Decision-support tools for economic optimization of Western Rock Lobster

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1. Non-Technical Summary

PROJECT NUMBER AND TITLE 2009/714.10 Decision-support tools for economic optimization of western rock lobster

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OBJECTIVES:

1 To estimate the annual catch and effort to achieve optimum economic yield

2 To evaluate intra-annual market-based management strategies.

3 To evaluate the economic effect of current and proposed management changes.

LIST OF OUTPUTS:

The key output from this project is that industry and management have access to the results of an economic evaluation of the fishery from a bioeconomic model that will help facilitate discussion on management harvest strategy that considers a socio-economic target harvest rate. These results include: (a) an understanding of the levels of catch and effort that are required to achieve maximum economic yield (MEY); (b) the economic evaluation of the effect of moving to an MEY level of effort; (c) an assessment of MEY initially under input-controls and then under an output-controlled fishery; and (d) the development of a draft socio-economic target reference range that has been informed by the assessment of the MEY and expected gross value of production (GVP) under an individual transferable quota system and the assessment of economic evaluation of moving to a lower catch and effort level in recent years.

Managers and Industry have been provided with the projected catch, effort, catch rates, egg production at different levels of harvest rate calculated as a legal proportion harvested (LPH) for the next 5 years as well as the estimated GVP and profit levels. The LPH is given as the proportion of the catch out of the total legal biomass as estimated from the stock assessment model. The target LPH range was proposed to be 0.37 to 0.47 for the 2014 season as it reflects the harvest rate in recent years and takes into account the MEY assessment and the levels of GVP.

Three publications utilising the results from this project are:

Reid, C., N. Caputi, S de Lestang, P. Stephenson (2013). Assessing the effects of moving to maximum economic yield effort level in the western rock lobster fishery of Western Australia. Marine Policy 39: 303-313

Department of Fisheries (2012). West coast rock lobster managed fishery - harvest strategy and decision rules proposals under a quota management system. Western Australian Department of Fisheries, 3rd floor the Atrium, 168 St Georges Terrace, Perth, Western Australia.

Department of Fisheries (2013). West coast rock lobster - Harvest strategy and control rules 2015-2019 – a discussion paper. Western Australian Department of Fisheries, 3rd floor the Atrium, 168 St Georges Terrace, Perth, Western Australia.

OUTCOMES ACHIEVED TO DATE:

This project has demonstrated the benefits of undertaking economic evaluation of fishery as part of the annual catch quota setting process for the fishery. For example, a profit increase of greater than $60 million is estimated for the catch quota-controlled year of 2010/11 compared to that expected under continued 2007/08 effort level The major outcome arising from this project is that industry and management have accepted the bioeconomic model as a decision-support tool in the management control rules for catch quota setting for the western rock lobster fishery leading to an improved profitability of the fishery whilst also improving the sustainability indicators. The bioeconomic model, which assesses the maximum economic yield of the fishery, has been used in the catch quota setting for the 2013 and 2014 seasons. The model has also been used in the harvest strategy discussion paper which was released in December 2013. Consultation with industry on the new harvest strategy is planned for February 2014. Once the Minister has signed off on the harvest strategy it will be the basis for catch quota setting for the 2015-2019 fishing seasons.

The western rock lobster (*Panulirus cygnus*) fishery was one of the first to be made limited entry with the number of licences restricted since 1963. Historically, the main focus of the assessment and management of the fishery has been on the status of the breeding stock to ensure biological sustainability. In the mid-2000s, however, the commercial fishery was facing significant economic pressure from increasing costs, lower prices and reduced catches as a result of low recruitment so there was a need to focus on the economics of the fishery.

For the effort-controlled fishery, the optimum level of effort estimated by the bioeconomic model that would result in the maximum economic yield (MEY) being obtained, was about 30-50% of the 2007/08 effort levels (i.e. 50-70% effort reduction). The MEY was assessed as the net present value (NPV) of profits over the period 2008/09 to 2013/14 with a discount rate of 10% per annum.   The assessment estimated the overall effect on the fishery of fishing at the MEY effort level would be an average increase in profits of over $40 million per year.   The assessment assumed that the cost per pot lift took into account both fixed vessel costs (e.g. depreciation) and variable costs (associated with numbers of pot lifts). Vessel numbers were assumed to decline proportionally in relation to effort reductions over 3 years. This MEY assessment also made the conservative assumption that lobster prices were not affected by declining catch levels. Catch estimates under the different levels of effort were derived using a stock assessment model employing data on annual puerulus settlement levels as a means for predicting catch and recruitment 3-4 years later. This high predictive ability of this modelling approach has been particularly useful recently as there has been a period of unusual puerulus settlement decline over the past seven years (2006/07 to 2012/13) including the two lowest observed settlements in the 40-year time series.

A sensitivity analysis that assessed the combined effect of a 20% increase in costs and a 20% decrease in lobster prices which showed that the optimum effort range reduces even further to 20-40% of 2007/08 levels. However if costs decreased by 20% and prices increased by 20%, optimum effort range would be higher at 40-60% of 2007/08 levels. Hence, effort levels at about 40% of 2007/08 levels were reasonably robust as a MEY effort level to changes in costs and prices.

As a result of the low puerulus settlement in recent years, substantial management changes were made in 2008/09 and 2009/10 (44 and 73% reduction in nominal fishing effort relative to 2007/08, respectively) to maintain the breeding stock at sustainable levels and have a carryover of legal lobsters into the predicted future years of lower recruitment to the fishery. While these effort reductions were undertaken for sustainability reasons, they were also at a level consistent with the estimated MEY level of effort. This provided a unique opportunity to assess the effect of a fishery moving to an MEY effort level within a two year period. Subsequently, in 2010/11, the fishery introduced individual catch limits on the fishery with an overall catch quota of 5,500 t and this resulted in a 71% effort reduction relative to 2007/08. The start date of the fishery was then moved from 15 November to 15 January so there was an extended season of 14 months from 15 November 2011 to 14 January 2013 (2011/13 season) to cover the changeover with a catch quota of 6,938 t.

The catch rate (CPUE) increased from 1.1 kg/pot lift in 2007/08 to 1.7 and 2.7 in 2008/09 and 2009/10, respectively, as a result of the effort reductions. The catch rates in these latter two years were much higher than the predicted levels (1.2 and 1.1, respectively) for those seasons if the 2007/08 effort had been maintained in these two years. The CPUE under catch quota in 2010/11 and 2011/13 was 2.3 and 1.8 kg/pot lift, respectively. The reductions in fishery revenue ($30-40 million), however, were much less than expected ($67-85 million) due to the prices being achieved for *P. cygnus* catches being higher than the assumed level of $27/kg, as the MEY assessment conservatively assumed constant prices. Improved lobster prices were also obtained in 2010/11 as a result of moving to catch quota. The higher prices reflected fishers being able to fish over an extended season, target their fishing during periods of higher prices and retain lobsters of a size and quality that fetched a higher price.

The vessel numbers declined by 14 and 36% in 2008/09 and 2009/10, respectively, compared to 2007/08. A significant reduction in fishery costs of $44 and $91 million, respectively, was achieved over the two years with the reductions being about 20% less than that predicted due to lower vessel reductions than expected. A cost decline of greater than $90 million was estimated for the 2010/11 season as the effort was similar to 2009/10 but a further small reduction in vessel numbers and bait usage was also recorded.

The fishery profit increased by $13 and $49 million for 2008/09 and 2009/10, respectively, compared to that expected under 2007/08 effort level. A profit increase of greater than $60 million was estimated for the 2010/11 season compared to that expected if the 2007/08 effort level had continued.

An assessment of the relationship between lobster prices and catch found a significant negative relationship, after taking into account the exchange rate. If this relationship is taken into account in the MEY assessment then the MEY level of effort would be about 20-40% of 2007/08 effort compared to 30-50% estimated using constant prices.

The stock assessment model for the *P. cygnus* fishery has been updated to reflect changes in the pattern of fishing under individual transferable quota (ITQ) as a result of the fishery moving to a 12 month season. An MEY assessment under ITQ estimated that AUD$20-40 million of additional profit per year will be made at the optimum level of fishing compared to fishing at lower or higher levels. This level of fishing also coincides with predictions of relatively stable catches, catch rates and egg production over the next five years.

A key component of this MEY assessment was estimating the number of vessels that would be operating each year. Two assumptions were assessed (a) the number of vessels would change as a result of any change in fishing effort required to achiever the quota; and (b) the vessels would generally remain the same as are currently (2013) operating i.e. about 280 vessels unless there was a very high level of effort required to catch the quota.

This assessment provides a clear demonstration of the economic benefits of fishing at a level close to MEY under either an input or output management regime. The management harvest strategy for the *P. cygnus* fishery has historically been based on maintaining the egg production above a minimum threshold level, an approach designed to ensure a low risk of stock collapse. A management discussion paper was released in December 2013 that includes a socio-economic target harvest range as well as a limit and threshold level of breeding stock. The proposal considers the option of the total allowable commercial catch (TACC) being set for the fishery based around an optimal range for the proportion of *P. cygnus* that can legally be harvested for producing catch rates that maximise economic returns from the fishery.

Managers and Industry have been provided with the projected catch, effort, CPUE, egg production at different levels of harvest rate calculated as a legal proportion harvested (LPH) for the following 5 years as well as the estimated GVP and profit levels. The target LPH range was proposed at the level of 0.37 to 0.47 for the 2014 season as it reflects the harvest rate in recent years and it took into account the MEY assessment and the levels of GVP. The target range represents the upper end of the MEY range where the catch and GVP would be relatively high, as would be the number of boats that are likely to be operating, hence generating a high level of employment in the fishery. It therefore incorporates a socio-economic target and the range provides industry and managers with additional choice about the socio-economic target they wish to achieve. The TACC for the 2014 season was set at 5859 t after consultation with industry and this reflects a 5.5% increase on the previous season but at the lower end of the LPH range proposed. Discussions with industry are planned to occur in February 2014 for the finalization of the harvest strategy that will be used for quota setting for the 2015 to 2019 seasons.

2. Background

The western rock lobster, *Panulirus cygnus,* is exploited by commercial and recreational fishers along the lower west coast of Western Australia (Figure 2.1). The commercial fishery is Australia's largest single-species fishery, worth $200–$400 million annually with catches over the past decade averaging about 11,000 tonnes. Western rock lobster is the basis of the economy of a number of coastal towns and also supports an important recreational fishery.

Historically, the main focus of the assessment of the fishery has been on the status of the breeding stock with the aim of ensuring biological sustainability. However, the commercial fishery has been facing significant economic pressure from increasing costs and lower prices for lobsters as well as predicted reduced catches as a result of low recruitment of lobsters into the fishery. A bio-economic assessment of the management strategy was therefore important to help facilitate economic optimization of the fishery as well as maintain an adequate level of breeding stock. In recent years, the economic performance of the fishery has been receiving greater scrutiny (Winzer, 2009) and a comparison of the economic effects of the different management strategies proposed for 2005/06 was undertaken (Thompson and Caputi, 2006). In 2008, an assessment of the maximum economic yield (MEY) was also undertaken to assess the level of fishing effort that would maximise the net present value of profits over a six year period.

MEY occurs when the sustainable catch or effort level for the fishery as a whole maximises the overall profits of the fishery, i.e. creates the largest difference between total revenues and the total costs of fishing (Kompas, 2005). As explained by Kompas (2005), when assessing if profits have been maximised, the level of boat capital and other resources, in combinations that minimise the costs of harvest at the MEY catch level, must also be taken into account. The fishery cannot be overcapitalized and vessels must use the right combinations of such inputs as gear, engine power, fuel, hull size and crew to minimise the cost of a given harvest. Some key aspects of MEY are that, in most cases, MEY will imply that the equilibrium stock of fish is larger than that associated with 'maximum sustainable yield' (MSY). Furthermore, the catch and effort levels associated with MEY will vary with a change in the price of fish, the cost of fishing and recruitment abundance. Thus, if the price of fish increases, it pays to exploit the fishery more intensively, albeit at yields still less than MSY. In contrast, if the cost of fishing rises, it is preferable to have larger stocks of fish and thus less effort and catch.

While the concept of MEY has been known and considered for many years (Gordon, 1954), it has not been implemented in the management of many fisheries. The Australian northern prawn fishery is one of the few that has adopted a dynamic version of the MEY target (Kompas *et al*., 2010). They use a size-structured population dynamic model for three prawn species in the fishery that forms the basis of evaluating the catch and fishing effort that maximizes the net present value (Punt *et al*., 2010). The move to MEY for this fishery was part of Australian Commonwealth fisheries harvest strategy policy which specifies that MEY is a target for the management of those fisheries (Department of Agriculture, Fisheries and Forestry, 2007). The western rock lobster fishery, however, is managed by the Western Australian Government (Department of Fisheries) which has decided to evaluate whether to use MEY as appropriate management harvest strategy target.

An important component in the stock assessment and management of the western rock lobster fishery for over 30 years has been catch predictions based on the level of puerulus settlement (post-larval settling stage that is sampled monthly using artificial collectors) 3-4 years earlier (Phillips,1986; Caputi *et al*., 1995; de Lestang *et al*., 2009). This has enabled managers, when considering management options for this fishery, to account for expected recruitment trends. This predictive ability has been particularly useful recently as there has been a period of unusual settlement decline over the last seven years (2006/07 to 2012/13) which include the two lowest settlements in 2008/09 and 2009/10 in the 40-year time series of recruitment data. Therefore, in addition to the economic difficulties experienced by the fishery in recent years, in 2008, the fishery had to deal with the prospect of an extended period of low recruitment to the fishery and predicted lower catches.

As a result of the low puerulus settlement, substantial changes were made to the management of the fishery for the 2008/09 and 2009/10 seasons (44 and 73% reduction in nominal fishing effort, respectively, relative to the 2007/08) to reduce catch levels in the fishery. This resulted in a significant carryover of legal lobsters into future years when lower recruitments to the fishery were expected.

While the changes to the management of the fishery were undertaken to achieve stock conservation objectives through the forecast recruitment downturn, the effort reductions were similar to those that were required to achieve the MEY level. These radical management actions provided a unique opportunity to assess the economic impact of a fishery moving to an MEY level over two years.

The purpose of this study was to: (a) estimate the MEY level of fishing effort, i.e. the level of effort that would maximise the net present value of profits over the period 2008/09 to 2013/14, taking into account the forecast decreases in recruitment; (b) assess the actual economic effect of implementing management measures in 2008/09 and 2009/10 that was similar to the MEY level of effort identified; (c) assess the economic effect of moving to Individual Transferable Quota (ITQ) system of management for 2010/11; and (d) undertake the MEY assessment under the ITQ management and reflecting the fishery moving to a 12-month season. This assessment provides valuable information for the development of the target level of fishing under MEY that may be appropriate for an economic objective in the management harvest strategy. This target would complement the current harvest strategy decision rule for the fishery which is focused on the sustainability objective of egg production being maintained above a threshold level.

Background to fishery

The western rock lobster fishery was one of the first to be made limited entry, with the number of licences restricted since 1963. Over the last 10 years, the annual catch ranged from around 8,000 to 14,500 tonnes while annual prices varied from around AUS$19 to 34/kg. The commercial fishery, which is divided into three zones – A, B and C (Figure 2.1), was managed using input controls until the 2010/11 season with a nominal target catch level set for 2008/09 and 2009/10 . The primary input controls were a limit on the total number of pots and available fishing days, which places an overall cap on nominal effort (measured as pot lifts). These controls were applied for achieving sustainability objectives, and for 2008/09 and 2009/10, were also used to achieve the nominal catch target.

Effort in the commercial fishery is unitised with a relatively liberal transferability provision which allows adjustment to the number of boats operating and individual operations in response to changing economic conditions. The number of units an operator holds is used to determine the number of pots that could be operated. This system of management is known as an Individually Transferable Effort (ITE) system. In effect, each unit represents a fixed percentage share of the total allowable effort in the fishery. Units are fully transferable resulting in an active market for the lease and purchase of units.

Historically, the input management regime focused on setting the total allowable effort (TAE) to levels aimed at delivering a sustainable breeding stock, rather than restricting catch to a given level. Following the lowest puerulus settlement on record (40 years) during the

2008/09 settlement period, management has been focused on ensuring the protection of breeding stock as well as providing for a carry-over of stock into future seasons i.e. into years when the lower recruitment was expected. This was achieved through the setting of a specific nominal catch level with severe effort reductions in pot numbers and on the number of available fishing days imposed, as well as other measures such as increased protection of large females, in the 2008/09 fishing season (de Lestang *et al*., 2012). These management restrictions were subsequently increased for the 2009/10 season in order to achieve a nominal target catch of 5,500 tonnes. The net effect of these reductions in unit value (i.e. pots allowed for fishing) and days fishing were reductions in nominal fishing effort of 44 and 73% in 2008/09 and 2009/10 compared to 2007/08.

For the 2010/11 season, a new management regime based on ITQs under which units are associated with a right to catch a specified weight of lobsters, was introduced.

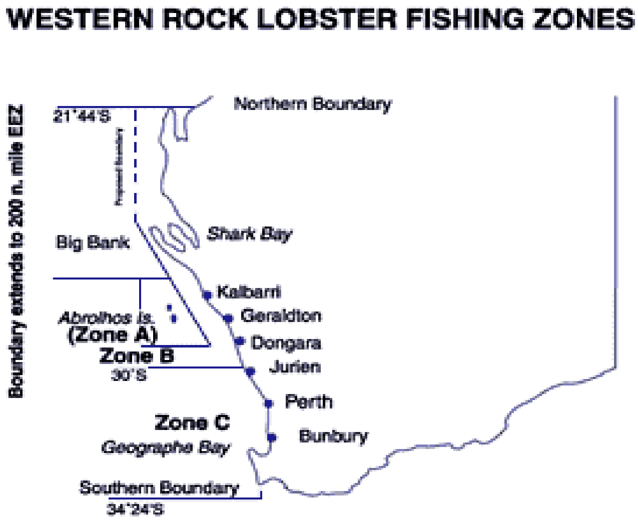

Figure 2.1. The boundaries of the western rock lobster fishery in Western Australia with the three management zones (A, B and C), with the Big Bank region being part of Zone B.

3. Need

The western rock lobster fishery was facing significant economic pressure in the mid-2000s from the cost-price squeeze as well as reduced catches as a result of low puerulus settlement and resultant management changes. It was therefore important to undertake a bio-economic assessment of the management strategies to ensure economic optimization of the fishery. As a result of the low puerulus settlement, there have been significant reductions in fishing effort (44-73% in 2008/09 and 2009/10) that have affected the economic aspects of the fishery e.g. MEY assessment and reducing the peak catches in March-April. The effort reductions have also been focused on periods of peak catches in December and March/April (4 days fishing allowed) compared to the non-peak periods (5 days fishing allowed) to obtain some market benefits. The move of the fishery from an input control fishery to an output control fishery using ITQ for the 2010/11 season has also changed the fishing strategy and hence cost structure of fishers which will affect the MEY assessment. It was thus important that an economic assessment was undertaken given this new strategy. The proposed use of the MEY assessment in informing the target for the harvest strategy control-rule framework for the management of the fishery means that it will be an integral part of the catch quota setting process each year.

4. Objectives

1. To estimate the annual catch and effort to achieve optimum economic yield
2. To evaluate intra-annual market-based management strategies.
3. To evaluate the economic effect of current and proposed management changes.

5. Methods

The approach adopted for the MEY assessment of the western rock lobster fishery involved two stages. The first stage estimated the catch and fishing effort for different levels of fishing using a stock assessment model. The original stock assessment model which was based on the effort-controlled fishery, was developed in 2007 and then updated as a result of two major reviews and the fishery moving to a catch-control fishery for the 2010/11 season (de Lestang *et al*., 2012). The second stage involved assessing the economic effects on revenue, number of vessels, costs and profits for the different effort levels based on the output from stock assessment model.

5.1 Optimum economic yield under effort controls

The objective of the MEY analysis was to estimate the level of effort in each Zone of the fishery that would maximise the net present value (NPV) of profits over the period 2008/09 to 2013/14. This was undertaken by estimating the difference between the predicted NPV of profits under a range of effort levels (10 to 90% of 2007/08 effort) and the predicted NPV of profits under 2007/08 effort levels over the specified period, using a discount rate of 10% per annum. The differences were driven by variations to fishing costs that arise through changes to the level of effort and catch in the fishery. Differences in fishery profit, by Zone, during a given season were obtained by estimating differences in fishery revenue and fishery costs between the 2007/08 effort levels and the range of different effort levels.

Inter-annual differences in fishery revenue, by Zone, were calculated using predicted differences in catches and recent prices. Differences between the catch predicted under the 2007/08 effort level and that predicted under alternative scenarios of effort levels ranging between 10–100% (measured by the number of pot lifts) were based on stock assessment modelling (de Lestang *et al*., 2012). This modelling estimated future catches using a recruitment level based on current levels of puerulus settlement and the level of effort level observed for the 2007/08 season.

Initially, prices were based on average prices for 2005/06 to 2007/08 of about $27/kg and were assumed to be perfectly inelastic, i.e. that changes in catch levels would not cause changes to the price received. Thus, differences in fishery revenue were assumed to occur solely as a result of changes in the level of catch taken. While it is recognised that prices will change from season to season as a result of exogenous factors, such as changes to exchange rates and global supply levels, the analysis was not seeking to predict these changes, but rather to predict the differences in revenue/costs/profits within a season under different effort/catch levels within that season.

Assuming a fixed lobster price was regarded as a conservative assumption as no increase in price was assumed with a lower catch. The assessment was also undertaken using a variable price based on a relationship between price, catch and exchange rate (with the USA dollar):

$$\text{Price} = a + b \log(\text{catch}) + c \log(\text{exchange rate})$$

where a, b, and c are regression parameters.

Differences in fishery costs, by Zone, were calculated using predicted cost per unit of effort (i.e. the cost of a pot lift) under 2007/08 levels and the given effort level relative to 2007/08. The cost of a pot lift under 2007/08 effort levels was estimated to be $25 per pot lift based on information provided by industry (Winzer, 2009). These costs include operating costs (excluding licensing fees) plus asset depreciation. The cost per pot lift at a given level of effort was based on predicted future vessel costs and pot lifts per vessel per season at the given effort level.

Predicted pot lifts per vessel per season under a given effort level were calculated based on predicted vessel numbers and the given effort level. Predicted vessel numbers were calculated as follows; under 2007/08 effort, vessel numbers were assumed to remain constant; while under a reduced effort level it was assumed that the number of vessels in the fishery would take three years to be reduced by a level commensurate with the effort reduction i.e. in 2008/09 vessel numbers would be proportionately one-third of the effort reduction less than 2007/08 levels; in 2009/10 vessel numbers would be proportionately two-thirds of the effort reduction less than 2007/08 levels and by 2010/11 vessel numbers would be proportionately the effort reduction less than in 2007/08 and would remain at this level through to 2013/14. This assumption would result under an effort reduction of 60%, for example, in vessel number and pot lifts per vessel per season being 20 and 50% lower respectively in 2008/09. In 2009/10 vessel numbers and pot lifts per vessel per season are 40 and 33% lower respectively than if effort remained at 2007/08 levels. In 2010/11 vessel numbers are 60% lower and pot lifts per vessel are at the same level as before the effort reduction. Predicted cost per pot lift was then calculated based on the assumption that 75% of vessel costs were fixed and 25% varied with vessel effort levels.

The above process results under an effort reduction of 60%, for example, in pot lifts per vessel being 50% lower, vessel costs 12.5% lower, cost per pot lift 75% higher and fishery costs 30% lower in 2008/09 than if effort had remained at 2007/08 levels. In 2009/10 pot lifts per vessel are 33% lower, vessel costs 8.3% lower, cost per pot lift 38% higher and fishery costs 45% lower than if effort had remained at 2007/08 levels. In 2010/11 vessel effort, vessel costs and cost per unit effort are the same as if effort had remained at 2007/08 levels but fishery costs are 60% lower.

The difference between predicted vessel profits at a given level of effort compared to that predicted under 2007/08 levels was calculated by Zone, based on the calculated differences in vessel revenue and costs. From this the difference between predicted fishery profits at a given level of effort compared to that predicted under 2007/08 levels was calculated by Zone based on the difference in vessel profits and the predicted fleet size at the given level of effort.

MEY is dependent on prices and costs and both can move significantly over short time frames. To obtain an indication of the sensitivity of the results to variation in prices and cost, the analysis was rerun under six scenarios: the combination of three cost levels (as estimated, 20% higher and 20% lower) and three price levels (as estimated, 20% higher and 20% lower). The sensitivity of the analysis to the discount rate was also assessed using rates of 0, 5 and 10%.

5.2 Assessment of 2008/09 and 2009/10 (effort-controlled years)

The catch, catch per unit effort (CPUE), revenue, vessel numbers, fishing costs and profitability that have occurred as a result of the nominal effort reductions of 44 and 73% for the whole fishery in 2008/09 and 2009/10, respectively (i.e. effort at 56 and 27% of 2007/08 level, respectively) were estimated and compared to what was predicted by the above MEY assessment.

The predicted catch and CPUE under the 2007/08 and actual effort levels are, as previously outlined, derived from the stock assessment modelling results. Predicted results under actual effort levels for 2009/10 are based on two seasons of effort reductions at the level specified when the MEY modelling was undertaken, assuming constant effort for the six years after 2007/08. For Zone C, for example, the actual levels of effort in 2008/09 and 2009/10 were 60 and 26% of the 2007/08 level. However, the predicted catch level under the actual effort level for 2009/10 is that associated with 26% of the effort level in 2007/08, for both 2008/09 and 2009/10.

The price-catch relationship was used to estimate the beach price that would have been obtained with catch achieved under the maintenance of 2007/08 effort level.

The difference in fishery costs was determined between that predicted under the maintenance of 2007/08 effort levels and that predicted for the reduced effort levels and actual costs. The assumption that 75% of vessel costs are fixed and 25% are variable was maintained as per the MEY assessment above in estimating difference in predicted and actual costs. The number of vessels in the fishery in 2008/09 and 2009/10 and the number of pot lifts made per vessel were determined and compared to the predicted levels. The operating costs per pot lift such as bait, fuel and crew costs were assumed to be the same for the years examined.

5.3 Assessment of 2010/11 and 2011/13 (quota-controlled years)

The assessment of the 2010/11 and the extended 2011/13 seasons provided a comparison between the effort and quota control seasons. An assessment was undertaken on the changes in (a) spatial and temporal pattern of fishing; (b) number of vessels operating; (c) effect of high grading; (d) effect on product type (e.g. percent live market) and grade categories; (e) variable costs such as bait and fuel; (f) beach price of lobsters and the price differences between months, grades and quality; and (g) licence values and lease costs.

The relationship between price, catch and exchange rate (with the USA dollar) (see Section 5.1) was also re-examined to assess the effect, on price, of the move to catch quotas:

$$\text{Price} = a + b \log(\text{catch}) + c \log(\text{exchange rate}) + d\,(\text{Quota years})$$

where a, b, c and d are regression parameters. The parameter d provides an estimate of increase in the average price obtained for rock lobsters since 2010/11 that could be attributed to the move to individual catch quotas where Quota years is a dummy variable with a value of 1 for years since 2010/11 and 0 for the earlier years.

5.4 Optimum economic yield under ITQs

The assessment of MEY under an ITQ system was undertaken to account for the associated management changes and resulting changes in the pattern of fishing as a result of moving from an input to an output-controlled fishery. There were two components to this MEY assessment: (a) stock assessment model for evaluating the effects of different levels of fishing; and (b) economic assessment of the stock assessment output.

The stock assessment was undertaken with an updated stock assessment model (de Lestang *et al*., 2012) that was similar to that used for the effort-controlled MEY assessment (Section 5.1) but modified to take into account the changes associated with moving to catch quotas (and include the most recent data in the analysis). Catch and effort data, up to and including the 2011/13 season, were thus included, as inputs, into the model as well as puerulus settlement data for 2012/13. The following assumptions were made in the stock assessment model:

- Puerulus settlement for years after 2012/13 and would be similar to 2012/13;
- Monthly effort distribution for future years in the coastal zones (B and C) would be similar to 2010/11 and 2011/13;
- Monthly effort distribution for the time periods that were not fished for the coastal fishery in Zones B and C (1 October to 14 November) up to 2011/13 was set at 80% of effort in September and for the Abrolhos zone the effort was set as per available data in the 2013/14 season;
- High grading would occur at the level of the 2010/11 season;
- The northern zones (A and B) and the southern zone (C) were evaluated separately;
- The catch quota would be taken for 2013 and that the effort would be spread over 12 months available for fishing;
- The catch shares for Zones A:B catch was fixed at 0.359:641 as proposed in the harvest strategy discussion paper and used in recent years of quota setting (Department of Fisheries, 2012, 2013 – see Attachment 1).

The assessment was undertaken for the 5 seasons (2014 to 2018 with the 12 month season starting on 15 January) for fixed levels of legal proportion harvest (LPH) from 0.1 to 0.9, where LPH was defined as the proportion of catch from the average legal biomass per month assuming no fishing had taken place for the year. The model outputs by northern (zone A and B combined) and southern regions for the five seasons for different levels of LPH were catch, effort (pot lifts), CPUE and egg production. The estimated effort to achieve the catch quota, and hence the catch rate is sensitive to the assumption of the monthly distribution of effort outlined above as catch rates vary significantly between months. Therefore projected annual catch rates under different scenarios of LPH are comparable to each other but are not directly comparable with historic annual catch rates as they were achieved under different monthly distributions of effort.

The economic assessment of the stock assessment output was undertaken to estimate the NPV of profits over the five seasons at different levels of LPH and hence estimate the range of LPH associated with MEY level of fishing. The following assumptions were made in the economic assessment:

- The number of vessels operating was dependent on changes in pot lifts, taking into account the number of vessels and pot lifts during two recent seasons (Fig. 5.4.1);
- Beach price - catch relationship to determine expected change in the annual beach price due to changes in catch after taking into account the price premium estimated to be associated with the move to ITQ and exchange rate (see Section 5.3);
- Costs were similar to 2007/08 with an estimated reduction for movement to quota due to lower bait and fuel costs as obtained from some preliminary estimates (see Section 6.3);
- There were three components to costs: (a) fixed annual costs including vessel depreciation ($85,000 per year); (b) operating costs including bait and fuel of $7 per pot lift; and (c) wages based on 30% of the value of catch.
- Discount rate of 5 and 10% per annum for future profits.

Some alternative relationships between vessel numbers and pot lifts were also examined as part of the sensitivity analyses in the MEY assessment based on fixing the boat numbers at the 2013/14 levels (280 boats) but only adjusting them if the maximum pot lifts per boat is exceeded. An estimate of the maximum effort per boat under the ITQ management arrangements was obtained assuming fishers would fish 10 months for 15 days/month using an average of 120 pots per day (i.e. assuming mostly 2-day soak times). This results in a maximum of 18 000 pot lifts per boat. If the level of effort required in any year to achieve the catch quota based on 280 boats resulted in greater than 18,000 pot lifts per boat then the boat numbers were estimated by dividing the total effort by 18,000.

Sensitivity analyses were also undertaken to assess the effects of:

- Discount rate used in the NPV assessment (0, 5 and 10%);
- Cost variation +/- 20%;
- Price variation +/- 20%;
- Cost and price variation in combination +/- 20%;
- Recruitment being set at average levels for recruitment to the fishery from 2014/15 to compare with the current actual levels of recruitment that have been below average for seven years.

The range of LPH and associated catch quotas that provided the MEY level over the next 5 years was then considered in the development of a reference target range for the management of the fishery under the harvest strategy being developed for the fishery. Additional considerations in the development of target reference range at different levels of LPH that were close to MEY were other socio-economic indicators such as:

- Value of production (GVP);
- Number of vessels (and hence employment) likely to be operating;
- Trends in catch rates over the 5 seasons.

An assessment was also undertaken of the effects of removing some existing management controls such as protection of female maximum size, setose (mature females) and lobsters 76-77 mm carapace length on the egg production, catch, catch rates and MEY results.

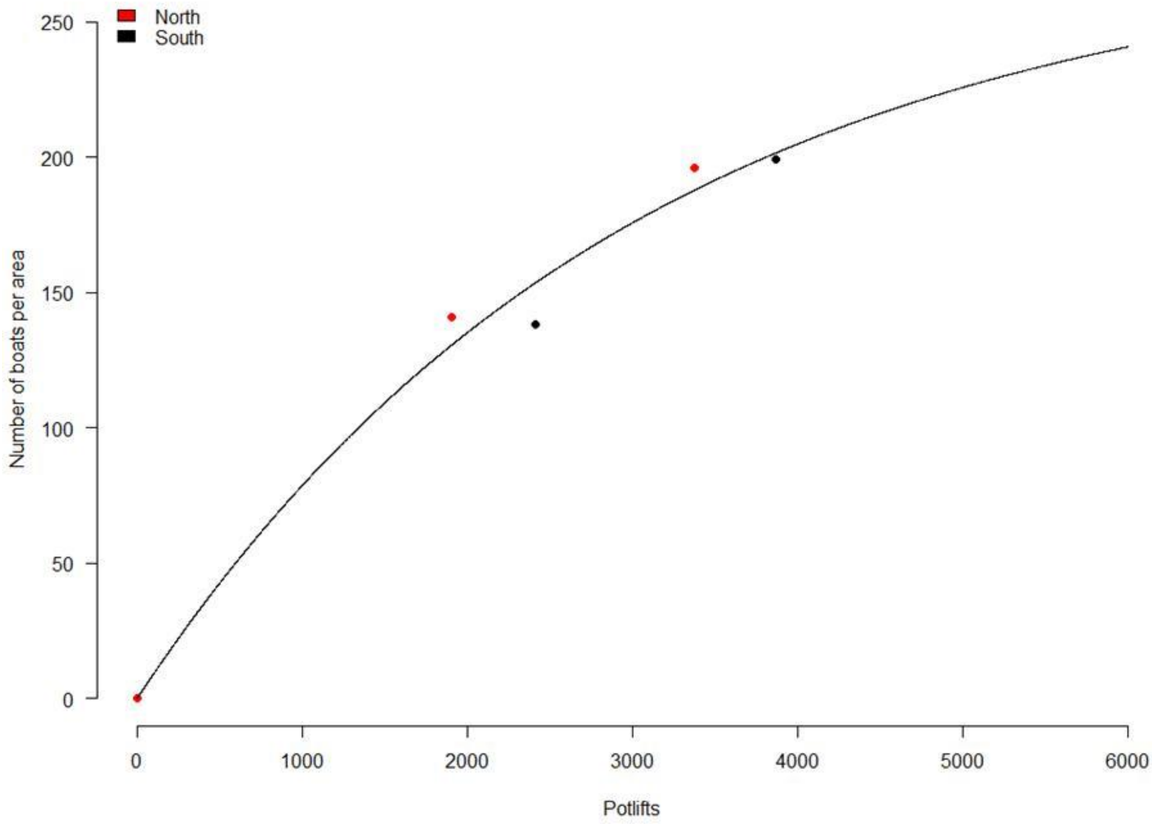

Figure 5.4.1. Relationship between expected number of boats that would be fishing in a given season in the northern and southern regions for the estimated pot lifts that would be expected to take the TACC. This assessment uses data from a recent fishing season with higher effort (2008/09) and the current season with an estimated lower effort (2013).

6. Results and Discussion

6.1 Optimum economic yield under effort controls

The effect of the different levels of effort reductions introduced in 2008/09 results in stock assessment model estimates of reductions in total catches over the period 2008/09 to 2013/14 were of a far lesser magnitude than the effort reduction itself (Figure 6.1.1).

For example, a 50% effort reduction introduced in 2008/09 was estimated to result in a catch reduction over the period 2008/09 to 2013/14 of 13% overall, with 6, 15 and 14% in Zones A, B and C, respectively, compared to catch estimates for continuing the 2007/08 effort levels. Much of the reduction in catch is borne in the first year of the effort reduction as the subsequent years gain the benefit of catch not caught in the preceding years (Figure 6.1.2). The catch reductions for the 50% effort reduction for the five years (2009/10 to 2013/14) after the first year was 8% overall and 4, 11 and 9% for Zones A, B and C, respectively.

Under effort reductions, predicted declines in catch levels are substantially mitigated by increases in catch per unit effort after the first year, as demonstrated by the effect on predicted CPUE under 2007/08 effort levels and under 50% of 2007/08 effort levels (Figure 6.1.3).

The estimated net present value (NPV) of the potential additional future profits under varying effort levels over the period 2008/09 to 2013/14 indicates that, in all Zones, the NPV of potential additional future profits is maximised with effort levels at 30-50% of 2007/08 levels i.e. effort reductions of 50-70% (Figure 6.1.4).

In Zone A, NPV of potential additional future profits is around $40-45 million dollars levels over the period 2008/09 to 2013/14 or about $7 million per season on average. In Zone B, it is around $70-80 million in total or about $12-13 million per season on average and in Zone C, it is around $135-145 million in total or about $22-24 million per season. This results in an overall effect on the fishery of over $40 million per year. It is important to note that as the fleet adjusts in the initial period following the effort reduction, fishery profitability may be less than if no action had taken place. For example, a 50% effort reduction in Zone C (Figure 6.1.5) was estimated to result in a loss for the first year following the change. This reflects the assumptions that the loss in catch would be highest in the first year (Figure 6.1.2) and the benefits associated with the reduced costs from vessels move out of the fishery taking three years to be fully realised.

The results indicate that MEY (measured as the NPV of future profits between 2008/09 and 2013/14) would be achieved with effort levels that are in the order of 50-70% lower than 2007/08 effort levels in all Zones. The results indicate that the percentage reductions in catch required to achieve MEY are far lower than the reduction in effort that would be required to achieve MEY. MEY is thus achieved with catch levels in the order of only 5-10% lower over the period 2008/09 to 2013/14 than that which would be taken if effort levels were maintained at 2007/08 levels in Zone A and 15-20% lower in Zones B and C. However, as shown above, after taking into account that a large loss would occur in the first year, the long-term effect on catch for the whole fishery would be about 5-10% based on a 50% reduction in effort to achieve MEY.

The sensitivity analysis indicates that changes in prices and costs influence the effort level associated with MEY. However, even under the most optimistic scenario where costs are 20% lower and prices are 20% higher, the effort level associated with MEY for the whole fishery is still in the order of 40-60% of the 2007/08 effort level (Fig. 6.1.6). Under the pessimistic scenario of costs increasing and prices declining by 20%, a lower effort reduction of 20-40% of the 2007/08 level is required to achieve MEY. Therefore, an effort level of 40% of 2007/08 level (i.e. effort reduction of about 60%) would be a reliable estimate of the MEY level under varying prices and costs for the fishery.

After the initial MEY assessment assuming a fixed price, an assessment was undertaken of the relationship between price, catch and the exchange rate. The multiple regression analysis indicated that total catch levels and exchange rates had a significant effect on beach prices (R^2=0.49, $p<0.001$) and the relationship was estimated as:

$$\text{Beach price} = 158.308 - 14.81 \ln(\text{Total catch}) - 9.669 \ln(\text{Exchange rate})$$

with the coefficient of the total catch being highly significant ($p<0.001$) and exchange rate being almost significant ($p=0.08$) (Figure 6.1.7).

The MEY assessment was then undertaken using this relationship to estimate the price and hence revenue associated with the different levels of catch and effort. The effect of using a variable price for reduced levels of effort and catch would be to increase the profitability associated with the effort reductions compared to the previous assumption of a fixed price irrespective of catch (Fig. 6.1.8). The level of effort associated with MEY under variable price is about 20-40% of the 2007/08 effort level compared to the 30-50% of 2007/08 level under a fixed price assumption.   Therefore, an effort level of 30-40% of 2007/08 would be optimal under both assumptions.

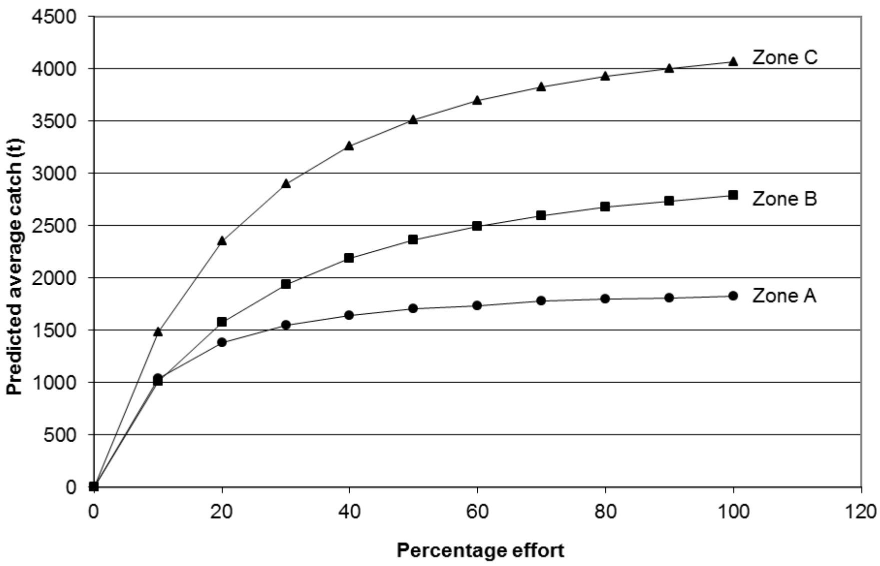

Figure 6.1.1. Predicted average catch over the 2008/09 to 2013/14 seasons by Zone under various effort levels, relative to the 2007/08 effort level, which is set at 100.

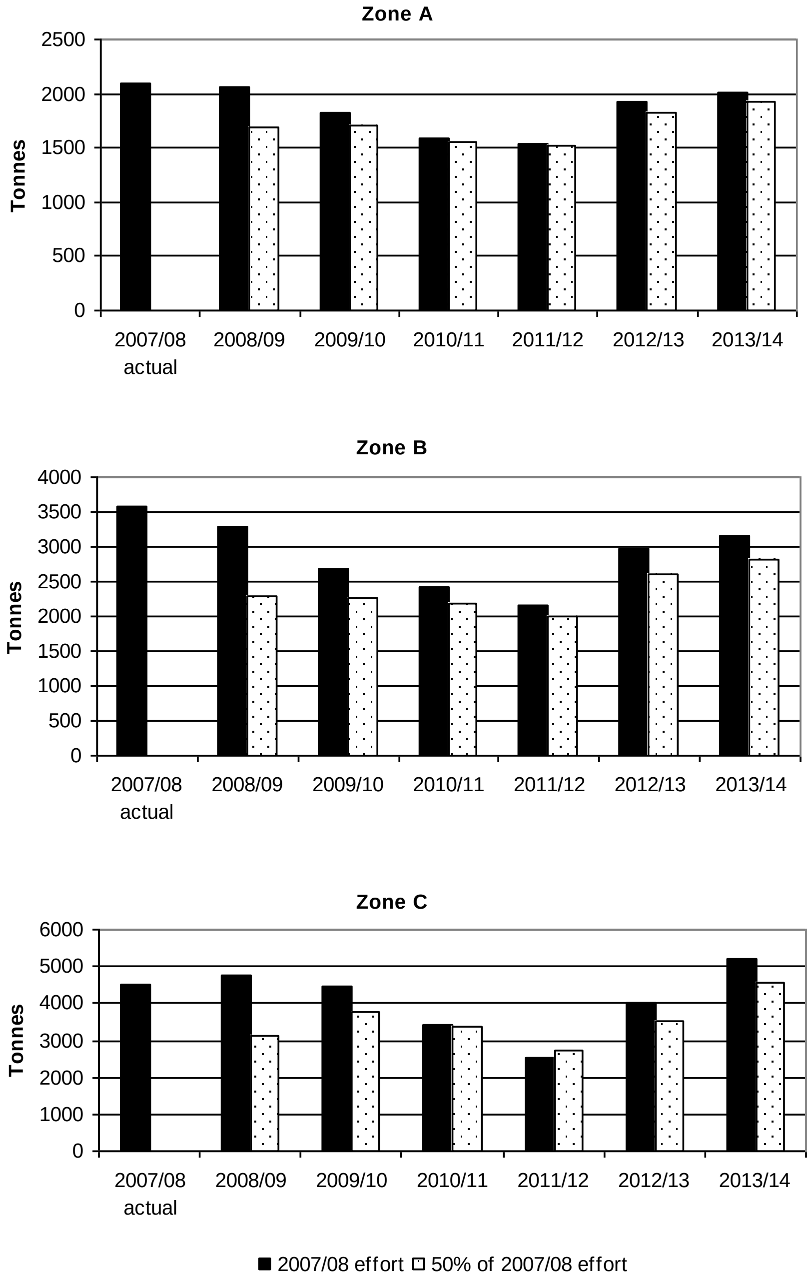

Figure 6.1.2. Predicted catch by Zone for 2008/09 to 2013/14 seasons under the 2007/08 effort level and 50% of the 2007/08 effort level.

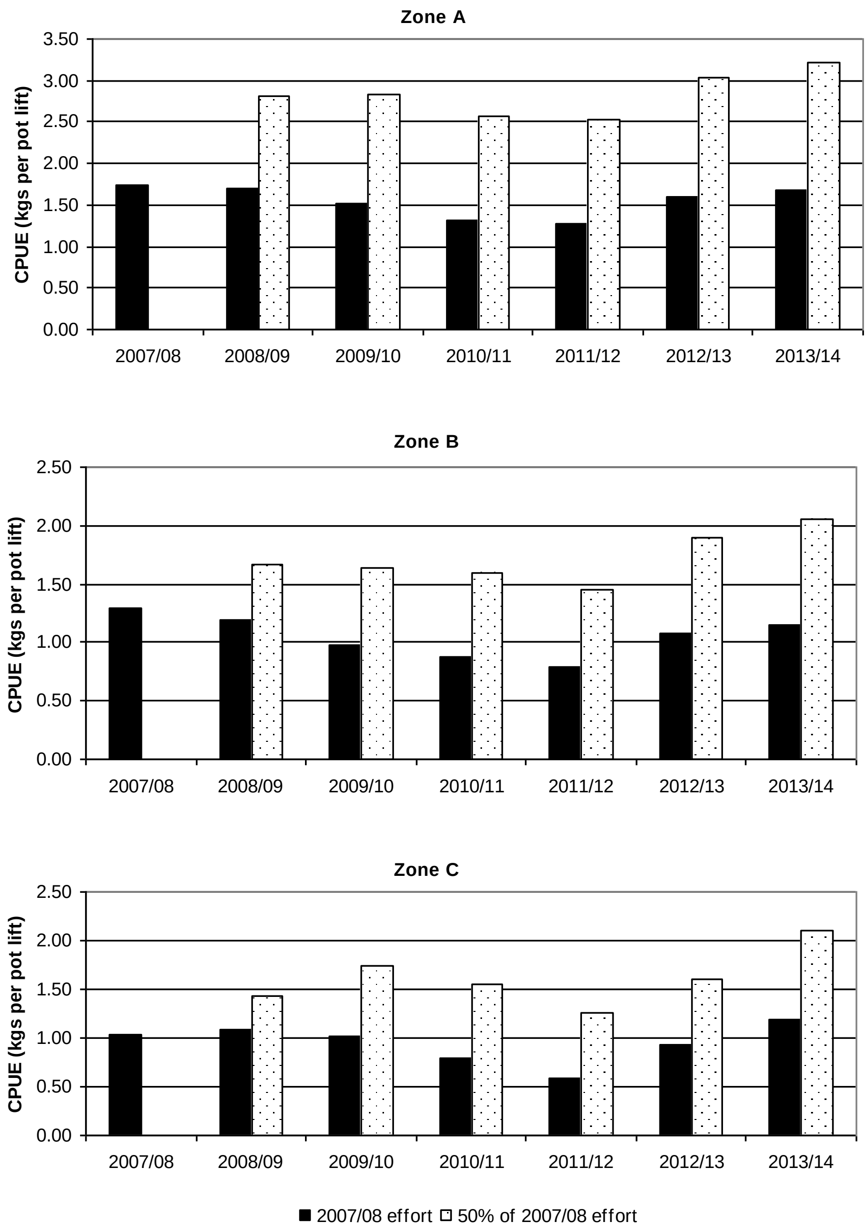

Figure 6.1.3. Predicted CPUE by Zone between 2008/09 and 2013/14 under the 2007/08 effort level and 50% of the 2007/08 effort level.

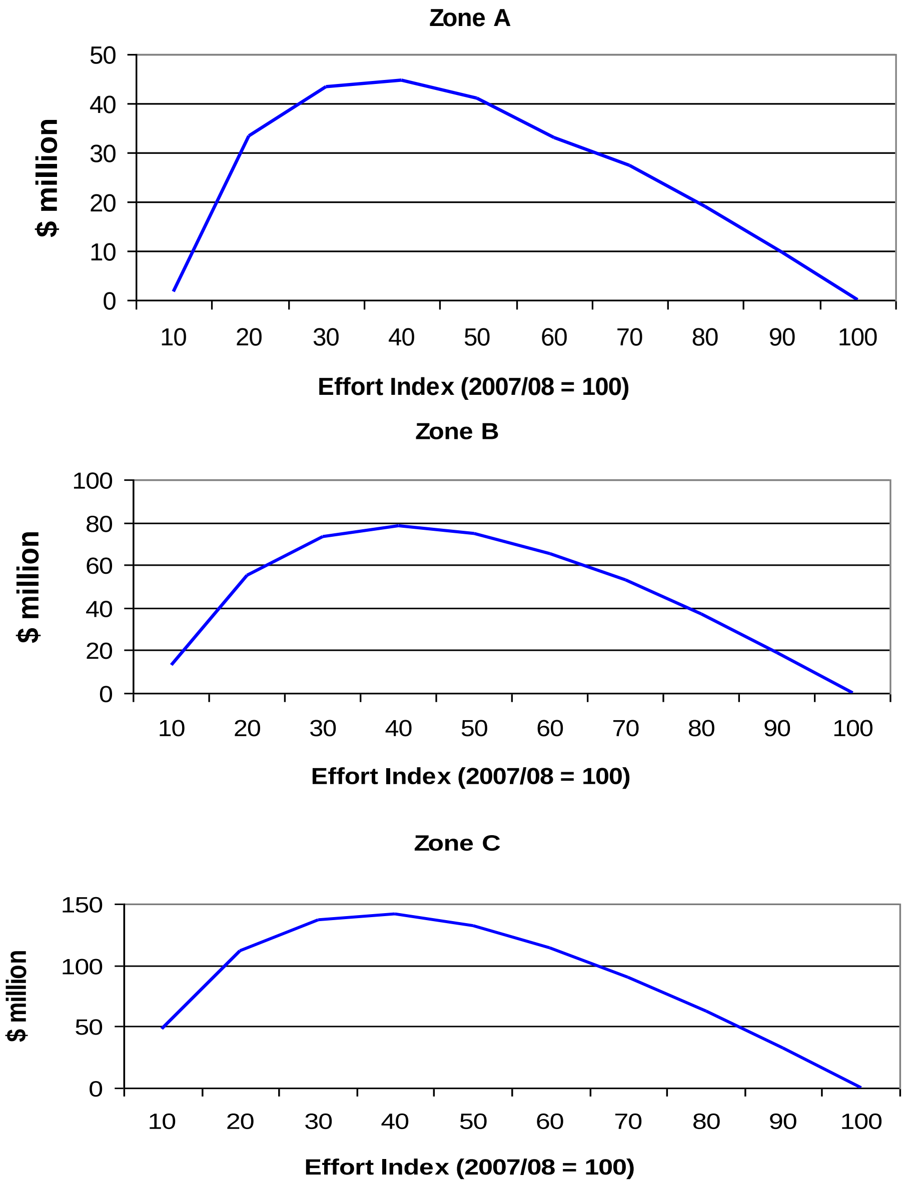

Figure 6.1.4. Total NPV by Zone of potential additional fishery profit between 2008/09 and 2013/14 under varying effort level.

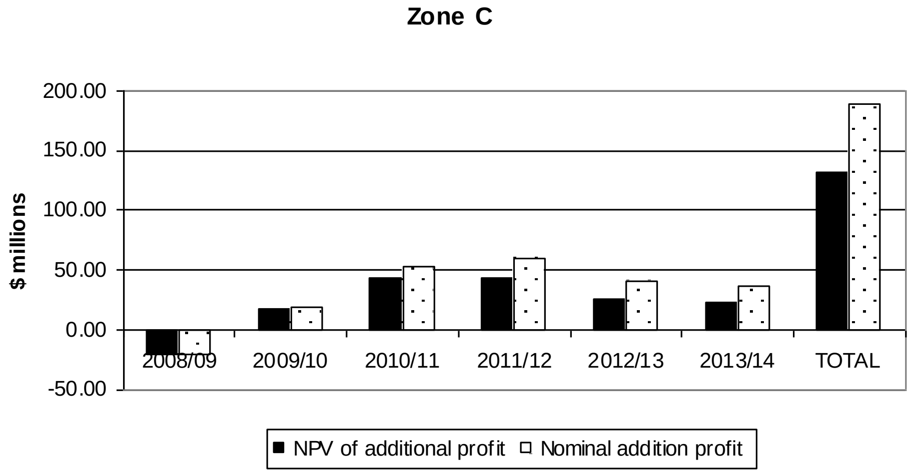

Figure 6.1.5. Nominal value and NPV of potential additional fishery profit by season for Zone C with effort at 50% of 2007/08 levels compared with 2007/08 effort levels for each year.

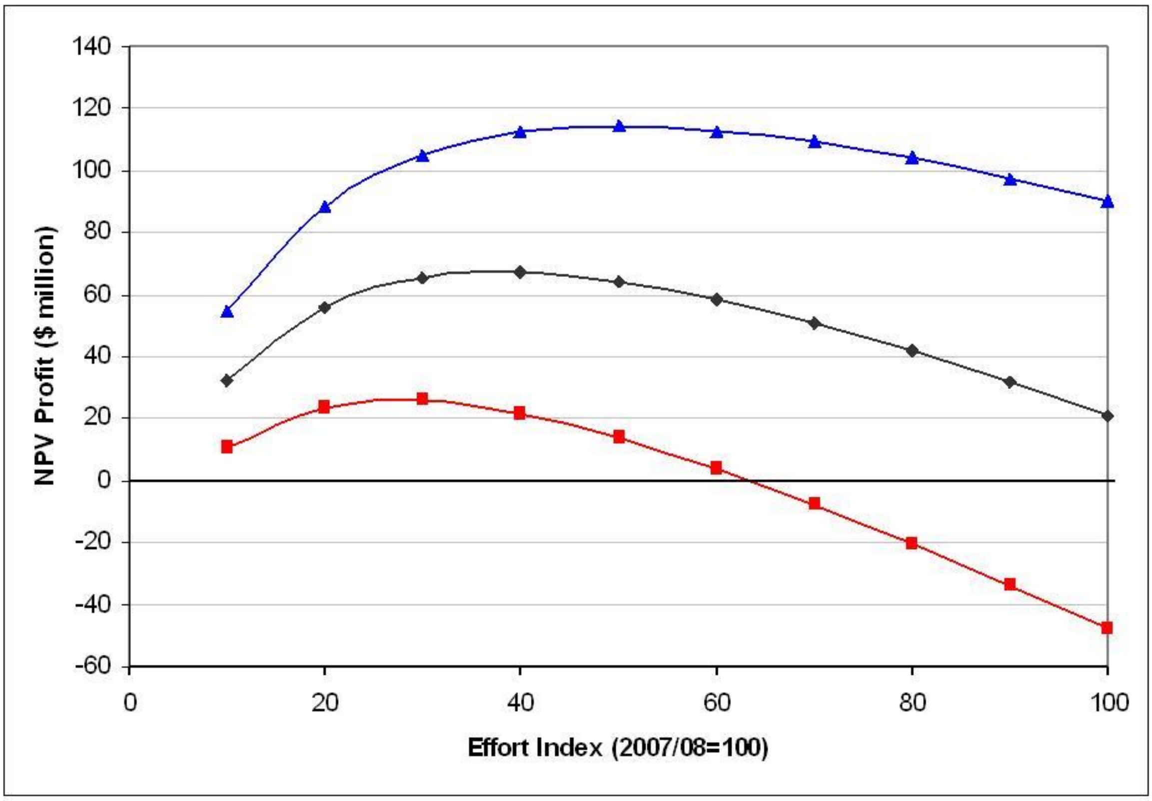

Figure 6.1.6: Average NPV of fishery profit per year between 2008/09 and 2013/14 under varying effort levels for the whole fishery. The middle black line represents the base case scenario while the upper blue line represents a scenario of a 20% increase in prices and a 20% decrease in costs, and the lower red line represents a scenario of a 20% decrease in prices and a 20% increase in costs.

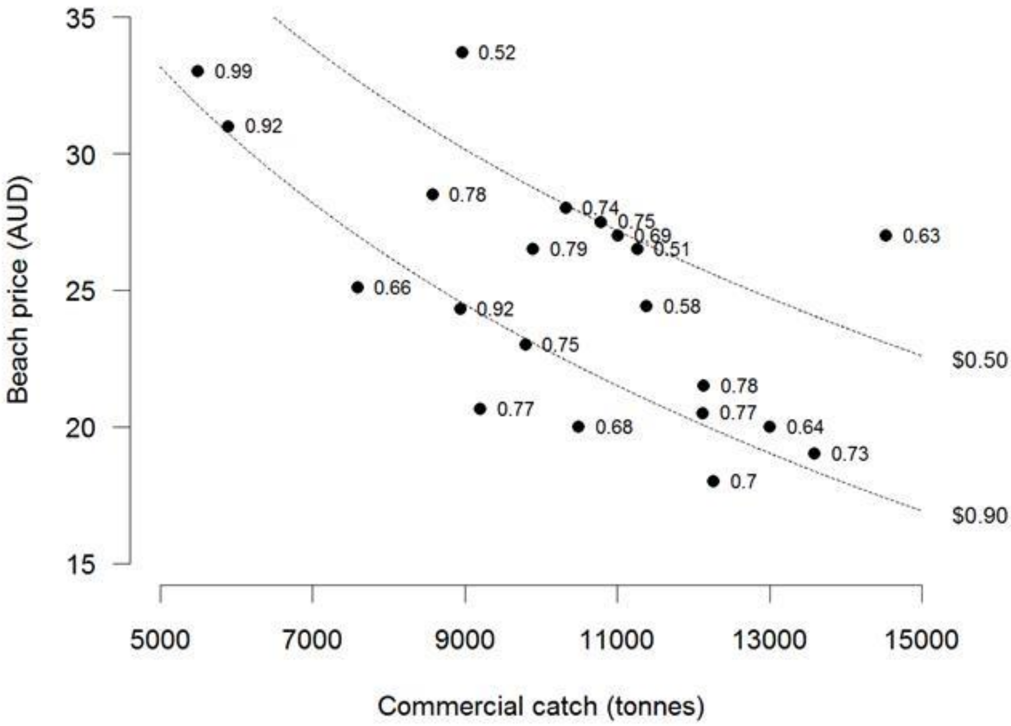

Figure 6.1.7. Relationship between the average annual price of lobsters paid to fishers and the annual catch (t) for 1992/93 to 2009/10 with the exchange rate between Australian and the US dollar for the year shown. The exchange rate for individual years is shown as well as the price-catch relationship at $0.50 and 0.90 exchange rates.

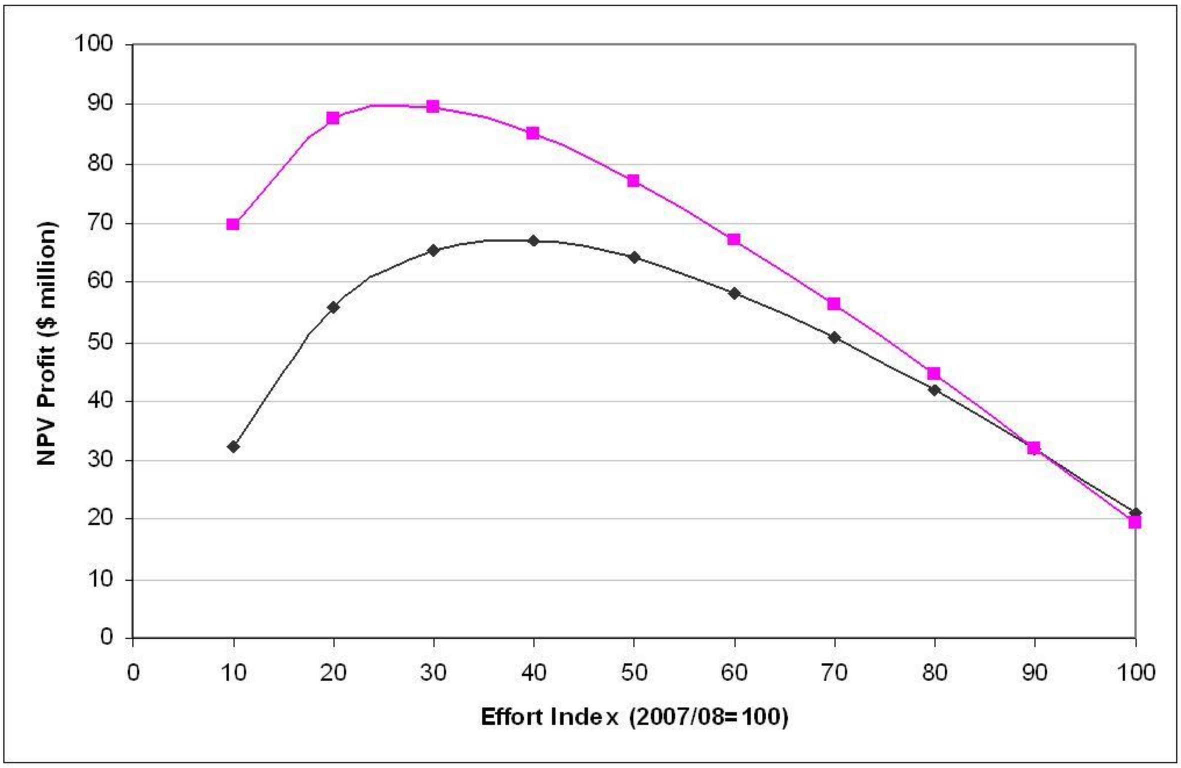

Figure 6.1.8. Average NPV of fishery profit per year between 2008/09 and 2013/14 under varying effort levels for the whole fishery. The lower black line represents the base case with prices fixed irrespective of catches while the upper purple line represents a variable price depending on the catch achieved.

6.2 Assessment of 2008/09 and 2009/10 (effort-controlled years)

The catch, effort and catch per unit effort (CPUE) for the fishery for 2008/09 and 2009/10 compared to the previous 40 years highlights the effect of the dramatic reduction in nominal fishing effort of 44 and 73% of the 2007/08 levels on the CPUE, with catch rates being double the historic average in the second year (Figure 6.2.1).

Fishery revenue

The predicted differences in fishery revenue by Zone were calculated using predicted differences in catch levels and as well as taking into account the difference in prices between the years.

Catch

Table 6.2.1 provides observed effort, catch and CPUE for 2007/08, 2008/09 and 2009/10 and predicted catch and CPUE for 2008/09 and 2009/10 under 2007/08 and actual effort levels for the respective season. The 44 and 73% effort reduction in 2008/09 and 2009/10 resulted in a 24 and 34% reduction in catch, respectively, compared to the expected catch under 2007/08 effort levels.

The modelling predicted significant increases in CPUE at the reduced effort levels that actually eventuated compared with levels predicted under a maintenance of effort at 2007/08 levels (Table 6.2.1). The actual CPUE did increase substantially compared with levels predicted under a maintenance of effort at 2007/08 levels. For the overall fishery, the actual changes in CPUE compared well with the predicted changes. For Zone A, the predicted CPUE increases under actual effort levels were greater than observed levels whereas for the B and C Zone they were less than observed levels. Nonetheless, the predicted CPUE under actual effort levels reflected the quantum of the actual observed changes reasonably well, in contrast to the scepticism expressed as to the likelihood of such CPUE increases being achieved (see, for example, Starck, 2009). This resulted in the predicted catch under actual effort levels being within 5% for the overall fishery and within ±20% of actual catch for the individual zones. This is a particularly good result, when consideration is given to the extremely large reductions in actual effort levels and that fishing activity at or near such effort levels have not been observed for decades in the fishery.

Prices and Revenue

The actual average beach price for 2008/09 was similar to that for 2007/08 while the average beach price for 2009/10 was about 25% higher than in 2007/08. Based on the price-catch relationship (Section 6.1) and the prevailing exchange rates, actual total catch and predicted total catch under 2007/08 effort level, it is estimated that prices during the 2008/09 season were 16% higher than they would have been under the maintenance of the 2007/08 effort level. Similarly, 2009/10 season prices are estimated to be 25% higher than they would have been under the maintenance of 2007/08 effort level. These estimates are used in calculating the difference between actual revenues and that predicted under the maintenance of 2007/08 effort level (Table 6.2.2). The higher prices associated with the lower catch are probably due to a higher proportion of the catch being sold to the live market.

For the whole fishery, the actual reductions in fishery revenue were much less than expected, mainly due to the higher prices than those that would have been received at catch levels associated with the maintenance of 2007/08 effort levels. These price changes were not taken into consideration in predicting fishery revenues in the MEY assessment. For Zone A the actual reductions in fishery revenue were similar to predicted reductions under actual effort with actual catches declining more than predicted but this being offset by higher prices. In Zones B and C, however, actual fishery revenue fell less than that predicted as a result of the reductions in actual catch being lower than predicted and the higher prices.

Fishery costs

The actual vessel numbers declined by 14% compared to 2007/08, with the predicted vessel numbers under actual effort levels in 2008/09 predicted to decline by 17% for the overall fishery (Table 6.3.3). In Zone A, the predicted vessel numbers under actual effort levels were 5% lower than actual vessel numbers, with the decline in vessels being 15% rather than the predicted 19%. In Zone B, predicted vessel numbers under actual effort levels were 10% lower than actual vessel numbers with the decline in vessels being 25% rather than the predicted 16%. In Zone C, predicted vessel numbers under actual effort levels were less than 1% lower than actual vessel numbers with the actual and predicted decline in vessels being 13%.

For 2009/10, the vessel numbers declined by 36% compared to 2007/08, however, predicted vessel numbers under actual effort levels were significantly lower for all Zones, being 21% lower overall. This discrepancy is probably due to the fact that effort reductions, particularly in the 2009/10 season, were achieved by a combination of reductions in pot numbers and the number of available fishing days whereas the MEY analysis implicitly assumed that effort reductions would be achieved solely through pot reductions, with changes in pot lifts being directly proportionate to changes in pot numbers. In addition, the modelled MEY assessment assumed that the effort reduction in 2009/10 was the same as 2008/09, whereas the actual reduction in 2008/09 (44% overall) was less than 2009/10 (73% overall), therefore a smaller reduction in fleet would be expected in 2009/10. This results in predicted pot lifts per vessel in 2009/10 being significantly greater than actual pot lifts per vessel (Table 6.2.3).

Significant reduction in fishery costs of $44 and 91 million in 2008/09 to 2009/10 were achieved over those two years with the reduction in fishery costs being about 20% less than that predicted for the overall fishery (Table 6.2.4).

The operating costs per pot lift, such as bait and fuel, were assumed to be the same for the years examined. However, the significant reduction in the days allowed to fish, such as that which resulted from weekend closures, may have led to a higher bait usage per pot lift that would have increased costs per pot lift. As the bait component was estimated to be about 10% of the total operating costs, this increase is unlikely to be a dominant factor.

Fishery profit

Actual fishery profit is estimated to be greater than predicted profits under the 2007/08 effort level in the overall fishery and in Zones B and C for both 2008/09 and 2009/10 (Table 6.2.5). This contrasts with the prediction that profits at actual effort levels would be lower in 2008/09 than under 2007/08 effort levels (Figure 6.1.5). This indicates that profitability in Zone B and C were greater than was predicted, despite the fact that fishery costs compared with the costs associated with the maintenance of effort at 2007/08 levels declined to a smaller extent than predicted, particularly in 2009/10. The driver of the greater than predicted increase in profitability, after taking into account the higher prices associated with reduced catch levels, was a less than predicted catch decline. In Zone A, in which the predicted catches at actual effort levels were greater than actual catches, in 2008/09 actual fishery profits is estimated to be similar to the predicted outcomes while in 2009/10 actual fishery profits were less than that predicted.

It is important to note that in the MEY analysis, the profit gains from reducing effort mainly accrue after the first two seasons following the effort reductions as the fleet has restructured and costs return to levels closer to the pre-effort reduction level. In addition, the benefit of a reduced catch in the first year or two is also reflected in higher catch rates in subsequent years.

Table 6.2.1: Actual and modelled effort, catch and CPUE changes for 2008/09 and 2009/10 relative to 2007/08

	Effort (*'000s pot lifts*)		**Catch** (*metric tonnes*)			**CPUE** (*kg per pot lifts*)		
	Actual	Change vs 2007-08	Actual	Predicted under effort level of 2007/08	Predicted under effort level of Actual	Actual	Predicted under effort level of 2007/08	Predicted under effort level of Actual
ZONE A								
2007/08	1,145	-	1,892			1.65		
2008/09	483	-58%	1,339	2,032	1,548	2.77	1.77	3.21
2009/10	239	-79%	1,103	1,823	1,314	4.62	1.59	5.50
ZONE B								
2007/08	2,669	-	3,053			1.14		
2008/09	1,520	-43%	2,588	3,196	2,423	1.70	1.20	1.59
2009/10	850	-68%	2,095	2,654	1,832	2.46	0.99	2.16
ZONE C								
2007/08	4,292	-	3,997			0.93		
2008/09	2,573	-40%	3,667	4,721	3,499	1.42	1.10	1.36
2009/10	1,115	-74%	2,701	4,446	2,626	2.42	1.04	2.35
TOTAL								
2007/08	8,106	-	8,942			1.10		
2008/09	4,576	-44%	7,594	9,949	7,470	1.66	1.23	1.63
2009/10	2,204	-73%	5,899	8,923	5,772	2.68	1.10	2.62

Table 6.2.2: Difference in fishery revenue and predicted revenue under actual effort compared with 2007/08 effort

	Actual ($ millions)	**Predicted under actual effort** ($ millions)
ZONE A		
2008/09	-12.9	-13.1
2009/10	-12.0	-13.7
ZONE B		
2008/09	-5.2	-20.9
2009/10	-1.0	-22.2
ZONE C		
2008/09	-12.6	-33.0
2009/10	-28.9	-49.1
TOTAL		
2008/09	-30.7	-67.0
2009/10	-41.9	-85.0

Table 6.2.3: Actual and predicted vessel numbers and pot lifts for observed 2008/09 and 2009/10 effort levels compared to those if the 2007/08 effort was maintained

	Vessel numbers			**Pot lifts per vessel**		
	Actual	Predicted under effort level of		Actual	Predicted under effort level of	
		2007/08	Actual		2007/08	Actual
ZONE A						
2007/08	126			9,087		
2008/09	107	126	102	4,514	9,087	4,748
2009/10	78	126	60	3,025	9,087	4,010
ZONE B						
2007/08	106			11,504		
2008/09	89	106	80	7,755	11,504	8,372
2009/10	71	106	56	5,903	11,504	7,348
ZONE C						
2007/08	228			18,825		
2008/09	199	228	198	12,930	18,825	13,026
2009/10	145	228	115	7,585	18,825	9,658
TOTAL						
2007/08	460			17,622		
2008/09	395	460	380	11,585	17,622	12,042
2009/10	294	460	231	7,497	17,622	9,541

Table 6.2.4: Difference in actual fishery costs and predicted costs for 2008/09 and 2009/10 compared to 2007/08 effort being maintained.

	Actual ($ millions)	**Predicted under actual effort** ($ millions)
ZONE A		
2008/09	-7.4	-8.2
2009/10	-13.8	-16.9
ZONE B		
2008/09	-15.2	-25.5
2009/10	-27.9	-35.0
ZONE C		
2008/09	-21.0	-21.3
2009/10	-49.2	-59.7
TOTAL		
2008/09	-43.6	-55.0
2009/10	-90.9	-111.6

Table 6.2.5: Difference in actual fishery revenue, costs and profits ($ millions), and predicted revenue, costs and profits under 2007/08 effort

	Change in fishery revenue vs predicted under 2007/08 effort		Change in fishery costs vs predicted under 2007/08 effort		Change in fishery profit vs predicted under 2007/08 effort	
	Actual	Predicted under actual effort	Actual	Predicted under actual effort	Actual	Predicted under actual effort
A ZONE						
2008/09	-12.9	-13.1	-7.4	-8.2	-5.4	-4.9
2009/10	-12.0	-13.7	-13.8	-16.9	1.8	3.2
B ZONE						
2008/09	-5.2	-20.9	-15.2	-25.5	10.0	4.6
2009/10	-1.0	-22.2	-27.9	-35.0	26.9	12.8
C ZONE						
2008/09	-12.6	-33.0	-21.0	-21.3	8.4	-11.7
2009/10	-28.9	-49.1	-49.2	-59.7	20.3	10.6
TOTAL						
2008/09	-30.7	-67.0	-43.6	-55.0	13.0	-12.0
2009/10	-41.9	-85.0	-90.9	-111.6	49.0	26.6

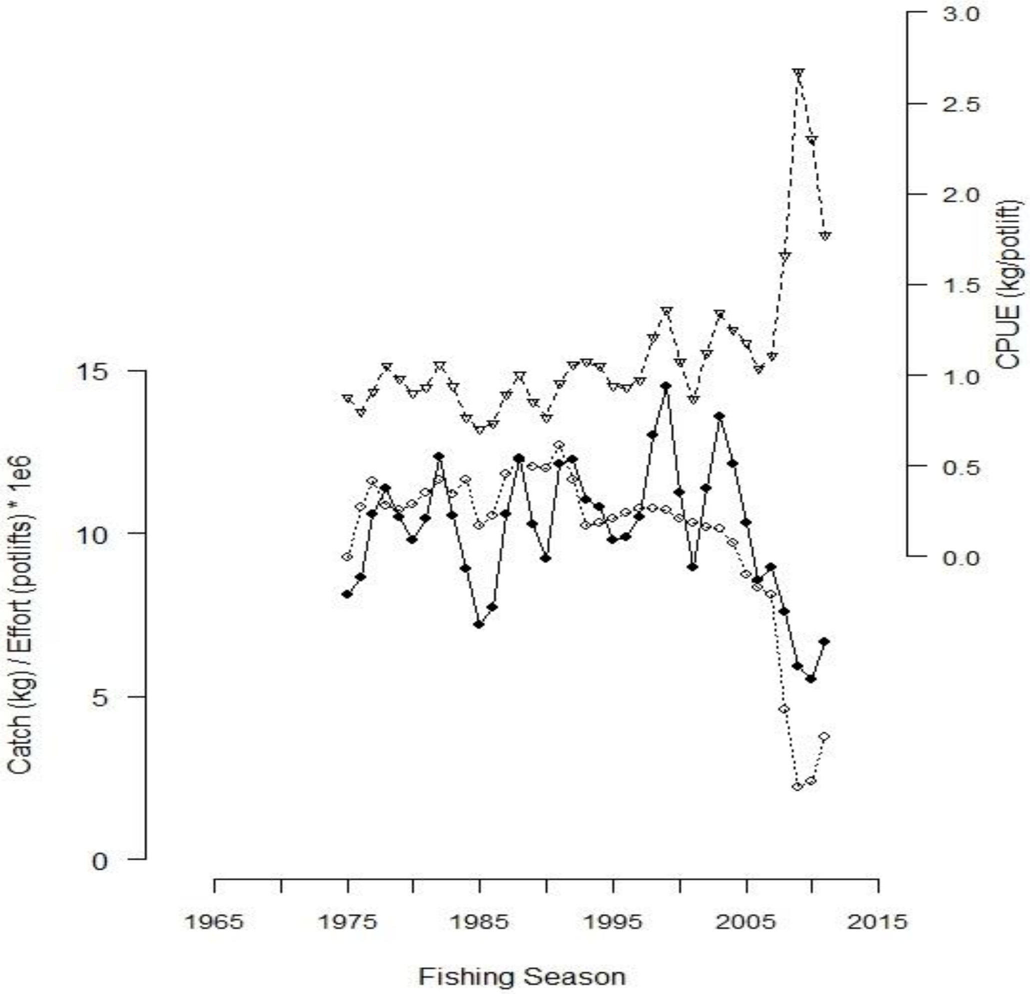

Figure 6.2.1. Catch (filled circles), effort (open circles) and catch rate (CPUE, open triangles) in the western rock lobster fishery.

6.3 Assessment of 2010/11 and 2011/13 (quota-controlled years)

The assessment of the quota-controlled seasons of 2010/11 and the extended 2011/13 season provided a comparison between the previous effort-controlled seasons. An assessment was undertaken on the changes in (a) spatial and temporal pattern of fishing; (b) number of vessels operating; (c) effect of high grading; (d) effect on product type (e.g. percent live market) and grade categories; (e) variable costs such as bait and fuel; (f) beach price of lobsters and the price differences between months, grades and quality; and (g) licence and lease value of units of entitlements.

Spatial and temporal pattern of fishing

The introduction of individual catch quotas for the 2010/11 season was accompanied by an extension of the season, 15 November to 30 June, by two months. The following season (2011/13) was an extended season so that the quota year could be realigned to start on 15 January. Another month, September, was also added to the fishing season. The 2013/14 season was realigned to commence on the 15 January and operate for 12 months in all zones.

The monthly catch and effort data for the last effort-controlled season, 2009/10, and the quota-controlled season, 2010/11, shows the reduction in both catch and effort during peak catch rate periods of December and March-April, and the spreading of the catch, as well as the increased effort in previously poor catch periods or closed month (Fig. 6.3.1). The increasing effort in the low catch rate periods resulted in a slightly lower catch rate for the 2010/11 season compared to the 2009/10 (Fig. 6.2.1).

The mean depth (weighted by number of pot lifts) reduced slightly at latitudes 30 and 32 in 2010/11, but not at other latitudes. This probably reflects the low recruitment occurring in 2010/11 as a result of the low puerulus settlement 3-4 years earlier.

Number of vessels

There was a 36% decline in the number of vessels operating in the fishery from 2007/08 (460) to 2009/10 (294) as a result of the 73% reduction in nominal effort over this period (Fig. 6.2.2). The introduction of individual catch limits in 2010/11 resulted in only a 5% further drop in the number of vessels to 279. A similar number of vessels were also operating in the subsequent season.

Price of lobsters

With the introduction of individual catch limits in 2010/11, the processors introduced different prices for different grades, colour and quality of product to encourage fishers to target lobsters that had a higher market value. These prices changed on a regular basis during the fishing season depending on the market conditions at the time. The average price difference between grades was typically about $10 per kg and about $20-25 difference between the best price for a grade and ‘second’ grade lobsters that were not suitable for the live market. There was also a significant price difference between months of up to 40% which reflected the level of landings and market demand at the time.

The effect of moving to individual catch quota system on the annual beach price was about AUD$6 based on the statistical analysis of annual beach price, catch, exchange rate and management system (effort or catch quota). The comparison on the price in USD from moving from an input-controlled fishery to an output controlled fishery shows a clear increase in price for the two years under output controls (Figure 6.3.3). This price increase reflects the combined effect of improved product quality, high proportion of catch for live export that generally provides the highest price, reduced fishing on peak catch rates when the price is generally lower, high grading based on quality and size grade, and the extended season that enables a greater spread of catch.

Product type and grades

The percentage live product was about 35-40% of the level experienced during the 1995/96 to 2007/08 seasons (Fig. 6.3.4 top) when the average catch was about 11,000 t. It then steadily increased to about 80% live product during the period of substantial effort reduction in 2008/09 and 2009/10 and catch quota seasons of 2010/11 and the extended 2011/13 season. In the last two fishing seasons, there was a progressive increase in the season from 7.5 to 10.5 months which enabled a higher proportion of live product to be sold.

The proportion of smallest grade lobsters (grade A) represented about 50% of the lobster catch during 1992/93 to 2002/03 (Fig. 6.3.4 bottom). It then declined to about 35% up to 2008/09 before a sharper decline since then to about 20% in recent years. There has been a corresponding increase in the larger grade lobsters (grade B to E+). The recent years would have been affected by the decline in puerulus settlement since 2006/07 that would have started to affect the catch 3 years later starting in 2009/10. The catch and effort reductions since 2008/09 have resulted in a higher carryover of legal lobsters into subsequent years that also contributed to the larger grades.

High Grading

The introduction of price differences between size grades and quality when individual catch limits were introduced for the 2010/11 season resulted in a level of ‘high grading’ of 10.8% i.e.10.8% of the legal lobsters that were caught were returned to sea by fishers because of the price. The main cause of high grading was due to product quality as prices for second grade lobsters were about 50% lower than for export-quality lobsters. Some fishers also high graded on size grades of lobster as the average difference in price between the best grade and worst grade was about 30-40%.

Fishing costs

Since moving to catch quotas, there has been only a small reduction of about 5% in the number of vessels so the fixed costs associated with vessels would not have changed markedly. Moreover, there would have been a reduction in operating costs as the use of bait per pot lift has declined (Table 6.3.1). Under the effort reductions in 2008/09 and 2009/10 there was an increase in bait usage as some of the effort reduction was achieved with weekend closures and fishers tried to maximise their catches during these closures by using additional bait. The introduction of individual catch limits in 2010/11 resulted in a major reduction in bait usage. It is expected that fuel used per day would also have declined as fishers would not be moving their gear as much to achieve maximum catch rates. However, some fishers are operating more on periods of lower catch rates to achieve higher prices and this would increase the number of days of fishing and hence some of their costs.

Licence and leasing values

The value of licences were declining in the 2000’s as the commercial fishery was facing significant economic pressure from increasing costs, lower lobster prices and reduced catches as a result of low recruitment. The licence value was lowest in about 2008/09 when the level of puerulus settlement was the lowest on record. As a result of the reductions, in the number of pots allowed to be used by fishers, many fishers wishing to continue fishing needed to purchase/lease entitlement units to remain economically viable. There was a significant increase of about 70% in licence value at time of the introduction of individual catch limits in 2010/11.

Table 6.3.1. Bait used compared to rock lobster catch and effort for the effort-controlled seasons up to 2009/10 and catch-controls from 2010/11

Season	**Catch** *(t)*	**Effort** *(pot lifts x 1000)*	**Bait** *(t)*	**Bait/Catch ratio**	**Bait/effort** *(kg/pot lift)*
2007/08	8926	8106	10127	1.13	1.24
2008/09	7595	4576	10904	1.44	2.38
2009/10	5899	2204	4576	0.78	2.08
2010/11	5500	2391	2738	0.50	1.15
2011/13	6647	3754	4003	0.60	1.07

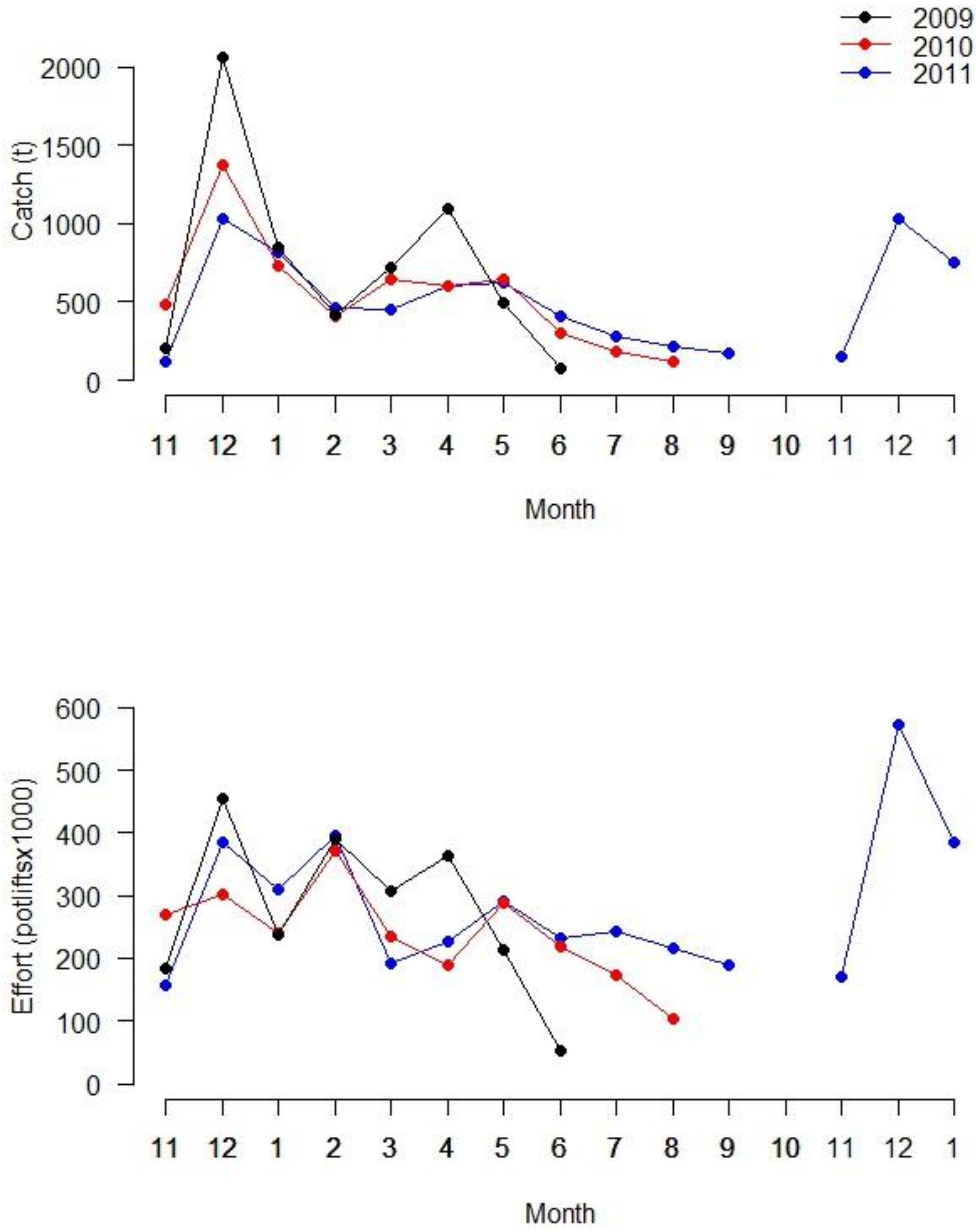

Figure 6.3.1. Monthly catches (upper graph) and monthly levels of fishing effort (number of pot lifts) (lower graph) for the effort-controlled 2009/10 season (2009) and the catch-controlled 2010/11 and 2011/13 seasons (2010 and 2011).

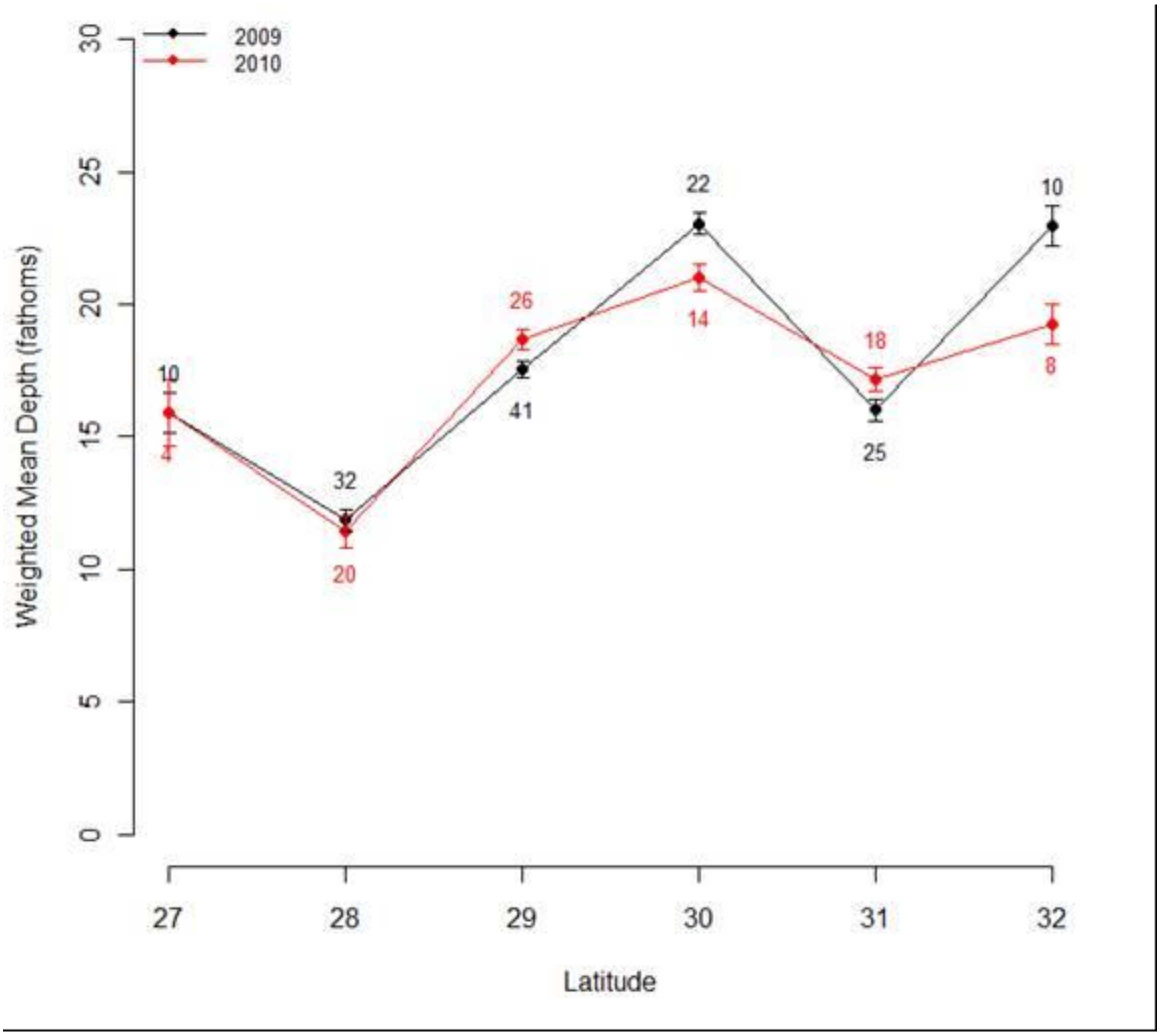

Figure 6.3.2. Weighted mean depth for the 2009/10 season (2009) and 2010/11 season (2010) with the standard error indicated. Numbers indicate the number of boats that gave returns in latitude for each year. Latitudes were restricted to 27-32 as there were comparable estimates for both years (no missing values).

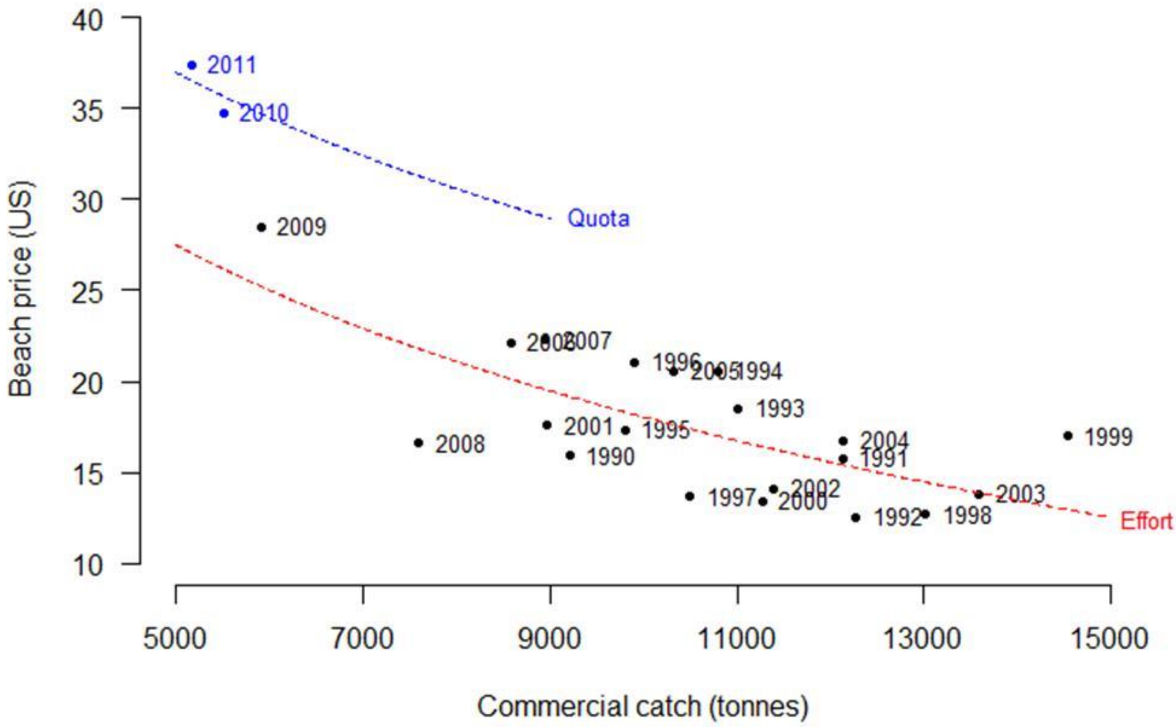

Figure 6.3.3. The rock lobster beach price (USD) compared to catch and comparing the price under effort controls (<2009/10 season) and catch quota (2010/11 and 2011/12 seasons).

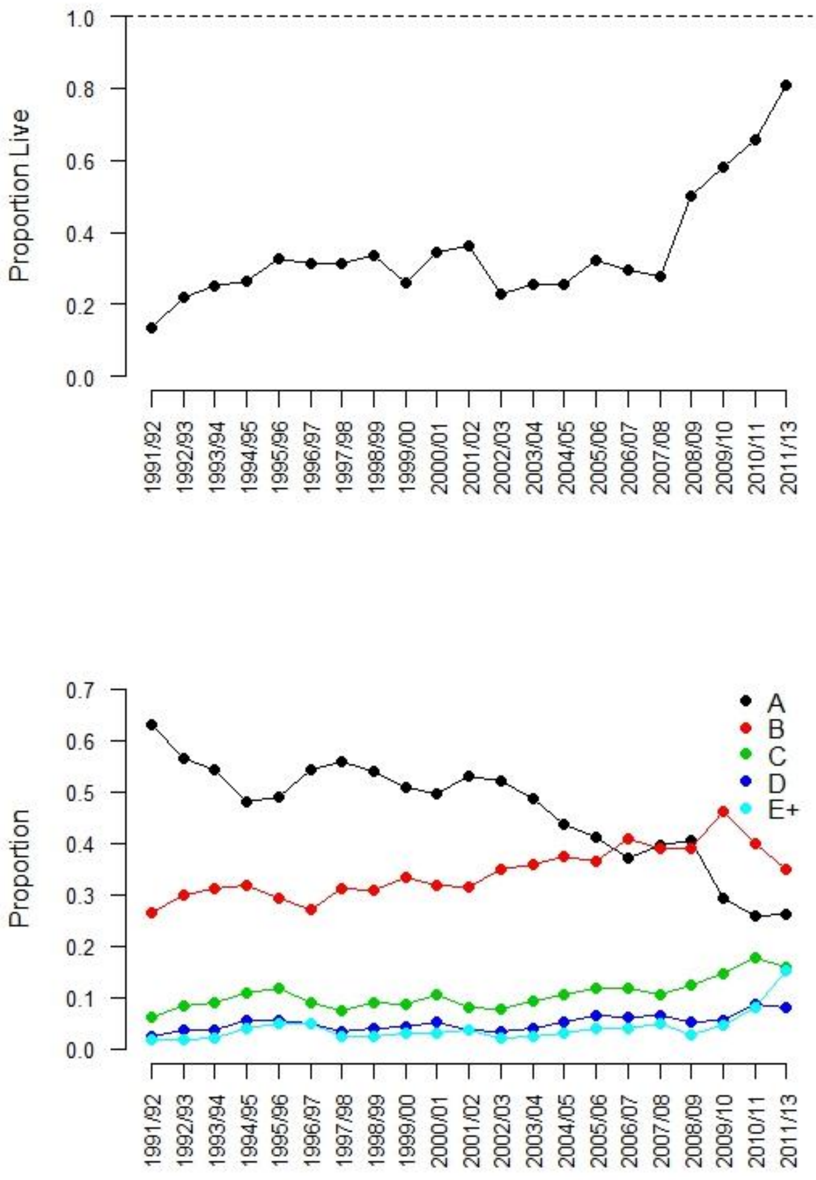

Figure 6.3.4. The proportion of lobster landed that were exported live (top) and proportion of lobsters by grade category from small sizes (A) to larger sizes (E+). The year represents the start year of the season i.e. 2010 represents the 2010/11 season.

6.4 Optimum economic yield under ITQs

This assessment was undertaken for the 5 seasons (2014 to 2018) for fixed levels of legal proportion harvest (LPH) from 0.1 to 0.9. The stock assessment model outputs for the northern (Zones A and B combined) and southern (Zone C) regions for the five seasons for different levels of LPH were catch, effort (pot lifts), CPUE (kg/pot lift) and egg production (Fig. 6.4.1 to 6.4.2). The initial assessment assumed that current regulations on female maximum size, setose and minimum size were maintained.

The northern (Zones A and B) and southern region (Zone C) assessments showed that low levels of LPH of 0.1 to 0.3 resulted in relatively low catches with the catches increasing over the five years (Fig. 6.4.1). The catch rates at low levels of LPH were relatively high and increasing over the five years (Fig. 6.4.1). At high levels of LPH of 0.6 to 0.9, catches were relatively higher in the first year and then decreasing with catch rates relatively low and decreasing over the five years (Fig. 6.4.1). At the intermediate levels of LPH of 0.4 and 0.5, the catches and catch rates of both regions were relatively stable for the five years assessed.

The current levels of egg production are generally at very high levels throughout the fishery (Fig. 6.4.2) and this is supported by fishery-independent surveys that have been undertaken since the early 1990s (de Lestang *et al.* 2012). Projections for future egg production indicate that it would be likely to increase at low levels of LPH (<0.4) but decrease at higher levels of LPH (>0.6), and remain relatively stable levels at intermediate levels of LPH (0.4-0.6). Given the current high levels of egg production, none of these levels are likely to breach the threshold level of egg production over the next five years.

An economic assessment based on outputs from the stock assessment model was undertaken to estimate the NPV of profits over the five seasons at different levels of LPH. This work indicated that a LPH of about 0.35 (range 0.28 to 0.47) would be associated with the MEY level of fishing for the overall fishery (Fig. 6.4.3). The assessment indicated that there was AUD$20-40 million additional profit per year made at this level of fishing compared to fishing at low LPH level of 0.15 or high LPH of 0.8. This level of fishing also coincided with relatively stable catches, catch rates and egg production over the next five years (Fig. 6.4.1, 6.4.2).

The effect of fishing at this MEY range of LPH of 0.28 to 0.47 resulted in a relatively wide range of catch for the 2014 season of 4365 to 7370 t and hence a wide range of GVP of AUD$180 to 240 million (Fig. 6.4.3). This wide range of catches and GVP has important socio-economic implications to the fishery. Fishing at the lower end of the MEY range would result in a loss of $60 million in GVP to the state, and a lower number of boats are likely to be operating to achieve the catch and hence also a lower level of employment in the fishery with a relatively high profit per boat. At the upper end of the MEY range, the catch and GVP would be higher and a higher number of boats are likely to be operating and hence a higher level of employment in the fishery.

Combining the MEY and GVP assessments at different levels of fishing shows that at about the top half of the MEY range i.e. about 0.37 to 0.47 provides a level of fishing that results in catches in the range of 5780 to 7370 t with corresponding GVP of AUD$200 to 230 million. This may be considered as an optimum socio-economic target for the fishery. The issue of developing a target harvest rate for the fishery will be outlined in a discussion paper for industry’s consideration.

Sensitivity analyses to assess the effects of cost variation +/- 20% showed that an LPH of about 0.3 was optimum at the higher cost compared to an optimum LPH of about 0.4 at the lower cost (Fig. 6.4.4a). The effect of price variations +/- 20% resulted in the LPH of 0.3 was optimum at the lower price and 0.4 was optimum for the higher price (Fig. 6.4.4b). If the higher cost was combined with lower prices then the optimum LPH was even lower at about 0.25 while the lower cost combined with the higher price resulted in an optimum LPH of about 0.5 (Fig. 6.4.4c).

Sensitivity analyses associated with the discount rate of 0 and 5% compared to 10% indicated that a marginal decline in the optimum LPH was associated with a lower LPH (Fig. 6.4.5). Maintaining the number of boats at the current levels of about 280 resulted in a slightly higher LPH of about 0.4 compared to the base case where number of vessels varied according to the effort levels. Examining the sensitivity of the LPH to recruitment being set at average levels for recruitment to the fishery from 2014/15 to compare with the current actual levels of recruitment that have been below average for seven years showed that a slightly higher LPH was optimum under average recruitment levels.

The assessment of the combined effect of removing some existing management controls such as protection of female maximum size, setose (mature) females and lobsters 76-77 mm carapace length on MEY results in an overall increase in profit of about AUD$15 million. If a similar level of egg production as per under the maintenance of these current rules is desirable, then the proposed catch quota would be similar to that resulting from maintaining the current restrictions i.e. about 6000-7000 t. However the major difference would result from the higher catch rates that would be achieved in the fishery with these regulations removed (Table 6.4.1) and hence the lower effort that would be required to achieve the quota and hence the lower cost of fishing. At a range of catch quotas from 6000 to 7000 t, the effect of removing female maximum size or the setose female regulation resulted in a modest 5-10% increase in catch rate for the 2014 season. However, the effect of removing both of these management regulations resulted in a significant increase of about 30% in the catch rate indicating that there is high proportion of females that are both setose and above the maximum size (Table 6.4.1). The effect of also reducing the minimum size from 77 to 76 mm carapace length increases the catch rate by about 5-10%.

The estimates of the projected catch rates in this section associated with different levels of harvest rate (LPH) and other management regulations in Figure 6.4.1 and Table 6.4.1 have all been undertaken under the assumption of effort being distributed over 12 months. Therefore these annual catch rates cannot be directly compared to recent increases in catch rates in 2008/09 and 2009/10 under effort controls when there was a focus on fishing peak months or even the more recent quota controlled seasons, 2010/11 and 2011/13, when there was less than 12 months of fishing (Fig. 6.2.1) and therefore more focus on the peak catch rate months. The projected catch rates are comparable for different levels of harvest rates (and hence different catch quota levels) (Fig. 6.4.1).

The assessment of the effect of removing of some existing management controls has also been undertaken assuming the monthly and spatial effort distribution does not change as a result of these additional management changes. However the effect of removing these regulations is likely to change the effort distribution of the fishery as fishers target the optimum catch rates that also takes into account the changes in prices for different size classes of lobsters that may result from the changes in these regulations.

Table 6.4.1. The effect of removing some existing management controls such as protection of female maximum size, setose (mature) females and lobsters 76-77 mm carapace length on the catch rates in 2014 under catch quotas of 6000 to 7000 t.

Management arrangement	6000	6500	7000
Current rules	1.35	1.32	1.29
No max. size	1.43	1.41	1.38
No setose	1.47	1.44	1.41
No max. size/setose	1.77	1.75	1.73
No max. size/setose/76 mm	1.88	1.84	1.81

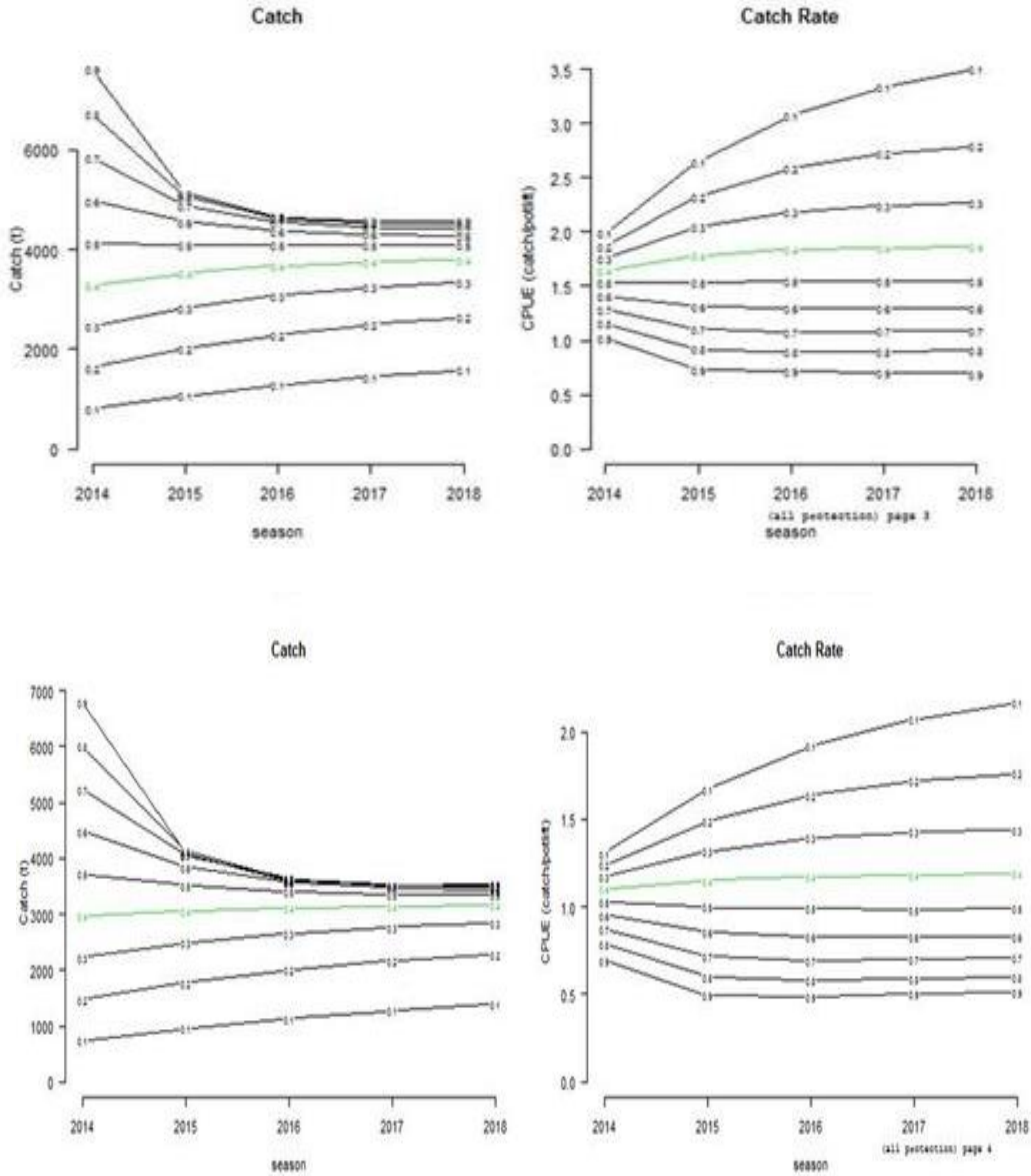

Figure 6.4.1. The stock assessment model estimate of catch and catch rate by northern (top) and southern (bottom) zones for the five seasons for different levels of LPH. The assessment assumed that current regulations on female maximum size, setose and minimum size were maintained.

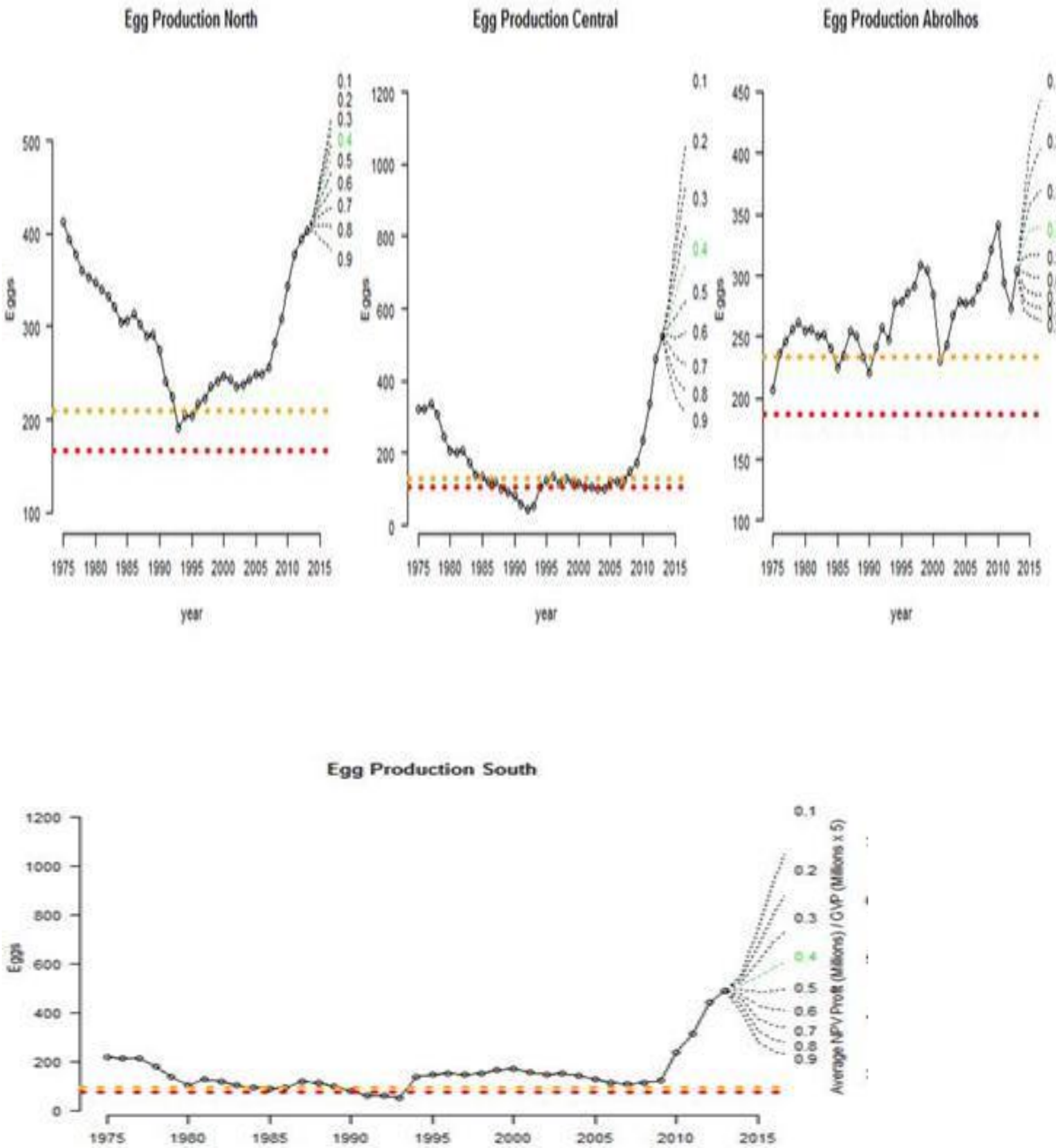

Figure 6.4.2. The stock assessment model estimate of egg production for the three breeding stock management areas for northern region (top) and for the one breeding stock management area for the southern zone (bottom) for the five seasons for different levels of LPH. The assessment assumed that current regulations on female maximum size, setose and minimum size were maintained.

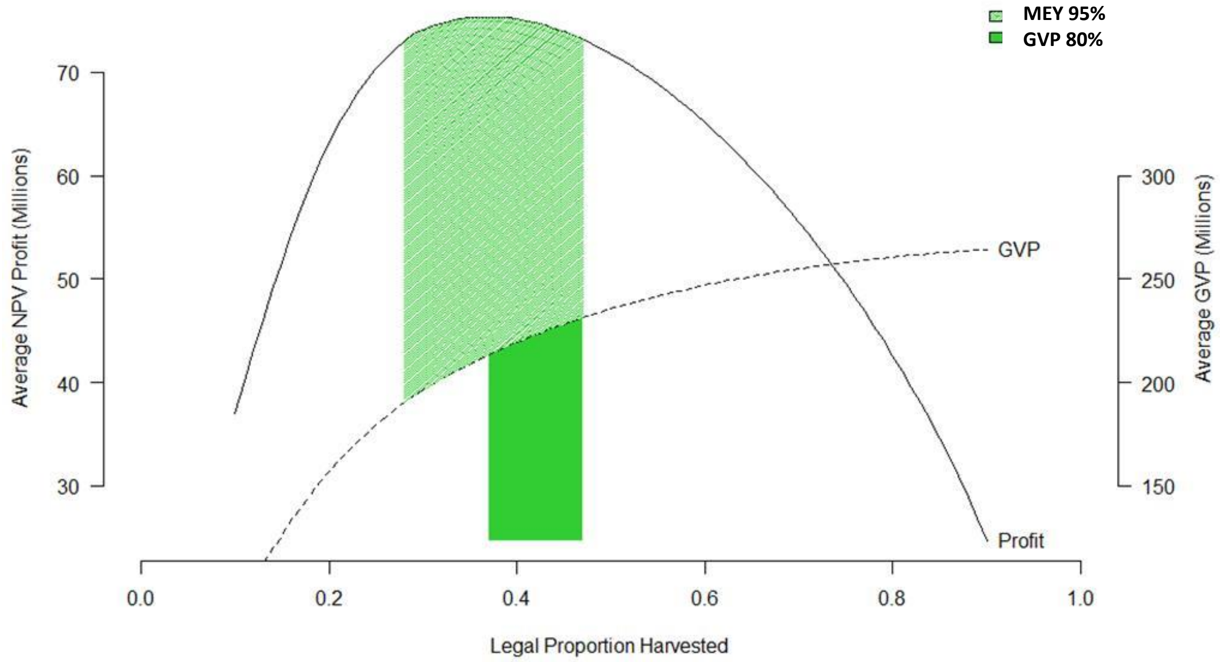

Figure 6.4.3. The NPV of profits over the five seasons at different levels of LPH for the whole fishery. The LPH of about 0.35 (range 0.28 to 0.47) was associated with the MEY level of fishing (light green shading) and LPH range of 0.37 to 0.47 (solid green shading) represented the range where there was overlap with about 80% of the maximum GVP and the MEY range.

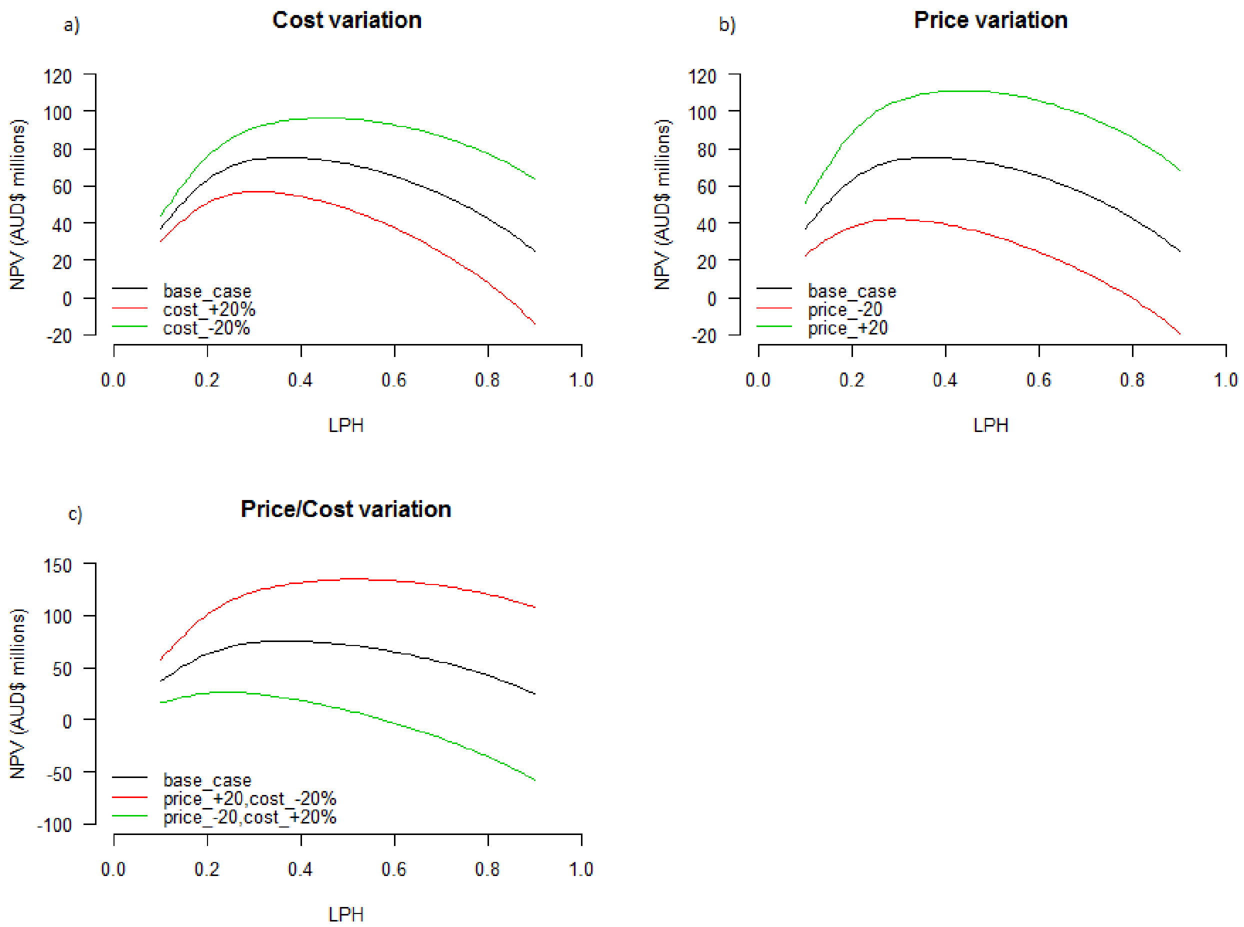

Figure 6.4.4. Sensitivity analyses to assess the effects of (a) cost variation +/- 20%, (b) price variation +/- 20%, and (c) cost and price variation +/- 20% on the average annual NPV of profits.

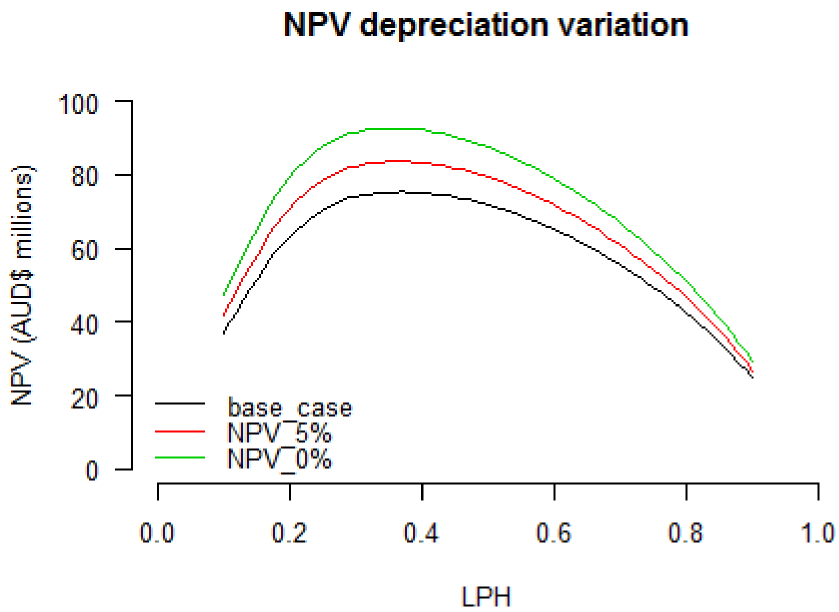

Figure 6.4.5. Sensitivity analyses to assess the effects of discount rates of 0, 5 and 10% on the average annual NPV of profits.

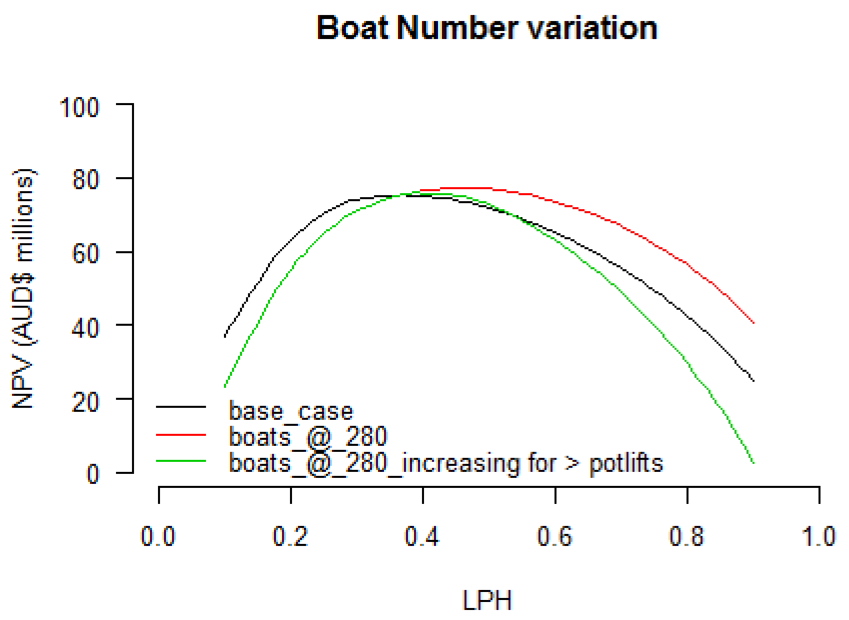

Figure 6.4.6. Sensitivity analyses to assess the effects of different number of boats operating on the average annual NPV of profits. The base case represents a variable number of boats based on the fishing effort required compared to a fixed 280 boats and fixed 280 boats that only increases if the average pot lifts per boats exceeds 18,000.

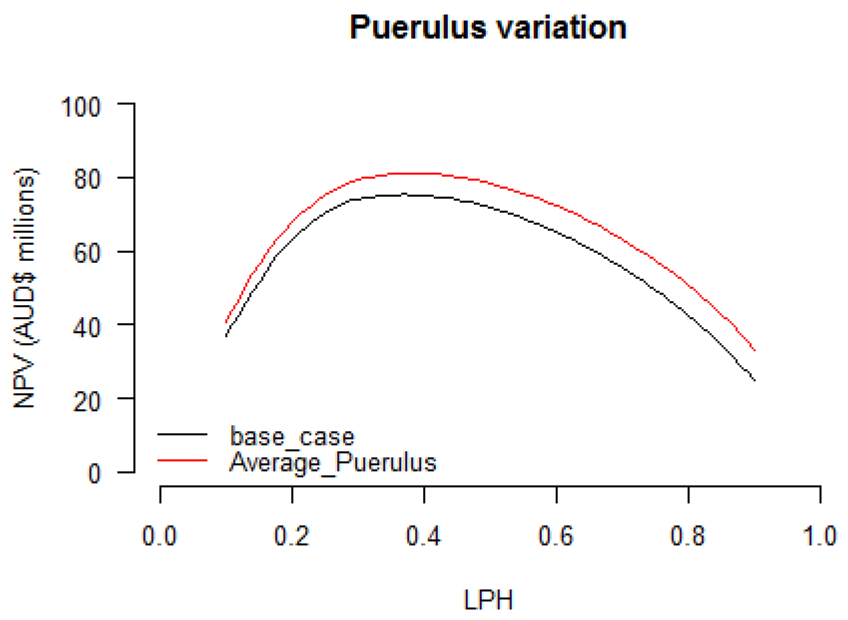

Figure 6.4.7. Sensitivity analyses to assess the effects of recruitment being set at average levels for recruitment to the fishery to compare with the current actual levels of recruitment that have been below average for seven years on the average annual NPV of profits.

7. Discussion and conclusions

MEY under effort control

The MEY analysis predicted that the NPV of profits in the western rock lobster fishery over the period 2008/09 to 2013/14 could be substantially increased by reducing effort to 30-50% of 2007/08 levels (i.e. 50-70% effort reductions). This prediction was driven by predicted increases in CPUE and declines in the total cost of producing the allowed effort. Nominal effort reductions of 44 and 73% in 2008/09 and 2009/10 compared to 2007/08 were aimed at dealing with the record low puerulus settlement but were also in the range required to achieve MEY. This provided a unique opportunity of examining effects of a fishery moving towards the MEY target over two years. Section 6.2 examined actual outcomes for the 2008/09 and 2009/10 seasons and compared these outcomes with the outcomes predicted by the MEY assessment (Section 6.1) and the outcome expected if the 2007/08 effort had been maintained.

The approach adopted for the MEY assessment of the western rock lobster fishery involved two stages. The first assessed a range of fixed levels of fishing effort on the catch and catch rate using a stock assessment model. The second stage involved assessing the economic effects on revenue, number of vessels, costs and profits for the different effort levels. This approach is much simpler that used in the Australian northern prawn fishery which developed a dynamic bio-economic model that integrates the biological and economic systems within the model (Punt *et al*., 2010)].

The western rock lobster assessment indicated that the predicted CPUE increases were generally as predicted overall although they were overestimated to some degree in Zone A and underestimated in Zones B and C. Although the fishery costs did decline, as predicted by the MEY assessment, the extent of the decline was less than expected because a lower number of vessels actually withdrew from the fishery than was predicted. In addition, the MEY assessment initially made the conservative assumption that there would be no change in lobster prices as a result of changes in catch levels but this report shows that average prices are now higher under lower catch levels which means that the difference in revenues between 2007/08 effort levels and reduced effort levels is narrowed. This is particularly important in the first year or two of the move to MEY which are examined here as these years are affected more strongly by the drop in catch.

The higher prices associated with lower catch levels are mainly due to the changing of the export market that the lobsters were destined for. The two major forms in which western rock lobster are sold are live product and frozen cooked tails with prices for live product generally being significantly higher than that which is processed into frozen cooked tails. However, there are limits to the quantity that can be processed and sold as live product. This means that as the total catch falls, the proportion of live product of the total catch increases which then increases the average price received for lobsters.

The process of substantially reducing effort has led to a significant improvement in the overall profitability of the fishery. The effort reduction was achieved by a combination of reduced number of days of fishing allowed and reduced number of pots allowed to be used. The reduction in the number of fishing days available is likely to have reduced the level of restructuring of the fleet than would be the case if reductions in pot numbers had been the sole tool used. However, overall the effort reduction measures put in place have been economically beneficial to the fishery.

Due to the large reduction in effort implemented over a short period of time for biological sustainability reasons, it was not practicable to have all the effort reduction focused on pot usage alone as the fleet would not have time to adjust to such dramatic reductions in pot usage. Therefore, a compromise was obtained between reducing effort using pot usage and days of fishing. Nevertheless a 36% reduction in the fleet over two years has resulted in a major upheaval in the fishery as fishers generally had to make decisions about whether to stay in the industry and buy/lease entitlement units or to sell/lease their entitlements and move out of fishing permanently or in the short term. This highlights an important issue in discussing the increased 'profit' of the effort reductions in that this estimate of fishery profit does not take into account the cost to individual fishers of having to buy/lease units to remain viable in the fishery or any licence fees. In addition, unlike the restructure in the northern prawn fishery's move to an MEY level of effort, where there was a considerable government subsidy for the buyout of vessels (Viera *et al*., 2010; Norman-López and Pascoe, 2011), there was no government buyout of vessels leaving the western rock lobster industry. Those choosing not to fish were only compensated by selling or leasing their units to those choosing to continue fishing.

An assumption in the stock assessment model is that, for example, a 50% reduction in pot lifts results in a 50% reduction in effective effort. In reality, a 50% reduction in pot lifts reduces effective effort by a lesser amount due to more efficient fishers remaining in fishery, reduced competition for best fishing grounds, and reduced competition between pots. While this reduces the level of carryover expected from the effort reductions, it provides an additional economic benefit as there is, over time, a 50% reduction in fishing costs but a lesser impact on catches than expected due to increases in fishing efficiency. Hence the expected reduction in catches and the economic benefits would be conservative estimates in the MEY assessment.

This report has demonstrated the economic benefits of reducing fishing effort to a level close to MEY under an input controlled management regime. Under input controls, managers try, explicitly or implicitly, to restrict catch to a given level through a set of inputs used in the production of fishing effort e.g. number of pots used and their design, the days on which fishing can take place. However, under any input control regime, there are some factors such as technology increases that can result in improved effective effort that cannot be directly controlled. Fishers will endeavour to find ways to cost-effectively maximise their share of the catch, e.g. by using unconstrained inputs, adopting better technology or using more bait. From the operator's perspective, such a strategy is rational and results in an increase in the profitability of their operation in the immediate term. However, in order to protect their share of the catch, other operators will also use similar approaches with the net effect that effort creep will occur, whereby the effective effort increases even though the nominal effort may remain the same. A simple example of this would be the introduction of GPS which occurred in the early 1990s (Brown *et al.,* 1995). This technology improved the effectiveness of catching lobsters which, in turn, resulted in an increase in effective effort. Management would have to counter this increase by reducing effort, as it did in 1993/94 by a reduction in pot usage by 18%, and introducing other measures to protect the breeding stock. Hence the target level of effort required to achieve MEY needs to be reviewed regularly, with effort creep dissipating overall fishery profits and thus requiring an adjustment to the input controls to maintain the fishery at MEY.

MEY under quota control

In 2010/11, the fishery moved towards an individual transferable quota (ITQ) management with each licensee being allocated a share of the total allowable catch based on the number of units they owned. As fishers were no longer competing to achieve a higher share of the catch as occurred under input controls, this resulted in lower fishing costs. There was also an increase in the average annual lobster price of about AUD$6/kg as fishers could target the timing of fishing and the size of lobsters retained to fit in with market requirements. The sensitivity analysis undertaken as part of the MEY assessment on the effects of different costs and prices showed that effort would have to be reduced to 50-60% of the 2007/08 effort level to achieve MEY if costs were reduced by 20% and prices improved by 20%. Hence a higher level of effort (and catch) would achieve MEY under output controls if costs are reduced and prices are improved, as may be expected to occur under an ITQ management.

An MEY assessment under ITQ showed that AUD$20-40 million additional profit per year would be made at the optimum level of fishing compared to fishing at lower or higher levels. This level of fishing also coincided with relatively stable catches, catch rates and egg production over the next five years. A key component of this assessment was estimating the number of vessels that would be operating each year. Two assumptions were assessed: (a) the number of vessels would change as a result of any change in fishing effort required to achiever the quota; and (b) the vessels would generally remain the same as are currently (2013) operating i.e. about 280 vessels unless there was a very high level of effort required to catch the quota. Managers and Industry are provided the projected catch, effort, CPUE and egg production at different levels of LPH for the following 5 years, as well as the estimated GVP and profit levels. The target legal proportion harvested (LPH) range was proposed to be set at the level of 0.37 to 0.47 where the LPH is given as the proportion of the catch out of the total legal biomass, as estimated from the stock assessment model. This LPH range was chosen as it reflects the harvest rate in recent years and was informed by MEY assessment, as well as taking into account the different levels of GVP. The target range represents the upper end of the MEY range where the catch and GVP would be higher and a greater number of boats are likely to be operating, leading to a raised level of employment in the fishery. It therefore represents a socio-economic target and the range provides industry and managers with additional choices about the socio-economic targets they wish to achieve. Discussions are currently underway with industry for the finalization of the harvest strategy based on the proposed management objectives and the setting of TACC for the 2014 season.

General

Due to the predictive ability of the stock assessment model based on puerulus settlement, the effort and/or catch quota are able to be set at levels commensurate to the recruitment abundances expected over the next 3-4 years. This represents a significant advantage over assuming an average recruitment in the stock assessment modelling, even if the latter approach accounts for recruitment variation. This has been particularly important during the period of low recruitment due to the low puerulus settlement over five years, 2006/07 to 2010/11, including a 40-year record low settlement in 2008/09. This has enabled the catch and effort levels to be set to levels that will maintain the commercial and biological sustainability of the fishery. This predictive ability has also been important in the MEY assessment in that it enables the determination of the MEY catch and effort levels that includes the level of recruitment expected over next 3-4 years based on the puerulus settlement. This contrasts with most MEY assessments that are based on the average catch-effort relationship (Kompas *et al*. 2011).

The MEY assessment in this study combined with the significant reduction in fishing effort in 2008/09 and 2009/10 associated with predicted low recruitment to the fishery has provided a unique adaptive management opportunity to assess the biological and economic effects of moving a fishery to an MEY level of effort in one or two years. This has provided industry, managers and researchers with an opportunity to compare the effects of fishing at the two levels of fishing effort to assist in the decision-making process as to whether to maintain the fishery at an MEY level or to revert to fishing at a level based mainly on maintaining the breeding stock level above a threshold reference point. The harvest strategy/decision-rule framework for the management of the fishery is currently based on having the egg production above a threshold level that enables the fishery to be managed sustainably.

However the MEY assessment has been undertaken so that a target reference point based on MEY principles and taking into account socio-economic indicators can be considered. Discussions are currently underway with industry for the finalization of the revised harvest strategy under catch quota system and the setting of TACC for the 2014 season.

The issue of whether to manage at MEY or MSY levels has generated significant controversy in recent years with the Australian Commonwealth fisheries harvest strategy policy specifying that MEY is a target for the management of their fisheries (Department of Agriculture, Fisheries and Forestry (2007). Significant funding has been provided to buy out fishing licences in four fisheries (Viera *et al*., 2010; Norman-López and Pascoe, 2011) as part of the management measures to move the fisheries to an MEY level with the Australian northern prawn fishery being one of the fisheries that has adopted an MEY target (Kompas *et al*., 2010). However managing at an MEY level does have downstream social and economic effects such as a decrease in the number of vessels and employment that need to be considered in the decision-making process. Some authors such as Christensen (2010) have argued that when you take into account the whole value chain of fishing, then fishing close to MSY is a more appropriate target. Bromley (2009) also argues against the use of MEY as an appropriate target for fisheries management, but noting that his arguments have been refuted (Grafton *et al.,* 2010). Others, such as Norman-López and Pascoe (2011), have used an input-output modelling framework to conclude that in the long-term, MEY provided a net economic benefit to society, although there were some short-term losses. Sumaila and Hannesson (2010) also assessed that the MEY concept remains useful even when the value chain is taken into account.

Besides the economic arguments, there is the significant issue that fishing close to MEY levels generally provides increased protection to the spawning stock that significantly reduces the likelihood of overfishing if there are short-term decreases in recruitment due to environmental effects including climate change. The lower levels of fishing also reduce the ecological risks of any effects on ecosystem that the fishery may have such as interaction with protected species and habitat, handling of protected components of the catch such as undersize and spawning females, bycatch and bait usage. These latter points have been used to highlight that moving to MEY levels results in a win-win situation for the fishing industry with higher profits and the conservation movement with greater protection to the spawning stock and ecosystem in general (Grafton *et al*., 2010).

8. Benefits and Adoption

This project has provided an understanding of the economic benefits of fishing at a level close to MEY under an input and output management regime. For the effort-controlled fishery, the optimum level of effort that would result in the maximum economic yield (MEY) being obtained, expressing this as the net present value (NPV) of profits over the period 2008/09 to 2013/14 using a discount rate of 10% per annum, was about 30-50% of the 2007/08 effort levels (i.e. 50-70% effort reduction). The assessment estimated that the overall effect on the fishery of fishing at the MEY effort level would be over $40 million per year. As a result of the low puerulus settlements in recent years, substantial management changes were made in 2008/09 and 2009/10 (44 and 73% reduction in nominal fishing effort relative to 2007/08, respectively) to maintain the breeding stock at sustainable levels and have a carryover of legal lobsters into the predicted future years of lower recruitment to the fishery. These effort reductions were undertaken for sustainability reasons but were also at a level consistent with MEY. This provided a unique opportunity to assess the effect of a fishery moving to an MEY level within two years. The fishery profit increased by $13 and $49 million for effort-controlled years of 2008/09 and 2009/10, respectively, compared to that expected under 2007/08 effort level. A profit increase of greater than $60 million is estimated for the quota-controlled year of 2010/11 compared to that expected under continued 2007/08 effort level.

The management harvest strategy decision-rule framework is currently based on having the egg production above a threshold level to ensure sustainability. A management harvest strategy discussion paper, which was released in 2012 and updated and revised in December 2013, includes a target harvest range as well as a limit and threshold level of breeding stock. The proposal is that the total allowable commercial catch (TACC) set for the fishery should target an optimal harvest rate (legal proportion harvest) range that would produce catch rates that would provide high economic returns from the fishery. The stock assessment model has been updated to reflect the changes in the pattern of fishing under ITQ as a result of the fishery moving to a 12 month season. The bioeconomic assessment used in the discussion paper also takes into account the available economic information to identify the harvest rate range (and catch quota range) to achieve the MEY and provide an estimated GVP for the range. A key component of this assessment was estimating the number of vessels that would be operating each year.

Managers and Industry were provided with the projected catch, effort, catch rate, egg production at different levels of target legal proportion harvested (LPH) for the following 5 years (2014-2018) when considering the catch quota to be set for the 2014 season. The target LPH range is estimated as part of this assessment where the LPH is given as the proportion of the catch out of the total legal biomass as estimated from the stock assessment model. The target LPH range was proposed to be set at the level of 0.37 to 0.47 for the 2014 season as it reflects the harvest rate in recent years and it takes into account the MEY assessment and the levels of GVP. The TACC for the 2014 season was then set at about 5859 t after consultation with industry and this reflects a 5.5% increase on the previous season but at the lower end of the LPH range proposed.

This project has demonstrated the benefits of undertaking economic evaluation of fishery as part of the annual catch quota setting process for the fishery. The bioeconomic model, which assesses the maximum economic yield of the fishery, has been used in the catch quota setting for the 2013 and 2014 seasons. The model has also been used in the harvest strategy discussion paper which was released in December 2013. Consultation with industry on the new harvest strategy is planned for February 2014. Once the Minister has signed off on the harvest strategy it will be the basis for catch quota setting for the 2015-2019 fishing seasons.

9. Further Development

Estimating the changes in fishing costs associated with the move to ITQ was not within the scope of this project. This project used the costs available under input control and modified them as appropriate with available information from industry. However there is a need to update these economic costs data under the current ITQ fishing arrangements with the fishing season operating over 12 months for the first time during 2013 with the quota season starting on the 15 January.

The stock assessment was also undertaken with an estimated distribution of effort over the 12 month season as the previous full season of data available for assessment included a 1.5 month closure for the coastal Zones B and C and a 5.5 month closure for the Abrolhos Is. (Zone A). Once the 2013 season's data is available it will provide a more reliable estimate of the monthly effort distribution based on 12 months of fishing.

If the retention of currently protected lobsters (setose and maximum size females) is approved then this could alter the effort level and distribution, the level of high grading and the average price received for lobsters. The harvest rate that achieves MEY would have to be assessed to take into account these biological and economic changes.

While the catch quota setting for the 2013 and 2014 season have taken into account the bioeconomic modelling that assesses the MEY, the formal adoption of the harvest strategy policy with a target harvest level that is based on the bioeconomic model, needs to be finalised. This is being undertaken with the release of a discussion paper in December 2013 and consultation with industry planned for February 2014 and industry submissions due on 17 March. This process is planned to be finalised by mid-2014 so that it becomes the basis for catch quota setting for the 2015 season.

10. Planned Outcomes

The major outcome arising from this project is that industry and management have accepted the bioeconomic model as a decision support tool in the control rules setting process for the western rock lobster fishery leading to an improved profitability of the fishery whilst also improving the sustainability indicators.

The bioeconomic model, which assesses the maximum economic yield of the fishery, has been used in the catch quota setting for the 2013 and 2014 seasons. The model has also been used in the harvest strategy discussion paper which was released in December 2013. This paper proposes the establishment of the target harvest level for the fishery that takes into account the bioeconomic model assessment of MEY. Consultation with industry on the new harvest strategy is planned for February 2014. Once the Minister has signed off on the harvest strategy it will be the basis for catch quota setting for the 2015-2019 fishing seasons.

Industry and management will have access to results of an economic evaluation that will help facilitate discussion on management harvest strategy that considers a socio-economic target harvest rate. These results include: (a) an understanding of the levels of catch and effort that are required to achieve maximum economic yield (MEY); (b) the economic evaluation of the effect of moving to an MEY level of effort; (c) an assessment of MEY initially under an input-controlled fishery and then under an output-controlled fishery; and (d) the development of draft socio-economic target reference range that has been informed by the assessment of the MEY and expected GVP under an individual transferable quota system and the assessment of economic evaluation of moving to a lower catch and effort level in recent years.

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12. References

Bromley, D.W. 2009. Abdicating responsibility: The deceits of fisheries policy. Fisheries, 34: 280-290.

Brown, R.S., Caputi, N., and Barker, E. 1995. A preliminary assessment of increase in fishing power on stock assessment and fishing effort expended in the western rock lobster, *Panulirus cygnus*, fishery. Crustaceana, 68(2): 227-237.

Caputi, N., Brown, R.S., and Chubb, C.F. 1995. Regional prediction of the western rock lobster, *Panulirus cygnus*, catch in Western Australia. Crustaceana, 68(2): 245-256.

Christensen, V. 2010. MEY=MSY. Fish and Fisheries, 11: 105-110.

de Lestang, S., Caputi, N., and Melville-Smith, R. 2009. Using fine-scale catch predictions to examine spatial variation in growth and catchability of *Panulirus cygnus* along the west coast of Australia. New Zealand Journal of Marine and Freshwater Research, 43: 443–455.

de Lestang, S., Caputi, N., How, J., Melville-Smith, R., Thomson, A., and Stephenson, P. 2012 Stock assessment for the west coast rock lobster fishery. Fisheries Research Report No. 217. Department of Fisheries, Western Australia. 200pp.

Department of Agriculture, Fisheries and Forestry. 2007. Commonwealth Fisheries Harvest Strategy Policy and Guidelines. Available from URL: http://www.daff.gov.au/__data/assets/pdf_file/0004/397264/hsp.pdf

Department of Fisheries 2012. West coast rock lobster managed fishery - harvest strategy and decision rules proposals under a quota management system. Western Australian Department of Fisheries, 3rd floor the Atrium, 168 St Georges Terrace, Perth, Western Australia.

Department of Fisheries (2013). West coast rock lobster - Harvest strategy and control rules 2015-2019 – a discussion paper. Western Australian Department of Fisheries, 3rd floor the Atrium, 168 St Georges Terrace, Perth, Western Australia.

Gordon, H.A. 1954. The economic theory of a common property resource: the fishery. Journal of Political Economy, 62: 124-142.

Grafton, R.Q., Kompas, T., Chu, L., and Che, N. 2010. Maximum economic yield. The Australian Journal of Agricultural and Resource Economics, 54: 273-80.

Kompas, T. 2005. Fisheries management: economic efficiency and the concept of ‘maximum economic yield’. Australian Commodities 12(1), March Quarter: 152-160.

Kompas, T., Dichmont, C.M., Punt, A.E., Deng, A., Che, T., Bishop, J., et al. 2010. Maximizing profits and conserving stocks in the Australian Northern Prawn Fishery. Australian Journal of Agricultural and Resource Economics, 54: 281-99.

Kompas, T., Grafton, R.Q., and Che, N. 2011. Target and path: maximum economic yield in fisheries management. ABARES technical report 11.3, Canberra.

Norman-López, A. and Pascoe, S. 2011. Net economic effects of achieving maximum economic yield in fisheries. Marine Policy, 2011, 35: 489-95.

Phillips, B.F. 1986. Prediction of commercial catches of the western rock lobster *Panulirus cygnus*. Canadian Journal of Fisheries and Aquatic Sciences, 43: 2126-2130.

Punt, A.E., Deng, R.A., Dichmont, C.M., Kompas, T., Venables, W.N., Zhou, S., et al. 2010. Integrating size-structured assessment and bioeconomic management advice in Australia’s northern prawn fishery. ICES Journal of Marine Science, 67(8): 1785-1801.

Starck, W. 2009. “Questioning the Western Rock Lobster Fishery”, Baird Marine, http://www.bairdmaritime.com/index.php?option=com_content&view=article&id=2454:western-rock-lobster-fishery-overfished-or-over-managed&catid=99:walter-starcks-blog&Itemid=123

Sumaila, U.R. and Hannesson, R. 2010. Maximum economic yield in crisis? Fish and Fisheries, 11: 461-65.

Thompson, N. and Caputi, N. 2006. An economic analysis of management options in the western rock lobster fishery of Western Australia. *In*: Sumaila, U.R., Marsden, A.D., editors. 2005 North American Economists Forum Proceedings. Fisheries Centre Research Reports 14: 157-164. Fisheries Centre, University of British Columbia, Vancouver, Canada.

Vieira, S., Perks, C., Mazur, K., Curtotti, R., and Li, M. 2010. Impact of the structural adjustment package on the profitability of Commonwealth fisheries. ABARE research report 1001, Canberra, ABARE.

Winzer, A. 2009. Improving economic efficiency through detailed review of input controls in the western rock lobster Fishery. Project Number 2007/052 Final report prepared for the Fisheries and Research Development Corporation (FRDC). Canberra. 104p.

Attachment 1. Harvest strategy and control rules 2015-2019: a discussion paper

Government of Western Australia
Department of Fisheries

WEST COAST ROCK LOBSTER

HARVEST STRATEGY AND CONTROL RULES

2015 – 2019

A DISCUSSION PAPER

FISHERIES MANAGEMENT PAPER NO. 263

Department of Fisheries
168 St Georges Terrace
Perth WA 6000

December 2013

ISSN 0819-4327

OPPORTUNITY TO COMMENT

The Harvest Strategy and Control Rules (HSCR) discussion paper has been prepared to invite further informed comment on a variety of matters in relation to setting the Total Allowable Catch (TAC) for the western rock lobster resource as well as the Total Allowable Commercial Catch (TACC) for the West Coast Rock Lobster Managed Fishery.
Interested persons are strongly encouraged to provide a written submission on any aspect of the discussion paper. Representations will be accepted until 4.30 pm, Monday 17 March 2014.
Submissions may be forwarded to:

Director General
Department of Fisheries
Locked Bag 39, Cloisters Square
WA 6850

or:

lobster.submissions@fish.wa.gov.au

In order to assist industry members in preparing submissions, consultation meetings will be conducted by the Department of Fisheries (the Department) in early 2014. Further information on dates and venues for these meetings will be provided in January 2014.

At the conclusion of the submission period the Department will provide a copy of the submissions to the Western Rock Lobster Council (WRLC) and Recfishwest. The Department will finalise the HSCR by preparing a short document that briefly outlines the outcomes of the consultation on this discussion paper, as well as a flow chart that will be used to guide future TACC setting processes. The HSCR document will then be provided to the WRLC and Recfishwest along with the submissions on this paper for their consideration and advice, prior to seeking final approval of the HSCR from the Minister.

INTRODUCTION

The purpose of this discussion paper is to update and to complement Fisheries Management Paper 254 'West Coast Rock Lobster Managed Fishery Harvest Strategy and Control Rules Framework Under a Quota Management System - A Discussion Paper' (FMP 254) with a view to finalising the harvest strategy for the West Coast Rock Lobster Managed Fishery (fishery). It has also been the Department's intention to develop a paper that is easily understood and provides further information on matters that arose from the consultation process around FMP 254 and the subsequent quota setting for the 2013 season of the fishery.

This document describes two proposed objectives that would underpin the Harvest Strategy and Control Rules (HSCR) framework and discuss the pros and cons of a number of principles that could be employed for setting Total Allowable Commercial Catches (TACCs) for the fishery. It also provides industry with the opportunity to have input and to comment on the various options that are discussed.

Lastly, the Department's Research Division has modelled a number of harvest strategy scenarios, based on the principles discussed in this paper, that illustrate the effects of various factors on TACCs, breeding stock levels and catch rates for 2014 through to 2018.

Why do we need an HSCR?

The clear and immediate need for developing an HSCR for the fishery is to provide a set of principles to guide the TACC setting process. These principles will make the TACC setting process more transparent and understandable to fishers and other stakeholders.

Having an HSCR in place for the fishery also represents international best practice for fisheries management and is consistent with the Department's initiative to establish a Harvest Strategy Policy for all Western Australian fisheries. The Marine Stewardship Council (MSC) has also made it a condition of the fishery's continued certification that it develops and implements a HSCR

To assist with the implementation of the HSCR, it is proposed that the Department will prepare a short HSCR document based on the outcomes of the consultation process on this discussion paper. Once approved, the final HSCR will become a "TACC setting rulebook" that will guide the TACC setting process in future seasons.

Integrated Fisheries Management Considerations

The western rock lobster 'resource' was the first fishery where the legal lobster catch was allocated to user sectors under the Integrated Fisheries Management (IFM) policy. Through this process the commercial sector was allocated 95% and the recreational sector was allocated 5% of the Allowable Harvest Level (AHL).

Under the principles of IFM[1], the AHL is based on the biologically acceptable catch that can be taken in a fishery. Catch levels may be set lower than the AHL due to a desire to have a larger biomass for the purposes of sustainability (rebuilding stocks), economic maximisation (commercial), or amenity optimisation (recreational). The process for setting the AHL and how the allowable take for each sector is determined under the principles of IFM is illustrated in Figure 1.

While the HSCR relates specifically to the commercial sector allocation (i.e. 95% of AHL), it is important to note that the Department intends to use the HSCR to set the recreational sectors "*Total Allowable Recreational Catch*" (TARC) for that season. In the case of the western rock lobster 'resource', and in accordance with the principles of IFM and past practice, the AHL will be calculated from the upper limit of the recommended TACC range as an outcome of the HSCR.

This means that should the commercial sector decide to take less than the AHL (i.e. less than the TACC at the upper range recommended by the HSCR), the recreational sector allocation would still be based on the AHL, not on the TACC that is implemented for the commercial sector. This is consistent with the way the TARC has been calculated in recent years.

For example in mid-2013 when determining the TACC for the 2014 season, the Department advised industry that the maximum allowable commercial catch (based on FMP254) was 7,370 tonnes. While industry advised the Minister that it wanted a significantly lower TACC, the recreational catch for the purposes of IFM (i.e. the TARC) was based on the following calculation:

TACC Range = 5,783 to 7,370 tonnes

AHL = 7,370 / 0.95 = 7,758 tonnes

TARC = 7,758 x 0.05 = 388 tonnes

[1] see *Consideration for the Implementation of Western Rock Lobster Sectoral Allocations*. Fisheries Management Paper 236 at http://www.fish.wa.gov.au/About-Us/Publications/Pages/Fisheries-Management-Papers.aspx

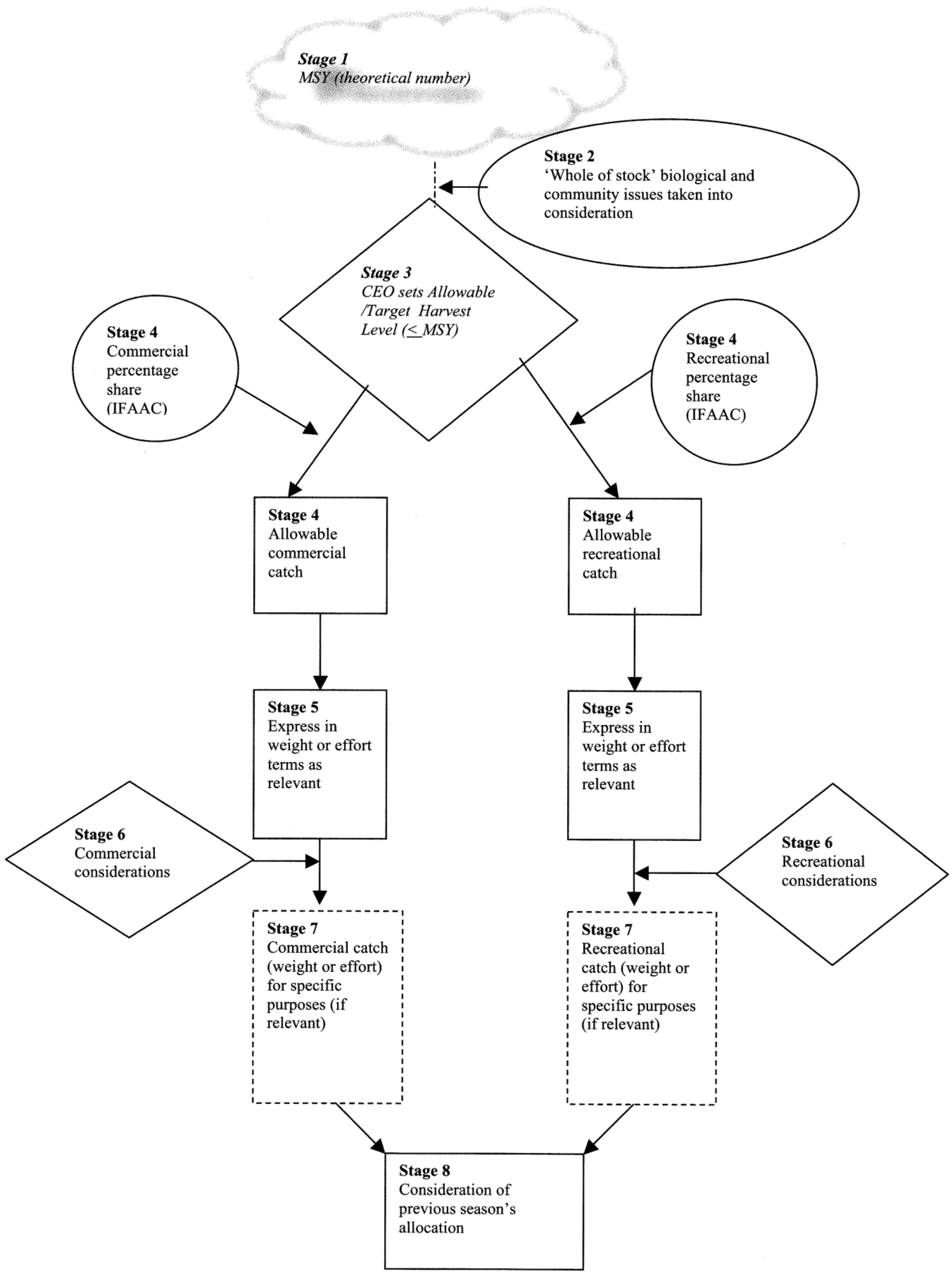

Figure 1. Extract from *Consideration for the Implementation of Western Rock Lobster Sectoral Allocations*. Fisheries Management Paper 236.

SUSTAINABILITY OBJECTIVE

The Sustainability Objective is the primary objective of the HSCR, and must be met irrespective of other principles or objectives in the HSCR. A full description as to how the Sustainability Objective is to be measured, and how the level of uncertainty around the estimates of egg production is to be taken into account, can be found in Appendix 1.

> The Sustainability Objective for the fishery is:
>
> *"To ensure that the egg production in Breeding Stock Management Areas of the fishery* (see Figure 2) *remains above its threshold value for the next five years with a probability greater than 75%"*

There are now four Breeding Stock Management Areas (BSMAs) which will be used to assess the status of the fishery (see Figure 2). This is a change from the three BSMAs which were previously assessed in the fishery, which were based on the breeding stocks in Zones A, B and C. The new BSMAs, as summarised below, are more aligned with the biological characteristics and differing habitats:

Northern region (Zones A and B)

BSMA 1 –Deepwater areas (>20 fm) of the fishery north of 28^{o}S. This encompasses the northern Abrolhos Is. and Big Bank regions.

BSMA 2 – Deepwater areas (>20 fm) of the fishery between 28^{o} and 30^{o}S. This encompasses southern Abrolhos Is. and offshore Geraldton and Dongara areas.

BSMA 3 –Shallow Abrolhos Islands (<20 fm around the Abrolhos Is.)

Southern region (Zone C)

BSMA 4 – Deepwater areas (>20 fm) of the fishery south of 30^{o}S. This encompasses all Zone C deepwater.

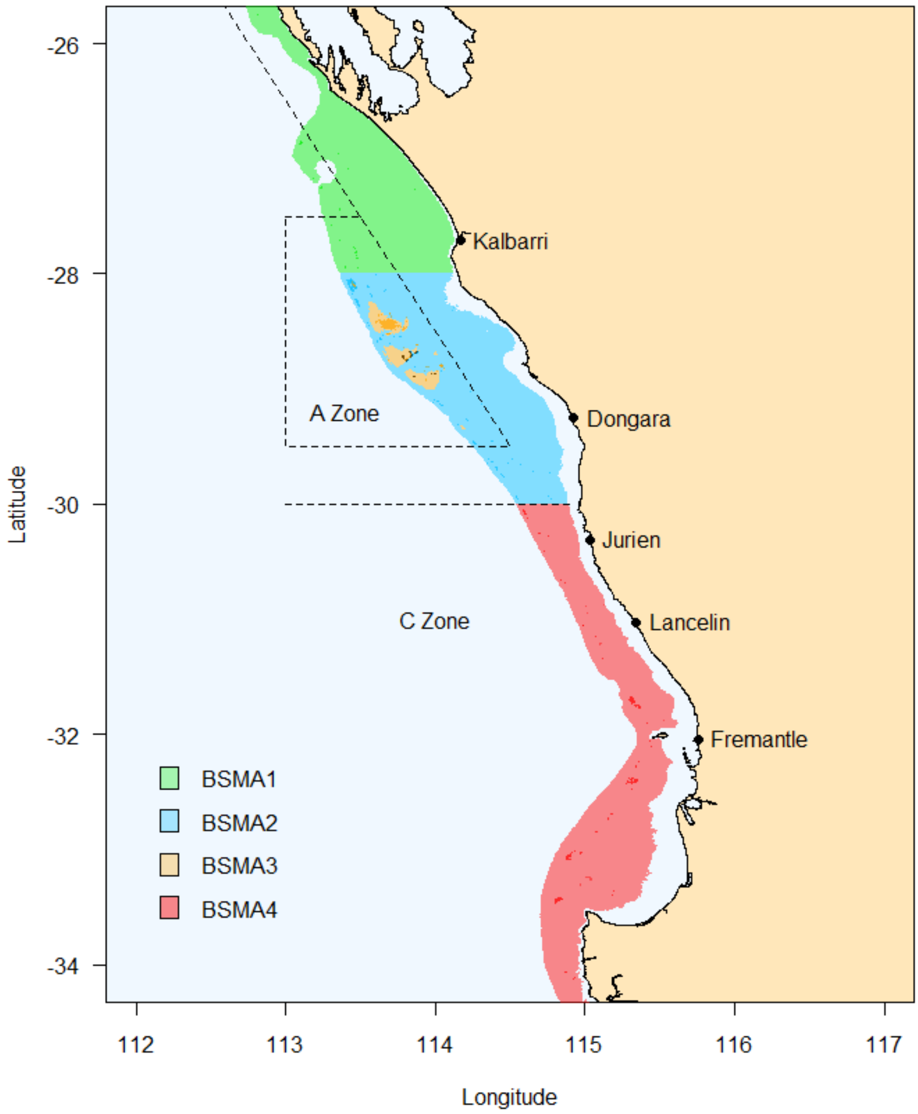

Figure 2. Four Breeding Stock Management Areas (BSMA) covering areas of significant egg production throughout the fishery.

Should modelling indicate that the threshold level in any one of the BSMAs may be breached within the five year projected time period, management action would be required to ensure that there is no breach of the threshold level. This would include a reduction in TACC for the relevant zone(s) or change in biological controls.

In general, the purpose of the Sustainability Objective is to ensure that egg production in all areas of the fishery does not fall below the levels that were observed prior to the increase in fishing effort and efficiency through technology uptake that occurred around the mid-1980s throughout much of the fishery (BSMA 2 – 4). In BSMA 1 the mid-1990s period is used as this area was only lightly exploited prior to this. These levels are known as the "threshold values". To ensure long term sustainability, egg production is projected out five years into the future and takes into account both puerulus settlement and future catch setting arrangements.

It is important to note that preliminary threshold and limit reference points for BSMA 1 have been determined and will be reviewed in the next 3-5 years as additional data is collected in this region. Despite these reference points being preliminary for BSMA 1, a breach of the reference points would still necessitate management action.

Application of the Sustainability Objective

Appendix 1 outlines in detail how the Sustainability Objective is to be applied in the fishery. In particular **Table 1** (**Appendix 1**) summarises the threshold and limit values for each of the BSMAs.

Given there is some uncertainty regarding the preliminary threshold and limits that have been set for BSMA1, the Department recommends that in the event the Big Bank area of the fishery is reopened, the abundance of lobsters in that area not contribute to the TACC setting for Zone B (as is the current practice). This would ensure that a precautionary approach to managing breeding stocks in the northern part of the fishery is maintained, while allowing some spread of fishing effort into the Big Bank area should it be reopened.

GENERAL PRINCIPLES FOR TACC SETTING

This section describes a number of proposals that, if adopted, would become principles of the final HSCR and would be used to inform the TACC setting process each year. Once adopted, these principles would not be debated annually. They would remain in place for the life of the HSCR (e.g. 5 years).

Fixing TACCs to increase lobster abundance

With the move to quota and the recent period of low recruitment and catches, the main focus of the fishery has been to rebuild breeding stocks and at the same time maximise its profitability by fishing closely to market requirements and reducing operating costs. This has been achieved through conservative TACCs set at or about 5,500 tonnes since the 2009/10 season (or the equivalent pro-rata for the 2011/13 season).

To enable fishers to take maximum advantage of these often short periods of high beach price, it is necessary to build up stock abundance to ensure that catch rates are very high.

One way of doing this is to fix TACCs at a conservative level for a period of time (e.g. three years). This is the "Harvest Strategy" that has been successfully employed by the New Zealand Southern Rock Lobster CRA8 Fishery, which is showcased as a model quota-based southern rock lobster fishery. In the case of CRA8, the management arrangements were designed to build catch rates to a target level by fixing TACCs at a conservative level. Once that level was achieved, the CRA8 decision rules afford a maximum 5% increase in TACC, provided the target catch rate was not compromised.[2]

A conservative fixed TACC over a period of time would provide a level of certainty and financial stability for fishers as well as financiers and investors and assist the industry with it future business planning

Fixing the TACC for a number of years (e.g. three) would also require fixing the catch proportions between Zones A and B, as explained below. In addition, due to the variable recruitment patterns across the Fishery, it is likely that lobster abundance would build up at different rates in some zones compared to others. For example, we know abundance in Zone A has already increased more rapidly than Zone B.

If a fixed TACC was adopted, it would be possible, if industry considered there could be benefits, to factor in a small incremental increase in catch each year to "test" the market's ability to absorb additional product, while still maintaining the highest beach price possible.

Fixed proportions between Zone A and Zone B

There is considerable stock interaction between Zones A and B and it is likely that fishing to a lower target of LPH will result in a significant increase in the amount of lobsters migrating between these two Zones. This migration is from Zone B northward into Zone A and the currently closed Big Bank area and out of Zone A into Zone B, mainly to Big Bank and the

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[2] http://nzsportfishing.org.nz/userfiles/file/CRA-IPP-Dec12.pdf

deeper water banks to the north of Geraldton and offshore from Kalbarri. There is also significant interaction between the fishers in this region, with many fishers holding quota in both Zones A and B of the fishery.

If the TACCs for Zones A and B were set independently, it is highly likely that a conservative harvest strategy would incrementally change the relative abundance of lobster in the zones, which would then affect future levels of TACC that could be set. This would be particularly evident if the TACC for the Fishery was fixed at a conservative level to increase lobster abundance.

As a consequence, it is proposed that, for the purposes of TACC setting, the proportional allocation of catch between Zones A and B continue to be fixed at the ratio of 0.36 to Zone A and 0.64 to Zone B. This is consistent with the historic 10-year average of 1998/99 to 2007/08 as illustrated in **Figure 3**. This approach is consistent with that adopted in the previous three seasons of quota setting up to and including the 2014 season.

Fixing the proportions between Zones A and B would significantly simplify the process for determining the TACC for these zones and allows them to share the benefits of any improvement in the abundance of stock. Similarly, the fixed proportions would require each zone to share the responsibility for rebuilding northern breeding stocks in BSMA 1, 2 and 3 (**Figure 1**). As a consequence, the Department supports maintaining fixed proportions between Zones A and B at this time, rather than setting their TACCs independently.

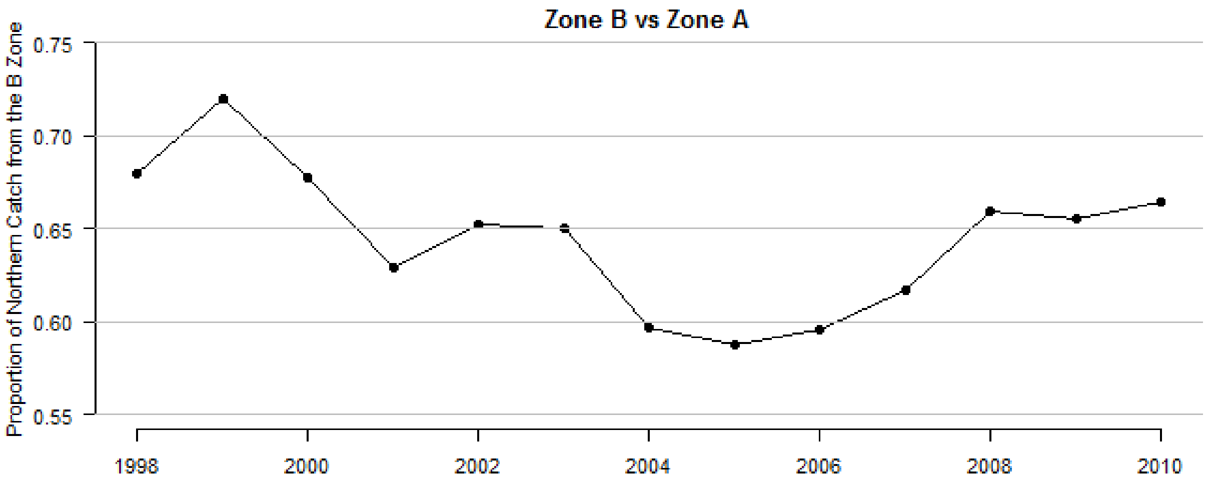

Figure 3. Proportion of the northern catch (combined Zones A and B) landed by Zone B.

Fixed proportions between the northern (Zones A and B) and southern (Zone C) regions

The long-term historical average proportions of catch landed between the northern (Zones A and B) and southern (Zone C) regions is about 50/50; however in any given year it can vary from up to 60/40 in either direction (see **Figure 4**). This is primarily due to differences in recruitment patterns between the north and south of the Fishery, but is also influenced by TACC setting processes and the level of "carry-over" or unfished stock remaining at the end of a given season.

Under the principles outlined in FMP 254 the proportions between the northern region and the southern region were not fixed when setting the TACCs for the 2013 and 2014 seasons, nor were they fixed in the three preceding years where the TACCs were fixed by the Government at (or about) 5,500 tonnes. The independent allocation between the northern and southern regions was permitted simply because of the differing recruitment patterns and level carry-over stock in each region. In addition, the level of stock movement between these the northern and southern regions are relatively limited in comparison to the movement of lobsters between Zones A and B.

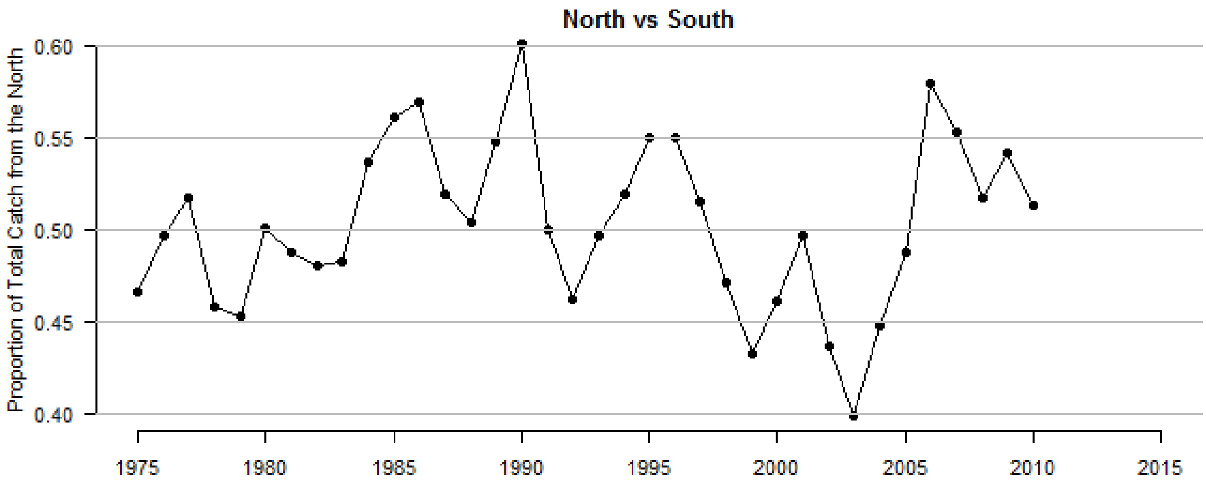

Figure 4. Proportion of the total catch landed by Zones A and B (north) since 1975.

The relatively limited movement between southern and northern zones is supported by tag-recapture information which is incorporated into the Rock Lobster Stock Assessment Model and used to estimate the movement of the stock between areas. Model estimates based on historical tagging data indicate that in Zone C, 30 – 50% of migrating whites move from shallow waters (< 40 m depth) directly offshore into deeper waters (> 40 m depth) over the course of a migration season. Approximately 1% of the migrating whites in deeper waters (> 40 m depth) off Lancelin and Fremantle move north into the 30 – 31°S latitudinal band (i.e. offshore from Jurien). Of the migrating whites initially located in the Jurien latitudinal band (30 – 31°S), only about 2% move further north over latitude 30°S latitude into Zone B.

In contrast the Stock Assessment Model estimates that 10% of the migrating white lobsters in deep-water Dongara move into the Abrolhos Islands and 9% of those in deep water Abrolhos move into northern and north eastern Zone B, including Big Bank. A tagging research program has been proposed to gain more information about biological parameters and to assess any changes in migration rates that may occur with the current low exploitation rates than as occurred during the historical tagging programs. If this tagging project is funded and further increases the Department's understanding of the movement of lobsters within the fishery, then this information would be incorporated into the Stock Assessment Model and may influence future TACC setting processes.

Despite this limited interaction between southern and northern zones compared to those between zones A and B, it would be possible to fix the proportion of the TACC taken by the northern and southern regions as a principle of the HSCR. Provided the Sustainability Objective is met, the fixed TACC proportion of 50/50 could be achieved by either:

1. determining an equal TACC within the range provided from the outcome of the Harvest Objective (discussed further in this paper); or
2. reducing the LPH of one zone (or zones) to the below the range determined by the Harvest Objective to the extent that the TACCs are equal.

While either scenario would provide TACC equality between the northern and southern regions in relation to zone TACCs, the effect is likely to result in a further separation in terms of catch rates and breeding stock indices between the zones. For example, increasing the LPH in one zone to match the TACC of another could result in a decrease in the overall abundance of lobsters in that zone, reduced catch rates and breeding stock. The reduced abundance would impact on the relative profitability of fishers in that zone. In contrast, reducing the LPH in one zone to match the TACC of another could result in an increased abundance of lobsters, catch rates and breeding stock in relation to the other zone to the extent that the forgone catch may artificially restrict the overall value of the fishery and the return to the community from the resource would not be maximised.

The MEY assessment undertaken for the next five years and the TACC range provided for 2014 for the northern and southern regions shows a considerable level of overlap in the ranges that enables a 50/50 allocation.

Allocation of quota to the Western Rock Lobster Council

The western rock lobster industry has many issues to address that require funding, but it is not always available from third parties such as Government or the Fisheries Research and Development Corporation (FRDC).

Some projects need to be funded on a one-off basis; others as continuing programs. Some projects identified by the WRLC include:

- continuation of the tag program to collect more data on movement of lobster;
- additional breeding stock analysis; extra puerulus monitoring;
- gear modifications for whale entanglement minimisation;
- investigating marketing issues;
- industry representative staff and director training (e.g. corporate governance);
- legal advice/representation;
- MSC certification cost.

One method of raising capital to finance these projects is by way of a compulsory unit levy. This has been done in the past, however, it is not popular and requires Ministerial approval. As part of this process, the Minister must consider the opinion of the Regulatory Gatekeeping Unit (Western Australian Department of Finance), which aims to reduce the regulatory burden on business. The Regulatory Gatekeeping Unit has previously questioned why Government should impose a compulsory levy on industry to fund industry-led projects.

An alternate method of raising funds for important industry initiatives could be through an allocation of a small percentage of lobster quota (by allocating additional units of entitlement) to the WRLC. The WRLC has suggested that it be allocated 0.5% of the quota in each zone above the usual allocation. This would provide the WRLC with an independent reliable source of revenue via leasing the quota to fishers. The WRLC has proposed that monies generated from leasing quota would go into a trust fund administered by the Council's Board of Directors.

To facilitate the WRLC's proposal, it would be necessary to allocate units to the WRLC under the West Coast Rock Lobster Managed Fishery Management Plan 2012 (management plan). As the commercial fishery's share of the western rock lobster resource is fully allocated, an increase in the number of units in each zone would result in a very small reduction in kg/unit compared to what would have been the case if units had not been allocated to the WRLC.

The WRLC has indicated that it would be willing to investigate mechanisms to reduce the small financial impact on fishers (e.g. over the course of time the WRLC could utilise a portion of the revenue raised each year to actually buy units. The units allocated to the WRLC could then be surrendered meaning that over time, the units held by the WRLC would no longer have any impact on unit values).

HARVEST OBJECTIVE

When the fishery was managed under input (effort) controls, the commercial catch was generally based on a principle of Maximum Sustainable Yield (MSY). Fishing effort restrictions ensured that the breeding stock threshold in each zone of the fishery was not breached. This was consistent with the Control rules for the fishery (Bray 2004) and led to the development of a Sustainability Objective for the fishery.

In response to the very low puerulus settlement in 2008/09, the fishery began to move away from MSY, with the goal of providing a carry-over of stock into the subsequent years of predicted poor recruitment as well as protection of breeding stocks. This was achieved by reducing fishing effort to target a TACC for the fishery of 5,500 tonnes for the 2009/10 and 2010/11 seasons as well as the equivalent pro-rata for the 2011/13 season (14 months), of 6,938 tonnes. This was approximately half of the fishery's long-term average catch.

Restricting the catch to relatively low levels in response to low puerulus settlement resulted in industry taking a greater interest in how to make the most of the available catch, particularly in terms of optimising profitability. This indicates that there would be benefit in establishing a Harvest Objective with a catch that is below the limit provided for by the Sustainability Objective. The main reason to have a Harvest Objective is to provide a catch target, or a target range within which the catch will be maintained, to enable the fishery to be managed in a way that achieves benefits of importance to stakeholders. A catch target or catch limit that is set by the Harvest Objective should result in TACCs that produce good catch rates and high profitability for the fishery, while at the same time protecting the breeding stocks. The development of a catch target reference point has also become an MSC condition for ongoing certification of the fishery.

In 2012, FMP 254 introduced the concept of using a Harvest Objective to inform the TACC setting process. It also introduced the concept of Legal Proportion Harvested (LPH), which is a measure of the fishery's performance against the Harvest Objective. FMP 254 proposed that the Harvest Objective be based on an optimal LPH range that would result in profitable catch rates for the fishery (i.e. provide high economic returns). The 'optimal LPH' range at that time was based on observed LPHs from the 2009/10 and 2010/11 seasons, which were acknowledged by industry as providing good economic returns. The target range of LPH was also informed by a preliminary Maximum Economic Yield (MEY) analysis conducted by the Department (Reid 2009; Reid et al. 2013).

In considering further research conducted by the Department on MEY, an Industry Reference Group (in collaboration with the Department and the WRLC) has recommended that MEY be incorporated into the Harvest Objective, to provide a target range of LPH for the fishery.

Proposed Harvest Objective:

Once the Sustainability Objective has been satisfied TACCs set for the fishery should use Maximum Economic Yield to determine an optimal range of legal proportion harvested that would optimise the economic value of the fishery by increasing stock abundance and catch rates and thereby providing high economic returns and greater amenity to the fishery and the WA community.

In the event that the egg production is below or predicted to fall below the threshold levels in one or more of the BSMA's, then the LPH for zones A and B (BSMA 1,2, or 3) or for Zone C (BSMA 4) is reduced until the Sustainability Objective is met. In this instance the Harvest Objective would not be used for determining TACCs for the affected Zone(s).

It should be noted that the MEY estimate that would be used under the proposed Harvest Objective would be a guide as to the optimum LPH for the fishery as a whole and may not represent the highest economic yield for individual fishers or processors.

A further explanation of the terms LPH and MEY is provided below.

Legal Proportion Harvested

LPH represents the percentage of the total amount of legal lobsters that are taken by the fishery (this is also referred to as "harvest rate"). Currently in the 2013/14 season "legal lobsters" do not include undersize, oversize, setose, tarspot or berried females. They do include the female lobsters that moult out of setose for a period during the year and undersize lobsters that become legal (by moulting) during the season. Under FMP 254, the maximum LPH for the 2014 season was 0.55 meaning that 55% of the total number of legal lobsters available in that season could be harvested. This is illustrated in **Figure 5** below.

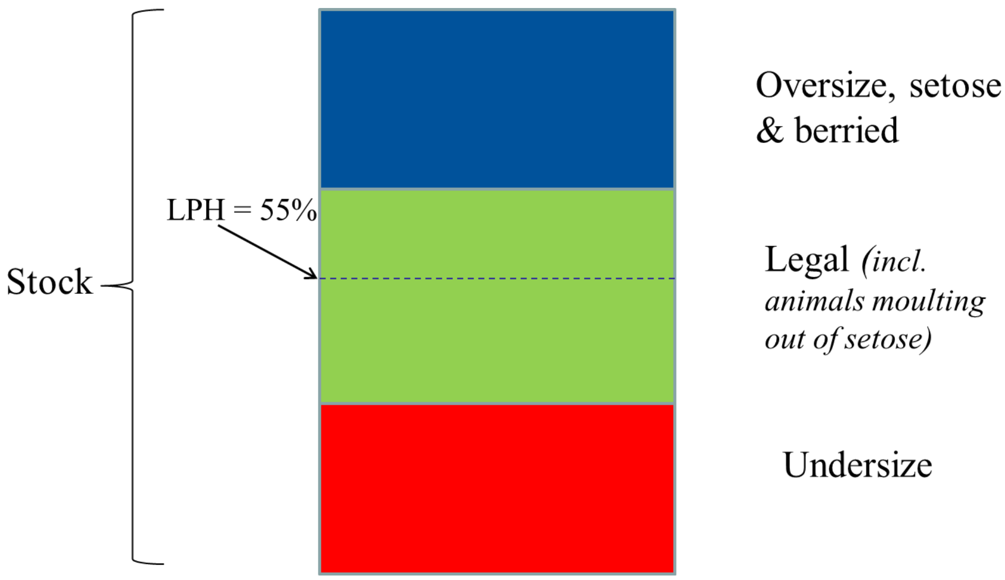

Figure 5. Illustrative example showing LPH on current management arrangements with an LPH of 55% of the legal lobsters.

The legal proportion harvested is determined using estimates from the Rock Lobster Stock Assessment Model (de Lestang et al. 2012) and is explained in more detail at Appendix 2.

If the LPH is relatively low, more lobsters are left in the water each year and hence their abundance increases together with the abundance of the breeding stock. A high abundance of lobsters results in higher catch rates, which allows industry to catch their quota with less effort. By comparison a high LPH usually results in fewer lobsters being left in the water at the end of the year and hence the abundance declines, including the abundance of the breeding stock. A low abundance of lobsters results in lower catch rates and results in both sectors being able to take their allocation more efficiently.

It should be noted that any given LPH only relates to biological controls that are current in the fishery. For example if the prohibition on oversize and/or setose females was removed, then the total number of "legal lobsters" in the fishery would increase. An LPH of 0.50 with these controls removed would therefore represent a significantly higher TACC and TARC than the equivalent LPH with the oversize/setose rules in place. Therefore the effect of any rule change on the abundance of the breeding stock would also have to be taken into account.

Maximum Economic Yield

There are a number of definitions for Maximum Economic Yield (MEY). The one favoured by the Department is:

> *MEY is the value of the largest positive difference between total revenues and total costs of fishing (including the cost of labour and capital) with all inputs valued at their opportunity costs.*[3]

The Department's MEY analysis simply examines the income of the fishery as a whole (total catch x beach price) and the costs of operating (vessels, fuel, bait and wages) to determine a level of catch that would provide the most profit. This assessment has been undertaken over five years with the profits in future years discounted in calculating the net present value (NPV) of profits. In determining income it is essential to incorporate a realistic supply and demand relationship, which in this case was derived from industry data relating to beach price, catch, exchange rate and management system.

The following assumptions were made in the economic assessment:

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[3] Other, more technical definitions include:

"*the catch or effort level for a commercial fishery that maximises average net economic returns over a number of years. Fishing to MEY will usually result in the equilibrium stock (biomass) of fish being greater than that associated with MSY*'; or

When relating total revenues from fishing to total fishing effort in a surplus production model, the value of the largest positive difference between total revenues and total costs of fishing (including the cost of labour and capital) with all inputs valued at their opportunity costs is the MEY".

- The number of vessels operating was dependent on changes in pot lifts, taking into account the number of vessels and pot lifts during two recent seasons;
- Beach price - catch relationship to determine expected change in the annual beach price due to changes in catch after taking into account the price premium estimated to be associated with the move to ITQ and exchange rate;
- Costs were similar to 2007/08 with an estimated reduction for movement to quota due to lower bait and fuel costs as obtained from some preliminary estimates;
- There were three components to costs: (a) fixed annual costs including vessel depreciation ($85,000 per year); (b) operating costs including bait and fuel of $7 per pot lift; and (c) wages based on 30% of the value of catch.
- Discount rate of 5 and 10% per annum for future profits.

It is also important to note that the calculations for MEY by the Department are based on the fishery as whole, i.e. as if the fishery was a single company and unit holders owned shares in the company. MEY does not represent the myriad of different fishing operations and individual financial circumstances in the fishery. Therefore, while the current calculation of MEY provides an indication of the level of catch that is most profitable for the fishery as a whole, it is unlikely to fully represent MEY for an individual fisher or fishing business. Furthermore, the analysis of MEY is at a preliminary stage and should only be used as a guide as the fishing arrangements such as season duration have changed in recent years. Scope exists for a far more detailed analysis of MEY that would encompass longer periods of data, updating economic data and greater input from industry. These opportunities may be pursued by industry and government over coming seasons.

The harvest rates associated with MEY can encompass a wide range of LPH values to provide the highest Net Present Value (NPV), or profit for the whole fishery. The range can vary depending on how close to the estimate of MEY industry may wish to be. For example, 100% MEY would be the exact top of the highest NPV point on the curve, whereas 95% MEY is 2.5% either side of the highest NPV, as shown in **Figure 6**.

Under the Harvest Objective, the range of LPH values at 95% MEY (shaded green) will provide a corresponding range of TACCs for the fishery that would result in good economic returns (**Figure 6**). Marketing issues aside, catching below MEY would result in the fishery as a whole experiencing very good catch rates but reduced income as more catch could be taken to offset fixed costs such as capital investments (e.g. boats, pen fees, insurance and pots etc.). Catching above MEY would result in the fishery experiencing larger overall revenue but poorer catch rates; so that the cost of catching lobsters would begin to significantly erode profits.

The optimal LPH range of 0.28 to 0.47, arising from the MEY analysis (as seen at **Figure 6**) results in a very large variation in TACCs for the fishery i.e. from 4,365 to 7,370 tonnes for 2014. Using the MEY analysis in the Harvest Objective provides industry with a broad range of TACCs from which to choose, while ensuring that the Sustainability Objective is met in each BSMA. The LPHs chosen within this range by industry may vary from year to year, and would be influenced by the principles for TACC setting that are discussed later in this document.

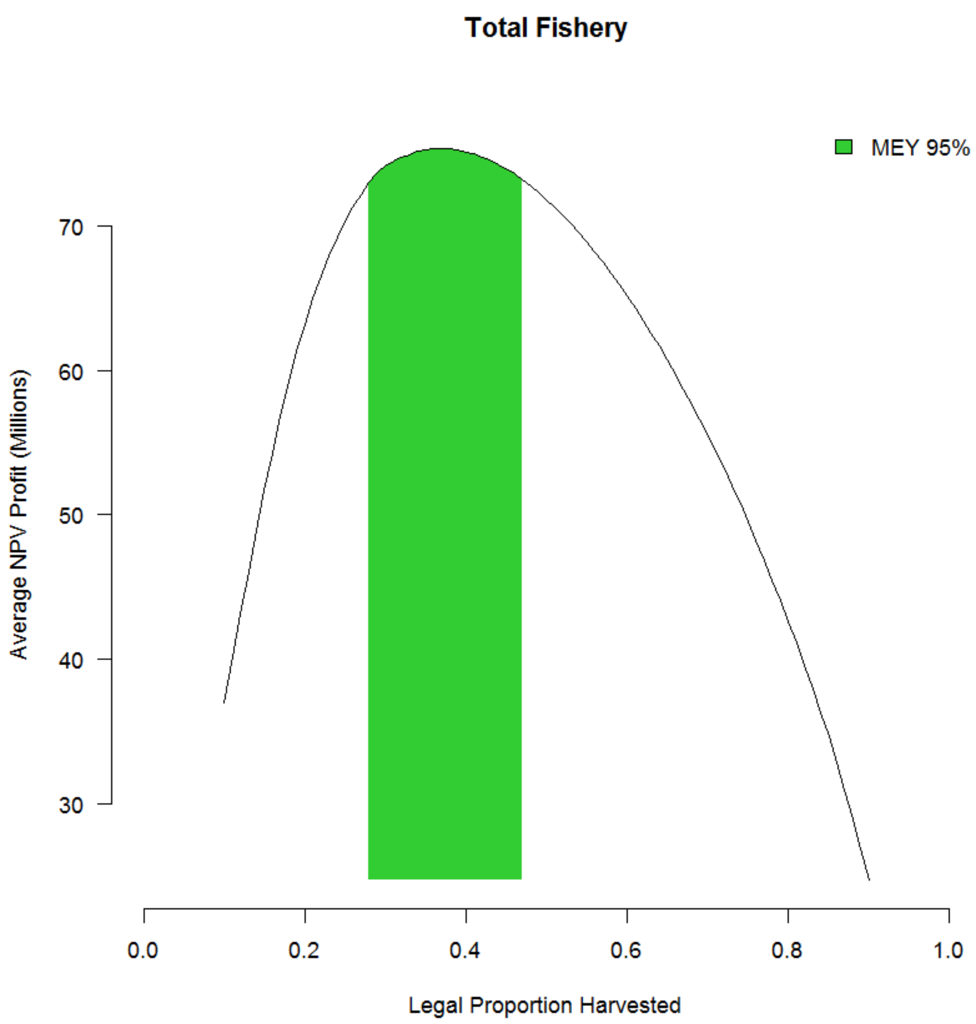


Figure 6. Example of MEY assessment showing the LPH range (green), based on a 12 month fishing season and existing biological controls, which results in 95% of the maximum NPV for the West Coast Rock Lobster Fishery over the next 5 years.

As the MEY analysis makes a number of assumptions concerning future beach prices and operating costs, a sensitivity analysis of these variables was conducted to determine what effect changing these would have on the overall MEY assessment. The results of this analysis showed that, while the overall profitability does move up and down when costs and beach price are varied, the range of LPH under MEY (i.e. about 0.4) does not markedly change. This demonstrates the robustness of the LPH values within the shaded area to changes in inputs within this analysis.

Narrowing the Range of TACCs

While the analysis of the 95% MEY provides a broad scope for the selection of TACCs under the Harvest Objective, some initial comments from the 2013 consultation suggest that there would be merit in narrowing the TACC range in order to provide a better indication on what level of catch should provide the greatest profitability for industry as a whole.

In order to provide a more focused range of TACCs, the MEY analysis has been narrowed to 99%, which provides a range that would is focused on the centre, or the upper-most region, of the MEY curve (**Figure 7**).

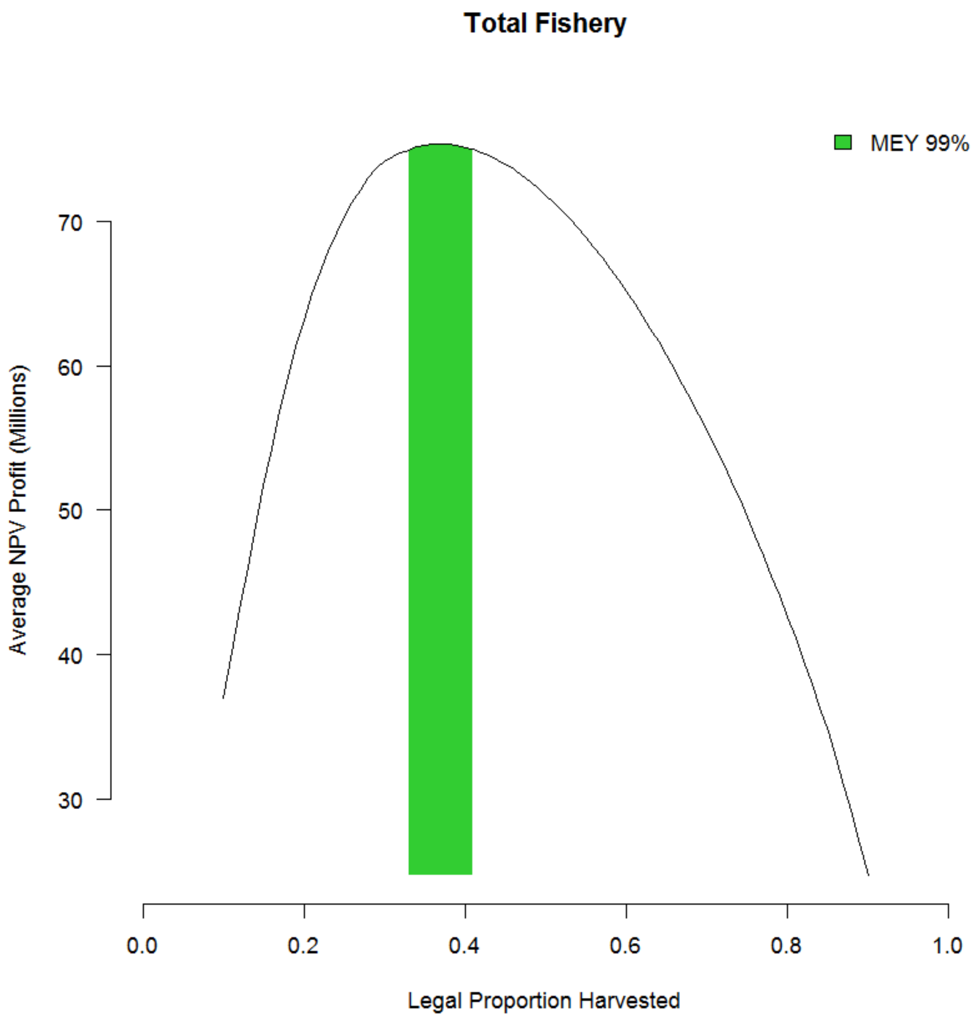


Figure 7. Example of MEY assessment showing the LPH range (green), based on a 12 month season and existing biological controls, which results in 99% of the maximum NPV for the West Coast Rock Lobster Fishery over the next 5 years.

The optimal LPH range, arising from the 99% MEY analysis (**Figure 7**) is 0.33 to 0.41, which results in a much narrower variation in TACCs for the fishery, i.e. from 5,152 to 6,417 tonnes for the 2014 season.

This method provides for a more focused approach to TACC setting under the Harvest Objective and is more in line with the approach taken by industry when providing its recommendations on the TACCs for the 2014 season.

Another way of narrowing the TACC range as discussed during the 2013 Annual Management Meetings, was to combine the MEY analysis with an assessment of the Gross Value of Production (GVP) for the fishery (total catch x estimated beach price). This method is discussed in more detail in Appendix 3.

Further research on MEY

It is recognised that the Department's initial research on MEY is preliminary. Further to this research (e.g. Reid, 2009; Reid et al. 2013), the Department has undertaken a three year research project to develop a bio-economic model for the fishery (Seafood CRC project 2009/714.10). This study uses available economic and catch data supplied by fishers to develop estimates of MEY. The preliminary results from this work have been incorporated into the current MEY analysis presented above.

In the longer-term, it will need to be determined whether more research on MEY is carried out and where responsibility for this lies (industry or Government).

RESEARCH MODELLING OF BIOLOGICAL CONTOLS

Assessment under current controls

An assessment using fixed levels of LPH from 0.1 to 0.9 was undertaken for the five seasons, 2014 to 2019. The stock assessment model produced outputs of catch, effort (pot lifts), and egg production by northern (Zones A and B combined) and southern (Zone C) regions for the five seasons for the different levels of LPH. This assessment assumed that current regulations on female maximum size, setose and minimum size were maintained (**Appendix 4**).

The assessments showed that for northern and southern regions low levels of LPH (0.1 to 0.3) resulted in relatively high catch rates with low catches increasing over the five years. At high levels of LPH (0.6 to 0.9) catches were far higher in the first year but then decreased with catch rates being relatively low and declining over the five years. At the intermediate levels of LPH (0.3 to 0.5) the catches and catch rates were relatively stable over the five years (**Appendix 4**).

Current estimated levels of egg production are at very high levels throughout the fishery (**Appendix 4**) and this is supported by fishery-independent surveys that have been undertaken since the early 1990s. Future projections of egg production indicate that they are likely to increase at LPH levels below 0.4 and decrease at levels above 0.6. Relatively stable levels of egg production are maintained at intermediate levels of LPH between 0.4 and 0.6. Given the current high levels of egg production, LPH levels between 0.4 and 0.6 are not likely to breach the threshold levels of any of the BSMAs over the next five years.

Varying the biological controls

At the request of industry, the Department has repeated the above analysis using a number of different scenarios, involving the removal of some of the key biological controls[4] (**Figure 8**). The MEY analysis included as a part of this assessment has been set at 99% of NPV, as discussed previously. The scenarios that were assessed against the current biological rules (Appendix 4) were the removal of the following prohibitions:

1. maximum female size — Appendix 5
2. setose lobsters — Appendix 6
3. maximum female size and setose — Appendix 7
4. maximum female size and setose and decreasing the minimum size from 77mm to 76mm — Appendix 8

The relaxation of any of these rules would result in higher catch rates (**Figure 8**) and thereby improve the profitability of the fishery. It would also provide the industry with a greater choice of size grade classes to target to maximise the value of the catch.

[4] These rules were implemented when the fishery was operating under input controls and the exploitation rate was greater than 80%; much higher than it is today.

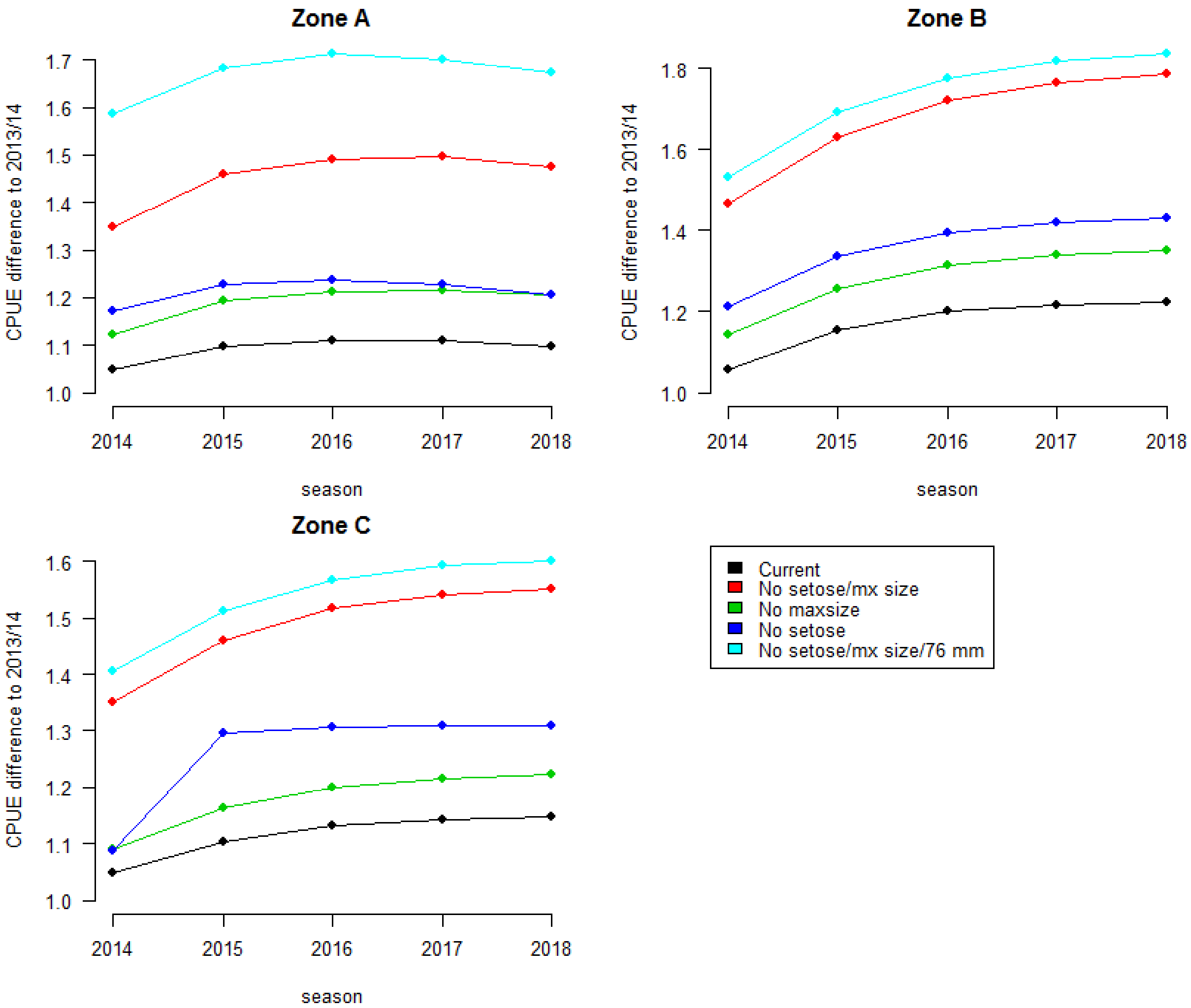


Figure 8. Comparison of the expected relative change in catch rates (kg/pot lift) from those experienced during the 2013 season as a result of changing biological controls.

POT USAGE

Clause 68 of the West Coast Rock Lobster Management Plan provides for the following arrangements regarding the number of pots that may be used in each zone of the Fishery:

> *"(1) The maximum number of pots that may be operated under the authority of a licence is -*
>
> *(a) in Zone A, the sum of -*
>
> *(i) the current entitlement of Zone A units multiplied by 0.05;*
> *(ii) the current entitlement of Zone B units multiplied by 0; and*
> *(iii) the current entitlement of Zone C units multiplied by 0;*
>
> *(b) in Zone B, the sum of -*
>
> *(i) the current entitlement of Zone A units multiplied by 0.028;*
> *(ii) the current entitlement of Zone B units multiplied by 0.05; and*
> *(iii) the current entitlement of Zone C units multiplied by 0;*
>
> *(c) in Zone C, the sum of -*
>
> *(i) the current entitlement of Zone A units multiplied by 0;*
> *(ii) the current entitlement of Zone B units multiplied by 0; and*
> *(iii) the current entitlement of Zone C units multiplied by 0.05."*

These arrangements maintain the same level of permitted pot usage as under the previous management plan. This is despite the changes to the number of units held by fishers and the grant of discrete Zone B units to Zone A fishers.

With fishers rapidly adapting to the management arrangements under quota, there has been some interest in re-examining the pot usage for the fishery.

Although pot usage does not impact on how the TACC is set, it can impact on fishing efficiency. It is understood that this is an important issue for industry and therefore submissions on pot usage are invited. Some options include:

- unlimited pots, reverting to current usage during the whale migration period;
- all fishers permitted a minimum pots then 0.05 pots per unit extra, once a certain number of units are held;
- limit of 0.05 pots for **all units** on the licence (i.e. combined A, B and C); or
- limit of 0.05 (or another ratio) pots for the **units in the zone** that is being fished.

TACC SETTING PROCESS

It is intended that in 2014, the TACC setting process for 2015 and the respective timelines will be linked to the adoption of the HSCR. It is expected that this process will be as follows:

Month	Action
December/March	Consultation.
March	Department of Fisheries to draft a HSCR "rulebook" outlining objectives and principles based on outcomes of consultation.
April	WRLC meeting to provide advice on final HSCR.
April	Ministerial approval of final HSCR.
June	Commence consultation on 2015 TACCs using approved HSCR (linked with the Annual Management Meetings).
August	WRLC final recommendations to the Minister on 2015 TACCs.

These timeframes should allow adequate time for the relevant legislation to be drafted in order for industry and the Department to be aware of approved TACCs well ahead of the coming licensing period.

The process would be similar in future years, but in keeping with the development of the HSCR, there would be no need to consult on the objectives and principles behind TACC setting, meaning that the process would commence in May with presentation of the latest research data and discussions on the TACC based on the approved HSCR.

An alternative process to set the TACCs could be the use of an independent committee to develop advice for the Minister's consideration rather than advice coming via the WRLC. This type of arrangement is in place in New South Wales where the TACC setting committee seeks submissions from stakeholders, examines the Government's scientific advice and recommendations and then provides their "independent" advice to the Minister[5]. Adoption of this model in WA would require Ministerial approval noting both the current provisions of the Management Plan with regard to consultation prior to amendment and as he/she is the decision maker in terms of TACCs.

[5] http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0019/400717/Rock-Lobster-Total-Allowable-Catch-Committee-Report-and-Determination-for-2011-12.pdf

REVIEW PERIOD/LIFE OF DOCUMENT

The benefit of having an HSCR in place for the fishery is that the general principles and processes around TACC setting do not need to be debated each year, thereby providing increased stability and certainty for industry. However, it is recognised that the fishery does change over time and that a review period should be built into the HSCR to ensure that it remains relevant.

It is recommended that once the HSCR has been approved by the Minister, it will remain in place for a period of five years, after which time it will be fully reviewed. However, should a situation arise that may require changes to the HSCR, then a review could be initiated sooner.

Determining the effectiveness of the Harvest Objective

In order to be consistent with the Harvest Strategy Policy, it is necessary to provide two checks in HSCR. If either of these checks fail without a satisfactory explanation, then a review of the Stock Assessment Model and/or the HSCR may be necessary. The checks are:

1. **That the fishery achieves at least a certain proportion of its quota each year**. If the quota is not achieved, then an explanation would be required to ensure that the reason is not due to a lack of lobster abundance. It will be necessary to determine what the acceptable level of uncaught quota should be.
2. **That the quota is achieved within a specified effort level**. The quota should be achieved at or above a specified catch rate. If this is not achieved then an evaluation may be required as this result could reflect a lower abundance of legal size than predicted by the Stock Assessment Model. The catch rate threshold will be determined in a few years when more information on effort distribution for a 12 month season is available.

REFERENCES

Bray, T., 2004, ‘Rock Lobster Decision Rules: Breeding Stock Report 21 September 2004’, Department of Fisheries Publication

de Lestang, S., Caputi, N., How, J., Melville-Smith, R., Thomson, A. and Stephenson, P. 2012. Stock Assessment for the West Coast Rock Lobster Fishery. Fisheries Research Report No. 217. Department of Fisheries Publication

Reid, C, 2009, ‘An analysis of Maximum Economic Yield in the Western Rock Lobster Fishery’. Department of Fisheries Publication

Reid, C., Caputi, N., de Lestang, S., Stephenson, P. 2013. Assessing the effects of moving to maximum economic yield effort level in the western rock lobster fishery of Western Australia. *Marine Policy* (39) 303-313

APPENDICES

APPENDIX 1.

MEASURING THE SUSTAINABILITY OBJECTIVE

13. Sustainability Reference Values – Egg Production Thresholds and Limits

Threshold and limit reference values[6] for egg production have been established for the four Breeding Stock Management Areas (BSMAs) such that the Sustainability Objective of the fishery can be applied 1 to 4.

Thresholds

For BSMAs 2, 3 and 4 (**Figure 1**), the threshold value for egg production be based on the mid-1980s level (Appendix 1, **Table 1**). This is considered as a period of relatively lower exploitation in the fishery (particularly in the deeper water breeding stock areas) that preceded the general uptake of major innovations in technology such as GPS, high definition colour echo sounders and computers.

Unlike the breeding females in the coastal areas of Zones B and C, most females in the Abrolhos shallow water BSMA 3 commence breeding below legal size and hence the breeding stock in BSMA 3 is not depleted by fishing to the same extent as in the other BSMAs.

Limits

Limit values for the fishery have been set at 20% below the threshold values for each of the BSMAs. Given the proposed Sustainability Objective is to maintain egg production above the threshold level at all times, it is most unlikely, barring some catastrophic event, that egg production would breach the limit level. However, if it did, it would result in significant and rapid management intervention.

Proposed threshold and limit reference values have also been determined for BSMA 1 (**Figure 1**). Unlike BSMAs 2, 3 and 4, BSMA 1 is relatively isolated and the Big Bank component of this area was not heavily fished until the early 1990s. As such, little data is available pre 1990 and, because of low fishing effort, for a number of years after this. In February 2009 a significant proportion of the fishing grounds that comprise BSMA 1 were closed to lobster fishing, as anecdotal information indicated a marked reduction in residual (particularly breeding) stock had occurred. To monitor the recovery of the population/breeding stock and produce a time series of data to aid in the modelling of this area, annual independent stock surveys were initiated in October 2009. This time series currently stands at four years and has now been integrated into the stock assessment model. Once a better understanding of the population recovery in BSMA1 has been obtained and there is agreement between the model and observed data for this area, firm threshold and limit values will be set. In the interim an indicative threshold value has been set based on the current model-estimated average egg production of the mid-1990s. An indicative limit value has also been set, which is 20% below the threshold value. The mid-1990s period has been chosen for BSMA 1 as it was shortly after fishing began in this area and was well before the abnormally low puerulus settlements were recorded in the fishery (i.e. since 2007/08).

Appendix 1, Table 1. Description and threshold reference years for each of the four breeding stock management areas. Note that egg production limit values are set 20% below the threshold values.

[6] A target reference value is not calculated for egg production because all values above the threshold are considered equally acceptable.

	Description	Threshold reference years	
BSMA 1	**Deep water areas north of 28°S**	**Preliminary estimate only mid-1990s, but will be revised as more years of survey data become available**	**1994-1996**
BSMA 2	**Deep water areas between 28° and 30°S**	**Mid-1980s**	**1984–1986**
BSMA 3	**Shallow Abrolhos Islands areas**	**Mid-1980s**	**1984–1986**
BSMA 4	**Deep water areas south of 30°S**	**Mid-1980s**	**1984–1986**

14.

15. Taking Account of Uncertainty

The HSCR can incorporate uncertainty by expressing the rules in terms of the probability of the indicators (in this case the estimated level of egg production) being above their reference values. For example, if the estimated egg production were equal to its threshold value this would be equivalent to stating that there was a 50% probability that the actual egg production was above the threshold value.

Stock assessment reviewers[7] have recommended that the Control rules associated with sustainability should be more precautionary by accounting for uncertainty and that there should be a greater than 50% probability that the egg production indicator value is above the threshold value. This has been incorporated into the Control rules by requiring a 75% probability level that the egg production indicator values are above their threshold values five years into the future (Appendix 1, **Table 1**). This is equivalent to stating that there is a 75% probability that the actual egg production is, and will continue to be, above its threshold value five years into the future.

16. Stock Status and Fishery Performance

The stock status and fishery performance is evaluated by estimating where an indicator value (e.g. level of egg production) is located in relation to one or more of the reference values. Based on the thresholds and limits, the level of egg production for the fishery would be classified as:

Acceptable – Mean value is above the threshold level, with greater than 75% probability for each of the five years. Given this precautionary approach, the stock and the fishery are therefore in an acceptable state by meeting the Sustainability Objective (**Figure A**).

Unacceptable – Mean value is below the threshold or is above the threshold, but with less than 75% probability in one or more of the five years. The fishery would be considered to be in an 'unacceptable' state, as it would not be meeting its Sustainability Objective (**Figure A**).

[7] See: the report of *Western Rock Lobster Stock Assessment and Harvest Strategy Workshop 16 – 20 July 2007* (Department of Fisheries 2008); the *Western Rock Lobster International Stock Assessment and Modelling Workshop Report* (Department of Fisheries 2010) and the *Review of the Western Australian Rock Lobster Stock Assessment – Report to the Western Australian Department of Fisheries* (Department of Fisheries 2008) at: http://www.fish.wa.gov.au/About-Us/Publications/Pages/Fisheries-Occasional-Publications.aspx

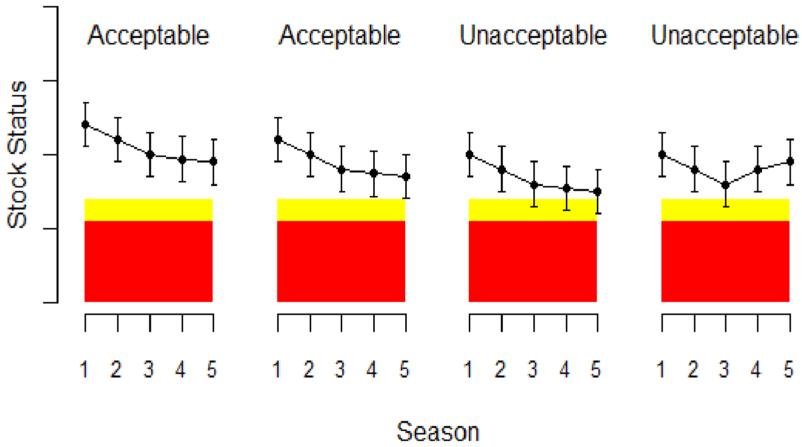


Figure A. Example of how a stock status indicator (showing a 75% probability level) is performing relative to a threshold/limit reference values could generate acceptable or unacceptable levels of stock status. The upper lines of the yellow and red areas are the threshold and limit values, respectively.

APPENDIX 2

EXPLANATION OF LEGAL PROPORTION HARVESTED

The Legal Portion Harvested (LPH) is represented by the equation:

$$LPH_s = \frac{C_s}{B_s},$$

where C_s is the commercial catch in season s and B_s is the average legal biomass if the fishery were to remain unfished for season *s*. Since the average unfished legal biomass over a season is derived only from the time-steps when fishing occurs, the magnitude of B_s can change if the number of time-steps that encompass a season changes (as was the case when the fishing season was increased from 7 ½, to 9 ½ and then to 12 months). As a season becomes longer more lobsters can moult into legal size and the average legal biomass over that season can therefore increase. Thus if the catch from a season remains the same while the average legal biomass is determined over two different periods the LPH value will change. This has been the case between determining LPH levels for setting the 2013 and 2014 seasons. The average unfished legal biomass over a season is currently based on every time-step in the Model since the season has now been extended to cover 12 months of the year.

APPENDIX 3

GVP AS A POSSIBLE TACC SETTING INPUT

Definition: Gross Value of Production (GVP) in the context of the HSCR for the western rock lobster fishery is measured as the total dollar return to all fishers in the fishery.

The wide range of TACCs from the MEY analysis (**Figure 5** in the main text) corresponds with a wide range of GVP values of between AUD$180 to $240 million that has important socio-economic implications for the fishery. Fishing at the lower end of the MEY (and hence GVP) range would result in a loss of AU$60 million in GVP. A smaller number of boats would be likely to operate to achieve the catch and hence there would be a lower level of employment in the fishery, however, there would be a relatively high profit per boat. In contrast at the upper end of the MEY (GVP) range, the TACCs and GVPs would be significantly higher, with a relatively larger number of boats likely to operate and hence a higher level of employment. However, the profitability per boat may be lower.

GVP could be used to narrow the target LPH range to select a level of catch that would provide a higher GVP (total dollar return) to achieve a socio-economic goal, if that was thought to be desirable. For example, selecting the LPH range that provides for at least 80% of the maximum GVP coincides with the top half of the MEY range, with LPH values of approximately 0.37 to 0.47 (**Figure B** below). This would result in catches in the range of 5,783 to 7,370 tonnes for 2014/15, with a corresponding GVPs of AUD$200 to $230 million. The corresponding TACC ranges for the zones would be:

A. 1,089 - 1,390 tonnes
B. 1,944 - 2,481 tonnes
C. 2,750 - 3,499 tonnes

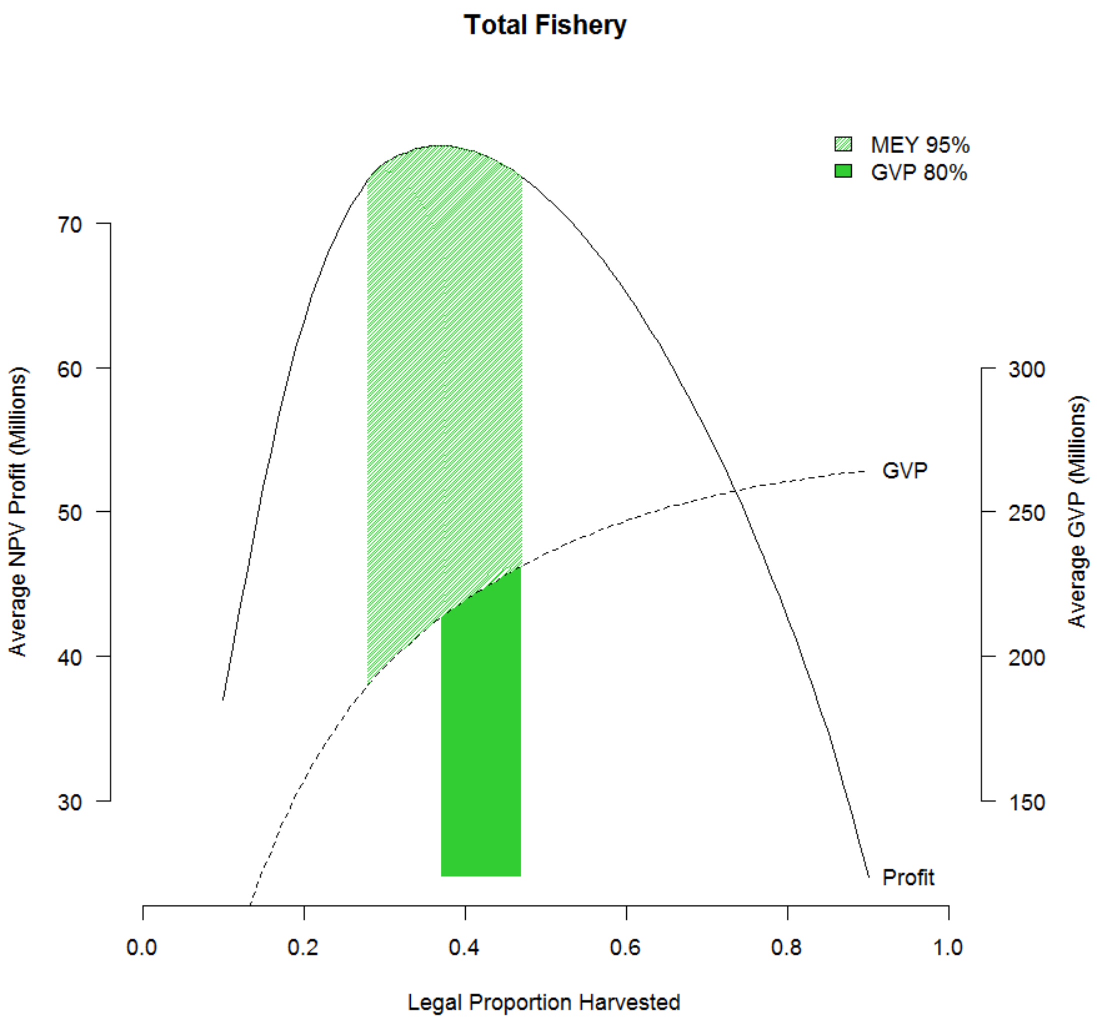


Figure B. Example of MEY based on 95% of the maximum NPV, and GVP based on a minimum of 80% of maximum GVP in the West Coast Rock Lobster Fishery

APPENDIX 4

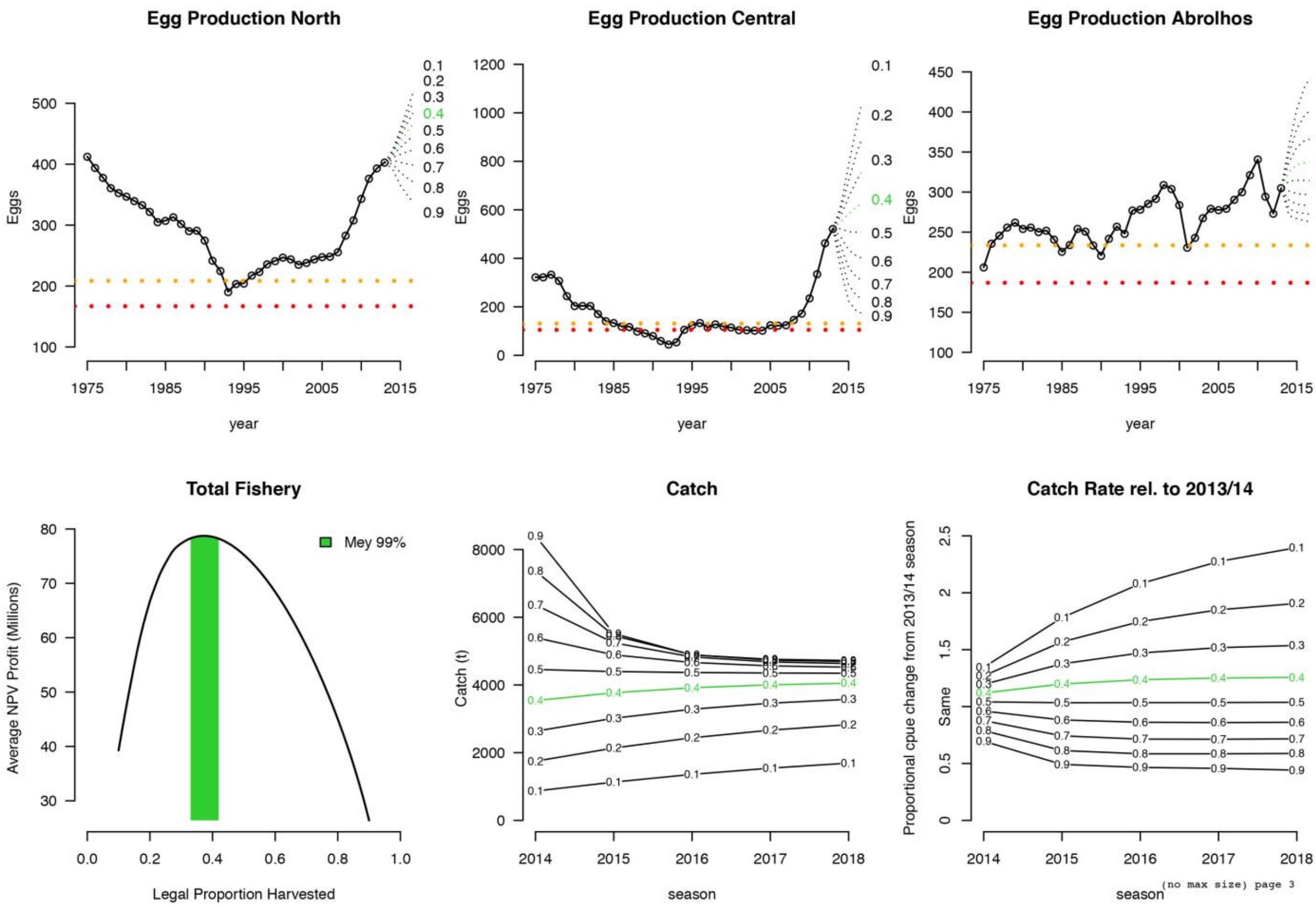
ASSESEMENT UNDER CURRENT BIOLOGICAL CONTROLS

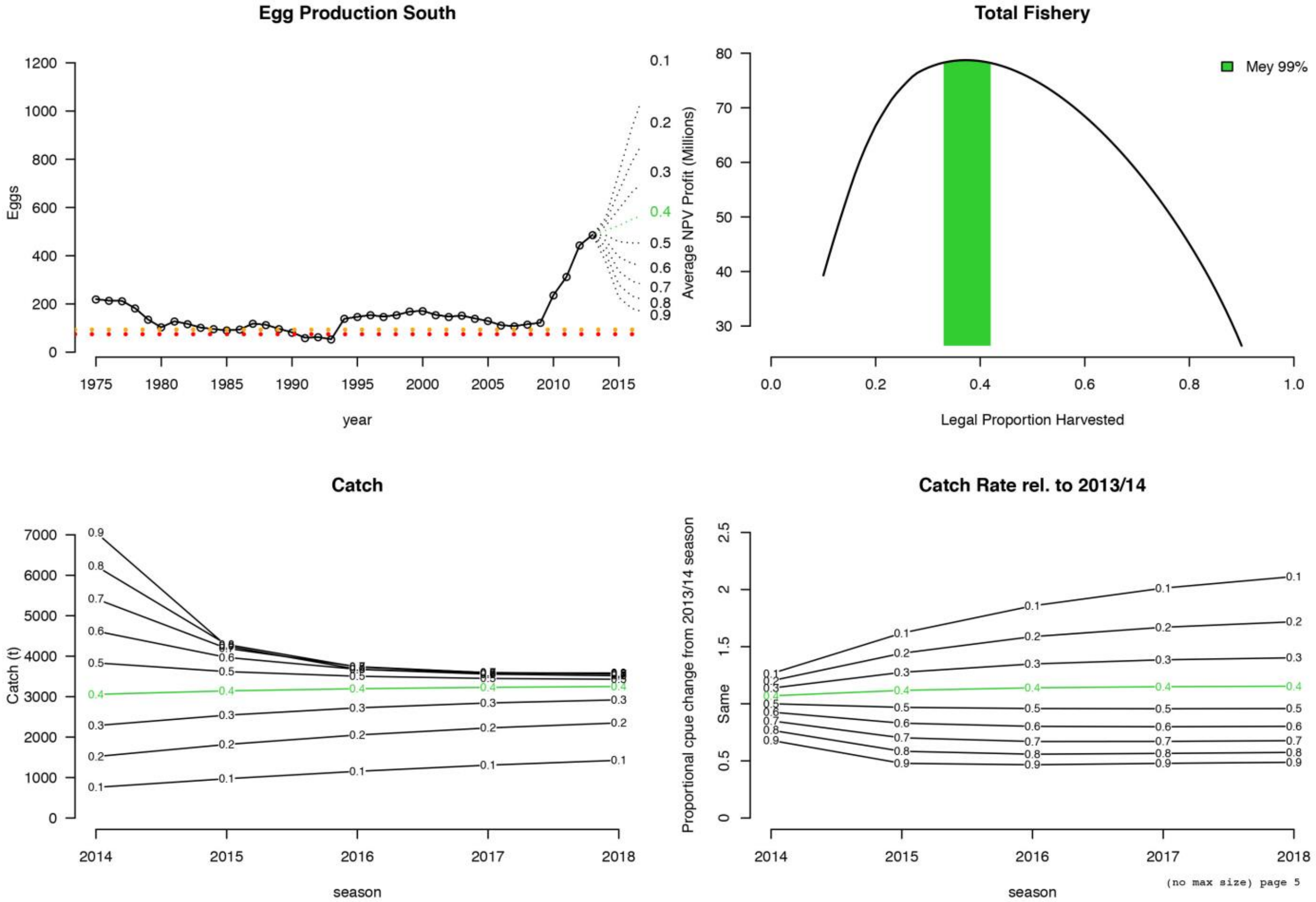
At the request of industry, the Department has repeated the above analysis using a number of different scenarios, involving the removal of some of the key biological controls. The MEY analysis included as a part of this assessment has been set at 99% of NPV, as discussed previously. The scenarios that were assessed against the current biological rules include the removal of the following prohibitions:

1. maximum female size	**Appendix 5**
2. setose lobsters	**Appendix 6**
3. maximum female size and setose	**Appendix 7**
4. maximum female size and setose and decreasing the minimum size from 77mm to 76mm	**Appendix 8**

APPENDIX 5

REMOVAL OF MAXIMUM FEMALE SIZE RULE





Egg Production South
Eggs
year
Total Fishery
Average NPV Profit (Millions)
Legal Proportion Harvested
Mey 99%
Catch
Catch (t)
season
Catch Rate rel. to 2013/14
Proportional cpue change from 2013/14 season
Same
season
(no max size) page 5

TACCs (2014/15 season)

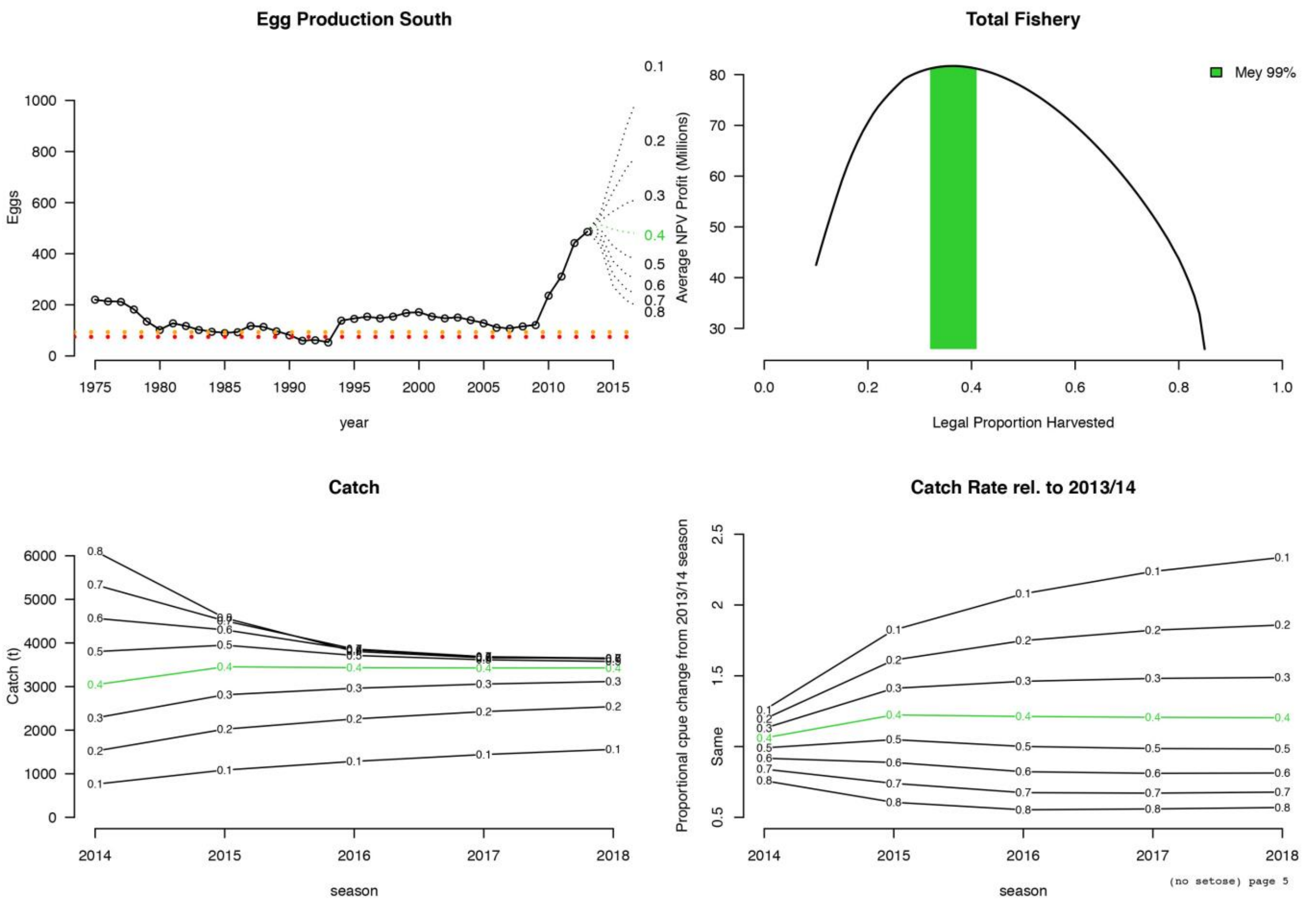
	Cth. North	Cth. South	Total	Delta_cpue_AB	Delta_cpue_C
0.21	1833	1595	3428	1.26	1.19
0.22	1922	1672	3594	1.25	1.19
0.23	2010	1748	3758	1.25	1.18
0.24	2099	1825	3924	1.24	1.17
0.25	2188	1901	4089	1.23	1.17
0.26	2277	1978	4255	1.22	1.16
0.27	2366	2055	4421	1.22	1.15
0.28	2455	2131	4586	1.21	1.15
0.29	2544	2208	4752	1.2	1.14
0.3	2634	2285	4919	1.2	1.13
0.31	2724	2362	5086	1.19	1.13
0.32	2813	2439	5252	1.18	1.13
0.33	2903	2516	5419	1.17	1.12
0.34	2993	2593	5586	1.16	1.11
0.35	3083	2670	5753	1.16	1.11
0.36	3174	2747	5921	1.15	1.1
0.37	3264	2824	6088	1.14	1.09
0.38	3355	2901	6256	1.13	1.09
0.39	3446	2979	6425	1.13	1.08
0.4	3537	3056	6593	1.12	1.07
0.41	3628	3134	6762	1.11	1.06
0.42	3720	3211	6931	1.1	1.06
0.43	3811	3289	7100	1.09	1.05
0.44	3903	3367	7270	1.09	1.04
0.45	3995	3444	7439	1.08	1.03
0.46	4087	3522	7609	1.07	1.03
0.47	4179	3600	7779	1.06	1.02
0.48	4272	3678	7950	1.06	1.01
0.49	4364	3756	8120	1.05	1.01
0.5	4457	3834	8291	1.04	1
0.51	4550	3913	8463	1.03	0.99
0.52	4644	3991	8635	1.02	0.98
0.53	4737	4069	8806	1.02	0.98
0.54	4831	4148	8979	1.01	0.97
0.55	4925	4226	9151	1	0.96
0.56	5019	4305	9324	0.99	0.96
0.57	5114	4384	9498	0.99	0.95
0.58	5208	4462	9670	0.97	0.95
0.59	5303	4541	9844	0.97	0.94
0.6	5399	4621	10020	0.96	0.93
0.61	5494	4700	10194	0.95	0.92
0.62	5590	4779	10369	0.94	0.92
0.63	5686	4858	10544	0.94	0.91
0.64	5782	4938	10720	0.93	0.9
0.65	5878	5017	10895	0.92	0.89
0.66	5975	5097	11072	0.91	0.88
0.67	6072	5177	11249	0.9	0.87
0.68	6170	5257	11427	0.89	0.87
0.69	6267	5337	11604	0.88	0.86

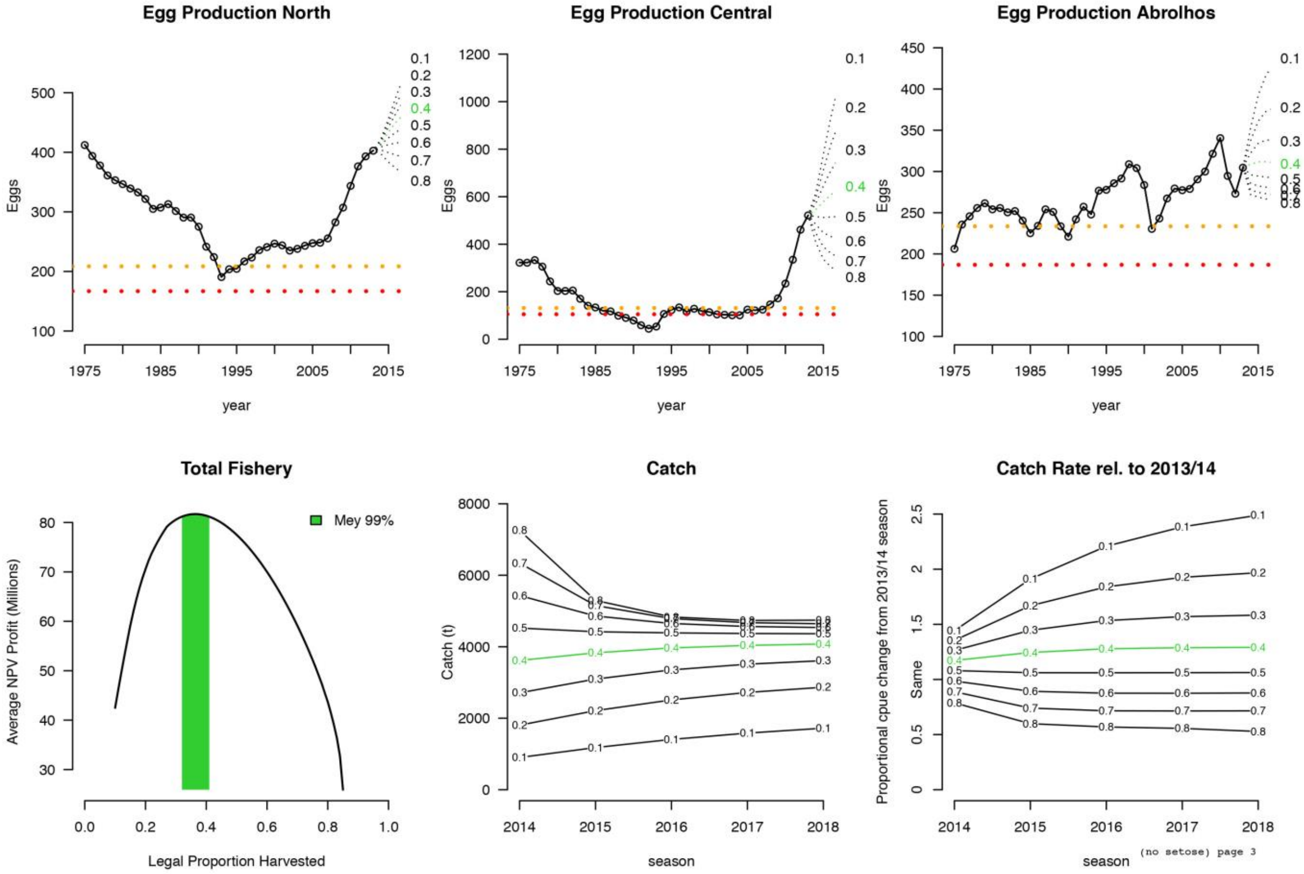
Green = 99% MEY target, Orange = Egg Production reduction >20% over 5 yrs
Delta cpue = Proportional change from 2013/14 season

(no max size) page 6

APPENDIX 6

REMOVAL OF SETOSE RULE




Egg Production North
Egg Production Central
Egg Production Abrolhos
Eggs
year
Total Fishery
Mey 99%
Average NPV Profit (Millions)
Legal Proportion Harvested
Catch
Catch (t)
season
Catch Rate rel. to 2013/14
Proportional cpue change from 2013/14 season
Same
season
(no setose) page 3

TACCs (2014/15 season)

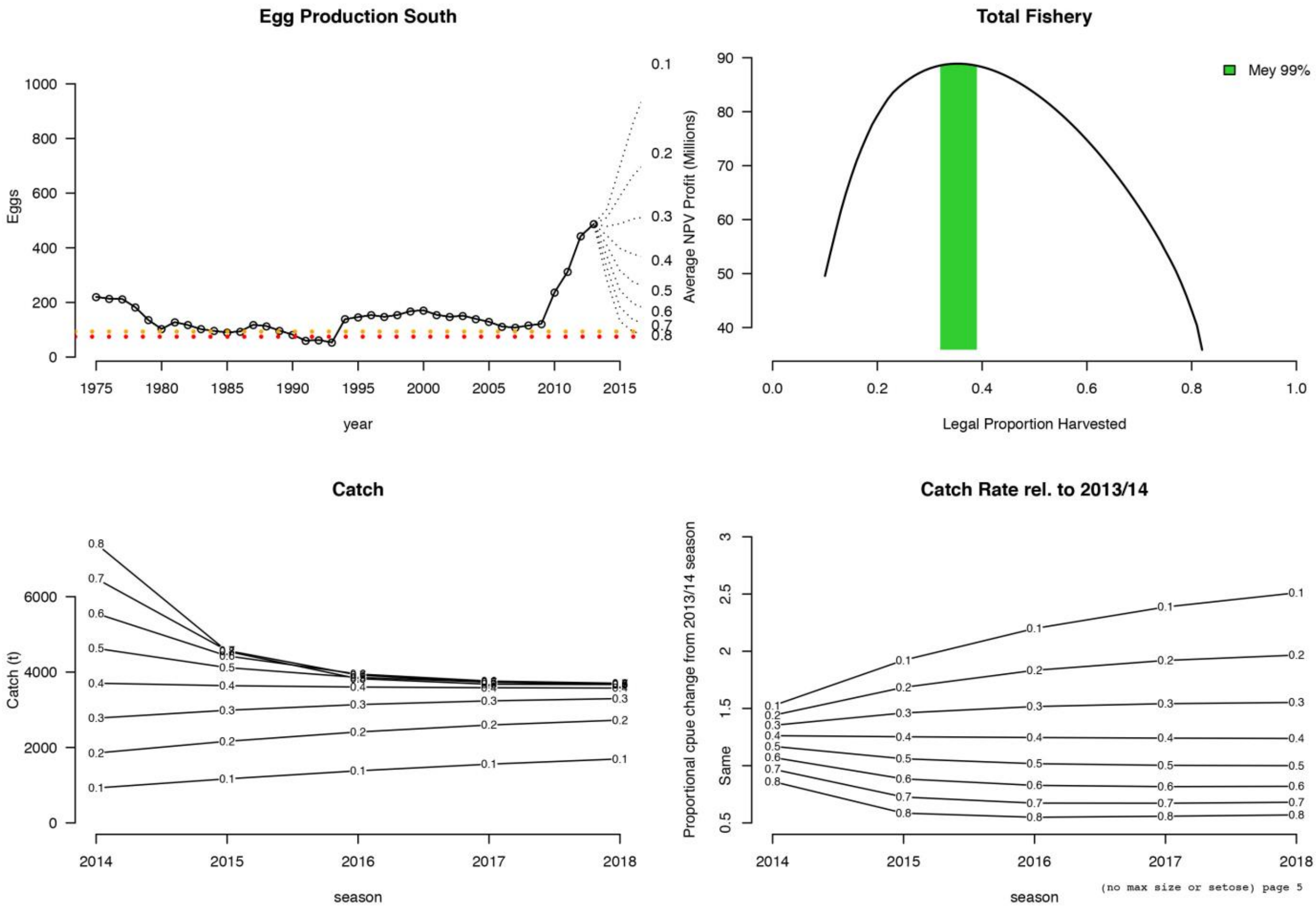
	Cth. North	Cth. South	Total	Delta_cpue_AB	Delta_cpue_C
0.21	1897	1595	3492	1.34	1.19
0.22	1987	1671	3658	1.34	1.18
0.23	2077	1747	3824	1.32	1.17
0.24	2168	1823	3991	1.32	1.17
0.25	2258	1899	4157	1.31	1.16
0.26	2349	1975	4324	1.3	1.15
0.27	2439	2051	4490	1.29	1.14
0.28	2530	2127	4657	1.28	1.14
0.29	2620	2203	4823	1.27	1.13
0.3	2710	2279	4989	1.26	1.13
0.31	2801	2355	5156	1.25	1.13
0.32	2892	2431	5323	1.25	1.12
0.33	2982	2507	5489	1.24	1.11
0.34	3073	2583	5656	1.23	1.11
0.35	3163	2660	5823	1.22	1.1
0.36	3254	2736	5990	1.21	1.09
0.37	3344	2812	6156	1.2	1.08
0.38	3435	2888	6323	1.19	1.08
0.39	3525	2964	6489	1.18	1.07
0.4	3616	3040	6656	1.17	1.06
0.41	3706	3116	6822	1.16	1.05
0.42	3797	3192	6989	1.15	1.05
0.43	3888	3269	7157	1.15	1.04
0.44	3978	3345	7323	1.14	1.03
0.45	4069	3421	7490	1.13	1.03
0.46	4160	3497	7657	1.12	1.02
0.47	4250	3574	7824	1.11	1.01
0.48	4341	3650	7991	1.1	1
0.49	4432	3726	8158	1.09	1
0.5	4523	3803	8326	1.08	0.99
0.51	4613	3879	8492	1.07	0.98
0.52	4704	3955	8659	1.06	0.97
0.53	4795	4032	8827	1.05	0.97
0.54	4886	4108	8994	1.04	0.96
0.55	4976	4184	9160	1.03	0.96
0.56	5067	4261	9328	1.02	0.95
0.57	5158	4337	9495	1.02	0.94
0.58	5249	4414	9663	1	0.94
0.59	5340	4490	9830	1	0.93
0.6	5431	4567	9998	0.98	0.92
0.61	5522	4643	10165	0.98	0.91
0.62	5613	4720	10333	0.96	0.9
0.63	5704	4797	10501	0.96	0.9
0.64	5795	4873	10668	0.95	0.89
0.65	5886	4950	10836	0.94	0.88
0.66	5977	5027	11004	0.93	0.87
0.67	6068	5104	11172	0.92	0.86
0.68	6159	5180	11339	0.91	0.86
0.69	6250	5257	11507	0.9	0.85

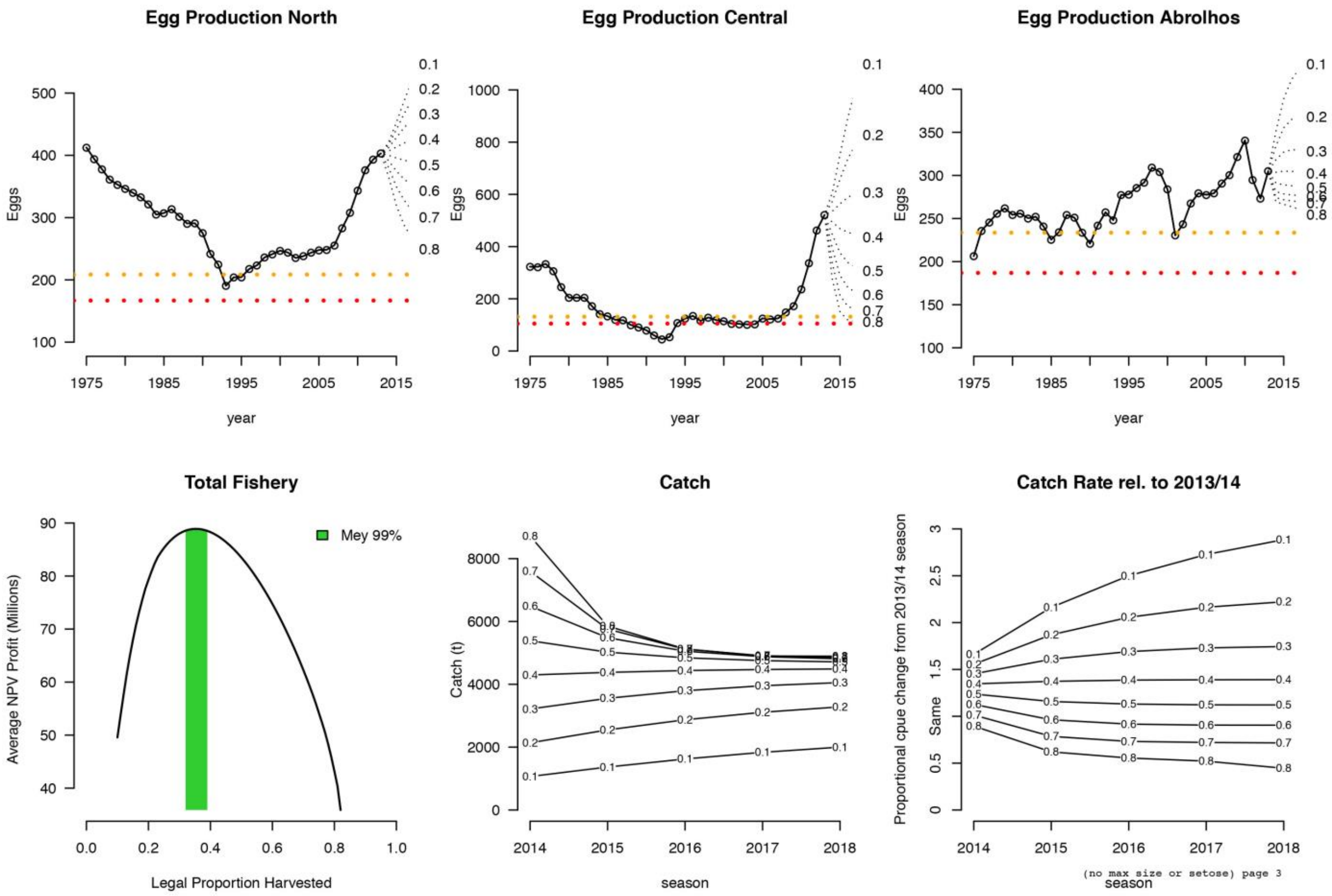
Green = 99% MEY target, Orange = Egg Production reduction >20% over 5 yrs
Delta cpue = Proportional change from 2013/14 season

(no setose) page 6

APPENDIX 7

REMOVAL OF MAXIMUM FEMALE AND SETOSE RULES




Egg Production North
Egg Production Central
Egg Production Abrolhos
Eggs
year
Total Fishery
Mey 99%
Average NPV Profit (Millions)
Legal Proportion Harvested
Catch
Catch (t)
season
Catch Rate rel. to 2013/14
Proportional cpue change from 2013/14 season
Same
(no max size or setose) page 3

TACCs (2014/15 season)

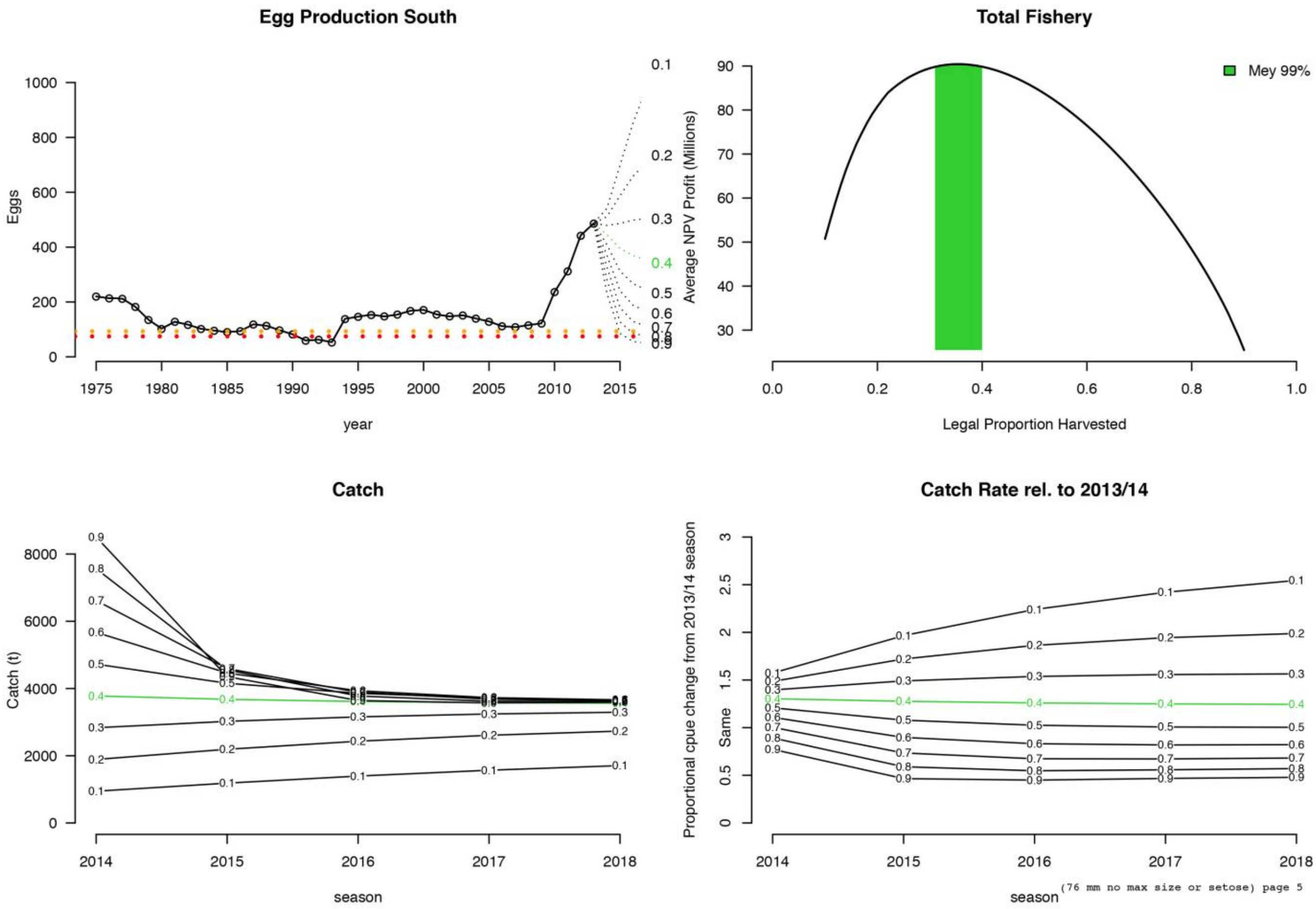
	Cth. North	Cth. South	Total	Delta_cpue_AB	Delta_cpue_C
0.21	2245	1945	4190	1.55	1.43
0.22	2353	2037	4390	1.54	1.42
0.23	2460	2130	4590	1.53	1.41
0.24	2568	2222	4790	1.52	1.41
0.25	2675	2315	4990	1.5	1.4
0.26	2783	2408	5191	1.49	1.39
0.27	2891	2500	5391	1.48	1.38
0.28	2998	2593	5591	1.47	1.37
0.29	3106	2685	5791	1.47	1.36
0.3	3214	2778	5992	1.45	1.35
0.31	3322	2871	6193	1.44	1.34
0.32	3430	2963	6393	1.43	1.33
0.33	3539	3056	6595	1.42	1.32
0.34	3647	3148	6795	1.41	1.31
0.35	3755	3241	6996	1.4	1.31
0.36	3863	3334	7197	1.39	1.3
0.37	3972	3426	7398	1.38	1.29
0.38	4080	3519	7599	1.37	1.28
0.39	4189	3611	7800	1.36	1.27
0.4	4297	3704	8001	1.34	1.26
0.41	4406	3797	8203	1.34	1.26
0.42	4515	3889	8404	1.33	1.25
0.43	4624	3982	8606	1.31	1.24
0.44	4733	4074	8807	1.3	1.23
0.45	4842	4167	9009	1.29	1.22
0.46	4951	4259	9210	1.28	1.21
0.47	5060	4352	9412	1.27	1.2
0.48	5169	4445	9614	1.26	1.19
0.49	5278	4537	9815	1.25	1.18
0.5	5388	4630	10018	1.24	1.17
0.51	5497	4722	10219	1.23	1.16
0.52	5607	4815	10422	1.22	1.15
0.53	5717	4907	10624	1.2	1.14
0.54	5827	5000	10827	1.19	1.13
0.55	5936	5092	11028	1.19	1.13
0.56	6046	5185	11231	1.17	1.12
0.57	6156	5278	11434	1.16	1.11
0.58	6267	5370	11637	1.15	1.09
0.59	6377	5463	11840	1.14	1.08
0.6	6487	5555	12042	1.13	1.07
0.61	6598	5648	12246	1.12	1.06
0.62	6709	5740	12449	1.1	1.05
0.63	6819	5833	12652	1.1	1.04
0.64	6930	5925	12855	1.08	1.03
0.65	7041	6018	13059	1.07	1.02
0.66	7152	6110	13262	1.06	1.01
0.67	7263	6203	13466	1.05	1
0.68	7375	6295	13670	1.04	0.99
0.69	7486	6387	13873	1.03	0.98

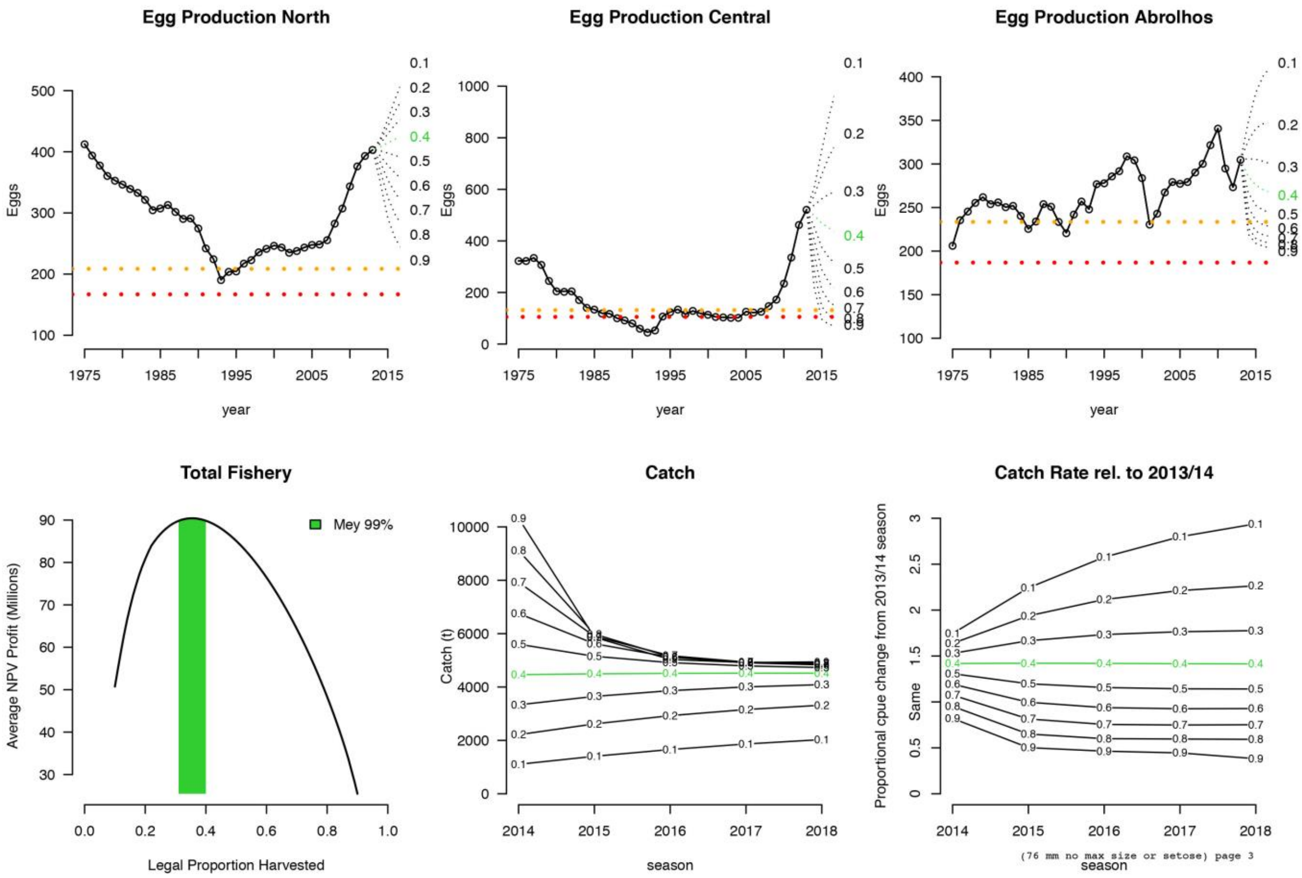
Green = 99% MEY target, Orange = Egg Production reduction >20% over 5 yrs
Delta cpue = Proportional change from 2013/14 season

(no max size or setose) page 6

APPENDIX 8

REMOVAL OF MAXIMUM FEMALE AND SETOSE RULES AND REDUCING THE MINIMUM SIZE TO 76mm




Egg Production North
Egg Production Central
Egg Production Abrolhos
Eggs
year
Total Fishery
Mey 99%
Average NPV Profit (Millions)
Legal Proportion Harvested
Catch
Catch (t)
season
Catch Rate rel. to 2013/14
Proportional cpue change from 2013/14 season
Same
(76 mm no max size or setose) page 3

TACCs (2014/15 season)

	Cth. North	Cth. South	Total	Delta_cpue_AB	Delta_cpue_C
0.21	2326	1983	4309	1.63	1.48
0.22	2438	2078	4516	1.61	1.47
0.23	2550	2172	4722	1.61	1.46
0.24	2662	2267	4929	1.59	1.45
0.25	2773	2361	5134	1.58	1.44
0.26	2885	2456	5341	1.57	1.43
0.27	2997	2550	5547	1.56	1.42
0.28	3109	2644	5753	1.55	1.41
0.29	3222	2739	5961	1.54	1.41
0.3	3334	2833	6167	1.53	1.4
0.31	3447	2928	6375	1.52	1.39
0.32	3559	3023	6582	1.5	1.38
0.33	3672	3117	6789	1.5	1.37
0.34	3784	3212	6996	1.48	1.36
0.35	3897	3306	7203	1.47	1.35
0.36	4010	3401	7411	1.47	1.34
0.37	4123	3495	7618	1.45	1.33
0.38	4236	3590	7826	1.44	1.32
0.39	4349	3684	8033	1.43	1.31
0.4	4463	3779	8242	1.42	1.31
0.41	4576	3873	8449	1.41	1.3
0.42	4690	3968	8658	1.4	1.29
0.43	4804	4062	8866	1.38	1.28
0.44	4917	4157	9074	1.38	1.27
0.45	5031	4252	9283	1.36	1.26
0.46	5145	4346	9491	1.35	1.25
0.47	5259	4441	9700	1.34	1.24
0.48	5374	4535	9909	1.33	1.23
0.49	5488	4630	10118	1.32	1.22
0.5	5603	4724	10327	1.31	1.21
0.51	5718	4819	10537	1.29	1.2
0.52	5832	4913	10745	1.29	1.19
0.53	5947	5008	10955	1.27	1.18
0.54	6063	5103	11166	1.26	1.17
0.55	6178	5197	11375	1.25	1.16
0.56	6293	5292	11585	1.24	1.14
0.57	6409	5386	11795	1.23	1.13
0.58	6525	5481	12006	1.22	1.13
0.59	6640	5576	12216	1.2	1.12
0.6	6756	5670	12426	1.19	1.11
0.61	6873	5765	12638	1.18	1.1
0.62	6989	5859	12848	1.17	1.09
0.63	7106	5954	13060	1.16	1.08
0.64	7222	6048	13270	1.15	1.07
0.65	7339	6143	13482	1.13	1.06
0.66	7456	6238	13694	1.12	1.05
0.67	7573	6332	13905	1.11	1.04
0.68	7691	6427	14118	1.1	1.02
0.69	7808	6521	14329	1.09	1.01

Green = 99% MEY target, Orange = Egg Production reduction >20% over 5 yrs
Delta cpue = Proportional change from 2013/14 season

(76 mm no max size or setose) page 6