WESTERN ROCK LOBSTER FISHERY: A CASE STUDY IN FISHERIES MANAGEMENT - FROM SUCCESS? TO RECRUITMENT FAILURE? AND WHERE TO NOW?

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ABSTRACT

Australia's western rock lobster fishery is its most valuable and hence from a biological perspective most tightly managed major commercial fishery, yet it has been beset by problems of miniscule recruitment over the past 3 years. This coming year 2010-11 is little better. It was the joint first Marine Stewardship Council certified fishery - first in April 2001, recertified in 2006 and again in Jan 2010.

Despite this, it has suffered all the well known problems of first, an open access fishery, and even in its current management mode of a total effort controlled fishery – based on total number of pots- is subject to ever shortening seasons and only moderate prices as a result of "the race to fish".

The paper first presents the results of a bio-economic model on the comparative costs and benefits of an ITQ versus ITE system for this fishery. The results were derived from a purpose built bioeconomic model with three separate bio-geographic 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 several versions of an individual transferable catch quota system. 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 modeled illustrated some of the tradeoffs between maximizing net economic returns and minimizing biological risks, as well as quantifying the impact of changes such as an extended fishing season.

The paper highlights the issues faced by most fisheries during their lifespan - from a progressive concentration of fishing and processing effort with business diversification and monopoly-like behaviour attempting to reduce/diversify risk by its most successful participants – to an industry in crisis simply fighting for its survival. The paper illustrates why undiversified fishing in such a situation as ITEs is too risky even for vertically integrated fishing and marketing companies.

The current situation is forcing a major rethink by the industry's leaders with ITQs again on the agenda to replace the current failed individual total effort (ITE) limit policy.

Keywords: ITQs, ITEs, "race to fish", fishing company strategies, Western Australia's rock lobster fishery, bioeconomic modeling, economic benefits

INTRODUCTION

The West Coast Rock Lobster fishery has been Australia's most valuable single species fishery for over 40 years, 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 (ex-vessel prices) annually even in the last two years. Around 95 per cent of the catch is exported, mostly to North Asia. Annual harvests have averaged around 10,500 tonnes from a gradually decreasing total number of vessels, which were 550 as recently as 2004-05.[i]

The fishery, which took off in terms of export markets after World War II, 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 2000, it was the joint[ii] first fishery in the world to be certified as ecologically sustainable by the Marine Stewardship Council.

The fishery is divided into three bio-geographical commercial fishing zones, A, B and C; and there is a limited harvest season from the 15th November to end of June. There is also a small (currently less than 5% of the annual quota) but important recreational fishery during the same period. Commercial pot numbers are restricted by zone, and pot licenses are tradable. Reliance on input controls has necessitated three significant pot reduction interventions prior to 2008-09 season, the last one of 18% occurring in 1993/94. Other minor adjustments happen quite frequently, such as moon closures that were imposed in the 2005/2006 season.

Over the last 20 years – since about 1990, the investment in effort creep that underpinned the need for pot reductions has coincided with rising input prices (fuel, labour, equipment) 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.

The first part of this paper reports in summary the results of an evaluation of a range of possible future management options, including the use of transferable quota that should improve industry efficiency and returns. The second part looks at the response of the industry and its major players to the changing fishery and market environment.

Development of the model was based on extensive consultation with fishers and fisheries managers. It was expected that results would inform consideration by the industry about a possible new management system. Extensive presentations were given on the results obtained – but the industry stuck to what it knew worked.

The development of the model, and results obtained, are documented in McLeod et al (2005) and McLeod et al (2006). Earlier bioeconomic analysis of the potential benefits of the use of a system of individual transferable quota (ITQ) in the industry can be found first in Morgan (1980) using a simple Gordon-Schaefer logistic model and in Lindner (1994) using a more sophisticated bio-economic model. The most recent analysis of the comparative costs and benefits of ITQ versus ITE was done by WA DoF economist Chris Reid (2009).

The alternative management options put forward by McLeod et al (2005, 2006) were being assessed against a backdrop of ongoing long-term industry rationalization, as shown in Figure 1. Between 1964/65 and 2003/04, pot numbers had been reduced by management interventions from around 76,000 to around 56,000 in three adjustments. Vessel numbers had declined continuously from around 850 to around 550 over the period, yet average catch had 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 lobster abundance in a given year. Effort measured as pot lifts per vessel had more than doubled over the period.

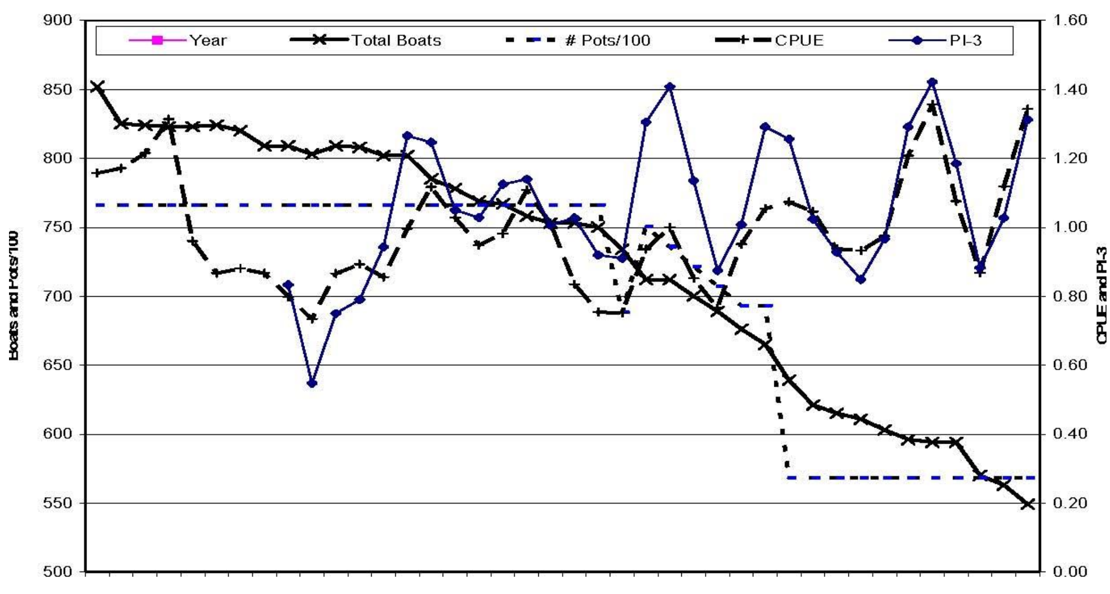


Figure 1. Pattern of change in the industry over 20 year period, 1964/65 to 2003/04.

MODEL STRUCTURE AND DATA

The assessment of the alternative options used a bioeconomic 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 nonlinear 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-3) from the fishery to simulate recruitment variation over a ten year period[iii]

The objective function was simply 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 with monthly catch data from the three zones. One measure of this robustness is the correlation between predicted and actual catches. The model tracks actual catch well, with the adjusted R squared between actual and fitted catch being very high at 0.93 for Zones A and B combined and 0.87 for zone C (McLeod et al 2005).

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 in 2004/05. 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:

- ✓ the 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 interseasonal 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.
- ✓ a pure ITQ based on a variable interseasonal 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.

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	Jun30	Aug31	Aug31	Aug31	Aug31	Aug31	Aug31	Aug31
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%
Race 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

Table 1. Features of the Alternative Management Options Modelled[3]

Notes:
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)
3. 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 20% higher pots per boat and a lower starting total boat number.

RESULTS

Economic Benefits

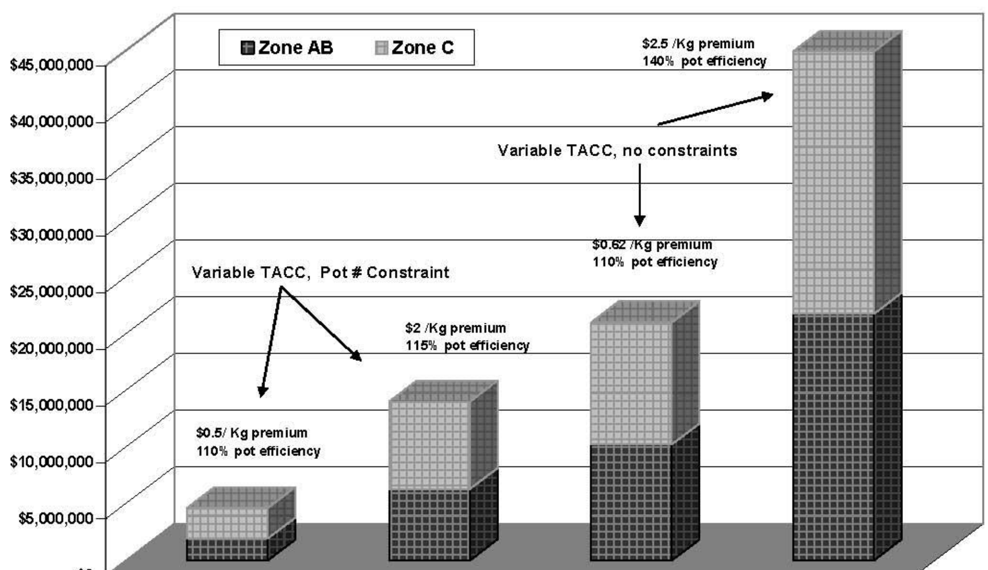
The non linear optimization model solves for the combination of inputs that maximizes the net benefit associated with a given management option subject to the various constraints specified for that option.

Below, a summary of the comparative results is 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 "race 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 (year 2004-05) 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. Also it 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 2 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%.



	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

Figure 2. Annual net benefit for options 3u, 3z, 4u and 4z relative to the base case.

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 3 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.

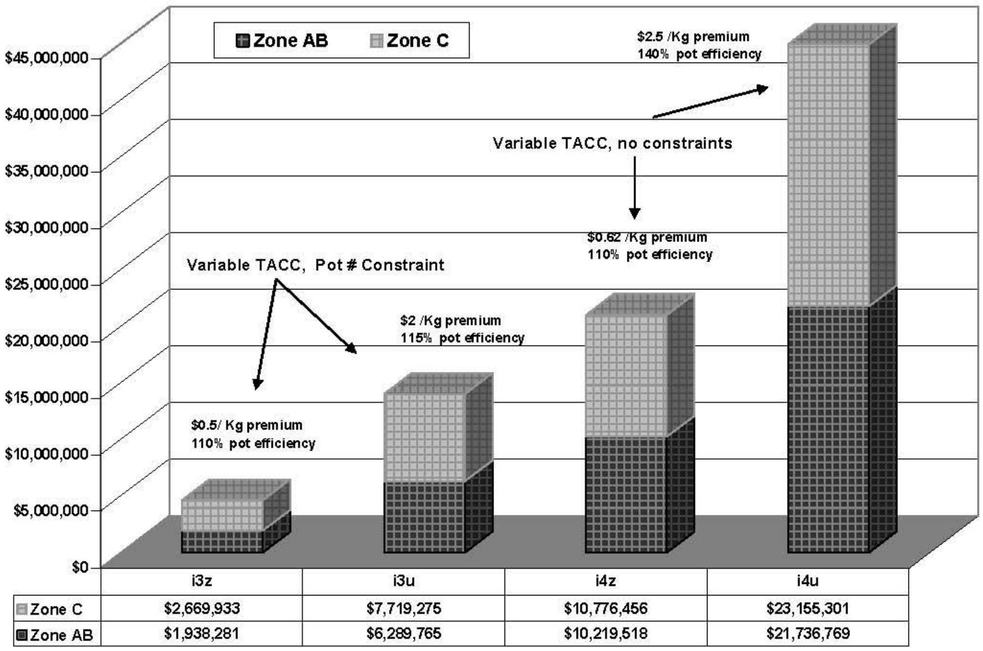
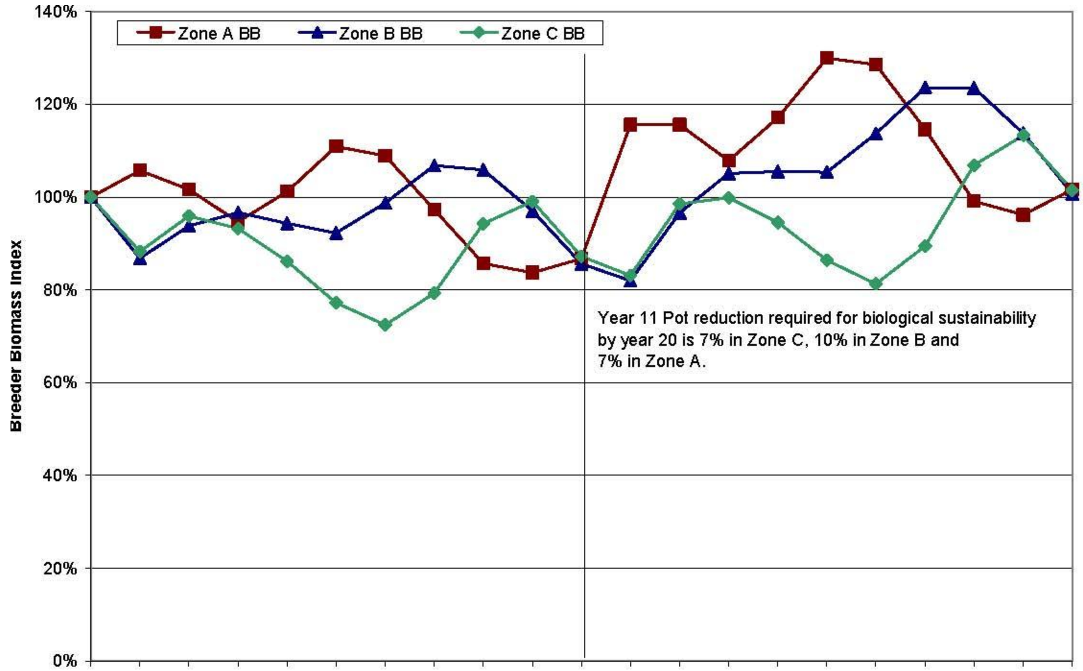


Figure 3. Sensitivity of annual net benefits to price and pot efficiency assumptions.

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 ongoing 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 and Zone B are shown in Figures 4, 5 and 6. 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.

The base case has the highest catches, but reduces biomass over the ten years (Figure 4). 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 (or 10,225 tonnes over the ten years) under the quota options.



1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

Start of Year

Figure 4. Breeder biomass index in the base case

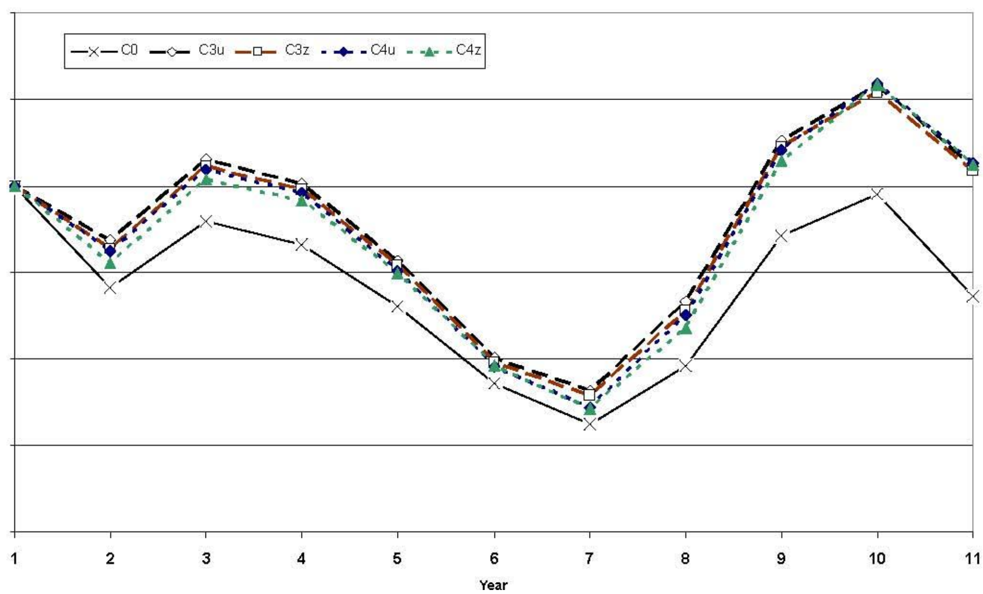


Figure 5. Breeder Biomass Index Zone C (Y-axis range is 60% to 130%)

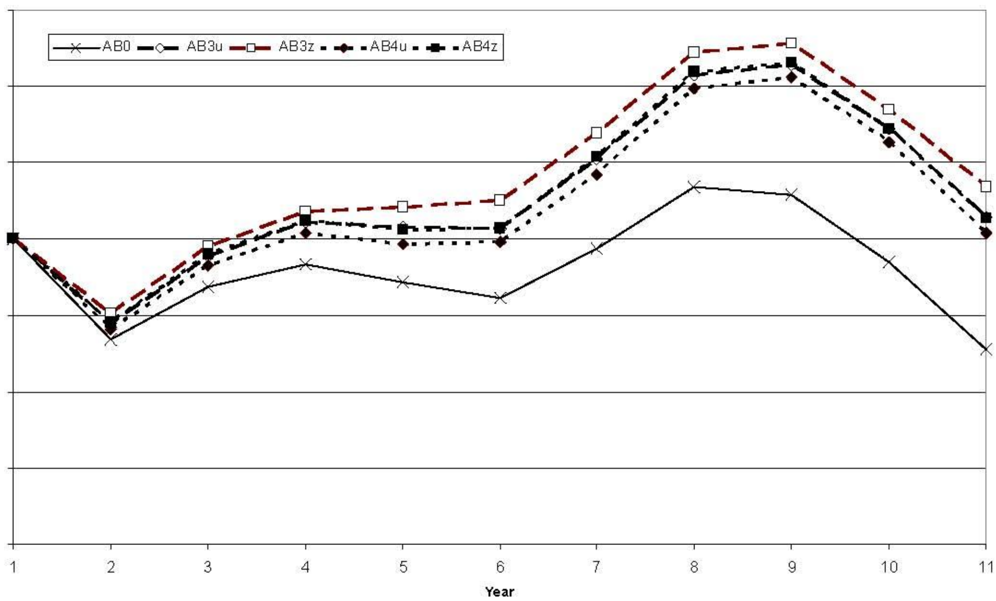


Figure 6. Breeder biomass index zone B (Y-axis range is 60% to 130%)

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, boat numbers subsequently declined to 549 by 2003/2004, a fall of 14.1%. In the modelling, opening boat numbers were set at 445 for Scenarios 1 and 3 (a reduction of 18.9% relative to 2003/04), and at 235 for Scenarios 4u and 4v (a reduction of 57.2% relative to 2003/04), and at 296 for Scenarios 4x, 4y and 4z (a reduction of 46.1% relative to 2003/04). 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 licence limitation scenarios where a skipper has to purchase an expensive license for every extra pot used [vi]. 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 (numbering from McLeod et al 2007) 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.

While monthly pot lifts shown in Figure 11 (numbering from McLeod et al 2007) 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.

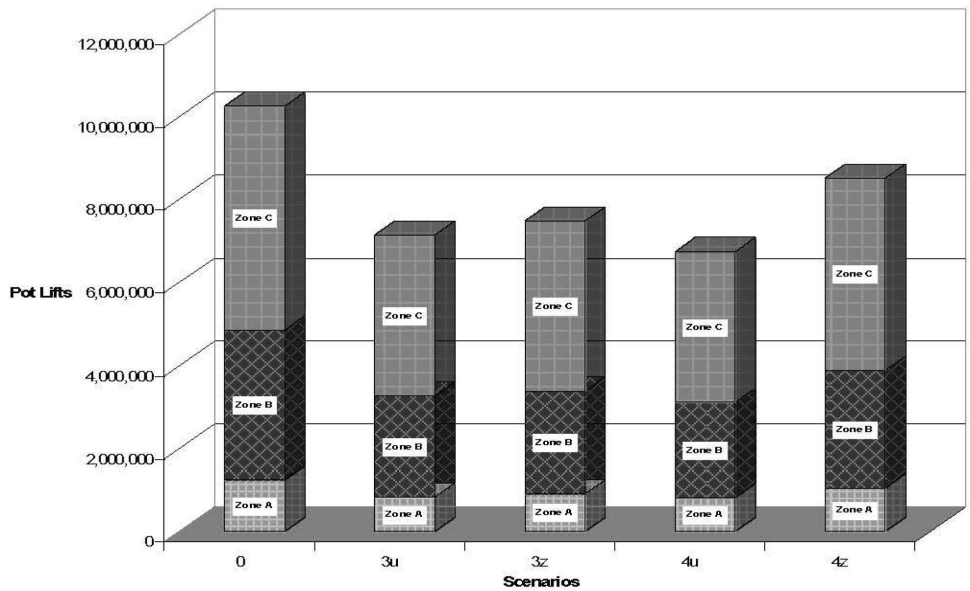


Figure 10. Average annual pot lifts

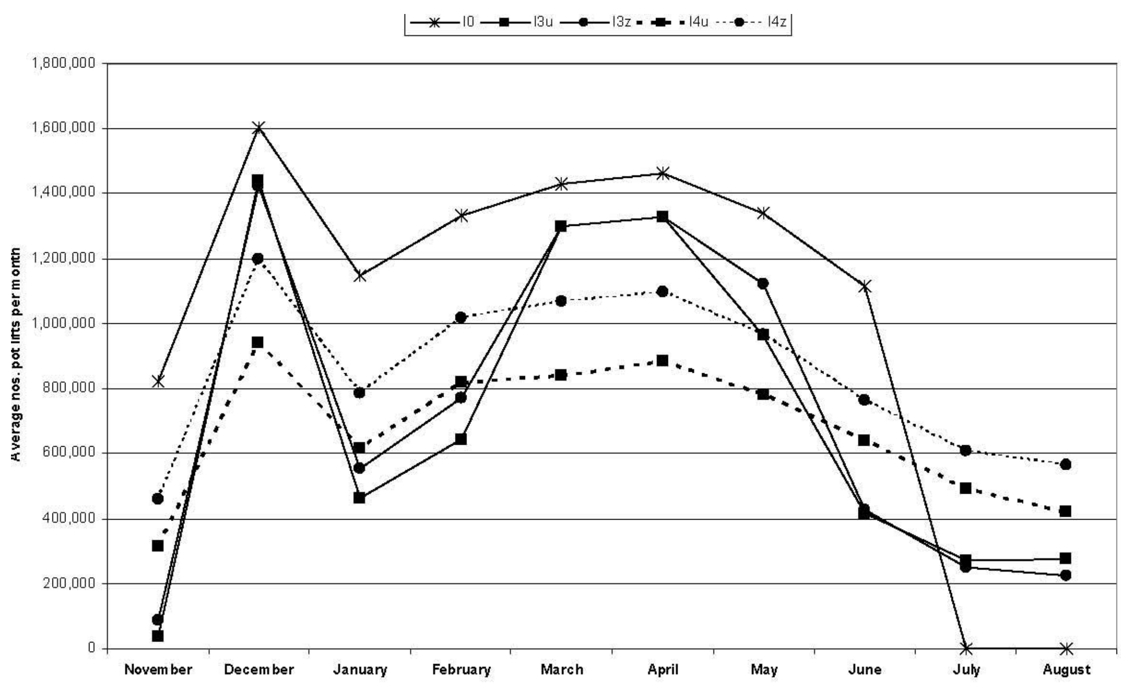


Figure 11. Average monthly pot lifts

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.

UP DATE TO 2010 - AND BEYOND

The Western Rock lobster industry in the last 40 years has gone through periods lasting several years when puerulus settlement and subsequent catches three years later have been significantly below average.

However, the puerulus settlement situation in the last three years – and 2010-11 has started off no better - has been lower than ever previously recorded which has resulted in dramatically reduced "safe" TACC catch levels being imposed (Figure 7). The most severe reduction in the recommended TACC came into effect in the 2009-10 season which ended in June, with a reduction in TACC to 5,500 tonnes, a little above 50% of the long-term average catch level. Current projections for 2011-12 suggest this TACC level could be roughly halved again.

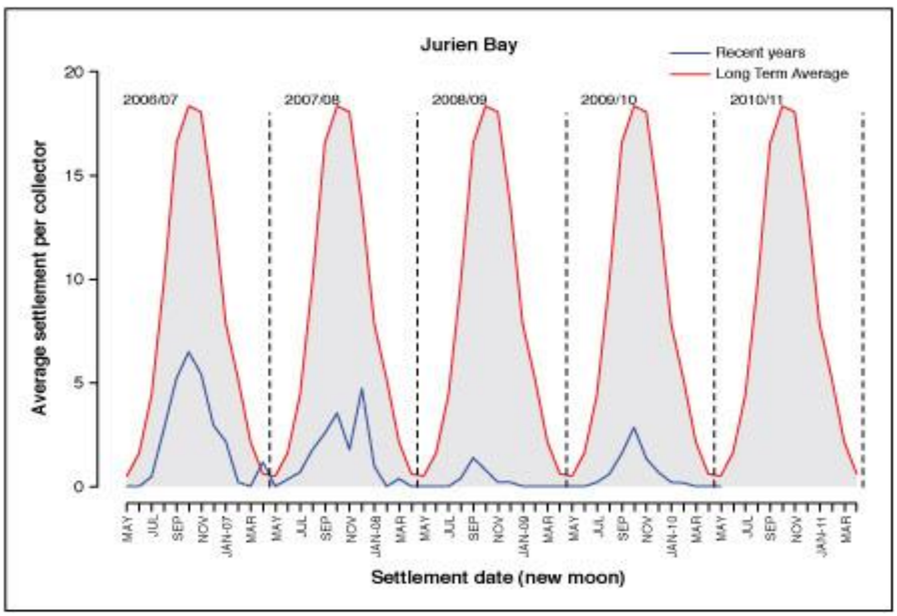


Figure 7. Collapse of Puerulus Settlement in Recent Years (WA DoF 2010).

This downturn in settlement has occurred at the same time as the Global Financial Crisis (2008 – 2010). Fortunately for most owners and crew, the opportunities in the mining sector in Western Australia have meant that shifting to alternative employment has been relatively easy, and encouraged by the poor earnings of the prior two years. The large shift in the fleet size, pot lifts, and catches and earnings is shown in Table 2.

Boat numbers have dropped from 500 in 2005-06 to 400 in 2008-09 to 300 in 2009-10, a 40% reduction. Boat numbers in 2010-11 are expected to fall to around 250, which is considered about the optimum for ITQs under normal circumstances but far more than needed now.

	2006	2007	2008	2009	2010
Boats	500	491	460	400*	300*
Pots (.82 to .42)	56,529	56,529	55,964	?*	?*
Catch	10,326	8,577	8,952	7,800*	5,500*
cpue	1.17	1.03	1.13	1.40*	1.70*
Pot lifts (million)	8.80	8.31	7.92	5.57*	3.24*
Catch/boat (mt)	20.65	17.47	19.46	19.50*	18.33*
Top Net Income/Man (A$)*	103,250	87,350	97,300	78,250*	59,600*

Table 2. Recent Development of Catch, Effort and Income.

*Notes: *estimated. Sources: WA DoF (2010) and authors' estimates.*

The industry in 2009-10 needed to be micromanaged, with a classic "race to fish" by those boats which decided to take part in the fishery. The WA DoF set target catch levels for the "reds" and "whites" seasons which were reached in record time. The fishery was closed down for Christmas and again in March. In the second period, fishing was restricted to 4 days per week as well as moon closures in an effort to spread out the catch. The fishery closed about 6 weeks early.

Interestingly, with lower numbers of pots deployed, catches per pot lift shot up to average about 70% higher than normal, thereby compensating for the reduction in pots deployed to 42% of those licensed.

By March 2010, the industry had had enough and informed the Minister they had decided to move from the current ITE system to an ITQ system – with allocation of catch shares based not on catch history, but on pot ownership as has occurred in other jurisdiction in Australia, most notably South Australia (WAFIC, pers. comm.)[vii].

Interestingly, many of those who have continued to operate their boats consider the economics of the fishery will improve with a recovery in stocks.

CONCLUSION

The modelling results indicate the potential for large gains for the Western Rock Lobster industry from moving to an individual transferable quota (ITQ) 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 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 a large reduction in fleet size relative to the current number of boats, reducing the number of pots used, from fishing the extended season, and smoothing effort over the longer season. Higher net gains can accrue if pot design is deregulated to allow greater productivity improvements and if monthly fishing catch and effort is more closely tied to market price driver (not modelled here).

Whilst the modelling indicates the large potential gains in resource rents 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.

Finally, a move to a quota based system will generate rents an order of magnitude higher than any expected increase in management and monitoring control and enforcement costs, some of which can be claimed by civil society through taxes on the large resource rents that can be earned in the long term provided the fishery recovers.

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ENDNOTES

i. For a technical and economic overview of the fishery, see Western Australian Department of Fisheries State of the Fisheries and ABARE annual fisheries statistical reports.

ii. The other joint first fishery to be certified by the MSC was the Thames herring fishery in April 2000.

iii. The model is similar to the Hall and Chubb model (2001) 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 the impact of different management scenarios on the economic outputs of the modelling to be revealed.

iv. The existing biological controls that disallow the taking of setose, tar spots 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.

vi. The value of an individual pot licence for a year under ITE has varied with the expected catch per pot deployed times the average price per lobster expected in the current season. Annual variations in pot licence prices can be large but the price premium is lower when catches are expected to be higher.

vii. Western Australian Fisheries Industry Council.