that provide representative locations for research and long-term ecosystem monitoring.

We conclude that there is a rational basis to support the establishment of additional marine sanctuary areas in WA waters where they have clear, measurable objectives and at a scale that relates to achievable benefits for tourism, biodiversity monitoring, research and other 'no-take' outcomes. Given the extensive fisheries management and marine habitat protection systems already operating in WA marine waters (which includes an extensive set of spatial closures and management arrangements), there is no scientific basis within the WA context to support their justification for the purposes of managing harvested fish stocks, where they are merely additional to current management controls. Experiences world wide have shown that the only effective methods for the overall conservation and maintenance of harvested species requires specific, directed and coordinated controls on the overall catch and effort across their entire range. Consequently, sanctuaries, or any fishing closure, should only be established as part of an overall plan for a bioregion that recognizes and compliments other marine management systems already in place that protect biodiversity and associated ecological attributes.

It is hoped that this review will enable stakeholders to better understand the complexities of the management needed to sustain the State's fisheries and biodiversity, and assist in the development of effective policies and strategies relating to fisheries and regional marine planning within WA, including the establishment of any new marine protected areas.

Keywords: marine protected areas, sanctuary zones, no-take areas, spatial closures, fisheries management, stock management, biodiversity, ecosystem based fisheries management.

1.0 Executive summary

There has been an ongoing debate about the relative value of sanctuary areas for the management of fish stocks, and biodiversity more generally. This debate can often be exacerbated by unrecognised differences among stakeholders in the definitions used and the scope and scale of the objectives to be achieved. Conflicts are also likely where there are strong expectations about the relative value of a specific strategy irrespective of the structure of the system to which it could be applied or the levels of management already being employed.

With marine sanctuary areas becoming an increasingly popular management tool, a critical assessment of their relative efficacy in meeting different government and community objectives is urgently required. This may assist in reconciling some of the areas of dispute and will hopefully result in better coordination in management approaches, more effective and efficient protection and broader community acceptance of the outcomes.

In Western Australia, the Department of Fisheries (DoF) is responsible for meeting the objectives of the Fisheries Resources Management Act (FRMA), which includes "*to conserve fish and protect their environment*". In this context "fish" is defined as "*aquatic organisms of any species except amphibians, mammals, birds, and reptiles*", therefore these FRMA objectives cover the conservation of most of the State's marine fauna and flora. More specifically the FRMA provides a basis for the management of all 'fish' species, including protection of their environment, associated food chains, and ensuring that the harvesting of these resources is undertaken in a sustainable manner throughout all waters off WA.

This paper considers the potential threats to the State's fish stocks and biodiversity under the current management controls and outlines the range of strategies available to add further protection. The review then assesses the relative benefits and limitations that 'no take' or sanctuary areas implemented under either Fisheries or Marine Park legislation, may have in assisting meet the state -wide objectives of the FRMA. It is not designed to be an all-inclusive review of MPA related literature (of which there are already many), nor does it cover the role of sanctuaries in meeting smaller scale objectives, such as those associated with individual marine parks; these are covered within the WA Government's *New Horizons Policy*.

The conclusions outlined in this paper have been developed taking into account the following background of management arrangements and related marine research findings in WA.

- The responsibilities and processes of the Department of Fisheries which are designed to provide overall protection for the marine environment and biodiversity for the entire WA coast, including the relevant 'Commonwealth waters' (beyond 12 nmiles out to either the 200 m depth contour or the 200 nmile limit).
- The Department operates using an Ecologically Sustainable Development (ESD) framework that now incorporates an ecosystem-based fisheries management (EBFM) approach. This includes the use of risk assessment processes to manage the impacts on target species, by-catch species, habitats, plus any potential indirect impacts of these removals on the broader ecosystem at both the fishery and bioregional levels.
- The Department's marine management strategies recognise that there is an increasing level of interest for non-extractive uses of the marine environment at specific locations arising from activities such as eco-tourism, which will require appropriately sized and accessible Fish Habitat Protection Areas (FHPA's) or sanctuaries within MPAs

- The Department has a long-standing history and significant expertise using spatial management systems (of which complete closures are just one form) for the management of fisheries resources in WA.
- Most WA waters are already protected by some level of closure or controls on fishing methods that can significantly impact directly on marine habitats (for example trawling). These management arrangements have taken into account the findings from significant research on the environmental effects of prawn and scallop trawling and other demersal fishing methods to ensure that such activities are restricted to benthic habitats where impacts will be minimal or transitory.

In summary this review concludes that:

- Marine habitats, and therefore a large proportion of the biodiversity in WA waters, are highly protected from negative fishery impacts compared to nearly all other locations in the world. Approximately 35% of continental shelf waters already have full habitat protection at levels equivalent to MPAs under IUCN categories IV, V and VI. The effective area of habitat protection generated through direct and indirect controls on trawl fisheries covers about 90% of continental shelf waters.
- There are few fish stocks in WA with reduced spawning biomass levels where general no-take areas would lead to increased recruitment levels of their juveniles. In such circumstances, highly targeted closures (not necessarily to all fishing activities or for the entire year) in conjunction with other broad scale actions have proven to be effective management options.
- Most of the marine species subject to fishing (including those with benthic stages) in WA are highly mobile either as adults, juveniles or both; which greatly reduces the efficacy of small, static, non-targeted spatial controls for their management at a stock level.
- The implementation of sanctuaries alone, will generally not improve the quality of fishing in the areas left open along the WA coast, as the re-direction of effort from a newly established sanctuary area is likely to result in a reduction in local catch rates within the surrounding regions.
- In contrast to agricultural production on land, ongoing commercial and recreational fisheries production within the WA marine environment is totally reliant on the natural ecosystem continuing to function in relatively normal manner.
- The main marine habitats in WA at risk are the estuaries and embayments where land-based, non-fishing activities have resulted in nutrient rich run-off and eutrophication, which has significantly altered ecosystems (e.g. the Peel–Harvey Estuary). In these situations closures would neither rebuild affected fish stocks nor assist with the protection of the broader ecosystem.

Based on these assessments this report supports the concept that clearly defined sanctuary areas (within marine parks or FHPAs) will play a valuable, but restricted part of an overall scheme of management to sustain resources and protect biodiversity in WA waters. This is consistent with another recent review, which concluded that "*MPAs must be designed and operated in the context of higher-order management frameworks"* (World Bank, 2006)",

Consequently, there is a rational basis to support the establishment of marine sanctuary areas where they have clear, measurable objectives that relate to achievable benefits for tourism, biodiversity, research and other 'no-take' outcomes. There is, however, little scientific basis within the WA context to support their justification where they are proposed as a precaution against undefined 'bad practices' in the management of fisheries.

Where a sanctuary zoning is being considered for a specific area, the planning process would be made more efficient by:

- ensuring there are clear, simple and measurable biodiversity, research, ecotourism or fisheries management objectives, which are meaningful to the key stakeholder groups and the general public, and that the area being set aside is of a scale relevant to its purpose;
- ensuring that the site proposed takes into account and complements any existing fisheries or other management arrangements that could assist with protection of biodiversity.
- having a clearly specified and fully costed research and monitoring program directly linked to the biological and socio-economic (tourism) objectives set, with appropriate performance indicators and a transparent reporting system.
- specifying periodic reviews that could include the provision of sunset clauses if any area is found not to be assisting in meeting the agreed objectives.

In regard to the use of sanctuaries or other types of complete no-take areas to meet the objectives of the FRMA, it is our assessment that:

- The static and non species specific nature of sanctuaries as a management tool will preclude their use as an efficient strategy to deal with the stock-level management of the majority of fished stocks in WA, which are typically free ranging and broadly distributed. The high level of overlap in the footprints of these species also conflicts with the complete 'no take' nature of sanctuaries and further limits their effective application for sustainable management of harvested species in WA waters.
- Sanctuaries (or equivalent FHPs) of appropriate scale will be valuable where their primary purposes relate to the preservation of representative examples of biodiversity; the provision of areas for various no-take uses (ecotourism), and/or as sites for long-term scientific monitoring.
- Declaration of a sanctuary will automatically raise resource use and allocation issues, with direct implications for the right of access (especially in near-shore areas) and possible compensation or litigation issues. This will be a particular issue for sedentary species such as abalone, where any such closures over productive abalone reef habitats directly reduces otherwise sustainable catches and is a clear reallocation from fishing to 'no take' use. It may be less of an issue for highly mobile fish species, except where the proposed sanctuary is to be situated over the only accessible fishing area (i.e. next to the only boat ramp or overlying the only safely fishable reefs within the region)*.
- The effective management of MPAs, which overlay the wider geographic fisheries regulations, will generally raise significant and ongoing compliance and education requirements, which will need to be adequately resourced. Multiple-use MPAs, incorporating significant sanctuary areas, are likely to exacerbate costs, resource use and allocation issues and therefore, should require a comprehensive cost benefit assessment during the design phase.
- A key issue for the evaluation of the efficacy of a sanctuary will be the dynamic nature of marine ecosystems and the ability to distinguish changes caused by human impacts (or management) from natural changes driven by environmental factors outside human control.
- Long-term monitoring programs, including time-series data for harvested fish species (and presumably other components) will be required to assess impacts from the establishment of the sanctuaries and whether they have met the expected objectives. This will require new

* There is a tendency for some planning schemes to impose sanctuaries over the most highly used areas rather than low use regions. This trend has been described as like trying to turn the main street of a capital city back into a National Park (see also Halse, 2003).

monitoring programs to be initiated, which will have to collect data at much finer spatial scales than has been previously undertaken for stock-wide assessments. Such programs must be adequately resourced so as not to compromise the current monitoring systems that are needed for stock-wide assessments.

- Thus the development and implementation of any additional sanctuary areas will automatically generate additional costs to Government associated with their declaration, management, monitoring and compliance. All of which would need to be justified related to the projected benefits.
- The establishment of an across-Government-agency process (covering both State and Commonwealth) for broad-scale marine planning, which integrates relevant policy and legislation, would greatly assist in achieving the best marine management outcomes for the WA community. It is further suggested that the planning process for future MPAs and sanctuaries within the marine waters of WA, would be more efficient and outcomes better if it were to follow the IUCN suggestion to recognise and build on the level of existing protection for marine biodiversity, such as those provided by the FRMA.

Whilst simplistic solutions (e.g. all fisheries need sanctuary zones) and generic rules ('x'% of the coastline always needs to be closed to fishing) are often proposed, these are rarely found to be optimal or appropriate when dealing with the management of complex natural systems. Experiences in WA, and elsewhere, have shown that the only effective methods for the overall conservation and maintenance of harvested species (i.e. not their local densities) requires specific, directed and coordinated controls on the overall catch and effort across their entire range. While these controls often involve stock-specific spatial &/or temporal closure systems, complete closures or sanctuaries will generally make only a minor contribution to the management required.

2.0 Introduction

There is considerable debate worldwide about the relative value of marine protected areas and particularly marine reserves (or 'no-take' sanctuary areas) for use in the management of fish stocks and biodiversity (e.g. Hilborn et al., 2004). Some groups state they are an essential part of any fishery management plan (e.g. WWF, 2004) whilst others suggest that they are not necessary to enable sustainable fisheries management (e.g. Murawski, 2007). Given the range of definitions of what constitutes a fish stock and what is meant by biodiversity, it is apparent that many disagreements have been generated by inconsistencies in terminology used, spatial scales examined and differing (often unmeasurable or undefined) objectives of the stakeholders involved.

Debates are also likely whenever there is an expectation or a doctrine that a single strategy must be applied irrespective of the type of impact or threat to be managed. The efficacy, costs and benefits of any marine management tool (of which protected areas are but one of many) will almost certainly vary depending upon the situation to which it will be applied and the objectives to be achieved. This is particularly noticeable for the management of marine systems where direct observation is difficult and the environment has an inherently high level of variability. Furthermore, the breadth of stakeholder interests and expectations being managed means that any one management strategy is unlikely to always produce the most appropriate or optimal outcomes.

There is also a high level of ambiguity about what constitutes a marine protected area. In their review paper, Ward et al. (2001) stated that MPAs may take many forms, and confer different levels of protection for biodiversity, depending on the uses permitted and the type and extent of management applied. For example the spatial closures referred to as MPAs in many published studies (e.g. Gell & Roberts, 2003) are actually specific fishery closures - i.e. they were not closed to all fishing activities, and were implemented to assist the management of a specific stock. In this context, the numerous spatial and temporal closures already implemented under fisheries legislation in Western Australia would be considered 'MPAs' under the IUCN guidelines*. Using this broader definition, a high proportion of the WA coastal shelf waters (even more for sensitive inshore habitats) would be classed as already being 'protected' by MPAs.

It is evident, however, that from the Australian public's perspective, the term MPA is assumed to refer only to fully 'no-take' sanctuary areas (i.e. not even an entire marine park), where no extractive activities are permitted (i.e. equivalent to many terrestrial national parks). These are generally the most contentious form of MPA, but are the only category that many Australian conservation lobby groups consider to be 'worthwhile' (Fletcher, 2003). Whilst often small in area they can, nonetheless, generate significant social or economic benefits &/or controversy especially where this results in the displacement of historical activities, for example sustainable fishing activities.

The establishment of sanctuary areas will continue to be an important and integral part of the overall regional marine planning process for the WA coast both through the marine park processes. These are administered in WA state waters by the Department of Environment and Conservation (DEC) and, in Commonwealth waters, by the federal Department of Environment, Water, Heritage and the Arts (DEWHA) and within Fish Habitat Protection Areas by the Department of Fisheries (DoF). For this reason there is a strong need to analyse their relative efficacy in meeting the different objectives for each of the agencies involved in the

* That is they largely conform to the IUCN definition [and meet MPA criteria IV, V, VI Kelleher, 1999] as they are designed to assist the protection of biodiversity and natural resources and are managed through a legal instrument.

management of the marine environment. This process needs to clearly outline the scale, scope and definitions of the objectives being pursued and under what circumstances sanctuaries are likely to be the most appropriate strategy* to achieve the desired outcomes.

The assessment undertaken here has been designed to assist in clarifying some of the areas of potential stakeholder dispute. It is hoped that this will result in more efficient marine management processes and wider community acceptance of the outcomes. Secondly, because there is a significant potential for sanctuary zones to redistribute fishing effort and therefore affect the wider outcomes of fisheries management arrangements, this review will focus on the efficacy of marine park sanctuary areas and no-take FHPAs in meeting the overall objectives of the *Fisheries Resources Management Act, 1994* (FRMA) within WA continental shelf waters. Such an analysis can then be used to assist in the development of policies and strategies relating to regional marine planning within WA, including the establishment of any new marine protected areas.

* Sanctuaries are a management strategy used to achieve an outcome; they should never be promoted as the management objective.

3.0 Background

During the last two decades there has been a significant shift in opinion about the management of natural resources across the western world towards the concept known in Australia as 'ecologically sustainable development' (ESD; CoA, 1992). This concept, which includes 'whole of ecosystem' and 'bioregional approaches' to marine resource management, is now considered to be the appropriate mechanism to deal with the environmental and ecological impacts on marine ecosystems that flow from growing human population pressure and society's expectations. In Australia, where the majority of the population lives along the coastline, the increasing pressure on the marine environment is contributing to the need for better planning for its protection to ensure that it remains in an acceptable state for future generations.

As Western Australia is one of Australia's fastest growing States, with nearly all population growth focused on the coastal fringe, this increase is likely to put greater pressure on our marine environment and fish resources over coming decades. Consequently, it is imperative that we implement the management strategies that will be the most efficient and effective given the scale of the coastline and the dynamics of the fish stocks, if we are to ensure their long-term sustainability.

The FRMA requires the Department of Fisheries to "*conserve fish*[*] *and protect their environment*" (including associated food chains and biodiversity) by ensuring that the use of these resources in all WA waters is undertaken in a sustainable manner. To assist in the achievement of these broad marine sustainability goals, the Department has developed an ESD policy for managing fisheries and aquaculture in WA (Fletcher, 2002). This policy, which is based upon the National ESD framework (Fletcher et al., 2002; 2005), incorporates the principles of ecosystem based fisheries management (EBFM), which not only covers impacts on target species, but also any impacts on by-catch species and habitats, plus potential indirect impacts of these removals on the broader ecosystem (Fletcher, 2006). This broader ESD focus implies that biodiversity must also be maintained because it underpins the productivity of all fished stocks. The work of the Department in this area was acknowledged in the Western Australian State Sustainability Strategy (Government of Western Australia, 2003), where it stated that:

Fisheries management and sustainability is one of the good news stories in Western Australia. This is due to the powerful regulatory system and technology and resources for monitoring and reporting. The Western Australian Government has adopted a policy on ecologically sustainable development of fisheries that is a world first.

In putting these ESD policies into action, a number of associated initiatives are being implemented by DoF to manage the increasing human pressures on the general marine environment. These include Integrated Fisheries Management (IFM), which will limit overall harvest of target species to sustainable levels by establishing specific levels of access to these fish resources by the various catching sectors (see DoF, 2006 for details). These allocation processes will include the major commercial fisheries along with the minor commercial, recreational, and indigenous sectors and, whilst not part of the formal IFM process, also acknowledge that no-take users may require their own allocation (Fletcher and Curnow, 2002). More recently through the WA Marine Science Institution (WAMSI) initiative, DoF is actively pursuing a regional level, ecosystem-based approach to fisheries management by undertaking assessments to ensure that the cumulative impacts of all fishing activities in each of the States four major marine bioregions are not causing unacceptable impacts on the relevant ecosystems (Fletcher et al., 2007).

* As defined under the *Fish Resources Management Act 1994*, 'fish' in this paper represents all marine species including finfish, crustaceans, molluscs, algae, corals etc (i.e. not just commercially or recreationally important species) but excludes reptiles, birds, amphibians and mammals.

It is recognised that a number of other sectors utilise or impact upon the marine environment but whose activities are not covered by the FRMA (e.g. shipping, coastal development, mining, agriculture). This may be addressed through the WA Government's initiative to develop a marine planning framework to coordinate the activities and management arrangements for all sectors and agencies that use, impact or have an influence on the marine environment (DPC, 2004). Thus, there is growing recognition that the effective management of the marine environment must be hierarchical in nature with different strategies being undertaken by agencies needing to clearly link together (Fletcher, 2006, 2009 – Figure 1).

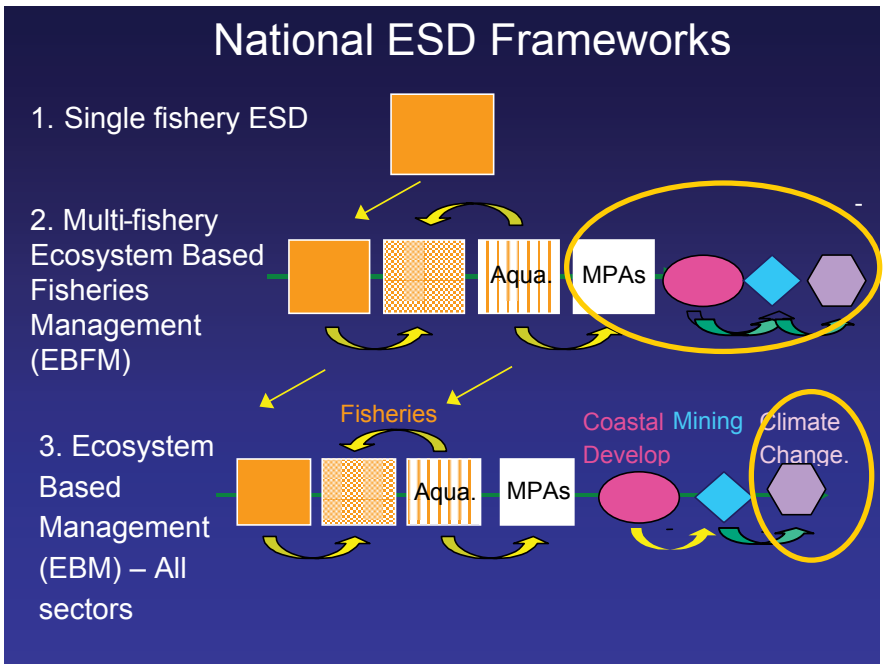

Figure 1. Relationship between the three ESD framework levels. The elements included in the gold ovals represent the difference in external drivers between EBFM compared to EBM – modified from Fletcher (2006).

One of the key WA Government initiatives within the marine environment not directly covered by the FRMA, but overlapping the FRMA legislative framework is the establishment of a series of marine protected areas (MPAs) as envisaged under the National Representative System of marine protected areas (ANZECC, 1998). The creation of MPAs, specifically to provide representative areas for biodiversity, has become an increasingly popular policy direction for both Commonwealth and State agencies with a role in the conservation of the marine environment. Within WA, the *New Horizons in Marine Management* policy (Govt of WA 1994, 1998) articulates the WA Governments' objectives for the creation of a number of different categories of MPAs, which typically include some sanctuary or 'no take' zones. These zones are in effect the only aspects of marine reserves under the CALM Act, which can significantly control fishing impacts. Because establishing no-take areas usually results in a reallocation of access to fisheries resources, if these processes are coordinated they could also assist meet the objectives of the FRMA that relate to both IFM* and EBFM† (see Figure 1).

* There is already a process through the Fishing and Related Industries Compensation (Marine Reserves) Act 1997 to cover potential compensation for the establishment of MPAs.

† Fletcher, W. J. (2006) Frameworks for managing marine resources in Australia through ecosystem approaches: do they fit together and can they be useful? Bulletin of Marine Science 78:691-704.

There are increasingly strong expectations from environmental lobby groups throughout Australia, and the world, that MPAs (especially 'no-take' sanctuaries) should be established for the protection of marine ecosystems, primarily from the impacts of fishing. The expectation that these no-take sanctuaries must also be present for good fisheries management (eg WWF, 2002) is, however, largely based on the international perception that traditional fisheries management measures do not (and cannot) work (Fletcher, 2003). The overall healthy status of fish stocks in WA (e.g. Department of Fisheries, 2009), however, indicates that conventional fisheries management regimes are, when applied effectively, capable of adequately protecting these resources and their environments at a state-wide level. This situation in WA is in clear contrast to other regions of the world, such as the North Atlantic and many parts of Asia's coastal areas, where fish stocks and marine habitats have been heavily impacted by large, uncontrolled multinational fleets, or where management and other governance arrangements are largely ineffective. Whilst there is little doubt that sanctuary zones can result in increased local densities and older/age structures (larger sizes) of some relatively sedentary species, there is minimal empirical evidence of their ability to increase abundance at the whole of stock level (Ward et al., 2001; Schipp, 2003; Hilborn et al., 2004; World Bank, 2006). This is, however, the scale at which the fish populations (and most ecosystems) exist and hence the scale at which to assess the overall success of fish stock management. Consequently, to meet the challenge of managing the marine resources across the entire WA coast, the Department of Fisheries currently employs a wide variety of spatial and other management tools.

This paper seeks to clarify the relative efficacy of sanctuary areas, compared to other procedures used in fisheries and marine resource management for achieving the overall sustainability of the living aquatic resources of the entire WA coast (i.e. out to the 200 nautical mile limit). The difference in scope between these state-wide FRMA objectives and the smaller scale MPA objectives under the CALM Act are, however, likely to significantly affect any assessment of the relative efficacy of any management tool, including sanctuary zones. Consequently, we do not attempt to cover the potential role of sanctuaries in meeting specific local objectives of any individual marine park; these are already covered within the WA Government's *New Horizons Policy*. Similarly, we have not provided a detailed assessment of the potential social, economic and governance benefits that sanctuary areas can generate, which, in many cases, are expected to be significant (Fletcher, 2003).

This examination of the relative efficacy of the various management tools used to maintain fish stocks/biodiversity within WA waters has been undertaken against the current threats to the WA marine environment and the level of spatial and other management controls already operating. As such, we did not include an exhaustive review of all MPA related material; there are already numerous examples of this genre (e.g. Ward et al., 2001; Russ, 2002; Willis et al., 2003). Moreover, many of the conclusions drawn for WA waters will not be directly applicable in many other jurisdictions where very different (usually substantially lower) levels of management/controls on fishing activity are currently being applied. This approach has been adopted to avoid the tendency to over-generalise the effects of sanctuaries, which is a common (but unfortunate) feature of articles on this topic.

4.0 Threats to marine biodiversity relevant to WA

4.1 Definitions of biodiversity and ecosystems

Before assessing the need to manage impacts on biodiversity and ecosystems, there needs to be a clear definition of what may be threatened. The term 'biodiversity' is widely used, including within legislation, government policies, scientific reports, popular press articles and also in general conversation. Despite this, and the existence of an agreed government definition of biodiversity in Australia*, there is clearly a level of disparity in how, in practice, this term is interpreted and what it represents to different groups. Similarly, the term ecosystem is widely used but rarely defined in a functional sense.

The official definition of marine biological diversity refers to 'the variety of living organisms in the estuaries and oceans, their genes and the ecosystems of which they form a part'. Thus, there are three levels of diversity - genetic, species and ecosystem diversity. Effectively, this means that the agencies responsible for meeting this objective should be operating to maintain all types of ecosystems, all species, and for each species, their overall genetic diversity. If this definition is used in conjunction with an equally functional definition of an ecosystem†, each level of diversity in the marine environment will generally operate at relatively large spatial scales that may extend over one or more bioregions or at least zones within a bioregion. This is a function of the relatively large areas that most marine species occupy and the generally high levels of mobility they exhibit at one or more of their life history phases. The clear exceptions to this general pattern are the rare marine species or populations that have highly restricted distributions and limited mobility through all stages of their life history (e.g. sedentary molluscs which produce live young).

Given the above definition of biodiversity, merely increasing the numbers, or having larger sized individuals of a species within an area, does not represent increased species biodiversity. Similarly, a minor change in the relative abundances of different species within a region also does not automatically represent a change in the biodiversity of the ecosystem‡. Consequently, achieving adequate biodiversity outcomes does not generally require the establishment or maintenance of 'pristine' areas. The expectation that pristine areas are needed to maintain biodiversity may be more related to a desire to protect social, heritage or research values§ typically associated with terrestrial wilderness areas. These may be important objectives to achieve, but they are not strictly biodiversity outcomes in a marine context.

For the general public, the term biodiversity is often interpreted as referring to the elements of the marine environment that are particularly visually attractive, or have some special cultural significance. For example, a coral reef with a multitude of highly visible fish and sessile invertebrates would generally be considered by the public as being more 'diverse' than a nearby sandy substrate where fish are rarely seen and the invertebrates are mostly in-faunal, yet the overall species diversity may be similar. The general public is, understandably, often

* National Strategy for the conservation of Australia's Biological Diversity, 1996.

† A functional definition of an ecosystem is equivalent in concept to a population - which is a of collection of individuals that together are self maintaining – thus a single patch of reef is not a functional ecosystem, whereas a collection of similar reefs across a bioregion may be.

‡ An identifiable change to an ecosystem must, by definition, produce a major change to some – presumably many - of the component species - otherwise the description of the ecosystem was probably not appropriate.

§ Society currently puts an overall value on areas/things considered to be of high heritage importance that may be beyond their direct ecological value, the extent to which this remains can change in either direction.

more interested in the variety of species that they can easily observe or 'visual diversity', rather than strict 'biodiversity' and this is the basis of most sanctuary based eco-tourism ventures. This inclination may be reflected by the acceptance of fish feeding stations in some (but not all) MPAs, which are designed to attract numerous large and/or attractive fish. These stations artificially increase the visibility of the elements of the ecosystem that are popular with tourists, yet in a strict ecological sense such activities may be impacting the local ecosystem to the same extent (but in a different way) as would extractions – both 'artificially' affect the local densities and size structures of the fish. However, in both cases biodiversity may not be affected.

For this review paper we have used the national definition of biodiversity as outlined above.

4.2 Threats to marine biodiversity

A suite of human-induced and natural phenomena has the potential to threaten marine species and biodiversity. Of these threats the direct effects of fishing are those most commonly associated with significant changes in marine ecosystems and are the focus of the most common controls under Western Australian fisheries legislation. These threats, their relevance and management responses in WA are summarised as follows:

Highly destructive fishing methods – inappropriate fishing methods such as dynamite fishing, reef blasting and the use of fish poisons (cyanide), as utilised in some developing countries, have contributed to broad-scale marine habitat destruction/ loss of marine communities and pose a significant threat to biodiversity in SE Asia. Since none of these methods are permitted (or occur) in WA waters there is essentially no threat to biodiversity from these activities.

Fine mesh gill netting/ Drift netting – These fishing methods can result in indiscriminate removal of a wide range of fin fish species and impact other protected fauna e.g. turtles. Fine mesh gill nets can have a significant impact on coral reef ecosystems, similar to explosives, through the removal of many herbivorous fish species which are not able to be caught by conventional line fishing methods. Where the abundance of the algae eating fish species in coral reef areas has been significantly reduced, as seen in the Caribbean, the impact has been to allow the normally low level of algal cover to expand dramatically and smother the slower growing corals (Bellwood et al 2004) with catastrophic effects.

Because the use of gill nets is strictly controlled under the FRMA, fishing impacts on these often, small algae eating species cannot occur in WA waters. These specific controls and the general limits on all fishing methods have historically provided a high level of protection for the States sensitive coral reef systems. Similarly, the use of drift nets has never been permitted under the FRMA, ensuring that the negative impact of this method has not occurred in WA waters.

Demersal fishing activities – fish trawling and prawn/scallop trawling and potting/trapping have the potential to impact on the sea floor benthic habitats. These are, however, highly regulated both in the areas of their operation and the levels of activity allowed within these areas through out WA waters. (Note: dredging, a highly destructive fishing method is not permitted in WA),

The potential affect from both fish trapping and lobster potting on demersal marine habitats have been investigated (Moran & Jenke, 1989; Chubb et al., 2002). Both of these studies showed that with the methods used, combined with the controls on fishing effort imposed, the impacts on the benthic communities in WA are likely to be negligible.

In WA, there are extensive areas (Figure 2) permanently closed to all trawling and the effective area where this activity actually occurs is a very small (about 10%) part of the WA continental shelf (Table 2). Thus, prawn/scallop trawling is restricted to relatively small areas of sandy or mud bottoms by the limited natural distribution of the target species and strict management controls on where this activity can occur even within these regions. Furthermore, assessments of the possible impact of this activity have not found any significant benthic or community related changes in biodiversity or ecosystems at the levels of effort that are permitted and occur in WA (Laurenson et al., 1993; Kangas, et al., 2007).

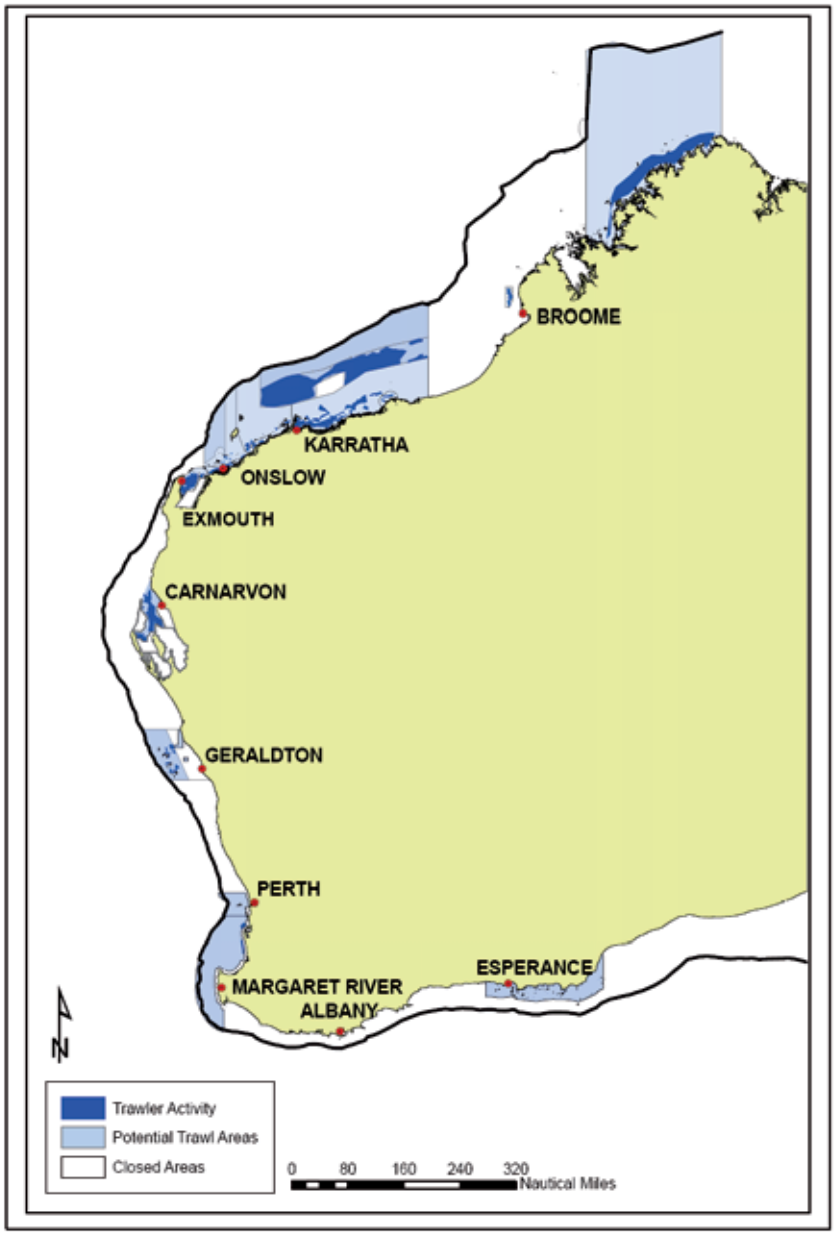

Figure 2. Areas and boundaries for trawl fisheries and non-trawling areas in WA waters. The white areas are where no trawling is allowed, the light blue areas are regions that are currently part of a managed trawl fishery boundaries, the dark blue areas are the boundaries of where trawling has occurred in the past 2 years. The solid line is the 200metre depth contour or edge of the continental shelf. The actual areas trawled are much smaller than the trawl fishery boundaries indicate and are set out in the fishery performance reports, Fletcher and Santoro (2008).

Trawling for finfish, which uses gear that can operate over more structured benthic habitats, and therefore can cause more significant change (e.g. Moran and Stephenson, 2000), is also highly limited in both space (mostly to an offshore section of the NW Shelf, and very small parts of the south coast) and time through a complex fishing effort management control system (e.g. Newman et al., 2003; Fig. 3). Significantly, the key target species of these fisheries (upon which the management is based) are reported to be strongly affected by changes to the benthic habitat (Sainsbury et al., 1997), therefore, as these stocks are currently being maintained (Stephenson and Newman, 2007), the habitat within the fished and surrounding areas, is unlikely to have been affected to an unacceptable level.

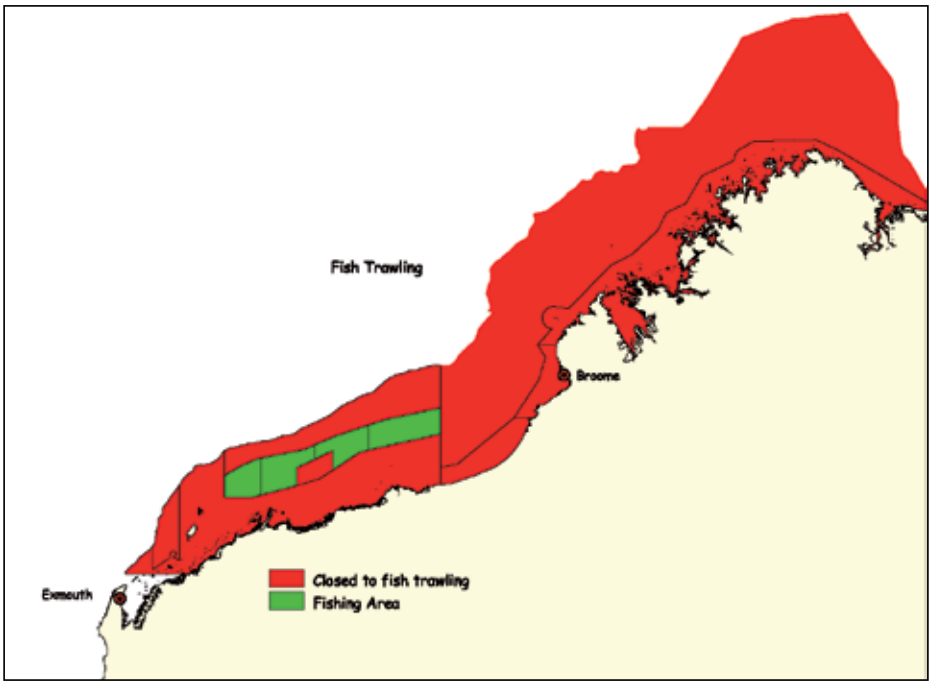

Figure 3. An example of the areas open and closed to finfish trawling within WA waters under the FRMA. Modified from Newman et al.(2003).

Due to the extensive precautionary closures to trawling first introduced in the 1960s specifically to protect coastal seagrass communities, and concurrently implemented licensing requirements, the WA trawl fleet is small (collectively <100 vessels) and decreasing. This downward trend is due to regular fleet restructuring by Industry/Government to improve economic performance and accommodate technology based efficiency gains. Furthermore, all these fisheries have to demonstrate that the total areas trawled are less than agreed performance (spatial) limits to fulfil their requirements and meet the Commonwealth Government's EPBC regulations (e.g. Kangas et al., 2006). These controls, particularly the strict limits on total fishing effort, ensure that the State's trawl fisheries can't enlarge their footprint and therefore have an unacceptable impact on biodiversity at the relevant bioregional or ecosystem level.

More specifically, the result of each trawl fishery's management arrangements is that large sections of the State's continental shelf habitats are legally excluded from any form of trawl impact and further expansion of the area trawled within each fishery cannot occur due to both effort and stock abundance limitations. The extent of these protected areas in each bioregion is set out in Table 2 which shows that approximately 35% of the continental shelf waters (i.e. out to the 200m depth contour), has full permanent habitat protection, and more than 90% of benthic habitats are, in practical terms, fully protected and may never have been trawled. As a result of these long standing

FRMA controls on trawling and related demersal fishing methods, there is effectively no current threat to overall biodiversity from these activities in the WA continental shelf waters.

Table 2. The areas and proportions of each of the four bioregions making up the continental shelf waters of Western Australia, where habitats are protected from the physical impacts of trawl fishing. Note a significant proportion of these areas of the shelf (also shown in Figure 1), which are subject to full habitat protection and have associated strict controls on commercial fishing, meet the IUCN criteria (IV, V, VI) for Marine Protected Areas.

Bioregion	North Coast	Gascoyne Coast	West Coast	South Coast	Total Coast
Total area of Shelf	98600 sq.nm	15800 sq.nm	19600 sq.nm	31800 sq.nm	165800 sq.nm
Area of shelf fully protected (%)	40700 sq.nm. [41%]	5600 sq.nm. [35%]	11000 sq.nm. [56%]	0 sq. nm[1]	57300 sq.nm [35%]
Maximum area trawled[2]	10500 sq.nm.	1100 sq.nm	300 sq.nm	500 sq.nm	12400 sq.nm.
Total area of habitat effectively protected (%)	88000 sq.nm. [89%]	14700 sq.nm [93%]	19200 sq.nm [98%]	31200 sq.nm [98%]	153100 sq.nm [92%]

[1] While there are no specific limits, the rough sea conditions and limited habitats for scallops limit fishing to approximately 2% of the shelf
[2] Area trawled, in practise, cannot be expanded due to fishery performance criteria limitations (under the EPBC Act) and associated FRMA controls on vessel effort.

Total fish removals from the ecosystem – significant reductions in total fish biomass through high levels of fishing can affect ecosystems, whereby all species of one or more higher trophic levels are effectively removed allowing other lower trophic levels to expand and become the focus of fishing ('fishing down the food web' – Pauly et al., 1998, 2002). Similarly, the excessive reduction of baitfish biomass or species making up other lower trophic levels can also result in a flow-on effect at higher trophic levels. Such 'trophic cascade' effects have not been demonstrated in areas where effective management controls on individual fisheries have been implemented. In WA, comprehensive controls on fishing were first introduced in the 1960s now apply to all significant commercial fisheries. These controls are designed to ensure that all catches are kept at sustainable levels, which in turn requires that the annual catch is a small proportion (typically ten to twenty percent) of the overall stock biomass. This process, which maintains relatively high biomass levels for all harvested species, compared with their unfished situation, ensures that all trophic levels are being kept at relatively high levels of abundance. For WA waters, these management requirements have significantly reduced the risk of such trophic flow on effects from occurring and none are evident in the long term trends in fish catches. To confirm this assessment, it is being formally investigated through a series of WA Marine Science Institution (WAMSI) projects (see www.wamsi.org.au) and preliminary results suggest that there have been no overall trophic levels impacts (Hall and Wise, 2009)

Removal of keystone species – There are rare circumstances within the marine environment whereby the reduction in abundance of a single "keystone" species (sensu Paine, 1966, 1974; this is not equivalent to just any higher order predator or group of predators- such as sharks) can result in a significant change to ecosystem out of proportion to their abundance (the most frequently cited examples are the decline of algal beds to create barren reef systems associated with the removal of a predator which allows the expansion of sea urchin populations)*. Such phenomena require

* More recently, a keystone species has been defined as a species whose effect on ecosystems is disproportionately large relative to its low biomass in the community as a whole (Power et al. 1996)

very specific conditions that are not common and are sometimes not even repeatable (e.g. Dayton, 1971, Underwood and Denley, 1984) or are sometimes incorrectly inferred (see Elner and Vadas, 1990). Probably as a result of the high levels of diversity in WA waters, there are no proven cases of keystone species in WA and extremely few situations that are even suggestive that such interactions could occur. Consequently there is essentially no risk to biodiversity from this effect in WA waters. Moreover, if situations were found where such impacts could be significant, this would need to be managed at the whole of system level, not just by establishing a relatively small closure*.

In addition to the direct effects of fishing, there are a number of other human related activities which can potentially impact on marine biodiversity in there own right or in combination with other direct fishing effects. In WA waters these include:

Run-off – changes in land use for the adjacent terrestrial hinterland, for example land clearing for agriculture, urbanisation and industry. High levels of fertiliser application, intensive stock holdings, industrial waste and sewage outfalls all may reach the waterways. Water run-off carrying high nutrient, sediment or chemical loads has the capacity to adversely affect marine water quality and benthic habitat. In WA, this has become a critical issue for a number of the estuaries and embayments of the west and south coast where it presents a risk to estuarine dependent species at a local level, rather than marine biodiversity generally. These runoff effects probably exacerbated by climate change and ongoing fishing activity have been implicated in the significant decline of some genetically isolated cobbler stocks in west coast estuaries (Smith and Brown 2006). This has resulted in a complete ban on fishing for this separate genetic stock of cobbler, which appears to have been largely lost from the Swan-Canning estuary.

Transport – fuel spills, introduced marine pests in ballast waters, boat noise (including naval vessels) and the dredging of navigational channels associated with international shipping all have the potential to directly affect marine water quality, benthic habitat and marine organisms. In WA, these general threats apply to all major ports, which are the focus for shipping activity, but are a relatively low risk due to tight management controls and their small area of impact relative to the size of the WA coastline.

Petroleum exploration – oil spills associated with offshore oil drilling activity, noise as part of seismic surveys and direct benthic habitat loss as a result of infrastructure (pipelines)†, have the potential to directly affect water quality, impact on cetacean behaviour and the benthic environment respectively. Until recently, these activities have had only local impacts in WA, and as a result of successful management few significant oil spills from oil production facilities have been recorded. The October 2009 incident off Broome highlights the potentially major impacts that can be generated from these operations.

Climate change – There is already information that the effects of climate change are beginning to affect marine communities including changes in iconic marine communities such as coral reef systems (Hobday et al., 2006). The WA marine environment has not been immune from these changes (Caputi et al 2009), however, developing the scientific understanding of the relationship between exploited fish stocks and the key environmental parameters (e.g. the Leeuwin Current) Lenanton et al (1991, 2009) will allow management adjustments to be made to compensate for changes, both positive and negative, to stock abundance and productivity‡.

* Experimental closures may, however, assist in identifying the magnitude of such issues.

† Although fishing is usually prohibited around these pipelines.

‡ Noting the stock-wide impact of these changes, it is unlikely that sanctuaries will provide protection or play a significant role in managing the effects of climate change on fished species.

In terms of marine biodiversity generally, the most likely effect of climate change in WA will be to cause a gradual southward shift in the distribution of most marine species and possibly cause changes in abundance, rather than diversity.

4.3 Summary

In general, compared with other parts of Australia and especially the rest of the world (Roberts et al., 2002), there are relatively limited human impact or environmental threats to the biodiversity of the marine ecosystems of WA and no evidence of large scale changes occurring. The exception to this general marine situation is the water quality driven changes in some SW estuaries and marine embayments e.g. Cockburn Sound (Wakefield,et al., 2009, Smith and Brown 2006) where local diversity has been affected and some estuarine dependent species are threatened.

When considering future impacts from these threats the risk also needs to be assessed relative to the performance of the management systems that are in operation. However as there is some potential for interaction between the various possible threats and for changes to management processes currently applied to protect WA's marine resources and environment, there will be an ongoing need to review the performance of the various management strategies being utilised against their relevant objectives.

5.0 Marine environment protection controls

A number of mechanisms currently exist to manage the impact of fishing and protect biodiversity within the marine environment under the FRMA (administered by DoF), and under the CALM Act (now administered by DEC). Both Acts provide for direct spatial controls but more frequently involve a range of more complex measures, many of which have spatial elements in their operation. The more significant of these controls under both Acts and their relevance to the managing human effects on fish and biodiversity are summarised as follows.

5.1 Fisheries and marine management under the FRMA

Under the provisions of the FRMA, the Department uses a range of management strategies to control fishing activities to protect and sustain fish stocks and habitats. These include an extensive system of conventional fisheries spatial closures along with many other management arrangements.

5.1.1 Spatially based management strategies

(i) Gear Based Closures

The primary category of fishery closures, are "gear" related, which protect marine habitats from the physical impacts of fishing gear such as trawling (note: dredge fishing is prohibited in all WA waters). These closed areas cover the majority of WA's continental shelf and directly protect most of the marine habitats from direct physical damage from fishing gear (see Figure. 1). These gear based closure systems, together with fishery or species specific closures in aggregate, provide significant protection for the WA marine habitats, biodiversity as well as harvested fish stocks. For more detailed information on this system see the State of the Fisheries Report 2008–2009 (Fletcher & Santoro, 2009).

(ii) Species Based Closures

For individual fisheries, closure arrangements are developed to meet specific biological or process targets. For example, the protection of small prawns in nursery areas from trawling or the protection of snapper spawning aggregations from line fishing can be achieved using permanent or temporary spatial closures of specific areas within a fishery. Such closed areas are designed specifically to assist in controlling catches (usually at some specific stage in the life cycle) to ensure stock sustainability or to protect aquatic habitats important to sustain the relevant fish stocks, however these closures do allow other compatible fishing activities for species, which are not the target of the closure. For example within the Pilbara region there are a number of large zones where fish trawling and demersal fish trapping is excluded, but fishing for pelagic species (e.g. Spanish Mackerel) or diving for pearl oysters is allowed (Fig. 2). Similarly, the snapper closure in Cockburn Sound only operates during their spawning season in this location – which occurs in late spring early summer.

(iii) Tourism Based Closures

Fisheries closures are also created to provide protection of special areas, from extractive fishing to enhance their use for tourism purposes. Examples of this type approach are the closures around the wreck of the HMAS Swan and the Busselton jetty. These structures both provide artificial fish aggregation areas, which are popular with divers and have become significant tourist attractions. Closures may also be created to protect popular sheltered sites where community support has clearly demonstrated the need for the area to be protected (Yallingup Reef, Cowaramup Bay).

(iv) Fish Habitat Protection Area Closures

Areas of waters may be reserved as fish habitat protection areas (FHPAs) pursuant to Section 115 of the FRMA. These areas can be created throughout WA waters (except in marine parks) and they are vested in the Minister for Fisheries. They may be established for a number of purposes, including the protection of the aquatic environment and the creation of reef or fish observation areas equivalent to sanctuary zones in marine parks. Under this process, the Minister for Fisheries has wide powers to control or prohibit some or all fishing activities which are not compatible with the purpose of the specific FHPA. The Minister may also make regulations to prohibit other human activities, which may harm or alter the aquatic environment in the FHPA.

FHPAs may vary in scale and typically involve the local community as well as the Department of Fisheries in ongoing management of the area.

The following FHPAs have been created along the WA coastline:

- Abrolhos Islands FHPA – recreational and commercial fishing (except rock lobster pot fishing in season) are excluded from large sections of the reef areas in the archipelago.
- Lancelin Island Lagoon FHPA – no recreational or commercial fishing is permitted.
- Cottesloe Reef FHPA – commercial fishing and spear fishing are not permitted (but angling for migratory species is permitted).
- Miaboolya Beach FHPA – commercial fishing is not permitted.
- Additional FHPAs are under consideration at Point Quobba, Kalbarri, and in the Kimberley.

(v) Spatially based Effort, Quota and Gear Controls

In addition to the direct spatial management controls, there are a large number of other management methods that include spatial elements, which are designed to ensure that the fisheries in WA are operating in a sustainable manner. Historically, each commercial fishery has been limited to a specific section of the coast and has controls on the effort, which can be applied to the target stocks within the designated fishing area. This process began in the early 1960s when WA was one of the first jurisdictions in the world to introduce limits on numbers of commercial vessels. More recently, buy backs and unit adjustments have been used to reduce vessel numbers/units to compensate for technology based increases in vessel efficiency. This process to ensure that annual harvest levels are kept sustainable in each fishery has resulted In the Western Australian fishing fleet being reduced from >4000 vessels In the 1960s to less than 1400 vessels in 2008.

These spatially based effort management arrangements have evolved into sophisticated 'total allowable effort' (TAE) systems with individual transferable effort (ITE) units. The ITE units are based on standardised gear and operate within a TAE, which is set to control the overall catch (or Total Allowable Catch or TAC) taken by the fishery. Where appropriate some commercial fisheries are managed by output controls, that is, through the direct use of the TAC, allocated to individual vessels as Individually Transferable Quotas (ITQs), These catch quota systems are also applied to specific sections of the coast.

The process of restricting recreational fishing effort/catch to an explicit sustainable harvest level through either a TAE or TAC is beginning to be applied as part of the IFM initiative. There are already restrictions on the number of recreational fishing charter boats, and, in specific circumstances, on the recreational catch that is allowed (e.g. Inner Gulf Shark Bay snapper) and through time closures (e.g. West Coast Abalone). These general management principles are being extended to other recreational fisheries where needed.

5.1.2 Management review processes

In addition to the spatially based management systems, the DoF undertakes annual fishery performance reviews/interventions and conducts ecological risk assessments to prioritise research and management needs.

(i) Management interventions

The management of any natural resource within the marine environment is typically a dynamic process. In most instances there is a high degree of variability in the productivity/recruitment level of species amongst years, which is often unconnected to the harvesting levels that are occurring. Furthermore, there will also be changes to the ways that fishery resources are used over time due to growth in the numbers of recreational participants, technological improvements and shifts in commercial market values. Consequently, the management systems for fisheries will rarely be able to operate for many years without requiring some level of adjustment or intervention. The need for these regular, adjustments to the fisheries management arrangements has, in some cases, been misinterpreted and therefore often reported in the media as a failure of the management system. However, such interventions reflect the normal operation of a fisheries management system and its successful adaptation to changing environmental conditions, stock levels or fishing activities.

The real test of any natural resources management system is how well the management feedback loop operates when circumstances change. This requires that there is adequate monitoring of stocks, to ascertain if their status is acceptable and that administrative systems are in place to ensure that management responds efficiently and effectively to redress any unacceptable impacts that arise. In general, WA has relatively few stocks that are below the acceptable level* (the 'State of Fisheries' reports-- on this annually)† and in each of these cases management interventions are in place or are being developed. The recoveries of the various snapper stocks within the Shark Bay region are examples that highlight the success of the WA management system when problems arise.

The real failure of fisheries management is when no, or (as is more often the case) insufficient interventions are undertaken to effectively deal with variations in stock abundance or changes in fishing efficiency that inevitably occur. There are numerous examples elsewhere in the world, where stocks have continued to decline because of inadequate management interventions or where they have been implemented too late.

(ii) Ecological Risk Assessment Approach

To assist in the efficient management of WA's marine resources, a formal ecological risk assessment process is now used at regular intervals to assess all key WA fisheries (Fletcher 2005). This process is used to determine which fishing impacts or issues require direct management action or monitoring and meet the environmental certification requirements under the Commonwealth's EPBC Act. Structured workshops (often with stakeholder involvement) have been used to identify potentially negative impacts across three ecological areas i.e. on the retained species, non-retained (by-catch) species and the broader ecosystem for each fishery. The risk of an unacceptable impact associated with each issue is assessed using a likelihood rating, multiplied by one of a number of possible consequence levels specifically developed for

* Given the precautionary levels of spawning biomass used as reference points this has not resulted in recruitment overfishing.

† http://www.fish.wa.gov.au/sof/index.html

use in fisheries risk assessment (Fletcher, 2005). The risk scores, for which suitably detailed justifications are written, determine the level of assessment and/or management required for each impact or issue identified. This ESD process specifically deals with fishing threats to marine biodiversity and has, for example, led to studies to examine the effects of trawling in Shark Bay (Kangas et al 2007) and the development of performance indicators for relevant fisheries, which ensure biodiversity is maintained.

This system provides a disciplined and consistent methodology for the calculation of the relative level of 'risk' associated with each ecological impact/issue, which is then used to determine the appropriate level of management response. Thus, the calculated risk value for each impact assists in determining whether it requires direct management and/or monitoring, a decision that is critical for the long-term performance of any fishery and its underlying resource base. These risk assessments are also used to ensure the most effective use of the available (often limited) management resources.

The current work that is being undertaken through a WAMSI project which is trialling the use of an EBFM framework to develop the methods to broaden the risk assessments to cover bioregional level assets. The first WAMSI case study of the West Coast bioregion has already generated risk assessments for each of the key ecosystems in this bioregion, each of the key habitats and each of the key suites of captured species. The results of these analyses are now presented within the State of Fisheries report (Fletcher & Santoro, 2009).

5.2 Marine Management under the CALM Act.

Under the provisions of the CALM Act there are a number of measures available to manage the marine species and environment. The primary management process for protection of marine environments under this Act is the creation of marine protected areas. In the international context, such MPAs are generally considered to be 'refugia' for the protection of marine organisms within a specific area. More specifically in Australian waters, MPAs have been defined as 'an area of seabed and overlying waters dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means' (ANZECC, 1998)*.

Marine Protected Areas in WA

In Western Australian waters, MPAs can be created under the New Horizons policy through the CALM Act, with all such marine reserves created being vested with the Marine Parks and Reserves Authority (MPRA) and managed under the direction of the MPRA by DEC.

Under the CALM Act there are three categories of marine reserves:

(i) Marine nature reserves:

This is the highest protection category of reserve and has the purpose of conserving and restoration of the natural environment, the protection, care and study of indigenous flora and fauna and the preservation of any feature of archaeological, historic or scientific interest. While their primary purpose is to protect areas or habitats of high conservation value, tourism activities are permitted but no extractive activity including commercial or recreational fishing

* Within WA, this definition primarily applies to the management of marine parks under the CALM legislation but could also apply to some of the closed areas enacted within FHPs under the FRMA.

is allowed. Petroleum drilling or production is also prohibited. In effect such areas have a similar function to sanctuary areas or no-take areas in terms of biodiversity protection.

Only one marine nature reserve, the unique Hamelin Pool Marine Nature Reserve situated in the Shark Bay World Heritage Area, exists at the present time.

(ii) Marine parks:

Multiple-use marine parks exist in WA, and are implemented and managed by DEC with the Department of Fisheries providing complementary management of fish stocks and fishing activities. Marine Parks are specifically to conserve and restore the natural environment, protect indigenous flora and fauna, and preserve of any feature of archaeological, historic or scientific interest. Commercial and recreational activities compatible with these objectives are permitted, and all other controls on fishing developed under the FRMA still apply*. Within a marine park, four categories of zone can be created: 1) sanctuary zones (where all extractive activity, other than for approved research purposes, is prohibited); 2) recreation zones (which provide for all recreational activities including recreational fishing); 3) special purpose zones (managed for a particular purpose of priority); and 4) general use zones (where conservation of natural resources within the park remains a priority but all activities including recreational and commercial fishing may be undertaken). While marine parks have broad conservation objectives some of the zoning elements have the potential to complement fisheries management controls if they are appropriately sited. Conversely the conservation objectives of marine parks can be enhanced by their positioning in areas subject to habitat protection areas created under fisheries management plans.

Existing examples of marine parks include the Shark Bay Marine Park, Rowley Shoals Marine Park, Ningaloo Marine Park, Marmion Marine Park, Jurien Bay Marine Park and Shoalwater Islands Marine Park. There are a number of other marine parks planned or in the process of implementation (eg the planned Cape Naturaliste to Cape Leeuwin marine park.)

(iii) Marine management areas:

The ability to establish marine management areas (MMAs) was established in 1997 via amendments to the marine reserve provisions of the CALM Act. MMAs recognise that while a particular area has a high conservation value, the potential use of part of the area for commercial purposes such as seismic surveys, exploratory drilling for petroleum, and the production of petroleum and associated activities, is also considered legitimate, provided there are appropriate environmental management safe guards in place (e.g. Murion Islands Marine Management Area).

In terms of operational management of these reserves, the MPRA is required to develop a management plan for each reserve, sets performance criteria and conducts periodic assessments of the management plans. For marine parks monitoring of the status of the flora and fauna in the reserve is required and reviews are undertaken at about ten-year intervals. These relatively infrequent review schedules are in keeping with the low levels of threats to WA's coastal waters and therefore the expected slow rate of change in conservation reserves. The outcome of the review process can include changes to the park boundaries and zoning within the reserve area.

* This prevents the inadvertent allowance of an activity within a marine park that would otherwise be prohibited under the FRMA.

6.0 Value and implications of sanctuaries as a marine management tool

As noted in the introduction, the general public perception of MPAs in Australia is that they are 'no-take' sanctuary areas, equivalent to national parks on land. Consequently, given this public perception of the role MPAs, and their implications for other marine management initiatives, the remainder of this paper will mostly focus on the relative value of sanctuaries (including no-take FHPAs under the FRMA) as a strategy for achieving state-wide fisheries and general marine sustainability objectives.

6.1 Expectations

Increasingly, international and Australian conservation groups (Australian Conservation Foundation, 2002) are suggesting that sanctuary zones should be implemented to provide a variety of benefits for the management of the world's marine environments. The World Wide Fund for Nature (WWF, 2002) suggests, for example, "that marine reserves (sanctuaries) are integral to marine ecosystem-based management as they:

i) Protect habitats and associated biodiversity otherwise impacted by some fishing activities, thus contributing to the maintenance of ecosystem structure and function;
ii) Allow for the natural dynamics and natural evolution of ecosystems; and
iii) Contribute to the social and cultural values of local communities".

There is little debate about (i). However, because most ecosystems usually operate at a bioregional or larger scale, (ii) is probably unrealistic given the size of most sanctuaries; and (iii) assumes that the fishing activities that occurred within the areas that are to become sanctuaries were not important social or economic activities for the local community. More recently, Murawski (2007) outlined that this view (that sanctuaries are integral to ecosystem management) was a widely held misconception and concluded "one does not have to implement MPAs in order to be successfully managing resources using an ecosystem approach to management".

WWF also suggested that, sanctuaries are needed to meet the following four additional objectives:

iv) To act as scientific reference areas for monitoring long-term environmental change;
v) To meet social expectations for areas protected from human activities, where visitors may be assured of being able to view a wide variety of aquatic life;
vi) To increase marine biodiversity; and
vii) To improve the productivity of fisheries.

While there is a reasonable basis to assume that sanctuaries can meet objectives (iv) and (v) and possibly (vi) where the ecosystem involved had been heavily impacted by an activity excluded by the sanctuary, the final objective (vii), is unlikely to be successful in most circumstances. For WA in particular, the management arrangements already in place under the FRMA and annual monitoring of fished stocks, suggests that there will be few if any of the assumed benefits to overall fisheries productivity or stock sustainability. This is due to the following assumptions and misconceptions about the benefits of sanctuaries (Fletcher, 2003).

6.2 The efficacy of marine sanctuaries and their effect on the productivity and sustainability of fisheries

Misconception 1: Sanctuary areas will operate similarly in marine and terrestrial ecosystems

It is commonly assumed that marine sanctuary areas will automatically generate a high level of protection for flora and fauna and therefore have a high ecological benefit. This assumption is largely derived from the general public's experiences with the way terrestrial reserves operate, where the protection of residual natural habitats (e.g. National Parks) is the primary method used to maintain biodiversity and ecological values. There are, however, a number of critical differences between the terrestrial and marine environments and the way that marine species interact with their environment, which affects this assumption. Such differences have been noted elsewhere (e.g. Fletcher, 2003; Halse, 2003)

Firstly, flora and fauna in terrestrial environments are heavily reliant on, and influenced by, the geophysical properties (particularly soil types) of an area, which affects all productivity and associated diversity outcomes. Primary production and diversity in marine environments, in contrast, is mostly determined by pelagic (or water column) processes and current patterns rather than solely by benthic derived or sedimentary based processes. Added to this, marine ecosystems are more complex three-dimensional systems, without the same clear physical boundaries found in terrestrial systems.

For example, within terrestrial communities, the migration rates of most species are relatively low, increasing the potential level of self-sufficiency of any sanctuary/reserve area. Moreover, these protected areas can be fenced to keep some wanted species in and keep some unwanted feral species out. The exception to these generalisations are bird populations which may remain in reserves through strong habitat associations but have some similar life history attributes to the typical marine species and may therefore not always be well protected by reserves.

In contrast to most terrestrial species, marine organisms (including plants) have relatively high levels of movement/dispersal during their larval stages, and are usually capable of significant migrations as adults or juveniles or both. Consequently there is much greater opportunity for the transfer of individuals of most marine species both into and out of any single area, including sanctuaries. Significantly, species cannot be fenced in or out in the marine environment and re-colonisation processes typically occur irrespective of the protection regime applied to a particular area. In a similar way, marine sanctuary areas cannot provide any refuge from the potential impacts of introduced/exotic species, nor can they protect against the human impacts resulting from degraded water quality e.g. arising from outfalls or run-off.

A second fundamental difference between marine and terrestrial systems is that almost all human development and activities within the terrestrial environment requires/results in an extreme level of modification to the natural ecosystems present (particularly the habitat) in the area. Thus, all urbanisation, industrial uses, farming and grazing systems result in the removal of the natural ecosystem and its replacement with an altered and frequently exotic ecosystem. Consequently, the total protection of residual natural terrestrial areas through reserves (sanctuaries) is generally accepted as the key method for protecting residual parts of the natural terrestrial ecosystem, which can then continue to function in isolation. This approach of protecting isolated residual natural habitats then leads to the push to create 'corridors' joining the reserves to allow or encourage movement of mobile species to avoid genetic difficulties in the retained isolated populations. Because of the dispersal mechanisms

and mobility available to virtually all marine species*, this concept of 'corridors' is almost irrelevant to marine biodiversity management. However, there is not even full agreement in the terrestrial environment that such networks of reserves alone provide an effective conservation strategy (Margules and Pressey, 2000).

In a further contrast to land based agricultural production, sustainable commercial and recreational fisheries production is totally reliant on the natural marine ecosystems continuing to function. That is, the harvested fish species and their associated habitats are part of the natural ecosystem and are therefore dependent on its overall maintenance for their productivity. If fishing levels (including catch and gear impacts) are such that they alter the ecosystem or habitat significantly, the catch levels &/or the composition of the captured species will also be affected substantially (as has been found in largely unmanaged marine systems; e.g. Pauly et al., 1998).

In WA, a comprehensive system of specific fishing closures, effort limitations and other controls on fishing gears dating back to the 1960s has been developed with the specific purpose of ensuring the sustainability of all harvested fish species and the protection of their habitats, to ensure their ongoing production. The effect of these early controls on destructive fishing practices is that at a bioregional level, most of WA's coastal habitats and biodiversity has not been directly or detectably affected by fishing activities. This does not mean that there has not been localized depletion of some targeted species but this is not an actual reduction in biodiversity if the national definition is used.

Misconception 2: More eggs produced automatically means more recruitment to a fish stock.

One of the most common and key arguments used for the establishment of marine sanctuary zones, is that the fish in these reserves will become more numerous and/or grow larger and hence produce more viable eggs. Increases in egg production from these larger fish are then assumed to 'automatically' result in comparable increases in the resultant level of juvenile recruitment both inside and outside the sanctuary, which will be of benefit to the fish stock and therefore fishers. The assumption that recruitment levels will always increase with higher levels of egg production is, however, generally incorrect. For most marine species, unless the stock is severely depleted over its entire distribution, such that the stock is suffering from what is called recruitment over-fishing†, increased egg production levels will not generate increased average recruitment.

The relationship for most fish species between the level of egg production and the recruitment that this generates (termed the spawning stock-recruitment [SSR] relationship), follows a pattern whereby recruitment only increases with egg production levels until it reaches an asymptotic level (see Fig. 4a). The spawning stock levels/egg production level‡ where this asymptote is reached varies between 10 - 60% of unfished levels, depending upon the life history characteristics of the species (Fletcher et al., 2003). Once the stock size/egg production levels are within this asymptotic region (or egg saturation zone; Fig. 3a), additional egg production will not increase the average number of recruits surviving to add to the population the following year§. Despite the many thousands of fished stocks worldwide there are only

* The exception to the larval/adult mobility in marine species are a small number of mollusc species eg cowry species, which bear live sedentary young and also have very limited mobility as juveniles/adults

† In such circumstances within WA, significant management controls have been imposed (e.g. Penn et al., 1998) and often require multiple strategies including complete closures of the fishery.

‡ Which includes the viability of eggs not just raw production, and is not the same as total biomass- which will be substantially greater because this will also include the non-mature part of the population.

§ The levels of recruitment in any one year are usually highly affected by environmental factors unrelated to egg production levels

a few cases in the literature (e.g. Penn et al 1997) where spawning stock levels have been unambiguously shown to directly influence recruitment.

The assessment of the levels of spawning stocks required to sustain marine populations is made difficult because the 'natural' environmentally driven variations in annual survival of recruits frequently obscures the underlying SSR relationship. While breeding stocks must clearly be maintained at adequate levels, the natural variations in abundance for many species leads to misconceptions about the need for additional breeding stock and therefore the benefits of sanctuaries which may protect some additional breeders.

The appropriate breeding stock levels for marine stocks is further complicated for some species; especially where the recruits inhabit the same space as the adults, and exhibit "Ricker" style SSR relationships (see Fig. 4b). In these situations increasing the stock of adults beyond moderate levels can actually reduce average recruitment levels, due to increased competition for space (eg abalone) or even direct predation of the eggs/juveniles by the adults (Valdes-Szeinfeld, 1993). Under these circumstances, the establishment of sanctuary zones, which generate higher adult stock levels, could potentially reduce local recruitment levels of these species (e.g. Barrett et al., 2003).

These examples for marine species where increased egg production above an asymptotic or optimal level does not increase the productivity of the fished stock, is the equivalent of exceeding the 'carrying capacity' of the land in a terrestrial farming context. In these terrestrial situations, reducing the numbers of larger older animals, in excess of the carrying capacity of the area, is a recognised way to maintain a productive population.

Given these SSR patterns, the primary objective used for the management of all fished stocks in WA (and most other locaions) is to keep their spawning biomass levels above the point where recruitment overfishing is likely to occur (the appropriate level is determined separately for each stock*). The spawning stock/egg production status of each of the main target species in WA is assessed annually to determine if this objective is being achieved. Furthermore, the potential for other non-target stocks to be affected by the fishery must now also be assessed at regular intervals (Fletcher, 2002).

Very few marine species managed within WA are currently assessed as being recruitment overfished (Fletcher & Santoro, 2009), therefore any increased egg production generated within sanctuary zones (or by any other management process) is unlikely to noticeably increase the level of recruitment of juveniles to these stocks either inside or outside of a sanctuary zone. For the WA species that require additional breeding stock management are already either subject to highly restrictive management controls or additional management proposals are under development. For some, such as the highly migratory sharks, small sanctuary zones will effectively provide no additional protection.

The SSR principles above apply to virtually all WA marine species, such that unfished populations or those just subjected to by-catch effects are unlikely to be impacted at a level where a sanctuary type closure can provide any direct benefit in the context of maintaining biodiversity. That is, secondary impacts of fishing have little likelihood of reducing breeding stock levels of non target species to a point where additional animals protected in closed areas will result in increased recruitment elsewhere in their geographic distribution.

* This level needs to take into account any species specific- size/age related changes in fecundity/egg viability, or spawning/behaviour

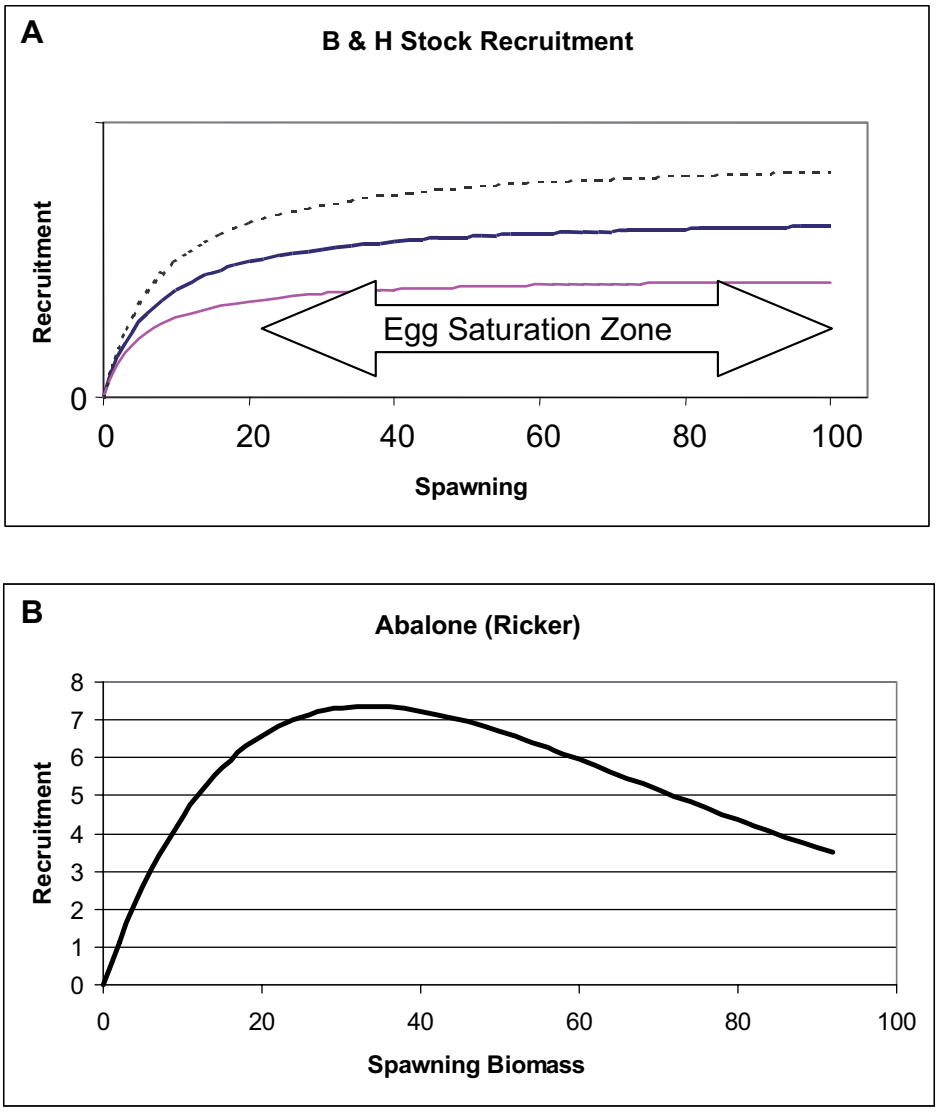

Figure 4. Basic Stock recruitment curves. A) The Beverton & Holt (B&H) curve is the curve mostly applied for finfish and many invertebrates. B) The Ricker curve applies to some species (such as abalone) where space for recruitment is limited and the density adults can affect survival of recruits at high breeding stock levels.

Misconception 3: Increased local abundance equates to increased productivity at a population level and will generate spill-over to adjoining areas.

The increases seen in the local abundance of some species within sanctuary zones is often cited as being proof that these areas have generated increased fisheries productivity. This was elaborated in theoretical detail by Ward et al. (2001), and is mostly based on research on changes in the local densities of fish stocks within marine protected areas in locations such as the Philippines (e.g. Russ and Alcala 1996; Russ et al., 2004) and Florida (Roberts et al., 2001), where normal fisheries management has been lacking or ineffectual and fish stocks and habitats outside the sanctuary have been severely depleted. There is, however, little empirical evidence for more widespread, whole-of-stock benefits resulting from such local increases.

Thus Russ (2002) concluded that:

*"The current literature on marine reserves as fisheries management tools is dominated by papers reviewing or modelling what marine reserves **could** [emphasis in original] do as fisheries management tools. There seems to be a remarkable paucity of good empirical studies…"*

Subsequent to this review, a number of studies have outlined benefits for fisheries from the establishment of sanctuaries. These were, however, still relatively small-scale, being restricted to the regions immediately surrounding the sanctuary (e.g. Russ et al., 2004; Roberts et al., 2001), not stock-wide benefits. Such improvements in local productivity are often categorised as 'spill over' benefits. They result, not from an increase in the recruitment of juveniles (from an increased spawning stock), but from the increased relative abundance of larger individuals building up* inside the sanctuary and then 'spilling over' into surrounding areas†.

The potential for 'spill overs' to be generated by a sanctuary is dependent upon the level of mobility of the species involved (e.g. Nardi et al., 2004), but not in a linear fashion. Mobility affects the rates of emigration of a species from the area, which for example, would be very high for most tuna and non existent for abalone. It also affects the potential effectiveness of sanctuaries in creating increased local densities but this is inversely related to mobility; i.e. the higher the rate of emigration, the less likely it is that any build-up in density will occur. Consequently, the only species with the potential for significant levels of spill over to occur, will be those with moderate levels of mobility i.e. they are resident long enough to allow their numbers to build up and individuals to grow, but not so resident that none or very few emigrate. (Such species are often subjected to 'nursery closures' under fisheries legislation to optimise their harvesting.)

The final factor in determining the potential spill over benefits will be directly related to the level of depletion in adjacent waters open to fishing. If the areas outside the sanctuary are highly depleted or degraded, then even small levels of spill overs from the sanctuaries may significantly increase productivity on a local basis (such as the examples cited above). However, if the areas outside are not severely depleted, then the benefits derived from spill overs from the sanctuary area may not even compensate for the loss of fisheries production that previously came from the sanctuary (this may also be affected by the level of effort redirection – see below).

Whilst there is some evidence that increases in local densities of some WA species may be generated in sanctuary areas (Westera et al., 2003; Nardi et al., 2004) the effect at a species or stock level is quite variable. For example in the Nardi et al 2004, Abrolhos Is study, no build up in the closures was detected for baldchin grouper (*Choerdon rubescens*), while the more sedentary coral trout (*Plectropomus leopardus*) took about 5 years to show any significant increase in abundance and then only in one of two study areas. Although the closed areas were relatively large in this case, representing 17% of the Abrolhos shallow coral reef habitat occupied by the baldchin grouper stocks, there was no evidence of benefit to this species in surrounding areas where it is the dominant species in the catches with production having remained relative constant from the mid 1990s to 2006 (Wise et al, 2007). Given the acceptable status of most fished stocks within WA (Fletcher and Santoro 2009), the net result from imposing significant "no take" closures could be a decreased total catch of fish from

* Given the speed of these build-ups they are often not a function of juvenile recruitment.

† In these circumstances the sanctuaries are assisting reduce 'growth' over-fishing

these stocks rather than creating a presumed increase in productivity. This highlights the need to determine the species for which this effect can occur and the possible level of benefits from spill overs within WA's current and proposed sanctuary areas where this is to be used as a justification for their establishment. Such assessments would need to be completed on an ongoing basis and at a regional level given the different species, oceanographic conditions and ambient stock levels that are present.

Misconception 4: Declaring a sanctuary will automatically reduce the fishing pressure on fished stocks in the area.

When sanctuaries are implemented it is often assumed that they will reduce fish catches proportionally to the area protected. While the fishing within a sanctuary is clearly reduced (assuming full compliance occurs) all closures can result in a redirection of some or all of the displaced fishing effort into the remaining 'open' areas. Therefore, unless there is a concomitant reduction in total fishing effort, the increased fishing effort in the remaining 'open' areas can, under certain circumstances, exacerbate long-term sustainability problems (Parrish, 1999; Haddon et al., 2003).

This effort redirection problem is particularly acute for relatively sedentary species e.g. in abalone fisheries, where the rate of migration out of the areas is virtually zero and there is relatively localized recruitment of larvae (Prince et al., 1988; Hancock, 2000). For these species, the loss of the available catch from a stock will be directly related to the area of reef located within a sanctuary zone (Hesp et al., 2008). Under such circumstances, not reducing the permitted catch to account for this loss of area could have serious implications for the sustainability of the remaining resource because of the increased exploitation rates that would be applied outside the closed area which could then become depleted.

Sanctuary zones or fisheries closures should not, therefore, be established in isolation from a review of other management arrangements operating in the region and must take note of the status of the stocks within the area and how these arrangements will interact.

Misconception 5: Reduced catch-rates for fished species automatically indicate that stocks are over-fished.

One of the rationales sometimes used for the establishment of sanctuary areas is that Individual fishers catch-rates have decreased therefore stocks must be overfished and local areas should be closed to fishing. That is, when individuals can no longer obtain what they consider to be a reasonable catch of fish, they assume that this indicates that the stocks of fish are unacceptably depleted and call for increased management, which often includes calls for the establishment of sanctuaries. This call may come from new fishers who are unable to catch many fish, but especially from long-term fishers who can no longer catch the same number of fish as they used to.

These observations on the 'abundance' of a fish stock may not, however, indicate that the exploitable stock of fish has declined to unacceptable levels*. Rather, it may reflect that the number of people trying to catch them has increased. That is, greater levels of competition amongst individuals will automatically result in each individual catching less on average even when the total amount caught has remained the same or even increased.

This effect is reflected in the simplified fisheries model (Figure 5) which shows the relationship between catch taken and the catch-rate achieved when varying levels of fishing effort is

* Any level of fishing will result in some reduction in the stock levels of the species that are harvested.

applied to a particular stock of fish. That is, as effort increases the total catch increases up to a maximum level (i.e. Maximum sustainable yield or MSY) and then decreases, as the stock is unable to replace itself and ultimately declines through recruitment overfishing. The corresponding relationship between catch-rate and fishing effort shows that as effort increases the catch rate automatically declines and is significantly reduced even when the maximum catch (MSY) is being achieved. It is this initial decline in catch-rate that is misinterpreted as indicating an overfished stock long before a real recruitment overfishing occurs. At a local level this declining catch-rate effect also occurs when fish movement into an area or increases in abundance through growth fail to keep up with local catches, and is particularly evident in highly accessible or preferred fishing locations. These locally reduced catch-rate situations can often reflect an allocation 'problem' between fishers or fishing sectors, rather than a stock sustainability problem,

Analyses of the total catch and effort of the entire fishery, along with an understanding of the impacts this level of catch has had on the overall age structure of the relevant fish stock and any changes in the catchability of the species through time, is necessary to discriminate between these alternatives. Such assessments are (or will be), the basis for determining the status and need for management (including closures) to protect the indicator stocks for each of our key fisheries in WA.

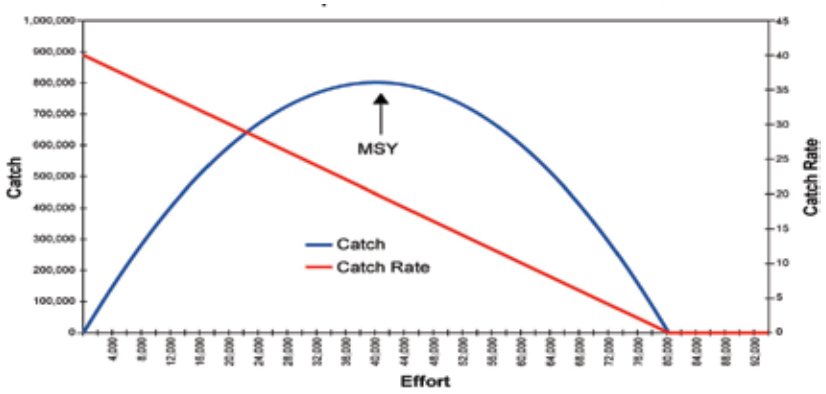

Figure 5. The theoretical relationship between the catches and catch-rates achieved from a fish stock with varying levels of fishing effort. The effort level where the maximum sustainable yield (MSY) is achieved and the point when the catch and catch rate reach zero and stock collapse has occurred is also shown.

Summary

In summary, the above misconceptions about the dynamics of marine fish stocks and how fisheries operate, suggests that the use of sanctuaries in WA, as a management tool is unlikely to generate the anticipated benefits to fisheries typically used to promote their introduction. Complete no-take closures/sanctuaries are in practice, a very coarse fisheries management tool because they are static, only area based and by definition cannot differentiate among fishing times/methods occurring in the area to be closed. Given the vastly different 'footprints' of each species that may reside within a region, any single sanctuary area will be a compromise in terms of the level of protection afforded to each species (Fletcher, 2003). The positioning of sanctuaries or complete no take fisheries closures can rarely be arranged to optimize the fisheries management requirements for more than one stock. Using this approach is therefore likely to result in a situation where any benefits of increased local abundance of some stocks may not exceed the loss of production for other sympatric species that could have been harvested on a sustainable basis from the closed area.

A good example of the management complexity required to protect a range of species in an area is the Shark Bay section of the Gascoyne bioregion of WA (Fig. 6). More than half this area is permanently closed to trawling, with other parts of the region having seasonally based trawling closures. This trawl closure system has been effective in maintaining the target prawn stocks over more than 40 years, but has also successfully maintained biodiversity in both the trawled and un-trawled areas of the Bay (Kangas, et al., 2007). Some other forms of fishing are, nonetheless, still allowed in these permanent and seasonal trawl closures (Fig. 6) which are subject to separate management systems, and in some cases include closures relevant to these other fish stocks. The overlapping fisheries include the commercial Inner Shark Bay Scale-fish and Gascoyne coast Blue Swimmer Crab fisheries and the recreational fisheries for snapper in the Eastern and Western Gulfs (Fletcher and Santoro 2009) The snapper closures and other regulations have different boundaries to the trawl closures because of the specific biological differences and processes being managed. The use of only no-take area management to accomplish all these sustainability outcomes would require the complete closure of the entire region, which would reduce the current sustainable catches generating annual income generated by the region by a minimum $A50 million.*

From this example, it is evident that to achieve long-term sustainability for WA's wild fish resources a comprehensive system of fishery-specific controls are generally required. For the Shark Bay fisheries, these include individual species size limits, seasonal and area closures (including some no-take or sanctuary areas) and catch quotas, as well as a suite of gear/effort-based rules setting out what type of fishing gear is permitted and areas of operation. While these controls together form a complex, but sophisticated mosaic of management arrangements, they have proved effective in ensuring the longer-term sustainability of all of these fish stocks concerned while also protecting their habitats and regional biodiversity.

* This does not include the value generated by recreational fishing or the processing sectors.

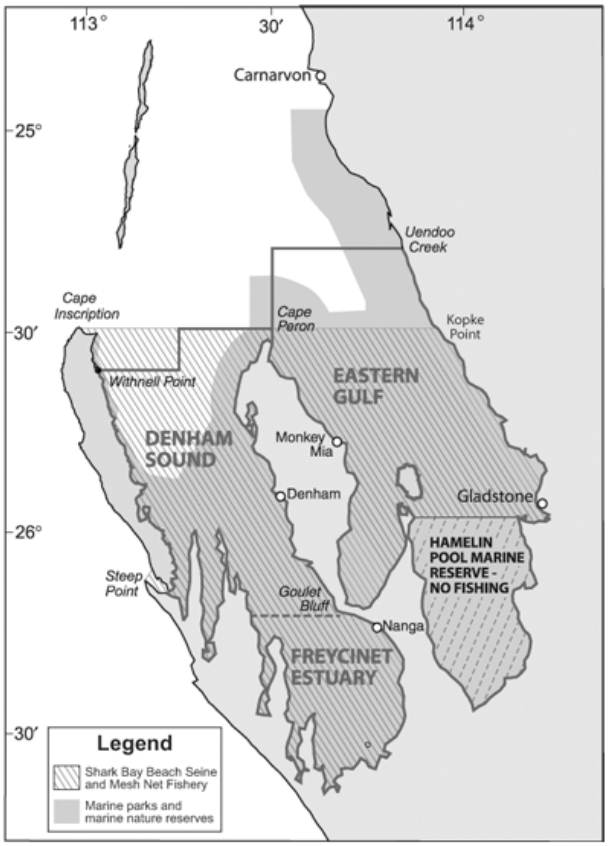

Figure 6a. The Shark Bay area showing the boundaries of the Beach Seine and Mesh Net Fishery, the boundaries of the Shark Bay Marine Park and the Hamelin Pool Marine Reserve (from Fletcher and Santoro, 2009)**.**

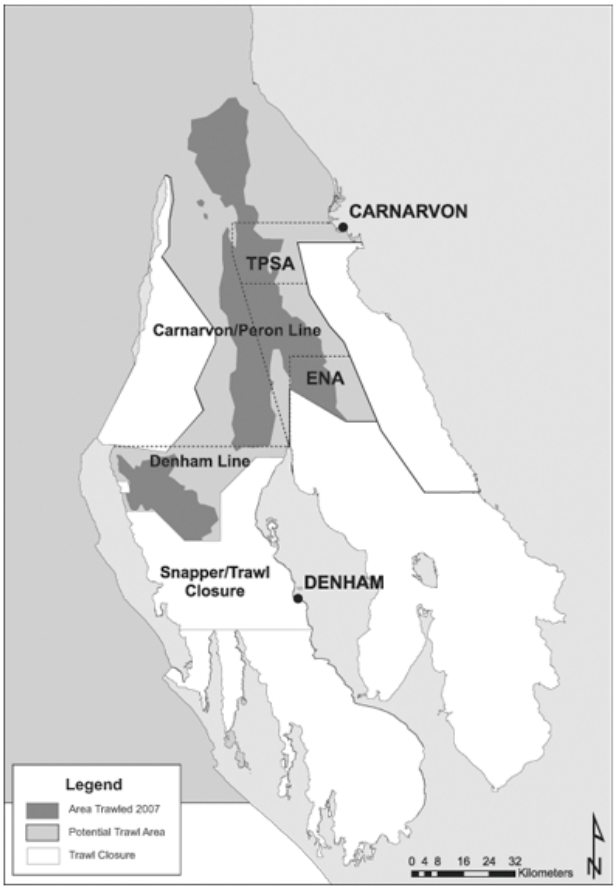

Figure 6b. The Shark Bay prawn fishery area showing the permanent closed areas, the temporary extended nursery areas (ENAs), tiger prawn spawning area (TPSA) closure, snapper trawling closure and the actual areas trawled (from Fletcher and Santoro, 2009)

6.3 The effective scale of monitoring for fisheries management and marine protected area performance

Any effective management system requires regular monitoring to assess if the objectives are being met. The current level of fish stock and resource monitoring undertaken in WA is comprehensive in scope and regular in frequency. This includes, all export fisheries having to undergo a regular (3-5 year) comprehensive, third party assessment process. Furthermore, the annual audit of the status of all fisheries and other significant marine resources are reported in detail annually within "State of Fisheries" reports, with summaries provided in the Annual Report to Parliament.

The status and assessment reports plus the underlying data collection systems are designed to provide information at the level appropriate to the distribution of the stock/species to enable assessments to meet the 'whole of stock' based objectives within the FRMA. The spatial scale of these assessments can cover the entire state, a full bioregion or in some cases just a specific management zone within a fishery. Therefore, the data recording systems and associated fisheries monitoring programs need to cover these large spatial scales related to fish stock distributions. These programs are not currently designed to provide information at scales relevant to individual sanctuary zones or in many cases even at the scale of the whole Marine Park, where the management issues are usually related to local abundances and biodiversity recording. Marine Park monitoring programs therefore require data on a scale considerably

smaller than the species/stock scale being assessed by the Department of Fisheries and are generally smaller than the statistical blocks used for fisheries data collection (eg Fig. 7).

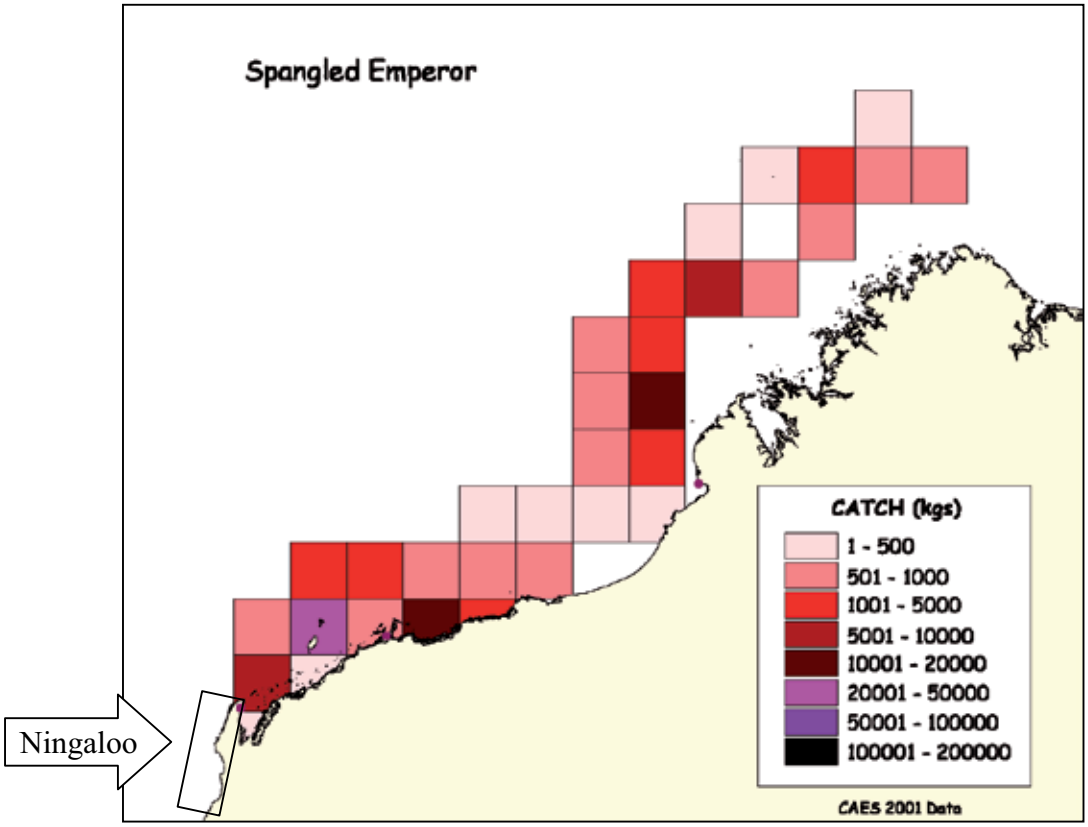

Figure 7. An example of the wide distribution of the stock of one of the key target species (spangled emperor, *Lethrinus nebulosus*) illustrated by the commercial catches in the Pilbara region of WA, in comparison to the area of the original Ningaloo Marine Park, which would be equivalent to about one of these statistical blocks. Note: commercial fishing is not permitted in Ningaloo (Figure modified from Newman et al., 2003).

The size of the standard commercial fisheries catch recording blocks (Figure 6) also highlights the mismatch in scale between the distribution of a typical fished species (spangled emperor, a key target species in the Ningaloo area) and the potential impact of fishing controls within a large marine park (eg Ningaloo Marine Park) on the stock as a whole.

Whilst the current data collection systems used by the Department are efficient in providing the necessary assessments at state-wide/stock level they have not been efficient in providing information for assessing the potential benefits or impacts of MPAs or even, more recently, in consideration of local scale objectives associated with IFM. Consequently, to demonstrate that the specific objectives of MPAs and their associated sanctuary zones are being achieved (and possibly for monitoring some IFM outcomes related to no-take uses), appropriately scaled new monitoring programmes will need to be established. These would require considerable changes to the data collection processes currently used and probably a substantial increase in the costs involved, resulting from the higher levels of variability often associated with the sampling of smaller areas.

6.4 Discussion

The dynamic nature of the marine environment, the general lack of physical boundaries and the extensive dispersal/colonization mechanisms available to almost all marine fauna and flora species noted above, are the primary reasons that management of fishing impacts on marine species and biodiversity requires more complex strategies than those employed to protect terrestrial species and their habitats. For the management of the harvested 'fish' component of marine biodiversity the public appreciation of the strategies required is further complicated by the largely counter-intuitive relationships between spawning stocks and recruitment, local fish abundance and total stock size, and the ability of fishers to actively respond to the management. These relationships are probably the main reason why there is a lack of empirical scientific evidence for benefits to overall fisheries productivity (not to be confused with the frequently recorded and expected outcome of locally increased densities) arising from 'non-specific'* sanctuaries. Moreover, the potential fishery benefits of sanctuaries will, by definition, be inversely proportional to the level of effective management being applied in the non-sanctuary areas.

In WA where comprehensive fisheries management arrangements, including a very high level of protection for marine habitats, were implemented during the early development phase for all major fisheries, the potential for fishing impacts on marine biodiversity has been relatively limited. No harvested fish stock has been reduced to a level where biodiversity has been affected and the general protection from habitat destructive fishing practices has prevented significant changes in the abundance of non-target species often seen elsewhere in the world. In this context, where WA has effectively a high level of 'marine protected areas' in the ICUN/ international context, additional sanctuary areas are unlikely to provide significantly increased overall protection for WAs relative pristine marine ecosystems and biodiversity.

With regard to fished stocks, the establishment of additional sanctuaries is also unlikely to improve the quality of fishing or quantity of fish caught in other sections of the WA coast. Furthermore, the areas surrounding sanctuaries may in some circumstances actually experience declines in catch rates due to effort being re-directed, and concentrated into a smaller space. Nonetheless, within an holistic, marine planning context small sanctuaries (or FHPs) in WA have the potential, if planned effectively, to provide useful 'socio-economic' and 'governance' benefits, as well as providing some necessary biodiversity reference areas and monitoring benefits as part of an overall scheme of management (Fletcher, 2003, World Bank 2006).

For sanctuaries within marine parks to be assessed and show whether they meet their specific objectives in terms of biodiversity benefits and scientific monitoring, data gathering at a finer scale than presently occurs through fisheries research programs will be required. Such programs are certain to require substantial additional funding if they are to be effective and not compromise the necessary broad scale/population based monitoring that is currently undertaken and critical to overall fish stock management. Thus, having clearly defined objectives and adequate resourcing for establishment of sanctuaries that recognise the biological, economic and social risks and expectations† that will arise from their implementation should be an absolute necessity.

* Closures not implemented to address specific stock concerns.

† This should take into account the opportunity cost of shifting access from one activity to another.

7.0 Conclusions and Recommendations

A review by Hilborn et al. (2004) concluded that the value of sanctuaries need to be evaluated in the context of (1) having clear biodiversity, ecosystem and fisheries objectives; (2) the social and institutional ability to maintain and enforce the closures; (3) they should compliment existing fisheries management actions and; (4) have the ability to monitor and evaluate success.

Each of these conclusions is relevant within WA. Furthermore, the assessments undertaken in this paper support the concept that clearly defined sanctuary areas will play a valuable, but clearly restricted part of an overall scheme of strategic marine management in WA. This is consistent with another recent review, which concluded that, "*MPAs must be designed and operated in the context of higher-order management frameworks"* (World Bank, 2006). Thus they must be designed specifically to:

- ensure that particular areas of the aquatic environment selected for sanctuaries are of appropriate size and in areas suitable for non-fishing/eco-tourism purposes ('no-take' uses; e.g. being able to easily see large fish) preferably as a part of meeting the overall regional planning outcomes;
- help protect identified vulnerable sedentary species needed to contribute to the biodiversity value of an area; and
- establish areas where marine habitats can be observed in the absence of most fishing-related impacts and therefore provide sites for research and the long-term monitoring of the marine environment (including the local ecosystem).

Consequently, there is a rational basis to support the establishment of marine sanctuary areas where they have clear, measurable objectives that relate to achievable benefits for tourism, biodiversity and other 'no-take' outcomes. There is, however, little scientific basis within the WA context to support their justification where they are proposed as a precaution against undefined and hypothetical 'bad practices' in the management of fisheries.

Where a sanctuary zone is being considered for a specific area, the planning process would be made more efficient by:

- ensuring there are clear, simple and measurable biodiversity, fisheries or ecotourism management objectives, which are meaningful to the key stakeholder groups and the general public, and that the area set aside is of a scale relevant to its purpose;
- ensuring that the site proposed takes into account and complements any existing fisheries or other management arrangements that could assist with protection of biodiversity.
- having a clearly specified, and fully costed research and monitoring program directly linked to the biological and socio-economic (tourism) objectives set, with appropriate performance indicators and a transparent reporting system.
- specifying periodic reviews that could include the provision of sunset clauses if any area is found not to be assisting in meeting the agreed objectives.

Whilst simplistic solutions (e.g. all fisheries need sanctuary zones) and generic management rules ('x'% always needs to be closed) are often promoted by lobby groups, this review suggests that they will rarely be optimal or appropriate when dealing with the management of complex, marine ecosystems and resources. Experiences in WA, and elsewhere, have shown that the only effective methods for the overall conservation and maintenance of fish stocks (i.e. not their local densities) and the management of fisheries are specific, directed and coordinated

controls on overall catch and effort across their entire range. Whilst these controls often include targeted, stock-specific spatial and/or temporal closure systems, complete no take closures (under either the FRMA or the CALM Act) that are not issue specific, will generally only make a minor contribution to meeting the community's broader fisheries and conservation objectives in the already highly protected coastal waters of Western Australian.

The effective management of MPAs, which overlay the wider geographic fisheries regulations, will also generally raise significant and ongoing compliance and education requirements, which will need to be adequately resourced. Multiple-use MPAs, incorporating significant sanctuary areas, are likely to generate significant costs and allocation issues for Government and therefore, should require a comprehensive cost benefit assessment during their design phase.

Long-term monitoring programs, including time-series data for harvested fish species will be required to assess impacts from the establishment of the sanctuaries and whether they have met the expected objectives. This will require new monitoring programs to be initiated, which will have to collect data at much finer spatial scales than has been previously undertaken for stock-wide assessments. Such programs must be adequately resourced so as not to compromise the current monitoring systems that are needed for stock-wide assessments.

The establishment of an across-State-Government-agency process for broad-scale marine planning, which integrates relevant policy and legislation, would greatly assist in achieving the best marine management outcomes for the WA community. It is further suggested that the planning process for future MPAs and sanctuaries within the marine waters of WA, would be more efficient and outcomes better if it were to follow the IUCN suggestion (Kelleher 1999) to recognise and build on existing protections for marine biodiversity, such as those provided by the FRMA.

It is anticipated that this review and analysis will be of use in the development of policies and strategies related to fisheries management and regional marine planning issues within WA, including the establishment of any new marine protected areas.

9.0 Acknowledgements

This paper has benefited from comments and discussion from a variety of people both within and outside of the Department.

10.0 References

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11.0 Further reading

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