The Allen Consulting Group

# The economics of marine protected areas

## Application of principles to Australia's South West Marine Region

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Report to the Conservation Council of Western Australia

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# Executive summary

## Introduction

The Commonwealth Government of Australia is currently in the planning and early implementation stages of developing a representative system of marine protected areas in Commonwealth waters by 2012. The primary goal is to establish a comprehensive, adequate and representative system of protected areas that will contribute to the long term ecological viability of marine systems, maintain ecological processes and protect Australia's marine biodiversity.

As part of this strategy, the Department of Environment, Water, Heritage and the Arts, in consultation with state and territory governments, is developing Marine Bioregional Plans for each of five regions. This focus of this report is on the South West Marine Region, for which a draft bioregional plan will shortly be released.

The Conservation Council of Western Australia has launched the 'Save Our Marine Life' campaign to ensure that conservation values are adequately considered as part of the planning process. The campaign is being supported by international and local conservation organisations, including The Nature Conservancy, WWF-Australia, the Pew Environment Group, Australian Conservation Foundation, The Wilderness Society, Conservation Council of South Australia, The Australian Marine Conservation Society, The Whale and Dolphin Conservation Society and Project Aware.

A variety of activities operate in the South West Marine Region, including commercial and recreational fishing, charter boat fishing, marine eco-tourism, shipping, petroleum exploration, defence, aquaculture shipping and ports. In some parts of the Region, competition for access to marine resources is intense.

## Project objectives

Currently the popular economic debate pertaining to marine protected areas is somewhat polarised by the economic losses that may occur should reserves be established and displace commercial and recreational fishing. Affected parties are putting forward a case for compensation. Less is understood or discussed about the potential 'win-win' outcomes and the economic benefits of marine protected areas for the community at large. This report has been written to redress this imbalance.

The report contains two main sections.

- First, the economic concepts and principles of marine protected areas are examined, with reference to the Australian and overseas economic literature. Contemporary thinking and evidence about the ecological benefits and economic value of marine protected areas are summarised.

- Second, the principles set out in the first section are applied to the Western Australian component of the region South West Marine Region. The aim of this analysis is to examine the indicative costs and benefits, to an 'order of magnitude', of establishing 'no-take' marine sanctuaries in the Region. It is beyond scope of the study to undertake primary data collection through survey or other means. All information presented is data that has been published elsewhere. The analysis should be regarded as a starting point to a more detailed study.

## Economic concepts and principles

There is clear evidence that marine protected areas result in ecological improvements within the no-take area. Based on observations reported in the literature, fish population densities in reserves are, on average, double that of populations in unprotected reference sites. Biomass is almost tripled and size and diversity of fish has been reported to increase by 20-30 per cent within reserves. Where reserves generate these ecological benefits, they appear to occur in a relatively short period of time of one to three years.

What is less certain is the extent of beneficial spillovers to adjacent areas outside the boundary of a marine reserve. Spillovers refer to the net export of fish larvae and/or adults from a marine protected area into a harvested area. The concept is that the protected area serves as a source of recruits to the surrounding fishery.

Transfers of larvae and fish out of a reserve need to be sufficiently high to ensure a spillover benefit to the adjacent fishery. But not so high that protection is no longer proffered by the reserve to spawning fish. The mobility of fish has a bearing on the effectiveness of a reserve as a means of protection.

There is evidence that ecological benefits of some (but not all) reserves have spilled over to neighbouring harvested areas and increased catch per unit effort and increased population size. The marine science literature suggests that spillovers are highly dependent on reserve design, especially if fish migrate on a seasonal basis and aggregate at different places and times throughout the year.

Bio-economics is the study of biological and economic relationships. In the context of marine protected areas, it is a modelling discipline that offers insights to:

- the costs to commercial fishermen in terms of closing off areas from harvesting;
- the economic value of subsequent increases in catch rates in areas adjacent to the protected areas (the 'spillover' effect);
- the behaviour of fishermen following a marine closure and the effect of this spatial redistribution of fishing effort on economic benefits; and
- the beneficial effect of marine reserves to commercial fisheries as a buffer or hedge against uncertain environmental shocks.

Bioeconomic modelling does not appear to have kept pace with the burgeoning policy interest in marine protected areas. While there is now a vast international literature on the ecological benefits of marine protected areas, less has been done to integrate economics with the biology.

Until recently, the accepted wisdom among many fishery economists was that marine reserves can only increase yields in fisheries that are experiencing substantially reduced recruitment.

But with increasing sophistication of bioeconomic modelling, marine economists are beginning to change their views on the value of marine protected areas as a fisheries management tool. Theoretical modelling has shown that due to the 'buffering effect' provided by marine reserves against environmental shocks and other forms of uncertainty, marine reserves can increase the cumulative harvest and generate positive economic payoffs even if harvesting is optimal and the fishery is not overexploited. Moreover, these benefits cannot be obtained from either input or output controls.

Australia's environment is highly variable from season-to-season and indications are that global climate change may exacerbate this variability, thus increasing the value of any buffer effect offered by marine protected areas.

### Implications for designing marine protected areas

The key message from the concepts and principles analysis is that policy makers need to be clear as to what goals marine protected areas are intended to achieve and must incorporate these objectives in the design of reserves.

The literature suggests that some design options will be highly successful at promoting biodiversity protection but deliver little in the way of beneficial outcomes for existing fisheries — and could in some cases impose significant costs. At the other extreme, the establishment of small sanctuaries or reserves that allow some limited extraction to continue (and hence cause limited displacement of fisheries) are likely to produce only weak improvements in biodiversity. The challenge is to identify the middle ground between these two extremes — that is design options that promote win-win outcomes where possible and that fulfil biodiversity goals without unacceptably high costs to other valuable uses of marine resources.

A second key message is that marine reserves should be understood as a complementary management tool to maintain or enhance yields rather than being used in isolation of effort and output controls. Marine protected areas cannot be expected to restore and maintain the 'health' of a fishery and the fish stocks it depends on in the absence of complementary controls on catch and effort.

A third implication of present research findings is that adaptive management is likely to be important. Marine ecosystems are complex, which often makes it difficult to be definitive about the status of fish stocks and other attributes contributing to ecosystem function. However, lack of absolute certainty should not be put forward as a reason to stall on policy interventions to protect ecological resources that appear to be at risk from irreversible damage. The 'best bet' set of design options should be identified that have the greatest chance of fulfilling the stated policy objectives. Then, once implemented, the marine sanctuaries should be monitored and evaluated for the purpose of making incremental improvements in reserve design where there is a strong case for doing so.

## The applied study

Indicative costs and benefits of establishing large scale marine sanctuaries in the South West Marine Region are estimated using available published information on the economic value of activities in the region, and expert assessment of the likely effect of protected areas on these activities — both positive and negative.

There is no detailed modelling underpinning this study. The estimates are based on approximate changes in economic values, working with information about the net value of existing fisheries and tourism activities in the region, together with estimates from the literature on non-market values ascribed to the marine environment.

### *Approach to measuring costs and benefits*

Costs and benefits are measured and defined in terms of changes in economic surpluses (or welfare costs/gains) that are likely to arise due to the implementation of marine sanctuaries. This approach ensures that all impacts are measured on a 'like-for-like' basis. The focus is on changes in the *net benefits* from alternative ways of using or conserving marine resources. A reduction in net benefit (or economic surplus) represents a cost.

All too often, the displacement costs of marine protected areas are misunderstood or misrepresented. For example, the cost to commercial fisheries is not equal to losses in the gross value of catch. This overstates the size of loss because gross values, by definition, do not take account of the cost of resources (labour and capital) involved in catching fish. If a fishery contracts as a result of a marine sanctuary, these resources would be freed up to be deployed in other productive uses in the economy.

Similarly, multipliers are often incorrectly used as a measure of the flow-on economic benefits generated by expenditures by commercial and recreational fishers on inputs and processing. But a large multiplier *does not* signify a large net benefit to the economy. The values involved are transfer payments between sectors rather than indicators of surpluses generated. The multipliers say nothing about whether land, labour and capital are being used most efficiently in terms of producing outputs with a high net value. Instead, the relevant measure of flow-on benefit is the aggregate sum of economic surpluses (or profits) generated by businesses servicing the fisheries.

### *Assumptions about the sustainability of existing fishing activities*

The fishery harvest benefits attributable to marine protected areas are partly dependent on the current biological state of the affected fisheries. All else being equal, fisheries that are overfished (with declining breeding stocks and catches that exceed maximum sustainable yield) stand to gain more from marine sanctuaries than those that are sustainably managed.

To the extent that the health of fish stocks are in jeopardy of failing or declining in some fisheries it would be incorrect to use figures of past economic profits in these fisheries as a measure of the benefits that may be lost if a marine sanctuary is established. Instead, losses would need to be calculated off a lower base.

This study adopts a conservative baseline whereby all fisheries continue to perform at their current levels. With the exception of a few fisheries, this is probably appropriate because according to the Western Australian Fisheries Department's 'State of the Fisheries Report 2007-08', most fisheries have adequate breeding stock levels and are not overfished. Exceptions include some shark species and some demersal scalefish species, for example dhufish, snapper and groper.

## Indicative dollar benefits

A network of large scale marine sanctuaries would principally serve to protect marine habitats and biodiversity for future generations, but also offer some benefits to existing commercial and recreational fisheries in terms of sustaining fish stocks through spillovers and a buffer against adverse environmental conditions. There are also benefits to ecotourism operators, whose businesses depend on the preservation of marine habitat.

Table 1.1

**INDICATIVE BENEFITS**

| Impact | Gain in economic surplus ($million per annum) |
|---|---|
| **Spillovers to commercial fisheries**<br>Will vary from fishery to fishery and be highly dependent on design of the protected area. A five per cent increase in catch per unit effort in the Rock Lobster Fishery is estimated to increase economic rent by $2.4 million. | Up to $2.4 million |
| **Fishery buffer benefits**<br>Likely to result in more stable catches and provide insurance against stock depletion. Improved catch stability would give professional fishermen better planning certainty for their business and possibly reduce the need for overdraft finance in low catch years. The buffer effect of marine protected areas could leave greater room for management error and buffer against adverse environmental events. | Not estimated |
| **Ecotourism direct benefits**<br>Currently $45 million in commercial revenues, with perhaps a net value of $10 million. Protected areas would support continued growth of the industry (relative to a scenario of a ceiling in visitor numbers). | $5 to $10 million |
| **Biodiscovery**<br>Marine sanctuaries protect genetic material for possible future screening and subsequent development of commercially valuable products. The value of preserving this future option is likely to be significant, but is difficult to estimate. | Not estimated |
| **Environmental non-market values**<br>A recent choice modelling study (McCartney, 2009) estimated that respondents were willing to pay, on average, $140 per year for a modest set of ecological improvements in Ningaloo Marine Park. When extrapolated to the State population aged 19 years and over, this equates to $222 million. | $100 to $200 million |

Table 1.1 summarises the indicative scale of these benefits in dollar terms. Spill-over benefits are conservatively estimated to be $2.4 million, representing the net increase in economic rent from a five percent increase in catch per unit effort in the Rock Lobster Fishery (the region's most valuable fishery). While ecotourism benefits arising from additional protection are important, and estimated to be in the order of $5 to $10 million per annum, the figures are dominated by the non-market values the community holds for non-harvest aspects of the marine environment – for example, diving, underwater photography, education and simply the knowledge that representative samples of the marine environment remain intact. Based on recent research, this could be in the vicinity of $100 to $200 million per annum.

### Indicative dollar costs

The proposed marine sanctuaries will partly displace some existing commercial and recreational fisheries. However, the combined loss in net economic value is likely to be less than $15 million per annum (Table 1.2). This estimate assumes that commercial and recreational fisheries operating offshore will contract by 15 per cent (in terms of both catch and profit). The charter fishing industry is likely to be more affected and could experience a 30 to 50 per cent reduction in value due to displacement from areas such as the Perth Canyon. This would represent at $0.75 million to $1.25 million loss in annual profit that would otherwise be generated if this industry was allowed to continue under the current arrangements.

The fishing losses are possibly at the upper end of the because of the conservative assumption that, in the absence of increased marine protection, all fisheries would continue to yield catches at their current levels. If this assumption did not hold and in fact catches reduced over time, then the displacement costs would be significantly less.

The flow-on impacts to businesses servicing commercial and recreational fisheries are not estimated. However, most if not all of these fisheries will continue to operate, so flow-on impacts are likely to be modest.

Reduced catches may lead to higher seafood prices, thus imposing a cost on consumers. But prices for rock lobsters are unlikely to be affected because price is set by overseas demand. Further, to the extent that fish stocks are declining and fishing costs are rising because of increasing scarcity, seafood consumers may experience real increases in price, even in the absence of marine protected areas.

Marine sanctuaries are unlikely to involve a significant displacement cost to the oil and gas industry because much of the South West Marine Region is not highly prospective for fossil fuels.

The establishment of a network of marine sanctuaries would give rise to management, administration and enforcement costs. The nature and size of these costs will be dependent on many factors, including the selected design for the sanctuaries and complexity of management rules. These costs have not been analysed in this study.

Table 1.2

**INDICATIVE COSTS**

| Impact | Loss in economic surplus ($million per annum) |
|---|---|
| **Displacement of commercial fishing**<br>Assumed that sanctuaries may result in a 15 per cent reduction in economic rent (or profit). This equates to $8 million in the Rock Lobster Fishery and $1 million in other commercial fisheries. | $9 million |
| **Displacement of recreational fishing**<br>15 per cent reduction in recreational boat catch in offshore waters, valued at $10 per fish (this value from composite results from various non-market willingness to pay surveys) | $1.8 million |
| **Displacement of charter fishing**<br>A 30 per cent to 50 per cent reduction in current aggregate profits for the industry (assumed to be $2.5 million) | $0.75 to $1.25 million |
| **Reduced demand for fishery support services**<br>Upstream and downstream businesses supporting the commercial and recreational fishing sector may be affected. However, most if not all of these fisheries will continue to operate, so flow-on impacts are likely to be modest. | Not estimated |

Notes: (1) The impact of marine protected areas on domestic seafood prices has not been included as a cost because it is be difficult to attribute definitively any observed price increases to marine protection. To the extent that fish stocks are declining and fishing costs are rising because of increasing scarcity, seafood consumers may experience real increases in prices even in the absence of marine protected areas. (2) Management, administration and enforcement costs associated with establishing a network of marine protected areas have not been included as these will be highly dependent on the institutional arrangements and other design parameters for the proposed marine protection plan, which have not been determined at the time of writing

## Conclusions

The key message that emerges from this study is that the direct economic losses to the recreational and commercial fishing sectors due to displacement are likely to be in the order of tens of millions as opposed to hundreds of millions. And this may be an over-statement of the direct losses because it does not allow for any positive buffer effects that marine reserves may confer on adjacent fisheries.

It is impossible to be more accurate than this without specific information about the exact location and design of marine sanctuaries, combined with advanced spatial and bio-economic modelling of the fisheries affected.

On the benefits side of the ledger, the figures are dominated by the non-market values the community holds for non-harvest aspects of the marine environment – for example, diving, underwater photography, education and simply the knowledge that representative samples of the marine environment remain intact. Values from a recent choice modelling study for Ningaloo and Ngari Capes suggest that this value could be large ($100 million plus), although it is not possible to apply this value with confidence to the marine protected areas mooted for Commonwealth waters without some customised survey work.

*Chapter 1*

# Introduction

## 1.1 Background

The Commonwealth Government has embarked on a strategy of developing a representative system of marine protected areas in Commonwealth waters by 2012. The primary objective of this strategy is to protect biodiversity. The goal is to:

> 'establish and manage a comprehensive, adequate and representative system of protected areas that will contribute to the long term ecological viability of marine and estuarine systems, maintain ecological processes and systems and protect Australia's biological diversity at all levels'
>
> Department of the Environment, Water, Heritage and the Arts, 2009.

As part of this strategy, the Department of the Environment, Water, Heritage and the Arts, in consultation with state and territory governments, is developing Marine Bioregional Plans, which are to include a system of marine protected areas in five Marine Regions around Australia — the South East, South West, North West, North and East Marine Regions. Marine Bioregional Plans are being established under Section 176 of the *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act). Planning is at different stages of completion for each of the Marine Regions.

### *The South West Marine Region*

This focus of this report is on the South West Marine Region, for which a draft bioregional plan will shortly be released. The Conservation Council of Western Australia has launched the 'Save Our Marine Life' campaign to ensure that conservation values are adequately considered as part of the planning process. The campaign is being supported by international and local conservation organisations, including The Nature Conservancy, WWF-Australia, the Pew Environment Group, Australian Conservation Foundation, The Wilderness Society, Conservation Council of South Australia, The Australian Marine Conservation Society, The Whale and Dolphin Conservation Society and Project Aware.

The Conservation Council is strongly supportive of establishing a network of large scale protected areas in Commonwealth waters that include large areas that are managed as 'no-take' areas, which would offer the greatest protection to fish stocks, biodiversity and habitat. In these areas, all forms of resource extraction would be prohibited but access would be allowed for non-extractive activities such as diving and whale watching tours.

The Commonwealth Government has stated that the Bioregional Plans may include protected areas with variety of levels protection status, ranging from 'no-take' to 'multiple use' (DEWHA, 2009). The latter refers to areas that would be zoned to include mixed harvest, restricted harvest and/or complete harvest prohibition areas, as well as other zones such as recreation or research. The Commonwealth Government is working from the principle that there may be no environmental reason for excluding extractive activities, provided that these activities can be well managed and it can be demonstrated that they have no adverse effect on biodiversity.

## 1.2 This report

Much has been written in Australia about the conservation benefits of marine protected areas. But much less is known about the economic costs and benefits that would ensue from establishing a network of protected areas in the South West Marine Region. Currently the 'economic debate' in the public policy arena is somewhat polarised by the economic losses of fisheries displacement and affected parties putting forward a case for compensation should the marine protected areas be established. Less is understood or discussed about the potential 'win-win' outcomes and the economic benefits of marine protected areas for the community at large.

This report has been written to redress this imbalance and dispel several common misconceptions about economics. First, there is a misconception that economics is only concerned about financial impacts and values. Because ecological impacts are mostly unpriced in markets, it is common for these aspects of resource use to be set aside and treated differently or worse still, not given the same level of prominence and attention as activities whose products have market values — such as commercial fisheries. In fact, economics is an 'umbrella' discipline that provides the tools to assess the values that the community holds for alternative ways of using and managing marine resources, including environmental and social values.

Second, the term 'value' has varied meanings and measures to different people. This adds confusion when it comes to comparing the effect of different options for using and managing marine resources. For example, gross value of fish catch is often used as a measure of the 'value' or contribution of commercial fisheries to the economy. And in the case of recreational fishing, expenditures on gear, bait, fuel and food is often taken as a measure of the contribution of this sector to the economy. From an economists perspective, neither of these are correct measures of contributions because economists have a precise definition of value. Value is defined in terms of economic surpluses (or welfare) gained and lost by people affected by a change in resource use.

These two principles are adopted in this report to examine the economics of marine protected areas. The report's objective is to provide a lay person with an interest in the current debate and policy proposals with a grasp of the key issues from an economic viewpoint and to provide an accessible guide to current economic thinking about the benefits and costs of marine sanctuaries.

Chapter two of the report contains a discussion of the economic concepts and principles of marine protected areas. It contains

- a synthesis of the Australian and overseas economic literature relating to conceptual frameworks for examining the economic benefits and costs marine protected areas; and
- a review of the 'accepted wisdom' about the ecological benefits and economic value of marine protected areas.

In Chapter three the concepts and principles set out in the previous chapter are applied to the South West Marine Region. The aim of this analysis is to examine the indicative costs and benefits, to an 'order of magnitude', of establishing 'no-take' marine sanctuaries in the Region. It is beyond scope of this study to undertake primary data collection through survey or other means. All information presented is data that has been published elsewhere.

It is stressed that the applied work in chapter three does not represent a rigorous cost-benefit analysis. It should be regarded as a starting point to a more detailed study.

*Chapter 2*

# Bio-economic principles and concepts of marine protected areas

## 2.1 Overview

This chapter contains a review of contemporary findings and 'accepted wisdom' about the ecological benefits and economic value of marine protected areas. The chapter opens with a discussion about the role of bioeconomic modelling and the various approaches to linkages between marine biology and economics. Next, the ecological benefits arising from marine reserves are examined, with particular focus on the significance (and evidence) of positive spillover effects to adjacent harvested areas. Factors influencing the scale of spillovers, and implications for the design of marine protected areas are examined.

This is followed by a summary of the main findings emerging from bioeconomic modelling to date — that is, in what circumstances are marine protected areas likely to produce a net economic benefit to commercial fisheries and what are the main 'success factors' responsible for delivering beneficial outcomes .

The chapter concludes with a discussion of the other potential benefits of marine protected areas that are unrelated to fishery production or recreational harvest. These benefits are set out in an economic framework, which demonstrates that the economic values of marine reserves extend beyond narrowly defined commercial or financial impacts.

## 2.2 What is bio-economic modelling?

The economics of marine protection is inextricably linked to the ecology of marine environments. A solid understanding of marine biology and the behaviour of fish stocks is therefore required to build a picture of the likely economic consequences of policy interventions such as the establishment of marine protected areas. Bio-economics is the study of biological and economic relationships.

It is common for bioeconomic models, or representations of reality, to be developed for the purpose of managing commercial fisheries. In these studies, physical information on the characteristics of fish populations, and the responsiveness of fish populations to human interventions (such as harvesting and habitat modification), is used to estimate the economic impacts of different levels of harvesting. Economic measures include catch per unit effort, value of harvest, economic rent and employment.

The value of bioeconomic modelling is to assist with understanding complex systems that cannot be easily conceptualised in a single dimension. When many variables interact to produce an outcome, it is often difficult to know the net effect of a change to the system in advance of connecting all the individual components of the system. Models can therefore be used as a tool for making more informed decisions.

There are a variety of approaches to bioeconomic modelling. Simulation models are designed to answer 'what if' questions — for example, what would happen to economic profits in a fishery if all half the commercial fishing boats were removed from the fishery? Optimisation models are designed to find a set of policy interventions that achieve one or more specified objectives — for example, the model would be set to 'solve for' the number of boats that would maximise sustainable economic returns in a fishery.

Models can be relatively simple or very complex. Some incorporate a time dimension, perhaps simulating or optimising over multiple years, while others are static in that one 'steady state' is compared against another steady state. The movement from one steady state to the next is not modelled or described. Some bioeconomic models incorporate uncertainty or risk, while others assume definitive functions for the modelled relationships. Yet another feature of these models is whether they are based on 'real data' or purely theoretic.

## 2.3 Bioeconomic models of marine protected areas

Bioeconomic modelling does not appear to have kept pace with the burgeoning policy interest in marine protected areas. While there is now a vast international literature on the ecological benefits of marine protected areas, less has been done to integrate economics with the biology.

The origins of bioeconomic modelling for commercial fisheries date back to 1954 with the development of the Gordon-Schaefer model. However, until relatively recently, little work had been done on the bioeconomics of marine protected areas. One of the first studies was a model of the efficacy of marine reserves developed by Holland and Brazee (1996). Since that time numerous other models have been developed, but according to Grafton et al. (2005) — who undertook an extensive review of the various bioeconomic models — there are relatively few published studies on marine protected areas that have integrated biology with economics.

The dozen or so models reviewed by Grafton et al. (2005) have examined one or more aspects of marine closures, with an objective of providing insight to whether this intervention produces net economic benefits measured in terms of long run commercial returns to fishermen and the main variables responsible for influencing the size of economic payoffs. A number of factors have been examined in these models:

- The immediate costs to commercial fishermen in terms of closing off areas from harvesting.
- Subsequent increases in catch rates in areas adjacent to the protected areas (referred to as the 'spillover' effect).
- Ecological factors influencing the size of the spillover effect.
- The behaviour of fishermen – how does effort redistribute following a marine closure? And what effect does this has on the economic benefits?
- The beneficial effect of marine reserves to commercial fisheries as a buffer or hedge against uncertain environmental shocks.

The key observations and conclusions drawn from these studies are discussed in the subsequent sections.

## 2.4 Ecological benefits within protected areas

The closure of areas from harvesting has the potential to change the population structure of fish species (characterised by age, gender or individual size) that, in turn, can increase breeding success. It can also prevent the marine habitat being damaged from certain types of fishing technique, such as bottom trawling.

There are various ecological indicators that marine scientists use to signal the health of fish populations. Areas that have been closed to harvesting are frequently observed to have fish of older age, larger size, increased number of species, greater abundance of individual species (that is, higher population densities and biomass), increased genetic diversity within a species and greater fecundity (number of eggs per female).

Many empirical studies have reported increases in fish abundance within a marine reserve after establishment of a no-take area. In a study of 112 independent measures of marine reserves, Halpern (2003) finds, relative to reference sites, that reserves on average appear to double population density, nearly triple biomass and raise size and diversity by 20-30 per cent within reserves. Where reserves generate these ecological benefits, they appear to occur in a relatively short period of time of one to three years (Halpern and Warner 2002). The empirical evidence also suggests that the ecological benefits are limited or negligible if only a partial closure of the area is implemented.

Kenchinton, Ward and Hegerl (2003) identify several factors responsible for the observed ecological benefits. Closed areas have the effect of

- protecting specific life stages, such as nursery grounds;
- protecting critical functions, such as feeding and spawning grounds; and
- providing dispersion centres for supply of larvae and new recruits.

In summary, there is unequivocal evidence of ecological changes in no-take areas following the formation of a marine reserve — albeit the extent of improvements being dependent of various biological factors. What is less certain is the extent of beneficial spillovers to adjacent areas outside the boundary of the marine reserve.

## 2.5 The spillover effect

### *Theory*

Spillovers refer to the net export of fish larvae and/or adults from a marine protected area into a harvested area. The concept is that the protected area serves as a source of recruits to the surrounding fishery. Larvae can increase recruitment into the fishery in the future and the migration of adults into the fishery are immediately available for harvesting.

The larger fish in protected areas produce more eggs and spawn more frequently (Roberts and Sargant 2000), thereby increasing the magnitude of the recruitment effect into surrounding areas. Moreover, these eggs are of higher quality (Venturelli et al. 2009).

Beverton and Holt (1957) were one of the first to conceptualise the spillover effect. They reasoned that if the rate of transfer of fish from a reserve to a harvested area is too low then a reserve will reduce aggregate catch from the fishery (because the reserve takes part of the fishery out of production). But if the transfer is too high, a reserve provides few harvesting benefits (for example, fish will not spend enough time in the reserve to benefit from its protection). They conclude that for a reserve to increase yields an intermediate case of fish transfer is required, and emphasise the difficulties of using reserves to manage fisheries because of the complexity in calculating the transfer of fish.

Grafton et al. (2005) note that transfers represent a trade-off in the sense that transfers out of a reserve need to be sufficiently high to ensure a spillover benefit to the adjacent fishery. But not so high that protection is no longer proffered by the reserve to spawning fish. Therefore, the mobility of fish may have a bearing on the effectiveness of a reserve as a means of protection. However, the science is divided on the ability of marine sanctuaries to protect highly mobile species. Hyrenbach et al. (2000) suggest that reserves are unlikely to be effective at protecting 'super mobile' fish such as large pelagic fish like tuna and bill fish that migrate over thousands of kilometres. Others take the view that there may be benefits to protecting critical habitat that is regularly visited for feeding and breeding by mobile species.

### *Evidence*

There is evidence that ecological benefits of some (but not all) reserves have spilled over to neighbouring harvested areas and increased catch per unit effort and increased population size (Gell and Roberts 2003, Roberts et al 2001) as well as harvests of larger and often more highly valued fish (Bhat 2003). Studies by Russ et al. (2004) and Beukers-Stewart et al. (2005) have demonstrated increases in the catch per unit effort of target species in adjacent non-reserve areas after the creation of a protected area. Alcalá and Russ (1990) found that catch per unit effort declined in adjacent areas after marine protection ended. Box 2.1 contains a number of case studies that demonstrate the spillover effect.

The marine science literature suggests that spillovers are highly dependent on reserve design, especially if fish migrate on a seasonal basis and aggregate at different places and times throughout the year. According to Lockwood et al. (2002), transfers from reserves to fished areas cannot be assumed to be a simple diffusion process without reference to currents or other physical factors. It requires both an understanding of dispersal distance and the number of population sources. The extent to which dispersal can occur naturally depends on a number of environmental variables (Kenchington, Ward and Hegerl 2003), including:

- prevailing water currents;
- the time of year when spawning occurs;
- the location of the young life forms;
- the ability of the young life forms to live without feeding; and
- the availability of suitable habitat and conditions outside the MPA for new populations to develop.

Although it is difficult to determine how many larvae protected areas supply to non-reserve areas, estimates suggest that the larvae of most fish and invertebrate species disperse further than the typical size of marine reserves (Halpern 2003).

Box 2.1

**CASE STUDY EVIDENCE OF THE SPILLOVER EFFECT**

***Cape Canaveral, Florida, USA (cited in Kenchington, Ward and Hegerl 2003)***

In 1962, two areas within the Merritt Island National Wildlife Refuge at Cape Canaveral – the Banana Creek Reserve and the North Banana River Reserve (totalling 40km$^2$) – were closed to fishing. This was as a security measure for the protection of the nearby Kennedy Space Centre, rather than for the purpose of biodiversity protection or fisheries enhancement. However, the closure of these areas proved to have significant spillover effects. Prior to the closure, there was intensive commercial and recreational fishing in the area and fish stocks were heavily exploited. In the decades after the closure, fish tagging studies have shown that at least two fish species (black drum and red drum) move out of the reserve and into surrounding waters. In addition, these fish have shown to be of record size compared to the same species caught in other parts of Florida. This is evidence for a substantial spillover of these fish from the reserve into the adjacent recreational fishery.

***The Philippines (cited in Salm, Clark and Siirila 2000)***

In 1985, a pilot project was introduced in three separate island communities in the Philippines in response to local concerns about overfishing and the destruction of coral reef systems. Under the program, 20 per cent of the coral reef of these islands was fully preserved, while other parts of the reef and fisheries were partially preserved. In the following year, fishermen on all three islands reported significantly improved fishing as a result of the preservation of the reef – which acted as a breeding ground for several fish species. A formal survey of Apo Island found a 32 per cent increase in total fish and an 83 per cent increase in edible fish. There was also a small increase in the number of species inhabiting the reef. Other projects in the Philippines have yielded similar successes.

***West Hawaii, USA (cited in Stevenson and Tissot 2009)***

In 1999, nine protected areas were created along the coast of West Hawaii in addition to the existing thirteen marine protected areas (MPAs). These new MPAs were established in response to public concern regarding perceived over-harvesting of reef fishes for the aquarium trade, and conflict between aquarium fishers and other community stakeholders such as environmental organisations and recreational diving operations. The new MPAs collectively prohibited aquarium fish harvesting along 35.2 per cent of West Hawaii's coastline. Seven years later, it was reported that both the total catch and the catch for the two most commercially viable species (yellow tang and goldring surgeonfish) in areas outside the MPAs were higher than at any time during the previous forty years. At least part of this increase is due to spillover from the MPAs (other factors such as an improved understanding of the reef have also contributed).

***Fiji (cited in Clua 2009)***

In 2002, four Fijian communities created a 'no-take' zone (Navakavu Marine Area) in their local fishing grounds in response to declining fish yields. Four years later, annual catch levels had increased by 3 per cent — an amount that is expected to increase in subsequent years, creating tangible economic benefits for the local community.

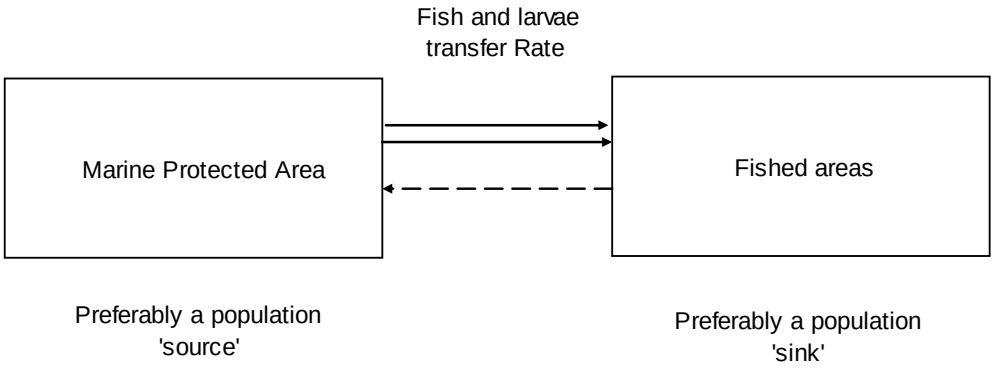
### *Protected area design factors*

A number of 'rules of thumb' emerge from the literature in relation to the effectiveness of marine reserves as a source of spillover benefits to adjacent fisheries, and ways that the reserves can be designed to increase their effectiveness.

- Reserves should be placed in 'source' habitats rather than 'sink' ones (Figure 2.1). Source habitats are those that support crucial life stages for fish, such as spawning grounds, nursery grounds and feeding grounds.
  - The role of no-take areas in protecting spawning grounds is particularly important. Many fish species migrate to spawning aggregation sites. If substantial fishing mortality were otherwise to occur at these sites (as fish are easier to catch when aggregated), then the creation of an protected area covering the spawning site should enhance larval production directly in proportion to the reduction in mortality that is provided (Halpern et al 2004).
- The spatial location of reserves is critical to population enhancement when there are directional currents. It is necessary therefore to consider larval and adult dispersal patterns.
- Protected areas need to be sufficiently large – for example, reserves of a small size may impose selective pressure for shorter larvae dispersal distance, that would not be beneficial for generating spillovers to adjacent exploited areas (Botsford et al. 2001).
- Single, isolated marine reserves favour the intensive redistribution of fishing effort along the reserve boundaries (Christie et al 2002). Current thinking is that a network of areas is more beneficial to the maintenance and abundance in areas adjacent to marine reserves.

Figure 2.1

**MARINE PROTECTED AREAS AS A SOURCE OF FISH**




## 2.6 Can protected areas generate economic benefits for fisheries?

There is a divergence of views on the net economic benefits of using marine protected areas as a fisheries management tool.

While there is clear evidence that protected areas produce ecological benefits within the no-take area and sometimes extending out as spillovers to harvested areas, this does not necessarily imply a net economic benefit to fisheries. This is because there are a number of economic factors that enter the calculation. For example, increases in catch per unit effort may not be sufficiently high to off-set the immediate loss of production from the areas closed to fishermen. The cost of catching fish also needs to be considered. Following the permanent closure of an area to fishing, fishermen will tend to redistribute their effort and possibly incur additional costs. How effort redistributes with a reserve depends not only on the biology but also on the costs and returns of harvesting in different locations. In some cases, spillovers could have a high economic value to fishers if they are located in areas that are close to port, and thus in 'low cost' areas.

In order to capitalise on spillovers, it is necessary to have adequate catch or effort controls in the fishery, otherwise some or all of the productivity gains from the protected area would be dissipated through increases in capacity.

A study by Goni et al. (2008), which investigated spillovers associated with six marine protected areas in the Mediterranean, reported positive spillovers that gave rise to increased catch per unit effort and subsequent increases in revenue extending up to 2500 metres from the boundary of the closed areas. The study found evidence of effort concentration and high fishery production near fisheries closures.

Halpern et al. (2004) reason that based on their observation of ecological improvements in no-take areas, adjacent fisheries should always obtain a net benefit from the establishment of protected areas. They estimate that, regardless of the size of the protected area or the number of fishermen displaced by the creation of the reserve, a doubling of the production of larvae inside the reserve should compensate for displaced fishing effort. Taking the conservative assumption that gamete production increases linearly with biomass, and given that the creation of marine protected areas leads to on average a tripling in biomass within the reserve, the authors estimate further that gamete production will at least triple within reserve — which would compensate for the displacement of fishing effort resulting from up to a 50 per cent closure of a fishery.

However this view is not shared by all. Until recently, the accepted wisdom among many fishery economists was that marine reserves can only increase yields in fisheries that are experiencing substantially reduced recruitment (Grafton et al. 2005). For example, Holland (2000) used simulation modelling to show that that protected areas can lead to increased levels of sustainable harvest and revenues in circumstances where (a) fish stocks had been reduced to low levels and (b) fishing effort was very high prior to the establishment of a marine reserve. Under these conditions, the reserve could allow populations to recover and spillover into adjacent fished areas.

Articles by fishery economists Hannesson (1998) and Anderson (2002) conclude that while protected areas could allow heavily exploited fish stocks to recover — and hence boost fishery revenues in the longer term, this could also be accomplished with more direct controls on fishing effort or harvest.

As the sophistication of bioeconomic modelling has improved, and risk and uncertainty has been incorporated, some marine economists are beginning to change their views on the value of marine protected areas as a fisheries management tool. Theoretical modelling by Grafton et al. (2006) has shown that due to the 'buffering effect' provided by marine reserves against environmental shocks and other forms of uncertainty, marine reserves can increase the cumulative harvest and generate positive economic payoffs even if harvesting is optimal and the fishery is not overexploited. Moreover, these benefits cannot be obtained from either input or output controls.

The general conclusion from recent theoretical economic work is that in a 'constant environment' a reserve is likely to reduce the economic payoff from fishing if effort controls are optimal. By contrast, in a fluctuating environment reserves can be ecologically and economically beneficial by reducing the variation in the population (and hence fluctuation in catch rate). Australia's environment is highly variable from season-to-season and indications are that global climate change may exacerbate this variability, thus increasing the value of any buffer effect offered by marine protected areas.

## 2.7 Protected areas as a form of insurance for fisheries

The literature shows that the value of marine protected areas is understated if environmental and other uncertainties inherent in biological systems are not taken into account. Marine reserves may also be of value as 'insurance' to management failure from an inability to control either fishing effort or harvests in exploited areas, or insurance against the risk of setting inappropriate total allowable catch due to a misreading of the available stocks.

Grafton et al. 2005 make the following points:

- In an uncertain environment, if a reserve reduces the mortality rate within its boundaries then it can also raise the likelihood that the reserve population (and also the entire population because of transfers out of the reserve) will not be depleted or destroyed due to a negative shock.
- Also, by separating a population into exploited areas and reserves, the nature of the negative shocks may be different and may even be mitigated in reserves if the shocks are correlated with the level of harvesting.

In a subsequent study, Grafton et al. (2006) identify a 'resilience effect', defined as the speed it takes for a harvested population to return its level before the shock, that increases with reserve size. Resilience occurs because a greater population density in the reserve allows for a transfer of fish to the harvested area. This is advantageous because it permits fishers to harvest at a higher rate immediately after a negative shock compared to a situation without a reserve.

## 2.8 Other economic impacts

From the preceding discussion it can be noted that bioeconomic models of marine protected areas typically focus on a sub-set of impacts — that is, the economic costs and benefits accruing to commercial fisheries (and sometimes recreational fisheries and/or the charter fishing industry) operating in the vicinity of the protected area. The main variables of interest in these studies are the nature and magnitude of the spillover effect and the scale of displacement costs.

But there are several other objectives of establishing marine protected areas that are quite independent of fishery management. These include:

- the preservation of 'good examples' of pristine marine habitat and biodiversity;
- the establishment of unfished 'control areas' for the purpose of scientific research; and
- the protection of natural or physical features from disturbance (either for ecological benefit or cultural/heritage purposes or both).

Table 2.1 contains a summary of the benefits arising from the pursuit of these other objectives, which are commonly cited in the literature. It is relatively straightforward to estimate dollar values for some of these benefits – for example, ecotourism and possibly biodiscovery, where there are established markets available for observing people's willingness to pay. But valuing cultural heritage, existence values, option values and bequest values in dollar terms is more difficult.

Economists have a strict interpretation of the term 'value'. Value is defined in terms of economic 'surpluses' gained and lost by people affected by a change in resource use. For consumers, the value of consumption is equal to the maximum amount the consumer is willing to pay for a unit of the good or service. While acknowledging the challenges of estimating these values, there are survey techniques available for collecting information on people's preferences and willingness to pay for alternative outcomes. The next chapter provides a summary of values estimated by a number of such studies that have been undertaken for marine reserves.

Table 2.1

**NON-FISHERY BENEFITS OF MARINE PROTECTED AREAS**

| Benefit | Description |
|---|---|
| Ecotourism | Areas with pristine marine habitats, unique or unusual seabed features and/or an abundance of fish are likely to be attractive for various forms of ecotourism, including diving, underwater photography and whale watching. This is particularly true for areas located inshore. |
| Biodiscovery | Marine biodiscovery refers to the limited harvesting of aquatic organisms for genetic screening with the aim of finding commercially valuable chemical compounds. Areas of high biodiversity are more attractive to bioprospectors because the probability of finding something useful is increased. Preserving genetic diversity now holds the promise of a possible future, and as yet unknown, benefit (for example, a medicinal drug). |
| Ecosystem services | Marine areas fulfil a wide range of 'services' that are often taken for granted — for example, nutrient cycling, shoreline maintenance, sand production and waste assimilation. |
| Education | Marine protected areas provide opportunities for people to experience and study marine plants and animals in their undisturbed state. |
| Scientific knowledge | Areas closed to harvesting or disturbance serve as benchmarks or reference points against which to compare other areas that have been exposed to harvesting. |
| Cultural heritage | Marine reserves can be used to protect places that have cultural significance, such as historic shipwrecks or archaeological sites as well as places that are sacred to Aboriginal Australians and Torres Strait Islanders. |
| Option value | The benefits relating to biodiversity protection are mainly related to non-use values, and more specifically to option values. Option value is a kind of insurance premium warranting the possibility of a future use. Quasi-option value is the value of information gained by delaying a decision concerning the use of a resource that results in irreversible effects. |
| Existence value | Existence value is an economics term given to the value that some people may hold for the very knowledge that the marine environment is maintained in a 'healthy' or sustainable condition. It is a non-use value as people need not visit the site to experience this value. |
| Bequest value | Bequest value is also a term from the economics literature. It refers to the value that people hold for passing on current environmental assets to future generations in the same or better condition. |

Source: Based on Kenchington, Ward and Hegerl (2003)

## 2.9 A framework for consolidating the benefits and costs

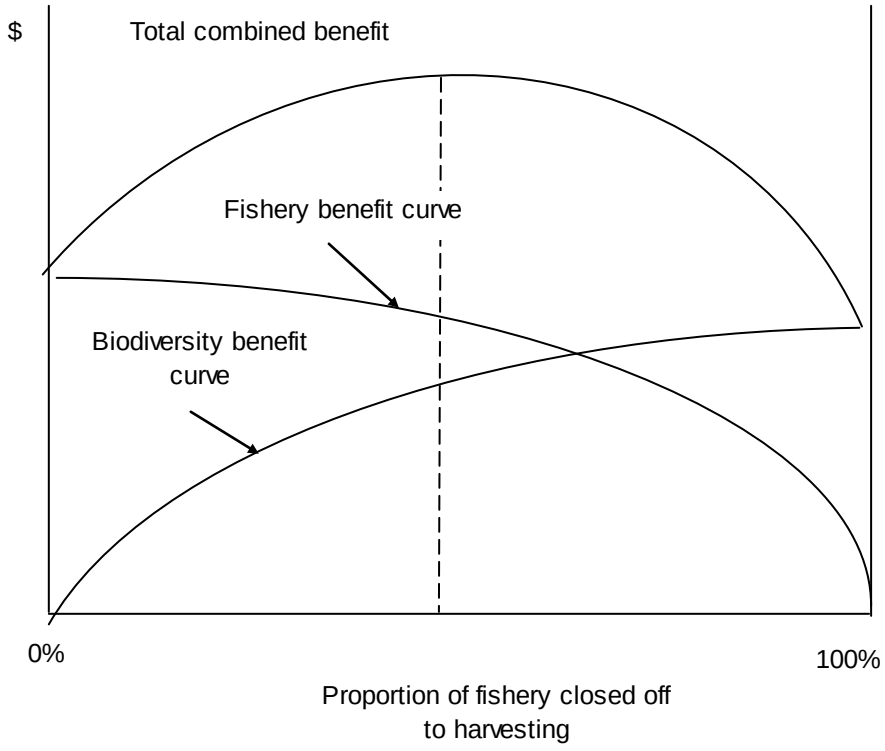
Owing to the multiple objectives that often underpin proposals to establish marine protected areas, it is important to adopt a framework that is capable of comparing the benefits and costs on an 'apples for apples' basis.

Some of the objectives of closing off areas from harvesting and other forms of extractive use are complementary. For example, as discussed above, there may be 'win-win' outcomes for the environment and for fisheries production. However, depending on the scale, number and chosen locations of the marine protected areas, there could be 'win-loss' outcomes.

The economics discipline can assist with understanding the size of trade-offs and identifying the best use of marine resources for maximum net benefit to society (including both market and non-market benefits). This concept is illustrated in Figure 2.2, which shows individual benefit curves for, (i) progressively larger allocations of the marine resource to commercial fishing; and (ii) progressively larger allocations of the resource to biodiversity protection. A third curve, overlaying these individual curves is a total benefit curve for different combinations of resource allocations between these competing uses. The dotted vertical line shows the allocation that generates the greatest combined benefit.

Figure 2.2

**CONCEPTUAL DIAGRAM OF ECONOMIC BENEFITS FROM COMPETING USES OF MARINE RESOURCES**



A recent economic study of management changes in the Great Barrier Reef Marine Park (GBRMP) exemplifies the concepts of maximising total social benefit from multiple uses of a marine resource. The GBRMP is one of the world's largest marine parks comprising 345,000 square kilometres extending from the tip of Cape York to just north of Bundaberg in Queensland. Numerous cost-benefit analyses have been undertaken since its declaration as a marine park in 1975. The case study set out in Box 2.2 illustrates the costs and benefits of introducing a new Zoning Plan in 2004 that expanded the total area of the GBRMP zoned as 'no-take' from 4.6 per cent to 32.5 per cent.

Box 2.2

**GREAT BARRIER REEF MARINE PARK**

Prior to expanding the 'no take' area of marine protection to 32.5 per cent of the GBRMP, an economic assessment was made of the proposal. Overall, this assessment found that:

- there was a strong linkage between maintaining the GBRMP in a health state, and safeguarding and enhancing the value of economic-use activities;
- economic-use activities undertaken in the GBRMP (tourism, fishing and recreation) had a direct gross value of production (GVP) in excess of $890 million per annum, and directly employed around 10,000 people;
- these economic-use activities created flow-on economic benefits of approximately $760 million annual in GVP, and indirect employment for around 7000 people; and
- the principal economic cost of the Zoning plan — the value of forgone fishing activity — was estimated at between $0.52 and $2.59 million per annum, including downstream impacts on fish processors.

The conclusion was that there was a strong case for introducing the Zoning Plan on purely economic grounds, as the potential benefits were highly likely to outweigh the expected costs. Even a minor increase in visitor numbers (resulting from the increased attractiveness of a well-maintained reef ecosystem) would represent a considerable boost to the economic impact of the tourism sector in the region.

Furthermore, if non-economic values were to be considered, the benefits of improving the GBRMP would be even greater. Such values include the range of cultural, social and Indigenous values associated with the Park, as a well as environmental values (such as existence values, option values, and ecosystem services). Part of the existence and option values alone has been estimated at approximately $98 million per annum.

Thus, the final conclusion was that 'given the high value of the environmental and economic benefits of the Zoning Plan relative to the modest aggregated economic costs, the Zoning Plan is likely to deliver substantial net benefits for Queenslanders and the broader Australian community'.

On the 1st of July 2004 the size of the no take areas was increased as per the Zoning Plan. Early signs suggest the zoning changes have met with some success. The GBRMPA has noted that recent research indicates that coral trout is now roughly 50 per cent more abundant, and research from James Cook University has indicated that the numbers of both coral trout and stripy sea perch were more than 1.7 times higher and average fish size was larger.

Source: Day (2002); P.D.P Australia (2003).

## 2.10 Conclusion

The key message from this chapter is that policy makers need to be clear as to what goals marine protected areas are intended to achieve and must incorporate these objectives in the design of reserves. The literature suggests that some design options will be highly successful at promoting biodiversity protection but deliver little in the way of beneficial outcomes for existing fisheries — and could in some cases impose significant costs. At the other extreme, the establishment of small sanctuaries or reserves that allow some limited extraction to continue (and hence cause limited displacement of fisheries) are likely to produce only weak improvements in biodiversity. The challenge is to identify the middle ground between these two extremes — that is design options that promote win-win outcomes where possible and that fulfil biodiversity goals without unacceptably high costs to other valuable uses of marine resources.

A second key message is that marine reserves should be understood as a complementary management tool to maintain or enhance yields rather than being used in isolation of effort and output controls. Marine protected areas cannot be expected to restore and maintain the 'health' of a fishery and the fish stocks it depends on in the absence of complementary controls on catch and effort.

A third implication of the material presented in this chapter is that adaptive management is likely to be important. Marine ecosystems are complex, which often makes it difficult to be definitive about the status of fish stocks and other attributes contributing to ecosystem function. However, lack of absolute certainty should not be put forward as a reason to stall on policy interventions that protect ecological resources that appear to be at risk from irreversible damage. The 'best bet' set of design options should be identified that have the greatest chance of fulfilling the stated policy objectives. Then, once implemented, the marine sanctuaries should be monitored and evaluated for the purpose of making incremental improvements in reserve design where there is a strong case for doing so.

*Chapter 3*

# Application of principles to the South West Marine Bioregion

## 3.1 Introduction

To date, extensive planning and consultations have been undertaken by the Commonwealth Government in preparing a draft Bioregional Plan for the South West Marine Region. The Draft Plan is yet to be published but the Department of the Environment, Water, Heritage and the Arts has released a document titled 'Areas for Further Assessment', which provides a broad overview of seven areas that have been identified for the development of marine reserves. These areas are shown in figure 3.1, shaded in blue on the map. The areas do not represent reserve boundaries, but do denote the areas containing representative marine ecologies, geomorphologic and oceanographic characteristics. It is expected that marine protected areas would be established within the boundaries of these areas.

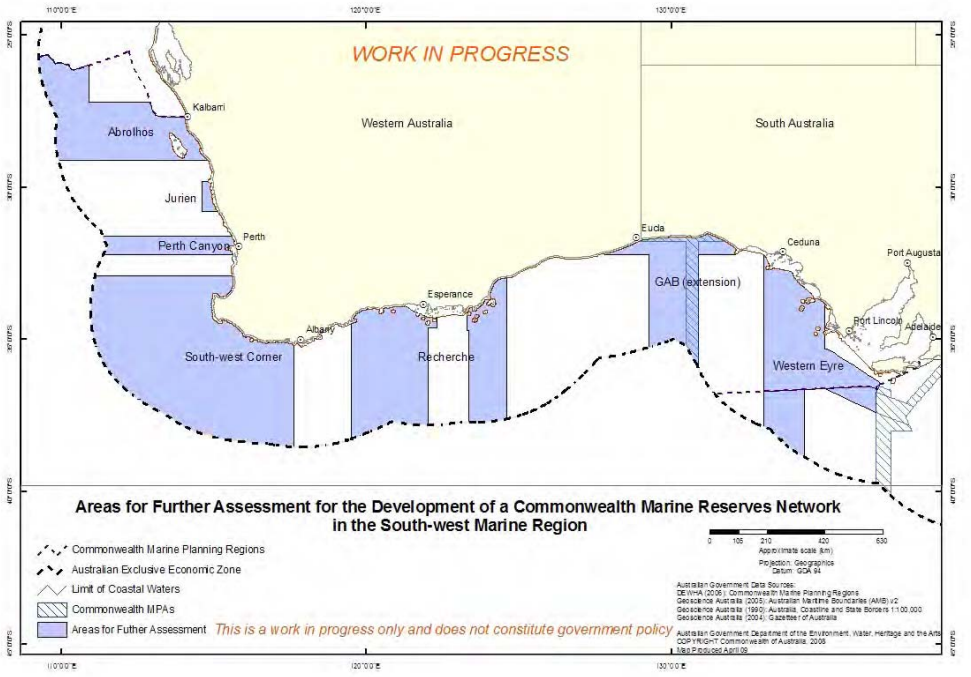
While detailed zoning has not yet been determined for the South West Marine Region, the Conservation Council of Western Australia has suggested that international and national benchmarks would give a good indication of the necessary protection for the Region. These benchmarks are typically set such that a minimum of 20 to 30 per cent of a marine area representing a particular habitat type is set aside as a 'no take' zone (The Ecology Centre, The University of Queensland, 2009). This level of protection is adopted in the Great Barrier Marine Park, Ningaloo Marine Park and accord with the recommendations of the IUCN World Parks Congress.

This chapter reports the findings of a 'rapid analysis' of the potential costs and benefits of establishing a network of marine protected areas in the Western Australian portion of the South West Marine Region. Waters located off the coast of South Australia are beyond the scope of this study. The analysis builds on the principles discussed in the previous chapter.

The purpose of the analysis is to examine the indicative costs and benefits, to an 'order of magnitude', of establishing 'no-take' marine sanctuaries in the Region. It is stressed that the study does not represent a rigorous cost-benefit analysis. It should be regarded as a template for a more detailed study as opposed to being conclusive.

Figure 3.1

**AREAS FOR FURTHER ASSESSMENT FOR THE DEVELOPMENT OF A COMMONWEALTH MARINE RESERVES NETWORK IN THE SOUTH-WEST MARINE REGION**




Source: Department of Environment, Water Heritage and the Arts (2009), *Areas for Further Assessment,* Marine Bioregional Planning in the South-west Marine Region.

## 3.2 Current activities in the region

A variety of marine activities, both commercial and non-commercial, operate in the region. They are:

- commercial and recreational fishing, including charter boat fishing;
- marine eco-tourism;
- shipping;
- gas and petroleum exploration;
- defence;
- aquaculture;
- biodiscovery (or bioprospecting); and
- ports.

The analysis confines its focus on a subset of these activities, namely commercial and recreational fishing, charter fishing, eco-tourism and biodiscovery. Aquaculture is not a prominent industry in south west Western Australia and where it does occur, the activity is mainly located inshore as opposed to Commonwealth waters. Defence, shipping and port activities are important and would need to be carefully considered in any marine park planning. However, these activities are not dependent on the biology of fish stocks and the marine habitat. The south west marine region is largely non-prospective for economically viable gas and petroleum deposits.

## 3.3 Western Rock Lobster Fishery

The Western Rock Lobster Fishery is the major fishery operating in the region and therefore is given the most attention in this paper. The fishery supports about 490 lobster fishing boats and has an average annual catch of 11,000 tonnes valued at about $250 million. It is estimated that approximately 1600 to 2000 people are directly employed in the fishery (ERA, 2006). This does not represent full time jobs, as the season runs for eight and half months and other employment is often pursued by owner skippers and crew in the 'off season'.

The fishery is characterised as having large seasonal variability in catches. While the long term average catch is about 11,000 tonnes, the quantity of rock lobsters caught can vary significantly from season to season, for example, by up to 4,000 tonnes either side of the average.

The sustainability of the fishery is maintained by limiting total allowable effort, including limitations on the number of licences, pots, fishing times, the size and breeding status of lobsters allowed to be taken and other gear restrictions.

The fishery ranges from Shark Bay in the north to Cape Leeuwin in the south and extends for approximately 60 kilometres off shore (figure 3.2). For management purposes, the fishery is divided into three zones:

- Zone A — Around Abrolhos Islands.
- Zone B — Northern boundary to 30th parallel, including an area referred to as 'Big Bank'.
- Zone C — From 30$^{th}$ parallel to the southern boundary.

Zone C is the largest and most significant part of the fishery, as it accounts for approximately 50 per cent of the catch and about half of all boats operate in this zone (table 3.1).

Figure 3.2

**WESTERN ROCK LOBSTER FISHING ZONES**

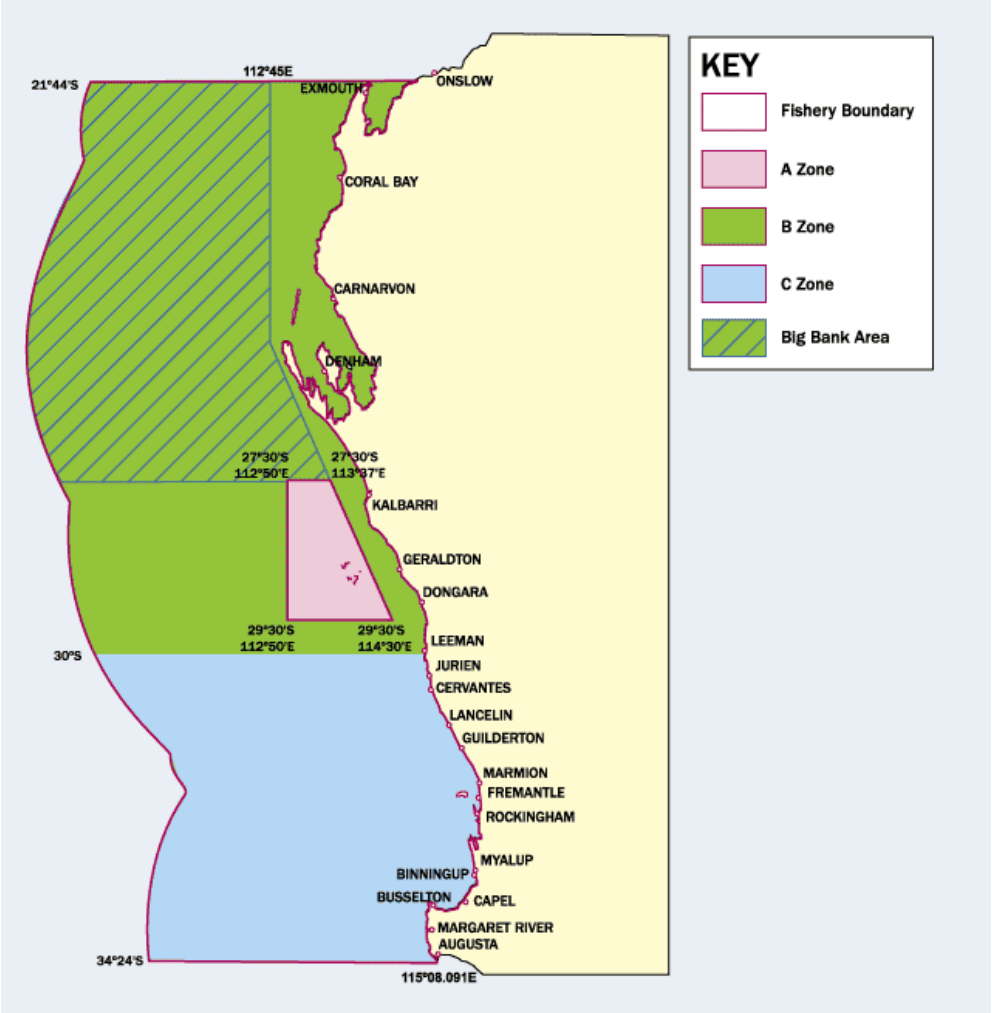



Table 3.1

**AVERAGE ROCK LOBSTER CATCHES BY ZONE**

| Zone | Number of boats | 10 year average catch in tonnes (1995-96 to 2004-05) | Catch as a per cent of total |
|---|---|---|---|
| Zone A | 128 | 1,823 | 16% |
| Zone B | 111 | 3,571 | 31% |
| Zone C | 252 | 6,091 | 53% |
| **Total** | **491** | **11,488** | **100%** |

Source: Economic Research Associates (2006).

### Status of rock lobster stocks

Based on assessments made by the Western Australian Department of Fisheries, the Western Rock Lobster fishery is regarded to be fully exploited and operating at sustainable levels of catch, estimated to be between 10,000 and 15,000 tonnes per year (see 'State of the Fisheries' Report 2007-08). While breeding stocks are considered to be 'adequate', recent modelling by the Department of Fisheries is predicting that catches in the 2010/11 fishing season will be the lowest catch in the previous 50 years (forecast at 7,200 tonnes) due to very low numbers of larval-stage lobsters (puerulus) settling on inshore reefs along the west coast (Fisheries Department 2009). Fishery scientists use puerulus settlement as an indicator of catches three to four years out because in the past there has been a strong correlation between settlement and future catch.

It is known that environmental factors such as the strength of the Leeuwin Current, winter/spring westerly wind patterns and water temperatures play an important role in determining the survival and settlement of larval lobsters. Historically, these environmental conditions have oscillated on a cyclic basis, varying from being favourable to unfavourable to puerulus settlement. However, in 2007-08 and 2008-09, puerulus settlement was poor even with conditions that should be favour good settlement. This is a marked departure from observed patterns that have prevailed since records first began in the 1960's. Fishery scientists are now reviewing the possible causes of the low puerulus settlement.

In February 2009, urgent measures were introduced to reduce effort in the fishery. Big Bank was closed for the 2008-09 season due to concerns about the level of breeding stock in the area, which could be a contributing factor to the recent low puerulus settlement. Effective from 1 March, the fishery is closed on Saturdays, Sundays and Mondays. And there has been a 15 per cent reduction in the 'unit values' of pots (which is means of controlling the number of allowable pot lifts per vessel).

### Economic impact of marine protected areas on the fishery

The designated 'areas of interest' set out by the Commonwealth for establishing marine protected areas partly coincides with the three zones in which the Western Rock Lobster Fishery operates. As about half the catch is generated from Zone C, the introduction of 'no-take' areas in this Zone is likely to have a proportionally greater impact on the fishery than the establishment of sanctuaries in either of the northern zones.

With reference to the previous chapter, marine protected areas can affect commercial fisheries in four main ways:

- Displacement — that is, loss of access to protected areas and consequent harvest loss from these areas.
- Spillovers — potential increases in catch per unit effort in areas adjacent to the protected area.
- Improved resilience of fish stocks to environmental shocks — which may result in less seasonal variability in catch and lower risk of a fishery 'crashing' should errors arise in the assessment of sustainable catch.

- Fishing costs per unit of catch — may change, depending on where the marine protected areas are located, how the fishing fleet redistribute its effort and how effort levels are managed or adjusted after establishing the marine protected area(s).

It is difficult to determine the scale of each of these impacts and the net economic effect they may have on the Western Rock Lobster fishery. There are two reasons for this. First, the scale of impact is likely to be sensitive to the exact location, size and number of sanctuaries — all of which have not been defined to a sufficient level of detail at this stage. Second, biological relationships that would govern the size of beneficial spillovers are not well known at this stage.

However, it is possible to provide some 'order of magnitude' estimates of the likely scale of economic loss under a range of displacement scenarios.

### *Displacement costs*

A simple approach to estimating displacement cost is to equate losses to reductions in gross value of catch that may occur as a result of establishing no-take areas. However, this would overstate the size of loss as gross values, by definition, do not take account of the cost of resources (labour and capital) involved in catching lobsters. If the fishery contracted, these resources would be freed up to be deployed in other productive uses in the economy.

Therefore, when assessing economic impacts, the relevant measure is the change in 'economic rent' generated by the fishery. Economic rent is the *net return* obtained from harvesting lobsters after subtracting all costs, including operating costs, capital costs and a rate of return on capital (which is required to keep capital employed in the fishery). The market price for pot licenses provides an indicative measure of the amount of economic rent being generated in the fishery. In recent years, pot licenses have traded at about $30,000 each. This represents the amount fishermen are prepared to pay now for a future stream of expected profits obtainable from the licence. There are 56,813 pots in the fishery, so the total capitalised value of the fishery is calculated to be $1.7 billion. At a discount rate of 3 per cent, this equates to an annual economic rent of $54 million, or $4.90 per kilogram of lobster (assuming an average catch of 11,000 tonnes).

This figure is commensurate with observations in the industry that costs make up just over 50 per cent of direct operational revenues (ERA, 2006). For example, in an average season the gross value of catch may be $250 million. Net profit (after direct operating costs) would be $125 million. After allowing for a rate of return on capital employed in the fishery (boats and equipment), this value could plausibly be reduced to a figure in the vicinity of $54 million.

A contraction to the fishery, caused by the establishment of marine protected areas, could result in reduced economic rents being generated — principally because fishermen have access to less of the 'available' stock. A simple analysis of the possible scale of impact is given in table 3.2. Losses in economic rent are calculated for three scenarios in which average catches are reduced by 10 per cent, 15 per cent and 25 per cent. If we assume that these catch reductions produce proportional reductions in economic rent, then the annual net losses are estimated to be $5 million, $8 million and $14 respectively.

This one-to-one relationship between catch and economic rent may not hold in reality because a share of total costs in a fishery are fixed, meaning that a one per cent reduction in catch may lead to a greater than one per cent reduction in rent. However, in the absence of more detailed modelling, the estimates presented in table 3.2 provide an indication of the likely scale of economic loss.

Table 3.2

**DISPLACEMENT COST TO THE ROCK LOBSTER FISHERY**

| Per cent reduction in average catch | Absolute reduction (tonnes) | Reduction in annual economic rent ($ mill) |
|---|---|---|
| 10% | 1100 | 5 |
| 15% | 1650 | 8 |
| 25% | 2750 | 14 |

The results of the analysis in table 3.2 are conditional on a number of other simplifying assumptions:

- It is assumed that costs per unit of catch do not change following the establishment of the no take areas. This could be achieved if total effort in the fishery is reduced to prevent over-capacity.
- The fishery is assumed to be optimally managed at present based on current stock levels and not subject to 'economic' overfishing (a term used to describe the situation where the amount of effort exceeds what is efficiently required to catch a given tonnage of fish). By starting with the assumption that the Rock Lobster Fishery is optimally managed, it implies that a controlled reduction in effort following the establishment of marine protected areas will not lead to an *increase* in economic rent due to the correction of any present overcapacity in the fishery. Effectively, effort would only be adjusted downward in response to the downsizing of the fishery so as to establish a new optimal level of catch and effort.
  - Contrary to this assumption, recent management reviews of the Rock Lobster Fishery have suggested that there would be economic efficiency gains from restructuring the fishery to a system of individual tradeable catch quotas and reducing effort to levels commensurate with maximum economic yield as opposed to maximum sustainable yield (see, for example, ERA (2006), Reid (2009) and Gardner (2008)).
  - If these observations are true, the establishment of marine protected areas within or nearby to the rock lobster fishing zones could therefore represent an opportunity to address economic overfishing as part of a package of management measures.

### *Spillover benefits*

Spillovers refer to the beneficial effects of larvae or adult lobsters entering the fishery from the protected areas. As reviewed in the previous chapter, many factors influence spillovers and spillovers do not necessarily translate to economic benefits. In this analysis a conservative approach is taken and spillovers are assumed to range from zero to a five per cent increase in productivity. If a five per cent spillover is achieved, expressed in terms of a five per cent increase in catch rate in the fishery, this would partly off-set the displacement cost. The value of this offset in terms of economic rent is estimated to be between $2.0 to $2.4 million, depending on scale of displacement effect (the higher figure relates to the 10 per cent catch reduction scenario).

There may be opportunities to maximise the likelihood of beneficial spillovers for the Rock Lobster Fishery by locating marine sanctuaries in areas that are 'low-cost' areas to fish, for example those areas closest to port.

### *Improved resilience and catch stability*

The literature review documented in the previous chapter revealed that, on the basis of theoretical modelling, protected areas may reduce seasonal variability in catch and serve as a buffer against possible management error. Improved catch stability would give professional fishermen better planning certainty for their business and possibly reduce the need for overdraft finance in low catch years. The buffer effect of marine protected areas could leave greater room for management error. The dollar value of this benefit could be equated to the avoidance of a complete crash in the fishery and the cost that this would represent, weighted by the probability of a crash occurring. While these are important potential benefits, no values are estimated for resilience effects in this analysis.

### *Other impacts*

The establishment of marine protected areas may result in a number of other flow-on economic impacts. To the extent that catches are reduced, there may be a subsequent increase in the domestic price of lobsters, which would result in a welfare loss for local seafood consumers. However, two factors mitigate this price impact:

- First, because most (95 per cent) of the lobster catch is exported overseas, price is largely a function of overseas demand and exchange rate, as opposed to size of catch (ERA, 2006). Therefore, the impact on consumers is likely to be negligible.
- Second, to the extent that rock lobster stocks are declining and the costs of catching lobster are rising because of increasing scarcity to the resource, then seafood consumers may experience real increases prices, even in the absence of marine protected areas.

On the strength of these factors, this analysis has not factored in any effect of marine protection on rock lobster prices – nor the prices of other locally caught seafood.

A reduction in the size of rock lobster catch could adversely affect seafood processing firms and other businesses servicing the fishery – for example, input suppliers. There are no published estimates of the economic surpluses generated by these firms, so it is difficult to determine the scale of economic losses that may eventuate if catch was reduced and there was a subsequent reduction in the demand for goods and services from these firms. As at 2006 there were 34 rock lobster processing establishments in Western Australia, with most being located in the Fremantle-Perth region (18 firms) and Geraldton (9 firms) (ERA 2006). With respect to other businesses servicing the fishery, there is little reliable information on the number or size of these firms.

It is tempting to use the dollar multipliers that have been estimated by McLeod and McGinley (1994) for the entire commercial fishing sector in Western Australia, which puts the flow-on impact at about $1 billion. Aside from this figure being more than a decade out of date, multipliers derived from input-output studies such as this overstate the size of indirect benefits because this approach assumes that there is no alternative use for labour and capital if it is no longer employed in the commercial fishing industry – which is not the case.

The multipliers provide a measure of how the demand for goods and services by the commercial or recreational fishing sector, for example, stimulate activity (revenues and expenditures) in the wider economy. This can be useful information (to the extent that it shows how onshore businesses' revenues and expenditures are linked to the demands of fishermen), but a large multiplier *does not* signify a large net benefit to the economy. The values involved are transfer payments between sectors rather than indicators of surpluses generated. The multipliers say nothing about whether land, labour and capital are being used most efficiently in terms of producing outputs with a high net value.

The correct measure of flow-on economic effects from downsizing a commercial fishery is the aggregate loss in economic surpluses (or profits) experienced by firms and businesses servicing the fishery. This loss is not estimated in this analysis because there is little published financial information about secondary that firms support commercial fishing in Western Australia.

## 3.4 Other commercial fisheries of economic significance

In addition to the Western Rock Lobster Fishery, five other major commercial fisheries operate off the coast of the southern Western Australia and intersect partially or fully with the 'areas of interest' set down by the Commonwealth for consideration as areas for increased marine protection. These fisheries are summarised in table 3.3 and the subsequent sections below.

The total gross value of production from these fisheries is in the order of $25 million per annum, although there is significant seasonal variation around this average due to some fisheries having very large season-to-season fluctuations in recruitment, such as the scallop fisheries. The combined economic rent generated from these fisheries is possibly one quarter of the gross value of production, equivalent to $6 million.

Table 3.3

**COMMERCIAL FISHERIES OPERATING OFF THE COAST OF SOUTHERN WESTERN AUSTRALIA**

| Fishery | Average annual Catch (tonnes) | Effort | Gross Value of Catch ($ million) | Status of stock |
|---|---|---|---|---|
| West Coast Rock Lobster | 11,000 | 490 boats | 250 | Fully exploited |
| Demersal Gillnet and Longline (sharks) | 1,300 | 83 licences | 6 | Dusky, whiskery and school sharks overfished, gummy sharks not overfished |
| Scallops<br>• Abrolhos Islands and Mid West Trawl<br>• South West Trawl<br>• South Coast Trawl | 500 - 6500 | 34 licences | 2.0 to 22 | Fully exploited |
| West Coast Deep Sea Crab | 200 | 7 permits | 3 | Breeding stock levels adequate |
| West Coast Demersal Scalefish (dhufish, pink snapper, groper) | 560 - 800 | 190 boats | 5 to 8 | • Pink snapper low<br>• Dhufish declining |
| South Coast Crustacean (lobsters, crabs) | 40 | 44 boats | 1 to 2 | Fully exploited |

Source: Based on information contained in Western Australian Department of Fisheries Annual Report 2007-08, Appendix 5.

As is the case for the Western Rock Lobster Fishery, it is difficult to determine the potential economic impact of establishing no take areas within the waters where these fisheries currently operate. A case by case assessment would be required and there are many factors to consider. However, if economic rents were to contract by 15 per cent due to the establishment of large scale marine sanctuaries, this would amount to a loss of $0.9 million (15% of $6 million).

### *Scallop fisheries*

Scallops are harvested in three areas off the south west coast of Western Australia:

- the Abrolhos Islands – which constitute the Abrolhos Islands and Mid West Trawl Managed Fishery;
- areas off Fremantle – which constitute the South West Trawl fishery; and
- areas off the south coast between Cape Naturaliste and east of Esperance — constituting the South Coast Trawl fishery.

Of these three scallop fisheries, the Abrolhos is by far the most significant in terms of catch and economic value. There are currently 16 licences issued for the Abrolhos Islands fishery. The majority of the fleet also have endorsements to operate in other fisheries. The fleet operates over a small proportion of the licensed fishing area (less than 10 per cent), focusing mostly on the eastern side of the Abrolhos. Annual catch is highly variable, ranging from just 100 tonnes to 6500 tonnes. In the past fifteen years, catch has exceeded 2000 tonnes only three times. Catch is dependent on sporadic recruitment, which appears to be strongly influenced by environmental conditions, such as the Leeuwin Current. Owing to the variable catch, the gross value of production in the last five years has ranged from as little as $2 million to $22 million.

### *Demersal Gillnet and Longline (Sharks)*

Sharks have been caught commercially in southern Western Australia since the 1940s. The industry began as a long-line fishery, taking gummy sharks from the Bunbury region. During the 1980s the fishery expanded up the coast to Shark Bay and catches peaked in 1988-89. The fishery is now managed as two separate fisheries — the West Coast Demersal Gillnet and Demersal Longline Fishery (which operates from Mandurah to Shark Bay) and the Southern Demersal Gillnet and Demersal Longline Fishery, which operates south of Mandurah to the South Australian border. Shark fishing is therefore undertaken in much of the water designated as 'areas of interest' for establishing marine protected areas.

Catches over the past few years have averaged about 1300 tonnes across the two managed fisheries, with an estimated gross value of $6 million. There are approximately 80 licensed fishermen in the industry.

Sharks are particularly vulnerable to overfishing due to their slow reproductive rate. Some commercially targeted species are now considered by the Western Australian Fisheries Department to be overfished, including dusky sharks, and whiskery sharks. The stock of Sandbar sharks has declined, but is not overfished. Gummy shark catches appear sustainable and their abundance appears to be increasing.

### *West Coast Deep Sea Crab*

This is a new commercial fishery that has only been fished on a full-time basis since 2000. The fishery operates between Cape Leeuwin in the south to the Northern Territory border in the north. Given its recent history, sustainable levels of fishing are still being determined. The fishery targets three species of crabs — giant (king) crabs, crystal (snow) crabs and champagne (spiny) crabs. The principal species, by size and value of catch, is the crystal crab. The catch of crystal crab fishery has fluctuated between 186 and 233 tonnes over the last seven years. The gross value of landed catch in 2007 was about $3 million (233 tonnes at $13 per kilogram). The fishery is regarded as being fully exploited and the harvest of crystal crabs has recently been capped at 140 tonnes with a total allowable catch quota. There are only four licensed operators in the fishery.

### *West Coast Demersal Scalefish*

The West Coast Demersal Scalefish Fishery focuses primarily on West Australian dhufish and pink snapper, but also targets a number of emperors, baldchin groper, eight-bar cod and coral trout. In total, more than 77 species are caught by 'wetliners' in this fishery, however, ten species comprise 91 per cent of the catch ('wetlines' is the term given to handlines and droplines).

In 2006-07 the estimated gross value of catch across all species was $4.8 million. Dhufish and pink snapper accounted for 63 per cent of this value. Employment in the fishery is difficult to assess because 78% of the boats in the wetline fleet are associated with other licensed fisheries.

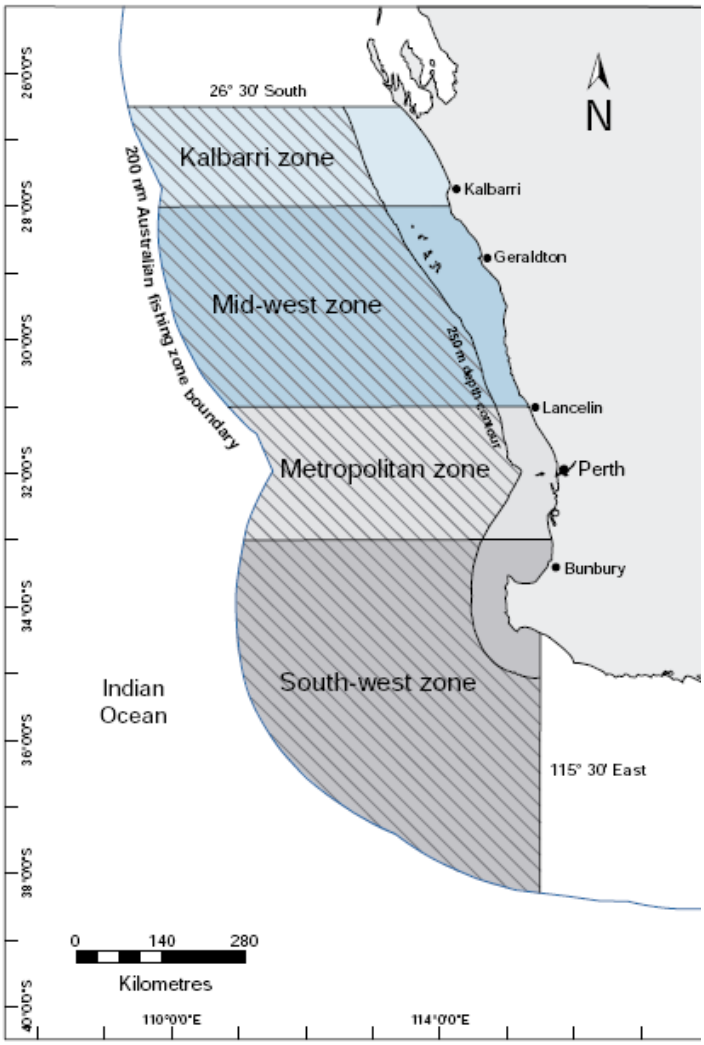
The fishery became a 'managed fishery' at the beginning of 2008, which means that increased input controls will be used to manage effort levels in the fishery. The fishery was formerly 'open access'. The commercial fishery extends from Kalbarri in the north to Cape Leeuwin in the south, and extends out to 200 nautical miles offshore (figure 3.3). For management purposes, the fishery is divided into five zones, comprising four inshore zones and one offshore zone. These zones partially coincide with the Commonwealth's 'areas of interest' for establishment of marine protected areas.

Recent stock assessments by the Western Australian Department of Fisheries have demonstrated that the stocks of the three major species of this fishery have been experiencing overfishing due to increasing catch and effort. The productivity of the Fishery relies on the maintenance of both the snapper and dhufish populations. Recent research on dhufish has found evidence of high recruitment in only four consecutive years in the last 20 years.

The spawning aggregation of pink snapper in Cockburn Sound contains the largest and most fecund (fertile) pink snapper in the West Coast bioregion and is thus considered to be the most important spawning and nursery location for the productivity of this species in this fishery.

Figure 3.3

**WEST COAST DEMERSAL SCALEFISH FISHERY**




### *South Coast Crustacean Fishery*

This fishery targets multiple species of crustacea but the predominant focus is on southern rock lobster (about 50 to 80 tonnes annually). Western rock lobster and giant crabs are also taken but form a much smaller component of the annual catch. The fishery operates along the south coast from Cape Leeuwin to the South Australian border. The gross value of catch in 2006-07 was estimated at $1.6 million. A total of 44 licensed boats operate in the fishery.

## 3.5 Recreational fishing

Recreational fishing is a popular past time in Western Australia, with approximately a third of the state's population over the age of five years participating in fishing at least once a year — equivalent to 538,000 persons. The south west coast of the state is particularly heavily used for recreational fishing because of its proximity to major population centres. It is estimated that 85 per cent of recreational fishing effort is expended in the West Coast Bioregion (Baharthah, 2006).

While much of the recreational sector comprises shore and estuary anglers, the establishment of marine sanctuaries in Commonwealth waters would have the greatest relevance for boat anglers. This paper therefore focuses on the current demand by boat anglers for fishing experiences in offshore and near-shore locations. Offshore boat angling includes both demersal and pelagic/game fishing opportunities around islands, adjacent to the Perth Canyon and on the edge of the continental shelf.

Recreational catch and effort in the rock lobster fishery has been estimated by the Fisheries Department to be 174 tonnes in 2006-07. A total of 22,000 licensed recreational fishers participate in the fishery each year.

In 2005-06 the Western Australian Fisheries Department undertook a comprehensive survey of offshore recreational boat fishing (with the exception of rock lobster fishers) between Augusta and Kalbarri on the west coast of Western Australia (Sumner et al. 2008). The survey was a repeat of a similar study undertaken in 1996-97. The results of the 2005-06 survey found that:

- Boat anglers spent a total of 1,557,000 fisher hours on the water, which is a 15.5% increase in nominal fishing effort compared to 1996/97.
- The most popular species, in terms of the number caught and kept, were whiting (404,400), Australian herring (288,400), squid (83,800), skipjack trevally (73,700) and King George whiting (48,400).
- A total of 450 tonnes of fish were caught and kept.
- The top six species, by tonnage, were dhufish (186 tonnes), followed by whiting (46 tonnes), pink snapper (40 tonnes), Australian herring (40 tonnes), skipjack trevally (34 tonnes) and baldchin groper (28 tonnes).
- About half the catch, by weight, was taken in the ocean directly west of Perth (the Metropolitan zone – see figure 3.4 for a map of the zones). The remaining half was split evenly between the Mid West zone and the Southern Zone. Only 1 per cent was taken in the Kalbarri zone (table 3.4).

Table 3.4

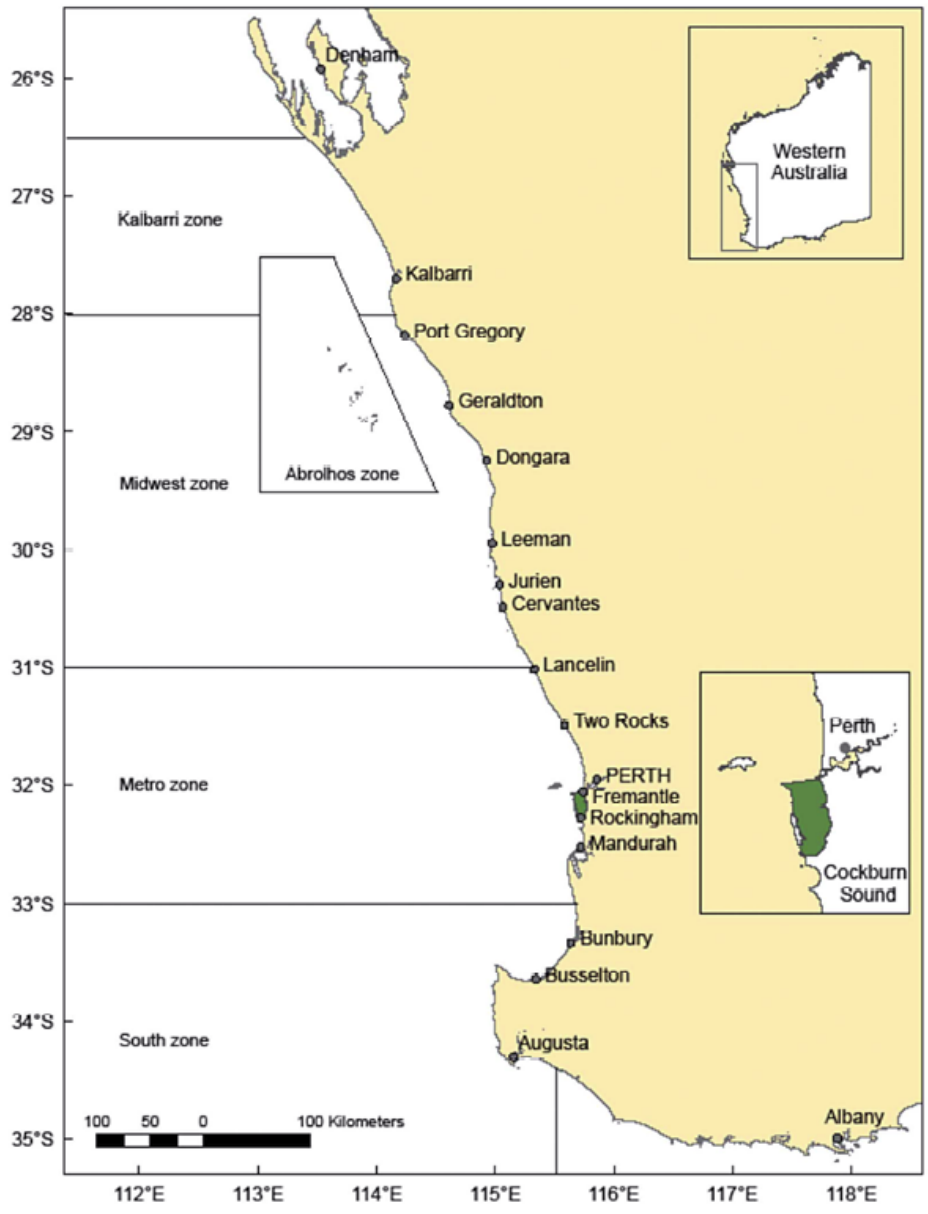
**DISTRIBUTION OF RECREATIONAL BOAT CATCH ALONG THE COASTLINE**

| Zone | Tonnes | Per cent of total catch |
|---|---|---|
| Kalbarri | **5** | 1% |
| Mid West | **116** | 26% |
| Metro | **219** | 49% |
| South | **110** | 24% |

Source: Sumner et al. 2008

Figure 3.4

**REPORTING ZONES FOR THE RECREATIONAL FISHING STATISTICS**




Source: Sumner et al. 2008

### *Recreational fishing values*

The value of the recreational fishing sector in Western Australia is often quoted as being in the order of $500 million (Department of Fisheries, 2004). This figure is based on surveys that show fishers spend this much money each year on equipment, fuel and other fishing-related items. While this figure provides an indication of the economic significance of the recreational sector, it is not equivalent to economic value or benefit. Using expenditures as a measure of recreational value is incorrect — just as it makes no sense to use costs incurred by commercial fishers instead of profits as a measure of economic benefit. The correct measure is the maximum amount anglers are willing to pay for access to fish stocks or a fishing location, net of the costs of travel, equipment and other fishing costs.

Expenditures are often used as a proxy for 'value' because, unlike commercial catches, there is no market price for the recreational 'product'. In the case of recreational fishing, the 'product' is the recreational experience — which is something that is enjoyed by the angler and therefore independent (and mostly unrelated to) the market value of fish, which is determined by seafood consumers. Catching fish is one element of the fishing experience, and no doubt contributes to the pleasure of the experience, but there may be other factors too such as aesthetics of the fishing location.

Numerous studies have sought to estimate dollar values for the recreational experience, either by asking anglers to state their willingness to pay, for example, to avoid reduced access to a fishery or reduced catch rates — or willingness to pay for higher catch rates. Alternatively, observations of actual visits to various fishing sites along the coast is another approach that is commonly used to make inferences about anglers' willingness to pay for a recreational fishing experience. Using this approach, a valuation function for fishing is derived based on the number of visits anglers make to particular sites and their observed travel costs to reach these destinations.

A number of these valuation studies have been undertaken in Australia and New Zealand. Past studies have examined angler values for higher catch rates of particular species (for example, increases in catch per trip) and the amount anglers are willing to pay to avoid closures to fishing sites. A selection of these are profiled below:

- In 1997, van Bueren (1999) conducted a valuation study of shore fishing in southern Western Australia. He used diary records of fishing trips made by 86 Perth anglers over a period of four months to collect trip destination, expenditures and catches. Information was collected for each of 903 trips. This information was used to estimate a choice model of fishing site and the values attributed to each site and various categories of fish (for example, "table fish" and "bread and butter" fish) . The study found that, on aggregate, Perth metropolitan anglers were willing to pay $13 million per year for maintaining access to north metropolitan beaches, $14 million per year for access to south metropolitan beaches and approximately $4 million for access to sites along the Mandurah coastline. On average, a 50 per cent increase in catch rate was estimated to increase the value of a fishing trip by approximately $4 per trip.

- Wheeler and Damania (2002) use a stated preference technique to estimate economic values of recreational fishing in New Zealand. The analysis is based on the results of over 4,000 interviews conducted at boat ramps and various fishing sites across New Zealand. The survey focused on the value of catching snapper, rock lobster, kingfish, kawahai and blue cod — as contributors to the overall fishing experience (Table 3.5). The study found that there are significant differences in the values held for each species.
- Campbell and Reid (2000) undertook a similar study in southern Queensland, which involved a survey of 505 boat anglers and 671 shore anglers. The results indicate that boat fishers value a day of fishing at $40.17, or $552 over the course of an entire year. Compared to the New Zealand study, there was a relatively high willingness to pay for the opportunity to catch additional fish, ranging from $18.72 per fish to $44.82 per fish depending on species (Table 3.6).

Table 3.5

**RECREATIONAL FISHING VALUES — NEW ZEALAND**

| Species | Value per fish kept/caught ($NZ) |
|---|---|
| Snapper | 5.73 |
| Kingfish | 19.76 |
| Blue cod | 1.61 |
| Kahawai | 3.44 |
| Rocklobster | 6.54 |

Source: Wheeler and Damania (2002)

Table 3.6

**RECREATIONAL FISHING VALUES — SOUTHERN QUEENSLAND**

| Species | Value per fish kept/caught ($AUD) |
|---|---|
| Bream | 18.72 |
| Whiting | 19.83 |
| Flathead | 44.82 |
| Other | 31.22 |

Source: Campbell and Reid (2000)

### *Economic impact of marine protected areas on recreational fishing*

#### *Direct impacts on fishers*

The studies reported above provide an insight to the magnitude of values held for fishing by recreational anglers and the what the recreational sector may stand to lose in dollar terms if 'no take' marine sanctuaries are established. However, the value estimates need careful interpretation. The scale of welfare loss from establishing marine sanctuaries will depend on:

- The scale of the marine protected areas.
- The proximity of these areas to major population centres.
- The degree to which the area to be closed off has attributes that are valued by recreational fishers — for example, whether or not it supports high-value sport fish, aesthetic aspects of the area (for example, sheltered areas in the lee of an island) and the 'productivity' of the area in terms of catch rate, reliability and diversity.
- The availability of similar or substitute areas that remain open for fishing.
- Any spillovers of fish from the protected areas into adjacent areas where recreational fishing is permitted. Spillovers may be particularly valuable in the recreational context because anglers are known to value large adult fish more highly than smaller fish of the same species.

The value-impact of increased marine protection on the recreational sector therefore needs to be assessed by first examining what 'attributes' fishers will be required to forego. A detailed economic study could call for a case-by-case assessment of the degree to which the recreational experience of anglers would be 'impaired', for example due to reduced access to fish stocks of a particular species. Dollar value estimates of reductions in these catches could then be applied using existing studies or tailor-made valuation surveys.

The results of the van Bueren (1999) study suggests that closure of entire stretches of coastline close to the metropolitan area would result in a welfare loss of approximately $15 million per annum. While this is a significant sum of money, it is substantially less than the $500 million per annum of recreational expenditures that are often cited as being 'threatened' if marine protected areas are established off the coast of south west Western Australia. Furthermore, many of the marine sanctuaries being envisaged by the Commonwealth are most likely to be located in areas infrequently visited by recreational boaters at some distance off shore. Thus, the $15 million estimate probably overstates the size of impact.

An alternative way of calculating the impact is to examine how many fish are currently being caught by the recreational sector, assess the impact of the protected areas in terms of reduced catch and then use the 'per fish' dollar values from studies such as those above to calculate the size of economic welfare loss. A worked example follows: We know that the total recreational boater catch in offshore waters of the West Coast Bioregion is about 600 tonnes. Assuming each fish weighs on average 500 grams, this equates to 1.2 million fish. A 15 per cent reduction in catch would translate to 180,000 fish. If each fish is valued at $10 by the recreational sector (an estimate commensurate with the results of the studies above), the total loss in welfare would be approximately $1.8 million per annum.

### *Flow-on impacts*

To the extent that recreational fishing participation and activity levels are adversely affected by the establishment of protected areas, there may be flow-on adverse economic effects on businesses servicing the recreational sector. However, these potential impacts are often overstated by parties opposed to marine sanctuaries. In the case of the Great Barrier Reef Marine Park, there were initial concerns that boat, tackle and bait supply shops would suffer following the establishment of the Park. But a recent study has reported that despite these initial fears, most businesses servicing the recreational sector have continued to enjoy strong trade (Access Economics, 2007).

Furthermore, it should be remembered that marine protected areas only affect ocean-going boat anglers and not estuary fishers or shore fishers. And in the South West Region a large component of the recreational sector comprises shore, river and estuary fishers. These fishers will continue to demand goods and services to support their pastime.

In this study, no estimates are made of the flow-on impacts of marine protected areas on tackle and boat businesses.

## 3.6 Charter fishing

Game fishing has become increasingly popular in Western Australia, with snapper, cod, dhufish, baldchin groper, shark, tuna and marlin being targeted. Most of the operators are based in Fremantle and conduct charters around the Perth Canyon and Rottnest areas, although Charter boats also operate out of a number of other bases, particularly the larger towns of Albany, Esperance, Jurien Bay, and Geraldton. The charter fishing industry is estimated to take about 115 tonnes of fish each year (Department of Fisheries 2004).

In the latter half of 2001, the Department of Fisheries introduced a licensing and management framework for the aquatic tour industry. This framework has regulated the industry and means that, with the exception of aquatic eco-tour operations conducted wholly within marine reserves, licences are required from the Department of Fisheries for any aquatic tour activity that has the potential to impact on fish stocks or the aquatic environment.

The three types of aquatic tour licence that the Department administers are:

- Fishing tours — the focus is on fishing activities where fish can be taken home at the end of the tour.
- Restricted fishing tours — the focus is on eco-type activities, such as snorkelling or scuba diving, with fishing only allowed for the purpose of a meal eaten during the course of the tour.
- Aquatic eco-tours — the focus is purely on eco-type activities, with no fishing allowed to take place on the tour.

As at 2005, there were 139 licensed fishing tour operators, plus and additional 21 restricted fishing tour and eco-tour licences operating in the West Coast Bioregion. Since 2002, the number of fishing charter fishing operators on the west coast has declined by 30 per cent, with many of these operators converting their licences to eco-based tours (Bennett, 2009). Consistent with this decline, the number of fishing tours has fallen from 2828 tours in 2002 to 2506 tours in 2004.

The total value of the charter fishing industry in south west Western Australia has not been estimated or published, but if it is assumed that the profit margin on each tour is $1000, it is conceivable that the aggregate profits generated by the industry could be in the order of $2.5 million.

While the establishment of marine protected areas in key fishing grounds frequented by charter fishing boats may give rise to economic losses in this sector, the recent observed growth in aquatic eco-tour operators (that do not depend on the fish resource) suggest that losses in the sector are likely to be offset by gains in market demand for ecotourism experiences.

## 3.7 Ecotourism

The proposed network of marine protected areas off the coast of southern Western Australia will be designed with the objective of protecting areas of high biodiversity, pristine marine habitats (or habitats in a relatively undisturbed state), unique underwater features and areas of cultural and/or heritage significance. It is these attributes that typically underpin marine ecotourism and attract domestic and overseas visitors to marine areas to participate in activities such as snorkelling, diving, underwater photography and marine mammal watching.

Over the past 15 years or so there has been a growing appreciation of the environmental resources of the areas between Perth and Shark Bay. One example is the Abrolhos Islands, which lie approximately 60 kilometres west of Geraldton. The Abrolhos consist of 122 islands that extend for 100 kilometres north to south. The diverse fish life, unique coral reef formations, bird life, shipwrecks and the coastal landscape of the Abrolhos are enticing increasing numbers of visitors to the region each year (Department of Fisheries 2005).

Whale, seal and dolphin watching are the main commercial tourism activities in the South West Bioregion. While dive tours are also popular, these are predominantly located in state waters as opposed to the areas further offshore where the marine protected areas would be located. In Western Australia, a commercial whale-watching industry was established in the waters off Perth in 1989, based on humpback whales migrating southwards from September to late November. Since then, the interest in whale watching has expanded, with charter vessels now operating from a range of locations including Albany, Geographe Bay and Denham.

Seal watching has also become popular along the southern coast of Western Australia, particularly around the town of Esperance. New Zealand fur seals and Australian sea lions are also common along the southern coast of the SWMR, and are becoming an increasingly important drawcard for tourists. Dolphin watching tours are now operated from a number of locations including Bunbury and Rockingham.

The number of whale watching permits has increased slightly from 91 to 110 between 1997 and 2005, whilst the number of dolphin watching permits has increased more than five fold over the same period. In Western Australia, it is estimated that there are 197 commercial operators in this industry, with revenues in the order of $45 million (Gardener, Tonts and Elrick, 2006). It is not known what proportion of this represents net revenue after expenses, but a conservative estimate might be $10 million.

The establishment of marine protected areas, depending on their location, should enhance the growth of this ecotourism industry by safeguarding the very attributes that visitors come to enjoy.

## 3.8 Biodiscovery

Biodiscovery is the term given to the taking of native biological resources (endemic to Australia) for the purpose of screening the material for useful genetic or biochemical compounds. The South West Marine Bioregion has one of the most diverse marine environments in the world and is potentially a valuable source of genetic material for commercial discovery and product development. Some of the biological resources may yield commercially valuable biologically active molecules, chemical synthesis pathways, genes and their products, or whole organisms. These may be developed into a range of applied products and services including, for example, pharmaceuticals, neutraceuticals, cosmetics, insecticides, herbicides, industrial enzymes, agricultural biotechnology and bioremediation. For example, sponges in Western Australian coastal waters have been found to have extremely high rates of exotic chemicals and anti-cancer compounds.

In theory, there is an option value for protecting biodiversity because without a diverse array of genetic material, the chances of making a future discovery of a valuable compound or bio-product will be lessened. And losing some genetic material may deny scientists the very genetic building blocks they require to make a 'breakthrough' discovery. However, in practice it is difficult to determine a dollar value for preserving this option.

## 3.9 Oil, gas and mineral exploration

The south west marine region of Western Australia is largely non-prospective for economically viable petroleum deposits. Moderate levels of petroleum exploration have been undertaken in the region over a number of years, mainly through seismic surveys, with only a few exploratory wells being drilled (Gardner, Tonts and Elrik, 2006). Only one commercially viable oil field has been found in the region and indications point towards this being an isolated reserve with a limited life expectancy (Clifton et al. 2007). It is located at the Cliff Head Oil Field located 10 kilometres offshore from Dongara. Production commenced in May 2006 with two million barrels extracted by December 2007. As of November 2006, there were 13 exploration permits active off the coast of south west Western Australia.

## 3.10 Environmental non-market benefits

People can hold values for environmental assets managed within marine sanctuaries that are not expressed or observed through purchase decisions. These values are referred to as 'non-market' values. These values may be realised, for example, by people making a private visit (that is, not on a commercial tour) to a marine sanctuary for diving or snorkelling. Alternatively, values for sanctuaries and the marine environment may be held by people who have never made visit but derive satisfaction from the knowledge that the ecology is being cared for or protected to allow them, or their children, to one day visit.

Economists have developed sophisticated survey techniques for estimating these types of values. A recently completed study of this kind has been undertaken by McCartney (2009) for the Ningaloo Marine Park, situated in the north west of Western Australia, and the proposed Ngari Capes Marine Park, situated in the south west or the state. The survey involved asking people to make choices between different packages of ecological improvements within the sanctuaries that were considered feasible under various management options. Improvements were presented in the questionnaire as being conditional on an annual fee that would be used to fund park management. People were given the choice of selecting a package of nominated improvements (subject to a specified fee) or choosing to pay nothing and getting no improvements. Separate questionnaires, one for each park, were administered to two groups of respondents, each receiving a different version. Completed surveys were obtained from 411 respondents.

The results of the study are summarised in Table 3.7. This contains information on the amount people are willing to pay for the various ecological improvements in each park. For example, survey respondents were, on average, willing to pay $51 per year and $46 per year, respectively, for a 5 per cent increase in fish populations in Ningaloo and Ngari Capes marine parks.

These results can also be used to calculate an indicative value for a package of ecological improvements within one or the other of the two marine parks. In the case of Ningaloo, for example, a management strategy that results in a 10 per cent increase in coral, 10 per cent more fish, five per cent more turtles and two per cent more whale sharks would be valued by taking the sum of willingness to pay amounts, which in this case equals $139 per year. If the respondent sample is representative of the Western Australian population aged 19 years and over, then this value could be aggregated to the entire 1.6 million persons residing in the state, which would amount to $222 million per annum.

Care needs to be taken in interpreting these survey results because it would not be correct to add the Ningaloo values to the value estimates for improvements in Ngari Capes Marine Park because people were asked to value each park separately. Had both parks been presented to people for valuation in the same questionnaire, then the individual values for each park may well have been considerably smaller.

Table 3.7

**NON MARKET VALUES FOR ECOLOGICAL IMPROVEMENTS IN NINGALOO AND NGARI CAPES MARINE PARKS**

| Ecological attribute | Annual values for improvements ($/year) | |
|---|---|---|
| | Ningaloo | Ngari Capes |
| Increase in coral populations | | |
| + 5% | 44 | — |
| + 10% | 51 | — |
| Increase in fish populations | | |
| + 5% | 51 | 46 |
| + 10% | 53 | 52 |
| Increase in turtle populations | | |
| + 5% | 8 | — |
| + 10% | 19 | — |
| Increase in whale shark population | | |
| + 2% | 27 | — |
| + 5% | 28 | — |
| Increase in seagrass populations | | |
| + 5% | — | 24 |
| + 10% | — | 39 |
| Increase in abalone populations | | |
| + 5% | — | 13 |
| + 10% | — | 27 |
| Decrease in whale collisions | | |
| - 25% | — | 23 |
| - 50% | — | 55 |

Source: McCartney (2009)

## 3.11 Summary of benefits and costs

All the benefits and costs noted in the preceding sections are drawn together and presented in table 3.8. The column labelled 'indicative value' summarises the potential *change* in value that may arise from the establishment of a network of 'no-take' marine protected areas in the south west marine region of Western Australia.

The key message to extract from this table is that the direct economic losses to the recreational and commercial fishing sectors due to displacement are likely to be in the order of tens of millions as opposed to hundreds of millions. This may be an over-statement of the direct losses because it does not allow for any positive spillover benefits that marine reserves may confer on adjacent fisheries.

Furthermore, the fishing losses are possibly at the upper end of the because of the conservative assumption that, in the absence of increased marine protection, all fisheries would continue to yield catches at their current levels. If this assumption did not hold and in fact catches reduced over time, then the displacement costs would be significantly less.

It is impossible to be more accurate than this without specific information about the exact location and design of marine sanctuaries, combined with advanced spatial and bio-economic modelling of the fisheries affected.

Table 3.8

**SUMMARY OF INDICATIVE BENEFITS AND COSTS OF LARGE SCALE MARINE PROTECTED AREAS IN SOUTH WEST WESTERN AUSTRALIA**

| Impacts | Key assumptions | Indicative change in economic surplus ($million per annum) |
|---|---|---|
| **Costs** | | |
| Displacement of commercial fishing | 15% reduction in economic rent derived from the Western Rock Lobster Fishery = $8 million<br>15% reduction in economic rents generated by other commercial fisheries = $1 million | -$9 million |
| Displacement of recreational fishing | 15% reduction in recreational boat catch, valued at $10 per fish (this value from composite results from various non-market willingness to pay surveys). | -$1.8 million |
| Displacement of charter fishing | A 30% to 50% reduction in current aggregate profits for the industry (assumed to be $2.5 million) | -$0.75 to $1.25 million |
| Reduced demand for services from upstream and downstream businesses supporting the commercial and recreational fishing sector | Not estimated. The multiplier effects obtained from input-output studies (often cited in the literature) overstate the size of indirect benefits because this approach assumes that there is no alternative use for labour and capital if it is no longer employed in the fishing industry. | — |
| Restrictions on oil and gas exploration | Not estimated. Region not regarded as being highly prospective. | — |
| **Benefits** | | |
| Spillover benefits to harvested areas | Will vary from fishery to fishery and be highly dependent on design of the protected area. A five per cent increase in catch per unit effort in the Rock Lobster Fishery is estimated to increase economic rent by $2.4 million . | +$0 to $2.4 million |
| Fishery buffer benefits | Likely to result in more stable catches and provide insurance against stock depletion. Improved catch stability would give professional fishermen better planning certainty for their business and possibly reduce the need for overdraft finance in low catch years. The buffer effect of marine protected areas could leave greater room for management error and buffer against adverse environmental events. | — |
| Ecotourism direct benefits | Currently $45 million in commercial revenues, with perhaps a net value of $10 million. Protected areas would support continued growth of the industry (relative to a scenario of a ceiling in visitor numbers). | +$5 to $10 million |
| Ecotourism flow-on benefits | Not estimated. | — |
| Biodiscovery | Marine sanctuaries protect genetic material for possible future screening and subsequent development of commercially valuable products. The value of preserving this future option is likely to be significant, but is difficult to estimate. | — |
| Environmental non-market values | A recent choice modelling study (McCartney, 2009) estimated that respondents were willing to pay, on average, $140 per year for a modest set of ecological improvements in Ningaloo Marine Park. When extrapolated to the State population aged 19 years and over, this equates to $222 million. | +$100 to $200 million? |

Notes: (1) A dash denotes no estimate made. (2) The impact of marine protected areas on domestic seafood prices has not been included as a cost because it is be difficult to attribute definitively any observed price increases to marine protection. To the extent that fish stocks are declining and fishing costs are rising because of increasing scarcity, seafood consumers may experience real increases in prices even in the absence of marine protected areas. (3) Management, administration and enforcement costs associated with establishing a network of marine protected areas have not been included as these will be highly dependent on the institutional arrangements and other design parameters for the proposed marine protection plan, which have not been determined at the time of writing.

On the benefits side of the ledger, spill-over benefits to commercial fisheries could be in the order of $2.4 million (based on a conservative five per cent increase in catch per unit effort in the rock lobster fishery). It is possible that the marine eco-tourism industry will, over the coming decade, expand as a result of the enhanced marine protection and this will contribute in the order of an additional $10 million in net value annually, which would go a large way towards offsetting the displacement losses.

The large 'unknown' that has not been adequately researched is the non-market values that the Western Australian community has for improved environmental outcomes in the proposed marine reserves. Values from the recent choice modelling study for Ningaloo and Ngari Capes suggest that this value could be large ($100 million plus), although it is not possible to apply this value with confidence to the marine protected areas mooted for Commonwealth waters without some customised survey work.

The results of the study indicate that even without the non-market benefits of marine protection, the combination of fishery buffer benefits, spillovers for commercial and recreational fishers and increased ecotourism benefits are likely to outweigh the displacement costs.

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