SHARK BAY PRAWN AND SCALLOP FISHERIES

Draft Review Report

FISHERIES MANAGEMENT PAPER No. 222

Published by
Department of Fisheries
168 St. Georges Terrace
Perth WA 6000

April 2007

ISSN 0819-4327

Department of Fisheries

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PROVIDING FEEDBACK

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In recent times, the Department of Fisheries has received representations from both sectors about the ongoing interaction of the fisheries and their respective management settings. As a result, a decision was made to comprehensively review the fisheries, taking into account matters of fishery sustainability and gear interactions, together with industry economics and market considerations.

The review has also addressed research requirements to ensure an appropriate scientific basis for decision-making into the future.

Interested parties can provide feedback on this report (Fisheries Management Paper No. 222). Anyone wishing to do this is encouraged to make reference to the particular proposal or section of the report they wish to comment on. If you disagree with a particular proposal or section, please try to suggest alternative ways to address or resolve the issues identified in the report.

The Department of Fisheries would like feedback to be sent electronically using the following email address: Lindsay.Joll@fish.wa.gov.au

Alternatively, they can be sent to:

Executive Officer
Shark Bay Prawn and Scallop Fisheries Review
Locked Bag 39
Cloisters Square Post Office
PERTH WA 6850

Note there is no formal closing date for feedback.

SECTION 1 INTRODUCTION

1.1 Reasons for Review

The Shark Bay Prawn Fishery and Shark Bay Scallop Fishery operate in the same general areas of Shark Bay (although there are some differences in their areas of operation). The inter-relationship between trawling activity for the two target species (prawns and scallops) has raised both management challenges and industry conflicts over time.

Harvest level settings for each fishery (in the form of effort levels and the timing and/or location of fishing) are independently set on the basis of recruitment and abundance surveys of each target species. However, each industry sector strongly believes that the interactions between the fisheries arise because of the physical effect of the other fishery's trawl gear on their particular fishery.

Industry conflict has increased to the point where further management innovations have been difficult to achieve in the absence of either an industry consensus position and/or research data which could shed some light on the real impacts of fishing gear in each fishery.

In recent times, the Department of Fisheries has received representations from both sectors about the ongoing interaction of the fisheries and their respective management settings. As a result, a decision was made to comprehensively review the fisheries, taking into account matters of fishery sustainability and gear interactions, together with industry economics and market considerations.

The review has also addressed research requirements to ensure an appropriate scientific basis for decision-making into the future.

1.2 Terms of Reference

The Terms of Reference for the review, as approved by the Minister, are:

1. To review management arrangements for the Shark Bay Prawn and Shark Bay Scallop Fisheries ("the fisheries").

2. Based on (1), to provide advice on emerging issues and future directions for management of the fisheries taking into account, but not limited to:
   - Sustainability issues;
   - Gear interactions and fishery interrelationships;
   - Environmental and conservation issues;
   - Industry economics; and
   - Market considerations.

3. To report on future research directions and information needs for the fisheries.

1.3 Review Process

The review has been undertaken by the Strategic Planning and Policy Branch of the Department of Fisheries. The review has been assisted by a steering committee, comprising:

Heather Brayford	Chair (Manager Strategic Planning and Policy, Department of Fisheries)
Graeme Stewart	(Shark Bay Prawn Trawler Operators' Association)
Hamish Ch'ng	(West Coast Trawl Association)
Lindsay Joll	(Manager, Commercial Fisheries Program, Department of Fisheries)
Nick Caputi	(Supervising Scientist, Research Division, Department of Fisheries)

Following initial scoping of the review process in liaison with the steering committee, written submissions were sought from the two trawl associations and licence holders in the respective fisheries. Details of the review were also provided to other interested parties.

Submissions to the review were received from Elmwood Holdings Pty Ltd, the West Coast Trawl Association and the Shark Bay Prawn Trawler Operators' Association. The Department of Fisheries also provided submissions – one from its Research Division and one from its (then) Commercial Fisheries Program. An overview of the submissions is provided in section 8 of this paper.

Interested parties can provide feedback on this report (Fisheries Management Paper No. 222). Anyone wishing to do this is encouraged to make reference to the particular proposal or section of the report they wish to comment on. If you disagree with a particular proposal or section, please try to suggest alternative ways to address or resolve the issues identified in the report.

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SECTION 2 HISTORICAL BACKGROUND

The early history of the prawn trawl fishery (up to 1976) is recorded in Penn and Stalker (1979), while the early history of the scallop trawl fishery is set out in Joll (1987). The submission to this review from the Commercial Fisheries Program of the Department of Fisheries also provided a comprehensive overview of the history and background to development of both fisheries and is repeated here.

The history of the prawn fishery to date can be summarised as encompassing a period of development (up to the mid-1970s); a period of stabilisation but with a steady creep in fishing power (when effort began to reach undesirable levels and tiger prawn catches declined [probably through recruitment overfishing]); followed by a short, sharp re-structure (through an internally-funded buy back scheme in 1990).

Following the re-structure, effort levels returned to about 80 per cent of pre buy-back levels and tiger prawn catches again began to climb to that seen in the 1970s. Since the late 1990s, effort (or at least *nominal* effort) has declined as the fishery has moved into tighter, real-time management and the catch of tiger prawns has moved to a slightly lower (but probably more sustainable) level.

Over the last 20 years or so of the fishery's 40-year history, prawn prices have remained relatively static (and therefore have declined in real terms), while fuel prices have climbed steadily, causing a slow but steady economic squeeze. Industry has responded to this by operational changes (e.g. moon closures, targeting larger [higher value] prawns) and more fuel-efficient fishing gear (bison boards, computerised engine management systems), but the economic margins have become thinner and thinner. The recent very steep increases in fuel prices have exacerbated this economic position.

Despite the ups and downs in the fishery over its 40 year history, the prawn fishery operates in what could be considered a relatively stable prawn recruitment environment compared to the scallop fishery.

The scallop trawl fishery began in the late 1960s and developed in the landscape provided by its relatively stable prawn trawl fishery "cousin". Variability of scallop recruitment has been a key aspect of the development of the scallop fishery. While the presence of scallops (and prawns) was known from survey work in Shark Bay in the 1950s and 1960s, the development of a trawl fishery in Shark Bay in the mid 1960s was focussed on prawns (although there are commercial scallop catch data from as early as 1966).

The first serious commercial catches of scallops were not until 1969, when a number of non-prawn trawlers specifically fished for scallops, while some vessels in the prawn fishery either took them as byproduct or also target fished. Scallop catches at the time were landed whole, as shucking at sea was not the practice at the time.

It is likely that the increase in catch at this time was the result of an increase in the recruitment levels of scallops. However, it seems likely that the increased recruitment was short-lived, as the catch scallop catch dropped to zero in 1971.

It is also understood that the scallops fished in 1969/70 were fairly old (1+ and 2+ year classes) as the scallop meats taken in the fishery were heavily infested with nematode worms (which typically only develop in older scallops).

Scallop abundance (or at least landings) declined, following the "showing" in the late 1960s/early 1970s, with the bulk of landings being by prawn trawlers. It is not clear if this low catch period represents a real reduction in abundance or simply a lack of interest in catching or landing scallops.

However, by the late 1970s scallops again began to be landed, suggesting an increase in abundance, although there was also a change in on-board handling methods evolving at this time (i.e. hand shucking on board) which improved the economics of fishing and encouraged scallop trawlers into the fishery.

Increases in the level of fishing also moved the fishery into a state where fishing effort was sufficiently high to effectively crop-off all or most of the incoming 0+ recruit group, with the result that the symptoms of nematode infestation declined, which improved the marketability of scallops.

Over the next few years the number of boats fishing for scallops increased, with 26 scallop trawlers operating in 1983.

In December 1982, the Minister for Fisheries and Wildlife announced the appointment of the Scallop Fishery Management Working Group. The Working Group was required to inquire into the commercial exploitation of the scallop fisheries in Shark Bay and at the Abrolhos Islands.

With respect to Shark Bay, the Working Group's recommendations included a temporary [three-year] freeze on boat numbers, together with strict selection criteria for determining those who could operate in the fishery and a ban on vessel transfers during the period of the freeze. A number of other management measures were recommended, including gear controls and a closed season aimed at stabilising the fishery given low recruitment which had been recorded in the fishery from time-to-time.

Recommendations were also made with respect to the prawn fleet's continuing ability to take scallops using prawn nets. One of the key recommendations was the need for a biological study [research] to better understand the scallop fishery and assist in determining future management arrangements. A report on this research was to be submitted to the then Minister by 1 November 1986.

Subsequently, a freeze on scallop trawlers operating in Shark Bay was announced in June 1983 and the 1983 season (which opened on 1 March) was closed on 31 August.

The research program commenced in September 1983. It was established with a four-year term, with a field component of three years and a further year for analysis and report writing. Consequently, the interim [freeze] arrangements for the scallop fishery were extended through 1987, at which time the research results would be known and further management arrangements considered. Joll (1987) summarised the results of the research program and discussed a management strategy including the option of moving to limited entry with controls on total effort.

As a result of the Joll report, and following discussions with both the prawn and scallop sectors on future scallop management arrangements, the scallop fishery was declared limited entry in 1987 (it had essentially been limited entry since 1983). Access to the fishery was restricted to 14 dedicated scallop boats operating alongside the then 35 boats endorsed to fish the limited entry prawn fishery under a catch-sharing arrangement.

Since that time the original number of dedicated scallop boats (14) has continued to operate in the fishery and the latter has been through a number of recruitment 'spikes' (of varying degrees) and quite a few years of 'average' recruitment (i.e. producing around 300 – 500 tonnes [meat weight] of

catch) as well as a significant number of years of 'below average' recruitment (i.e. 100 – 300 tonnes meat weight). Over time the fleet has gradually re-configured itself to cope with these recruitment variations, mostly by ensuring it has 'fall-back' options in other scallop fisheries - particularly the Abrolhos Islands and Mid-West Trawl fishery and the South Coast (Esperance) Scallop fishery, but also in some prawn fisheries.

Like the prawn fleet, the scallop fleet is now feeling the effects of high fuel prices, although the impact of the fuel price is not quite so great in the scallop fishery – primarily because when the scallop fisheries are in 'hyper abundance' (as has happened in two recent years at the Abrolhos) their costs of catching are significantly lower than in prawn fisheries (with their more stable recruitment/steady catch mode of operation due to prawn migration to the trawl grounds) and when scallops are in low abundance the scallop fleet just stops fishing. Nevertheless, in most years there has been overcapacity in the scallop fleet.

SECTION 3 DESCRIPTION OF THE SHARK BAY PRAWN FISHERY

The Shark Bay Prawn Fishery exists within the waters of Shark Bay off the mid west coast of WA. The fishery is an otter-trawl fishery, with prawn trawling occurring in a much smaller area than the overall boundary of the fishery.

The fishery targets two main species - western king prawns (*Penaeus latisulacatus*) and brown tiger prawns (*Penaeus esculentus*). King prawns are the dominant species, comprising approximately 70 per cent of the catch. Tiger prawns make up most of the remaining 30 per cent.

The fishery is a Managed Fishery under the *Fish Resources Management Act 1994*, with 27 boats currently licensed for prawn trawling.

The total landings of major prawn species (penaeids) during the 2004 season were 1,748 tonnes - comprising 1,164 tonnes of king prawns, 576 tonnes of tiger prawns and eight tonnes of endeavour prawns. Sixty five tonnes of minor penaeid prawns (coral prawns) were also landed.

The multi-species nature of the fishery requires the levels of harvest for both king and tiger prawns stocks to be carefully monitored.

Current stock and recruitment studies for king prawns indicate that, at current exploitation levels, the stock remains above the level where recruitment is affected by spawning stock levels. Thus, at the current level of exploitation, most fluctuations in the annual king prawn harvest are likely to have resulted from varying effort levels and environmental effects on recruitment, not from the abundance of the spawning stock.

In contrast, the recruitment levels of tiger prawns were, during the 1980s, significantly impacted by reduced spawning stock biomass. Management practices have subsequently been improved to increase the level of these spawning stocks. Such measures have included spatial and temporal closures as well as a reduction in fishing effort.

Historical catch and effort data for the fishery is provided in Figure 1 below.

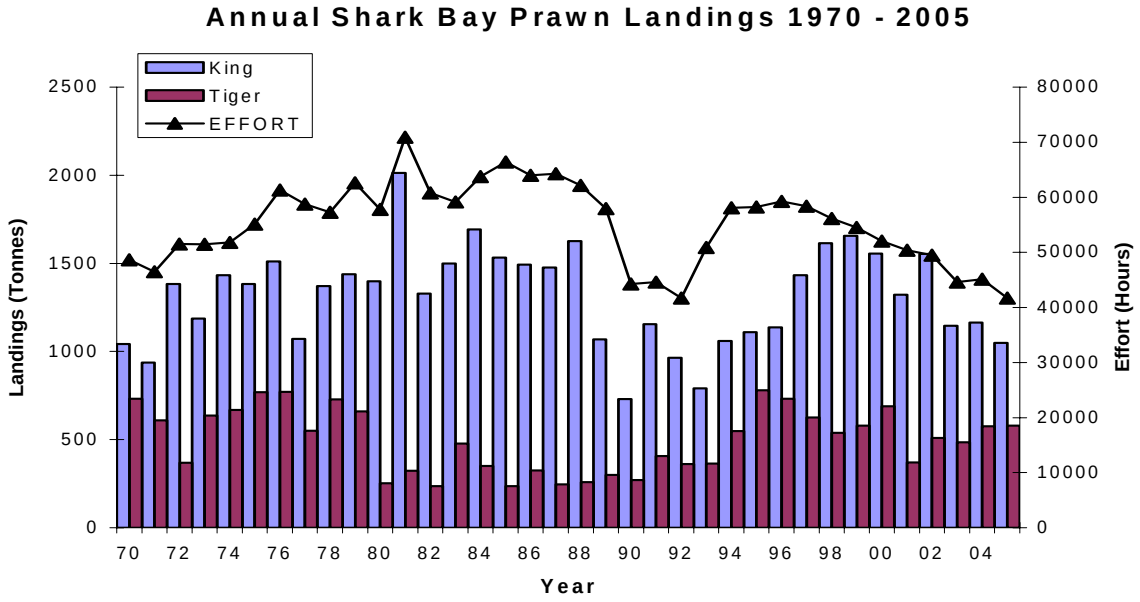

Figure 1: Annual prawn landings and effort (adjusted to twin-rig vessels) 1970-2005

SECTION 4 DESCRIPTION OF THE SHARK BAY SCALLOP FISHERY

The Shark Bay Scallop Fishery exists within the same overall boundary as the Shark Bay Prawn Fishery. Within this overall area, scallop trawling only occurs in waters east of the outer islands of Shark Bay, in depths between 16 metres and 40 metres. The fishery targets the western saucer scallop *Amusium balloti*.

The catch is taken using otter trawl by boats licensed to take only scallops (14 A-Class licences) and boats that also fish for prawns in the Shark Bay Prawn Managed Fishery (27 B-Class licences).

The fishery is a Managed Fishery under the *Fish Resources Management Act 1994*.

The total scallop landings for the fishery in 2004, were 1,665 tonnes whole weight, of which 916 tonnes was taken from the grounds known as Red Cliff and North West Peron and the remaining 749 tonnes from Denham Sound. A Class licence holders caught 1,185 tonnes or 71% of the total catch with B Class licence holders taking 480 tonnes.

Scallop landings have varied dramatically over the last 15 years depending primarily on the strength of recruitment. To date, recruitment strength has been thought to be mainly independent of spawning stock size and largely environmentally driven. This particular issue is discussed in more detail in section 9.1.

Historical catch and effort data is provided in Figure 2 below.

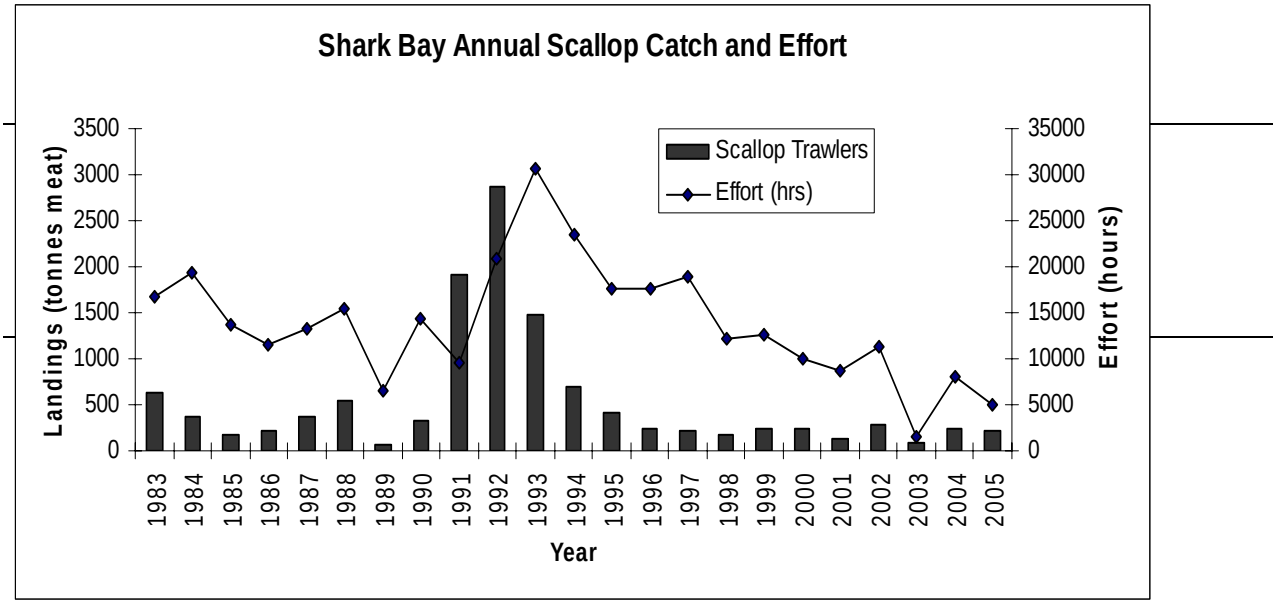

Figure 2: Shark Bay annual scallop catch and effort for scallop boats for the past 23 years

SECTION 5 CURRENT MANAGEMENT FRAMEWORK

5.1 Shark Bay Prawn

Aside from limited entry (27 licensed fishing boats), management of the Shark Bay prawn fishery is based on a series of sophisticated input controls including gear controls, spatial and temporal closures together with Vessel Monitoring System (VMS) monitoring of the fleet.

Fishing effort in the fishery is monitored with the aim of reducing ineffective trawl hours (e.g. around full moon phases) while maintaining high catch rate levels, thus reducing overall effort to improve economic and energy efficiency within the fleet.

The yearly cycle of operation for the fishery is dynamic and multi-faceted. Opening and closing dates vary each year, depending on environmental conditions, moon phase and the results of surveys, which predict recruitment dynamics.

The timing of the opening of the season allows the harvesting of the current season's recruits and the large residual prawns not caught in the previous season. Permanently closed nursery areas within the fishery prevent the fishing of small size prawns and provide habitat preservation, while spatial and temporal closures serve to protect tiger prawn breeding stocks at a threshold catch level and small size king prawns in the Extended Nursery Area from August onwards.

Within the main fishing period, there are various subsidiary openings and closings designed to increase size, quality and market value, while protecting stocks from recruitment overfishing. Moon closures (no fishing) around each full moon also operate to increase economic efficiency by shifting fishing effort away from these times of reduced catch rate.

The fishery is also subject to a range of gear controls, including restrictions on mesh size of nets, length of head rope, number of trawl nets that can be towed, size of the ground chain and

dimensions of otter boards. There is also a requirement for a VMS to be installed and used on all boats. Bycatch reduction devices are also mandatory within the fishery.

5.2 Shark Bay Scallop

As with the prawn fishery, management of the scallop fishery is based on input controls, including limited entry [14 A-Class (scallops only) and 27 B-Class (scallops and prawns) fishing boats], season and area closures, gear controls and crew limits.

Management is currently aimed at catching scallops at the best size and condition for the market, thereby maximising economic return whilst maintaining appropriate levels of the breeding stock to ensure sustainability. Management settings have been refined through time with an adaptive management approach based on pre-season surveys that measure the strength of scallop recruitment into Shark Bay.

The scallop stock commences spawning in mid-April (continuing through until the end of November) and meat condition declines as spawning continues. Therefore, the opening date of the season is a compromise between breeding stock levels (measured by a pre-season survey of stock abundance and commercial catch rates during the fishing season) and the seasonal decline in meat condition associated with spawning.

The fishery is generally closed between November and April [this has changed in recent years to take advantage of the optimum meat size earlier in the season and so the opening has been occurring in February/March and closing when a threshold catch level is achieved].

The closure is generally aligned with the Shark Bay prawn closure times, but the A-Class fleet (scallops only) usually ceases fishing before the declared scallop closure date, as scallop catch rates are often reduced to non-economic catch rate for scallop boats. This usually occurs prior to the closing date for the prawn fishery.

The Shark Bay scallop fishery is also subject to a number of area closures. Only the more marine (i.e. western) areas of Shark Bay are open for scallop trawling. As with the prawn fishery, permanent area closures are in place. During the scallop season, trawling by A-Class boats can take place 24-hours a day, with B-Class vessels restricted to specified prawn trawling hours (1700 – 0800 hours) or 15-hours per day.

There is also a range of gear controls, including mesh size, number of nets, the length of trawl net head rope, and the size of trawl otter boards and ground chains. There is also a requirement for VMS to be installed on all A and B-Class licensed fishing boats.

Bycatch reduction devices in the form of grids and secondary fish escape devices are required to be fitted in the nets in this fishery.

SECTION 6 CURRENT RESEARCH PROGRAM

The Research Division of the Department of Fisheries has a strong and well established relationship with the prawn and the scallop sectors. With continued low scallop stock levels in Shark Bay (and the reasons for this being unclear), resource sharing and gear interaction issues between the scallop and prawn fleets have increased in prominence over the last few years, placing a stronger focus on research outcomes and future requirements.

The thrust of the current trawl research program is focussed on monitoring the status of stocks through daily research logbooks providing location, catch and effort, size grades, recruitment, spawning stock, size management surveys and real-time monitoring. Information on general fleet dynamics, processor unloads and prawn and scallop prices is also collected, which assists in providing an overall view of the fisheries performance.

Over the last five years, significant improvements in real-time management, assisted by timely surveys, have allowed better optimisation of the prawn and scallop resource. Significant changes in harvesting strategies have been implemented since the late 1990s, in liaison with industry, to optimise the value of the available resource.

A collaborative three-year project with industry to review the impact of trawling on non-target species, funded by the Fisheries Research and Development Corporation (FRDC), was completed in 2004. A further FRDC-funded project is examining the biodiversity of bycatch in trawled and untrawled areas of Shark Bay and is shortly due for completion.

An FRDC project with Edith Cowan University has been examining the spatial distribution of abundance of the scallop recruitment and the spatial distribution of catch during the fishing season to improve catch forecasting. In addition, analysis of prawn daily logbooks for king and tiger prawn size categories and abundance may assist in refinement of current prawn closures.

SECTION 7 COMPLIANCE

Significant resources are put into ensuring compliance within the fisheries. Over time, compliance activities have included at-sea and aerial patrols to ensure closed seasons, closed areas, and operational rules are being adhered to.

Since 2000 [for prawns] and 2002/03 [for scallops], the use of VMS in the fisheries has assisted in monitoring vessel location and speed, thus increasing compliance with closures and decreasing the need for untargeted patrol activities. Licence and gear checks are also undertaken both at sea and in port.

In more recent times, compliance activities in the fishery have been based on a risk-based approach. This has assisted in the allocation of compliance resources to appropriate areas and enhances cost efficiency. As a result of the risk assessments, key compliance strategies now include pre-season briefings of skippers, pre-season inspection of the trawl fleet and at-sea inspections.

The implementation of VMS in the fisheries, in particular, expands the scope for real-time and adaptive management within the fisheries and may be an important element of the management solution to the Shark Bay “problem”. Although VMS is used to check on legislative lines, the presence of VMS has enabled short-term area closures to be implemented by industry agreement.

SECTION 8 OVERVIEW OF SUBMISSIONS

Submissions on the review were received from the West Coast Trawl Association (representing Shark Bay scallop licensees) and from the Shark Bay Prawn Trawler Operators Association (representing Shark Bay prawn licensees). A submission was also received from Elmwood Holdings Pty Ltd, a scallop licensee. The Department of Fisheries also provided submissions. An overview of the submissions is provided below.

The West Coast Trawl Association (WCTA) provided two submissions. The first comprehensive submission described the decline of the scallop fishery in Shark Bay and suggested, given industry economics, that restoring the productivity of the scallop resource was critical to the future prosperity of both prawn and scallop industries. The importance of maximising the combined value of the prawn and scallop catch was also highlighted.

The submission rejected the proposition that a decade of recruitment failure was the product of a sustained period of unfavourable environmental conditions [noting that even in periods of presumably favourable environmental conditions, recruitment has failed]. Rather, its decline was attributed primarily to a process of evolutionary change in the management arrangements for the prawn fishery. It was argued that these changes have resulted in a high level of effort targeting prawns on the main scallop grounds; have altered the historical distribution of the prawn fleet's effort; and have had a devastating impact on the recruitment to, and productivity of, the scallop fishery.

The submission argued for a more robust management system and further investigation into other, possibly non-environmental factors, these having a far more important role in scallop recruitment than previously considered. Further research on the extent of trawl-induced mortality upon juvenile scallop stocks was suggested.

Accordingly, the submission called for the introduction of a significant closure area on the main scallop grounds of Shark Bay. The submission also concluded that so long as the Department's strategy for the recovery of the scallop fishery amounted to little more than waiting for the return of 'favourable environmental conditions', the pattern of poor recruitment on the main scallop grounds would persist.

The submission also suggested that the prawn and scallop fisheries are confronted by two quite distinct problems. For the scallop industry, the problem in Shark Bay is essentially biological in nature. While the industry will inevitably have to come to terms with the economic problem of excess capacity, it is a problem that is presently subservient to the more pressing problem of ongoing recruitment failure. When the catches of the last decade compare so unfavourably to the catches that were achieved in the eight years before the redistribution of the prawn fleet's effort[1], it is clear that the scallop fishery in Shark Bay is not operating at its full potential.

The supplementary submission from the West Coast Trawl Association explored in more detail the potential benefits of introducing a closure on the main scallop grounds in Shark Bay. The submission reviewed the successful implementation of closure areas in the United State's Sea

[1] A comparison of the catches from 1983 to 1990 to the catches from 1996 to 2005 illustrates the extent of the fishery's decline. The catch data shows that the total average annual catch between the 2 periods has fallen by 133 tons of meat weight.

Scallop (*Placopecten magellanicus*) Fishery and assessed whether some of the management initiatives undertaken in that particular fishery might also be applied in Shark Bay.

The submission then explored the potential for further, largely economic, management reforms which could follow the successful implementation of a closure area. A key reform suggested was the introduction of industry-based quotas to formally allocate future scallop catch on the basis of the historical catch ratio between the prawn and scallop fleets[2].

It was argued that a formal catch share allocation would eliminate the resource sharing conflict between the two fleets and allow a stronger focus on management initiatives to rebuild the scallop resource. Such a system would also allow for a market-driven process of fleet rationalisation over time.

The submission from Elmwood Holdings Pty Ltd was along similar lines to the submissions from the WCTA. Elmwood Holdings Pty Ltd argued strongly that the reason for the decline in Shark Bay scallop yield was due to the constant trawling by prawn vessels over sensitive known scallop grounds.

The submission also discussed at length the equity issues associated with the scallop catch by both A-Class and B-Class licensees. Elmwood Holdings pointed to an erosion over time of the historical catch "share" of 80 per cent of the catch to the scallop fleet and 20 per cent of the catch to the prawn fleet. The submission also argued for standardisation of gear.

The Shark Bay Prawn Trawler Operators' Association (SBPTOA) also provided a detailed submission. The SBPTOA argues that dissatisfaction with management of the Shark Bay prawn and scallop fisheries has arisen, in part, from the high expectations that scallop fishers have of the returns expected from the fishery.

The submission points to the many past warnings to the scallop fleet about the ability of the Shark Bay scallop resource to provide a regular or profitable income. The submission also draws attention to the enormous inter-annual variability of scallop abundance and the resultant management difficulties and potential sustainability issues as a result of the low level of residual scallop stock left after fishing and prior to spawning.

The submission dismisses the proposition that there is a connection between prawn management boundaries and scallop catch rates. It suggests that while total scallop catches have fallen, catch rates have not.

The submission also argues that efforts by prawn licensees to introduce real-time management and profit maximisation in the prawn fishery have been frustrated by prawn mortalities caused by the operation of scallop trawlers on grounds that have been closed to prawn trawling. It points to the continued sustainability of the prawn fishery as a result of continual management adjustment including the buy-back in the early 1990s.

The submission also describes concessions of the prawn fleet in the past to assist the scallop fishery [such as providing access to scallopers to Denham Sound early in the season with prawners not operating] resulting in shifts in equity arrangements between the A-Class and B-Class fleets. The submission recommends a rationalisation of the A-Class scallop fleet via a scallop industry funded buy-back.

[2] A scallop catch share ratio of 72 per cent to A-Class and 28 per cent to B-Class licensees is recommended by the WCTA, based on historical catch records.

With respect to research, the SBPTOA suggests the need to determine whether or not a stock recruitment relationship exists in the scallop fishery. If a stock recruitment relationship can be established, research is required to determine the appropriate level of scallop abundance (catch rate per hour) to ensure that only the environment (not stock abundance) is influencing scallop recruitment in the following year. If a stock recruitment relationship cannot be determined, then research is required to identify the major determinants of Shark Bay scallop abundance.

The submission also suggests research to determine more accurately the extent of damage caused to prawn stocks and habitat from scallop trawling.

The Department of Fisheries provided two submissions – one from the Research Division and one from the Commercial Fisheries Program. The Research Division submission has largely been reflected in sections 6 and 11 of this report.

The Commercial Fisheries Program submission provided a detailed historical background to development and operations of the prawn and scallop fisheries, which is incorporated in section 2 of this review report. It also addresses a number of biological and gear interaction issues, and fisheries management issues and possible solutions, which are reflected in the following sections.

SECTION 9 MANAGEMENT ISSUES

9.1 Scallop Recruitment

A key focus of this review is the cause of the low recruitment that has persisted in the scallop fishery since the mid 1990s.

There are three key factors that warrant further investigation that separately, or in combination, may have contributed to low recruitment. These are environmental conditions (eg water temperatures, hydrology of Shark Bay and various other Leeuwin Current influences), inadequate spawning stock and trawling negatively impacting on recruitment.

With respect to environmental conditions, available data do not indicate a strong stock-recruitment relationship in the scallop fishery, although there is (or at least, was) evidence of a stock-recruitment-environment relationship. Previous research identified a relationship between years of weak Leeuwin Current (which are associated with ENSO years) and good recruitment. However, recent ENSO years in 1997 and 2002 have not been associated with good recruitment.

A closer look at the Fremantle Sea Level (FSL) [an indicator of the strength of the Leeuwin Current] over the last 30 years shows an interesting trend that may be affecting scallop recruitment. From 1977 to 1994 the annual mean FSL was below 70 cm in 11 of the 18 years and these low FSL years were usually associated with ENSO years.

Since 1995, none of the 12 years have a mean FSL below 70 cm. The lowest annual FSL have been in the ENSO years, 1997 (70.4 cm) and 2002 (71.5 cm). This is probably due to an increasing trend in FSL of about 1.5 mm per year identified by CSIRO oceanographers (Feng *et al.* 2004).

The effect of the Leeuwin Current on water temperature may also be a critical factor, as the good recruitment measured in November 2006 appears to be associated with cooler water temperatures during the spawning season. The implications of these to the environment in Shark Bay and its

effect on scallop recruitment will be further investigated as part of a proposed FRDC project for commencement in 2007/08.

The second factor relates to spawning stock. The spawning stock has varied significantly in Shark Bay due to variations in recruitment. Previous assessments have indicated that, in the range of spawning stocks experienced, spawning stock has not had a significant impact on recruitment and that environmental conditions were the main cause of recruitment variation.

An assessment of the spawning stock indicators in recent years should be undertaken to determine if the current levels are still within the range that have previously produced good recruitment. The decision rule framework (i.e. catch rate thresholds) associated with the change in the pattern of fishing also needs to be re-assessed to ensure adequate breeding stock protection.

In years of very low recruitment, as identified in the November research survey, consideration should be given to not fishing the stock if it is going to reduce spawning stock to very low levels.

The third factor that needs to be assessed is whether changes in the spatial closures associated with the prawn fishery have contributed to increased trawling on the scallop grounds and whether the 'disturbance' of the scallop recruits has affected their survival. This issue is discussed in more detail in section 10.2.2 of this document.
The first part of this can be assessed by examining the changes in the prawn closures relative to the timing and location of scallop recruitment. The second part may be assessed by an adaptive management approach using 'research' closures to assess the relative survival of the scallops settling in the closed areas, compared to the areas open to trawling.

This assessment may take a number of years, as it will require a reasonable level of recruitment to evaluate the effects of the closure. The Research Division suggests these closures should have minimal impact on prawn fishing, as the prawns will migrate through these areas and are available for capture before or after they enter the areas.

9.2 Gear Interactions and Fishery Interrelationships

This is a complex and pressing issue facing the Shark Bay fisheries and is a key driver for this review. It is also inextricably linked to the scallop recruitment issue discussed in 9.1 above.

The issues include:
- impact of scallop gear on prawns; and
- impact of trawl gear on scallops.

9.2.1 Impact of Scallop Gear on Prawns

It is argued in the submission from the SBPTOA that the operations of scallop trawlers cause prawn mortalities and impede real-time management and profit maximisation in the prawn fishery.

The Department of Fisheries, in its Commercial Fisheries Program submission, explain that newly settled and juvenile prawns (both kings and tigers) in Shark Bay are not located on the main trawl grounds but migrate there at larger (fishable) sizes from the inshore nursery areas in the south and the shallows on the eastern banks. Because of this, the Department considers that there is low risk of incidental fishing mortality on juvenile prawns from either prawn or scallop trawling in the main grounds of the fishery in the autumn months [i.e. February to March].

If scallop trawling does damage prawns, any incidental fishing mortality risk to newly recruited stocks increases sharply from around May/June, as higher abundances of recruiting prawns move onto the more central areas of the trawl grounds where scallop trawlers typically operate.
Scallop trawling in the early part of the year potentially poses some risk to residual adult prawns and early recruiting prawns, as they occur in some of the areas where scallops typically occur - although under the current prawn fishing arrangements, the numbers of adult prawns available at this time (March to May) is relatively low due to their stocks having been fished down in the previous season.

The notable exception to this is the deep water fishery for tiger prawns in the Quobba area in the early part of the prawn fishing season (March). However, the Quobba area is not known for scallop recruitment (and, therefore, scallop trawling), which precludes any potential gear interaction issues in this area.

The other issue is that scallop gear (currently 100mm mesh) does catch some prawns - despite earlier studies which showed that the prawn catch in 100mm mesh was nil to minimal. The degree to which 100mm mesh retains prawns depends on the size of the prawns (larger prawns are more readily retained) and the degree of clogging of the 100mm mesh by scallops or other catch.

It is also likely that there is some mortality of prawns that pass through the 100mm mesh or are damaged in the cod end. The fate of prawns that enter scallop nets is one of the major unanswered questions in the gear interaction issue (but one which could be answered by a targeted research program such as the proposed FRDC project mentioned in section 9.1 above).

The other gear issue is whether or not the ground chains of scallop gear have any effect on prawns buried in the seabed. Given the diurnal behaviour of prawns (i.e. burying themselves during the daylight hours), it is unclear whether scallop trawl gear (which is currently the only trawl gear permitted to be operated between 8am and 5pm) has any effect on buried prawns.

The ground chain is meant to be set to 'skim' across the surface of the substrate, but depending on exactly how the gear is rigged or how heavy the trawl gear has become as catch accumulates, some 'digging' of the substrate can occur. Again, how this impacts on the fate of buried prawns in the path of the net is unclear (but potentially also answerable [or at least inferable] by a targeted research program)[3].

9.2.2 Impact of Trawl Gear on Scallops

Unlike prawns, juvenile scallops recruit directly onto the fishing grounds and are vulnerable to gear impacts from the time they settle. This vulnerability arises from the fact that, as far as is known, juvenile scallops settle onto the sand substrates that are the habitat of adult scallops and reside in the top few millimetres or the first centimetre of the sandy seabed.

Given the fragility of their shells they are (or at least appear to be) vulnerable to crushing or fatal shell fractures from trawl ground chains or dragging cod-ends (which might be either prawn or scallop gear) passing over them.

[3] Any proposal to move trawling for scallops by A-Class vessels to a daylight-only to "capitalise" on this aspect of prawn behaviour will need to consider the maritime safety issues of having A-Class scallop trawlers at anchor during the night when prawn trawlers will, at some times of the year, be operating over the same ground. There may also be issues of diurnal differences in catchability (with scallops possibly being less catchable during the day) which would need to be considered more closely if a time-split between the fleets was actively considered as an element of any solution

Whether or not there are any impacts on juvenile scallops can be a function of *where* they settle, given the patchiness of scallop recruitment. However, given that scallop recruits are potentially present on the trawl grounds from around mid-May (arising from spawnings in mid-April), they may be vulnerable to gear impacts from trawlers (prawn or scallop) operating in their recruitment areas.

Whether or not this is happening, and is the (or a) cause contributing to low scallop catches in recent years, may be interpretable from a research study to examine the spatial relationships between scallop recruitment, fishing effort in the area of the recruitment and subsequent catches (as is currently being undertaken by ECU). The other option would be for a laboratory-based research study using hatchery-reared juvenile scallops and 'dummy' trawl gear, in order to carry out experiments on gear impacts.

9.3 Scallop Catch Share

Historically, catching scallops has been an important component of the viability of the prawn fleet, with the prawn fleet enjoying total access to the scallop fishery until the introduction of formal management arrangements for the latter in the 1980s.

As part of the management package, the then Minister introduced a catch guideline, directing the Fisheries Department to implement a management strategy to effect a catch distribution of 80 per cent to dedicated scallop vessels and 20 per cent to the prawn fleet. The prawn fleet did not accept the catch share arrangement, arguing that it was based on an inappropriate period of fishing history and questioning its legal basis. This catch guideline was removed in 1991.

Irrespective of the above, there has continued to be ongoing 'tension' over scallop catch share between the A-Class and B-Class licence holders.

The WCTA argues in its submission for a formalised catch share allocation within the scallop fishery to eliminate the resource sharing conflict between the respective fleets and allow a greater focus on management initiatives to rebuild the scallop resource. This position was supported in the submission from Elmwood Holdings Pty Ltd.

9.4 Prawn Fishery Sustainability

An assessment of the ESD and *State of the Fisheries* reports do not indicate any overriding stock sustainability concerns within the prawn fishery, given the current management settings. Assessments indicate that target species are currently being maintained above levels necessary to maintain ecologically viable stock levels. They do however point to the need to remain vigilant with respect to catch and effort monitoring, particularly in relation to tiger prawns, given their susceptibility to overfishing.

Aside from the interaction issues with the scallop fleet, the submissions from the SBPTOA and the Department of Fisheries similarly do not indicate any specific stock sustainability concerns with the prawn fishery.

However, this position of stock sustainability has not come about without costly and specific research/management over a long period of time aimed at protecting prawn stocks. Notable management interventions to ensure long-term sustainability have included an industry-funded buy-

back in the early 1990s; the introduction of nursery area closures; and a range of other input controls including spatial and temporal closures.

There are, of course, a number of issues related to industry economics and the impact of the cost-price squeeze on the prawn fleet and on licence holders. These issues are discussed in section 9.5 below.

9.5 Economic Issues

The profitability of the Shark Bay Prawn and Scallop fleets has suffered considerably over the last few years, with declining prices and rising costs. This section focuses on factors affecting the profitability of fishing (including the trends in those factors).

9.5.1 Prawn Trawling

9.5.1.2 Revenue Factors

The Shark Bay Prawn industry is the third largest fishery in Western Australia, (after the Western Rock Lobster and White South Sea pearl industry), with an annual Gross Value of Production (GVP) of between $25 million and $30 million.

Production is usually spread over 8 months of the year with the season starting in mid March. The seasonal pattern of production is a significant factor in determining the economics of fishing with production peaking early in the season and being interspersed with fishery closures over the period of the full moon when catch rates are relatively low.

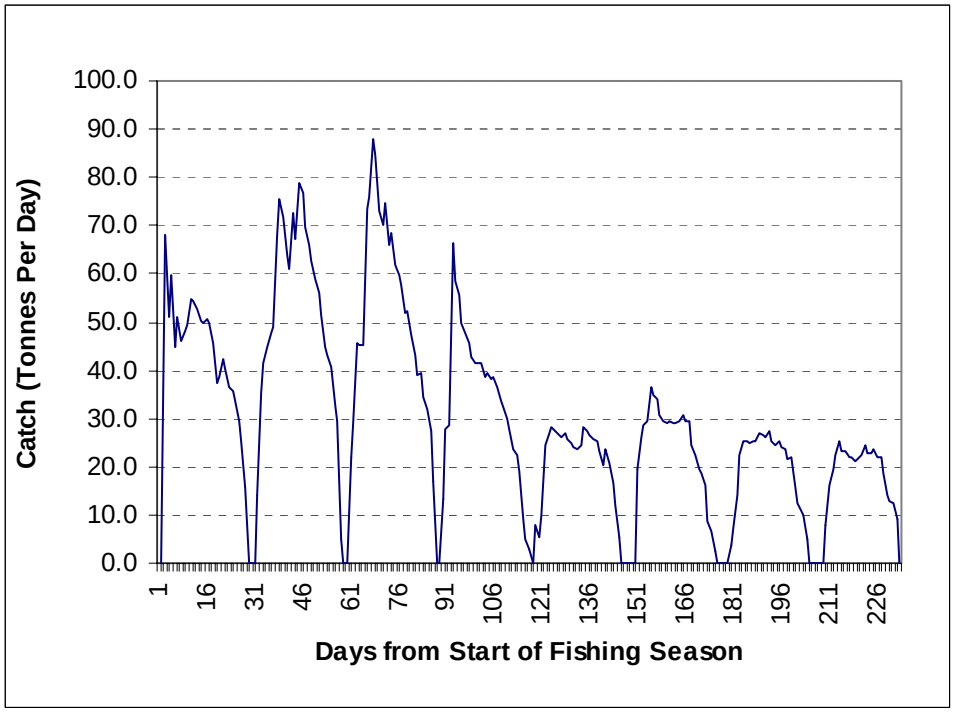

Figure 3: Average daily prawn catch (synchronised with moon cycles and season opening) 1998 – 2004

The average catch rates through the year have shifted somewhat to later in the year, due to research/management efforts, with production peaking more obviously in the third moon cycle than is indicated by Figure 3. These management measures have been designed in order to encourage later harvesting of prawns in order to improve their size and quality.

The variations in allowable trawled areas and opening and closing times of the season appears to be an important contributor to the economics of fishing (within seasons) because these have the potential to limit the efficiency of fishing effort throughout the season and can also spread the catch more evenly from month to month. The primary role of such closures, in protecting the breeding stock, is unquestionably important for the long-term economic sustainability of the fishery.

Generally, prawn production patterns are relatively stable from one season to the next. The GVP of the Shark Bay prawn trawl fleet is made up of two major species of prawns and between 20 per cent and 40 per cent of scallops caught within Shark Bay, noting that the dedicated scallop trawl fleet catches the balance of scallops in Shark Bay. There are two parameters to GVP - volume caught and the prices received.

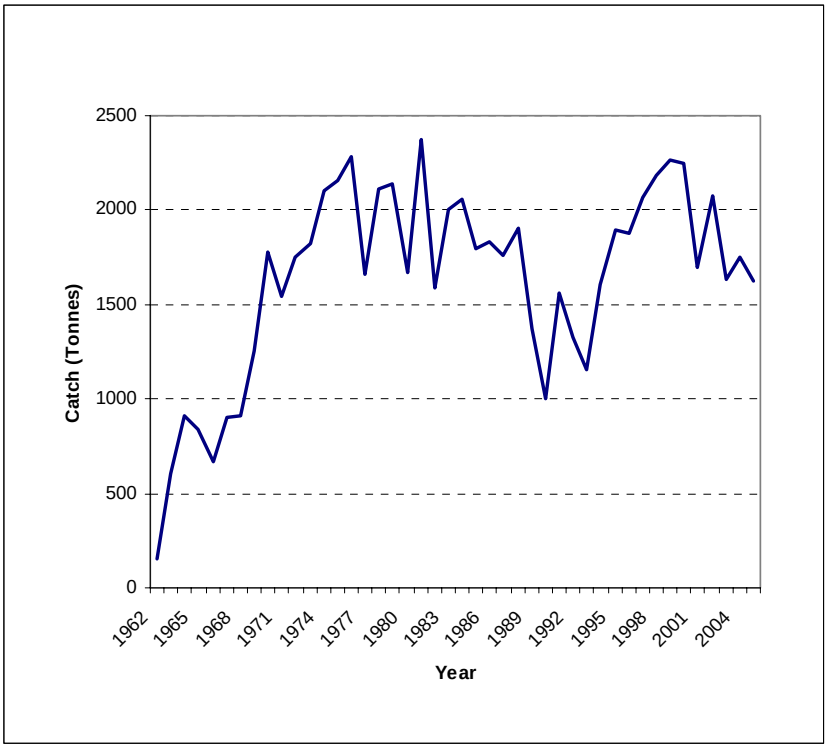

Figure 4: Shark Bay prawn catch over the last 40 Years

Prawn catches are determined as a function of:

- seasonal factors, such as recruitment, previous fishing effort; and
- trawling effort, being the number of vessels, hours trawled per vessel and fathoms of headrope used in trawling nets.

There were some sustainability concerns in the late 1980s that were addressed by an effort reduction (and prawn fishing boat licence buy-back) in 1990. This was followed by a reduction in catch and then an increase in catch, as stock improved and fishing activity adjusted to the new total allowable effort (refer Figure 4).

The other component of GVP is price. Beach prices in Australia are mainly determined by the world price of prawns (and shrimps) including those fished from the wild and those grown in aquaculture, (noting that research has shown a link between the price of cultured Thai shrimp and wild shrimp *Penaeus subtilis* fished in the Caribbean) and changes in the exchange rate.

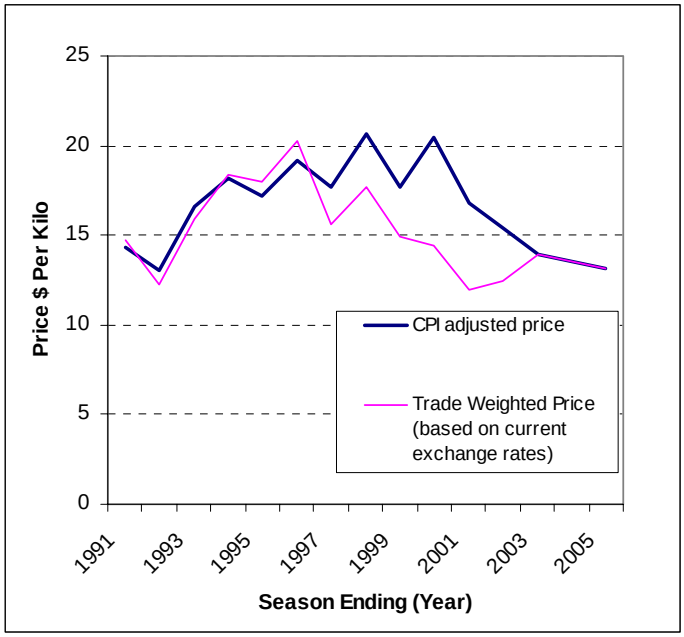

Figure 5: The average beach price of prawns caught in Shark Bay

Figure 5 shows that inflation adjusted prices have risen steadily until about 2000, since when they have undergone a steady decline. The reduction in beach price since 2000 can be attributed to two main factors:

1. The rapid increases in the production of aquaculture-reared prawns over the same period. While the local market represents a small proportion of the total sales from Shark Bay, this market has contracted in recent years as it has been swamped by cheaper imports. This is particularly relevant in the period 2002 – 2004 when imports increased rapidly. In November and December of 2004 alone, imports of *Penaeus vannamei* averaged (for the first time) 2,500 tonnes per month[4], which is equivalent to the total annual prawn production of Shark Bay in a good year.

2. The increase in the Australian Dollar against the US Dollar. The Trade Weighted Price is the price that prawners would have received if the value of the Australian dollar had remained fixed at 74 US cents over the period 1991 – 2005. The trend in the Trade Weighted Price indicates that world prices of prawns began declining from a peak of $20 per kg in 1996. The fall in the Australian dollar buffered producers from falls in world prices for a period of time from 1997 to 2003.

An issue of concern for the prawn industry is that future trends in prices are likely to be, at best, levelled out around $13 per kilogram, down from a (inflation adjusted) peak of $20 per kilogram, given the ongoing development of aquaculture around the world.

[4] Reported in the Sydney Morning Herald, 22 May 2004

This poses a problem for the economics of fishing over the longer term, given the likelihood that fuel costs could increase at a rate above inflation if some of the more pessimistic predictions around oil demand and supply prove to be correct in the next ten years.

The Australian Bureau of Resource Economics paints a more optimistic outlook for prawn trawling in its 2006 Commodities Outlook document, suggesting that fuel prices will decline over the short term and that the Australian dollar could weaken. Such predictions would appear, on face value, to be fraught with risks.

Trends in declining beach prices and catches in Shark Bay in the last five years have had a considerable impact on the profitability of fishing over the same period.

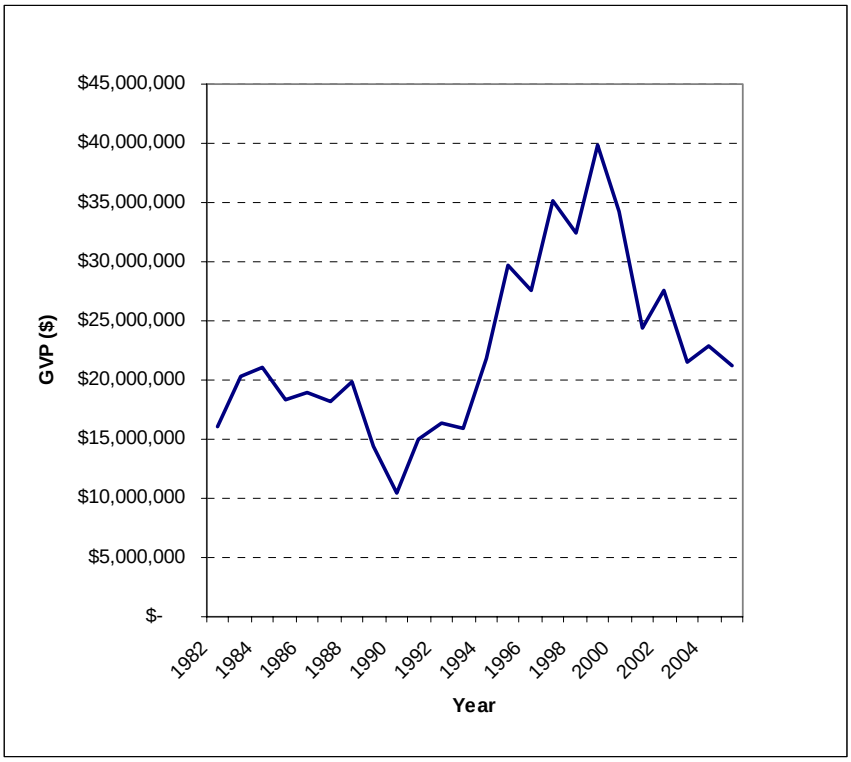

Figure 6: The gross value of production of Shark Bay prawns

Prawn trawlers also supplement their income by fishing scallops through the season. However, this only represents about 6 per cent[5] of the total gross value of production of the prawn trawlers, so it forms a relatively small part of the economic equation in the prawn fishery.

Nevertheless, there is considerable concern by prawn fishers to maintain their share of the Shark Bay scallop fishery which is currently running between 35 per cent and 40 per cent, although it has in the past 20 years only averaged 28 per cent of the fishery.

King prawns are the main species caught (in terms of kilograms and total value). Figure 7 demonstrates the catch and value pattern typical of recent times. Nevertheless, tiger prawns usually have a higher value per kilogram than king prawns. On average this is about 20 per cent higher and in 2002 this differential was 39 per cent.

[5] Over the last 8 years, there has been very little variation in this figure (between two per cent and seven per cent), although in 1992, during a hyper-abundant year for scallops, scallops were 52 per cent of the value of prawn trawlers' catch.

The inter-temporal pattern of catch and the differences in value of king prawns and tiger prawns could have a bearing on the economics of fishing within a season, although this difference is smaller than the difference in total catch rates and the change in value of prawns as they mature into different size grades.

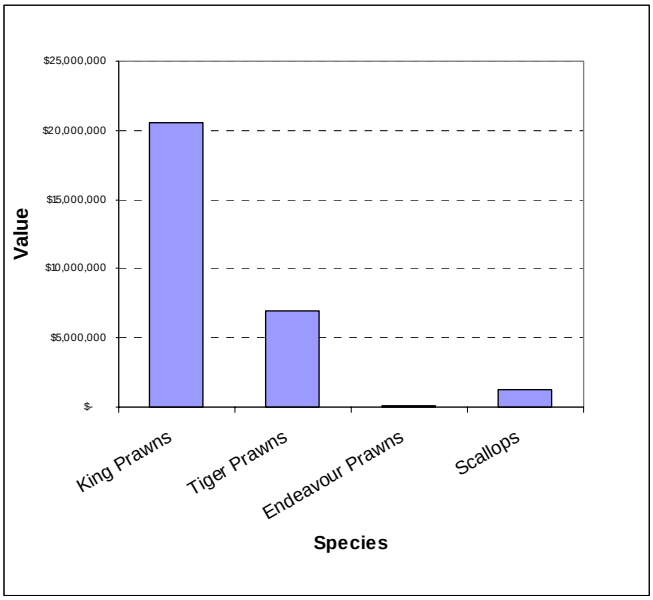

Figure 7: The composition of catch value by species (in 2002)

9.5.1.2 Cost Factors

The costs of trawling can be broken into three broad categories that are:

- fuel and other variable costs associated with running vessels while trawling;
- labour costs which are usually set as a percentage of the catch (often around 25 per cent); and
- fixed costs of maintaining vessels (including the cost of depreciation).

The hourly rate of trawling can vary depending on the vessel size, engine power, the size of the nets towed and the speed at which the boats trawls for prawns. However, net sizes have been fixed, at two nets of eight fathoms head rope length, so all vessels are currently operating with the same net drag.

It is estimated that an average vessel uses about 150 litres of fuel per hour of trawling which currently costs around $170 per hour (ex-fuel tax rebate).

Trawling efficiency has been increased over the years, as a result of three main management measures:

- The industry financed fleet reduction of 1990 (from 35 boats to the current 27) saw a considerable reduction in hours trawled, although this trend was reversed as vessels increased their individual trawling rates (see Figure 8).
- Introduction of moon closures which suspend fishing for periods of up to 10 days (and now up to 12 days) over the low catch periods of the full moon.
- Inter-temporal spatial closures which encouraged greater effort later in the season concentrating in areas where catches are higher.

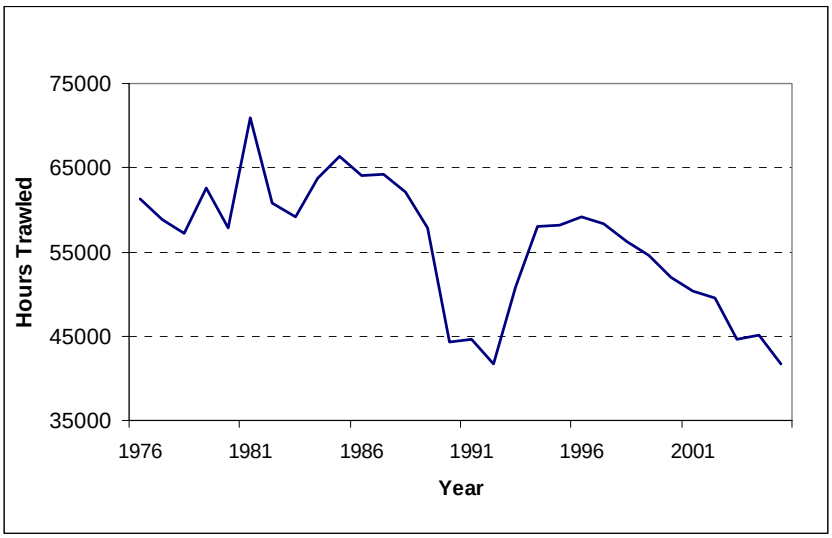

Figure 8: Trends in hours trawled by prawn trawlers

The ongoing efforts to improve trawling efficiency have underpinned the fleet's profitability over the last 16 years by ensuring that the revenue generated per hour trawled has stayed above $500 (see Figure 9). Certainly, without the fleet reduction of 1990 and the subsequent management changes (such as moon closures), trawling returns would be much less than they are today.

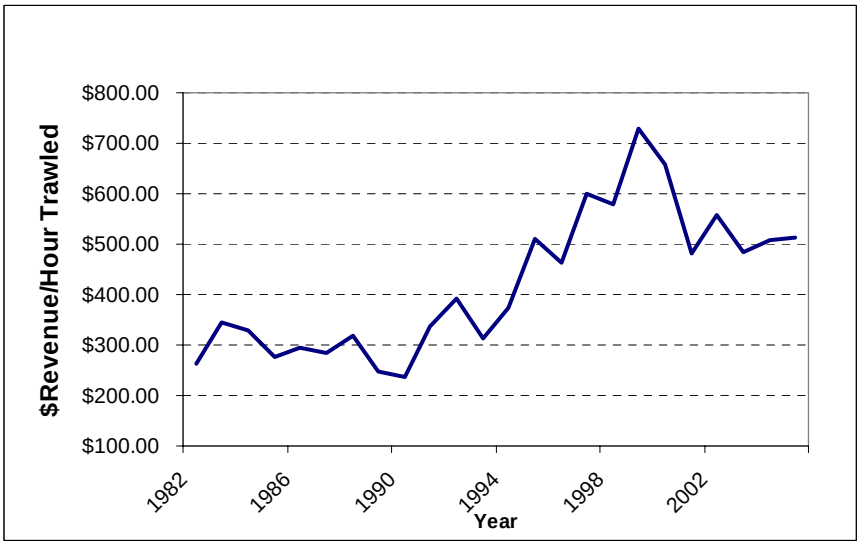

Figure 9: Revenue generated from prawn trawling per hour trawled

The problem for the fleet is that attempts to manage trawling efficiency have not kept pace with rising costs.

If it is assumed that the average prawn trawler uses 130 litres per hour while trawling, then in the 2006 season, this equates to diesel costs of about $143 per hour[6]. Fuel costs have risen markedly in recent years and the long-term outlook is for continuing high prices, although some short-term relief may be felt in the 2007 fishing season (refer Figure 10).

[6] Based on a cost of $1.10 per litre ex-tax. Source: Fuel Watch at www.fuelwatch.wa.gov.au .

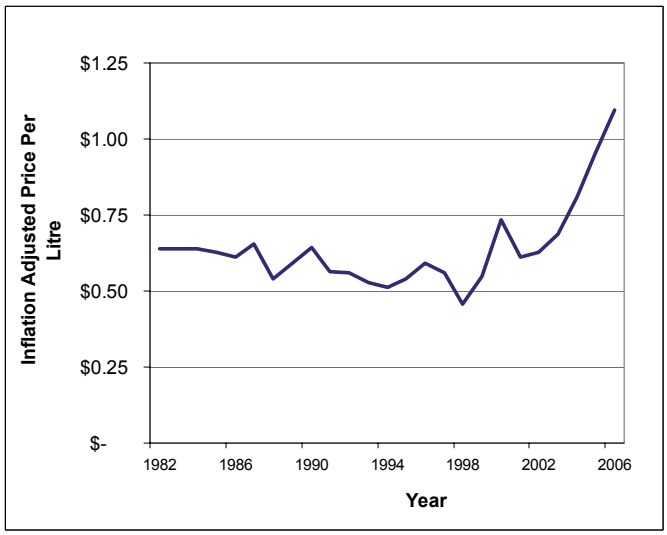

Figure 10: The estimated (inflation adjusted) price of diesel fuel (ex-tax)[7]

Given that a major component of trawling is the fuel cost, the index provided in Figure 11, which estimates the ratio of the value of catch over the cost of fuel, is a telling barometer of the industry's economic health.

Figure 11: Ratio of catch value/fuel costs over time– prawn fishers

Figure 9 shows that the industry is in a similarly precarious position to that prior to the 1990 fleet restructure where one third of revenues are consumed by fuel costs.

Clearly, the industry is at a crossroads again, requiring either major amendment to the management controls or a complete change to the system of management, in order to reduce catching costs.

[7] Based on the world price of oil and an assumed relationship between that and the price of diesel.

9.5.2 Scallop Trawling

9.5.2.2 Revenue Factors

The Shark Bay Scallop industry has an annual GVP of about $3 million to $6 million per annum, with one exceptional period in the early 1990s when its value was over $50 million in one year (Figure 13). A-Class licensees (who are only authorised to catch scallops) catch about 70 per cent of the total harvest, while B-Class licensees (who also fish for prawns) catch the remainder.

For the dedicated scallop fishers, production in low abundance years is usually confined to a very short season at the beginning of March (only in recent years) extending for about a month in duration, whereas prawn fishers catch scallops throughout the much longer prawning season. However, the scallop season can be extended if there is a high abundance of scallops.

Usually, after fishing at Shark Bay, the dedicated scallop fishers move to the Abrolhos Islands, where they can catch up to $1.5 million in product per vessel in a good year. The same boats occasionally fish in the State's northern waters or on the south coast at Esperance, depending on the season. However, these options typically form a very small part of the majority of revenue earned by holders of Shark Bay scallop authorisations.

The major feature of the catch in the Shark Bay area is the production 'spike' around 1991, which extended over a period of about three years. This spike has never been repeated, although similar variation has occurred in the Abrolhos Islands in subsequent years.

The prices of scallops have trended in a similar pattern to the prices of prawns, with a peak in 1995 – 1998 and declines in real (inflation adjusted) prices over the last five years (Figure 12).

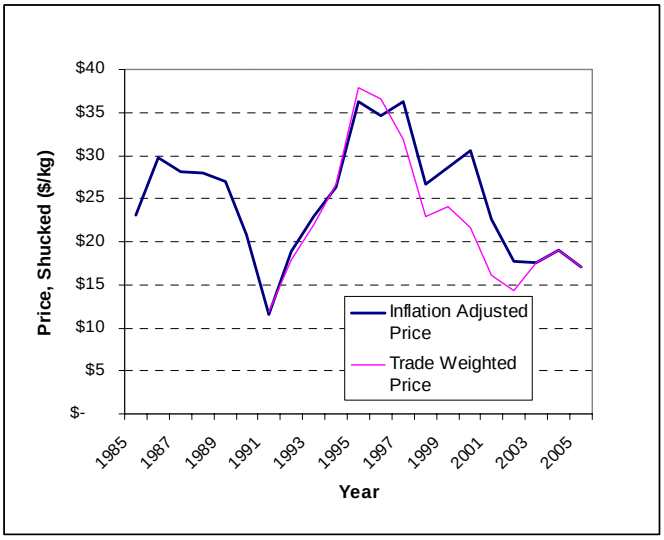

Figure 12: Scallop prices[8]

The variation in scallop prices has been around 120 per cent, compared with a 50 per cent variation in prawn prices over the same period. Combined with the extreme variation in catch over the same period, it is apparent that the scallop industry is subject to much greater economic variability than the prawn industry.

[8] The Trade Weighted Price demonstrates the trend in underlying world prices, with Australian producers being buffered by exchange rate variations in the period 1998 to 2002.

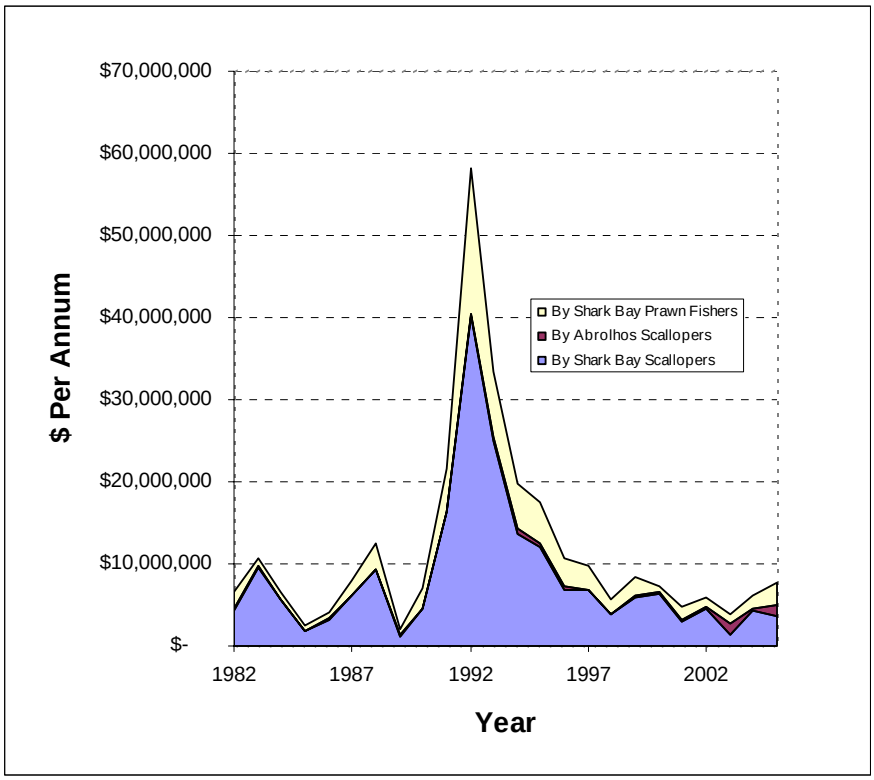

Figure 13: The gross value of production from scallops caught at Shark Bay and the Abrolhos Islands

A-Class and B-Class licensees differ in their behaviour (with the former targeting scallops, while the latter target prawns) and their allowable mesh sizes. Over the longer term, prawn fishers have taken 28 per cent of the total scallops caught, but this percentage has been higher in recent years as overall scallop catches have been lower in Shark Bay (see Figure 14).

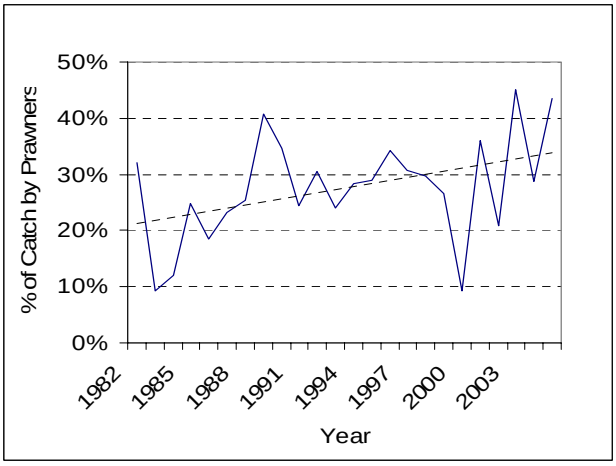

Figure 14: Trend in scallop catch by B-Class licensees

9.5.2.3 Cost Factors

Under the current fisheries management regime, there are two key effort variables in a given season, which fishers can adjust in order to adjust to market and seasonal fishing conditions. These are:

- the hours trawled each day; and
- the number of days trawled in a season.

Other parameters such as net size, spatial allocation of trawled areas and trawling speed can be regarded as 'givens'; that is to say they are either set under management plans or determined by economic fundamentals and therefore not able to be varied much at all.

As is the case with prawn trawling, the cost of scallop fishing is highly dependent on the time spent trawling. However, unlike prawns, the seasonal variability can be considerable and this leads to problems around overcapacity (in poor seasons).

In high abundance years, fishing is limited by the processing capacity of trawlers so the hours trawled in any given day are reduced as the fishers stop trawling to shuck their catch before moving on for another trawling run. The result in those years of high abundance is a longer fishing season, so more of the available catch can be harvested.

The rate at which shucking can occur depends on the processing infrastructure (including cold storage capacity on the vessel) and the number of deck hands that can be kept on the boat. It is noted that in Shark Bay, there have been no high abundance years since the early 1990s, which means, over the period of the analysis (undertaken to demonstrate the profitability of options), the median year is similar to the average year. However, this is not true for catches from the Abrolhos Islands, with the median year being significantly lower than the average year, over a 9-year period.

Figure 15 is a hypothetical relationship between the maximum fishing capacity of a vessel and the hours trawled in any given day (a 24-hour period).

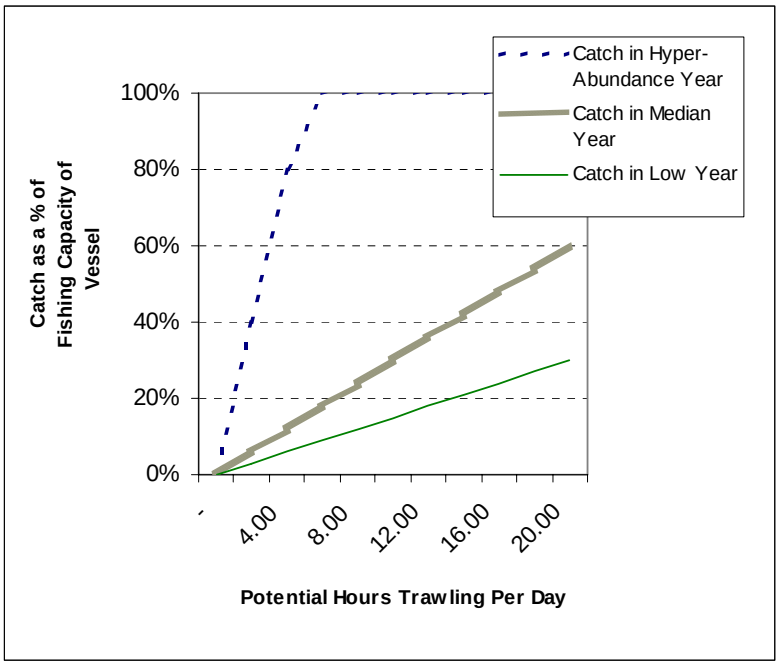

Figure 15: The relationship between fishing capacity and hours trawled

However, hyper-abundance years are the exception rather that the norm and need to be set aside when considering the relationship between catch and hours trawled. Figure 16 shows the linear relationship between the area swept and catch (demonstrated by plotting logbook data that exclude hyper-abundance years).

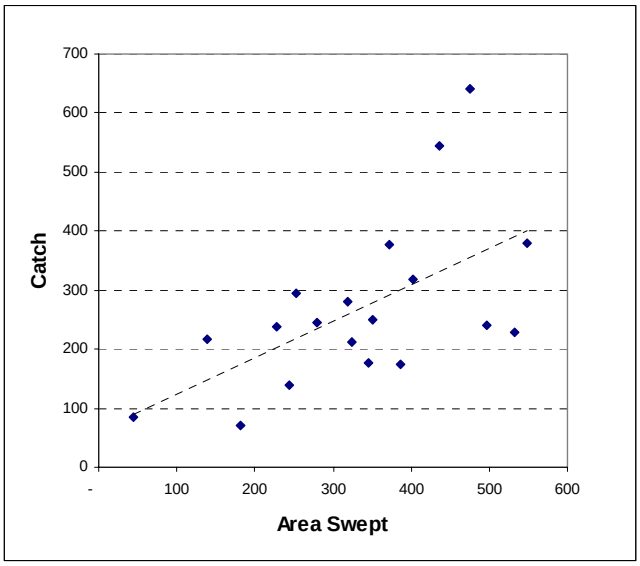

Figure 16: The relationship between catch and area swept

Comparatively, scallop fishers have lower fuel consumption rates to prawn fishers for three main reasons:

1. Scallop fishers use seven fathom nets (2 by 7) compared to the eight fathom nets used by prawn fishers.
2. They trawl at lower speeds because there is no risk of scallops escaping nets at speeds of about 2.5 knots, as opposed to prawn fishers who travel at approximately four knots in order to ensure they capture mobile prawns.
3. The mesh size of 100 mm used by scallop fishers imposes less drag compared to the mesh size of 50mm used by prawn fishers.

As a result, scallop trawlers estimate their fuel consumption to be about 60 litres per hour, compared to the 130 litres per hour used by prawn trawlers. In other respects, the fishing activity is the same as prawn trawling.

On the basis of the above, the following index[9] of catch to fuel consumption can be calculated. A logarithmic scale has been used to remove the emphasis the few hyper-abundance years have on the visual representation, so that the more recent trend (which is a downwards one), can be observed more clearly (Figure 17).

[9] Only includes data for A-Class licensees and assumes catches from the Abrolhos Islands are also incorporated on a pro-rata basis to numbers of vessels operating in that fishery.

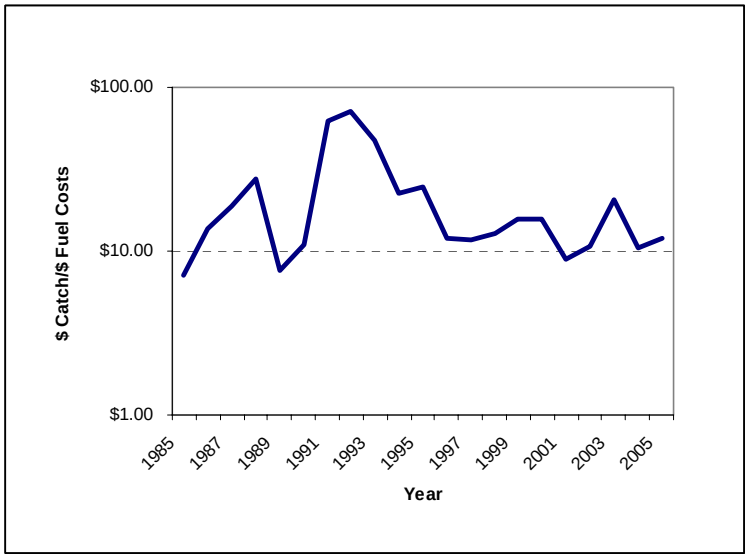

Figure 17: Ratio of catch value/fuel costs over time– scallop fishers

In summary, scallop trawlers are facing similar cost price pressures as the prawn trawling fleet although their cost and revenue structures are different in some important ways. The important differences are:

- the variability of fishing revenue and costs are much greater in the scallop fleet;
- there is a heavily skewed distribution of catching rates with few good years and many poor years for scallops, whereas the prawn fishery tends to operate more predictably around the mean/median year; and
- the Abrolhos Islands fishery provides another source of scallops for the Shark Bay scallop fleet.

In conclusion, there are a number of factors that impact on profitability of prawns and scallop trawling in Shark Bay. However what is clear is the increased economic pressure being placed on the fleet as costs rise and revenues remain static or even decline. It is important that the fisheries be reformed in order to ensure long term economic sustainability as well as long term biological sustainability.

9.6 Scallop Growth-Meat Condition-Reproductive Cycle

The meat condition issues with scallops are closely linked to their reproductive cycle. Scallop meat "condition" (a term which covers both the weight of the meat as well as its dry tissue content [which varies from around 17 per cent to 25 per cent of the wet weight]) deteriorates as the reproductive season (April to November) progresses.

This is because the tissues of the adductor muscle are used as a store of nutrients to 'power' the production of gametes and the long period of gamete production during the April to November spawning period "drains" the adductor muscle.

Shell growth also slows over this period (typically from around 90mm shell height). While there is a broad relationship between shell size and meat weight, the outcome of the slowing in shell growth

and the fairly rapid changes in meat weight, as tissues are 'drawn off' to power reproduction, is that meat weights can decline even if the shell is getting larger.

The texture and integrity of scallop meat also deteriorates as tissue matter is drawn off to power reproduction, which can impact on product quality (and result in more broken meats).

There are also some local variations in meat condition that modulate the broader scallop meat condition/reproductive cycle relationships. The reasons for this variation are not entirely clear and it is also not clear if it is a consistent pattern from year-to-year.

Denham Sound in particular is often reported to be 'out of phase' with other areas of the fishery (and some of this shows up in the studies reported by Joll and Caputi 1995). An improved understanding of this phenomenon could aid in the "micro-management" of the scallop fleet and improve yields from the fishery.

9.7 Environmental and Conservation Issues

Under Commonwealth environmental legislation [*Environment Protection and Biodiversity Conservation Act 1999* (EPBC)], all export fisheries are required to have an assessment of their environmental sustainability.

The Department of Fisheries has published Ecologically Sustainable Development (ESD) reports for both the Shark Bay Prawn and Shark Bay Scallop Fisheries (Kangas *et al.* 2006a and b). These documents form part of the Department of Fisheries ESD reporting processes and were used as the basis of submissions to Environment Australia (now the Department of Environment and Heritage) to meet the requirements of the Australian Government's Guidelines for the *Ecologically Sustainable Management of Fisheries* and to obtain export approval for both fisheries.

The ESD reports relate to performance of the fisheries from an ecological perspective and include reference to the operational objectives, performance measures and indicators that will be used to assess the performance of the fisheries.

The fisheries were awarded export status in 2003 by way of an exemption to Part 13A of the EPBC Act for a five-year period. A number of recommendations were made by the Australian Government in relation to these exemptions.

The recommendations cover a range of operational matters around consultative and decision-making processes, and recommendations related to byproduct and bycatch. For the Shark Bay Scallop Fishery, it was also recommended that a 'decision rule' to close the fishery or prevent commencement of the fishing season, when recruitment of scallops is sufficiently low, should be pursued as a priority.

This work is essentially complete by virtue of current management processes and decision rules used in the fishery on a season-to-season basis.

The fisheries operate within the Shark Bay Marine Park and World Heritage areas. There is a need to ensure that sustainable fishing practices – which have been demonstrated over the last 40 years - continue to be an important value of the World Heritage Area.

SECTION 10 FUTURE MANAGEMENT DIRECTIONS

10.1 Introductory Comments

The interaction between the prawn and scallop fleets within Shark Bay is a classic example of the complexities and difficulties that face those who operate in and manage fisheries.

A series of previous management decisions and iterations has resulted in two separate fleets under separate management arrangements 'sharing' the same fishing ground and, at times, the same resource. Finding solutions to these types of issues has preoccupied fisheries managers, governments and fishing industries for many years and "win-win" outcomes are difficult to achieve.

In the situation of the Shark Bay prawn and scallop fisheries, each sector blames, to some extent, the other. The scallopers argue that recruitment failure can be attributed, in part, to the operations of prawn trawlers on historical scallop grounds. In contrast, the prawners argue that there are too many scallop trawlers for economic viability and that scallop fishing impacts on the prawn fishery.

There are few, if any, points of agreement in the industry submissions. It can also be said that these issues are not new and have been around since the formal commencement of the scallop fishery.

The overriding objective of this review is to ensure sustainability long-term and to maximise the overall return to the community from the prawn and scallop resource. For this to be achieved, a new approach is required.

In considering future management directions, it needs to be clearly recognised that the prawn and scallop fisheries operate under separate legal instruments [Management Plans]. In this respect, the scallop fishery is of no less legal standing than the prawn fishery and *vice versa*.

It should also be recognised that prawn trawlers are also scallop trawlers with B-Class scallopers [prawners] operating under the same Management Plan as A-Class scallop licensees.

The Department of Fisheries has a responsibility to manage both fisheries for long term sustainability and community return. There are significant issues in the scallop fishery, in particular such as "priority of access" between A-Class and B-Class licensees and catch sharing arrangements.

There are also historical elements that have resulted in considerable tension within the fleets, related principally to government decision-making associated with the establishment of the scallop fishery.

While history is important and provides valuable lessons, it is perhaps more important to focus on the future to the mutual benefit of [hopefully] both fleets. Without a spirit of co-operation and compromise in resolving inter-fishery conflicts, there is a significant risk that one or both of these fisheries may face serious economic decline.

10.2 Management Options

There is a range of management options available in relation to the Shark Bay prawn and scallop fisheries to address issues associated with the long term biological and economic sustainability of both fisheries and to deal specifically with the issue of scallop recruitment. Some options are of a lower order and essentially 'tweak' existing arrangements or assist in more micro or real-time management.

Others, however, are more fundamental and represent a real shift in management measures. The majority of the options are focussed on the scallop fishery, given the scallop recruitment issue, and the interrelationship between A-Class and B-Class scallop licensees.

The options need to be considered on their merit, given the knowledge of factors affecting prawn and scallop recruitment and/or fishing mortality or their ability to contribute to that knowledge, their practicality of introduction (including compliance costs), their capacity to achieve or support management objectives, and their economic consequences.

Before considering future management options, there is merit in identifying the underlying principles of current management arrangements, particularly with respect to the scallop fishery.

These are:

- Sustainability of the scallop stock (i.e. ensuring there is adequate breeding stock through development of a catch rate decision rule (or rules), particularly if fishing is allowed before scallops reach maturity;
- Providing access to scallop stocks to both the A-Class and B-Class fleet at an optimum time for meat yield and condition;
- Provide protection to stocks during periods where the size of the scallops and/or meat yield and/or condition are not optimum, through use of closures based on, or "a", meat size/condition decision rule (or rules);
- Provide some certainty and stability around scallop catch sharing arrangements;
- Provide arrangements that will maximise the economic benefits to licence holders, crew and the community; and
- Minimise the impact of fishing-induced mortality on both prawn and scallop stocks.

The available alternatives for managing the fisheries are set out below with a summary provided at Appendix 1. At this stage, there has been no attempt to determine the "best" option (or combination of options). This will be a matter to be determined by all parties (the Minister, industry and the Department of Fisheries) once they have had the opportunity to consider and evaluate the options.

10.2.1 Scallop Fishing Season

Since 1994, the timing of scallop fishing in Shark Bay has historically been 'tied' to the prawn fishery. However, in the development of the Shark Bay fishery (i.e. pre-1984) there was no set fishing season, although scallop boats tended to fish in the months when the weather was more benign (March to October).

Prawn trawlers had only been able to take scallops in conjunction with their prawning activities during the prawn season (typically March to November at that time). While they could have fished outside that period for scallops using 100mm mesh nets, they had generally had enough of fishing by the end of the prawn season and were either laid-up or in re-fit immediately prior to the normal opening of the prawn fishery. As a result, the prawn trawlers did not engage in scallop fishing outside the normal parameters of the prawn fishery season (i.e. March to October/November).

Since 1984 the timing of the scallop fishery has been set within the constraints of the prawn season, so that prawn boats were able to continue to take scallops as by-product in their prawning operations (and subsequently as B-class licensees in the scallop fishery). However, this practice has brought with it the mind-set that the scallop season can only run during the overarching framework of the prawn fishing season.

Given the nature and timing of the scallop reproductive cycle in Shark Bay, and the level of fishing which has occurred in most years, the available 0+ year-class scallop stock has generally been fished down to the point where scallop fishing is no longer economic (for A-class scallop boats) by around July to September.

This economic 'bottom-out' is around 150 – 250 kg (meat) per day –depending on the economic parameters of the boat (crew numbers, fuel usage), although it has tended towards the higher value in recent years as fuel prices have increased. Thus the scallop catch in most years has largely depended on the strength of the incoming recruit group to provide the fishable stock.

In only a few of the last 20 or so years (1984 and 1992 [and maybe 1987]) - when the recruitment to the fishable stock in the previous year was of such a magnitude that it overwhelmed the capacity of the prawn and scallop fleets to fish it down - has the scallop fishery had a significant level of older (1+ age class) scallops present in the fishery.

The reproductive (and to some extent the growth and recruitment) problem is that recruiting scallops (i.e. 0+ age class) do not commence spawning until around mid-April (Joll and Caputi 1995). Therefore, with a scallop fishery that is tied to the prawn fishery season (March to October/November) there is a risk that scallop fishing could commence before the spawning season has begun.

In years of low recruitment, this would severely reduce the overall abundance of scallops (or their density – thereby possibly limiting effectiveness of fertilization) before the scallop stock has had an opportunity to spawn.

It is this scenario which is behind the development of the "matrix" which, among other things, attempted to deal with the interacting issues of total abundance and the relative abundances of the 0+ and 1+ year classes to determine a start date for the scallop fishery (but only within the mind-set of a March to October/November season framework).

Consideration should be given (at least in 'normal' seasons) to scallops being fished as 1+ age-class animals in the period January to March/April, which would put them into the biologically equivalent phase of scallops at the Abrolhos Islands.

At this time the scallops would be post-spawning, so there would be no issue of scallops being fished before or during their spawning period, the meat condition would be at a premium and moved into their post-spawning and the shells would all be large (which, in combination with the meat condition parameters, would mean a large meat size).

This fishing arrangement could be considered to be a development of the "matrix" which was not "constrained" by the timing of the prawn season.

However, there are some problems with such a proposal including-

- The prawn fleet would be cut out from taking scallops, unless they also fished at that time or, alternatively, just took any remaining scallops as by-product to their prawning operations. (Note that, if appropriate catch cut-offs were applied to scallop fishing early in the year, it would be possible to pass some of the 1+ scallops through to the prawn fleet).
- Late 0+/early 1+ scallops would be present on the trawl grounds during the prawn trawling season and, depending on the degree of overlap in prawn and scallop distributions, may be caught by prawn trawlers, who would then have to discard them. (Note also that if this fishing was adopted, then it may be necessary to apply some sort of size limit or other control to

scallops taken by prawn fleet to stop the latter from fishing down the 0+ year-class, which would be the following year's fishery for scallop trawlers).

- In years of hyper-abundance the presence of large amounts of scallops on the trawl grounds could be a real nuisance to prawn trawlers - particularly if they couldn't take them while prawn trawling, although this situation could be resolved by allowing prawn trawlers to retain scallops.
- In years of hyper-abundance, unless scallop stocks were fished down before the scallops got much past April - May in their 1+ year (i.e. moving to become 2+ year class), there could be a return of the problem of nematode blemishes in the meats. The problem occurs with older scallops, as the development of the nematodes is a function of time and the blemishes are not usually overtly expressed until scallops are nearing the end of their 1+ year.
- There is currently nothing in the management plan that allows for A-Class and B-Class licensees to be treated separately when it comes to the areas or times when scallops may be fished in Shark Bay.
- A scallop fishery operating in January to April would probably need to use larger mesh to avoid significant capture of incoming 0+ recruits (which would typically be around 70 – 80mm SH at that time).

Despite some of these difficulties, moving the scallop fleet to fish in January – March/April would mean that the scallop fleet was, in general, not trawling during the prawning season or at least when recruiting prawns had moved onto the main fishing grounds).

This would alleviate some of the scallop trawling/prawn interaction issues, although it might create a new issue of scallopers trawling in January – March/April in areas where large prawns occur at low abundance – which are the residual stock from the previous year and form part of the early season fishery for the prawn boats).

One possibility may be to have a much more dynamic approach to setting the parameters for the scallop season (effectively a modified "matrix"), which takes into account low-to-medium recruitment years (when fishing would be in the period January - March) and hyper–abundance years (when fishing could be timed to operate in a balance between a pest-removal mode and a meat size and condition mode).

This approach would also need to be teamed with catch-rate thresholds for the cessation of fishing, rather than just allowing the fishery to effectively close by reaching its economic 'bottom-out, in order to ensure that adequate breeding stock levels and/or densities remained - and, in the case of the A-Class fleet, to leave scallops for the prawn fleet (B-Class fleet) to catch.

10.2.2 Trawl Closure

The submission from the WCTA argues strongly for the implementation of a trawl closure on the main scallop grounds to determine if trawl-induced mortality is the primary cause of recruitment failure in Shark Bay. Indeed, the Association considers a closure to be its highest priority.

The WCTA argues that while the impact of intensive trawling on juvenile or emerging scallop populations is difficult to measure, they consider that, given the fragile nature of juvenile scallops, it is highly likely to have an effect. Previous research on this issue has been inconclusive and the extent of trawl-induced mortality on juvenile scallop stocks has not been properly quantified.

The closure would need to be meaningful and attempt to determine, with a degree of confidence, the impact of trawling on emerging or juvenile scallop stocks. As a result, it would need to be located

on historically important or key scallop grounds, of a sufficient size (the WCTA suggests no smaller than 10nm X 3nm), and in place for a sufficient period (the WCTA suggests at least five years). This scenario would provide a reasonable likelihood of a closure being in operation when there was sufficient recruitment to provide a 'signal'.

To support the case for a closure, the WCTA points to the recovery of the USA's sea scallop fishery for the long-lived scallop species *Placopecten magellanicus.*

This particular closure has been examined by the Research Division of the Department of Fisheries to assist this review process. The Research Division has advised that in this fishery, there was a significant stock decline in the Georges Bank area.

Year-round closed areas were implemented in 1994, as part of a suite of management strategies. The biomass increased in the Georges Bank area by 18-fold and the increase was attributed to the area closures (Hart 2003, Hart and Rago 2006).

However, assessment of a recruitment increase was inconclusive and the long-term mean scallop recruitment in the closed and open areas was similar. The physical effects of trawling and dredging on juvenile scallops were also tested, but no area effect on recruitment was found.

Hart (2003) considers rotational fishing as part of a precautionary strategy rather than a solution to all woes. Rotational closures are only effective in a fishery when size at capture is below optimal and other fishery management measures are not able to manage this issue.

In the Western Australian context, this optimal size of capture may also be attained through other mechanisms, such as a larger mesh size which allows smaller scallops to escape.

Another long-term closure experiment with scallops has been conducted in the Isle of Man (Beukers-Stewart *et al.* 2005). In this case, a closed area and an adjacent fished area have been monitored for a period of 14 years for the long-lived scallop species *Pecten maximus*.

When the scallop closure was implemented in 1989 the overall scallop densities were very low. Once the closure was in place, the abundance increased significantly, in both the open and closed area. By 2003, there was seven times the amount of scallops in the closed area than there had been at the start of the closure.

As would be expected, there was a shift in size and type to a much larger and older stock in the closed area than before. This resulted in both the biomass and reproductive biomass being significantly higher in the closed area. This reproductive output should result in some larvae being exported out of the closure area as well.

It was also demonstrated that juvenile scallops had higher survival and individual growth rates in the closed area than in other places. It was hypothesised that this was due to less fishing disturbance in the former.

There are substantial differences in the life history traits of the two species discussed above compared to *Amusium balloti* – the scallop species which occurs in Shark Bay - which must be recognised. Both *Placopecten magellanicus* and *Pecten maximus* are long-lived species, living up to 20 years of age and therefore biomass accumulation can be highly positive in closed areas.

For *Amusium balloti* – which generally only live up to two years - very little benefit would occur in biomass increase for closures longer than two years, unless the closure area also results in increased

recruitment in closed and/or adjacent areas. Also, in *Amusium balloti*, a high incidence of nematode infestation occurs in older, larger animals and this detracts from their market value.

In Queensland, the introduction of a rotational harvest strategy for *Amusium balloti* commenced in 2001. The effectiveness of seasonal and rotational protected area (SRA) management strategies in stabilising recruitment and maximising yields in the fishery is still being assessed.

The current rotational strategy allows for a nine-month fishing period, followed by a 15-month closure. To date, a highly significant relationship has been found between the proportional increase in scallop catch rate within SRAs, in relation to closure duration in years. Queensland authorities currently consider the rotational harvest strategy areas to be a suitable management strategy to ensure the sustainability of scallop stocks (DPI Annual Status Report, 2006).

Given the above, advice from the Department's Research Division suggests that closures may be beneficial if the displacement of effort is not counterproductive in the areas that remain open to fishing. Physical damage to small recruiting scallops may also be an issue, but no study has yet conclusively demonstrated this.

It is likely that repeat recapture and release increases mortality rates and the level of physical damage to juvenile scallops. This means that areas with high recruitment could be closed off to optimise the good recruitment and enhance the survival of those recruits.

The closure of a reasonable abundance of scallops may also increase egg production if the closure is maintained during the spawning period. However, there is no easy way to measure the success of this strategy, as it is unlikely that the resultant offspring will end up in the closure area due to the length of larval life (two to three weeks) and advection of larvae.

Confounding effects will make it difficult to deduce whether an improvement in recruitment could be attributed to the protection of the spawners in the closed area or due to purely natural environmental factors.

No studies to date categorically state that area closures have resulted in higher recruitment success, even though the biomass has increased in areas closed to fishing in comparison to those generally open to fishing.

In the USA's Atlantic sea scallop fishery, it was indicated that there may have been some evidence of downstream effects of increased recruitment in one part of the fishery, but this was not an overall observation. The 'hit-and-miss' nature of larval settlement may preclude the ability to demonstrate benefits of increased recruitment.

Murawski *et al.* (2000) suggest the incorporation of critical source areas for larval production in any closure scenario. Studies of scallop larval production in relation to hydrographic circulation on Georges Bank (Tremblay et al. 1994) have emphasised that some areas may be self-seeding, whereas others are net exporters of larvae widely across the bank and to scallop grounds south and west.

Permanent or long-term closures for spawning protection may increase overall recruitment to the stocks. Additional modelling work incorporating historical circulation patterns and distributions of adult and juveniles scallops is needed to verify the predictive capabilities of these models.

This type of research is part of the Research Division's proposed Fisheries Research and Development Corporation (FRDC) project for Shark Bay, i.e. spatial closures and oceanographic modelling.

No one advocates permanent closures for the primary aim of increasing yield, as increases in recruitment outside the areas must increase sufficiently to make up for the loss of yield in the closed areas. However, permanently closed areas may be appropriate for other reasons, such as habitat protection, and the reasons for closures or specific closures need to be explicit and understood by all stakeholders.

Although no spawning stock recruitment relationship is evident at current stock levels in Shark Bay, there must be a level to which a stock can be driven that would result in poor recruitment. However, the large variation in recruitment due to environmental conditions makes it difficult to determine the minimum spawning stock level required.

The scallop and prawn fleet in Shark Bay have high fishing efficiency and the capacity to fish down the scallop stocks rapidly. During the latest Shark Bay survey (November 2006), the amount of residual scallops was minimal, indicating the capacity of the fleet to take the available stock in one fishing season. This indicates that some protection of the spawning stock during the peak spawning period is critical to ensure some spawning success.

Traditionally the prawn boats commenced prawn fishing prior to the opening of the scallop season and the operational areas of prawn and scallop boats have some overlap. When the scallop season opened, both prawn and scallop boats retain scallops.

The scallop boats leave the fishery when catches are economically unviable to continue fishing. The prawn fleet then continue to take scallops until the end of their prawn season (usually November).

As early fishing has been an option in recent years (fishing pre spawning) to take advantage of the better quality meat at this time of year, other mechanisms to protect some portion of the spawning stock (including area closures) may be required as a precautionary measure. There is little protection afforded to the spawning stock of scallops if fishing commences much earlier than the spawning season (i.e. February/March) and then continues all year.

As a result, catch rate thresholds and/or closures are required to protect the breeding stock. Modelling of larval transport mechanisms may allow for a more strategic placement of a closure area in the future, which may give the best chance of optimising spawning potential.

In summary, the options for closed areas include:

- Protection of 0+ scallops identified in the November surveys - noting there are two parts to the Shark Bay scallop fishing area - Denham Sound and Shark Bay north.
- Denham Sound - this appears to be resolved with early fishing (Feb/Mar) by scallop boats only during daylight hours (to minimise prawn interaction) and then complete cessation of fishing at a catch rate threshold leaving adequate spawning stock and scallops for prawn boats to catch later in the season (but noting that later in the year, scallops tend to be of poor meat quality).
- Northern Shark Bay - this would appear to be at least partly resolved with scallop fishing commencing for both prawn and scallop boats at the same time, until a catch rate threshold level is reached and with a cessation of retention of scallops for the period May – June, although fishing for prawns continues over these grounds. Scallop fishing could then re-commence until the end of the prawn season or cessation of scallop retention could continue

to avoid taking sub-optimal scallop meat weights (and with the result that most of the scallops would be available in optimal meat condition in the early part of the following year). However, there is no specific area closure in the northern part of Shark Bay to protect scallops.

- Protection of spawning stock - if used, this would require a large area to offset early fishing (much prior to spawning season) in all of Denham Sound and Shark Bay. This assumes that spawning is limited or disturbed by fishing.
- Protection of settling recruits after spawning period (i.e. after April/May). This closure would be based on areas where good recruitment has been traditionally observed.

This can be tested with research closures to compare 0+ survival inside and outside closed areas. This should be done for at least two years and, ideally, several replicate areas chosen. There are several scenarios that could arise from the experiment – see the table below.

Age group	Open	Closed	Result
0+	poor abundance	poor abundance	No result can be determined.
0+	good abundance	poor abundance	Closure is not adding any benefit.
0+	good abundance	good abundance	No result can be determined.
0+	poor abundance	good abundance	Closure is likely to be positive.

10.2.3 Formalised Scallop Catch Share Arrangement

Notwithstanding, the highly variable nature of scallop recruitment, management that is based on the control of catch, either overall or proportionally between the A-Class and B-Class fleet, is worthy of consideration.

While not addressing the fundamental problem of poor scallop recruitment, a formalisation of catch share arrangements would resolve one current management 'tension' between the A-Class and B-Class scallop fleets. Subject to the relevant management tool (e.g. catch cut-offs, competitive Total Allowable Catch, etc) this would deliver a sustainability benefit by ensuring that adequate breeding stock remain for spawning.

It should also be noted that even with other management reforms such as fleet or gear adjustment, the issue of 'catch share' will remain between the A-Class and B-Class fleet. There is considerable merit in resolving this issue.

In considering this matter, it is acknowledged that the prawn sector will point to the history of development of the scallop fishery and discussions at the time the scallop fishery was declared limited entry. However, the benefit of providing some certainty to the fleets, with respect to catch allocation and removing the ongoing tension with respect to catch share, has considerable merit and is strongly recommended for consideration.

10.2.4 Quotas

The alternative of output controls (namely individual transferable quotas) could be considered for the scallop fishery, given the potential of output management tools to improve the incentives to cut fishing costs. If other obstacles concerning the management of the fishery and the assessment of compliance could be overcome, output controls (combined with appropriate input controls governing for example spatial and temporal fishing restrictions) might overcome the inefficiencies in gear and lack of flexibility around the unitisation of gear.

On the positive side, quotas could:

- allow fishers to target the most appropriate time to fish, e.g. when prices were highest or catch efficiency was higher;
- allow fishers to use a range of fishing gear and thereby trial fishing innovations more readily (noting the need to ensure data consistency for research purposes);
- possibly reduce some aspects of the compliance effort (although other aspects may be increased);
- potentially provide more direct control to managers over the sustainability of stocks through the setting of a realistic TAC; and
- increase the incentive of fishers to reduce fishing costs, by eliminating (or at least reducing) the incentive to 'rush to fish'.

On the negative side, quotas could:

- be difficult to operate because of difficulties in predicting the catch from one year to the next in order to establish a realistic TAC[10]; and
- potentially add compliance costs in order to more effectively monitor catch and/or provide better stock level predictions.

In the case of the scallop fishery, there is a fairly well developed catch prediction system, which could be adapted to a quota or catch sharing management arrangement.

Further consideration of a quota system could be advantageous, given the potential benefits in increasing fishing efficiency.

10.2.5 Unitisation of Head Rope Entitlement

Under the current management settings, there is considerable inflexibility around the specification of gear (input) controls. Long-term sustainability concerns have obviously been a major factor in the development of restrictive gear options, but inflexibility around how those gear options are unitised, transferred and rearranged on vessels (e.g. combining net entitlements on one vessel) would appear to limit the economic performance of the fleet.

Similarly, changes in the future that prescribe certain configurations of gear and create incentives for fishers to fish hard and as quickly as possible could work against the long-term economic condition of the fishery. This is particularly true in a fishery where the catch-to-effort ratio varies markedly through the season.

More flexible arrangements, such as the unitisation of head rope entitlement, would allow fishers to decide which gear they use at a particular time, provide greater efficiency within the sector and lead to more active trading of headrope entitlement (either in fathoms or as a full complement of nets) as fishers adjusted their operations to suit different economic conditions.

One of the major issues related to this option is the difficulty in calibrating the effort across a range of different gear configurations. Therefore, the calibration of the performance of various gear options would need to be acceptable if greater flexibility was allowed. A number of approved combinations could be developed that provide industry with some flexibility, while still providing the Research Division with meaningful research data.

[10] It would appear that quotas in the Golden Bay Scallop Fishery of New Zealand are rarely met by the actual catch, effectively meaning the TAC has no impact on fishing effort.

An illustrative scenario for each sector in relation to gear changes is provided in Appendix 2.

10.2.6 Buy-Back

Given economics and over-capacity issues, consideration could be given to a restructure of one or both fleets, with a view to reducing the number of boats and associated gear entitlement within the fisheries.

A buy-back scheme would allow vessels to leave the industry with compensation, paid for by industry through a Government facilitated buy-back scheme. The economics of such a scheme are supported by the lower interest rate provided through Government guaranteed funds, although these sorts of schemes do impose their own risks on Government.

Separate discussions are underway by Shark Bay Prawn licensees and A-Class scallop licensees, (in the case of Shark Bay Prawn, discussions are well advanced) with respect to the options for a buy-back scheme in the respective fisheries. It is likely that in one or both fisheries, buy-back arrangements will progress ahead of the final outcomes of this review.

10.2.7 Gear Controls

As a means of improving economic efficiency and minimising gear interactions across the prawn and scallop fisheries, there would be merit in reconsidering scallop mesh size to more closely align mesh size with the target size class. This is related to the timing of the scallop season discussed in 10.2.1 above.

In addition, consideration could be given to the introduction of square mesh cod ends for the scallop fleet to limit/reduce any impacts on prawns caused by 'filtering' them through the current 'diamond' mesh scallop nets.

Quad gear or increased headrope of twin gear could also be a mechanism to facilitate "get-in or get-out quickly"-style fishing for scallops (particularly in years of lower stock levels). Given that the prawn fleet is targeting larger size prawns than it did in the 1970s and 1980s, there may be merit in reviewing the mesh size used for prawns.

10.2.8 Single Trawl Fleet

At various times the notion of a single trawl fleet, targeting prawns and scallops, has been informally suggested.

In essence, this would result in an amalgamation of the prawn and scallop fleets, with both having the capacity to take prawns and scallops under one trawl management plan. Whilst this may sound straightforward, in practical terms it is not easy to see how this could realistically be achieved.

While solving some issues, the formation of single trawl fleet would create a range of other very serious and complex management and equity issues, with the benefits unlikely to outweigh the costs. That is not to say that in the long term, a single fleet is not a desirable outcome and may, in fact, be possible through industry and market-facilitated re-structuring. It is not proposed at this stage as a viable management option.

10.2.9 Integrated Scallop Management

There may be merit in considering management of the State's scallop fisheries on an integrated basis, aligned under a single scallop management plan.

Under this scenario, the WA scallop fishery would be broken into zones, with greater capacity and flexibility for the Department of Fisheries in decision-making (e.g. openings and closings of zones, based on the best overall outcome). Such an approach would also focus management on optimising value across the WA scallop fishery.

10.2.10 Other Measures

There are a number of other, less substantive, changes which could be considered to help improve overall management of the fisheries. These include:

- changes to the Prawn and Scallop Fishery Management Plans to provide greater flexibility for the implementation of spatial and temporal closures and provision for differing management arrangements for A-Class and B-Class licensee in the scallop fishery; and
- the possibility of daylight fishing only for A-Class scallop licensees to assist in minimising any gear impacts on prawns.

As a final comment, once a future management framework is settled, there is a need to ensure clear understanding of the mode of implementation of the various management options (e.g. legislation, determinations, 'gentlemen's agreements', etc).

There is also likely to be a need for Management Plan amendments and, potentially, for development of an underpinning Ministerial Policy Guideline, particularly in relation to matters such as decision rules.

It is important that licensees within the Shark Bay prawn and scallop fisheries and the Department of Fisheries (including the Research Division and Fisheries Management Services Division) are clear on their respective roles and responsibilities and the overall governance arrangements for management of the fisheries. This will provide for greater certainty and understanding into the future.

SECTION 11 FUTURE RESEARCH DIRECTIONS

As noted earlier, the Department of Fisheries' Research Division has a very strong relationship with industry. Indeed, much of the real-time management within the fisheries occurs as a result of direct communication between operators and Research Division staff.

There have been a number of targeted research programs in the Shark Bay prawn and scallop fisheries over the years, although the results of some have not proved conclusive. The current management settings including adaptive, real-time management have also provided a degree of experimentation in relation to questions surrounding scallop recruitment and gear interaction[11].

[11] However, as noted by the Department of Fisheries in its submission, the uncontrolled nature of these experiments, in the scientific sense, have not been able to demonstrate anything particularly useful.

This review provides an opportunity to identify research work which may 'put to bed' a number of issues, such as those around gear interaction and the benefit of a closure(s) in the scallop fishery.

An important point in relation to research is that the data derived from the fishery has had a very high degree of comparability and useability because of the high level of standardisation of fishing gear. Fishery-dependent data is one of the key data sources used to manage the fisheries. It is critical that changes in management settings do not result in the loss of comparability of fishery-dependent datasets.

Notwithstanding the above, and as part of the review process, a number of future research needs have been identified which are relevant to both the prawn and scallop fisheries, but with the main focus on scallops.

There is an urgent need to develop an understanding of the level of gear interaction between the prawn and scallop sectors and whether this may be a cause for the recent low scallop recruitment and subsequent catches in the fishery, and if scallop fishing negatively impacts on prawns.

This urgency was noted at a recent workshop that reviewed the research and management needs in the Shark Bay trawl fisheries. Both prawn and scallop sectors support the need to fully and rigorously address the issue of gear interactions in those areas of the fishery where the distribution of the target species overlap.

Several research gaps in relation to gear interactions will be addressed as part of the proposed FRDC funding application to be submitted for commencement in 2007/08.

The use of adaptive management techniques, such as trialling spatial closures within specific areas of the scallop fishery, will provide key information about the usefulness of such a management approach for the short-lived and sedentary scallop species *Amusium balloti* and to assess the impact of the closures on the capture of migrating prawns.

The proposed FRDC project will be used as a pilot study to assess whether closures can assist to increase scallop recruitment, mitigate the impact of continued release and recapture on mortality, and whether or not area closures could be used as a possible management strategy in the future. Completion of this project should result in information that is required to help optimise the use of these resources and assist to resolve the resource sharing conflicts between sectors within the region.

A further objective of the proposed FRDC project is to develop an understanding of the oceanographic effect on recruitment within Shark Bay, which may assist in determining the reasons for the persistent low scallop stock levels in the bay.

In addition, prawn larval behaviour could also be incorporated to investigate annual variations in prawn recruitment. Developing specific models of water and scallop larval movements within Shark Bay, along with an assessment of relevant environmental variables (e.g. SST), would also provide insights into the potential causes of the relatively low level of scallop recruitment in areas that were traditionally reliable scallop grounds.

Analyses of environmental factors such as the Leeuwin Current and sea surface temperatures on recruitment and scallop catches, combined with trends in relation to climate change, will need to be conducted. These analyses can be incorporated with updated analyses of spawning stock-recruitment-environment relationships.

An analysis of improved fishing power is required to ensure that catch rate thresholds used for management purposes remain appropriate. Vessel gear configurations and impact of other boat changes to fishing power also need to be monitored, particularly given the need, as outlined above, to ensure fishery-dependent data remains useable.

A range of other research needs have been highlighted by the Department of Fisheries, including a review of the logbook data and improved Geographical Information System (GIS) analyses, and an analysis of existing data (logbooks and surveys) including assessment of day-night catch patterns for scallops.

In regard to scallops specifically, and in addition to the above, the Research Division suggests that earlier biological studies may need to be supplemented by more recent scallop biological information, particularly meat weight and reproductive cycles in relation to spatial and temporal changes recently observed in Denham Sound, North West Peron and Red Cliff. This could be achieved by establishment of a commercial sampling program using selected scallop and prawns boats (when scallop boats have left Shark Bay).

SECTION 12 NEXT STEPS

This draft report has been prepared to document issues and possible options for future management of the Shark Bay prawn and scallop fisheries. The report also addresses future research requirements.

The report will be released for comment by industry members and other relevant stakeholders. Submissions on the draft report will be reviewed and a final report prepared.

It is proposed that the final report will then be used as the basis for discussions with industry members to map out future management and research directions of these fisheries.

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APPENDIX 1 SHARK BAY PRAWN AND SCALLOP FISHERIES DRAFT MANAGEMENT OPTIONS

Option	Description	Reason/Basis	Comments
1. Adjustment to scallop season (early start with explicit season finish).	• **Early fishing (i.e. in February/March) of 0+ and residuals from previous season (1+), subject to survey results.** • **Explicit (and fairly high) catch rate thresholds (or total catch taken) for cessation of fishing (season closure).** **[refer Attachment 1 for more detail]**	• **Maintenance of spawning stock.** • **Optimise meat yield and condition.** • **Catch share management tool [refer (3) below)].**	• **Could incorporate spatial micro management (e.g. Denham Sound versus main grounds). Such micro management is already undertaken.** • **Needs formalised decision rules for opening/closings.** • **Note impacts on existing survey/catch prediction model (based on March/April opening). May need season adjustment or re-working.** • **If leaving higher level of residual stocks, would need to be matched with a increase in catch cut-off.** • **Would require explicit catch level controls for CPUE trigger limits in the prawn fleet and the return of scallops to the water by the prawn fleet during the prawn season once those triggers had been reached.**
2. Trawl closure.	• **Implementation of a trawl closure [prawns and scallops] for at least 3 years. Could be open in Feb/March/April period for early prawn and scallop fishing but then closed.**	• **Assist in resolving research question around scallop recruitment and impact of trawl gear.**	• **Current FRDC project proposal.** • **Closure area and timeframe needs to be meaningful. Permanent area needs to be positioned in area of high likelihood of scallop recruitment, but there also needs to be scope to include any areas of high scallop abundance on an adaptive basis from year-to-year.** • **Prawns will migrate through closure area and hence still be available to prawners, provided areas into which prawns migrate are open for the purpose of catching those prawns.** • **Longer term closure (need and area) subject to research results.**

3. Catch Share.	• **Introduction of a formalised catch share arrangement based on competitive TAC [in-season] or catch cut-offs [established pre-season].**	• **Will deliver sustainability benefit by leaving spawning stock and resolve catch share issue.** • **Note that catch share outcome is dependent on having the threshold level correct to provide the catch level. Initially, the survey data may not provide accurate catch share amount(s).**	• **Would need to be based on average catch share over history of scallop limited entry fishery.** • **Would need to be on an annual basis.** • **Some compliance issues although less with a competitive TAC than with ITQs. Need daily reporting and total landing reconciliation.** • **Competitive TAC would need to be set on a precautionary basis in the initial years, due to uncertainty in the accuracy of prediction.** • **Could be incorporated with option 1 as the control on catch levels by the two fleets.**
4. Quotas (scallops).	• **Individual transferable quotas**	• **Economic efficiency**	• **Various pros and cons**
5. Unitisation of head rope entitlement.	• **More flexible gear arrangements which could be considered across both fleets.** • **For prawn fishery, consider progressing unitisation as a matter of priority [noting flow-on to B-Class scallop licensees] together with rationalisation of gear configurations across the fleet.** • **For scallop fishery, consider unitisation including possible capacity for fleet contraction in 'poor' years and expansion in 'good' years. Need to couple unitisation with rationalisation of gear configurations across the fleet.**	• **Primarily economic efficiency.** • **May get some fleet reduction by way of gear amalgamation.** • **Some catch share implications if there are changes in relative ratios of headrope between fleets.** • **May allow for flexibility in fleet size within the current limited entry parameters.**	• **Need level of standardisation for research purposes.** • **May need to include a gear 'discount' or net reduction as part of unitisation process.** • **Should be matched with gear unitisation in the Abrolhos Islands.** • **Requires that CPUE thresholds be recalibrated to the new gear.**
6. Buy-Back.	• **Industry driven re-structure through industry funded buy-back (direct buy-out of licenses and net allocation).**	• **Fleet rationalisation. Reduction in capacity.** • **Economic efficiency.** • **Reduction in real fishing effort with sustainability benefits**	

7. Gear Controls.	• **Reconsider scallop mesh size (i.e. need appropriate mesh size to take target size class). Note linkage to (1) above.** • **Consider square mesh cod end for scallop fleet (size?).** • **Consider quad gear (as part of the unitisation process). Linked to (5) below.** • **Review prawn mesh size.**	• **Minimise any scallop gear impacts on prawns.** • **Improve economic efficiency and/or size selectivity.**	• **Proposed FRDC proposal will address much of this.** • **Could consider trials initially of 100mm mesh.** • **Needs to be examined in the context of any season shifts and for changes in target sizes.**
8. Single trawl fleet.	• **A formal merger of the two Management Plans to establish one Shark Bay trawl fishery.**	• **Minimise gear interactions.** • **Economic efficiency.**	• **Not considered a practical, realistic option.** • **Could be a long term possibility, particularly with internal re-structuring within and between the fleets.**
9. Integrated scallop management.	• **A formal merger of all the existing scallop fisheries to create one Scallop Management Plan, with a number of zones within the fishery (alternatively, focus on a formal integration of Shark Bay and Abrolhos Islands).**	• **Benefit would be greater capacity and flexibility of the Chief Executive Officer of the Department of Fisheries in his decision making (e.g. openings and closings of zones based on best overall outcome).** • **Would focus management on optimising value across WA scallop fishery.**	• **May have implications for those licensees who do not hold other scallop authorisations.** • **Would formalise what we try to do presently.**
10.Management Plan adjustments.	• **Need greater flexibility in Management Plan for spatial/temporal closures and for ability to implement different management arrangements for A-Class and B-Class licensees.**	• **Management flexibility.** • **Can be used as one tool for catch-sharing outcomes.**	

11. A-Class daylight fishing only.	• **A-Class daylight fishing only.**	• **Minimise any gear impacts on prawns.**	• **Possible option to consider in the absence of more substantive measures such as unitisation and catch share arrangements. Could be used while gear interaction issue is worked through.** • **Probably more of a tool to be used on occasions.** • **Currently in place in Denham Sound.** • **May have efficiency impacts and therefore may need to increase gear size to offset these efficiency changes.** • **Possible marine safety issues with anchored scallop vessels at night and mobile prawn vessels.** • **Could cause nasty fleet interactions.**
12. Governance issues.	**Once management framework settled, need:** **- clear understanding and processes for legislative gazettals, determinations and gentlemen's agreements.** **- Need Management Plan amendments.** **- May need underpinning Ministerial Policy Guideline.**	• **Clear understanding by both fleets and Department of processes and decision rules.**	• **Need an agreed and robust process for industry consultation.**

ATTACHMENT 1 MANAGEMENT OPTION – ADJUSTMENT TO SCALLOP SEASON (EARLY START)

NB: This is indicative only. If considered worthwhile as a management option, then full details would need to be mapped out with industry.

- Overriding philosophy for the timing of the opening [and closing] of the scallop season is:
  - maintenance of scallop spawning stock (i.e. to ensure an adequate level of spawning stock is present during the spawning season);
  - optimisation of meat yield and condition; and
  - equitable catch share outcomes.

- Subject to annual survey results in November, opening date would be determined taking into account the abundance of pre-recruits (0+) and residuals (1+). Note that Denham Sound and the rest of Shark Bay could be treated separately.

- Following November survey, decision steps would include:

  1. If *good* (i.e. high abundance) survey result for 0+ (or residual 1+) [need decision rule here], then look at modal/mean size classes within the 0+ population. If *large* (i.e. 60+mm mode) and abundant 0+ then move to an early opening in February/March. If *smaller* (i.e. 50 - 60mm mode) open March/April (to allow for some more growth). Fishery should then be closed at a certain point to retain spawning stock [based on a decision rule] (e.g. kg per hour or catch share taken) [adjusted by headrope used (if unitised) or different mesh size used].

     Under this scenario, the option is open for differing arrangements for the A-Class and B-Class fleets. A decision could be taken to close the fishery to A-Class licensees but leave it open to B-Class licensees to take their share later [as they commence prawn fishing]. A decision rule for closure of the fishery to B-Class and [consequently the fishery overall] would also be required. This approach would require formalisation of the catch sharing arrangement between the two fleets. If no formal catch share arrangement is in place, then suggest total opening and closing of the fishery across both the A- and B-Class fleets.

  2. If *medium* or *low* abundance of 0+ survey result (i.e. low recruitment or smaller size classes), should not open the fishery at all [need decision rule] or only open the fishery for a limited period [possibly April (with smaller 0+ size classes in November survey) or March (with larger 0+ size classes in November survey)]. Could also require use of larger mesh nets to shift catch towards taking only residual 1+. A separate decision rule would also be required overall for seasonal closure of the fishery.

The above decision steps are summarised in the table below (noting further issues of details would need to be considered, in liaison with industry).

Estimated catch/ survey result	**Abundance/condition of recruits (0+)**	**Abundance/condition of residuals (1+)**	**Indicative opening – A Class**	**Indicative opening – B Class**
High >500t ?	High >300t (abundant and/or large 0+)	>200t ?	February/March	Early/late March, but dependent on moon phase
Medium <200t ?	Medium <100t (less abundant and/or smaller 0+)	<100t ?	Limited opening – March/April	Limited opening – March/April
Low <100t ?	Low <50t (low abundance)	< 50t ?	Close	Close

APPENDIX 2 UNITISATION OF HEAD ROPE ENTITLEMENT – FOR ILLUSTRATIVE PURPOSES

Possible Gear Changes - Prawns

Gear configurations could be amended in the prawn fleet such that trawling capacity is increased, thereby allowing for the structural adjustment of the fleet from 27 vessels to, say, 18 vessels.

In this scenario, options would include amending specifications of gear from two nets of eight fathoms in length to four nets of 5.5 fathoms in length. It is assumed that this configuration would result in a 50 per cent increase in the catch per vessel, partially resulting from the increase in headrope and partially from an increase in the overall share of available prawn stocks.

In order to reflect this, it is assumed there would be a 20 per cent increase in the hours trawled.

Under this new scenario, in a median year, the average vessel would earn around $1.34 million in revenue (including scallop catch). In average years, this figure would be around $1.49 million.

These revenues result in an estimated median net profit of about $688,000, which is an improvement of $244,000 per vessel, based on the following assumption:

Vessel cost	$550,000 (depreciated at 13 per cent per annum)
Annual refit cost	$100,000
Administration	$30,000
Insurance	$30,000
Annual licensing costs	$35,000
Labour at 25 per cent of catch value	
Fuel at $150 per hour	

This corresponds to a 12 per cent return on investment in median years and a 13 per cent return on investment in average years if it is assumed that gear entitlements are worth $5.2 million[12] after the consolidation of entitlement value (on a ratio of 27:18). While the reform does not significantly alter the return on investment (from 11 per cent to 12 per cent), it importantly increases net profit per vessel.

The driving factor behind increases in profitability is the reduction in fixed costs required per kg of prawns caught.

[12] Indicative only. Figures will depend on the capital value of entitlements.

Possible Gear Changes: Scallops

Similar to the prawn proposal, scallop gear configurations could be amended to increase trawling capacity, thereby allowing for the structural adjustment of the fleet from 14 vessels to, say, 9 vessels.

In this scenario, an option could include amending scallop gear specifications from two nets of seven fathoms in length to four nets of 4.5 fathoms in length. The analysis below has been undertaken on the assumption that trawling hours would need to be increased by 56 per cent, which is the ratio at which the fleet is reduced and a higher ratio compared to that assumed in the prawn industry (20 per cent increase in trawling hours).

It is assumed also that this configuration would result in a 50 per cent increase in the catch per vessel, partially resulting from an improvement in the average catch and availability of scallops as more vessels leave the fishery.

Under this scenario, in a median year, the average vessel earns around $510,000 in revenue. In average years, this figure is around $736,000.

These revenues result in an estimated median net profit of about $110,000 (and average profit of $264,000) which is an improvement of $76,000 in median profit, based on the following assumptions:

Vessel cost	$250,000 (depreciated at 13% per annum)
Annual refit cost	$60,000
Administration	$30,000
Insurance	$30,000
Annual licensing costs	$20,000
Labour at 25 per cent of catch value	
Fuel at $75 per hour	

This corresponds to a four per cent return on investment in median years and a eight per cent return on investment in average years, if it is assumed that gear entitlements are worth $3.1 million[13] after the consolidation of entitlement value (on a ratio of 14:9). While the reform does not significantly alter the return on investment (from two per cent to four per cent in median years), like prawns, it importantly increases net profit per vessel.

[13] Indicative only. Figures will depend on the capital value of entitlements.

List of Fisheries Management Papers

Not all have been listed here. A complete list is available online at http://www.fish.wa.gov.au

141 Fish Protection Measures in Western Australia (June 2001)

142 Fisheries Environmental Management Plan for the Gascoyne Region (June 2002)

143 Western Rock Lobster. Discussion paper for seasons 2001/2002 and 2002/2003 (July 2000)

144 The Translocation of Brown Trout (Salmo trutta) and Rainbow Trout (Oncorhynchus mykiss) into and within Western Australia. Prepared by Jaqueline Chappell, contributions from Simon Hambleton, Dr Howard Gill, Dr David Morgan and Dr Noel Morrissy. (not published, superseded by MP 156)

145 The Aquaculture of non-endemic species in Western Australia - Silver Perch (Bidyanus bidyanus). As amended October 2000. Tina Thorne. This replaces Fisheries Management Paper No. 107.

146 Sustainable Tourism Plan for the Houtman Abrolhos Islands (February 2001)

147 Draft Bycatch Action Plan for the Shark Bay Prawn Managed Fishery (Full Report) (April 2002)

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149 Final Plan of Management for the Lancelin Island Lagoon Fish Habitat Protection Area (March 2001)

150 Draft Plan of Management for the Cottesloe Reef Proposed Fish Habitat Protection Area (April 2001)

151 Inventory of the Land Conservation Values of the Houtman Abrolhos Islands (July 2003)

152 Guidelines for the Establishment of Fish Habitat Protection Areas (June 2001)

153 A Five-Year Management Strategy for Recreational Fishing on the West Coast of Western Australia. Final Report of the West Coast Recreational Fishing Working Group (August 2001).

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155 Plan of Management for the Cottesloe Reef Fish Habitat Protection Area (September 2001)

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157 Policy for the Implementation of Ecologically Sustainable Development for Fisheries and Aquaculture within Western Australia. By W.J. Fletcher (May 2002)

158 Draft Plan of Management for the Miaboolya Beach Fish Habitat Protection Area (March 2002)

159 The Translocation of Barramundi (Lates calcarifer) for Aquaculture and Recreational Fishery Enhancement in Western Australia. By Tina Thorne.

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161 Plan of Management for the Miaboolya Beach Fish Habitat Protection Area (September 2002)

162 Reseeding of grazing gastropods and bivalves into the marine environment in Western Australia – a discussion paper. By Jane Borg.

163 Review of recreational take of coral in Western Australia – a discussion paper October 2002.

164 Report of the Mackerel Independent Advisory Panel to the Executive Director, Department of Fisheries, on criteria for access to, and management arrangements for, the proposed Mackerel Fishery (Interim) Management Plan (November 2002)

165 Report to the Minister for Agriculture, Forestry and Fisheries by the Integrated Fisheries Management Review Committee (November 2002)

166 Fisheries Statutory Management Authority Inquiry. A background paper (February 2003)

167 Draft Fisheries Environmental Management Plan for the Northern Region (in press)

168 Aboriginal Fishing Strategy: Report to the Minister for Agriculture, Forestry and Fisheries by the Hon E. M. Franklyn QC, Chairman of the Aboriginal Fishing Strategy Working Group (May 2003)

169 Hardy Inlet discussion paper (February 2004)

170 Management of the proposed Geographe Bay Blue Swimmer and Sand Crab Managed Fishery. By Jane Borg and Cathy Campbell (August 2003)

171 Draft Aquaculture Plan for Shark Bay (April 2004)

172 Draft Aquaculture Plan for Exmouth Gulf (April 2004)

173 Draft Plan of Management for the proposed Point Quobba Fish Habitat Protection Area (August 2003)

174 Translocation of Golden Perch, Murray Cod and Australian Bass into and within Western Australia for the Purposes of Recreational Stocking, Domestic Stocking and Commercial and Non-commercial Aquaculture (December 2003)

175 Fish Stock and Fishery Enhancement in Western Australia - a discussion paper. By Jane Borg (February 2004)

176 Fish Stock and Fishery Enhancement in Western Australia - a summary report. By Jane Borg (February 2004)

177 Fisheries Environmental Management Plan for the Gascoyne Region (in press)

178 Draft Plan of Management for the Kalbarri Blue Holes Fish Habitat Protection Area (March 2004)

179 A Draft Policy for the Translocation of Brown Trout (Salmo trutta) and Rainbow Trout (Oncorhynchus mykiss) into and within Western Australia for the Purposes of Recreational Stocking, Domestic Stocking and Commercial and Non-Commercial Aquaculture (August 2004)

180 The Sustainable Management of Western Australia's Temperate Shark Fisheries (July 2004).

181 A Quality Future for Recreational Fishing in the Pilbara/Kimberley. Proposals for Community Discussion. A five-year strategy for managing the recreational component of the catch, prepared by the Pilbara/Kimberley Recreational Fishing Working Group (July 2004)

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186 Management of the West Coast Rock Lobster Fishery - Advice to Stakeholders on Resource Sustainability Matters. (in press)

187 Proposals for community discussion on the future management of pink snapper fishing in Cockburn Sound and surrounding waters. (October 2004).

188 Plan of Management for the Kalbarri Blue Holes Fish Habitat Protection (in press).

189 Proposed Management Arrangements for the Gascoyne Commercial 'Wetline' Fishery. A Discussion Paper Prepared By The West Coast And Gascoyne Wetline Review Management Planning Panel (January 2005).

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195 Nature and Extent of Rights to Fish in Western Australia (June 2005).

196 The Aquaculture of Live Rock, Live Sand, Coral and Associated Products (in press).

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