Out of the pot and into the money:
Managing the Western Rock Lobster Fishery by ITE's or ITQ's? *

Paul McLeod,
UWA Business School,
The University of Western Australia.
pmcleod@biz.uwa.edu.au

Bob Lindner,
School of Agricultural and Resource Economics,
Faculty of Natural and Agricultural Sciences,
The University of Western Australia.
blindner@fnas.uwa.edu.au

John Nicholls,
Economics Research Associates,
jnicholls@daa.com.au

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ABSTRACT

The West Coast Rock Lobster fishery is Australia's most valuable commercial fishery. Around 550 vessels harvest an average of 10,500 tonnes of lobster per annum. The industry has an enviable track record of biological management based on a variety of input controls, although three significant pot reduction interventions have been necessary in recent years. An evaluation of a range of possible future management regimes is reported in this paper. The results were derived from a purpose built bio-economic model three separate biological zones in the fishery using non linear optimization to produce ten year steady state solutions for alternative management options. Management options included the current pot control system, and versions of variable transferable catch quota. Key outputs for each scenario include: net economic benefits, breeder biomass index, annual catch, annual pot lifts, number of pots and vessel numbers. The results indicate significant potential net economic gains from moving away from the current input control regime. The range of scenarios modelled illustrated some of the tradeoffs between maximising net economic returns and minimizing biological risks, as well as quantifying the impact of changes such as improved pot design and extended fishing seasons. The results will inform consideration by the industry about a possible new management system.

Keywords: rock lobster, quotas, ITQs, Western Australia, bioeconomic, economic benefits.

INTRODUCTION

The West Coast Rock Lobster 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. Around 95 per cent of the catch is exported. Annual harvests average around 10,500 tonnes from 550 vessels. [i]

The fishery was the first fishery in Western Australia to be declared limited entry in March 1963, and has an enviable track record in terms of biological management. In 1999/2000, it was the first fishery in the world to be certified ecologically sustainable by the Marine Stewardship Council.

The fishery is divided into three geographical access or commercial fishing zones, A, B and C; and there is a limited harvest season from the 15th November to end of June. Pot numbers are restricted by zone, and pot licenses are tradable. Reliance on input controls in recent years has necessitated three significant pot reduction interventions, the last one of 18% occurred in 1993/94. Other minor adjustments happen quite frequently, such as moon closures that were imposed in the 2005/2006 season.

In recent years, the investment in effort creep that underpinned the need for pot reductions has coincided with rising input prices and more competitive world lobster markets. This has exposed the industry to greater financial pressure and increased interest by fishers and fisheries managers in ways to achieve increased industry wide efficiency and greater returns.

This paper reports the results of an evaluation of a range of possible future management options, including the use of transferable quota, that might improve industry efficiency and returns. Development of the model[ii] was based on extensive consultation with fishers and fisheries managers. The results will inform consideration by the industry about a possible new management system. The development of the model, and results obtained, are documented in McLeod et al [3] and McLeod et al [4]. Earlier analysis of the potential for the use of quota in the industry can be found in Lindner [2].

The alternative management options are being assessed against a backdrop of ongoing rationalization, as shown in Figure 1. Between 1964/65 and 2003/04, pot numbers have been reduced by management interventions from around 76,000 to around 56,000 in three adjustments. Vessel numbers have declined continuously from around 850 to around 550. Over the period average catch has not fallen. Fluctuations in catch per unit of effort closely mirror the Puerulus Index 3 years earlier (PI-3) which is the leading predictor of abundance. Effort measured as pot lifts per vessel has more than doubled over the period.

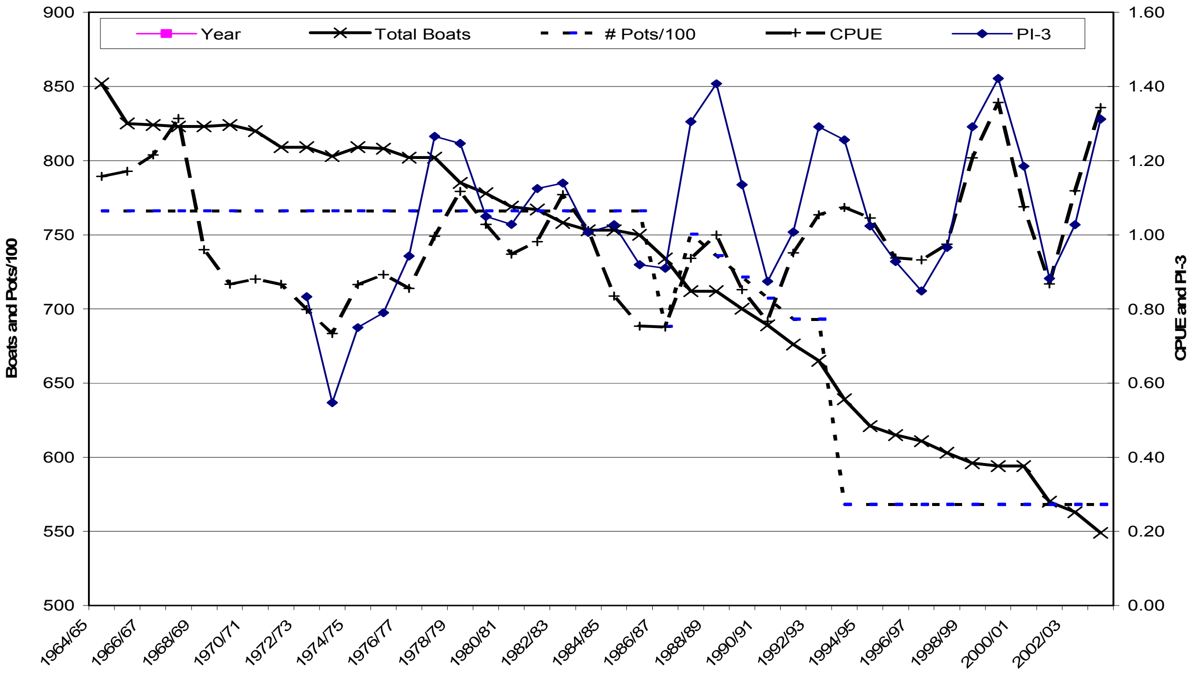


Figure 1: Overview of pattern of change in the industry

MODEL STRUCTURE AND DATA

The assessment of the alternative options used a bio-economic model comprised of:

- a biological simulation model with up to 3 "age" cohorts of lobster to simulate the population dynamics of the West Coast Rock Lobster Fishery in each of three separate zones; embedded within:-
- a non-linear mathematical programming model that optimised industry annual net economic benefits; embedded within:-
- a recursive algorithm that linked the biological population of one year to the next, and used a sequence of puerulus indices (PI) from the fishery to simulate recruitment variation over a ten year period[iii]

The objective function was to maximize the net economic return to the fishery. Economic optimization was carried out separately for Zone C, and jointly for Zones A and B combined because some vessels have licences to fish in both the A & B zones at different times of the year. Key decision variables for each of the ten years in the model included: vessel numbers, pot numbers, days fished by month, and pot lifts by month. The biological models for Zones A, B, and C are self contained, and include the following variables: available breeders, recruits and survivors by month and closing biomass for recruits, breeders and survivors. Aggregate and monthly catch are determined by the above variables as well as by model parameters, and can be constrained to simulate selected management options.

From a biological perspective, the model starts with given opening stocks, and then simulates recruits, survivors, and breeders on an annual basis. The model then optimizes annual net economic benefits for each year of the ten-year evaluation period. Closing stocks are transferred to the next year. 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.

The robustness of the biological models was evaluated using historical data over the period 1993/94 to 2003/04 using monthly catch data from the three zones. One measure of this robustness is the correlation between predicted and actual catches. This is shown in Figures 2 and 3. The model tracks actual catch well, with the R square between actual and fitted catch being very high at 0.93 for Zones A and B combined and 0.87 for zone C.

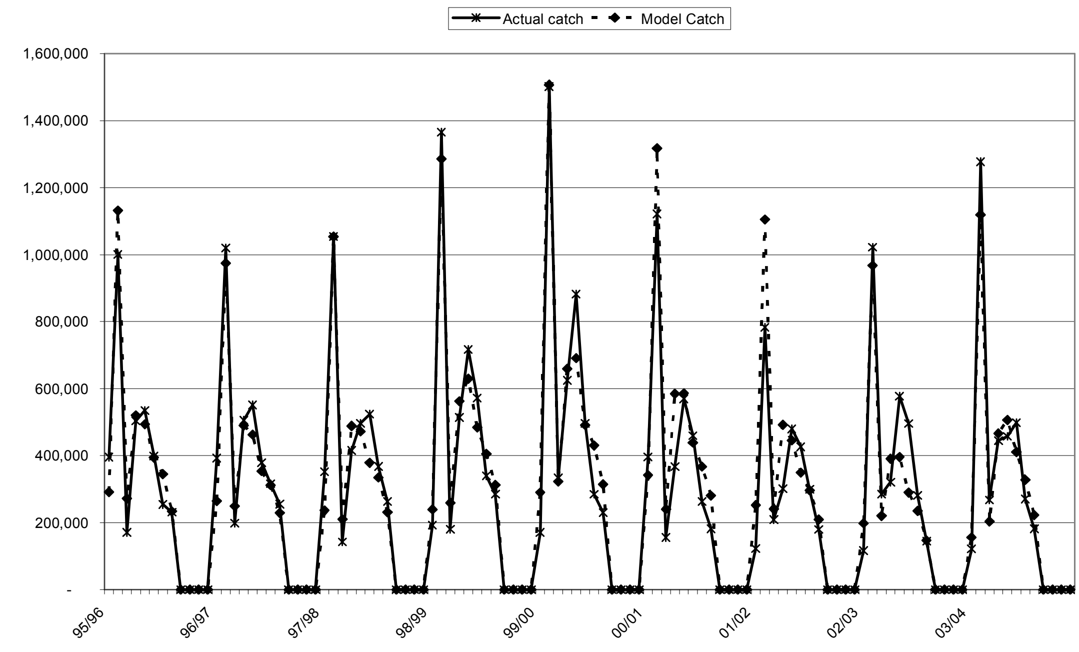


Figure 2. Catch validation of model using monthly catch for zone A,B.

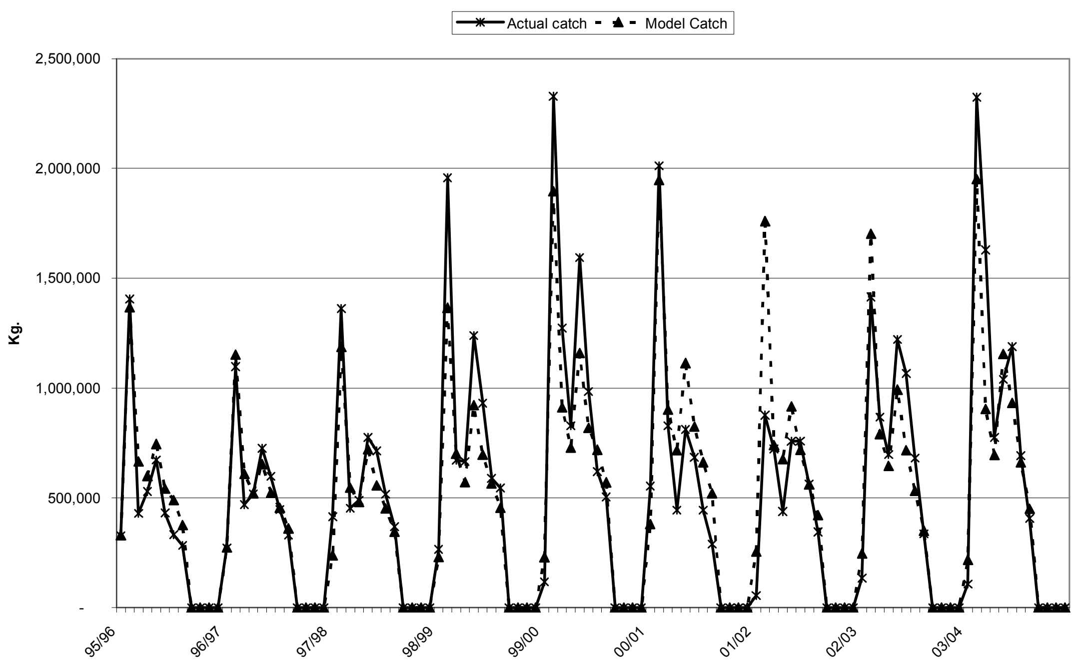


Figure 3. Catch validation of model using monthly catch for zone C.

The structure of the economic component of the model is based on the concept of a representative boat being the unit of production. Cost data was provided by fishers for a variety of vessels by zone, and this was used to construct a cost profile that was representative of boats operating in the fishery. The costs for the representative boat are different for each zone. In all three cases, the representative boat is crewed by a skipper and two deckhands.

MANAGEMENT OPTIONS

Management options in the model are defined by the selection of parameter values (e.g. monthly prices for lobster and monthly catchability coefficients) and by the specification of constraints (e.g. total allowable annual commercial catch (TACC), or a specified number of pots). The three broad classes of management options evaluated were:

- **t**he current management rules based on pot controls with the continuing need for periodic effort adjustments to ensure resource sustainability over time. This is Scenario 1;
- a mix of ITQ based on a variable inter-seasonal TACC and input (pot number) controls with an extended fishing season, and permitted changes in pot design that allow for a modest increase in productivity. This is Scenario 3.
- an ITQ based on a variable inter-seasonal TACC with an extended fishing season, no controls over pot numbers, and few restrictions over pot design allowing for a greater increase in productivity. This is Scenario 4. [iv]

Scenario 1 is based on current input controls, and incorporates a pot reduction at the start of year 11 in a 20 year sequence to maintain a sustainable biomass in the face of effort creep. It was found that a pot reduction of between 7 % and 10% was required at the end of year 10 to get the biomass back to opening stock levels by year 20. The ITQ Scenarios 3 and 4 have annual catch limits set to bring biomass back to opening stock levels at the end of year ten.

A selected set of model options are summarized in Table 1. In the discussion below we concentrate on options 3z and 3u and 4z and 4u. Options 3u and 4u incorporate the most generous set of assumptions used under Scenario 3 and Scenario 4 respectively, whilst 3z and 4z reflect the most conservative set of assumptions used.

Table 1: Features of the Alternative Management Options Modelled

Features	ITE Existing Rules	Mix of Output (Variable TACC Quota) and Input (Pot #) Controls		Pure ITQ (Variable TACC Quota with no Pot # Controls)				
Scenario Code	1	3u	3z	4u	4v	4x	4y	4z
End of Season	Jun-30	Aug-31	Aug-31	Aug-31	Aug-31	Aug-31	Aug-31	Aug-31
Price Differentials	$ -	$2.00/kg	$0.50/kg	$2.50/kg	$1.25/kg	$2.50/kg	$1.25/kg	$0.62/kg
Extra Costs [1]	$ -	$7,200	$7,200	$2,200	$2,200	$2,200	$2,200	$2,200
Pot #'s	Limited	Limited	Limited	Flexible	Flexible	Flexible	Flexible	Flexible
Pots/Boat	100%	100%	100%	120%	120%	120%	120%	120%
Rush to Fish	Yes	No	No	No	No	No	No	No
Effort Creep	1%/pa	0%	0%	0%	0%	0%	0%	0%
Catchability	100%	115%	110%	140%	140%	110%	110%	110%
Opening Boat #'s	Preset at 450	Preset at 450	Preset at 450	Flexible	Flexible	Flexible	Flexible	Flexible
TACC Variation	NR	90% [2]	90% [2]	90% [2]	90% [2]	90% [2]	90% [2]	90% [2]
Illegal Catch	NR	5% of TACC	5% of TACC	5% of TACC	5% of TACC	5% of TACC	5% of TACC	5% of TACC

[1] Extended season increases firm cost by $7,200 and ITQ's reduces firm cost by $5,000.

[2] Variable TACC= (90% of 'predicted' current year catch for Scenario 1+10% of year average catch for Scenario 1)

The table shows the various combinations modelled and indicates the nature of the differences. For example, comparisons such as comparing 3v to 3y or 4v to 4y are based only on varying pot efficiency, whilst others such as comparing 3u to 3v or 4u to 4v show only the effect of varying prices. For some scenarios there are differences that were not subject to sensitivity analysis. In particular, Scenario 4 has a 20% higher pots per boat and a lower starting boat number.

RESULTS

Economic Benefits

The non linear optimization model solves for the combination of inputs that maximizes the net benefit associated with a given management option subject to the various constraints specified for that option.

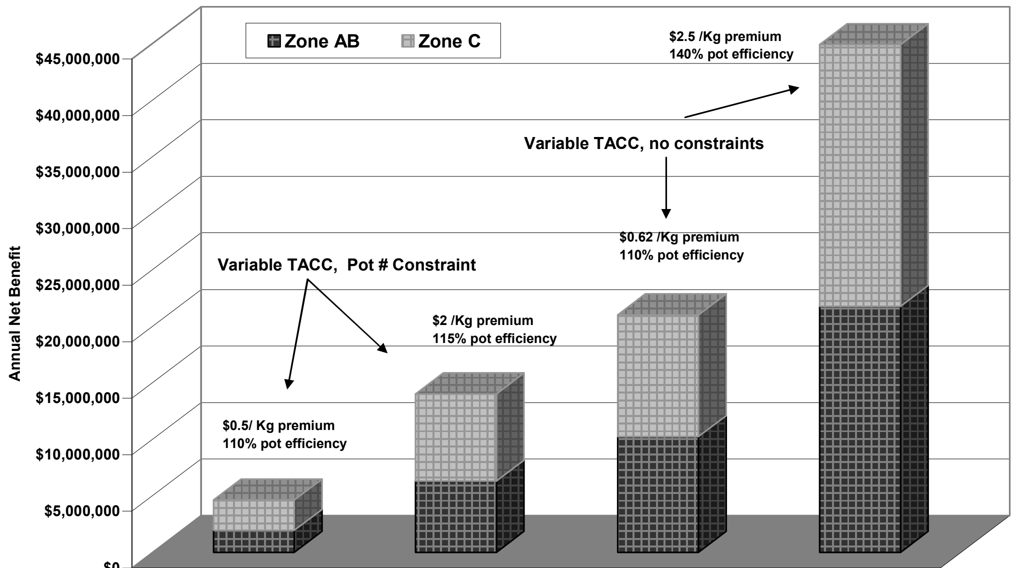
Below, comparative results are presented of the estimated economic benefits for the fishery as a whole for each alternative management option relative to the base case of continuing with the current input controls. The model for this base case was modified to simulate a "rush to fish" and "capital stuffing", and it was assumed that a further pot reduction of 7% to 10 % would be required in year ten to offset effort creep, and to ensure a similarly sustainable level of the biomass vis-à-vis the quota scenarios. The estimates reported below are based on the present value of the net benefits over the period of the model (ten years for quota based Scenarios 3 and 4 and twenty years for Scenario 1) and are expressed as net present values converted to an annual net benefit figure. Based on estimates provided by the Department of Fisheries, additional monitoring and enforcement costs of $2.178 million per annum have been deducted from the relative net benefits for each of the quota scenarios.

For the pure ITQ Scenarios (options 4u to 4z), the model was unconstrained in the choice of the best combination of inputs to harvest the specified TACC. Specifically, an extended season with no constraint on pot numbers, minimal constraint on pot designs, and higher numbers of pots per boat, were assumed. It also was assumed that there would be no effort creep, "rush to fish", or "capital stuffing" for these scenarios. Because average fishing mortality is controlled by the TACC, the optimal solution can be expected to continue in long term steady state. For the pot controlled quota scenarios (Scenarios 3u to 3z), the model optimizes net benefit subject to the constraint that the number of pots used must remain the same as in the base case, and only limited changes in pot design and consequent increases in pot efficiency are permitted.

Figure 4 below shows the additional annual net benefits for the overall fishery for the alternative quota based options 3u and 4u and 3z and 4z. Relative to the base case, the results indicate that the net benefit for the quota based options under both Scenario 3 and Scenario 4 are higher than those for the input control base case. Scenario 4 has higher net gains than Scenario 3. Given conservative assumptions in Scenario 3z, annual benefit was estimated to be $4.6 million higher than for the base case. For the more generous assumptions in Scenario 3u with the highest price premium and a 15% improvement in catch efficiency, annual net benefit increases to $14 million above the base case.

Relative to the base case, basing fishery management on ITQs produces an annual net benefit that is $20.9 million higher than the base case in Scenario 4z, which increases to $44.9 million for Scenario 4u with more buoyant assumptions including the highest price premium, a 40% improvement in catch efficiency, and an increase in pots per boat of 20%.

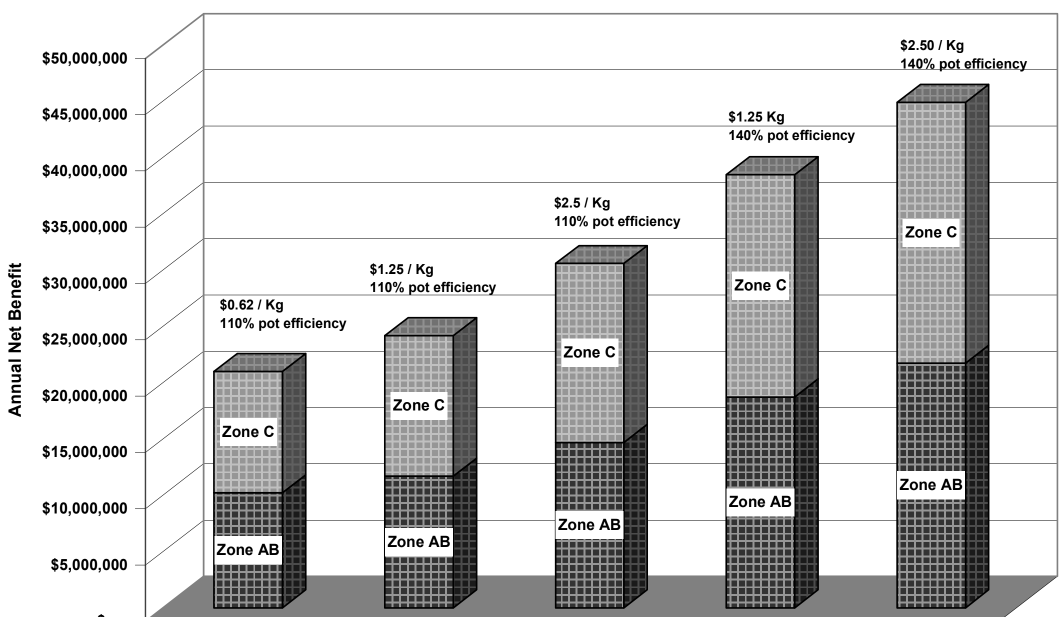
Relative to the base case, all of the options produce increases in net benefits in each year and this is the case across all zones. Scenario 4 options have consistently bigger net benefit estimates than the options in Scenario 3 and this applies in every year. Within each scenario moving to higher price premiums and higher catchability through pot design changes increases net benefits. Figure 5 shows the effect of price and pot efficiency improvements on relative net benefits within Scenario 4. Having higher pots/boat and associated reduced fleet numbers as occurs in Scenario 4, increases net benefits even further. Again this is true for each year of the model period and for all fishing zones.



	i3z	i3u	i4z	i4u
Zone C	$2,669,933	$7,719,275	$10,776,456	$23,155,301
Zone AB	$1,938,281	$6,289,765	$10,219,518	$21,736,769

Scenarios

Figure 4. Annual net benefit for options 3u, 3z, 4u and 4z relative to the base case.



	i4z	i4y	i4x	i4v	i4u
Zone C	$10,776,456	$12,478,290	$15,880,019	$19,739,731	$23,155,301
Zone AB	$10,219,518	$11,694,869	$14,698,092	$18,729,168	$21,736,769

Scenarios

Figure 5. Sensitivity of annual net benefits to price and pot efficiency assumptions.

Breeder Biomass and Catch

To ensure sustainable outcomes, options were constrained to bring biomass back to opening values at the end of the period modelled. For the base case that relies only on input controls, biomass declines over the first ten years due to effort creep, so pot numbers have to be reduced sufficiently at this point to bring the biomass back to its starting point by the end of year 20. Estimates of the required pot reductions were obtained by an iterative procedure, and were 7% in Zone C, 10% in Zone B, and 7% in Zone A. Actual pot reductions required could be different, and would be based on-going monitoring of the fishery over time to provide managers with information on breeder biomass. The breeder biomass indexes for the base case and for the various options in Zone C, Zone B and Zone A are shown in Figures 6, 7, 8 and 9.For the quota based options, biomass at year 10 equals, or is a little above opening biomass. These management options work directly on catch levels, and catch quota was set in the model to ensure that the biomass was maintained at a sustainable level.

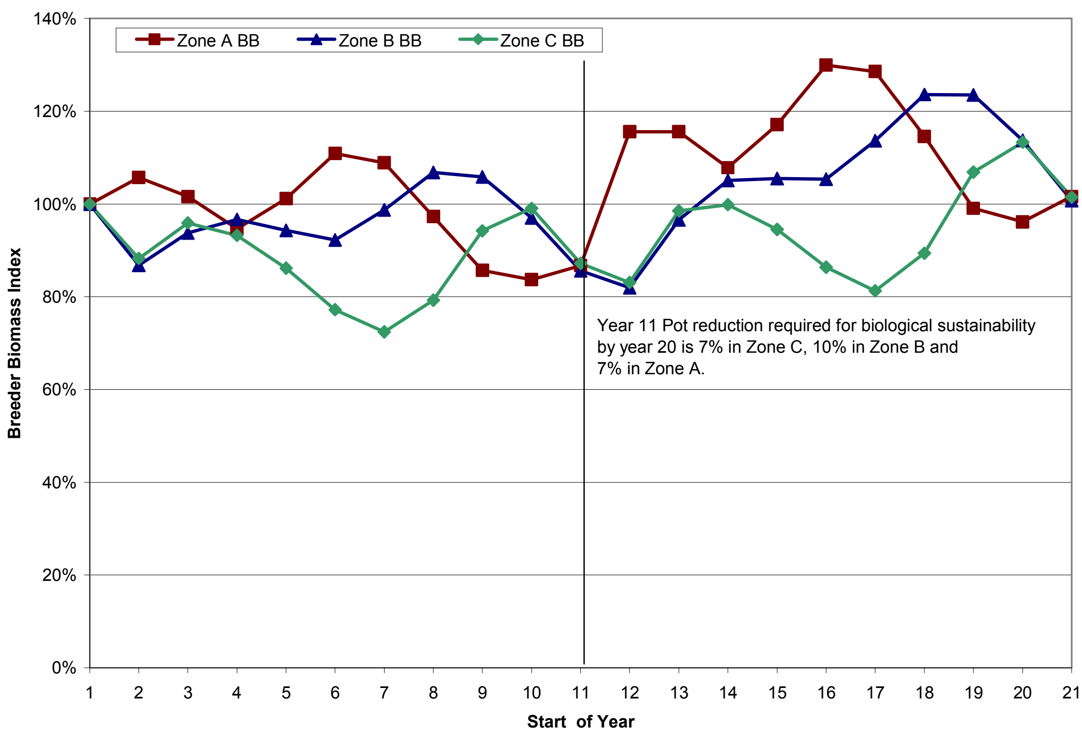


Figure 6. Breeder biomass index in the base case

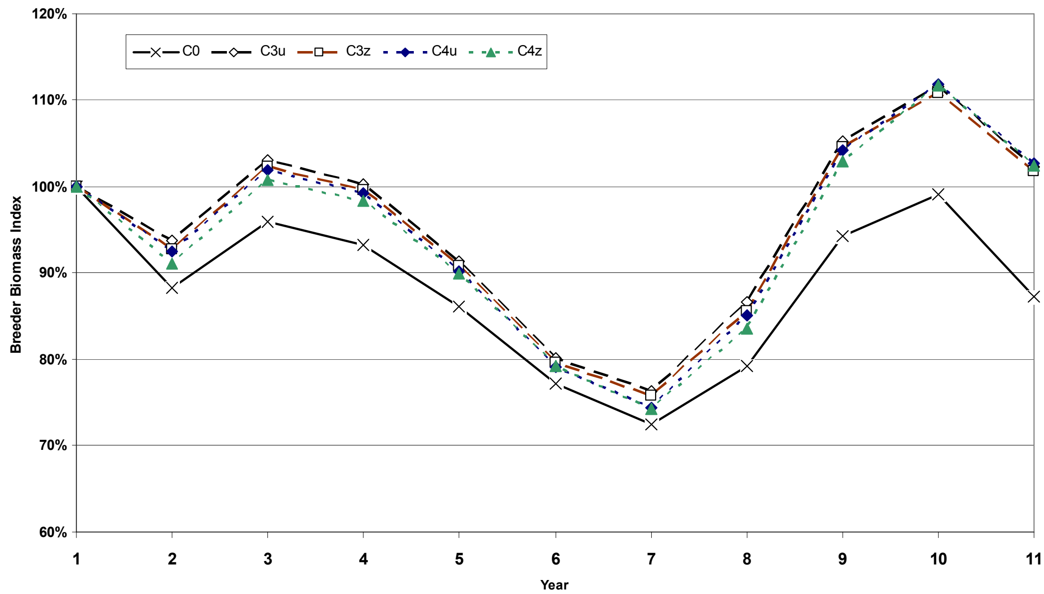


Figure 7. Breeder Biomass Index Zone C

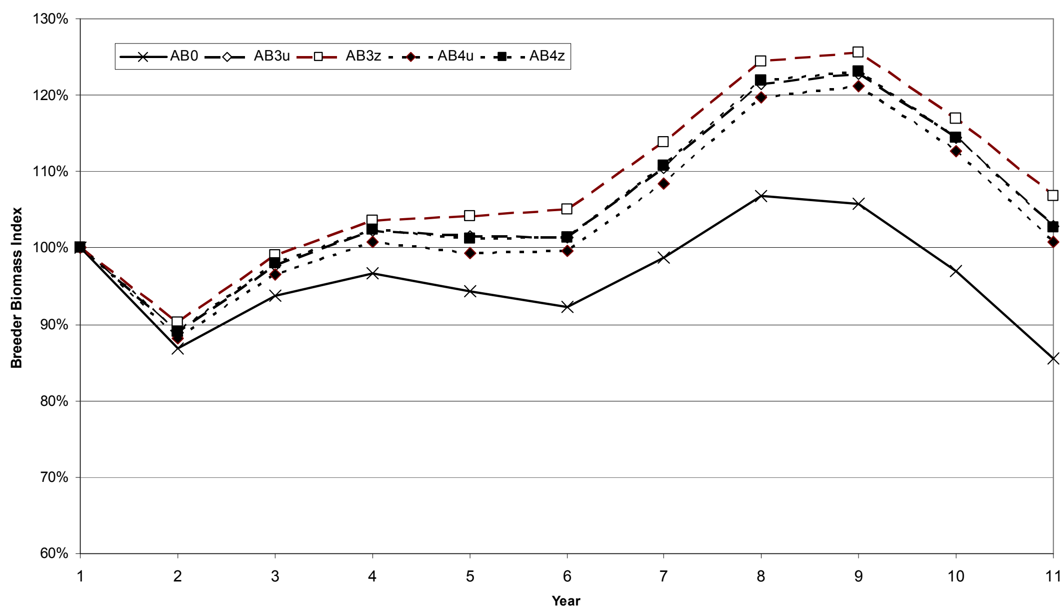


Figure 8. Breeder biomass index zone B

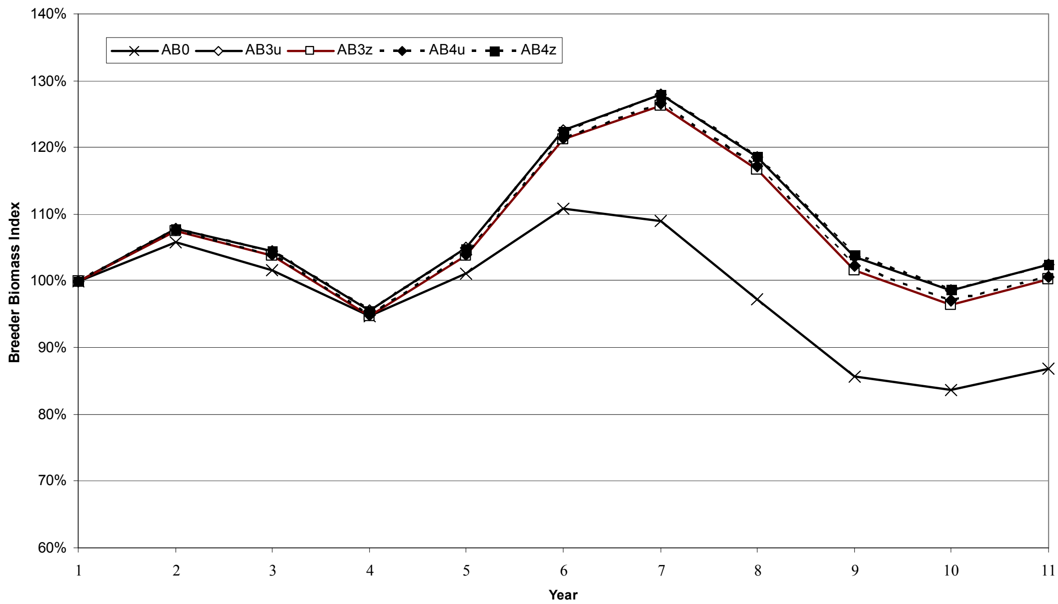


Figure 9. Breeder biomass index zone A

The base case has the highest catches, but reduces biomass over the ten years (Figure 6). Pot reductions are needed at the end of this period to move biomass back to a sustainable level. All other options use the same quota setting rule which is 90% of the average catch in the industry over the last ten years plus 10% of the variation between actual and average catch over the same period. Hence these options have the same catch patterns but a lower average catch consistent with achieving biomass sustainability over the period.[v] Annual catch averages 10,975 tonnes over the ten year model period under the base case, but is on average 750 tonnes lower under the quota options.

Boat Numbers

There are two aspects to boat numbers in the modelling. For each scenario, there is an implicit transition period, followed by the ten year equilibrium modelling.

Following an 18% pot reduction in 1993/94 when boat numbers were 639, they subsequently declined to 549 by 2003/2004. In the modelling, opening boat numbers were set at 445 for Scenarios 1 and 3, and at 235 for Scenarios 4u and 4v, and at 296 for Scenarios 4x, 4y and 4z. Clearly, pots per boat and boat numbers are inversely related when total pot numbers are held constant, so there is less scope for vessel reductions. Under Scenario 4 options, the cost of adding extra pots to a boat is less than the license limitation scenarios where a skipper has to purchase an expensive license for every extra pot used. Hence, it was assumed in the model that boats would use up to 20% more pots per boat for the "pure" ITQ scenarios relative to Scenarios 1 and 3 where pot numbers are constrained.

Effort

Figure 10 shows average annual pot lifts over the ten years for selected scenarios. These are highest for the base case, which is constrained to use the current level of pots, and has no increase in pot efficiency. They are lowest for option 4u which has the highest increase in pot efficiency, lower pot numbers, fewer boats and an increase of 20% in pots/boat. Pot lifts under option 4z are higher than option 4u, and higher than for Scenario 3. Whilst option 4z has an increase of 20% in pots/boat, and fewer pots, it has only a 10% increase in pot efficiency.

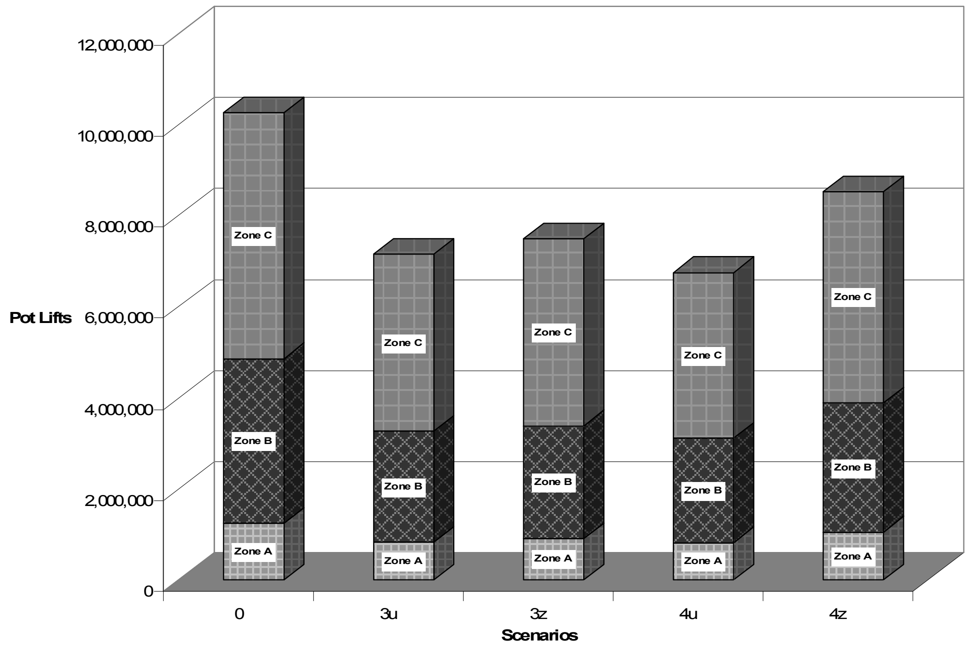


Figure 10. Average annual pot lifts

While monthly pot lifts shown in Figure 11 broadly reflect differences in annual pot lifts, there are some interesting disparities. For instance, under Scenario 4u where vessel numbers, pot numbers, and annual pot lifts are smallest, catch is maintained by fishing more days, and by spreading effort out over the whole season. Conversely, under Scenario 3u where total pot numbers are held at current levels, both vessel numbers and pot lifts are higher than under 4u, and the optimal result involves significant reductions in days fished in some months.

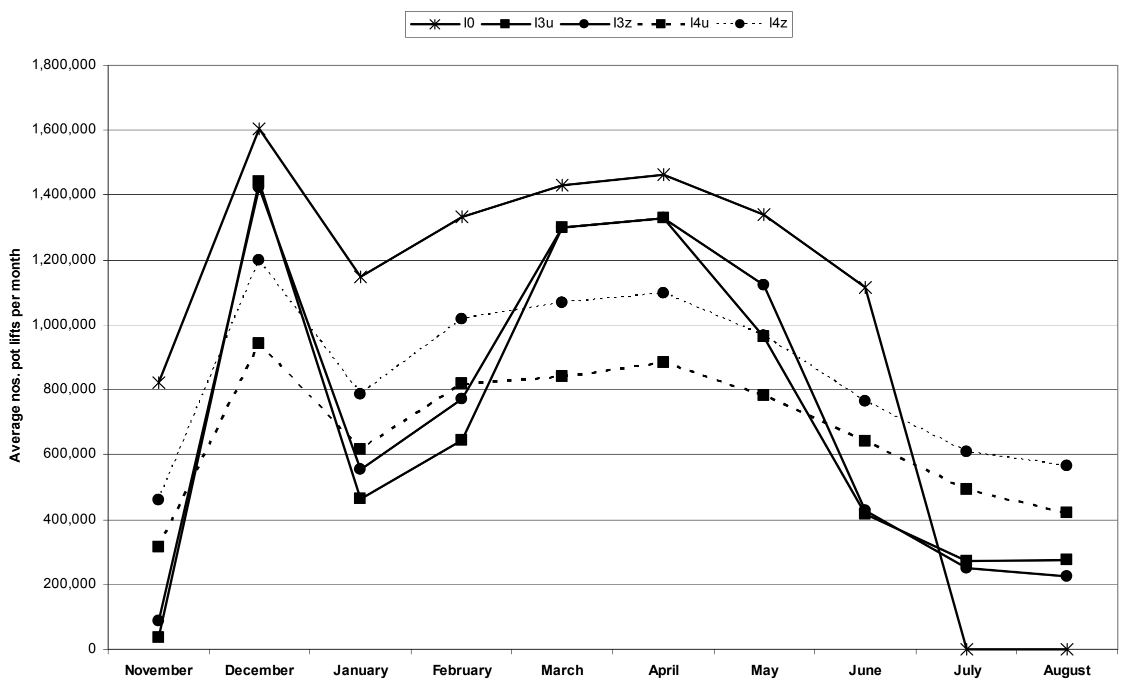


Figure 11. Average monthly pot lifts

Overview of Bio Physical Results

Scenario 4u assumes a 40% increase in pot efficiency due to relaxation of the regulations on pot design, and 20% more pots per boat. As a result, fleet size is smaller, and pot numbers and pot lifts are the lowest of all scenarios. On the other hand, days fished and capital utilisation are greater than for the options under Scenario 3, and the highest of all options for scenario 4.

Scenario 3 is constrained to use the current number of pots, has no increase in pots per boat, and increases in pot efficiency are only either 10% or 15%. With pot numbers fixed at current levels, with smaller efficiency gains, and with more boats than option 4u, optimization involves significantly reduced fishing days compared to 4u, but with more pot lifts than for option 4u.

Scenario 4x is based on the same assumptions as Scenario 4u, except that pot efficiency is increased by only a modest 10%, which is comparable to that used in Scenario 3. Again, there is no constraint on pot numbers, and 20% more pots per boat. Consequently, more boats are used than for Scenario 4u, but less than in Scenario 3. the optimal result uses fewer pots than in Scenario 3, but more than under option 4u. Days fished are similar to option 4u, but higher than options 3x and 3u. Pot lifts are higher than for Scenario 3 and significantly higher than in option 4u which has the lowest pot lifts. Given the larger boat numbers in option 4x, in effect higher pot lifts are making up for the reduced pot efficiency compared to option 4u.

CONCLUSION

The modelling results indicate the potential for large gains for the Western Rock Lobster industry from moving to a quota based management regime. Depending on the exact assumptions used, it is estimated that quota based options can increase industry average annual net benefits from around $4 million up to over $40 million. The higher benefits are associated with options having the greatest flexibility to adjust key inputs. Estimated net gains arise primarily from fleet rationalization, reducing the number of pots used, from fishing the extended season, and smoothing effort over the season. Higher net gains can accrue if pot design is deregulated to allow greater productivity improvements.

Whilst the modelling indicates the potential gains from a move to quota based management, there are challenges in implementing such a change. The most significant of these is likely to be the rules for the initial allocation of quota, and the implications that any given initial allocation system has for the financial position of individual fishers.

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ENDNOTES

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* This paper is an edited version of a paper previously titled "Modelling The Economic Implications of ITQs and ITEs in Western Rock Lobster Fishery" that was presented to the IIFET 2006 Conference, Portsmouth.

[i] For a technical and economic overview of the fishery, see Western Australian Department of Fisheries [5].

[ii] In addition to the authors, Ross Kingwell and Bruce Phillips contributed to the development of the model.

[iii] The model is similar to the Hall and Chubb model [1] in terms of the way it models 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.

[iv] The existing biological controls that disallow the taking of setose and tarspots and undersized lobster remain under all three alternative approaches.

[v] In an earlier report, fixed quotas and a variable quota rule based on 50% of the average plus 50% of the variation were modelled. These scenarios produced unacceptable fluctuations in the biomass, and are not reported here.