A Cost Benefit Analysis of Alternative Management Options for the Australian Northern Prawn Fishery

Sustainable Environment Group

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Non Technical Summary

2008/052 A cost benefit Analysis of Alternative Management Options for the Australian Northern Prawn Fishery

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OBJECTIVES:

1. Conduct full cost benefit analysis (CBA) on the short list of alternative management arrangements for the Northern Prawn Fishery as agreed by the NORMAC workshop
2. Prepare a detailed report on the results of the CBA
3. Present the results of the CBA to NORMAC and AFMA

NON TECHNICAL SUMMARY:

OUTCOMES ACHIEVED TO DATE
This research has provided information on the costs and benefits of managing a range of prawn species with individual transferable quotas in the Northern Prawn Fishery. AFMA will make a decision on which species to place under ITQ management in 2009 so this research has provided valuable input to making that decision.

Dr Tom Kompas has presented the results of the research to industry meetings, RAG meetings and MAC meetings.

KEYWORDS: northern prawn fishery, cost benefit analysis, individual transferable quota.

As a part of the Ministerial Direction to AFMA and the Australian Government's Securing our Fishing Future Structural Adjustment Package, AFMA is considering which prawn species in the Northern Prawn Fishery should be managed under the primary management tool of individual transferable quotas (ITQs).

A range of options were developed at NORMAC workshops and to determine which of these options would likely provide the greatest net benefit and best pursue AFMA's objective to maximise the net economic returns to the Australian community a cost benefit analysis was commissioned. A summary of the results of the research are presented below. Dr Tom Kompas, the lead author, also presented the draft and final research findings to industry meetings, RAG meetings and NORMAC meetings.

The benefit cost analysis compared the costs and benefits of three options relative to the costs and benefits of the optimised status quo. These differences were presented as net present values over a 50 year planning horizon using a 3 per cent p.a. discount rate.

The benefits included in the analysis include:

- increased profit in the tiger prawn season from using the correct management tool that best manages uncertainty
- efficiency benefits (both tiger and banana prawns) that flow from quotas in terms of
    - transfers from high cost to low cost fishers and
    - the freedom to choose the combination of fishing inputs to lower costs
- benefits from a conservative quota in the banana prawn season which results in a larger reduction in fishing costs compared to the associated reduction in revenue.

The costs considered were increases in management costs, including direct management officers, data (including observers), licensing, compliance and research costs.

For each of the options a range of possible net present values were discussed. The reason for this range is that the costs and benefits and therefore the net present values change under different assumptions. These include the level of observer coverage, the efficiency improvements achieved under quotas and whether or not a price premium is created for banana prawns when under quota. A summary of these results is presented in Table 1.

Under both options two and four, the net present value is always positive under each scenario. That is, the benefits outweigh the costs compared to the optimised status quo.

Table 1 – summary of results (figures are net present values over a 50 year period at a 3 per cent p.a. discount rate)

		Option		
		Option 2 ITQ both species	Option 3 ITQ tiger only	Option 4. ITQ banana only
Base case 1 (15% efficiency gain, 15% observer coverage 1st 5 years then 2% observer coverage)	NPV $m	63.6	9.7	52.1
Base case 2 (5% efficiency gain, 15% observer coverage 1st 5 years then 2% observer coverage)	NPV $m	25.4	3.5	20.1
Minimum case 1 (5% efficiency gain, 15% observer coverage)	NPV $m	3.3	-10.7	11.7
Maximum case 1 (15% efficiency gain, 2% observer coverage)	NPV $m	67.6	12.4	53.9
Maximum case 2 (15% efficiency gain, 2% observer coverage, price premium on banana prawns)	NPV $m	98.3	12.4	85.0

Each management option involves extra management and research costs (Table 2). However, these extra management costs are already included in the calculation of the net present values of the options in Table 1.

Table 2 – additional management and research costs (figures are net present values over a 50 year period at a 3% discount rate)

		Option		
Level of observer coverage		Option 2 ITQ both species	Option 3 ITQ tiger only	Option 4. ITQ banana only
2% observer coverage	NPV $m	11.7	8.9	4.1
15% observer coverage 1st 5 years then 2% observer coverage	NPV $m	15.7	11.6	5.9
15% observer coverage all years	NPV $m	37.8	25.7	14.3

A number of important factors were not quantifiable in the report such as the costs of effort creep under input controls and differences in the level of autonomous adjustment between the options.

Despite the larger management costs associated with the three ITQ options, the estimated benefits more than outweigh these costs in all but one scenario (Table 1).

The outcome from this research is a significant contribution to the decision on which form of ITQ management AFMA will adopt for the northern prawn fishery. While the decision on which form of ITQs will be adopted has not yet been made, it is clear the research has provided valuable input to that process.

Acknowledgements

The Australian Fisheries Management Authority (AFMA) would like to thank FRDC for its financial contribution to the project. AFMA would also like to thank the project Steering Committee as well as the Northern Prawn Fishery RAG and MAC for valuable comments on the draft report.

Background

During the last few years, AFMA and the Northern Prawn Fishery (NPF) industry have been investigating options for managing the Northern Prawn Fishery under individual transferable quotas (ITQs) as part of the Government's 2005 Ministerial Direction that Commonwealth fisheries will move to ITQ management by 2010, and the agreement of NPF industry to pursue the implementation of ITQs in return for structural adjustment funding. During this time, NORMAC and the ITQ sub-committee have investigated a number of approaches for implementing quotas. In addition, an industry/AFMA funded independent study of ITQ options for the NPF was undertaken by MRAG et al in 2006–07 to identify options which would provide the greatest sustainability and economic benefits to the fishery.

In 2006, the Australian Government's Securing our Fishing Future Structural Adjustment Package removed 42 B Class SFRs and approximately 30 per cent of the effective effort from the NPF. The industry has formed an industry company 'NPF Industry Pty Ltd' that incorporates around 93 per cent of the fishery gear SFR holders.

Currently, the NPF is managed by a series of effort controls (i.e., gear units, season length, and statutory fishing rights) with a maximum economic yield (MEY) target level of catch.

Along with benefits to stock status and sustainability, there are a number of potential economic costs and benefits that result from introducing ITQs. Potential benefits include:

- Increased profits due to standard efficiency gains across the fleet. (Examples include quota trades from high to low marginal cost vessels; less or different restrictions on inputs, such as gear configuration, engine size, season length, etc.; and different and more profitable input combinations on average in the fleet.)
- Increased profits due to efficiency gains and changes in operation at the vessel level (when to catch, how to catch, changes that generate higher quality or more valuable product and the potential for autonomous adjustment).
- Increased profits from matching instrument choice to the source and extent of uncertainty
- Asset value gains from increased profitability and more secure fishing rights
- Reduced effort creep.

Potential costs include:

- Increases in management costs, including the costs of compliance, licensing, research, data collection and observer costs.
- Transitional management costs and adjustment costs for industry.

AFMA with the industry evaluated a number of potential alternative management options in a semi-quantitative manner through the MRAG report and two NORMAC workshops. This work highlighted that the following management options were most likely to be appropriate for the NPF:

- Optimised Status Quo

Limited entry; boat SFRs, individual transferable gear SFRs; mandatory TEDs/ BRDs, mandatory VMS; in-season management including decision rules and trigger limits to extend the banana and tiger prawn fishing seasons when appropriate; and spatial and temporal closures. The banana and tiger prawn fisheries (including endeavour and king prawns) will continue to be managed by a combination of gear SFRs and set season length (season length adjustable by in-season management). Spatial and temporal (including mid-year) closures would continue to be used to protect small prawns and nursery grounds, and to control effort on pre-spawning tiger prawns as determined appropriate by the stock assessment.

- Individual Transferable Quotas (updated TAC for common banana prawns)

Limited entry; boat SFRs, individual transferable quota SFRs; mandatory TEDs/ BRDs, mandatory VMS; spatial and seasonal closures; and fixed season length. Key target species (common bananas, red leg bananas and tiger prawns) would be subject to TACs. There would be no limit on boat/engine size and no gear constraints (other than TEDs/BRDs). The fishery would have a fixed fishing season commencing no earlier than 1st March and closing no later than 1st December. Permanent area closures would be retained and some spatial and temporal closures would be retained to protect small prawns. Each operator would be allocated individual transferable quotas. The initial banana prawn TAC would set based on historical catches and the TAC would subsequently be updated using the data collected, perhaps in the annual recruitment survey or another fishery independent device.

- MRAG Proposal

1st Season (Banana Prawn Season): Gear units system; in-season management to determine season length; 2nd Season (Tiger Prawn Season) ITQs for the tiger prawn fishery; fixed season length; and no gear constraints. This is a hybrid system that will require the use of different types of SFRs and different approaches to licensing, data collection, compliance, stock assessment and fishery adjustment during the banana and tiger prawn seasons. The banana prawn fishery would be managed by boat and gear SFRs and season length. Spatial and temporal closures would continue to be used to protect small prawns and nursery grounds. Decision rules and trigger limits will be in place to limit catches and season length.

- 1st Season: ITQ’s for Banana prawns during first season/input controls (gear and time) in the tiger season

Limited entry; boat SFRs, individual transferable quota SFRs; mandatory TEDs/ BRDs, mandatory VMS; spatial and temporal closures; the first season will be managed by quota. Banana prawns would be the only species available as target catch. Existing tiger prawn trigger limits would apply in the first season. There would be considerable flexibility in relation to the timing of the banana prawn fishing season (e.g. any time between March and June). Banana prawn TACs would be set based on a historical average. There would be no constraints on gear towed.

Following the identification of these options a formal cost-benefit analysis was commissioned, the results of which are presented in this final report.

Need

The MRAG report and the two alternative management workshops highlighted a short-list of four management scenarios (including three ITQ scenarios). Semi-quantitative techniques were used to provide a preliminary evaluation of these scenarios and a preliminary cost-benefit analysis was also conducted. This preliminary work was unable to combine all of the relevant costs and benefits for each management scenario because the full data set for such calculations was not yet available, and there was significant time and budget constraints that did not allow a full analysis to be performed.

Given the clear message that any agreed future management regime for the NPF should include ITQs or be demonstrably ‘better than ITQs’, a full cost-benefit analysis of the four short-listed management scenarios was required.

Objectives

1. Conduct a full cost-benefit analysis on the short-list of alternative management arrangements as agreed by NORMAC Workshop
2. Prepare a detailed report on the results of the CBA
3. Present the results of the CBA to NORMAC and AFMA

Methods

A Steering Committee was appointed by NORMAC to oversee the project and develop and assess the tender documents. It consisted of NPF Industry and management personnel. The Steering Committee also reviewed the initial results of the cost-benefit analysis prior to its release to broader stakeholders.

A CBA required estimating changes to the relevant costs and benefits of each option relative to the optimised status quo. This involved:

1. estimates of the increased profitability from matching the management instrument to the source and extend of uncertainty;
2. estimates of potential efficiency gains associated with changes in operational costs at the vessel level resulting from more freedom to choose the combination of fishing inputs;
3. estimates of potential efficiency gains from trades in quota between vessels
4. measures of the relative management costs (e.g., compliance, monitoring, licensing, etc.) associated with each management option; and
5. measures of changes in the banana prawn fishery profitability associated with each management instrument.

Item 1 required the construction of relevant bioeconomic models to measure differences (including the variation) in estimated profitability. This involved relevant biological data and economic survey data. Items 2 and 3 involved econometric estimation techniques (stochastic frontiers), to measure the difference between maximum potential harvest, given inputs, technology and environmental variation with actual harvest. This utilised logbook and economic survey data. Item 4 was estimated by input from AFMA and CSIRO staff. Item 5 was estimated using a cost benefit analysis and a simulation model that utilised historical catch information and economic survey data.

Results/Discussion

Bioeconomic results

Bioeconomic model results for the tiger prawn fishery are obtained for two different model specifications and three different solution algorithms. The main task is to determine relative profitability and its variance in the comparison of a TAC with a TAE (total allowable effort) control. Setting any potential effort creep aside, which instrument is most appropriate (input or output controls, TAC or TAE) depends on the source and magnitude of uncertainty. If environmental uncertainty is high, or, in some contexts, where there is large variance in the stock-recruitment relationship compared to the harvest function, or the variance in catch per unit of effort, then input controls will be preferred. If the reverse holds, output controls are the better choice. The issue, in short, is all about the choice of instrument compared to the desired target.

Using a 50 year time horizon and a 3 per cent discount rate, the first 'standalone' bioeconomic model indicates that a TAC control out-performs a TAE control in terms of expected profits: \$314 million with a TAC and \$302 million with a TAE control, or a difference of \$12 million discounted dollars over the 50 year period. The standard deviation is also considerably lower with a TAC control, as expected, or \$14.4 million versus \$26 million. In the second basic 'delay-difference' bioeconomic model results show that again a TAC dominates a TAE. Profit for the TAC control is \$310 million and \$298 million, or a difference again of \$12 million , with now a relative variance of \$16.4 million versus \$28.6 million. Note that these calculations assume that MEY is obtained in the fishery regardless of the management instrument. Overall, the results thus favor a TAC in the tiger prawn fishery. The more recent data provided by AFMA resulted in less variance in harvest per unit of effort in the tiger prawn fishery, and lower expected returns to a TAC relative to a TAE control, compared to the draft report.

Efficiency results

Increases in profitability in a fishery often result from increased efficiency. This can take many forms including using inputs in different levels and proportions and trades in quota among vessels. The later gains in profitability can be considerable. In this report, potential efficiency gains are measured by estimates of stochastic frontiers for the banana and tiger prawn fisheries taken separately. Stochastic frontiers measure the difference between maximum potential output, given inputs, technology and any seasonal environmental variation, and actual harvest, both on average and for individual vessels.

Core stochastic frontier results are based on a relatively small data set for the years 2004–05 to 2007–08. This is done for two reasons: (a) a good part of this data is post structural adjustment and thus a better indicator of recent vessel and overall fleet efficiency; and (b) the core results rely only on catch and effort logbook data, along with measures of engine power, so that concerns with financial and economic data provided by ABARE can be ignored. Points (a) and (b) necessarily require a ‘parsimonious’ model specification since data points are limited. As a check on the results, other more elaborate specifications using ABARE survey data are also provided or discussed.

Estimates for both the initial data set provided by AFMA in the preparation of this report and the revised data set, including the 2008 tiger season are reported. The new data set changed the preferred specification and coefficient values, but as expected resulted in no difference in the mean value and distribution of efficiencies in both the tiger and banana prawn fisheries.

Results indicate that for vessels in the banana prawn fishery over the years 2005–08, the mean efficiency measure is 0.696, so that vessels on average are producing roughly 70 per cent of maximum available harvest given inputs and seasonal variation. There is also considerable variance among vessels, with a range of 92–29 per cent in efficiency. Banana prawn vessels roughly fit into ‘high’ and ‘low’ efficiency categories, with a relatively large ‘tail’ of boats with efficiency scores in the neighbourhood of 30–60 per cent. Both the low mean value of efficiency in the banana prawn fishery and the bimodal nature of the distribution of efficiency scores suggest considerable room for improvement in efficiency and some consolidation of transferable quota. Under an ITQ system it is conceivable (if not likely) that highly efficient vessels would purchase quota from parts of the fleet with lower vessel efficiencies. It is also likely that with ITQs vessels may postpone catches to achieve a more optimal size distribution in prawns, and thus increase the value of harvest.

For vessels in the tiger prawn fishery, from 2005–08, mean efficiency is higher than in the banana prawn fishery, at roughly 88 per cent. Also, unlike the banana prawn case, there is much less variance in the distribution of efficiency scores across the fleet and a much ‘tighter’ distribution. Therefore, there is much less room for efficiency improvements in the tiger prawn fishery and perhaps much less scope for quota reallocation.

Translating these efficiency measures into potential dollar values of efficiency gains is a difficult task. First, it is somewhat unclear (especially given the few data points for post ‘structural adjustment’) to what extent ITQs may result in changes in efficiency, although as indicated there is much more scope for these improvements in the banana prawn fishery. Second, although net gains with improved efficiency could be calculated as increase in net revenue from harvest, holding costs constant, it is unclear what the exact effect on profitability is, even assuming that an MEY target is met in the fishery. If an MEY target is not met it is possible to have an efficient fleet without substantial profitability.

However, having said this, and based on comparable studies of efficiency gains in ITQ fisheries (e.g., Kompas and Che (2006) and Grafton et al. (2000)), it would not be surprising to get a least a 10–15 per cent increase in efficiency in the banana prawn fleet, and mild increases in the tiger prawn fishery. For the purposes of this report, however, two measures are used: (a) a very conservative measure of efficiency gains is assumed at a 5 per cent increase for the NPF as a whole, and (b) a 15 per cent increase in efficiency is assumed. This sets the likely bounds for efficiency gains with the expectation that a number closer to 10–15 per cent is likely to be realized. The reason for estimating with a conservative value is that the data set spans both before and after the 'structural adjustment package' (SAP), so some of the efficiency gains may have already been realized with the fall in boat numbers, post-SAP. (Although from the actually data and frontier estimates it is not clear that the most inefficient vessels left the fishery.) At 5 per cent, assuming an MEY target is achieved, and given the profitability measures obtained in the tiger prawn bioeconomic model above and average profitability in banana prawns (revised Kompas (2007) estimates these at $320 million for the 50 year period), this would imply an increase in net profitability with ITQs (due to increased harvest with the same or roughly similar input costs) of roughly $19.1 million present value dollars over a 50 year period, at a 3 per cent discount rate, for a 4 per cent and 1 per cent split of the 5 percent increase between the banana and tiger fisheries. At the 15 per cent rate for the increase in efficiency the extra gains total 57.3 million NPV dollars.

ITQs for banana prawns

This report also considers the impact of moving to output controls (catch quotas under an ITQ system) in the banana prawn fishery of the NPF, using a cost-benefit analysis (CBA). Common banana prawns (*Penaeus merguiensis*) are included in the study, while the analysis of red-legged banana prawns is restricted due to uncertainty in the stock status and lack of economic data for the fishery. The overall change in the profitability of the fishing season under different ITQ scenarios compared to the *status quo* (input control system) is evaluated taking into account changes in operational costs under each system and the assumed value of the product.

Catch restrictions have the potential to reduce the extent of the fishing season decreasing fishing costs. Under the current system fishing units tend to race-to-fish, an aspect of the fishery which could be eliminated under a catch quota system when the catch is restrictive and each participant can plan accordingly when and how to take their share. There are also implications for the quality of catch and the price that can be obtained in a fishery under output restrictions. In this analysis of the impact of output controls, the Total Allowable Catch (TAC) is set on the basis of a Harvest Control Rule (HCR) that is either a single constant TAC based on historical catches (that can be set at various levels as part of the evaluation), or an adaptive system where an initial precautionary TAC is set then later updated based on the annual pre-season recruitment survey. These rules only apply to the first season. The potential that there are still common banana prawns in the second season that can be caught is excluded from the analyses. This is because the degree to which this occurs would require a detailed assessment – presently unavailable. The HCRs used within this evaluation should not be seen as final, but rather good examples of the two classes of rules that can be applied.

Several alternative scenarios are presented and compared with the present input control system, the *status quo*. These scenarios relate to the degree with which the output system reduces the race to fish, whether the TAC is set conservatively or not, whether the TAC is updated or not using the recruitment index (Constant TAC or Updated TAC), and the magnitude of the coefficient of variation around the relationship of the observed catch versus the recruitment survey index. In the scenarios where race-to-fishing is considered, the assumption is made that this phenomenon only occurs in years where the TAC is not restrictive, i.e. in cases where the TAC is set (incorrectly) at a higher level than the possible catch. No implementation error is assumed: that is, the actual catch is never greater than the TAC.

A cost-benefit analysis (CBA) is used in a simulation model that includes price and cost data to calculate profit. This is used to test the differences in profit between the present input control system and moving to an output control system. Under the existing system, research has indicated that about 85 per cent of the stock in any year is caught (Zhou *et al.* 2007), thus the magnitude of past catches can be assumed to be a good indicator of the productivity of the stock (in fished areas). Other studies have also made this assumption (Venables *et al.* 2003; Kompas 2007). On the basis of this evidence, the past catch time series (1990–2007) is used to generate model predicted future catches.

The key aspect of the CBA in this study is its direct comparison with the *status quo* (input control), assuming each system could be subject to the same future potential productivity. To assess the relative performance of the different scenarios, relative change in profit to the input control system is calculated (termed incremental profit). Based on the results, the following can be concluded:

1) Output restrictions (TACs: Constant and Updated) reduce excessive effort resulting in lower costs which offset potential revenue losses. This leads to:
   a) higher average incremental profits. The HCRs consider the effects of the precision of the pre-season recruitment survey and the TAC set on the basis of conservative (low) or risk tolerant (high) stock productivity assumptions,
   b) higher average incremental profits are obtained (compared to input control) when output restrictions apply in years when catches are “average” (1500–3500 tonnes); whereas peak years (> 5000 tonnes) will not result in higher incremental profits if output is excessively restricted. This occurs because losses in revenue will not be compensated by cost savings (due to effort being inadvertently restricted when profitable catches are still available). The degree to which this loss occurs would depend on how many banana prawns can be caught in the second season.
2) Assuming future catches will be in the range of those recently observed over the period 1990–2007, setting a Constant TAC at conservative levels (the 30 per cent quantile of observed catches or lower) results in higher average incremental profits than setting the TAC at risk tolerant levels (the

40–100 per cent quantile of observed catches). Obviously, as the level of the TAC at a quantile of 100 per cent (of the observed catches) is never restrictive this scenario is equivalent to the input system.

3) Furthermore, again assuming future catches will be in the range of those recently observed over the period 1990–2007, assumptions regarding the precision of the pre-season recruitment survey (Updated TAC) will also affect the magnitude of the average incremental profits obtained, in that as the strength of the relationship of the pre-season recruitment survey to predicted catch decreases, the potential average incremental profit decreases. However, this precision can only be increased with time rather than necessarily more extensive surveys. At present, there is little contrast in the data as most of the surveys occurred during average catch years.
4) The incremental profits are greater if the assumption is made that when race-to-fishing is not occurring, a price premium is obtained (Updated TAC-price premium). The greater the price premium, the greater the incremental profit. A price premium is only likely to be obtainable if the TAC is restrictive, and incentives are created to enhance the quality of the catch rather than the quantity. If the TACs were not binding, it was assumed that a price premium would not be obtained. However, changes in behaviour as a result of the definition of quota shares may still result in incentives to improve quality. Hence, the benefits of an ITQ system may be understated.
5) Although a Constant TAC results in greater on average incremental profits relative to an input system, in a large number of cases under this scenario the incremental profits can be lower than the *status quo*. Applying an Updated TAC on the basis of a pre-season recruitment survey results in greater than average incremental profits relative to the input system and results in less cases where the incremental profits are lower than an input controlled system (in comparison to the Constant TAC scenario).

It is not possible to estimate what the corresponding relationship between these variables for red-legged banana prawns without detailed cost data for this fishery. However, for red-legged banana prawns a series of conservative estimates assuming a 15 per cent reduction in costs and a 10 per cent reduction in revenue would yield increases in average profit for the data presented in Table 2 of about $0.25 million per year. These estimates are only relevant for the historical average catch and average effort assuming no trends in catch (and no reduction in recruitment), and also not applying a precautionary penalty (which is likely to occur based on the Commonwealth Harvest Strategy Policy).

However, there are very noticeable downward trends in the catch data for red-legged banana prawns; as the last three years (from 1990–2007) are the lowest in the time series (except for 1992). Even a conservative TAC management strategy set at a quantile of observed catches (from 1990–2007) of 0.3 would not restrict catch in the last few years. With no restriction in catch (and thus effort) using a constant TAC system without a stock assessment and relevant economic data, there are no economic benefits to an output control system. In the current fishery our estimates of incremental profit that would occur due to a switch to a TAC would be $0 dollars.

Therefore, in all the scenarios in this analysis no adjustment was made to the estimated incremental profit computed for common banana prawns to account for red-legged banana prawns as the net effect would be zero due to the downward trend in catches. This does not imply that an output control is not an effective measure and input controls should be used in this fishery. It is best that a stock assessment is developed for red-legged banana prawns, if at all possible, and on the basis of an assessment an evaluation of such measures could be undertaken. Although, our discussion only explicitly refers to common banana prawns, on the basis of the above preliminary estimates of red-legged banana prawns, our evaluation of the scenario relates to both stocks.

Overall, the analysis suggests that an ITQ system for banana prawns could, on average, result in increased benefits to the industry. These benefits may only be marginal if quality cannot be improved and a price premium is not obtained. However, there is evidence of price premium being achieved by other fisheries under ITQs (Grafton 1996; Bernal *et al.* 1999) and that this potential exists for the NPF common banana prawn fishery.

Extra management and research costs

The research team consulted with Melissa Brown and David Galeano at AFMA and Cathy Dichmont at CSIRO to obtain estimates of both the on-going and transitional management costs of all four management options. The NPV of the management costs associated with each scenario are given in Table 3. Table 4 indicates incremental costs for each scenario, compared to the status quo. Management costs are clearly highly dependent on the assumed amount of observer coverage. At 2 per cent coverage the differences between each scenario and the status quo is relatively small, but this difference is very large at 15 per cent coverage over the entire 50 year period.

Table 3 *Management Costs of the Various Management Options (Net Present Values over a 50 year period and a 3% discount rate)*

Total Costs (2% observer coverage)	1. Status Quo	2.ITQs (tiger and banana prawns)	3. MRAG proposal	4. 1st season ITQs; 2nd season input controls
AFMA	$35,893,021	$39,906,864	$37,616,915	$37,359, 617
CSIRO	$11,856,791	$19,533,742	$19,019,147	$14,520,302
Total	**$47,749,812**	**$59,440,606**	**$56,636,062**	**$51,879,920**
Total Costs (15% observer coverage, 50 years)		2.ITQs (updated TAC)	3. MRAG proposal	4. 1st season ITQs; 2nd season input controls
AFMA	$35,893,021	$66,022,574	$54,469,910	$47,522,874
CSIRO	$11,856,791	$19,533,742	$19,019,147	$14,520,302
Total	**$47,749,812**	**$85,556,317**	**$73,489,057**	**$62,043,176**
Total Costs (15% observer coverage for 5 years, then 2% coverage)		2.ITQs (updated TAC)	3. MRAG proposal	4. 1st season ITQs; 2nd season input controls
AFMA	$35,893,021	$43,953,325	$40,364,196	$39,162,382

CSIRO	$11,856,791	$19,533,742	$19,019,147	$14,520,302
Total	**$47,749,812**	**$63,487,067**	**$59,383,343**	**$53,682,684**

Table 4 *Incremental Management Costs of the Various Management Options Compared to the Status Quo (Net Present Values over a 50 year period and a 3% discount rate)*

Total Costs (2% observer coverage)	2.ITQs (tiger and banana prawns)	3. MRAG proposal	4. 1st season ITQs; 2nd season input controls
Total	**$11,690,794**	**$8,886,250**	**$4,130,108**
Total Costs (15% observer coverage, 50 years)	2.ITQs (updated TAC)	3. MRAG proposal	4. 1st season ITQs; 2nd season input controls
Total	**$37,806,505**	**$25,739,245**	**$14,293,364**
Total Costs (15% observer coverage for 5 years, then 2% coverage)	2.ITQs (updated TAC)	3. MRAG proposal	4. 1st season ITQs; 2nd season input controls
Total	**$15,737,255**	**$11,633,531**	**$5,932,872**

Short-run changes in asset prices will occur in the NPF if there is a change in the existing management regime that governs access to the common pool. The biggest change in current asset prices in the NPF should arise with the introduction of ITQs in both the tiger and banana prawn fisheries (management option 2). Provided that the TACs are binding on fishers, the full asset price currently reflected in gear SFRs should be reallocated to the quota SFRs as individual quotas rather than gear SFRs will become the constraining factor in terms of access to the net benefits from the fishery. The price of boat SFRs should also decline but should still remain positive provided that boat SFRs are required to operate in the fishery as there are other prawn species (such as endeavour prawns and king prawns) that will still be caught and will not be regulated by ITQs.

Beyond the immediate or short-run changes in asset prices, the management options that generate the highest net return from the fishery as whole over time will also maximise the asset prices that constrain fishing effort in the NPF. Given the incentives associated with ITQs to minimize harvesting costs for a given level of catch and the probability that a longer fishing season associated with ITQs will increase the market price of prawns, ITQS in both tiger and banana prawns (management option 2) will likely generate the highest combined asset prices (primarily in the price of quota SFRs) than any other option. The partial ITQ alternatives (management options 3 and 4) will likely generate the next highest combined asset price with the optimised status quo providing the lowest asset price increase over time.

Finally, there are a number of preconditions for successfully introducing ITQs:

1. There must adequate monitoring, control and surveillance so that fishers are unable to harvest without ITQs and if they fail to respect the compliance rules there is a reasonable probability that they will be

caught and punished. Without strong enforcement, individual output controls will not achieve their desired effect of reducing the race to fish, preventing effort creep and ensuring sustainable fish stocks. For this reason ITQ fisheries will often cost more to manage than equivalent input controlled fisheries as they require a system of quota reconciliation and possibly greater monitoring of fisher activities and more precision in the setting of a total allowable catch (TAC).

2. The TAC should be binding to ensure the ITQs represent a valuable property right. While ITQs promote economic efficiency, if the TAC is set incorrectly then the gains from moving towards an ITQ system of management will be diminished.
3. There needs to be sufficient flexibility in reconciliation of quota and incentives to allow fishers to balance their actual catches with quota holdings and to reduce the incentives to discard by-catch at sea and ‘high grade’ or dump lower valued fish. All else equal, the less able fishers are to target individual species and the greater the number of species that potentially can be caught, the more difficult it will be to manage ITQs in a given fishery (Squires et al. 1998).
4. ITQ regulations need adequate coverage in terms of the principal target species otherwise fishers could substitute to non-ITQ species and threaten the sustainability of other fisheries (Dupont and Grafton 2001).
5. If recreational fishers catch a substantial part of the total harvest then allocating ITQs to only commercial fishers can aggravate conflicts, especially if an expansion of the recreational catch leads to a fall in the commercial TAC.
6. Proper consideration must be given to variability in the biomass from year to year as regulating a TAC relative to setting a total allowable effort (TAE) could be more difficult if it requires in-season adjustments to ensure sustainability of stocks.

ESD impacts

Three issues of positive ESD impact from ITQ implementation are identified, four issues of negative ESD impact one of which (the re-opening of the mid-season closure) has potentially large implications, and Four issues which we think will have neutral or uncertain impact.

There is considerable uncertainty about fleet behaviour and ultimate impacts on ESD in our analysis. A very precautionary implementation of quotas would reduce catches of target and bycatch species, a positive ESD impact, but with the cost that industry fishing opportunities and revenues will be significantly reduced. Accurate calculation of quotas will not lead to either this ESD gain or the economic loss.

There is potential for increased benthic impact if the relaxation of the current race to fish under the effort management system leads to exploration of alternative fishing areas which are currently lightly- or un-fished; on the other hand this could reduce benthic impacts in those areas that are currently very heavily fished. The introduction of an ITQ system on a number of prawn species whose population status is difficult to ascertain could lead to increased highgrading and discarding if fishing opportunities on key species are constrained by limitations on bycatch species.

These problems and uncertainties are not insurmountable, but would require additional research and monitoring. The costs of such monitoring would have to be borne by industry, but to avoid the potential for compromising observers it would be best if this was a third party scheme rather than extension of the CMO scheme. The cost would be considerable.

Final assessment

It is clear that incremental management costs provided by AFMA and CSIRO in moving to an ITQ system in the NPF are considerable, particularly under the scenario of 15 per cent observer coverage.

Results show that an ITQ system for banana prawns could, on average, result in increased benefits to the industry even if conservative estimates are assumed. For example, the minimum net present values of expected increased profitability for a constant TAC, an updated TAC and an updated TAC with a price premium, are $10 million, $12.8 million and $41.4 million respectively. These are discounted amounts over a 50 year period using a discount rate of 3 per cent per annum.

Of course the benefits may only be ‘marginal’ under option 3 if quality cannot be improved and a price premium is not obtained in banana prawns (ignoring any other potential efficiency gains). There may also be years in which potential catches of banana prawns are much larger than the typical historical range for harvest, indicating lost profitability without the status quo.

On the other hand, it should also be noted that none of the typical gains from quota allocation in the banana prawn fishery, the gains that could be achieved from increased efficiency in the transfer of quota, were accounted for in the banana prawn TAC control analysis. The estimates of potential efficiency gains indicate that these could be considerable, given the relatively low mean efficiency in the banana fleet and the bimodal distribution of fleet efficiency. The calculation of potential efficiency gains is problematic, but conservative results suggest that for both the banana and tiger prawn fishery they may be in the order of $19.1 million discounted dollars over 50 years. It could be less than this amount, but it also and more likely could be much more depending on the extent of the extra gains in the banana prawn fishery in particular. At a 15 per cent efficiency gain the amount is $57.3 million for both fisheries combined.

Results also suggest that a TAC control in the tiger prawn fishery will dominate a TAE control, with less variance in profitability and a higher mean return. The difference in mean profitability, again discounted over a 50 year period at 3 per cent, is roughly $12 million.

A summary of these results in presented in the following tables. A key issue is the level of observer coverage. Under the status quo, observer coverage is 2 per cent. However, given concerns surrounding discarding of quota species, the two 'base case' results presented below assume 15 per cent observer coverage for the first 5 years, followed by 2 per cent coverage thereafter. Two base cases are presented: Base Case 1 assumes 15 per cent efficiency gains and Base Case 2 assumes only a 5 per cent efficiency gain. In all cases the minimum potential gains from a TAC on banana prawns is assumed, or $10 million.

Table 5 *Base Case 1: 15% efficiency gains from quota trade with 15% observer coverage for the first 5 years, then 2% observer coverage. All values are 'net present values', discounted over 50 years at 3%.*

	Extra Gains (Million AUD)				Extra Costs (AUD)	Net Extra Benefits (AUD)
	TAC Tigers	Quota Trade	TAC Bananas	Total		[Current AUD, per year, preferred option]
ITQs Tiger and Bananas	12	57.3	10	79.3	15,737,255	63,562,745
						[2,470,000]
MRAG	12	9.3		21.3	11,633,531	9,666,469
ITQs Bananas		48	10	58	5,932,872	52,067,128

Table 6 *Base Case 2: 5% efficiency gains from quota trade with 15% observer coverage for the first 5 years, then 2% observer coverage. All values are 'net present values', discounted over 50 years at 3%.*

	Extra Gains (Million AUD)				Extra Costs (AUD)	Net Extra Benefits (AUD)
	TAC Tigers	Quota Trade	TAC Bananas	Total		[Current AUD, per year, preferred option]
ITQs Tiger and Bananas	12	19.1	10	41.1	15,737,255	25,362,745
						[982,000]
MRAG	12	3.1		15.1	11,633,531	3,466,469
ITQs Bananas		16	10	26	5,932,872	20,067,128

Both cases favour scenario 2, or ITQs for both the banana and tiger prawn fisheries. The MRAG scenario is clearly the least preferred. Results are also presented for extreme cases. The following table illustrates the most likely conservative case: only 5 per cent efficiency gains with 15 per cent observer coverage for the entire 50 year period.

Table 7 *'Minimum' Case: 5% efficiency gains from quota trade with 15% observer coverage for the entire 50 year period. All values are 'net present values', discounted over 50 years at 3%.*

	Extra Gains (Million AUD)				Extra Costs (AUD)	Net Extra Benefits (AUD)
	TAC Tigers	Quota Trade	TAC Bananas	Total		[Current AUD, per year, preferred option]
ITQs Tiger and Bananas	12	19.1	10	41.1	37,806,505	3,293,495
						[128,000]
MRAG	12	3.1		15.1	25,739,245	-10,639,245
ITQs Bananas		16	10	26	14,293,364	11,706,636
						[345,000]

In this case the gains from an ITQ system are small, and ITQs in the banana prawn fishery only is the preferred instrument. Finally, the following two tables indicate likely maximum gains for each scenario, compared to the status quo. The first with a 15 per cent efficiency gain and 2 per cent observer coverage, and the second with an additional price premium for banana prawns.

Table 8 *'Maximum' Case: 15% efficiency gains from quota trade with 2% observer coverage for the entire 50 year period. All values are 'net present values', discounted over 50 years at 3%.*

	Extra Gains (Million AUD)				Extra Costs (AUD)	Net Extra Benefits (AUD)
	TAC Tigers	Quota Trade	TAC Bananas	Total		[Current AUD, per year, preferred option]
ITQs Tiger and Bananas	12	57.3	10	79.3	11,690,794	67,609,206
						[2,631,000]
MRAG	12	9.3		21.3	8,886,250	12,413,750
ITQs Bananas		48	10	58	4,130,108	53,869,892

Table 9 *'Maximum' Case with Price Premium in Banana Prawns: 15% efficiency gains from quota trade with 2% observer coverage for the entire 50 year period. All values are 'net present values', discounted over 50 years at 3%.*

	Extra Gains (Million AUD)				Extra Costs (AUD)	Net Extra Benefits (AUD)
	TAC Tigers	Quota Trade	TAC Bananas	Total		[Current AUD, per year, preferred option]
ITQs Tiger and Bananas	12	57.3	41.4	110.7	11,690,794	98,309,206
						[3,822,000]
MRAG	12	9.3		21.3	8,886,250	12,413,750
ITQs Bananas		48	41.1	89.1	4,130,108	84,969,892

In both cases, scenario 2 or ITQs in both fisheries is again preferred.

Other issues

The results for banana prawns differ in this study, compared to both the MRAG (2007) report and the preliminary CBA (Kompas 2007). In particular, the MRAG report and Kompas (2007) argue that without updating, a TAE is the preferred instrument. The difference in results is due to the fact that in MRAG (2007) and Kompas (2007) it was assumed that effort was always just sufficient to match predicted harvest, i.e., there was no excess effort and thus no increased fishing costs that go with 'race-to-fish' behaviour. The current report specifically accounts for the increased cost that goes with excess effort under input controls, and on this basis tends to favour a TAC.

Finally, there are at least three important cost-benefit related measures that were not quantified in this report:

- The potential costs of 'effort creep' in an input controlled system.
- The benefits of autonomous adjustment.
- Precise measures of the costs of potential discarding.

In terms of the costs of discarding, the study by Rose and Kompas (2004) argues that his must be small for a fishery like the NPF, since price differentials across grades do not make discarding profitable relative to the costs of keeping already caught but lesser-valued prawns on board. Admittedly this was done in a simple 'in principle' setting, and perhaps requires more work before definitive statements can be made. Some of the concerns over potential discarding are clearly expressed in section 9 on ESD impacts of various management scenarios in the NPF.

It is not possible to exactly calculate future losses from effort creep. A historical series could be constructed, measuring the difference between MEY and actual profits in the fishery, but to determine the costs of effort creep would require some assumption about the exact extent of effort creep over time. The fishing power series constructed by CSIRO may give some measure of this, but since the 'structural adjustment package' these measures must surely have changed. However, there is no doubt that there are costs to effort creep, and many economists would argue that the value of the recent 'structural adjustment package' for the NPF, thereby reducing over-capacity, is a good indication of these costs — costs that would be incurred by autonomous adjustment under an ITQ system (with a properly set TAC), rather than by government and industry as a whole.

One final point: all values in this report are estimated over a 50 year period at a 3 per cent discount rate. The choice of the time period and discount rate is largely non-consequential, since the evaluation of the various scenarios is always relative to the status quo. So, in other words, a change in the discount rate will affect the streams of revenues and costs in both the status quo and the alternative management scenario more or less equally. There are two notable exceptions to this: (a) a higher discount rate will lower the present value of management costs (especially observe coverage) for systems with an ITQ, and (b) if efficiency gains with trade in ITQs commence not in the first year (as assumed in this report), but after several years have passed, a higher discount rate will imply lower net present value returns from quota.

Benefits and adoption

A range of scenarios were considered in the research report. The scenarios varied assumptions regarding the levels of observer coverage, the assumed efficiency gains and whether or not a price premium for banana prawns is possible under ITQ management. Given the variations and the three ITQ options, the net present value of the ITQ options compared to the status quo vary from -$10.7 million to $98.3 million. Depending on the ITQ option implemented, these expected net present values would accrue to the northern prawn fishery property right holders. In the original application it was expected that 100 per cent of the benefits of the research would flow to the northern prawn fishery.

The results from the research are currently being considered by AFMA with a decision on which ITQ option to implement expected to be made in 2009.

Further Development

No further development is required.

Planned outcomes

The planned outcome from this research is a significant contribution to the decision on which form of ITQ management AFMA will adopt for the northern prawn fishery. While the decision on which form of ITQs will be adopted has not yet been made, it is clear the research has provided valuable input to that process.

Conclusion

Despite the larger management costs associated with the three ITQ options, the estimated benefits more than outweigh these costs in all but one scenario (Table 10). In this scenario (ITQ tiger prawns, input controls banana prawns) where only a five per cent efficiency gain is assumed and 15 per cent observer coverage is required (tiger prawn season only) the expected net present value is -$10.7 million over the 50 year planning horizon.

In all other scenarios considered the net present value of change is positive. In addition in four of the five scenarios considered, option two (ITQs both species) provides the greatest NPV compared to the other two ITQ options. Where only a five per cent efficiency gain is assumed and 15 per cent observer coverage is required (tiger prawn season only) option four (ITQ banana prawns and input controls tiger prawns) is preferred with an expected net present value of $11.7 million over the 50 year planning horizon. This option is preferred mainly due to the significant observer costs associated with ITQs on tiger prawns incurred over the 50 years.

Table 10 – summary of results (figures are net present values over a 50 year period at a 3 per cent p.a. discount rate).

		Option		
		Option 2 ITQ both species	Option 3 ITQ tiger only	Option 4. ITQ banana only
Base case 1 (15% efficiency gain, 15% observer coverage 1st 5 years then 2% observer coverage)	NPV $m	63.6	9.7	52.1
Base case 2 (5% efficiency gain, 15% observer coverage 1st 5 years then 2% observer coverage)	NPV $m	25.4	3.5	20.1
Minimum case 1 (5% efficiency gain, 15% observer coverage)	NPV $m	3.3	-10.7	11.7
Maximum case 1 (15% efficiency gain, 2% observer coverage)	NPV $m	67.6	12.4	53.9
Maximum case 2 (15% efficiency gain, 2% observer coverage, price premium on banana prawns)	NPV $m	98.3	12.4	85.0

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Appendix 1: Intellectual Property

While the research outputs are valuable to AFMA in terms of contributing to a management decision, the research outputs do not include any commercially exploitable intellectual property.

Appendix 2: Staff

The AFMA staff involved in the project includes the principal investigator, David Galeano, Senior Economist, and the co-investigator, Melisa Brown, Manager, northern prawn fishery.