ASSESSMENT OF WESTERN ROCK LOBSTER STRATEGIC MANAGEMENT OPTIONS
(4 volumes)

A BIO-ECONOMIC EVALUATION OF MANAGEMENT OPTIONS FOR THE WEST COAST ROCK LOBSTER FISHERY
Volume 2

By Economic Research Associates Pty Ltd

A REPORT PREPARED FOR
THE DEPARTMENT OF FISHERIES

FISHERIES MANAGEMENT PAPER NO. 210

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Disclaimer

The analysis in this report is undertaken at an aggregate industry level to assist in the consideration of alternative management arrangements for the fishery. The results should not be construed as offering investment advice and should not be used or relied on in any way by individuals or business entities to make investment decisions.

Preface

This report finalizes the requirements of the original brief and of the supplementary request for extra modelling work. The additional modelling requested required some new assumptions to be tested.

Whilst the additional modelling added new scenarios, it also changed the substance of some of the results from the modelling work around the original brief. This is because of changed assumptions on certain key variables that needed to considered and reworked across all scenarios to ensure consistency in the modelling results.

This report includes this additional work and presents the results across scenarios on a consistent basis.

Executive Summary

The Task

Economic Research Associates (ERA) was commissioned to evaluate the relative 'socio-economic' benefits of alternative management Scenarios for the Western Rock Lobster Managed Fishery. This study is intended as input into industry's consideration of the future management policy direction for the fishery.

The Alternative Scenarios

The key variables for defining management scenarios related to the Total Allowable Commercial Catch or TACC (either fixed or variable), number of pots (fixed versus flexible), prices (positive marketing price premiums for extended season and inter (between) and intra (within) seasonal catch stability) and pot design. In all eleven alternative management scenarios were modelled with varying combinations of the key variables.

There were three broad management approaches encompassed in the scenarios modelled. These were:

- Input or effort controlled (ITE) scenarios that include the existing management rules (Scenario 1), a variant of the existing regime in the form of a 20 per cent pot reduction (Scenario 1a), and a modified ITE regime based on pot/fishing days with an extended fishing season that provided scope for greater flexibility around the choice of when to fish (Scenario 2).
- Catch quotas coupled with input controls over pot numbers, but with some modest flexibility in pot design and an extended fishing season. The alternative options under this grouping specified either a fixed TACC (Scenario 3a); or a variable TACC (Scenarios 3b, 3c, and 3d). Key issues for these Scenarios were assumptions around sustainability rules used for the determination of catch quotas, the bases for operating quota in Zones A and B, and various marketing price premium assumptions.
- Catch controlled options based on pure ITQ scenarios, where there was greater freedom over pot numbers, and pot design, including an extended fishing season. The alternative options under this grouping specified either fixed TACC (Scenarios 4a) or variable ITQ (Scenarios 4b, 4c, and 4d). Again key issues for these Scenarios were assumptions around sustainability rules used for the determination of catch quotas, the bases for operating quota in Zones A and B, and various marketing price premium assumptions.

The existing regime (Scenario 1) was used as the base case against which the outcomes for other scenarios were compared and assessed. In making the assessment particular attention was paid to the sustainability of the biomass and the estimated net benefits, although for each scenario a variety of outputs have been estimated.

This approach provided modelling results on a sound and consistent basis across a broad spectrum of possible management options within each of these management approaches.

The Evaluation Model

The evaluation of the alternative management Scenarios is based on a highly non linear optimization model that integrated the biology of the fishery in each zone with the economics of fishing activity in those zones. The biological component was tested extensively and closely replicates historical data from the West Coast Rock Lobster Fishery on biomass, catch and effort over a ten-year period.

The model runs recursively over a ten-year period to allow the biological cycle that typically characterized the fishery in past data to be played out in full. Hence, the results for each scenario cover a ten-year period for each of the key output variables such as catch, pot lifts, biomass and net economic benefits.

For each management Scenario, these optimization results reflect ten years in long term, steady state, equilibrium. That is, the results are for a ten-year cycle that commences once all the implementation or transition adjustments that occur in response to the adoption of any particular scenario have taken place. This modelling approach ensures that alternatives were assessed and compared on a consistent basis.

The optimization is based on maximizing net economic returns or benefits for Zone C and for Zones A and B combined under each of the alternative management regimes. A management regime is captured by specifying a number of constraints, such as a constraint on catch or days fished.

Zones A and B were combined in the optimization because all of the fleet accesses the Zone B biological stock for the first part of the fishing season, but only some of the fleet accesses the Zone A biological stock in the Abrolhos Islands for the second part of the fishing season. Among other things, this approach avoided the difficulty of splitting the fixed costs between the respective zones for fishers with Zone A authorizations that can fish in Zone B until mid-March. In the circumstances, producing combined Zone A/B results for net economic benefits was seen as the most plausible approach. Whilst this was necessary for the modelling, it should not be taken as advocating a change to the existing boundaries in the northern region of the fishery.

In analysing the alternative management Scenarios, we were also asked to take account of any marketing benefits (in the form of price gains) that might arise under the alternative Scenarios. The results, therefore, incorporate efficiency gains as well as price gains associated with moving to any of the possible alternative Scenarios specified.

The focus of the modelling is the assessment of the relative net economic benefits associated with the various scenarios modeled. Some variables affect the absolute level of estimated net benefit but have little or no impact on the relative net benefits across scenarios. General cost increases and exchange rate variations are in this category. The model does not factor in general price rises/cost increases or exchange rate variations. Where cost increases affect some scenarios but not others they have been specifically accounted for. The major one in this category is the additional fishery management costs under the TACC scenarios.

Data Used

Extensive research work on the existing regime has resulted in a comprehensive body of data on stocks, effort and catch going back several years. These data have been used in the model building and testing.

In the case of the alternative Scenarios, there was no such body of data, so some original data collection was necessary on many matters. This was collected through discussions with fishers and processors on how behaviour and prices might change under the alternative Scenarios; as well as from observable developments in other jurisdictions (e.g. South Australia and New Zealand) where management regimes similar to the alternative Scenarios had been adopted.

Modelling Results

The modelling was undertaken in accordance with the Tender requirements.

The results allow consideration of the relative gains (measured as net economic benefits) from moving from the current to the specified alternative management regimes. Although gains in net economic benefits is the logical starting point for assessment, the analysis produces comparison data on many important variables, including annual catch by zone, annual pot lifts by zone, breeder biomass index by zone and biomass of mature, recruits and breeders by zone.

The original brief did not ask us to model the implementation or transition phase for each of the alternatives. Hence the estimated net economic benefits do not include any such costs that might be associated with the implementation of these alternatives. While these costs can be significant, they were ignored when considering the alternative scenarios.

The comparative results show that:

- All the alternatives produce net benefit outcomes greater than the existing regime (Scenario 1);
- The net benefit gains were higher under TACC based Scenarios (Scenarios 3 and 4 options); and
- The net benefit gains were greatest under the ITQ regimes (Scenario 4 options).

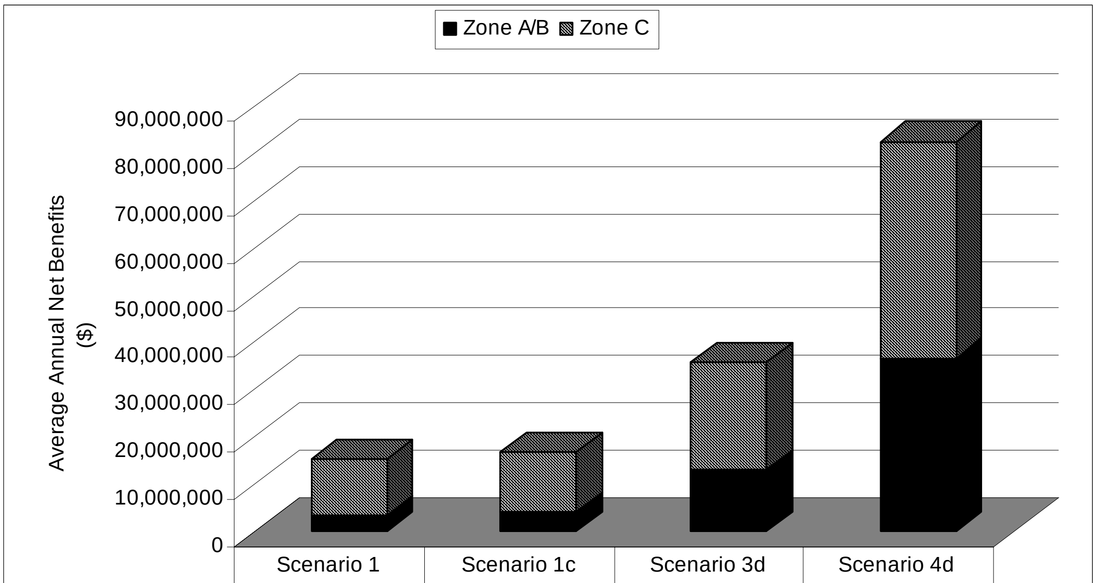
The ITQ Scenario 4 produces significantly higher net benefits. The significant gains associated with Scenario 4 reflect the relaxation of the constraints on pot numbers, pot design and the extended fishing season. They arise from a combination of increased pot efficiencies, fleet rationalization driven by having more pots per boat and increased input (cost) efficiencies which arise as fishers focus on minimizing the cost for a given level of catch.

The Comparative Net Economic Benefits

Based on consultation with the Project Steering Committee, it is suggested that industry focus their attention on the key issues by comparing three options that appeared to be the most ‘realistic’ alternatives to the existing base case (Scenario 1). These are options that minimise the biological risks posed by changes to the management arrangements for the fishery, and make conservative assumptions about the potential price premiums due to improved marketing.

The three alternative scenarios were a variation of the base case in the form of a 20 per cent pot reduction (Scenario 1a), a variable TACC alternative based on conservative quota determination rules and marketing price premium combined with a constraint over pot numbers and some improvements in pot design (Scenario 3d); and a variable ITQ which was a pure catch quota regime with no constraint over pot numbers and much more efficient pot design (Scenario 4d).

The comparative net economic benefit results for these three alternative compared to the base case are shown below. These are modelling results and should not be seen as predictions but rather as a guide to the extent of the possible net economic benefits.



	Scenario 1	Scenario 1c	Scenario 3d	Scenario 4d
Zone C	12,101,428	12,864,621	22,640,503	45,867,652
Zone A/B	3,309,887	4,058,537	13,199,199	36,805,714

Whilst the absolute levels of these estimated aggregate net economic benefits are significant, the key consideration from a policy evaluation perspective is the relative level of the net economic benefits between the Scenarios.

The net economic benefit estimates may be conservative, as the actual implementation of alternative management arrangements could induce behavioural changes that may enhance efficiency in ways that we cannot easily identify and /or model at this stage. For instance, while operating more that one quota entitlement on a single fishing boat license might increase efficiency, this possible development has not been modelled.

The ITQ regime (Scenarios 4d) results show relatively greater gains from improved efficiency. In an industry where costs associated with lobster fishing activities are largely fixed, this may offer a realistic way for individual fishers to significantly drive down costs per unit of catch in the long run and improve viability in an industry that is increasingly commoditized and is facing declining terms of trade (i.e. costs are rising faster than prices received in this commoditized trade).

The net benefit estimates for these alternative Scenarios were a combination of price differentials and pure efficiency gains. In the case of the three alternatives above, the source of the net gains in net economic benefits over the base case were largely attributable to efficiency gains, even for the variable TACC scenarios 3d and ITQ Scenario 4d, reflecting the conservative marketing price premium assumptions.

The Sensitivity of Net Economic Benefit Results to Marketing Price Premium Changes

Prices and marketing premiums over those prevailing under the existing regime used in modelling alternative options drew on discussions with the processing sector and reflected the existing state of knowledge about world lobster markets.

From these discussions, we identified three possible sources of extra price gains. They consisted of ‘extended season’ marketing price premiums (for Scenarios 2, 3, and 4), ‘inter-year’ stability marketing price premiums (for certain Scenario 3 and 4 options), and an ‘intra-seasonal’ stability marketing price premiums (under Scenario 4 options). Scenario 1a is simply a variation of the existing regime with the same marketing price premium assumptions as the base case, whilst the variable TACC Scenario (3d) and the variable ITQ Scenario (4d) which generally followed the catch experience of base case catch, factored in conservative assumptions about extra marketing price premiums.

In practice, the actual price levels and marketing price premiums will only be known once the processing sector commences marketing on the basis of whatever management regime is adopted. There will be a degree of uncertainty about the extent to which the price assumptions under each of the alternative Scenarios are reasonable and realizable, particularly as they are dependent on world market developments that are outside the industry’s control.

Efficiency gains across scenarios are generated from within the industry. In this sense, the efficiency gains are relatively more “bankable”.

A comparison between two sets of variable ITQ Scenarios (4c and 4d) with the same management rules and where the only difference was the assumed marketing price premium, shows that the resulting net economic benefits, whilst impacted, were not markedly different. This analysis reaffirmed that a major source of the net benefit gains was in terms of potentially ‘bankable’ improvements in economic efficiency.

Employment and Social Impacts

In the catching sector, boat numbers and pot lifts largely drive employment. There are reduced boat numbers, compared to the current level, under all Scenarios. However, the greatest rationalization in the fleet occurs under Scenario 4 options, where ‘representative’ boat numbers are approximately halved. In practice, the actual boat number outcomes under each of the alternatives Scenarios could be different and will depend on how individual lobster businesses respond to the any changed management regime or rules that may be adopted.

Deckhand employment is driven by pot numbers, pot lifts and regulated minimum crewing levels for boats above a certain size operating deeper waters.

Taking account of both vessel numbers and pot lift changes, the most significant potential employment impacts occur under Scenarios 4 options (the fixed and variable ITQ’s).

However, employment in rock lobster harvesting is not significant in any affected Shires, but is more significant in term of some regional centres. Assessing how the changes in employment might occur across urban and regional centres is virtually impossible as it depends on individual decisions made by boat owners and crew that are not modelled.

The model is a long run equilibrium model and we expect any adjustments to take several years. This is important because growth in the key Mid-West region is generating alternative attractive employment opportunities, which are already putting pressure on the industry to keep crew. Other centres are experiencing population growth through urbanization which is reducing rock lobster significance to them.

Fisheries Management Implication Issues

Several resource sustainability risks are outlined in the report. These risks are greater for the fixed TACC Scenarios 3a and the fixed ITQ Scenario 4a than they are for the existing regime (Scenario 1 or its variant Scenario 1a) t during low abundance periods based on the TACC setting rule used in the modelling. However, the more conservative the level at which the fixed TACC/ITQ is set under Scenarios 3a and 4a to mitigate this risk the greater the impact on fleet rationalization.

These sustainability risks under the TACC controlled Scenarios tend to be greater in Zone C, and, although not insignificant in Zone A, this stock has been shown to be quite resilient in the past although the biological reasons are not entirely clear. The modelling results suggest the risk profile in Zone B under these TACC Scenarios does not appear to be material for the TACC setting rules used in the model.

The modelling results also highlight the need for effort reductions (pot numbers and/or fishing days) under the existing regime and the alternative pot/fishing days Scenario at or before the end of the ten-year period to ensure stocks remain sustainable.

The additional fisheries management costs likely under the TACC controlled Scenarios were advised by the Fisheries Department. These extra costs are presumably related to activities designed to minimize these risks and are detailed in the report. The additional management costs were incorporated into the modelling of the TACC/ITQ controlled Scenarios.

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1 Background

1.1 Introduction

The Western Australian Government requested the Department of Fisheries in conjunction with the Rock Lobster Industry Advisory Committee to review the management arrangements in place for the West Coast Rock Lobster Managed Fishery. In this review, any further efficiency gains from additional changes to the current regulatory regime, including but not limited to the costs and risks of management failure, were to be quantified.

The review is being conduct in an Ecologically Sustainable Development (ESD) framework, so as to enable:

- The Department of Fisheries to continue to pursue excellence in fisheries management, and
- The Government to address the ‘public interest’ test[i] of National Competition Policy (NCP) when considering the future management of West Coast Rock Lobster Managed Fishery.

The review is a three-phased process that is being managed by a joint Department-Industry Steering Committee.

1.2 Scope of this Evaluation

The evaluation of the economic efficiency gains and social impacts under alternative fisheries management options covered by this report are input into the first of this three-phased review process. The required tasks were progressed in consultation with this joint Steering Committee[ii].

The evaluation requested concentrates only on the fisheries management arrangements applying to the commercial harvest and post harvest of western rock lobster. The recreational management arrangements in this fishery and the inter-sectoral allocation issues were specifically excluded from this evaluation. The later can affect the optimizing outcome from commercial use depending on overall use of the resource between these sectors that optimizes the economic and social benefits to society.

1.3 Meeting Statutory Obligations

The Fish Resources Management Act 1994 requires the Department of Fisheries to manage the West Coast Rock Lobster Fishery so as to deliver the optimum long-term mix of economic and social benefits to the State in an ecologically sustainable manner. Hence, the economic and social benefits that flow to the community from ecologically sustainable use of the western rock lobster resource have to be assessed in an integrated manner.

In particular, the Department of Fisheries needed to know which management approach provides:

- the greatest incentives and opportunity for growth in economic return from all sectors of the rock lobster industry to Western Australia; and
- a net ‘socio-economic benefit’ to the Western Australian community by encouraging the maintenance and development of regional communities.

Also, with regard to the related need to comply with the National Competition Policy and the associated competition policy principles agreed between the Commonwealth and all the States, this evaluation is designed to provide guidance as to the extent to which alternative management arrangements for the West Coast Rock Lobster Managed Fishery satisfy the determined 'public interest' test, and contribute to the achievement of 'non-economic' government objectives (e.g. conservation of the marine environment, support for regional development and rural employment).

This evaluation report is not a formal NCP review of the restrictions under the alternative management options. However, the results of the analysis contained in this report will provide useful input for the Project Steering Committee, and policy makers:

- To evaluate the net 'socio-economic' benefits of alternative fisheries management options, including the trade-offs between economic and social outcomes among the management scenarios, and
- To address the 'public interest' test of national competition policy when resolving the future direction of management arrangements in this fishery.

1.4 The Required Task

The required task called for an objective and soundly based analysis of material costs and benefits associated with three broadly specified management scenarios using an interactive and integrated model. The management scenario that existed at the time of the Tender was taken as the benchmark case against which alternate management scenarios were compared and assessed.

The integrated assessment of the relative advantages and disadvantages of each of the three specified scenarios were in the context of the above objectives for the review. In particular, the evaluation focused on material economic and social costs and benefits in an integrated way, including the following aspects:

- Cost of production, and identification of economic opportunities and consequent changes in wealth distribution patterns that could be realized under alternate management systems;
- Consideration of the costs of fisheries management, including the risk of biological or management failure under each scenario; and
- Potential and likely market developments, or market advantage opportunities, under alternate management scenarios, and, for consistency purposes,
- All alternatives were to be analysed in terms of the long term, steady state once all implementation or transition adjustments had taken place.

After presentation of the modelling results for the alternative management options specified in the original brief, we were subsequently asked to model additional scenarios. The original and additional scenarios, which included a 20 per cent pot reduction option under the existing management, are discussed in Chapter 3.

1.5 The Specified Alternative Fisheries Management Scenarios

There are numerous possible combinations of spatial, temporal, biological, input and output controls that could be applied in designing alternative management regimes for the West Coast Rock Lobster Fishery. However, for practical purposes of this evaluation, the Tender brief specified three management scenarios.

The three broadly specified management scenarios that "…needed to be equally assessed side by side" in this evaluation were as follows:

- **The Status Quo of Individually Transferable Effort (Pot) Controls** – i.e. the system based on sustainable commercial utilization of the rock lobster resource by limiting the number of pots that can be fished in each zone, a range of biological controls and a limited season. This was based on the management rules that existed after the maximum pot entitlement or so-called '150 pot rule' was discontinued but before the pot reductions and other management rule changes that were announced for the 2005/2006 season.

- **An Individually Transferable Effort System (ITE)–** i.e. a management system based on individually transferable quotas on time and effort in each zone, and with the ability to set the Total Allowable Effort and biological controls based on sustainability needs and socio-economic objectives, but with more flexibility for individual operators to choose when they fish and how much gear they use at different times of the year.
- **An Individually Transferable Quota System (ITQ)–** i.e. a management system based on individually transferable catch quotas in each zone, and with the ability to set the Total Allowable Commercial Catch (TACC) and biological controls based on sustainability needs and socio-economic objectives, but with the potential to provide the greatest freedom to operators in terms of when they choose to harvest their share of the catch.

The specifications that were given for the alternative management scenarios are outlined in Chapter 3.

1.6 The Approach and Process

The following approach was employed to undertake the required task.

1.6.1 Literature Review

An extensive review of the fisheries management and economic literature both here and overseas to identify any published material elsewhere that was relevant to the required tasks of this evaluation.

1.6.2 Specifications of the Management Rules

The management rules that were to be incorporated in the model for each of the management scenarios were clarified with the Project Steering Committee. These are shown in Chapter 3.

1.6.3 Model Development

The development of a model that was able to identify and quantify the material differences in the benefits and costs of the three management scenarios for the West Coast lobster fishery. This built on related research previously undertaken by Prof Lindner.[iii]

The interactive model needed to be capable of integrating information across the biological, economic and social disciplines. In particular, the cost benefit analysis must consider biological, economic and social issues based on current understanding of the western rock lobster and its environment.

The developed model needed to be an optimising model; one that was robust and simple to use in providing a guide to industry behaviour under alternative management scenarios.

Also, the model needed to be sufficiently interactive to predict the effects, trends and rate of change on key variables such as fleet size, fleet distribution, concentration of ownership, wealth distribution, net value of production, and employment shifts taking into account the sensitivity of regional community to changes within the rock lobster industry.

Whilst third parties provided extensive directly observable data relating to pre-existing management regimes which was used to develop estimates of coefficient value contained in the interactive model, the outcomes in relation to these key variables had to be predicted for the benchmark scenario as well as the alternative scenarios.

For instance, in the case of the benchmark scenario, the way in which lobster fishermen will adapt to the recent removal of the maximum entitlement holding (i.e. the ‘150 pot rule’) and its impact on further fleet rationalization, and on consequent reductions in the fishery’s capacity or number of usable pots, can not be observed directly, and needed to be predicted. Likewise, outcomes of the other two scenarios also needed to be predicted because at present they are counterfactual scenarios that have not been implemented in the West Coast Rock Lobster Fishery. The inferential tasks in developing these scenarios should not be under-estimated when considering the results of the model contained later in this report.

The outcomes of the ‘bio-economic’ optimisation model needed to be linked to the social consequences for West Coast regional fishing communities associated with the lobster fishery. The results from the model needed to be spatially distributed and linked to the social profiles of these regional communities. The UWA Regional Development Unit is carrying out the social profiling tasks under a separate research project.

1.6.4 Data Requirements

A wide range of data needed to be collated and interpreted so as to estimate values of the large numbers of coefficients in the developed model. For instance, estimates needed to be made, inter alia, of the biological characteristics of the fishery, and changes in catching costs, in catch returns, and in resource rent from the fishery due to reduced boat numbers, more or less intensive pot use, extended fishing season, and altered seasonal catch variations.

Apart from a harvest ‘cost of production’ survey, there was no provision for original data collection. All aggregate data requirements were generally sourced from the Department of Fisheries or through relevant members of the Steering Committee in the case of lobster market and price information. Also, whilst in South Australia and New Zealand, Prof. Lindner used the opportunity to talk to relevant fisheries policy and industry people regarding experiences in managing lobster fisheries in these jurisdictions.

A ‘cost of production’ survey of individual lobster fishermen in each of the three commercial fishing zones was undertaken with the co-operation of the Department of Fisheries. Individuals’ financial data were sent directly to ERA and matched to their catch and effort return information that they had authorized the Fisheries Department to release to ERA. These individual data, which were obtained in accordance with the requirements of the Privacy Act, were provided to ERA on a strictly confidential basis and were used solely by ERA for aggregate statistical purposes in this report.

1.6.5 Consultative Processes

Regular meetings were held with the Steering Committee, during the course of this evaluation. These meetings, which are listed in Appendix 1, generally coincided with pre-determined project milestones.

Two Focus Groups of lobster fishermen were formed with assistance of the Department of Fisheries and the Executive Director of the Western Rock Lobster Council. One related to Zone C, whilst the other jointly covered Zones A and B.

The Focus Groups were used as a means of obtaining insightful information into fishing practices and behaviour under the alternative management scenarios, including typical cost structures and of validating whether key underlying parameters and assumptions contained in the model were not unreasonable.

ERA also consulted two small groups made up of people, one with particular knowledge and expertise relating to the biology of the fishery and the other focused on the economics of the fishery, as a means of ground truthing the data used and the structural relationships contained in each of these respective components of the evaluation model.

1.7 The Report

Chapter Two provides a snapshot of the current size and regional distribution of the commercial lobster fishing and processing activities. Chapter Three gives an outline of the management rules specified by the Steering Committee that were incorporated into the modelling of alternative management scenarios. Chapter Four sets out and explains the basic structure of the biological and economic models. Chapter Five describes the outputs from the model and the use of the model to compare scenarios. Chapter Six presents results for the various scenarios for each fishing zone as well as for the whole fishery. Employment in the fishery and the way it may be impacted by the adoption of each scenario is considered in Chapter 7. Finally, Chapter 8 works through a variety of management implications of the results.

In the report abbreviations are used for each of the alternative management options that we were requested to model. These abbreviations are shown in Table 1-1 below and used consistently throughout the report.

Table 1-1: Abbreviations Used for Alternative Management Scenarios Modelled

Regime Type	Scenarios	Options	Option Code Used
Input Controlled	Current Regime	Existing Rules [1]	Scenario 1
		20% Pot Reduction	Scenario 1a
	Modified ITE	Pot/Fishing Days	Scenario 2
Catch Quotas with Pots Controlled	Seasonal Quota with Limited Pot Numbers	Fixed TACC	Scenario 3a
		Variable TACC	Scenarios 3b[2], 3c[3], 3d[a]
Pure ITQ	Seasonal Quotas	Fixed ITQ	Scenario 4a,
		Variable ITQ	Scenarios 4b[2], 4c[3], 4d[a]

Notes: [1] 2004-05 season's rules. [2] Robust TACC determination rule and price assumptions. [3] Conservative TACC determination rule and robust price assumptions. [a] Conservative TACC determination rule and price assumption.

For these scenarios and all related data throughout the report the term "pots" is used to reflect pots in the water unless otherwise specified. A description of other abbreviations and terms used in this Report is presented in Appendix 2.

2 The Western Rock Lobster Fishery

2.1 Background

The commercial West Coast lobster fishery, which extends from Cape Leeuwin in the South to NW Cape in the north, was the first fishery in Western Australia to be declared limited entry in March 1963. It was also the first fishery in the world to be certified ecologically sustainable by the internationally recognised Marine Stewardship Council.

The fishery is the most valuable single species fishery in Australia, typically representing around 20 per cent of the gross value of the catch of Australian fisheries, or, on average, around $200 million to $390 million (at ‘beach’ prices) annually in recent years. The industry has a strong export orientation with usually around 95 per cent of the catch exported.[iv]

The historical data relative to the harvesting and processing sectors reflected in this Chapter represents observed adjustments to changes in management rules in the fishery under the existing regime (Scenario 1) and in trading and economic conditions that prevailed in the past. However, sufficient time had not elapsed at the time of this study to observe the full impact of industry adjustments to the withdrawal of the so-called ‘150-pot rule’. Nor do they reflect any industry adjustments to the management rule changes announced for the 2005-2006 season.

The fishery is divided into three access or commercial fishing zones. Lobster are caught using baited pots with commercial fishing by driving is banned. As pot numbers are restricted, pots have become valuable assets to commercial fishers.

2.2 The Biology of the Fishery

Based on Fisheries Department research, the Western rock lobster spawn and hatch their eggs mainly in deep waters, 40m or more in coastal waters, including the Abrolhos which is a major spawning area. After spending around 9 to 11 months in the open ocean between 400 to 2500 kilometres offshore, the larvae are carried towards the coast by currents.

On returning to the continental shelf, they metamorphose to the next stage (called puerulus), and swim across the continental shelf, aided by wind and waves, to settle on inshore reefs where they moult within a week or two into juveniles.

Each year in coastal waters between November and January, large numbers of pale-coloured, recently moulted juveniles four to five years old (known as ‘whites’) migrate from inshore to deeper reefs offshore. During the ‘whites run’, the lobsters are highly vulnerable to fishing and large catches are taken by the commercial fleet (and recreational fishers).

On making the deeper water breeding grounds, the lobsters mature and spawn a year or two later, when six or seven years old. Adult and non-migrating lobsters (known as ‘reds’) generally form the catch between February and 30 June. The survivors represent the closing stock of biomass in the fishery.

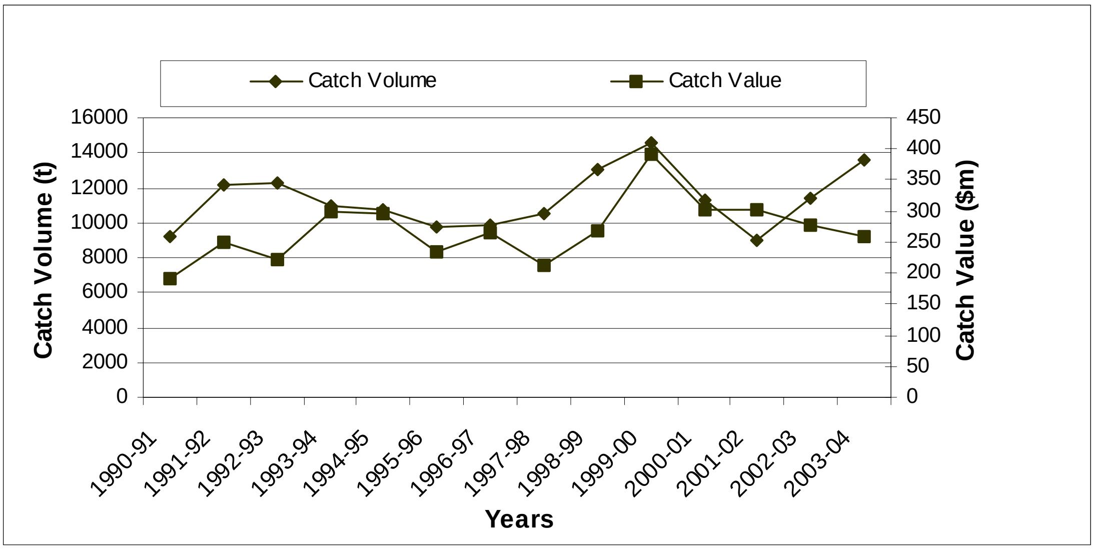
Recruitment in the fishery is usually viewed in two stages. First, the annual settlement of the puerulus on the inshore reefs and then each season’s lobster that reaches the legal catchable size. The relationships between these recruitment levels provide a generally reliable guide to future sustainable catches from the fishery.

Puerulus settlement is affected by the strength of the El Nino affected Leeuwin Current and westerly wind conditions. The stronger the Leeuwin Current and winter westerly storms, the better the settlement and vice versa.

2.3 Commercial Harvest Sector

2.3.1 Catch Volumes and Values

The commercial harvest of lobster from the West Coast fishery is characterized by 'season-to-season' fluctuations in both catch volumes and value under past management arrangements. Over the past 14 years, catch volumes ranged from 9000 tonnes to 14,500 tonnes, whilst the estimated annual values of the landed catch ranged between $190 million to $392 million. These data, which are given in Appendix 3, are shown in Figure 2-1 below.



Source Data: Fisheries Department

Figure 2-1: Catch Volume and Catch Value-1990-91 to 2003-04 Lobster Seasons

In general, around 55 per cent of the total catch is taken from the southern zone (i.e. Zone C) of the fishery, whilst about 30 per cent is caught in northern Zone B and the remaining 15 per cent is taken at Abrolhos Group of Islands off the mid-northwest coast.

Lobster catches are landed at thirty-four mainland locations along the West Coast, and are generally the most valuable species in terms of the total value of all landed fish catches for fishing communities located between Mandurah and Kalbarri. These data are shown in Table 2-1 below.

Table 2-1: Western Rock Lobster Fishing Fleet, Crew Numbers, and Catch by Coastal Locations-2003-2004 Season[1]

Locations	Boats[2]	Landed Catch				Landed Value	
	(No.)	Lobster Crew[2] Estimates (No.)	Quantity (t)	Prop'n of the total WRL Catch[3] (%)	Prop'n of the all species catch landed at the location (%)	$Million	Prop'n of the total value of all species catch landed at the location (%)
Kalbarri	9	27	522	3.8	63.8	9.914	86.1
Port Gregory	10	30	121	0.9	89.6	2.293	97.6
Horrocks Beach 4	8	24	87	0.6	95.6	1.651	99.9
Geradton 5	132	396	2608	19.2	47.8	49.581	87.5
Dongara 6	58	174	892	6.6	91.2	16.947	97.6
Leeman 7	37	111	498	3.7	93.1	9.467	98.2
Knobby Head 4	2	6	36	0.3	97.3	0.677	99.6
Cliff Head	2	6	114	0.8	97.4	2.162	99.5
Freshwater Point	17	51	362	2.7	97.3	6.872	99.5
Desperate Bay	3	15	103	0.8	99.0	1.959	99.6
Green Head	9	27	225	1.6	93.0	4.274	98.6
Jurien Bay	17	51	591	4.4	89.0	11.238	97.7
Cervantes	18	54	656	4.8	97.0	12.460	99.2
Little Bay 4			37	0.3	94.5	0.702	99.0
Lancelin 8	43	129	1239	9.1	96.2	23.531	99.1
Ledge Point	24	72	603	4.4	96.8	11.463	99.3
Sandy Point 4			27	0.2	100.0	0.510	100.0
Seabird	5	15	293	2.2	99.9	5.560	99.9

Locations	Boats² (No.)	Landed Catch				Landed Value	
		Lobster Crew² Estimates (No.)	Quantity (t)	Prop'n of the total WRL Catch³ (%)	Prop'n of the all species catch landed at the location (%)	$Million	Prop'n of the total value of all species catch landed at the location (%)
Fremantle 9	141	423	2938	21.7	56.8	55.820	89.5
Mandurah	24	72	924	6.8	74.5	17.547	93.9
Bunbury	2	6	167	1.2	21.3	3.176	65.0
Busselton 10	1	3	312	2.3	30.3	5.934	83.0
Hamlin Bay			214	1.6	75.4	4.071	94.6
Augusta			116	0.9	30.2	2.204	37.7
Total	561	1683	13,685			260..013	

Source: Department of Fisheries, Australian Bureau of Statistics

Notes:

1 The 2003-2004 season is regarded as an above average catch season.

2.Boat numbers represent the homeports of vessels with an attached west coast rock lobster managed fishery license. Boats may land lobster catches in fishing locations other than their homeports. Crew number estimates based on the average of crew (skipper plus 2 deckies)/ boats. The home residence of individual crew members can be different to that of the boats home port. For example, crew on a lobster boat home ported at Dongara may come from Geraldton.

3 The same percentage also applies for the landed value of lobster catch given the same average 'beach' price applies across the fishery.

4 The other reported catch landed at these locations relates entirely to lobster fishing activity.

5 Includes lobster catches landed at the Abrolhos and Pelsart Islands, Drummond Cove, and Coronation Beach.

6 Includes lobster catch landed at 7Mile Beach.

7 Includes lobster catch landed at Beagle Island.

8 Includes lobster catch landed at Wedge Island.

9 Includes lobster catches landed at Two Rocks, Yanhcep, Mindarie Keys, Hillarys, Perth and Safety Bay.

10 Includes lobster catches landed at Quindalup and Dunsborough.

There have been significant 'year-to-year' fluctuations in landed catch volumes and values in these coastal locations (See Appendix 4). This has meant significant annual income fluctuations that these regional locations have autonomously adjusted to.

2.3.2 Boats, Crew, Pot Numbers and Pot Lifts

There has been a shift to a smaller, more concentrated, lobster fishing fleet comprised of a greater proportion of larger vessels with, on average, a greater number of attached pot entitlement under the existing management arrangements.
Licensed boat numbers in the fishery, which are given in Appendix 5, have declined from 858 when the limited entry fishery was created in 1963 to 572 in the recent 2003-2004 season, or, almost one third. Figure 2-2 shows the trend in the lobster fleet since the adoption of the limited entry fishery management arrangements in 1963.

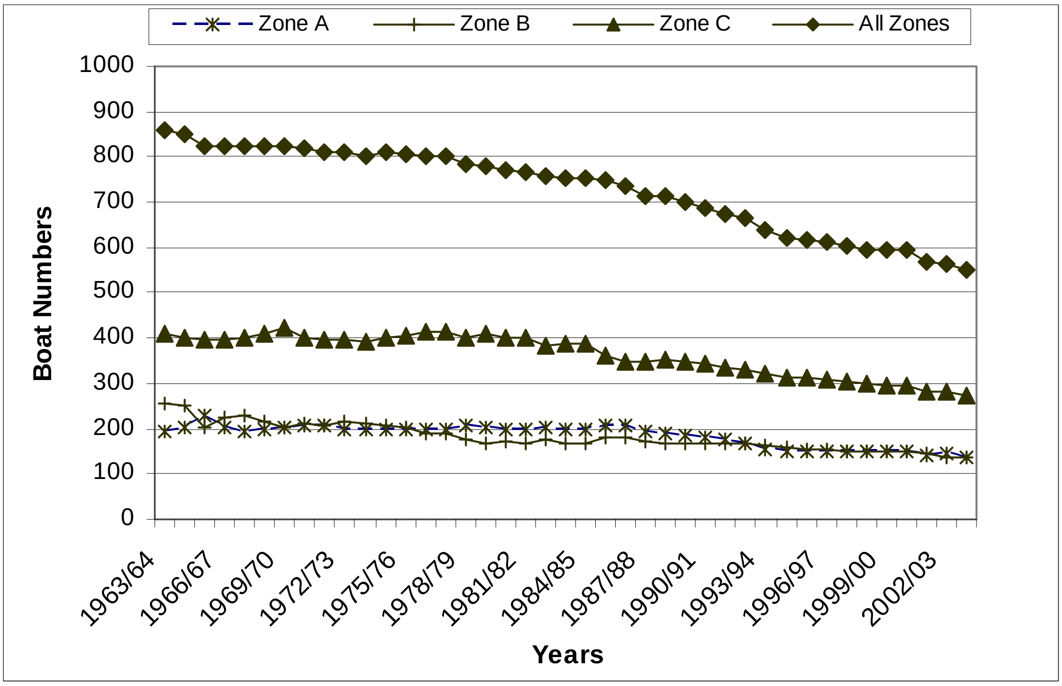
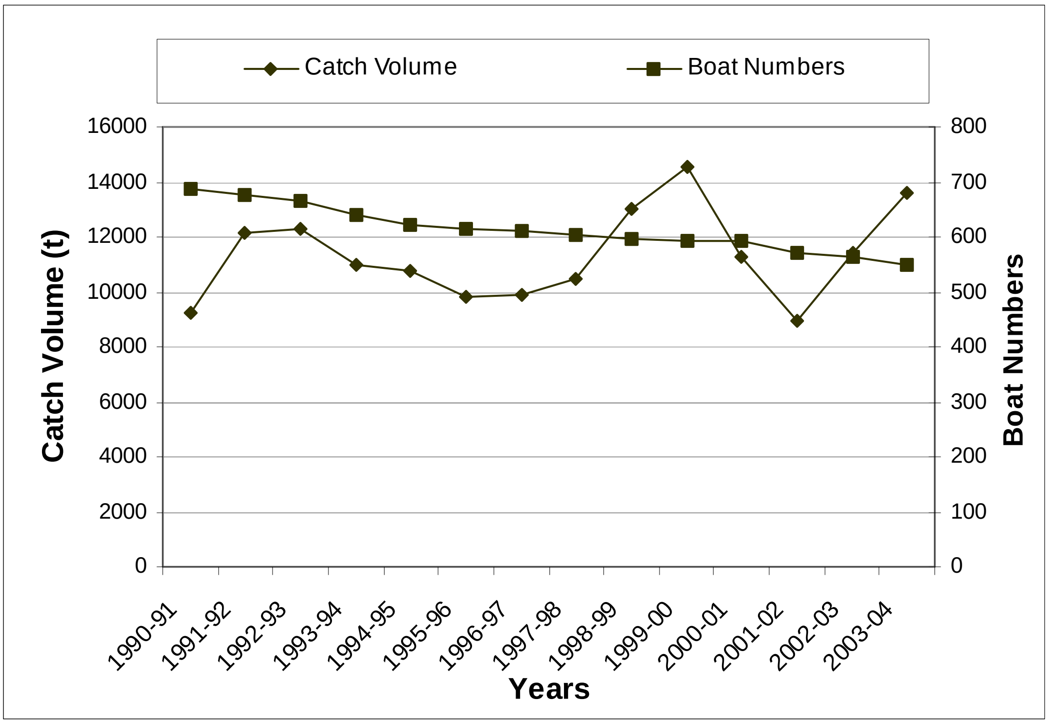


Figure 2-2: Lobster Boats with Attached Lobster Entitlements: 1963/64 to 2003/04

Of the 572 boats in the 2003-04 season, 554 were able to fish having an attached west coast rock lobster managed fishery license that met the minimum pot holding requirement.
These data also indicate that the key variable of catch and boats are not related. This is illustrated by Figure 2-3.



Source Data: Fisheries Department

Figure 2-3 : Boat Numbers and Catch-1990/91 to 2003/04 Seasons

The distribution of the lobster fleet by homeport is shown in Table 2-1. Almost one half of the lobster fishing fleet is home ported in the regional environs of Fremantle and Geraldton. This increases to 82% of the fleet when boats home ported in Dongara, Leeman, Lancelin, Ledge Point and Mandurah are included. Despite this heavy concentration in the homeport of the lobster fleet, the fleet has become more mobile in recent years with catches being landed in ports other than the homeport of the boat. Currently, all lobster fishers have the right to access the West Coast 'Wetline' fishery but not all fishers exercise this right.

The number of boats by crewing levels by month over recent years is shown in Appendix 6. Around 80% of the boats operate with three crew (a skipper and two deckhands), although this can vary within and between seasons as shown by Figure 2-4 below. The number of three-crewed boats has been trending upward, whilst the two-crewed lobster boats have done the opposite. This appears to be indicative of a shift towards larger boats in the fleet. In this context, there is a legal requirement for lobster fishing boats which are 15 metres and longer operating in distant water, to carry a minimum of three crew members.

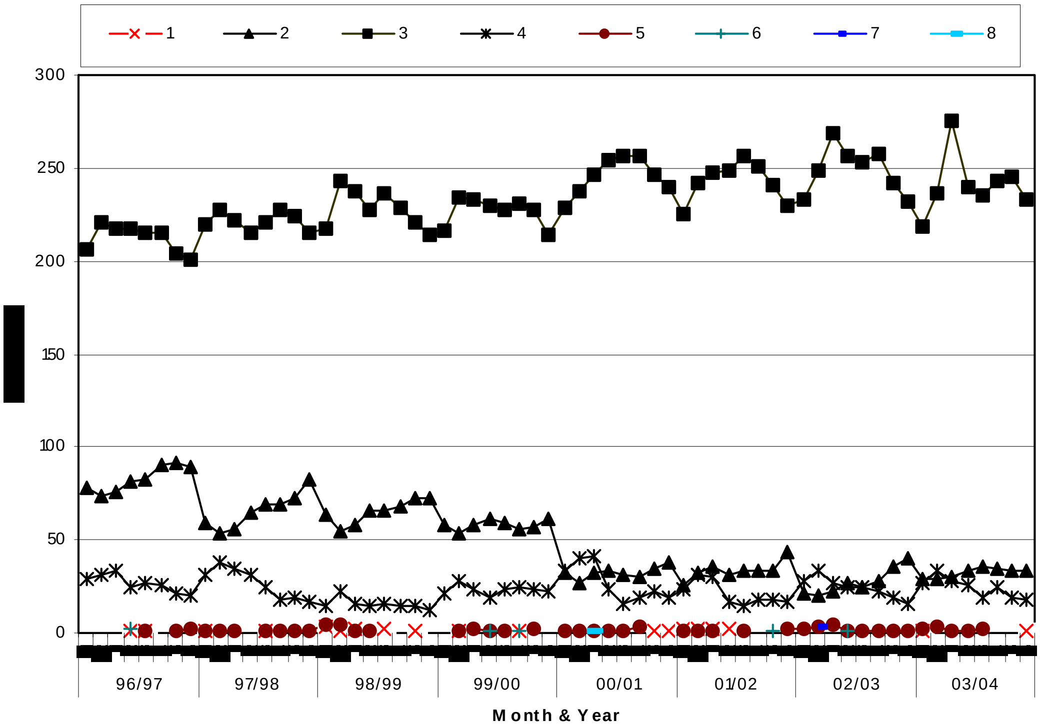
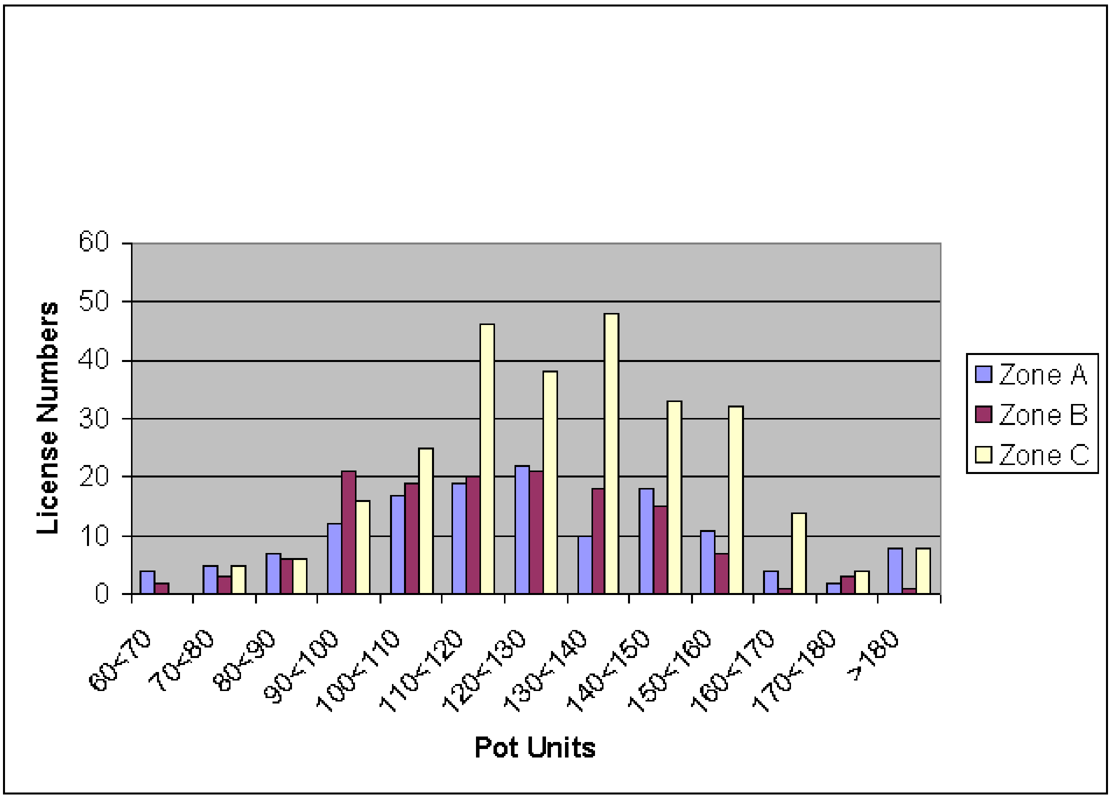


Figure 2-4: Boat Numbers by Crewing Levels by Month-1996/97 to 2003/04

Contrary to an often generally held impression, the contraction in fleet size and the movement towards larger vessels in the fleet may not have acted as negatively on aggregate employment opportunities in the commercial lobster fishing industry. Whilst a reduction in the number of vessels may have reduced the demand for lobster boat skippers, the higher crewing level on larger vessels may have offered continued employment opportunities for deckhands in the commercial lobster fishing industry, although these opportunities may have been locationally different to those that existed in the past.

The number of pots that may be operated in the fishery was reduced by 18 per cent from the 1993-94 season for resource sustainability reasons. The number is currently around 56,813 pots. These kinds of adjustment to the commercial fishing effort can be expected from time to time in effort controlled fisheries if ‘technological creep’ in fishing practices threatens resource sustainability.

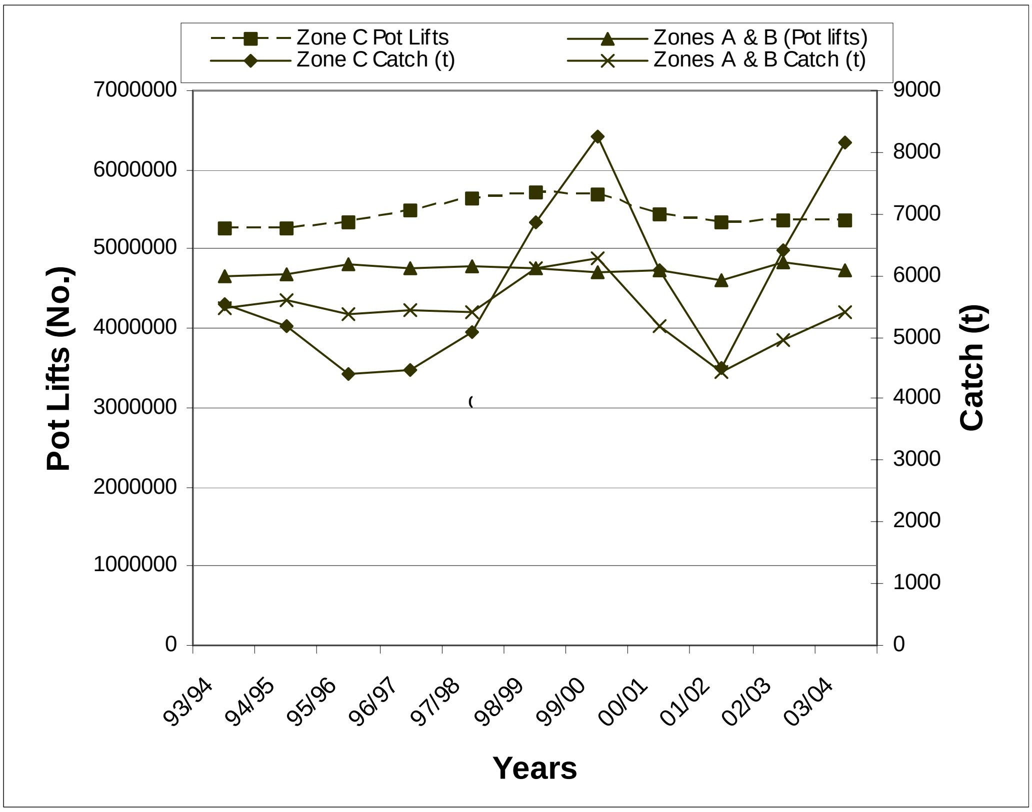
The distribution of Western Rock Lobster Managed Fishery Licenses by endorsed pot unit entitlements is shown in Appendix 7 and in Figure 2-5 below. These data suggest that the pot unit entitlement category with the most number of licenses tend to be slightly higher in Zone C than Zones A and B, although in Zone A there are a proportionately greater number in the largest pot unit entitlement category.



Source: Fisheries Department

Figure 2-5: Distribution of Western Rock Lobster Managed Fishery Licenses by Pot Unit Entitlements: 2003-04 Season

In broad terms, the number of pot lifts by season by zone since the 18% pot reduction effective from 1993/94 season, which is shown in Appendix 8 has not shown the same degree of variability as catch levels as highlighted by Figure 2-6 below. For instance, catch volume in 2001-02, which is considered to be a below average catch season, and 2003/04 being indicative of an above average catch season, the industry's catch volume changes by 51.3% but the pot lifts varied by only 1.5%. In the case of Zones A and B combined, the catch volume varied by 21.4% whilst the pot lifts changed by 2.5%. In Zone C the differences in variability were more pronounced with catch volumes up 78.5% between the two seasons, whilst pot lifts changed by just 0.7%. As pot lifts is a crew dependent variable, this smaller variability in pot lifts trends to supports the earlier observation that employment opportunities for deckhands may not have been as negatively impacted by the fleet contraction as first impression might have led us to believe.



Source Data: Fisheries Department

Figure 2-6: Pot Lifts and Catch by Zones-1993/94 to 2003/04

2.3.3 Business Structures of Lobster Fishing Operations

The distribution of business structures shown on Western Rock Lobster Managed Fishery licenses and on fishing boat licenses with an attached WRLMF license were broadly similar, although, the entity holding the fishing boat license and the entity shown on the attached WRLMF license were not always the same.
These data are shown in Table 2-2 below.

Table 2-2: Business Structures of Lobster Fishing Operations

Business Structures	Percentages (%)
Sole Trader	15
Partnerships[1]	30
Companies[1]	46
Trusts[1]	7
Other[2]	2

Notes:
[1] Predominately family partnerships, companies, and trusts.
[2] Included deceased estates
Source Data: Fisheries Department

2.3.4 Costs and Cost Structures

Twenty-one lobster fishing businesses responded to our cost of production survey. For those which operated more than one lobster boat, individual boat data were provided. This gave us in total data for 23 lobster boat operation covering Zone A (5), Zone B (12) and Zone C (6).

The number of responses from lobster fishermen, whilst not as extensive as was sought, provided insightful information on cost items and cost structures for a cross section of fishing operations by size (measured in terms of the number of pots and boat size) for each of the lobster fishing zones. These data also included information on cost-volume relationships for individual enterprises, that is, the extent to which harvest cost change in response to changes in expected catch volumes.

These data were supplemented by information obtained in discussions with two Focus Groups of lobster fishermen (one comprising Zone C fishermen and the other consisting of both Zone A and B fishermen) and individual respondents to the cost of production survey. This provided a broad insight into the typical fishing practices in each of the lobster fishing zones and into the key fixed and variable costs associated with boats, pots, catch and the running of the lobster fishing business.

There was considerable heterogeneity among individual lobster fishing respondents within and between zones in terms of pot fishing methods used and production costs. As the respondents were mostly family run businesses, these differences were due in part to difference family objectives, values and attitudes. However, there was one aspect that was common to all respondents. The costs of operating the lobster fishing business under the existing fishery management rules remained relatively unchanged irrespective of the predicted catch volumes (a below or above average season). The boat fuel, bait costs, crewing levels, pot numbers tended to be broadly similar across seasons. This suggests the cost of operating a lobster fishing operation were driven more by the biology of the fishery than the economics.

Indeed, the extra cost of the respondent fishermen in harvesting an increased catch volume or the marginal costs of lobster harvesting tended to be low and appeared to change little across the catch volume ranges used. (The volume range reflected the catching experiences of the past decade.) This was consistent with the general impressions obtained during the discussions with the Focus Groups of lobster fishermen.

The marginal cost differed among respondents, between enterprises of different size and between zones (although the extent of the differences between some size categories in Zone A was more a reflection of the limited number of observations) . Despite these limitations, these data provided an insight in to how marginal costs changed with catch volumes across zones and boat sizes under the existing management arrangements.

These marginal cost data are summarized in Table 2-3 below , which is consistent with what we would expect based on economic theory, gave us the basis for developing evidenced based assumptions about costs and cost structures under the alternative Scenarios. These assumptions were further tested in discussion with the Zone Focus Groups of lobster fishermen.

The marginal costs were driven principally by crew costs. This primarily reflected the basis on which crew were paid, including workers compensation premiums and the contribution to employee superannuation and, in some instances, changes in crewing levels between different catch volumes.

For the respondents, crew costs reflected, in most instances, a catch revenue-operating cost sharing arrangement, that is, a percentage of the catch revenue less a percentage of the fuel and bait costs, although the actual percentages and conditions varied among the respondents. There were also other costs beside those associated with crew that can vary with catch volume and are included in these marginal cost estimates. These included cost items such as fuel, bait and the amount paid relative to the Development and Better Interest Fee (DBI). This fee, which is included in pot fee paid by lobster fishermen to the Fisheries Department, is based on a percentage of the gross value of the industry's lobster catch. In consequence, as the industry's gross revenue rise or fall with changes in catch volume so to does the amount of the DBI fee paid per pot.

Table 2-3: Marginal Costs by Operational Size and Lobster Fishing Zone ($/kg)

Firm Size	Zone A			Zone B			Zone C		
	Below to Average Season	Average to Above Average Season	Above Average to Peak Season	Below to Average Season	Average to Above Average Season	Above Average to Peak Season	Below to Average Season	Average to Above Average Season	Above Average to Peak Season
Small[1]	5.95	5.97	5.97	6.34	6.40	6.42	6.82	6.90	7.00
Medium[2]	6.77	6.77	6.77	5.33	6.15	6.48	4.49	4.57	4.74
Large[3]	6.76	6.79	6.80	6.35	6.45	7.20	4.67	4.94	5.48

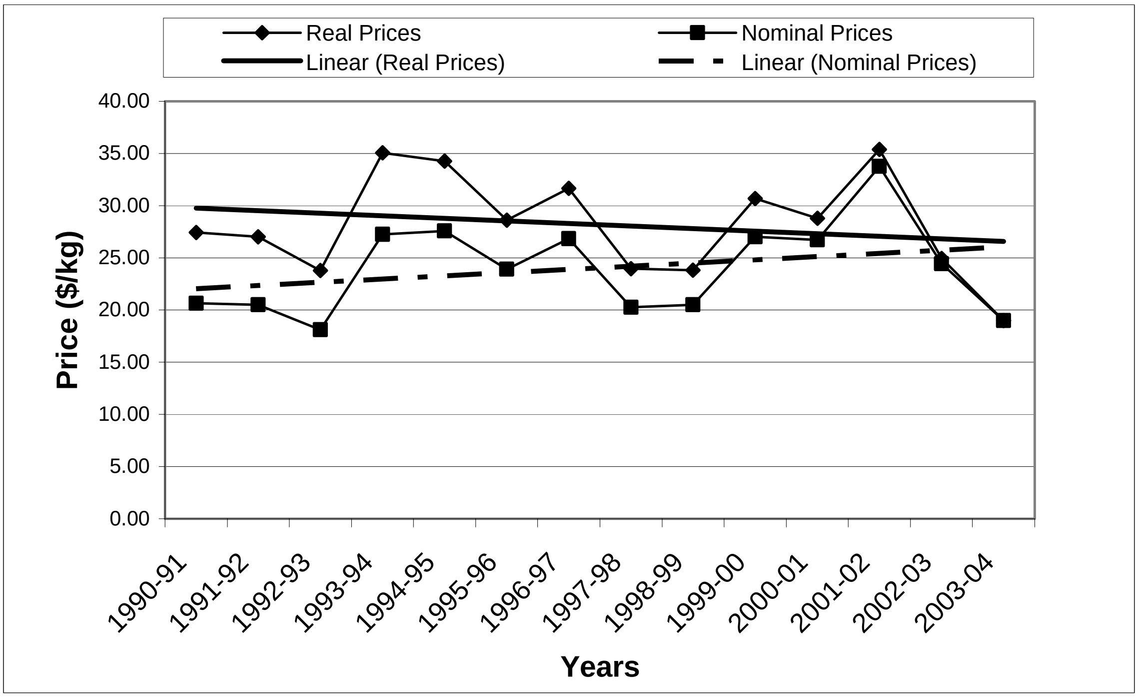
Notes:
[1]Firms with 60-80 pots operating a lobster boat <12 metres
[2]Firms with 100-120 pots operating a lobster boat >12 metres and <15metres
[3]Firms with >130 pots operating a lobster boat >15 metres.
Source: Survey Respondents

2.3.5 Lobster 'Beach' Prices

Historical 'beach' price data shows, in general, that, whilst price can vary within and between seasons, a similar or single 'beach' price per kilogram was paid to fishermen irrespective of lobster grade, colour or zone from which the lobster originated. Under past and existing management rules in the fishery, there is a strong 'rush to fish' incentive among fishers to optimise catch shares. This fishing behaviour optimises the catch volumes that are effectively passed to processors to sell at the best returns that can be obtained from the market rather than fishing to optimise the aggregate industry revenue from a catch.

2.3.6 Trends in Annual Beach Prices

Annual average 'beach' prices for western rock lobster in both current and constant (2003-04) money values over the past 14 years are shown in Appendix 9 and are reproduced in graphical form in Figure 2-7 below. These data show that, whilst current prices have trended upwards over this period, the rate of increase has not kept pace with domestic inflation as reflected by the downward trend in the real prices. (That is, the current prices adjusted for movements in the Perth Consumer Price Index).

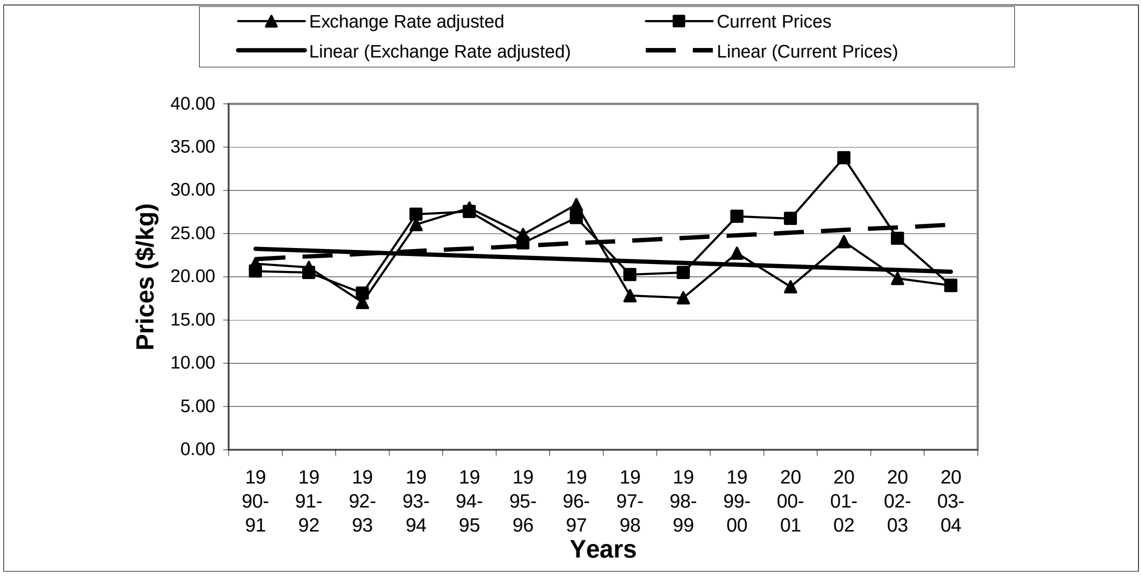


Sources: Fisheries Department and Australian Bureau of Statistics

Figure 2-7: Annual Average 'Beach' Prices-1990-91 to 2003-04

These data in Appendix 9 also show that the 'year-to-year' fluctuations in current prices are not due solely to 'year-to-year' changes in the catch volumes, but are, in large part, attributable to exchange rate variations. For instance, almost $10/kg or around two-thirds of the $14.75/kg fall in the annual average 'beach' price between the 2000-01 below average catch season ($33.75/kg) and the above average 2003-04 season ($19/kg) can be attributed to exchange rate changes. The remaining one-third of this price decline can be attributable to the 51% increase in catch volume between these years.

The current prices over the 14-year period standardized to reflect 2003-04 exchange rates are shown in Figure 2-8 along with the current prices. This shows that, if the Australian dollar had not weakened over the mid-90's to 2002-03 season, the 'beach' price would have trended downwards rather than upwards exacerbating the industry's declining terms of trade.



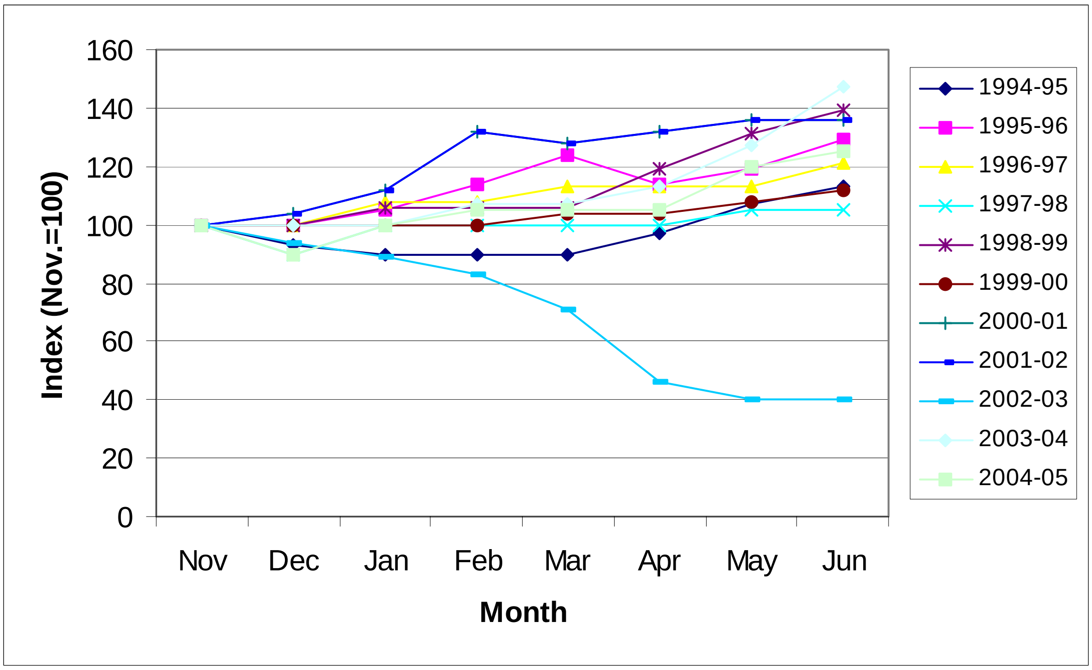
Sources: Fisheries Department and Reserve Bank of Australia

Figure 2-8: Current and Exchange Rate Standardized Annual Average 'Beach' Prices-1990-91 to 2003-04

The data suggests that, apart from volume and exchange rate movements and the loss of consumer confidence in Asia and the United States following the SARS outbreak and September 11, there appears to have been other factors at work that have contributed to these past 'beach' price fluctuations. This could include factors such as changes in the grade mix of the commercial catch, the product mix exported, the costs of lobster processing and exporting, overseas buyers responding to known changes in expected catch volumes, and perhaps even underlying changes in consumer tastes and preferences in certain key markets.

2.3.7 Seasonality in Beach Prices

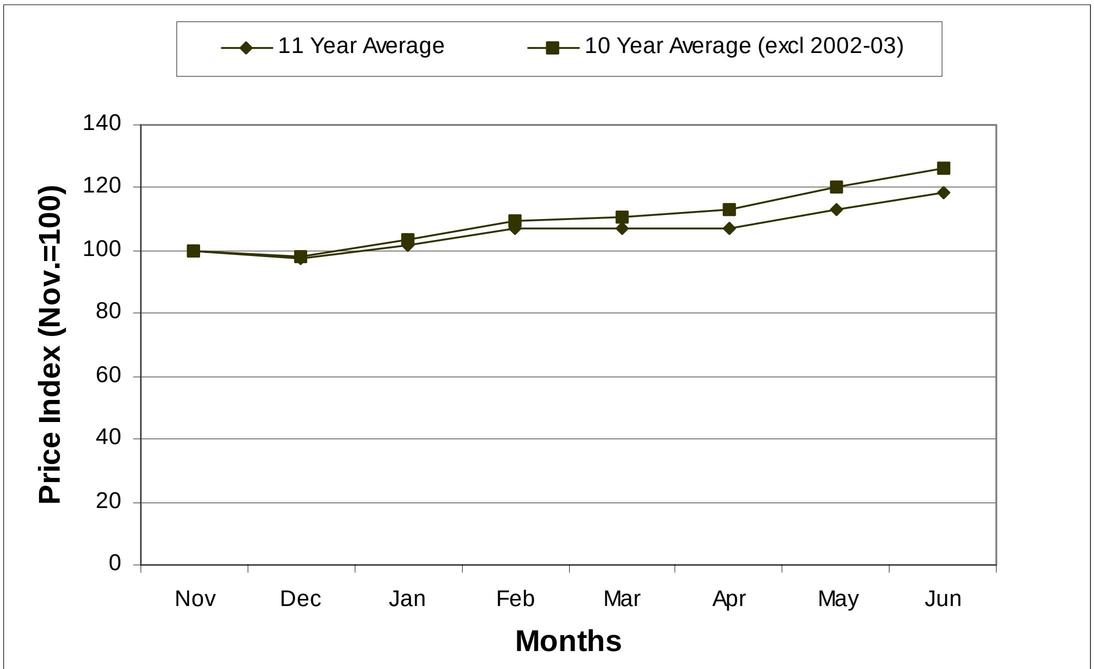
Within season 'beach' prices data for each of the past 11 years were analyzed to remove any cyclical component and to isolate any systematic pattern within seasons. The within season beach prices pattern, which is shown in Figure 2-9 below, indicates that, as a general rule, the end of season prices have been typically higher than those earlier in the season.



Source: Processors

Figure 2-9: Pattern of Within Season Beach Prices: 1994-95 to 2004-05

The pattern of within season beach prices averaged over this 11-year period is shown in Figure 2-10 below. If 2002-03 were excluded as being an exceptional year, the within season pattern of beach prices is not materially different as shown Figure 2-10 below.



Source: Processors

Figure 2-10: Pattern of Within Season Beach Prices: Averages

2.3.8 Capturing Beach Prices in the Evaluation Model

There were no data available to suggest that the 'beach' prices for lobster should not be treated as exogenous for modelling purposes. That is, the modelling assumes that lobster product prices are determined externally rather than by any action taken from within the WA industry. This is the basis on which lobster prices were incorporated into the model.

Whilst historical data provide an insight into past developments under the existing ITE regime, the evaluation of alternative management arrangements required information on how price levels and relativities might change under the varying supply conditions that would be associated with these alternate management scenarios.

For the purposes of our evaluation modelling, ERA estimated possible below and above average catch and price scenarios by grade and by month following discussion with the Project Steering Committee, processors and Fisheries Department. The extended season catch estimates for the modified and more flexible ITE management arrangement (Scenario 2) were made on the assumption that appropriate input controls would be in place to ensure catch in the extended period were within sustainable levels. Given a strong rush to fish incentive exists under the existing (Scenario 1) and modified (Scenario 2) ITE regimes, the 'beach' prices during the extended season would need to be sufficiently attractive to entice lobster fishermen to take the risk of delaying fishing from the earlier to the later months of the season.[v].

These estimates, which are set out in Appendix 8, were sent to these parties for comment. Our estimates, whilst not endorsed by them, were considered to be not unreasonable for use in our evaluation.

Discussions with processors gave us an insight into the marketing price premiums that were likely above those in the existing management system if catch occurred over an extended season with a leveling of intra-seasonal catch and if inter-seasonal variability in catch was reduced. The price differentials used in the modelling are discussed in detail in Chapter 5.

2.4 Lobster Processing

As part of the existing fisheries management arrangements, there is a requirement for lobster processing establishments to be licensed by the Fisheries Department. There are currently 37 issued licenses for processing western rock lobster. This consists of a 19 unrestricted (Export and Australian domestic markets) licenses and 18 restricted (Australian domestic markets only) licenses.

Unrestricted lobster processing licenses are currently limited to the existing number on issue. Eight firms operate 16 of the 19 unrestricted licenses. Two are presently attached to non-operational establishments.

The number of restricted licenses for processing lobster for domestic market is not restricted.

Lobster processing facilities are mostly located in Fremantle/Perth and Geraldton with most of the operational establishments in these locations. These data are shown in Figure 2-4 below.

Table 2-4: Western Rock Lobster Processing Establishments: 2003-2004 Season

Location	Unrestricted	Restricted	Total
Geraldton	6	3	9

Dongara	1	1	2
Jurien		1	1
Lancelin	2		2
Fremantle/Perth	7	11	18
Bunbury		1	1
Albany		1	1
Total	16	18	34

Source: Fisheries Department

Since Table 2-4 was prepared there has been subsequent rationalisation of processing facilities among processors. This appears to be designed to achieve improved capital utilization in order to drive down average costs and to improve efficiency in an increasingly competitive environment.

As lobster exports account, on average, for around 95 per cent of the lobster catch, this means that, in the case of 2003-04 season for example, around 12,886 tonnes with an estimated ‘beach price’ value of about $245 million were accounted for by the eight (now 6) firms that operated the 16 active unrestricted (export) licenses. On this basis, this left around 678 tonnes worth around $13 million (at beach prices) that was handled by the lobster processors that were licensed to sell domestically.

3 Alternative Fisheries Management Scenarios

3.1 Background

Fishing controls are aimed at restricting catch to sustainable levels to maintain enough breeding stock to support the fishery and to ensure fish is available for the future. In designing these controls, Government also aim to optimize the economic and social benefits to society from the use of the community-owned marine resource.

The current management regime is allowing economic and social benefits to flow to the community, while maintaining the ecological processes upon which the western rock lobster fishery depends, as required by the Fish Resources Management Act 1994. However, at this stage, it is unclear whether the current management regime is delivering the optimum mix of economic and social benefits within an ecologically sustainable framework.

3.2 Alternative Management Approaches

Alternative management approaches needed to be considered so as to identify which is most likely to achieve the optimal mix of economic and social benefits within an ecologically sustainable framework. The alternative management strategies that were contained in the Tender fell into two broad groupings; one related to more flexible ITE regimes, whilst the other involved annual catch controls.

The broad differences between these alternative approaches compared to the existing regime are summarized in Table 3-1. The existing management regime is the benchmark against which alternate management S were compared and assessed.

Table 3-1: Key Differences between the Alternative Management Scenarios and the Existing Management Scenarios (Scenario 1) in the Western Rock Lobster Fishery

Controls	Alternative Management Scenarios		
	Scenario 2: Modified ITE with Pot Fishing Day Entitlements	Scenario 3- Modified ITE with Seasonal Catch Limits	Scenario 4-ITQ
Spatial	Three Zones	Three Zones	Three Zones
Temporal	Fishing season extended- 31 August	Fishing season extended- 31 August	Fishing season extended-31 August
Effort: -Nature	Pot fishing day	Catch Quota/pot	
-Maximum Gear Usage	No Change	No Change	None
-Pot Design	No Change	Improved pot design[1]	Improved pot design[2]
-Restricted to one pot setting & lift /day	No Change	No Change	None
Access	More than one WCRLMFL per FBL allowed but only one entitlement can be fished on any day	More than one WCRLMFL per FBL allowed but only one entitlement can be fished on any day	More than one WCRLMFL per FBL allowed but only one entitlement can be fished on any day
Biological	No Change	No Change	No Change
Annual Catch	None	Fixed & Variable Seasonal TACC	Fixed & Variable Individual Seasonal Catch Quota
Transferability	Pot fishing days entitlements transferable within zones but not between zones	Pot/quota entitlements transferable within zones but not between zones	ITQ entitlements transferable within zones but not between zones
Cost Recovery	No Change	No Change	No Change
Processing[3]	No Change	No Change	No Change

Notes:
[1] Allows for pots with a 50% increase in volume and three necks. [2] Allows for pot designs that increase catching efficiency by 40%
[3]Export licensing constraints are subject to compliance with Competition Policy principles

3.3 The Alternative Management Options

The specifications provided by the Project Steering Committee for management scenarios under each of these broad alternative approaches that were contained in the original brief are shown in Appendix 11.

The existing ITE management system reflected the management rules prevailing at the time of the 2004-05 season. The effort reduction management rule changes to apply for the 2005-06 season were not specified and not incorporated as part of the base case for modelling purposes.

Following presentation of the modelling results for these initially specified management scenarios, we were asked to model additional options. In effect, these extra options were variations of previously specified options to account for a wider range of circumstances. The additional options included: a variation to the existing management regimes in the form of a 20 per cent reduction in pot numbers, variations to the quota controlled scenarios by building in conservative rules for the determination of variable quotas, more modest price differential assumptions, and alternative quota specification rules in Zones A and B.

The key differences in the features of the alternative management options modelled are outlined in Table 3-2. The’ whites’ and ‘reds’ quotas referred to in this Table relate to within season quotas, that is, the November to Mid-March and Mid-March to 31 August respectively. This approach was agreed with the Project Steering Committee as a way of allowing for the ability of vessels with Zone A endorsements to fish both zones.

Table 3.2: Key Differences in the Features of the Alternative Management Options Modelled

Features		Input Controlled Regimes			Quotas with Pots Controlled				Quota Controlled			
		Existing Regime		Modified ITE Rules	Fixed TACC	Variable TACC			Fixed TACC	Variable TACC		
		Exiting Rules	20% Pot Reduction									
Zones	Scenario Code	1	1a	2	3a	3b	3c	3d	4a	4b	4c	4d
All Zones	End of Season	Jun-30	Jun-30	Aug-31	Aug-31	Aug-31	Aug-31	Aug-31	Aug-31	Aug-31	Aug-31	Aug-31
	Price Differentials	$ -	$ -	$2.00/kg	$5.00/kg	$3.50/kg	$2.00/kg	$1.00/kg	$5.50/kg	$4.00/kg	$2.50/kg	$1.25/kg
	Extra Costs [1]	$ -	$5,000	$7,200	$7,200	$7,200	$7,200	$7,200	$2,200	$2,200	$2,200	$2,200
	Pot #'s	Limited	Limited	Limited	Limited	Limited	Limited	Limited	Flexible	Flexible	Flexible	Flexible
	Pots/Boat	100%	100%	100%	100%	100%	100%	100%	120%	120%	120%	120%
	Limited Pots/Days	No	No	Yes	No	No	No	No	No	No	No	No
	Rush to Fish	Yes	Yes	Yes	No	No	No	No	No	No	No	No
	Effort Creep	1%	2%	1%	0%	0%	0%	0%	0%	0%	0%	0%
	Catchability	100%	110%	100%	115%	115%	115%	115%	140%	140%	140%	140%
	Opening Boat #'s	Preset	Preset	Preset	Preset	Preset	Preset	Preset	Flexible	Flexible	Flexible	Flexible
	Boat #'s Decline pa	1%	1.5%	1%	1%	1%	1%	1%	1%	1%	1%	1%
	TACC Variation	NR	NR	NR	0%	50% [2]	90% [3]	90% [3]	0%	50% [2]	90% [3]	90% [3]
Zone A	Whites Quota	No	No	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes
	Reds Quota	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Whites Quota	No	No	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Zone B	Reds Quota	No	No	No	No	No	No	No	No	No	No	No

Zone C	Whites Quota	No	No	No	No	No	No	No	No	No	No	No
	Reds Quota	No	No	No	No	No	No	No	No	No	No	No

Notes: [1] Extended season increases enterprise cost by $7,200; ITQ's reduces enterprise cost by $5,000; and pot reduction increases enterprise cost by $5,000.
[2] Variable TACC= (50% of 'predicted' current year catch for Scenario 1+ 50% of the ten year average catch for Scenario 1)
[3] Variable TACC= (90% of 'predicted' current year catch for Scenario 1+ 90% of the ten year average catch for Scenario 1)

4 Modelling the Alternative Management Regimes

4.1 Overview of Model

The bio-economic model consists of:

- a biological model with up to 3 "age" cohorts of lobster to simulate the population dynamics of the West Coast Rock Lobster Fishery; embedded within:-
- a highly non-linear mathematical programming model used to optimise industry annual net economic benefits; embedded within:-
- a recursive algorithm that links the biological population of one year to the next, and uses a sequence of puerulus indices (PI) from the fishery to simulate recruitment variation over ten year period

It simultaneously optimizes across the biological and economic sub models to maximizing the net economic return to the fishery by searching for the optimal combination of a number of decision" variables, which depending on the scenario, may include various combinations of some of the following:

- **Representative boat numbers.**
- **Total pot numbers.**
- **Days fished by Month**
- **Number of boat trips by Month**
- **Pot Lifts by Month.**
- **Aggregate catch**
- **Available breeders, recruits and survivors by month.**
- **Closing biomass for recruits, breeders and survivors for each of the ten years in the model.**

4.1.1 Use of Model to Optimise Under Various Scenarios

The model can optimize under a variety of scenarios by changing appropriate variables, and/or model structure, including:

- **Months when fishing is allowed,**
- **Data inputs such as the price received for rock lobster, catchability coefficients, etc.,**
- **Placing constraints on values of solution variables. For example for an ITQ, annual catch is limited to being less than or equal to the nominated TACC. Similarly, the number of pots may be constrained to be a certain level.**

4.2 Model Structure

The biological models for Zones A, B, and C are separate and completely self contained. There is one optimization model for Zone C, and another for Zones A and B combined, because some vessels fish in both the A & B zones at different times of the year. Hence, optimization must simultaneously deal with Zones A and B. This simultaneous modelling of Zone A and B should not be taken as advocating the removal of the existing boundaries in the northern fishery.

The model runs recursively for a ten year period. From the biological perspective, this means that the model starts with given opening stocks, and then simulates recruits, survivors, and breeders on an annual basis. Closing stocks of each are transferred to the next year, and the model then optimizes annual net economic benefits for each year of the ten-year evaluation period. The final closing stocks of recruits, breeders and survivors at the end of ten years relative to opening stocks at the start of the ten year period provide an indication of sustainability of alternative management scenarios.

Reflecting standard economic methodology, the model gives estimates of long run equilibrium. For example, for a given scenario, the boat numbers and the closing biomass are steady state equilibrium values after an adjustment or transition period is complete.

The basic economic structure is the same across zones, but the level of specific variables varies for each zone.

4.2.1 Biological Model Structure

A schematic of the structure of the biological model is shown in Figure 4-1.

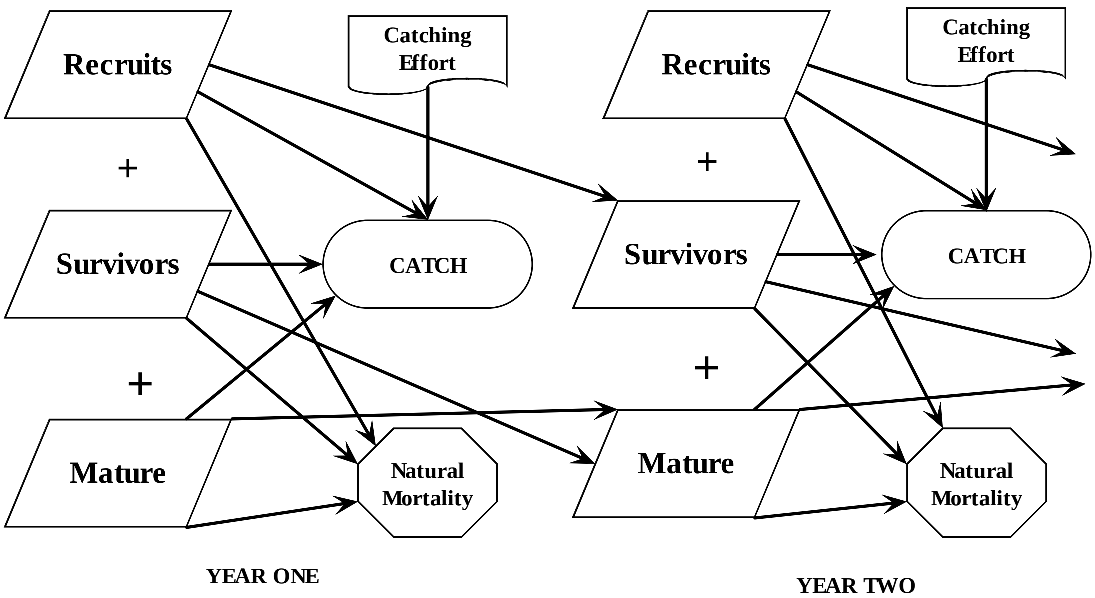


Figure 4-1: Basic Structure of Biological Model

The model is similar to the Hall and Chubb model (2001)[vi] in terms of the way it approaches modelling key elements, such as variable recruitment from a series of Puerulus settlement indices, as well as death rates. Of necessity, it is considerably simpler than the Hall and Chubb model. The objective in developing the model structure was to capture the key aspects of the biology but keep the model simple enough to allow tractable integration with the economic aspect of the modelling.

The three different biological stocks in the Abrolhos, the Northern (except for Abrolhos) and the Southern: zones were simulated independently. While there is only 1 size class of lobster in the Abrolhos, there are 3 size classes, or "age" cohorts, of lobster in the biological stocks of each of Zones B & C. Catch simulation is for all legal size animals. The breeding stock in Zone A is all legal size lobsters.

As shown in Figure 4-1 the models for Zones B and C have three classes. These are:

- "recruits" consisting of lobster that have been legal size for less than one year;
- survivors consisting of lobster that have been legal size for more than one year, but less than two years; and
- mature/breeders consisting of lobster that have been legal size for more than two years.

Breeding stocks in Zones B and C are mature class lobsters.

The model has been "truthed" with reference to the analysis of several fishery databases (potlifts, catch, size distribution of catch, boat numbers, crew numbers, CPUE, etc.). In particular, the model structure and parameters have been "truthed" against:

- Monthly record of catch and fishing effort for all boats for the past 10 years,
- Voluntary "log book" data with more detailed information for about 40% of fishers for the past three years,
- Commercial catch monitoring data for the past three years, and
- Lobster processor data for the past three years

The model coefficients in the biological models were chosen to minimise times series deviations between actual and simulated levels of catch generated from actual levels of effort. The model was run for ten years to capture the full degree of variation in the fishery based on the know PI data. Opening stocks were current stock levels. Closing stocks were set to be equal to or higher than opening stocks.

In order to test the robustness of the validation of the biological models, they were evaluated using historical data over the period 1993/94 to 2003/04 for the zones. The calibration results for Zones A and B combined and C are shown in the Figures 4-2 and 4-3 (respectively) below. The model tracks actual catch well, with the R square between actual and fitted catch being very high (see Table 4-1).

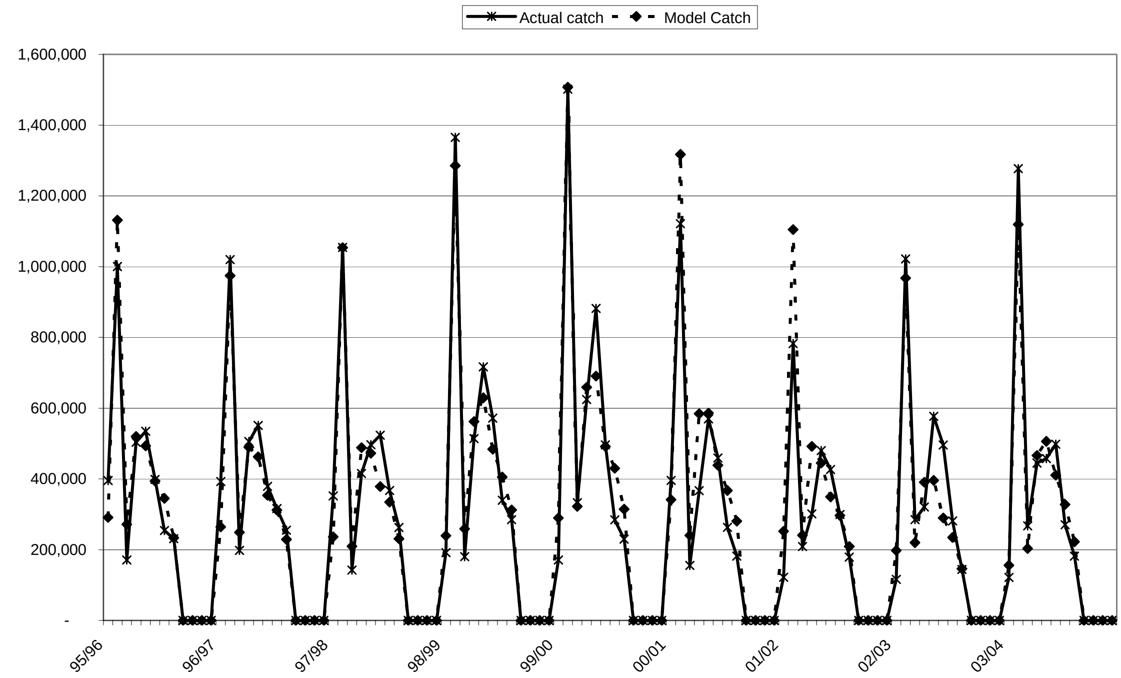


Figure 4-2: Catch Validation of Biological Model for Zones A and B

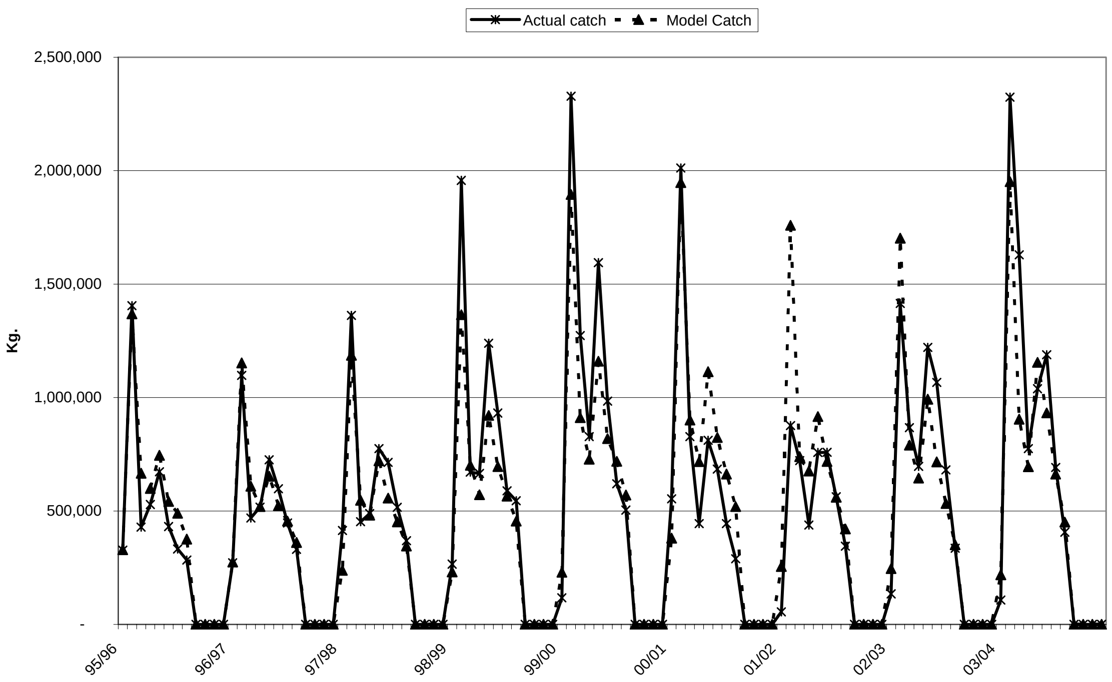


Figure 4-3: Catch Validation of Model for Zone C

The regression results for the biological model validation are shown in Table 4-1 below.

Table 4-1: Regression Statistics for Biological Model Validation

Regression Statistics	Zone AB	Zone C

Multiple R	.968	.937
R Square	.936	.877
Adjusted R Square	.929	.869
Observations	132	132

The biological model, which has up to 3 “age” cohorts of lobster to simulate the population dynamics of the West Coast Rock Lobster Fishery, is embedded within-

- a highly non-linear bio-economic mathematical programming model used to optimise industry annual net economic benefits; embedded within:-
- a recursive algorithm that links the biological population of one year to the next, and uses a sequence of PI from the fishery to simulate recruitment variation over a ten year period

The two bio-economic models cover 3 separate geographical regions, namely;

- Abrolhos zone fished by Zone A license holders, mid March to June 30
- Northern zone fished by Zone A license holders, mid November to mid March; and by zone B license holders, mid November to June 30
- Southern zone fished by Zone C license holders, mid November to June 30

Effort levels generated by these models were compared to actual effort levels as measured in data sets over the ten year period for which we had data. The results are shown in Figure 4-4 and 4-5 below, each of which shows the following six bars for each month.

- Model minimum, average, and maximum pot lifts over the ten year period, and
- Actual minimum, average, and maximum pot lifts over the ten year period,

The figures show how well matched are the actual and model data on effort.

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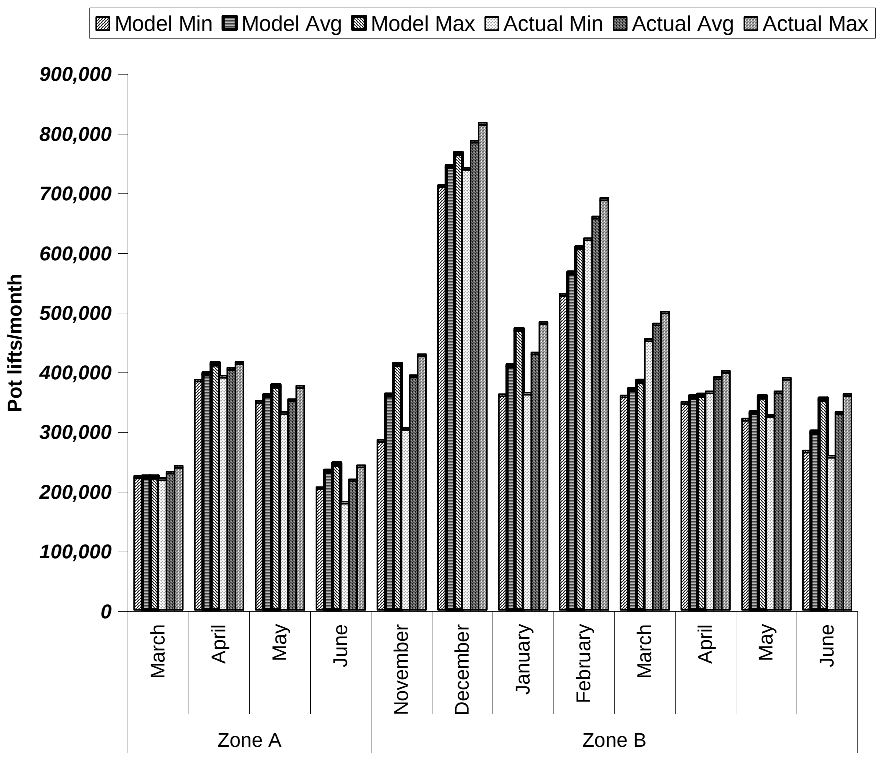


Figure 4-4: Minimum, Average, and Maximum Effort for 10 years: Model vs. Actual in Zones A&B

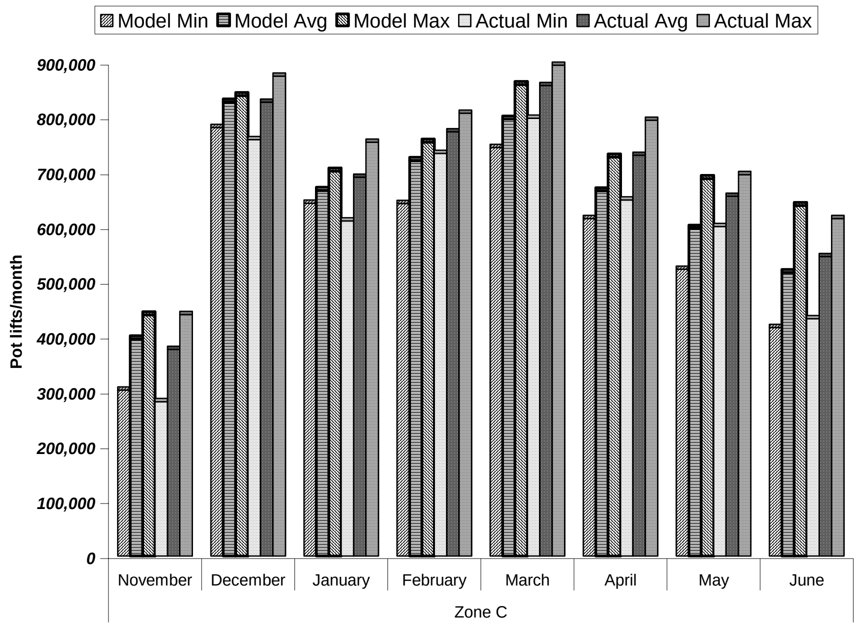


Figure 4-5: Minimum, Average, and Maximum Effort for 10 years: Model vs. Actual in Zone C

Another way to look at the correspondence between actual and model results is to look at catch/pot lift CPUE data. The actual and model CPUE by month for zones A, B and C are shown in Figure 4-6. Again the results indicate a very high degree of correspondence between actual and model data on CPUE.

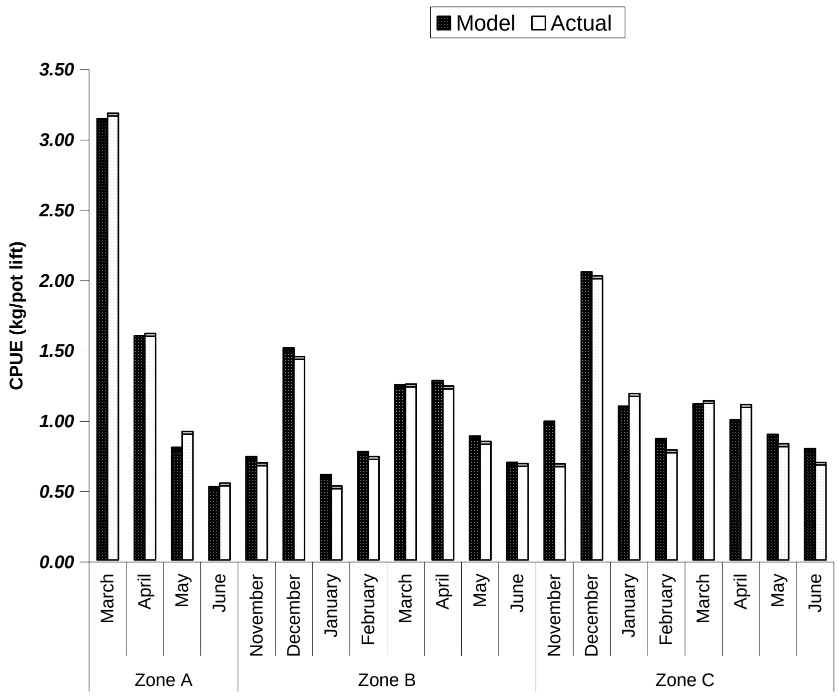


Figure 4-6: 10 year average CPUE: Model vs. Actual

Taking the validation results in Figure 4-2 through to Figure 4-6 as a set, we can see that the model captures the actual fishery circumstances closely and is a solid base on which to build the scenario analysis.

4.2.2 Economic Model Structure

4.2.2.1 Model Uses a Representative Boat

The structure of the economic component of the model is based on the concept of a representative boat being the unit of production like, for instance, a farm or a factory. It is common practice in complex economic modelling to use a representative production unit. In this case, the representative boat captures, on average, what boat behaviour is likely to be for a representative boat operating in the fishery[1].
The representative boat in each zone reflects material differences between each of the fishing zones in the fishery. In all three cases, the representative boat is crewed by a skipper and two deckhands.

4.2.2.2 Costs and Cost Structures

For modelling purposes, the key cost drivers needed to be identified (e.g. boats, pots, pot lifts, catch, etc) and, relative to each cost driver, those elements of costs that were fixed (that is, an item where the cost remains the same over the season regardless of activity level) and those that were variable (that is, an item where cost changes with the level of activity). These cost structure data are outlined in Table 4-2 below.

Table 4-2: Cost Structure of a Typical Lobster Fishing Business

Cost Drivers	Cost Items	
	Fixed	Variable
Boat	•Capital value of boat (incl. associated equipment) & moorings[1] •Boat Survey, • Boat Registration and fishing boat license fees •Mooring Fees •Annual Overall	•Fuel •Repairs & Maintenance of boats & moorings • Incidentals
Pots	• Capital cost of pots[1] [2] • Access Fees •Annual Overall	•Replacement of lost Pots & Gear •Repairs & Maintenance
Pot Lifts		• Bait and • Fuel [3]
Catch		• Crew [4]
	•On-Shore Assets[1]: -Office & Office Equipment and -Vehicles -Sheds, Dinghy, Trailers -Island Campsites	

[1] This technique is used in economics where behaviour is standardized in the aggregate rather than one that reflects each individual boat, factory, farm or consumer. In economics, the typical behaviour is a reflection of what is likely in a broad ‘on average’ sense rather than a reflection of how each individual boat, factory, farm or consumer might behave.

Other	•Recurrent Items: -Accountant, -Taxation & Legal Advice -Marina Fees -Workers Compensation, -Employee Superannuation -Campsite costs (fuel, fees & charges), -Campsite & Island jetty Maintenance, -Office Expenses (power, telephone, etc) - Consumables	

Notes:
[1] Capital value of assets reflects the replacement value for a particular assets of an equivalent age. The opportunity cost of this capital value of these assets, which is the return that would have been received otherwise if it had been invested elsewhere, is the cost of these items used in the model.
[2] This relates to the real cost of buying a replacement pot and associated gear like floats and rope and not the capital value of a pot unit entitlement on a West Coast Rock Lobster Managed Fishery License.
[3] Fuel costs whilst at sea lifting pots as distinct from fuel cost incurred whilst steaming from port to the fishing ground and returning from the fishing ground to the port of landing.
[4] Uses a typical sharing arrangement based on the gross value of catch and cost of fuel and bait.

Changes in Input Costs

No allowance was factored into the model for changes in input prices over time. Indeed, it would have been inappropriate to predict what might happen to future input costs for the purposes of this modelling exercise. This modelling is making a comparison between management alternatives for the fishery on a sound, consistent basis as a snapshot in time. In any event, even if changes were factored into the model, it will simply change the amount of the net benefits for all of the scenarios, but, more importantly, it will not materially alter the relative results among the scenarios.

Capturing the Opportunity Cost of Invested Capital

Asset values (excluding licensed pot values but including the true cost of a pot, including the rope and floats) were based on the replacement value of the particular asset of an equivalent age. The opportunity cost of this invested capital is incorporated into the modelling. This is taken to be the return that that capital might otherwise achieve in alternative investments. For modelling purposes, a long-term rate of 7% was used as a reflection of the opportunity cost of invested capital.
In theory, the license value of a pot reflects the expected share of the flow of future net surpluses accruing to fishers. The inclusion of these values into the asset mix would amount to double counting as this is reflected in the flow of net benefits estimated by the modelling of the alternative scenarios.

4.2.2.3 Lobster Product and Beach Prices

Lobster prices were treated as exogenous for modelling purposes. That is, the modelling assumes that lobster product prices are determined externally rather than by any action taken from within the WA industry. The lobster product prices were the basis of ‘beach’ prices included in the model. This was done on the grounds that the processing sector is competitive with no evidence of extra-ordinary profit taking by that sector. In this case the processing sector adds a competitive margin and product prices reflect beach prices. In taking this approach the modelling has effectively incorporated both the harvesting and processing sectors The net benefits (surpluses) estimated in the model cover both processing and harvesting sector. This is true for all scenarios but the distribution of any net benefits as between the two sectors will ultimately be a function of the way the two sectors adapt to the scenarios.

No allowance was made for exchange rate variations over the ten-year period. In any event, exchange rate movements will simply raise or lower the prices in Australian dollar terms. This can raise or lower beach prices and input costs and consequently net benefits. In general, the impact on net benefits will be across all scenarios and all zones which may change the amount of the net benefits for each scenario in each zone and for the industry overall but the net benefit relativities among the Scenarios are not likely to be materially changed.

4.2.2.4 Economic Data Linkages in the Model

The variable cost structure, which is effectively a function of days fished (boat trip costs), pot lifts, and catch volumes, fixed costs (including with the opportunity cost of capital) for our representative boats, along with monthly levels and pattern of 'beach prices' for recruits, survivors and breeders are built into the model. These economic data are linked to the biological components of the model, reflecting both stock abundance and monthly catchability coefficients.

This enables the model to determine a monthly pattern of catch for each year in the ten year cycle that makes the greatest contribution towards covering the fixed costs and to optimize the industry's seasonal economic surpluses for each of those years in the ten year cycle, whilst ensuring stock sustainability. Therefore, in general the model solves for the optimum catch rather than the actual catch. The main caveat concerns scenarios 1 and 2, where there are effort controls, but no independent control of catch levels, for these scenarios, the model structure is modified slightly to simulate the "rush to fish" that occurs in fisheries subject only to input controls. This captures the idea that under these scenarios there is greater incentive to catch sooner rather than later relative to the catching behaviour that would maximize returns over the season. The model does this by simulating the greater incentive for fishermen to catch early in the season relative to later in the season.

In general, the relationship that determines net economic benefit or surplus is represented in Figure 4-7 below.

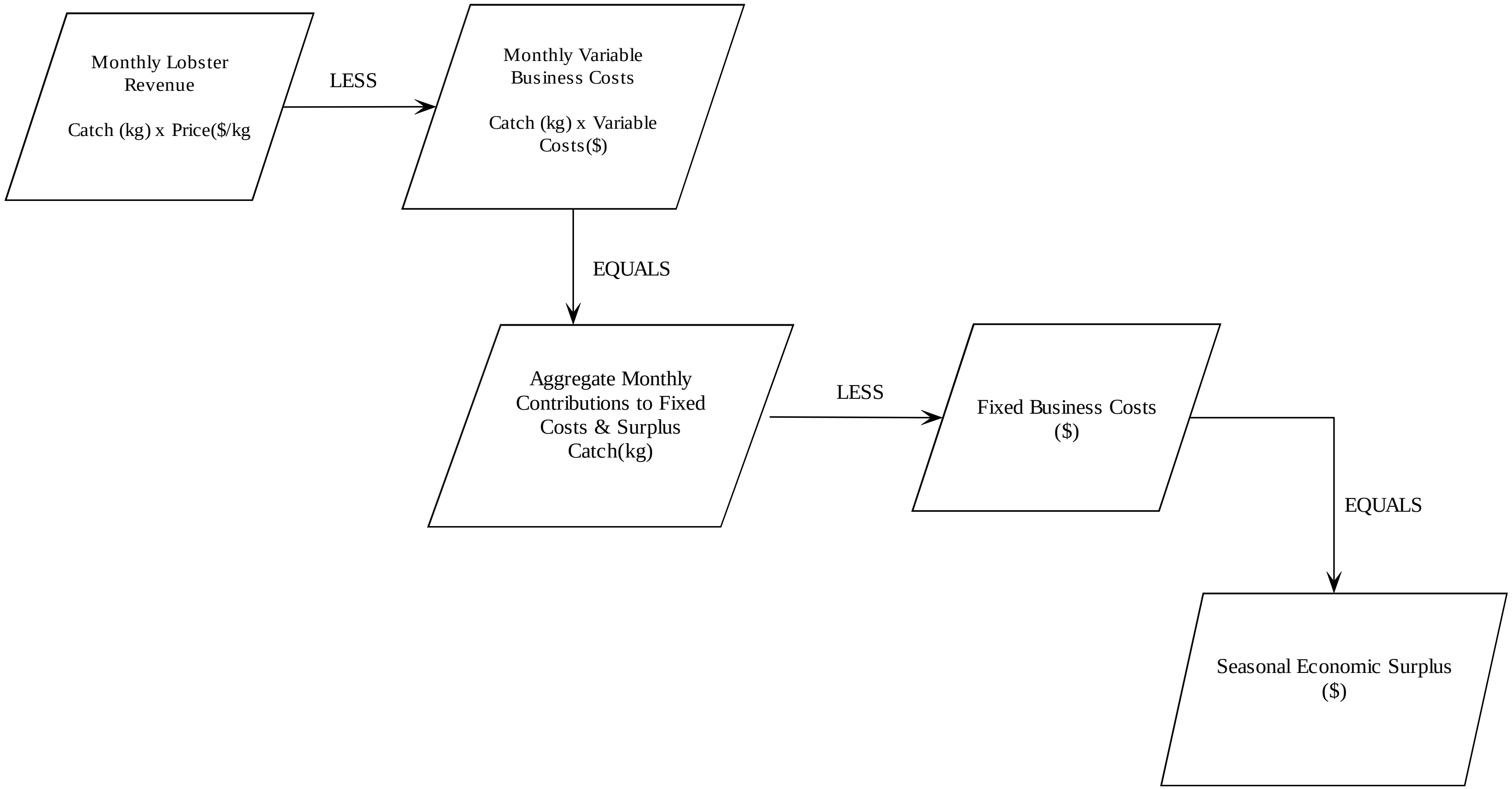


Figure 4-7: Revenue-Cost-Surplus Relationships

4.2.3 Economic Data

Apart from a cost of production survey, there was no original data collection by ERA. The data required to specify all economic variables in the model relied on information facilitated by the various industry sectors on the Project Steering Committee or obtained from official sources like the Australian Bureau of Statistics.

4.2.3.1 Cost and Cost Structure Data

The 'cost of production' survey of lobster fishermen provided data on the cost structures of individual fishing businesses across each of the lobster fishing zones and by three broad groupings of enterprise size (that is, small, medium and large measured by vessel size and pot numbers). In cases where a respondent operated more than one boat, cost data relating to individual boat activities were provided.

These data also included information on lobster enterprise related assets and asset values, crewing levels and remunerations arrangements as well as the residential location of crew.

The survey data were supplemented in discussions with two Focus Groups of lobster fishermen; one comprising Zone C fishers and a combined Zone A/B and Zone B fishers.

In all, the data available gave insightful information on fishing behaviour and cost structures under the existing ITE management scenario. This information was used to specify and quantify for a representative boat in each of the fishing zones the fixed and variable cost components in the model related to boats, pots, pot lifts and catch as well as other costs associated with operating a lobster fishing business and the dependent relationships in the cost structures. For instance, the number of pot lifts is a determinant of crewing levels, whilst crew remuneration based on a sharing arrangement is a function of catch revenue and of fuel and bait cost.

There was no such observable data in relation to the alternative management scenarios. In these cases, reliance was placed on three sources of information to gauge how behaviour of commercial fishers and processors might change under the alternative scenarios and how this might impact on costs structures of the representative lobster fishing boats and price structures. First, there were discussions with the Two Focus Groups of lobster fishers on how typical fishing behaviour might change under the alternative scenarios. Second, discussions took place with lobster processors on how their behaviour might change under the alternative scenarios. Finally, observed experiences in other jurisdictions, like South Australia and New Zealand, which have adopted management regimes similar to those involving seasonal catch limitations in the alternative management scenarios.

4.2.3.2 Productivity Gains Used in the Modelling

Data available for the existing management regime (that is, Scenario 1) indicates catching efficiency gains were running at around 1% per annum due to technology creep. The same percentage productivity gain was factored into Scenario 2.

The specified management rules for Scenarios 3 and 4 provided for more flexible pot design. In the case of Scenario 3, these rules allowed for pots with a 50% increase in volume and three necks. The Focus Groups of lobster fishermen thought these changes in pot design could increase catching efficiency in the peak catching period of December-January and March-April by as much as 15%. The Fisheries Department thought this estimate was conservative. For modelling purposes, we used a pot design productivity gain of 15% in the fixed and variable TACC regimes under Scenario 3.

In the case of the ITQ Scenario 4, the specified management rules allowed for pot design changes that increased catching efficiency by 40 per cent. This efficiency gain was factored into the modelling for the Scenario 4 options.

4.2.3.3 Lobster Product and Marketing Price Premiums under Alternative Scenarios

The processing sector provided monthly 'beach price' data over the past ten years. The sector also provided estimates of the relative pattern of monthly product prices by grade and colour for the current and extended season, including, from their knowledge of the lobster markets, estimates of what marketing price premiums could be reflected in beach price under the alternative scenarios that incorporate fixed and variable TACC.

In discussions with ERA, processor considered the current intra-seasonal peaks and the inter-seasonal variability of lobster catch were, from a marketing perspective, detracting from the optimization of industry returns from the commercial use of the fishery. In general, the processors considered that reducing the intra-seasonal peaks and inter-seasonal variability in the catch would achieve product returns and ultimately marketing price premiums in the beach price differentials higher than would be experienced under the existing management arrangements.

The processors indicated that there was significantly greater marketing benefit in reducing the inter-seasonal variability compared to the intra-seasonal variability. Once the extended season is accounted for, there was only minor net marketing benefit associated with any further reduction in intra-seasonal variability, bearing in mind that monthly variations can more easily be smoothed out compared to variations across years.

The marketing price premiums above the Scenario1 base case that were used in the modelling of the alternative management Scenarios, which were derived from discussions with processors, were as follows:

- An 'extended season' catch premium of around $2/kg;
- An 'inter-year' stability catch premium for fixed TACC Scenario options of about $3/kg (and one half of this differential in the case of variable TACC Scenarios); and
- An 'intra-year' stability catch premium where there is a greater flattening out of catch within a season ITQ Scenario 4 options of the order of $0.50/kg

These marketing price premiums were built into 'beach' prices across all three fishing zones for modelling of each of the alternative management scenarios. Whilst the level of prices was different between the various Scenarios, the monthly pattern of price relativities within the season remained the same across all Scenarios, that is price was low at the beginning of the season and high towards the end of the season..

4.2.3.4 Fisheries Management Costs

Data on access (and other Fisheries) fees paid by West Coast lobster fishermen under the existing management regime were available.

Our modelling of the alternative Scenarios required information on how management costs might change under the alternative Scenarios and what impact this might have on the level of access fees under the alternative regimes.

The Fisheries Department provided estimates of how these costs could change under the alternative Scenarios as a basis for modelling purposes. These management cost changes are shown in Appendix 12 and summarized in Table 4-2 below, which also shows the impact on access fees under the alternative Scenarios.

Table 4-3: Fisheries Management Costs Under Alternative Scenarios

	Scenario 1 (2004-05 Regime) Base Case	Additional Direct Costs (Above the Base Case)				
		Scenario 2 (Pot/Fishing Days)	Scenario 3 (a) (Pot/Quotas)		Scenario 4 (a) (ITQ)	
			One-off	On-Going	One-off	On-Going
Total Direct Costs	$6,371,650	No Change	$900,000	$2,720,000	$900,000	$2,720,000
			$2,810,000 (b)		$2,810,000 (b)	
MFL Fees						
Access Fee	$134/pot	No Change	+$41/pot (c)		$0.61/quota kg (e) +$0.27/quota kg (f)	
MFL Fee/Pot Used	$158/pot (d)	No Change	+ $48/pot (d)		Not Applicable	

Notes:
(a) Assumed to be the same whether seasonal quota is fixed or variable.
(b) Express all costs in recurrent equivalent terms, i.e. the $2,720k plus $90k (the one-off $900k amortized over 10 years).
(c) the overall additional cost could be slightly higher depending on how allocated costs play out in the cost attribution and allocation model used by the Department.
(d) Expresses the access fee in terms of pots used (i.e. maximum gear usage) for modelling purposes
(e) Expresses the pot access fee in $/quota kg based on a quota of 10,500 tonnes
(f) This represents the additional direct cost expressed in $/quota kg on the same basis mentioned in (d) above.
(g) for an individual quota of 15,000 kgs this would be equivalent to a seasonal access fee of $13,200 based on an industry aggregate TACC of 10,500 tonnes.

Source: Fisheries Department

5 Understanding and Interpreting Modelling Results

The model optimizes based on the criterion variable (net economic benefits) and a range of input and constraint variables.

5.1 Specification of ITE and ITQ Scenarios in Modelling

The management rules that were specified for modelling purposes for each of the alternative management approaches for the fishery are set out earlier in this report (see Chapter 3, Table 3-1 and Table 3-2).

There were three broad management approaches encompassed in the scenarios modelled. These were:

- Input or effort controlled (ITE) options that include the existing management rules (Scenario 1), a variant of the existing regime in the form of a 20 per cent pot reduction (Scenario 1a), and a modified ITE regime based on pot/fishing days with an extended fishing season that provided scope for greater flexibility around the choice of when to fish (Scenario 2).
- Catch quotas coupled with input controls over pot numbers, but with some modest flexibility in pot design and an extended fishing season to increase efficiency. The alternative options under this grouping specified either a fixed TACC (Scenario 3a) or a variable TACC (Scenarios 3b, 3c, and 3d). Key issues for these Scenarios were assumptions around sustainability rules used for the determination of catch quotas, the bases for operating quota in Zones A and B, and various marketing price premium assumptions.
- Catch controlled options based on pure quota (ITQ) scenarios, where there were no controls over pot numbers, more flexible pot design, and an extended fishing season to increase efficiency. The alternative options under this grouping specified either fixed ITQ (Scenarios 4a) or variable ITQ (Scenarios 4b, 4c, and 4d). Again key issues for these Scenarios were assumptions around sustainability rules used for the determination of catch quotas, the bases for operating quota in Zones A and B, and various marketing price premiums.

The existing ITE scenario (Scenario 1) was used as the base case against which the other management scenarios were compared.

5.2 Key Output Variables

The key output variables are:

- **Net annual return or benefit by zones**
- **Representative boat numbers by zones.**
- **Annual and monthly pot lifts by zones**
- **Annual and monthly catch by zones**
- **Annual and monthly boat trips by zones**
- **Breeder Biomass by zones**
- **Annual and monthly days fished by zones**

For most variables outputs also include the minimum, maximum and monthly average over the ten years.

The following sections discuss results by management scenario and by zone for each of these key output variables.

5.3 Comparative Results, the Underlying Assumptions

5.3.1 The Modelling Results

The model results are not forecast of the future. They simply provide decision makers and interested stakeholders with an assessment of the different policy alternatives on a sound, consistent basis.

The outcomes from the modelling assume that the fleet is comprised of a defined number of representative boats for each fishing zone. The results should not be interpreted as the outcome that will apply for each individual lobster fishing operation. Individual operators will need to think through how each of the alternative Scenarios is likely to impact on their operation.

In particular, the outcomes of the model include the assumed number of representative boats under each scenario. For all scenarios except the various permutations of scenario 4, the number of representative boats is the same because aggregate pot numbers is constrained by regulation. For scenario four, the number of representative boats was based on the fleet size that maximised net economic benefit when pot numbers were not constrained. In practice, the actual number of boats emerging under any given scenario will to some extent reflect the actual size distribution of boats in the fishery, the way that individual boat owners react and adjust to changed management arrangements, and the individual characteristics and circumstances of the owner. However, by working with the representative boat, the model captures the various adjustment incentives that exists under each scenario and allows the relative magnitude of those incentives and the associated efficiency gains to be meaningfully quantified.

In interpreting the results of any model, it is important to be aware of the underlying assumptions. The results of any model are only ever as good as the reasonableness of its assumptions. This does not mean that the model needs to be absolutely accurate in all respects to be useful, but rather, when considered in its totality, the overall results are reasonable given the current state of knowledge.

In the case of the existing management arrangement (Scenario 1), there is an existing body of observable data that was used to develop and calibrate the model and then to test the model to see how it performed against known outcomes from the past. Whilst our modelling results for the existing arrangements have closely tracked past outcomes, there is no such similar set of observable data to use in modelling the alternative management Scenarios.

For these other options, except for those relating to the 20 per cent pot reduction (Scenario 1a) which are discussed separately below, the modelling relied on information obtained from industry on how existing behaviour might change under the alternative management Scenarios and how this impacts on key variables used in the model.. This information was based on discussions with the Focus Groups of lobster fishermen, the processing sector, the Fisheries Department and experiences observed in other jurisdictions (e.g. New Zealand and South Australia) that have adopted similar management regimes to those being modelled.

In addition to the features of each of the various management options outlined in Section 3.3, Table 3.2, there are other key assumptions underlying the modelling that are discussed below.

5.3.2 Profit Optimizing Behaviour

We assumed the operator of the representative boats in each fishing zone would engage in profit optimizing behaviour. This means, for instance, the operator will not go fishing on days where it is not profitable to fish for lobster even when an entitlement (fishing days or quota) may not be fully utilized. In practice, all individual fishermen may not always behave in this way because of non-economic factors that may influence a lobster fisherman's decisions about when and where to fish for lobster that may not be economically optimal.

5.3.3 Factoring in Beach Marketing Price Premiums into the Modelling

The marketing price premiums identified in discussions with the processing sector (see Section.3.3, Table 3.2) for each of the alternative Scenarios are outlined in Table 5-1 below. These differentials were used to adjust the variable price levels that presented under the existing Scenario 1 base case to derive the beach price levels for each of the other Scenarios. However, the monthly pattern of prices within a season was the same for all Scenarios, that is, low at the beginning of the season and higher at the end.

Table 5-1: Comparative Marketing Price Premiums Factored into Beach Prices for Alternative Management Scenarios

Alternative Management Scenarios			Marketing Price Premiums ($/kg)			
Regime Type		Scenario Code	Extended Season	Inter-Season Stability	Intra-Season Stability	Total
Input Controlled	Existing	1	No	No	No	No
		1a	No	No	No	No
	Modified ITE	2	2.00	No	No	2.00
Catch Quotas with Limited Pot Numbers	Fixed TACC	3a	2.00	3.00	No	5.00
	Variable TACC	3b	2.00	1.50	No	3.50
		3c	2.00	No	No	2.00
		3d	1.00	No	No	1.00
Pure ITQ	Fixed ITQ	4a	2.00	3.00	0.50	5.50
	Variable ITQ	4b	2.00	1.50	0.50	4.00
		4c	2.00	No	0.50	2.50
		4d	1.00	No	0.25	1.25

These are indicative marketing price premiums.
No allowance was made for exchange rate variations over the ten-year period. In any event, exchange rate movements will simply raise or lower the prices in Australian dollar terms. This can raise or lower beach prices and input costs and consequently net benefits. In general, the impact on net benefits will be across all scenarios and all zones. Whilst this may change the amount of the net benefits for each scenario in each zone and for the industry overall but the net benefit relativities among the Scenarios are not likely to be materially changed.

5.3.4 Factoring in Productivity Gains into the Modelling

In modelling ITE Scenarios 1 and 2, there was 1% per annum productivity gain from effort creep. The "rush to fish" behaviour typical of input controlled fisheries also was simulated for these two scenarios and Scenario 1a. No allowance was made for effort creep or the "rush to fish" behaviour in the modelling of the alternatives with limitation on annual catch, that is, the Scenario 3 and Scenario 4 alternatives.

The pot designed changes specified for Scenario 3 options of a 50% increase in pot volume and three necks would improve 'catchability' by 15 per cent. Similarly, under Scenario 4, the allowable pot design changes would improve 'catchability' by 40 per cent.

The management rules specified for Scenario 4 alternatives placed no limit on pot number. Whilst theoretically there is no constraint on the pot numbers that could be used on a boat under this Scenario, the actual number of pots will reflect the physical carrying capacity of the boat, as well as safety and economic considerations and these will ultimately determine the actual pot numbers/boat.

In order to model the Scenario 4 options, we needed to make an assumption about what might happen to pot numbers on our 'representative' boat. The New Zealand experience, where a similar rule applies, indicates that there has not been a dramatic increase in pot numbers/boat. Therefore, for modelling purposes for the ITQ scenarios we have assumed that the pot numbers on our representative boat would increase by 20 percent in the longer term steady state analysis.

5.3.5 Factoring in Input Costs

5.3.5.1 Fishery Management Costs

For modelling purposes, we assumed the access fees expressed on pot used basis for Scenarios 1, 1a and 2, remained unchanged over the ten-year period. The existing access fees were expressed on quota equivalent basis and then adjusted for increased management costs under the seasonal catch controlled Scenarios 3 and 4, which were then held constant over the steady state ten-year period.

5.3.5.2 Opportunity Cost of Invested Capital

Asset values (excluding licensed pot values but including the true cost of a pot, including the rope and floats) were based on the replacement value of the particular asset of an equivalent age. The opportunity cost of this invested capital is incorporated into the modelling. This is taken to be the return that that capital might otherwise achieve in alternative investments. For modelling purposes, a long-term rate of 7% was used as a reflection of the opportunity cost of invested capital.

5.3.5.3 General Cost Increases

No allowance was factored into the model for other general cost changes over time. Indeed, it would have been inappropriate to predict what might happen to future input costs for the purposes of this modelling exercise. This modelling is making a comparison between management alternatives for the fishery on a sound and consistent basis as a snapshot in time. In any event, even if input price changes were factored into the model, it will simply change the amount of the net benefits for all of the scenarios, but, more importantly, will not materially alter the relative results among the scenarios.

5.3.5.4 Other Input Cost Changes among Alternative Management Options

There are extra costs factored into the modelling for operating in an extended season. This extra cost is assumed to be $7,200 (see Section 3.3, Table 3.2) for our representative boat and applied to all management options where the management rules allow for an extended season.

In the case of the ITQ (Scenario 4) options, there are reduced costs factored into the model. This is because there is greater freedom for the operator of the representative boat to use all inputs (including pot numbers and pot designs) more cost efficiently. The reduced input cost for the representative boat under the ITQ options is assumed to be $5.000. This reduced cost, when taken into account with the extra cost of operating in the extended season, means that relative to the base case, the net input cost increase for our representative boat operating under the pure ITQ options is $2,200 (see Section 3.3, Table 3.2).

5.4 A 20% Pot Reduction Option, the Underlying Assumptions

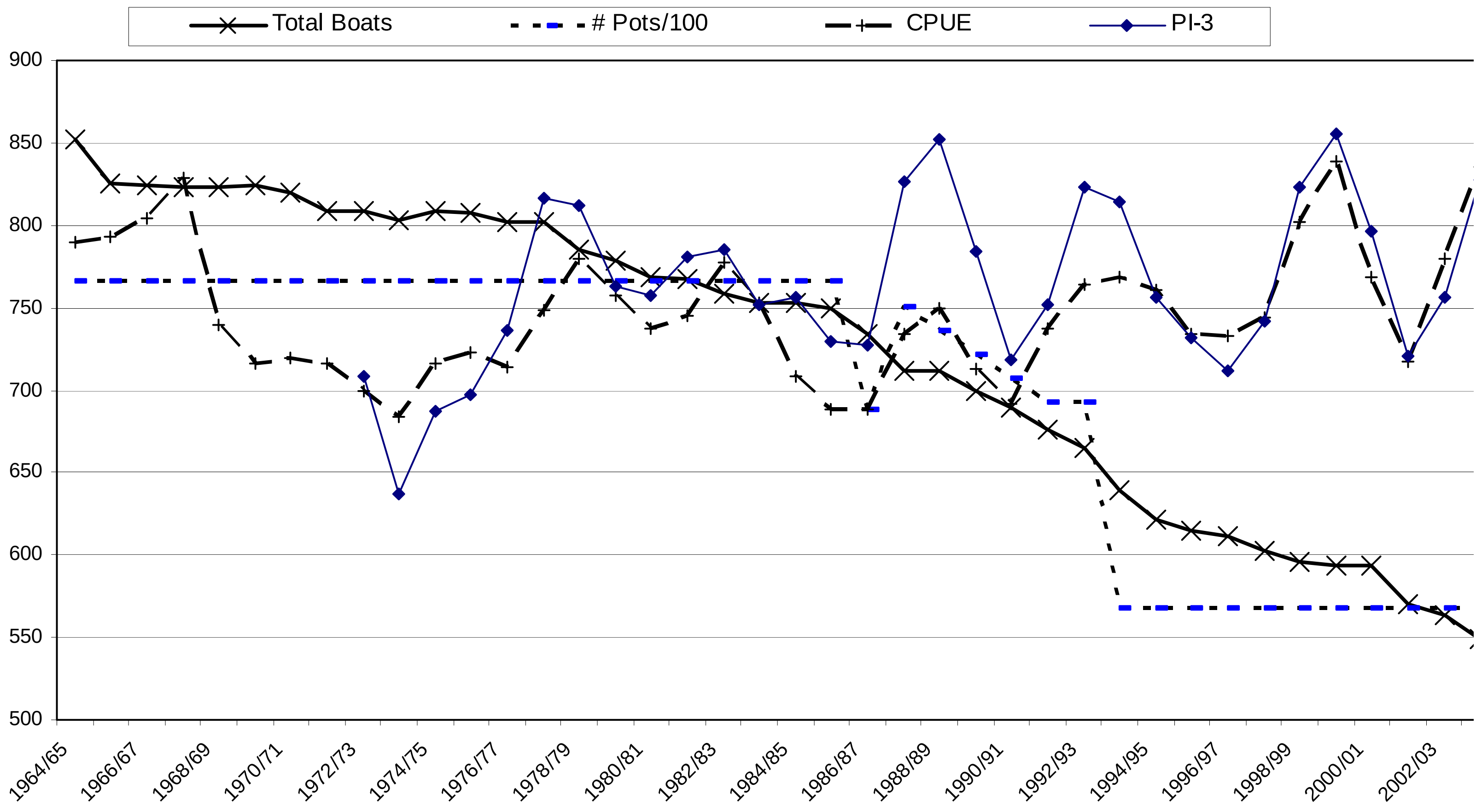
After presenting the modelling results for the management options covered by the original brief, we were subsequently asked by the Fisheries Department on behalf of the Project Steering Committee to model an ‘upfront’ 20 percent pot reduction option under the existing management regime operating in the fishery. This option, which is referred to as Scenario 1a in the report, is characteristic of the existing regime, where, in the interest of resource sustainability, effort reductions typically occur over time in response to fishing effort increases from technological creep among fishing operations. The modelling results presented in Chapter 6 relating to stocks highlight such an outcome for Scenario 1.

In order to model a 20% pot reduction option, assumptions needed to be made about how certain key variables might change following the pot reduction. These assumptions were developed in consultation with the Fisheries Department. The key variables related to catchability coefficients over time, catch rates, boat numbers, pots/boat, extra business costs arising from fishing with reduced pot numbers, etc. as a basis for modelling what might happen under this option over a ten-year period.

To do this we relied on statistical analysis of past data to provide insights into what might be reasonable assumptions about how these key variables change in response to a pot reduction. Data on how these key variables have changed in the past are presented in Figure 5.1.

In interpreting these past data it is important to recognise that, apart from pot reductions, there were other forces at work over the period that also impacted on these key variables. This is graphically illustrated in Figure 5.1 below where boat numbers declined significantly over the period 1964-65 to 1986-87 when pot numbers were stable. In order to come to some ‘evidence-based’ assumptions about these variable, we relied on statistical analytical techniques to try as best we could to separate how these variables were likely to change in response to a pot reduction as opposed to changes taking place in those variables in response to these other forces.

Figure 5-1: Changes in Key Variables-1964-65 to 2003-2004



5.4.1.1 Boat Numbers and Pots/Boat

For instance, a statistical analysis of past data indicates that, whilst pot reductions are statistically significant in explaining the reduction in boat number (i.e. fleet rationalisation), forces other than pot reductions were also statistically significant in explaining this rationalisation. Our ‘best fit’ regression model “predicts” that the fleet would reduce from 547 boats in 2003-04 to 467 boats by 2013-14 if there were no pot reductions, but boat numbers would reduce from 547 in 2003-04 to 444 by 2013-14 if there were a 20 percent pot reduction. Hence, a 20 percent pot reduction would drive an extra 23 boats out of the industry over a ten-year period compared to what would have occurred without the pot reduction..

In modelling terms, this is an equivalent impact to an annual percentage reduction in boat numbers of 1.5 percent in Scenario 1a compared to the 1 percent applied in Scenario 1. The 1.5% was factored into the modelling was factored into the modelling of Scenario 1a on this basis (see Section3.3, Table 3.2). Pots/boat was then derived accordingly.

5.4.1.2 Other Assumptions

The other key assumptions related to catchability, effort creep and extra costs for Scenario 1a. Catchabilty was assumed to be 10 per cent higher than for Scenario 1(the base case) to reflect less competition for prime fishing locations due fewer pots. It also was assumed that technological creep would be faster at 2 per cent per annum because of the greater scarcity of pots.

There are typically extra business costs because of significantly reduced pot numbers. These reflect not only the additional gear but the other extra costs, including additional time taken in placing pots to better target lobster. These extra business costs were assumed to be $5,000/season (see Section 3.3, Table 3.2).

There may be an increased pot values and extra capital outlays and finance costs for those firms which adjust pot holdings towards the pre-pot reduction status, but these outlays or extra finance costs are not built into the model. These pot values reflect the expected future profits or the cost of borrowing as part of future surpluses. To include such capital outlays or finance costs on such extra pot acquisitions would amount to double counting.

It was also assumed that the costs of managing the fishery would be broadly the same as under Scenarios 1 and 2.

5.5 Presentation of Modelling Results

The comparative modelling results for each of the fishing zones and the aggregate results for the fishery are given in Chapter 6.

6 Modelling Results for Fishery Zones

There were three broad management approaches and the twelve alternative management scenarios modelled were simply variations in one form or another of one of these broad approaches.

The first group were the input or effort controlled (ITE) scenarios. These consisted of the existing management rules (Scenario 1) and a variant of the existing system in the form of a 20 per cent pot reduction (Scenario 1a). The other reflected a modified more flexible ITE management system based on pot/fishing days with an extended fishing season that provided for greater flexibility around the choice of when to fish (Scenario 2).

The second grouping included management scenarios that coupled catch quotas with the controls over pot numbers but with some flexibility in pot design leading to a modest improvement in pot efficiency. The alternative scenarios under this grouping reflected either fixed (Scenario 3a) or variable (Scenarios 3b, 3c, and 3d) TACC and various alternative assumptions regarding sustainability rules used for the determination of catch quotas. The basis for operating quota in Zones A and B, and marketing price premium assumptions also varied.

The final grouping consisted of pure catch quota scenarios where there were no controls over pot numbers and more flexible pot design. The alternative options under this grouping reflected either fixed (Scenarios 4a) or variable (Scenarios 4b, 4c, and 4d) ITQ and various alternative assumptions around sustainability rules used for the determination of catch quotas. Again the basis for operating quota in Zones A and B, and marketing price premium assumptions also varied.

6.1 Interpreting the Comparative Modelling Results

The model used maximises profit. It does this by choosing best combination across all inputs that maximizes the surplus subject to the various constraints specified..

In the case of the pure ITQ scenarios the model is allowed to choose the best combination across all inputs because there is no constraint on pot numbers and provision to use more efficient pot designs. In this case, the optimal solution can be expected to continue in longer term steady state without change, because all variables have been freely adjusted in the optimization. A change to the optimal solution would have to come from some shock external to the industry, such as a change in world prices.

On the other hand, in the case of the input controlled options, the model is not allowed to optimize across all inputs because of the constraints built into the model which include controls over pot numbers, fishing days, pot lifts and/or pot design. In these instances, the management rules are generally in a constant state of change over time because changes in fishing behaviour and practices in response to the management changes put pressure into the industry for further changes.. Such management options seldom reach a long term steady state and generally operate in climate of disequilibrium, as is observed when controlled pot numbers have to be periodically reduced.

These fundamental differences between the alternative management options need to be kept in mind when comparing and interpreting the modelling results.

6.2 Iterative Evaluation Process

The assessment of scenarios was an iterative process where, in the light of modelling results, variants to particular scenarios were developed, considered and then modelled. This process was designed to deal with a range of issues but in particular to deal with biological risks, fine tuning operational rules for quotas within Zones A and B, and with varying views of the potential marketing price premiums. The objective was to provide a representative cross section of possible management scenarios within the context of the broad management strategies outlined in the original brief.

The outcome of this evaluation process, which involved feedback from the Project Steering Committee and the Department of Fisheries was an increasing focus on four options that were seen to be the most realistic for industry to consider. The key to these four was keeping the biological risks within "acceptable" limits from a fishery management perspective and taking a modest view of the potential for marketing price premiums. These options were:

- The base case (Scenario 1) refecting the existing system, with the alternatives being,
- a 20 per cent pot reduction option (Scenario 1a), and
- variable TACC and variable ITQscenarios with a conservatively set catch quota and a modest marketing price premium assumption (Scenarios 3d and 4d).

Whilst the comparative modelling results for these four management scenarios are the focus of the presentation in this Chapter, the comparative results for the other alternative scenarios that were modelled are given in Appendix 13.

These include the more flexible ITE pot/fishing days (Scenario 2) that was specified in the original brief. Scenario 2 was the subject of detailed analysis, and, on reviewing the modelling results (which are detailed in Appendix 13), the Project Steering Committee saw this alternative as not being practical or worthy of being the focus of industry consideration. This is because the net benefit outcomes are totally attributable to uncertain marketing price premiums for an extended season and, in the event that this 'extended season' marketing price premium were not realized, the chances are the industry could be worse off, facing with the prospects of efficiency losses.

6.3 Presentation of the Modelling Results

The key comparative results by fishing zone and the fishery in aggregate for each of these four scenarios over a ten-year period are presented in this Chapter. These relate to:

- Biomass
- Annual Catch
- Annual Number of Representative Boats
- Annual Number of Days Fished
- Annual Number of Pot lifts
- Average Annual Net Economic Benefits

Crew numbers are not shown in the comparative results below because employment is not an output of the model. Employment is derived from the number of representative boats for each zone where each boat has three crew members (i.e. a skipper and two deckhands).

The changes in the aggregate number of representative boats and pot lift/boat for each zone under each alternative management scenario provides an indicative guide to the possible employment impact differences. Skipper numbers are dependent on boat numbers in the fleet, whilst deck hand numbers are largely determined by pot numbers and pot lifts. These social aspects are discussed in Chapter 7.

6.4 Zone C Results

6.4.1 Stocks – Breeder Biomass Index

Table 6-1 shows comparative results for the breeder biomass index under each of the four alternative management scenarios at the end of each year over a ten-year, period. The variables that explain the differences between the alternative management scenarios are how and when the catch is taken and stock abundance.

The X-marked horizontal line in Figure 6-1 represents the closing stock in Year 0 that is the opening stock for the ten-year period. The Year 1 stock number is the outcome for first year with the biological model switched on and represents the closing stock at the end of Year 1. This Year1 closing stock can be below the opening stock for each of the Scenarios because fishers fished hard in Year 1.

The sustainability rule that is applied is whether closing stock at the end of the ten-year period (that is, the Year 10 closing stock) is at or above the opening stock at the beginning of the ten-year period (that is, the Year 0 closing stock).

The comparative results show that the closing stock in each year over the ten year period for the conservative variable TACC Scenario 3d and variable ITQ scenario 4d closely follow those of the Scenario 1 and remain within the existing biological parameters over the ten year period. The closing stocks at the end of Year 10 are marginally below the Year 1 and opening stocks for all three Scenarios

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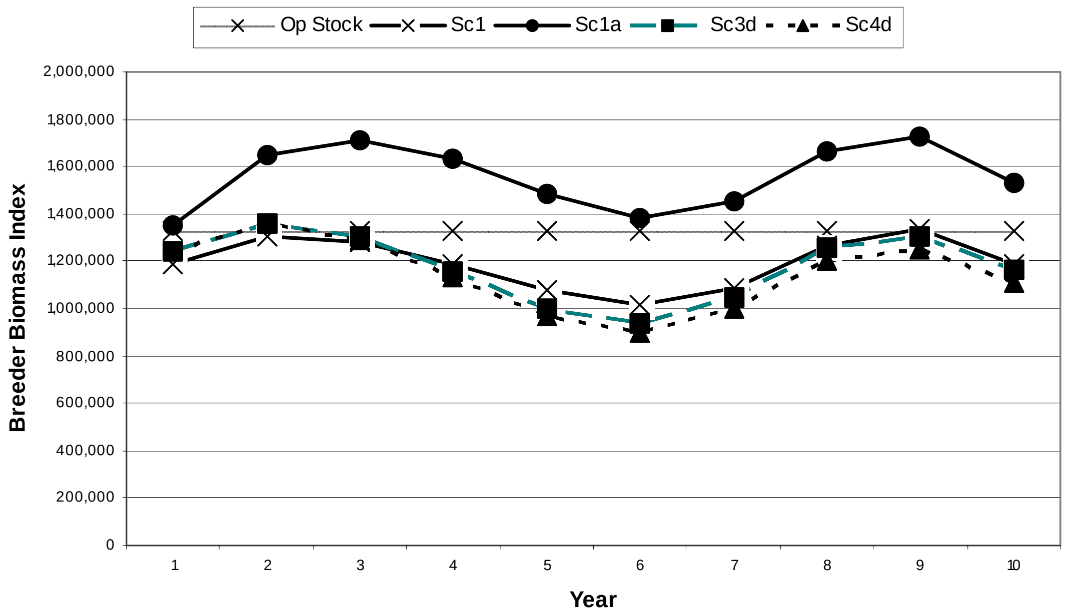

Figure 6-1 Zone C Breeder Biomass Index over the Steady State Ten-Year Period

Under the 20 per cent pot reduction Scenario1a, closing stocks for all Years over the ten year period are at or above the opening stock and the Year 10 closing stock is significantly above the opening stock at the beginning of the ten year period.

6.4.2 Annual Catch

Table 6-2 below reflects annual catch for each of the four alternative scenarios over the ten-year period. The falling annual catch up to year 5 in all or some of these years for each scenario is due to declining stock abundance.
The annual catch over the ten year period for the conservative variable TACC Scenario 3d and variable ITQ scenario 4d closely follow the annual catch pattern of Scenario1. The annual catch under the 20 per reduced pot Scenario 1a, whilst initially below that of Scenario 1, returns to the Scenario 1 pattern by Year 3.

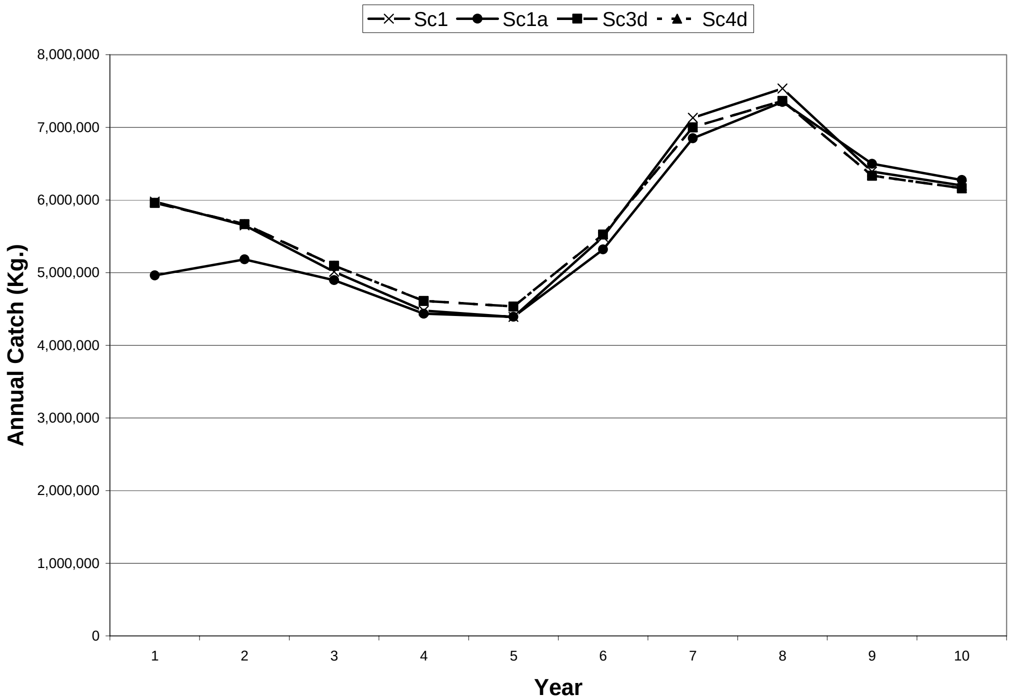

Figure 6-2: Zone C Annual Catch over the Ten-Year Period

6.4.3 Boats

Table 6-1 below shows the comparative results for the number of boats under each of four alternative scenarios. The boat numbers in these comparative results reflect the number of representative boats under each Scenario. This is a variable that is dependent on the number of fishing days, pot efficiency and pot lifts.

Table 6-1: Zone C Lobster Fleet

Reference Points	Boat Numbers	Reduction in Boat Numbers
10 Years Ago	322	
Current [1]	275	- 47
Closing Fleet at the End of the Ten year period: Scenario 1	260	-15 [2]
Scenario 1a	247	-28 [2]
Scenario 3d	260	-15 [2]
Scenario 4d	138	-137 [2]

Notes:
[1] The current boat numbers makes no allowance for the impact of removal of the 150-pot rule where adjustments to this rule change are still playing out within the industry.
[2] Compared to the current boat numbers

Representative boat numbers, whilst declining under all scenarios, do not fall dramatically under Scenarios 1, 1a and 3d over the ten-year period as they do under the variable ITQ Scenario 4d.
In the case of Scenario 4d, the model chooses fewer representative boat numbers to achieve the specified TACC under the optimizing solutions. The modelling results are simply saying that, in the long run steady state, around 138 representative boats are all that is required to achieve the specified TACC in the model. This outcome in Scenario 4d is result of unconstrained pot numbers and the use of more efficient pot design.

6.4.4 Days Fished

The comparative days fished results for each of the four management Scenarios is shown in Figure 6-3 below. Scenario 1 reflects the historical inter-seasonal pattern of days fished observed for the existing management arrangements with the pot reduction Scenario 1a following closely the pattern exhibited by Scenario1.
The higher number of days fished under conservative variable ITQ Scenario 4d compared to the conservative variable TACC Scenario 3d reflects the fewer boat numbers in Scenario 4d.

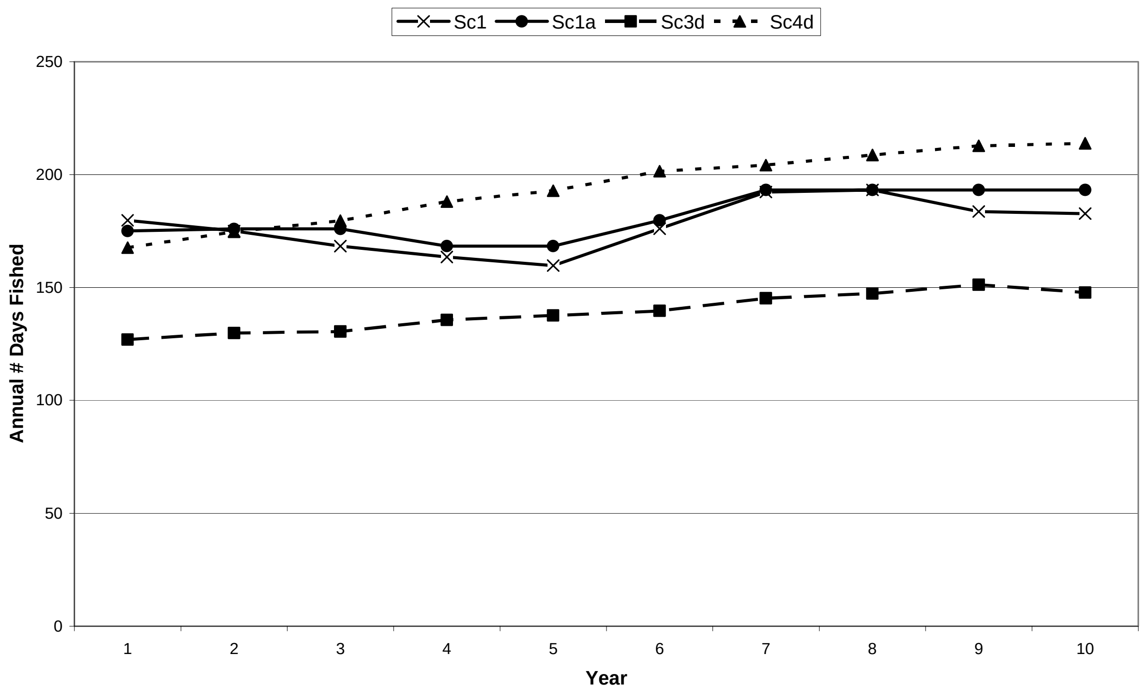

Figure 6-3: Zone C Annual Number of Days Fished Over the Steady State Ten-Year Period

6.4.5 Annual Pot Lifts

Figure 6-4 shows the aggregate number of annual pot lifts for each of the four management scenarios. Scenario 1 reflects the observed inter-seasonal pattern of pot lifts for a ten-year period under the existing management arrangements.

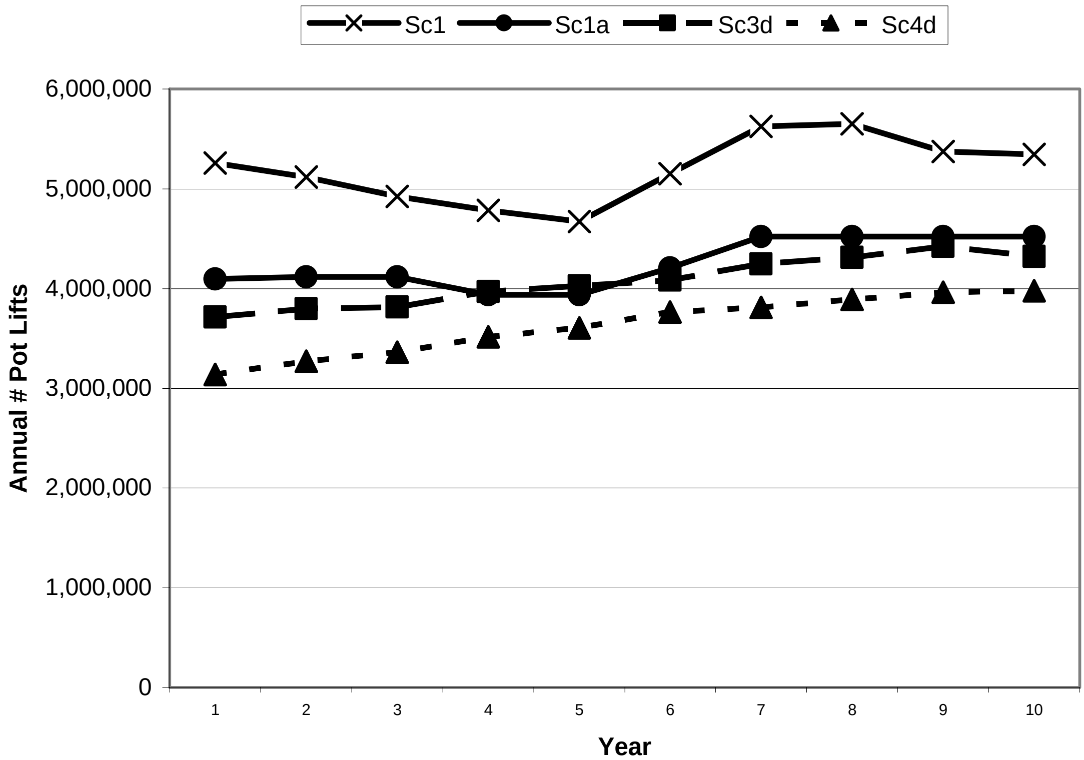

Figure 6-4: Zone C Annual Number of Pot Lifts Over the Ten-Year Period

The differences in annual pot lift numbers between Scenario 1 and Scenario 1a reflects the reduced pot numbers where pot lifts/day are constrained. Under both of these Scenarios, the' rush to fish' is switched on in the model
In the case of the two quota based Scenarios, the difference reflects the more efficient pot design and the lack of any constraint on pot numbers in Scenario 4d compared to Scenario 3d.

6.4.6 Annual Flow of Net Benefits

Figure 6-5 below shows the annual net economic benefits under each of the four alternative scenarios over the ten-year period. The flow of net benefits is higher for the two variable TACC and ITQ Scenarios compared to both Scenario 1 (the base case) and the 20%pot reduction scenario (Scenario1a). This outcome reflects the use of more efficient pot designs (Scenarios 3d and 4d) and removal of the constraint on pot numbers (Scenario 4d) which allows for greater fleet and capital rationalization.

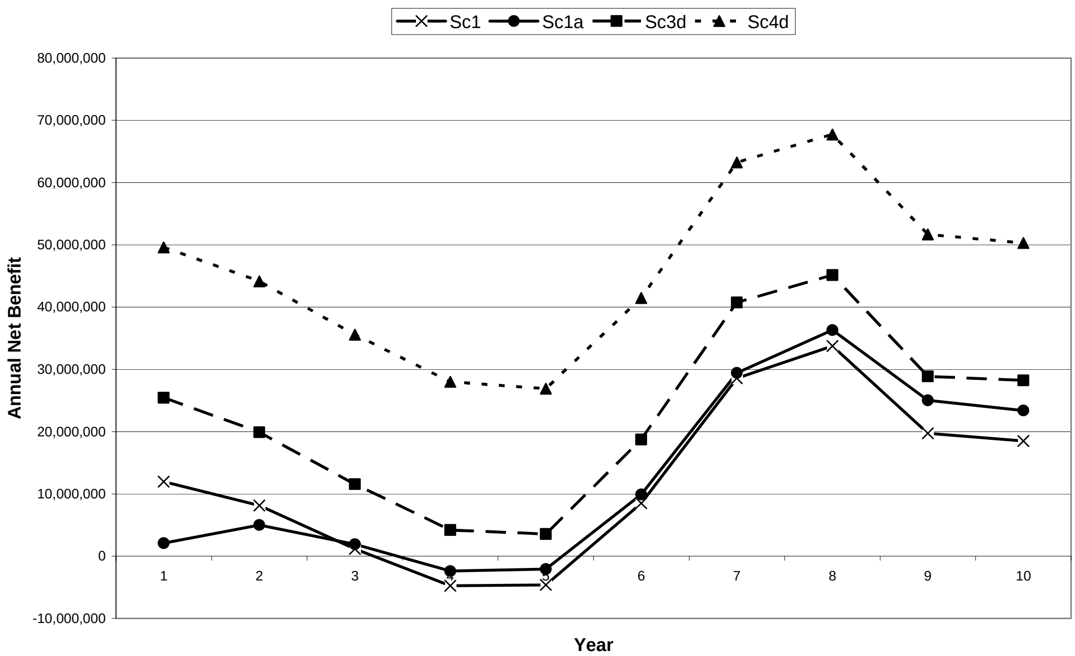

Figure 6-5 Zone C Annual Net Economic Benefits Over the Ten-Year Period

As shown in Appendix 13, the flow of net benefits is not greatly higher for these variable TACC options under the larger marketing price premium assumptions.
The net present values (NPV) of the flow of annual net benefits for each of the alternative scenarios have not been calculated. The outcome depends on where Year 1 starts. The NPV could be different over a ten-year period depending on whether, for instance, Year 1 commenced in a high or low stock abundant year.

6.4.7 Average Annual Net Benefit over the Ten-Year Period

Figure 6-6 shows the comparative results of the average annual net benefits over the ten-year period for each of the four management scenarios.

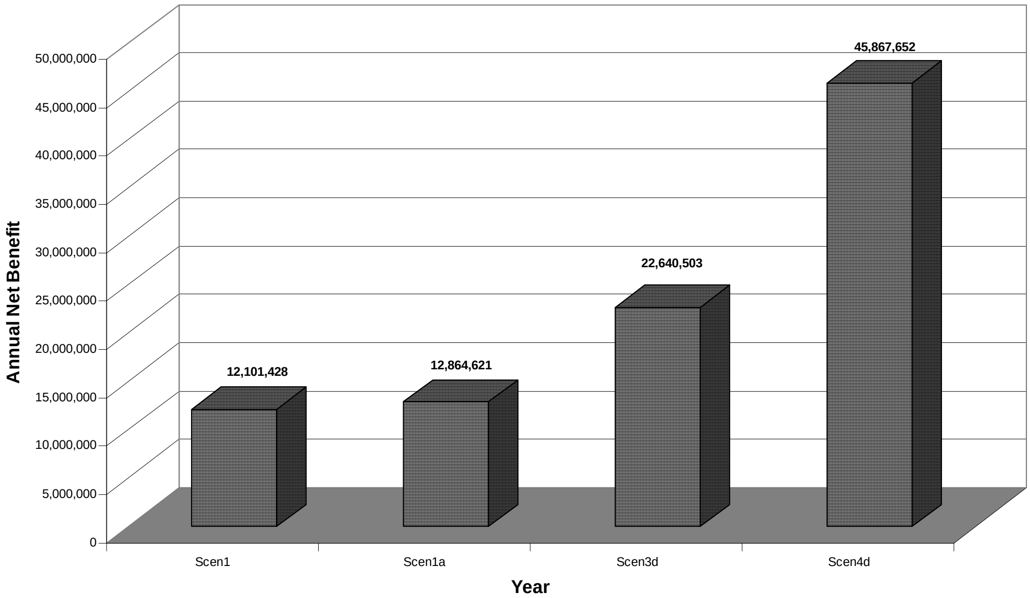

Figure 6-6: Zone C Average Annual Net Benefits over the Steady State Ten-Year Period

The reasons for the higher average annual net benefits of the alternative management options compared to the Scenario 1 base case (which includes a productivity gain from technological creep of 1 per cent/annum over the ten-year period) are explained by efficiency gains and pricing differentials built into the model for each of these alternative management Scenarios (see Section 3.3, Table 3.2).
The extent to which marketing price premiums and efficiency gains explain the differences in net benefits of the alternatives Scenarios is outlined in the aggregate fishery results shown in Section 6.8 below.

6.5 Zone B Results

6.5.1 Stocks – Breeder Biomass Index

Figure 6-7 below shows comparative results for the breeder biomass index for each of the four alternative management scenarios over a ten-year, period. The variables that explain the differences between the alternative management scenarios are how and when the catch is taken and stock abundance.
The X-marked horizontal line in Figure 6-7 represents the closing stock in Year 0 that is the opening stock for the steady state ten-year period. The Year 1 stock number is the outcome for the first year with the biological model switched on and represents the closing stock at the end of Year 1. This Year 1 closing stock can be below the opening stock for each of the Scenarios because fishers fished hard in Year 1.
The sustainability rule that is applied is whether closing stock at the end of the ten-year period (that is, the Year 10 closing stock) is at or above the opening stock at the beginning of the ten-year period (that is, the Year 0 closing stock).

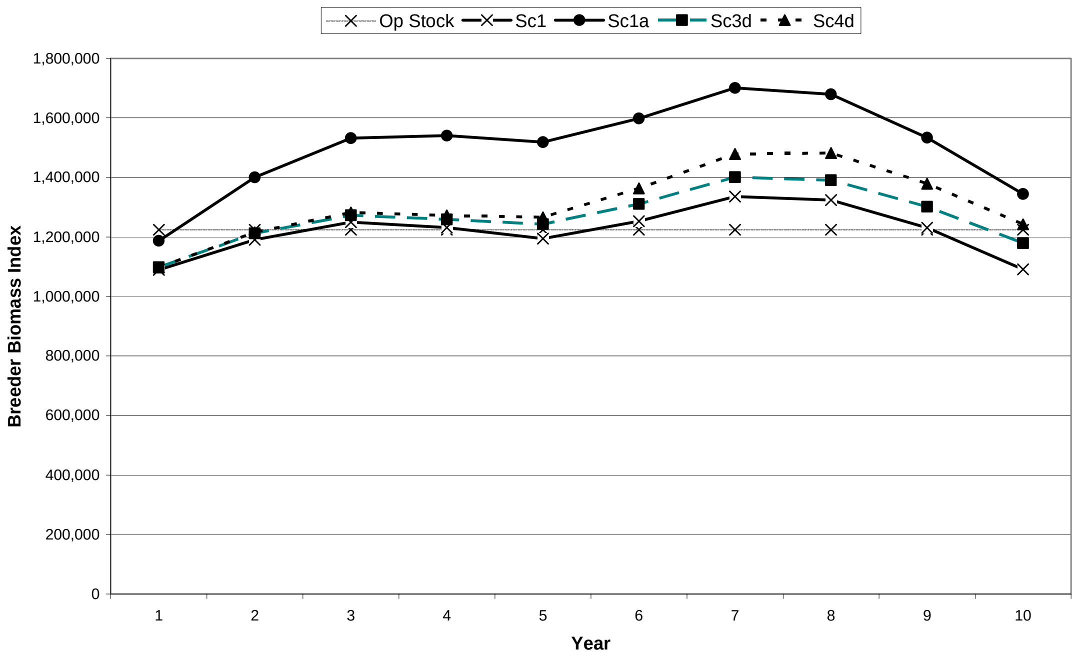

Figure 6-7: Zone B Breeder Biomass Index over the Ten-Year Period

The comparative results show that the closing stocks at the end of the ten-year period are at or above the opening stocks at the beginning of the period for these management Scenarios, except Scenario1. This is particularly the case for Scenario 1a where closing stocks are significantly above opening stocks at the end of the ten year period.

In the case of Scenario1, the closing stocks are on a par with the closing stocks at the end of year1, and, during the intervening years, the closing stocks are at or above the opening stock. This suggests that biological risks remain marginally within the stock sustainability parameters.

6.5.2 Annual Catch

Figure 6-8 below reflects annual catch for each of the four alternative scenarios over the ten-year period. The annual catch over the ten year period for the conservative variable TACC Scenario 3d and variable ITQ scenario 4d closely follow the annual catch pattern of Scenario1. The annual catch under the 20 per reduced pot Scenario 1a, whilst initially below that of Scenario 1, returns to the Scenario 1 pattern by Year 4.

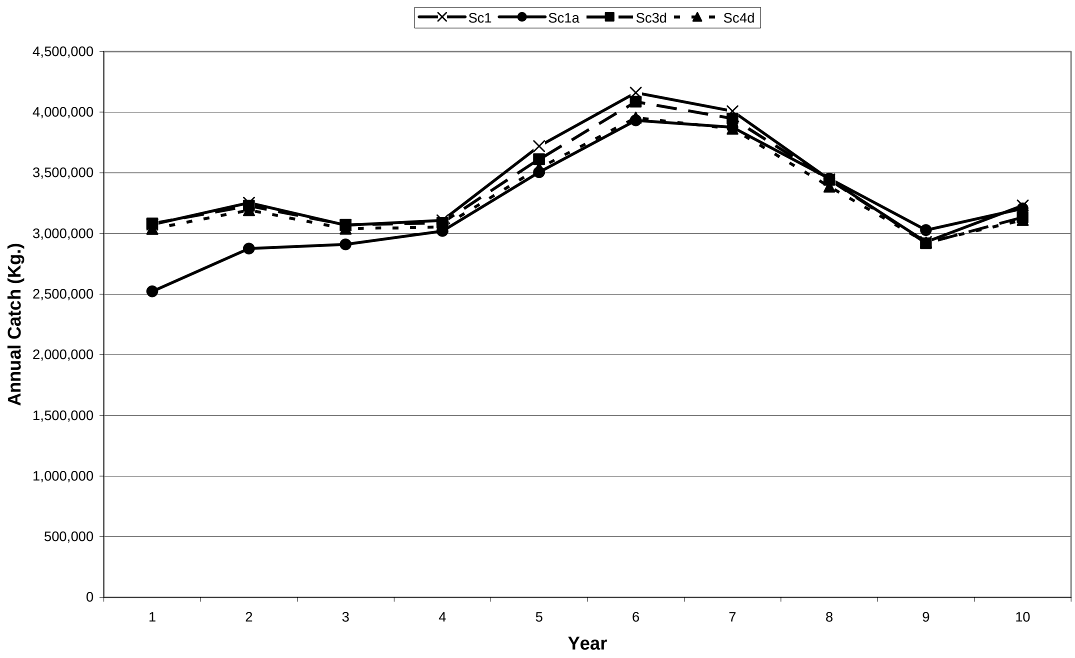

Figure 6-8: Zone B Annual Catch over the Ten-Year Period

6.5.3 Boats –Zone B

Table 6-2 below shows the comparative results for number of boats for each of the four alternative management scenarios over the ten-year period. The boat numbers in these comparative results reflect the number of representative boat under each Scenario. This is a variable that is dependent on the number of fishing days, pot efficiency and pot lifts.

Table 6-2: Zone B Lobster Fleet

Reference Points	Boats Numbers	Reduction in Boat Numbers
10 Years Ago	164	
Current [1]	136	- 28
Closing Fleet at the End of the Ten year period: Scenario 1	121	- 15 [2]
Scenario 1a	115	-21 [2]
Scenario 3d	121	-15 [2]
Scenario 4d	58	-81 [2]

Notes:
[1] The current boat numbers makes no allowance for the impact of removal of the 150-pot rule where adjustments to this rule change are still taking place within the industry.
[2] Compared to the current boat numbers

Boat numbers, whilst declining under all four scenarios, do not fall as much under Scenarios 1, 1a and 3d over the ten-year period as they do under the variable ITQ Scenario 4d.

In the case of Scenario 4d, the model chooses fewer representative boat numbers to achieve the specified TACC under the optimizing solutions. The modelling results are simply saying that, in the long run steady state, around 58 representative boats are all that is required to achieve the specified TACC in the model. This outcome in Scenario 4d is result of unconstrained pot numbers and the use of more efficient pot design.

6.5.4 Days Fished

The comparative days fished for each of the four alternative management Scenarios is shown in Figure 6-9. Scenario 1 reflects the historical inter-seasonal pattern of days fished observed for the existing management arrangements. The pot reduction Scenario 1a broadly follows the pattern exhibited by Scenario1.

The higher number of days fished under variable ITQ scenario S 4d compared to the conservative variable TACC Scenario 3d reflects the fewer boat numbers in 4d.

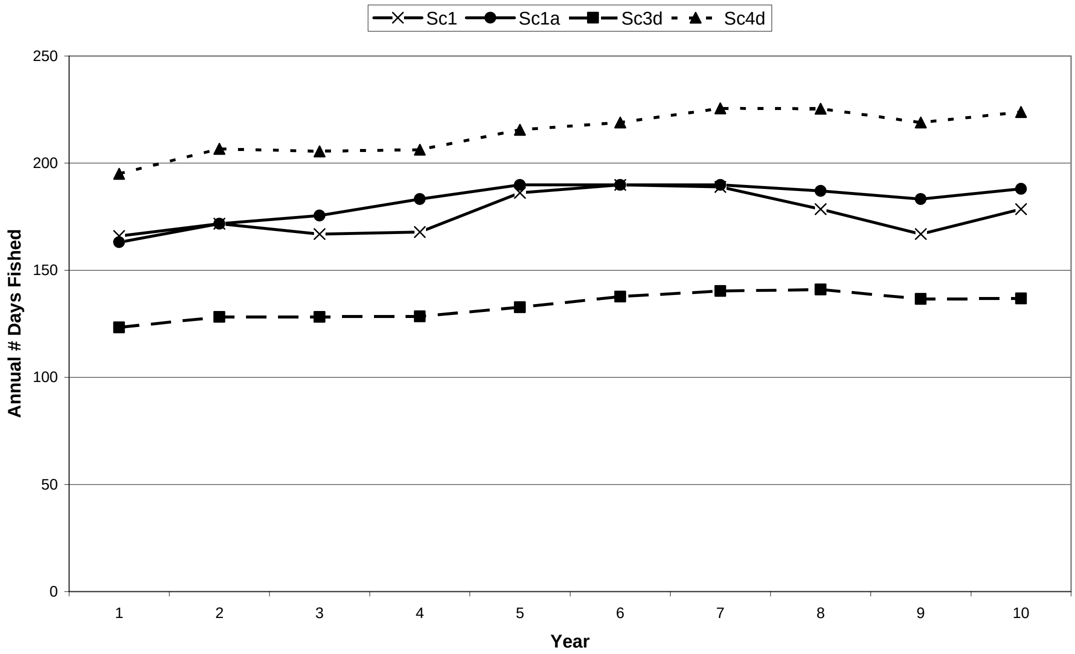

Figure 6-9: Zone B Annual Number of Days Fished over the Ten-Year Period

6.5.5 Pot Lifts

Figure 6-10 shows the aggregate number of annual pot lifts for each of the four management scenarios. Scenario 1 reflects the observed inter-seasonal pattern of pot lifts for a ten-year period under the existing management arrangements. In the case of Scenario 1a, the reduced number of pot lifts reflects the reduced pot numbers where pot lifts/day is constrained. Under both Scenarios, the' rush to fish' is switched on in the model.

The differences in annual pot lift numbers between the catch controlled Scenarios 3d and 4d reflects the more efficient pot design and the lack of any constraint on pot numbers in Scenario 4d compared to Scenario 3d.

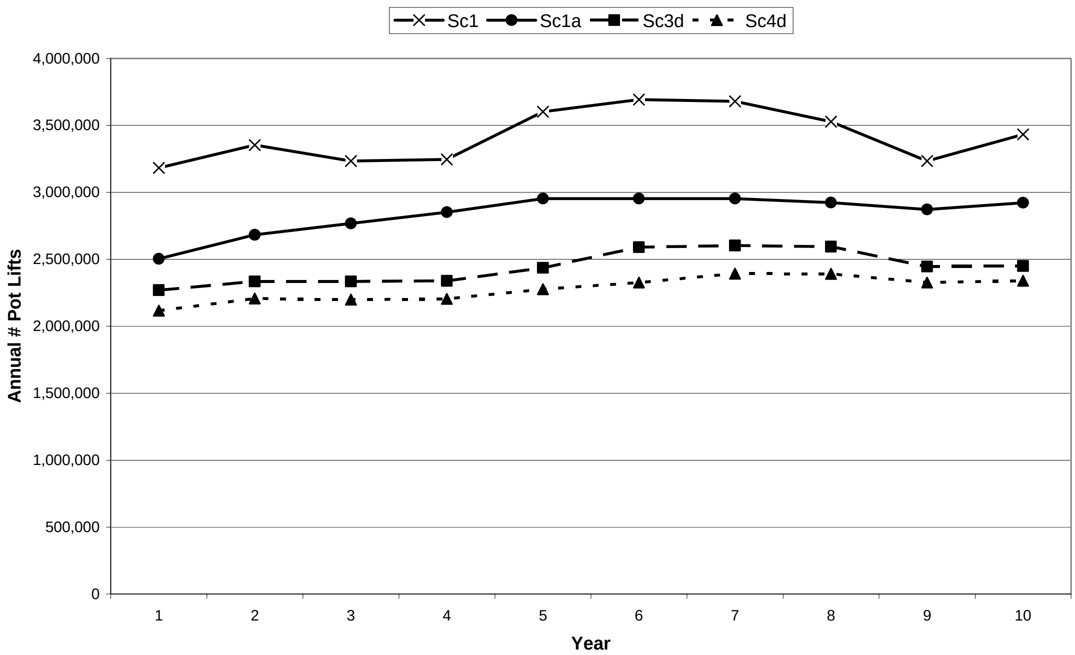

Figure 6-10: Zone B Annual Number of Pot Lifts over the Ten-Year Period

6.5.6 Net Benefits

The Zone B net benefits are combined with Zone A. This is because boats with a Zone A authorizations are entitled to fish in Zone B up until the 14 March, and the Islands fishing season commences on 15 March. The fixed costs of Zone A operators cannot be easily split between the Zone A and Zone B activities, except by using an arbitrary rule. In these circumstances, a combined Zone A/B optimization outcome was a more plausible approach.

The combined Zone A/B results are shown separately below.

6.6 Zone A Results

6.6.1 Stocks – Breeder Biomass Index

Figure 6-11 below shows comparative results for the breeder biomass index under each of the alternative management scenarios over a ten-year, period. The breeder biomass in Zone A is very sensitive to the management scenarios. This is only of concern if the biology of Zone A is independent and self-contained. In Zone A the breeder biomass has been modelled as independent but not self-contained.

The X-marked horizontal line in Figure 6-11 represents the closing stock in Year 0 that is the opening stock for the steady state ten-year period. The Year 1 stock numbers for each of the Scenarios are the outcomes for first year with the biological component of the model is switched on and represents the closing stock at the end of Year 1. The Year1 closing stocks for each of the Scenarios can fall below or rise above the opening stock for each of the Scenarios because fishers fished either harder or less intensively under that Scenario in Year 1.

The sustainability rule that is applied is whether closing stock at the end of the ten-year period (that is, the Year 10 closing stock) is at or above the opening stock at the beginning of the ten-year period (that is, the Year 0 closing stock).

The comparative results show that the closing stocks at the end of the ten-year period are below the opening stocks at the beginning of the period for all management scenarios. The fall and rise in breeder biomass during the ten-year period reflect respectively low and high abundance periods.

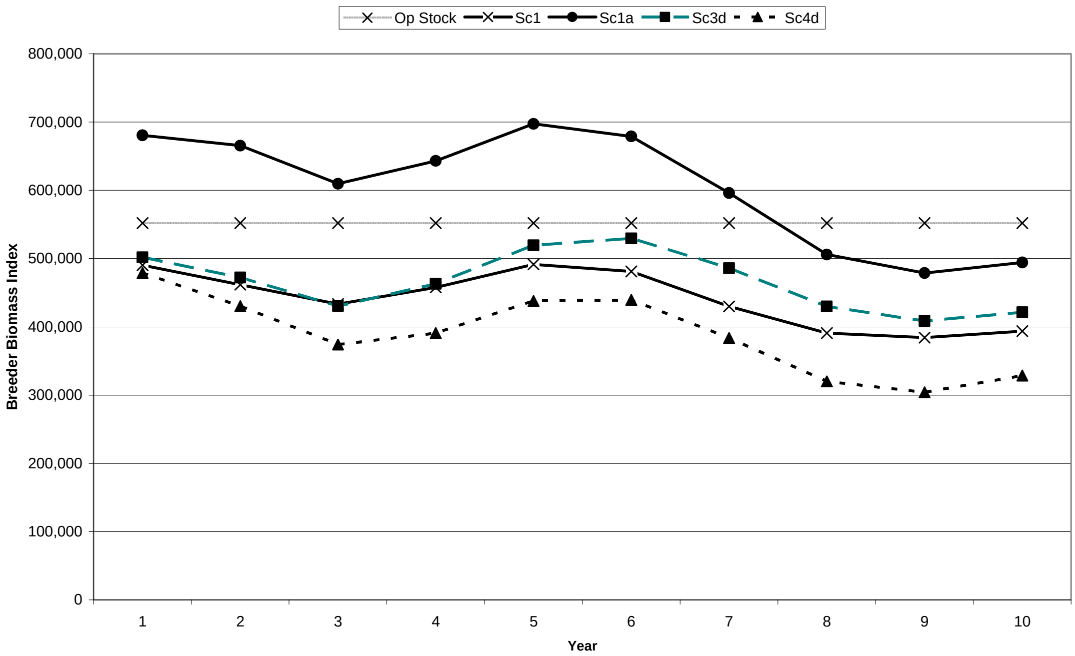

Figure 6-11: Zone A Breeder Biomass Index over the Ten-Year Period

The closing stock pattern over the ten-year period for Scenarios1a and 3d options is at or above those for Scenario1 and the closing stock under these Scenarios, whilst lower than the opening stocks at the beginning of the period, are above the Scenario1 closing stock, especially in the case of Scenario1a.
Under the variable ITQ Scenario 4d, there is a significant run down in stock over the ten year period.

6.6.2 Annual Catch

Figure 6-12 below reflects annual catch for each of the four alternative scenarios over the ten-year period, which does not differ greatly among the Scenarios, largely reflecting the relatively stable year-to-year catch pattern exhibited in this Zone in the past. The annual catch under the 20 per reduced pot Scenario 1a, whilst initially below that of Scenario 1, returns to the Scenario 1 pattern by Year 3.

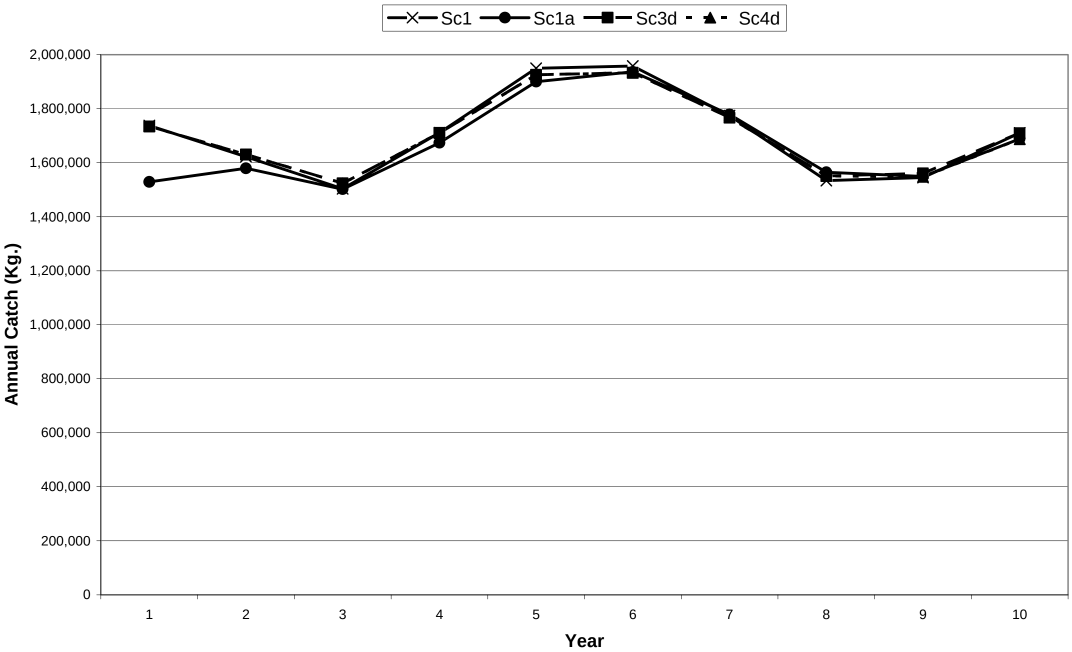

Figure 6-12: Zone A Annual Catch over the Ten-Year Period

6.6.3 Boats-Zone A

Table 6-3 below shows the comparative results for number of boats under each of the four alternative scenarios over the ten-year period. The boat numbers in these comparative results reflect the number of representative boats for each zone in the fishery. This is a variable that is dependent on the number of fishing days, pot efficiency and pot lifts.

Table 6-3: Zone A Lobster Fleet

Reference Points	Boat Numbers	Reduction in Boat Numbers
10 Years Ago	153	
Current [1]	138	- 47
Closing Fleet at the End of the Ten year Period: Scenario 1	124	- 15 [2]
Scenario 1a	118	- 20 [2]
Scenario 3d	124	-15 [2]
Scenario 4d	60	-78 [2]

Notes:
[1] The current boat numbers makes no allowance for the impact of removal of the 150-pot rule where adjustments to this rule change are still taking place within the industry.
[2] Compared to the current boat numbers

Boat numbers, whilst declining under all scenarios, do not fall dramatically under Scenarios 1, 1a and 3d over the ten-year period as they do under variable ITQ Scenario 4d.

In the case of Scenario 4d, the model chooses fewer representative boat numbers to achieve the specified TACC under the optimizing solutions. The modelling results are simply saying that, in the long run steady state, around 60 representative boats are all that is required to achieve the specified TACC in the model. This outcome in Scenario 4d is result of unconstrained pot numbers and the use of more efficient pot design.

6.6.4 Days Fished

The comparative days fished for each of the four alternative management Scenarios is shown in Figure 6-13. Scenario 1 reflects the historical inter-seasonal pattern of days fished observed for the existing management arrangements. The days fished for the pot reduction Scenario 1a broadly follow the pattern exhibited by Scenario1.
The higher number of days fished under variable ITQ Scenario 4d compared to the other conservative variable TACC Scenario 3d reflects the fewer boat numbers in Scenario 4d.

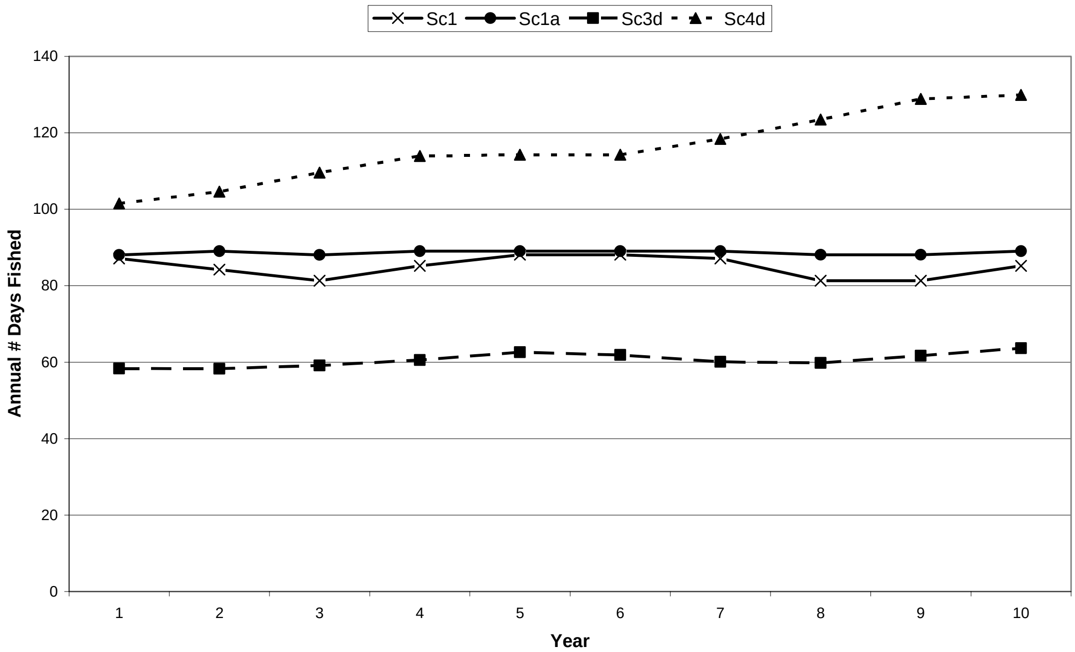

Figure 6-13: Zone A Annual Number of Days Fished over the Ten-Year Period

Scenario 4 options, where there are no constraints on pot numbers allow for greater fleet and capital rationalization. This means fishers will work their capital base harder over an extended season to achieve the seasonal catch limits.

6.6.5 Pot Lifts

Figure 6-14 shows the aggregate number of annual pot lifts for each of the four alternative management scenarios. Scenario 1 reflects the observed inter-seasonal pattern of pot lifts for a ten-year period under the existing management arrangements. In the case of Scenario 1a, the reduced number of pot lifts reflects the reduced pot numbers. Under both Scenarios, the' rush to fish' is switched on in the model.
The differences in annual pot lift numbers among the catch controlled Scenarios 3d and 4d reflects more efficient pot design and no constraint on pot numbers in Scenario 4d compared to Scenario 3d.

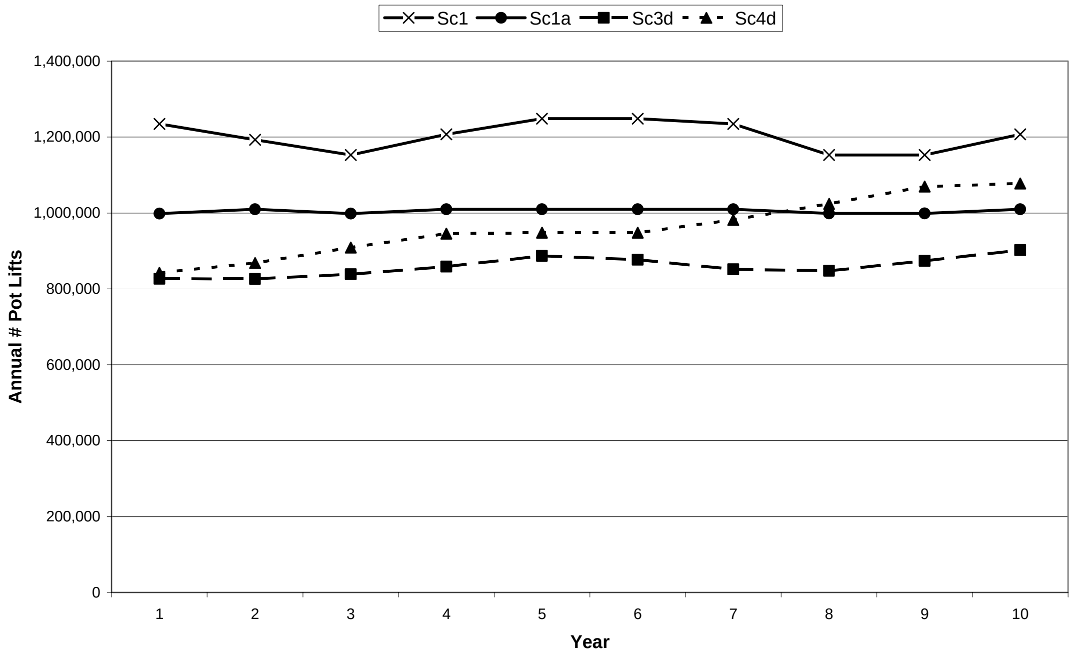

Figure 6-14: Zone A Annual Number of Pot Lifts over the Ten-Year Period

6.6.6 Net Benefits

The Zone A net benefits are combined with Zone B. This is because boats with a Zone A authorizations are entitled to fish in Zone B and usually do so up until the end of February, when they gear up for the commencement of Islands fishing season on 14 March. The fixed costs of Zone A operators cannot be easily split between the Zone A and Zone B activities except by using an arbitrary rule. In these circumstances, a combined Zone A/B optimization outcome was a more plausible approach. The combined Zone A/B results are shown separately below.

6.7 Combined Zones A/B Net Benefit Results

6.7.1 Annual Flow of Net Benefits

Figure 6-15 shows the comparative annual net benefits for combined Zones A/B for each of the four alternative management Scenarios over the ten-year period.