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EX POST BENEFIT/COST ANALYSIS

PROJECT NO: 1996/254

**Commercialisation of bycatch reduction
strategies and devices within northern
Australian prawn trawl fisheries**

Prepared for the FRDC

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TABLE OF CONTENTS

SUMMARY	1
1. INTRODUCTION.....	3
2. BACKGROUND	3
3. PROJECT OBJECTIVES.....	4
4. RESEARCH FINDINGS	5
5. COST/BENEFIT ANALYSIS.....	7
a. Project Costs	7
b. Application of Project Results.....	7
c. Potential Benefits.....	9
d. Realisation of benefits	10
Improved ecological performance	10
Improved industry profitability	12
e. Net Benefits	15

Summary

The project was developed in the context of growing community and government concern over the impacts of commercial fishing on non-target species. This issue was particularly relevant for the northern Australian prawn trawl fisheries, where the catches of prawns – the target species – may on occasions represent as little as 20% of the total catch.

Prior to the project, there was widespread industry resistance - in some cases hostility - to using TEDs due to a general lack of information and concern over the potential lowering of catch rates. By the end of the project, this initial hostility was replaced by industry being actively involved in developing and testing alternative TED designs and having a real sense of responsibility for making TEDs work.

Industry representatives consider the project to have been an outstanding success, with the Queensland Seafood Industry Association (QSIA) referring to the project as ‘a landmark study that led to a real change in fishers attitudes and behaviour’, while representatives from the Northern Prawn Management Advisory Committee described the project as ‘being one of the most successful FRDC projects ever undertaken in the fishery’.

The project was designed to reduce bycatch levels and maintain the economic viability of the industry, rather than to improve industry profitability. Results have been spectacular - TEDs are effectively being used in each of the northern Australian trawl fisheries, with results suggesting that turtle bycatch has fallen by 99%. The implementation of TEDs has been so effective that turtle mortalities are no longer a significant issue in the fishery.

Despite these outcomes, quantifying the benefits of the project is not readily possible:

- while the project is attributed with positively changing industry attitudes regarding TEDs and enabling industry to effectively use TEDs, the bycatch species that have been saved have no commercial value;
- similarly, there is too much uncertainty to predict with any confidence what additional management measures may have been introduced had the implementation of TEDs not been so effective, or to attempt to quantify what the likely economic impact of such additional measures would have been on commercial fishers.

While not possible to quantify the actual benefits, it is possible to identify several threshold values that would justify FRDC’s investment in the project:

- it is assumed that the project enabled the widespread use of TEDs three years earlier than otherwise would have occurred. Benefits and costs arising from the use of TEDs over these three years are thus attributed to the project. In the NPF, the accelerated implementation of TEDs is estimated to have saved around 3300 turtles over this three-year period. Given that 48 per cent of the research effort was funded by FRDC, 48% of these saved turtles can be attributed to FRDC's contribution to the project. If the community is prepared to pay at least 5 cents/person to save the 1600 turtles attributable to the FRDC contribution, FRDC's investment in the project is justified based solely on the number of turtles saved in the NPF, let alone the benefits from the turtles saved in the other northern fisheries or the value to the community from reduced mortalities of other non-market species such as rays and sharks;
- in the absence of this project it is likely that the respective fisheries management agencies would have been faced with a continuing turtle interaction problem and may possibly have introduced additional management restrictions. A restriction that resulted in a modest 1% reduction in catch across the northern Australian fisheries would have incurred a cost to industry of foregone profits of around \$500,000/year. The net present value of these foregone profits over a ten-year period is \$3.6m, 48% of which (\$1.7m) can be attributed to FRDC's contribution to the project. FRDC's investment in the project would be justified based on the saving of these foregone profits alone.

Other non-quantified benefits arising from the project include:

- i) the building of more cooperative relationships between industry, researchers, conservationists and fishery managers - in direct contrast to the confrontational outcomes experienced in the United States - and the saving of management/enforcement/legal costs than may otherwise have been incurred;
- ii) flow-on benefits to prawn fisheries in South Australia and Western Australia;
- iii) the strategic value to Australian prawn exporters from regaining market access to the United States, and from having an improved marketing image for Australian prawns more generally; and
- iv) a strengthening of Australia's international reputation in terms of environmentally sustainable fisheries management.

1. Introduction

This report describes an ex-post cost/benefit analysis undertaken on FRDC project 1996/254, ‘Commercialisation of Bycatch Reduction Strategies and Devices within Northern Australian Prawn Trawl Fisheries’, implemented by the Department of Primary Industries, Queensland, in collaboration with CSIRO Marine Research, Brisbane, and the Australian Maritime College.

2. Background

The project was developed in the context of growing community and government concern over the impacts of commercial fishing on non-target species. This issue was particularly relevant for the northern Australian prawn trawl fisheries, where the catches of prawns – the target species – can on occasions represent as little as 20% of the total catch.

In response to these concerns, in 1993 FRDC established a sub-program responsible for coordinating research and development with respect to the impacts of trawling. Two key research areas were identified:

- i) the need to quantify the impacts of trawling on the marine environment; and
- ii) the need to develop strategies – such as modifying fishing gear and changing fishing practices – to minimise such impacts.

Many of the projects implemented under the sub-program examined the potential for reducing bycatch through modifying fishing gear. These initial projects were concentrated in two main areas:

- developing Turtle Excluder Devices (TEDs) - the modifying of fishing gear to include a barrier that excludes large animals (such as turtles, sharks and rays) from entering the codend; and
- developing Bycatch Reduction Devices (BRDs) – the modifying of the trawl net to include specially designed and located escape openings so that unwanted smaller swimming species caught inside the trawl could evade capture.

Several alternative TED and BRD designs had been developed and tested in limited research and commercial conditions. Results from the testing had been variable, and it was difficult to

predict which particular gear design would work most effectively in any particular area of the fishery. More extensive at-sea trials using the various gear designs were needed. However, the costs associated with large-scale research testing would be prohibitive – the required testing could only proceed with industry involvement.

Given the ease with which the devices would be modified, and the practical difficulties in enforcing the at-sea use of TEDs and BRDs throughout Australia's northern prawn fisheries, a legislative approach mandating the use of TEDs and BRDs was unlikely to be successful. Industry acceptance of the need to use TEDs and BRDs was considered to be a key process if bycatch issues in the prawn trawl fisheries were to be effectively addressed.

However, the results from a survey of Queensland east coast trawl fishers indicated that less than 2% of the fleet had used a BRD, and only two vessels had used a TED, prior to 1997. The lack of available information, together with concerns over perceived potential lowering of catch rates, the costs of installing the devices and operational problems in adjusting to the new fishing gear, resulted in commercial fishers generally being hesitant to experiment with TEDs and/or BRDs at sea.

3. Project Objectives

- i) Inform and consult commercial trawl fishers about ways and means of reducing the catch of non-target organisms in their trawl nets;
- ii) Further develop promising bycatch reduction devices and other bycatch reduction strategies under commercial conditions;
- iii) Document, accumulate and publish performance data of turtle excluder devices and bycatch reduction gears suitable for the commercial fishing industry of the Queensland East Coast, the Torres Strait, the Northern Prawn Fishery and other interested parties;
- iv) Encourage and promote the use of bycatch reduction devices by commercial trawl operators.

4. Research Findings

Though the project concerned the use of both TEDs and BRDs, the bycatch of turtles was the most pressing issue at the time, such that TEDs were given priority. Also, while the project covered the three northern Australian fisheries, work was concentrated more on the Queensland east coast fishery and the northern prawn fishery (NPF) rather than the Torres Strait fishery.

Work undertaken during the project focused on three main areas:

- i) extension;
- ii) evaluation of TED and, to a lesser extent, BRD performance; and
- iii) research on the vertical distribution of prawns in the water column.

Extension activities

A number of innovative approaches were used to inform and change attitudes among fishery stakeholders – predominantly commercial fishers – regarding TEDs and BRDs:

- i) more than 400 stakeholders – including fishers, netmakers and conservationists - participated in 21 bycatch workshops held throughout northern Australia during 1996-1999;
- ii) six issues of a user-friendly bycatch newsletter were produced and distributed to fishers and other stakeholders;
- iii) two bycatch videos were produced and distributed free to fishers;
- iv) two booklets summarising bycatch reduction devices and TED design and components were produced and 500 copies distributed;
- v) information sheets identifying various TED designs and their performance based on results from at-sea trials were produced and updated twice-yearly;
- vi) a gear library was established in which 70 TEDs and 13 BRDs constructed during the project were lent to commercial fishers for use on their vessels;
- vii) project staff participated with fishers during 36 at-sea trials of alternative TED and BRD designs and assisted with evaluating and documenting performance; and

viii) the creation of an award – the Prawn Trawling Innovation and Adoption Award - to recognise outstanding leadership by individual fishers in developing, implementing and promoting the use of TEDs and BRDs within the industry. The award included a tied grant of \$10,000 to support an overseas study tour to examine the use of TEDs and BRDs in other prawn trawl fisheries and was offered in 1997 and 1998.

Evaluation of TED and BRD performance

Results indicated that TEDs were very effective at excluding large animals (turtles, rays, sharks and large fish) and large sponges, but not very effective at excluding smaller fish. The effect of TEDs on prawn catch was highly variable depending, among other factors, on the type of fishing ground and the design of the TED.

Field-testing of BRDs was limited to the Queensland east coast fishery. The use of a BRD had no noticeable impact on either prawn quantity or quality. The impact on bycatch depended upon the type of BRD being used, the time of the trawling (night/day), and the type and quantity of bycatch being caught. In general, bycatch was found to reduce by 40% during day trawling and 20% during night trawls.

Vertical distribution of prawns

Sea trials were undertaken using a purpose-built trawl net containing removable horizontal panels that separated the trawl net and codend into three distinct sections. Trawling with different configurations of the panels identified the vertical distribution of where the prawns and bycatch were caught.

The tests indicated that 96% of the prawn catch and 90% of the bycatch was taken within 600mm of the seabed. In other words, both prawns and bycatch species are found in the same strata of the water column, such that reducing the headline height of the trawl net would have only a modest impact on bycatch levels.

Many bycatch species were found to exhibit strong upward response to an approaching trawl, such that many species may be able to avoid capture if escape panels were available at the top of the trawl net. This result supported the likely success of appropriately designed BRDs in reducing unwanted bycatch.

5. Cost/Benefit Analysis

There are two major components of net economic benefit in cost/benefit analysis - producer's surplus and consumer's surplus. In the context of this project, producer's surplus is a measure of the net economic benefit generated in the northern Australian prawn fisheries as a result of fishers using TEDs and BRDs earlier than they otherwise would. Although somewhat simplified, producer's surplus can be thought of as the additional profits generated in these fisheries as a result of the earlier use of TEDs/BRDs

Consumer's surplus is a measure of net economic benefits to consumers. For example, if the use of TEDs and/or BRDs changes either the quantity or quality of the prawn catch, which in turn leads to a change in prawn prices on the domestic market, then consumers will be affected.

Cost/benefit analysis involves the calculation of the net economic benefits that are generated from the research investment, which are in turn compared to the initial research investment.

a. Project Costs

Total costs of the project are estimated at more than \$2.1m of which FRDC contributed just over \$1m, or 48% of the total.

Table 1 Costs of Research Investment for Project 1998/322

FRDC	Department of Primary Industries	Other sources	Total
\$1,020,687	\$1,083,329	\$35,500	\$2,139,516

b. Application of Project Results

Given that the focus of the project was on transferring the results from previous TED and BRD research to the commercial industry, for any benefits to be attributed to the project it needs to be demonstrated that the project had a positive impact on industry attitudes regarding the use of TEDs and BRDs.

The range of extension services employed - the port meetings, the articles in Queensland fisheries magazines, the videos, the lending of TEDs/BRDs gear to industry, the at-sea trials,

the leadership awards – resulted in the project had a very high profile within the industry, particularly in Queensland.

- evidence of the effectiveness of these extension services is that the project itself received awards - project staff won the 1997 Queensland Seafood Festival Award for environmental promotion within the fishing industry and were nominated in 1998 and again in 2000 for the QDPI Excellence Awards for Research and Development.

At a subjective level, representatives from the northern prawn and east coast prawn fisheries contacted during this review expressed overwhelming support for this project. The Queensland Seafood Industry Association (QSIA) referred to the project as ‘a landmark study that led to a real change in fishers attitudes and behaviour’. Annie Jarrett, Executive Officer for the Northern Prawn Management Advisory Committee (NORMAC) described the project as ‘being one of the most successful FRDC projects ever undertaken in the fishery’. Equally positive comments were received from the fishing industry (Alan Hansen, the then-trawling committee representative from the QSIA, David Carter, from Newfishing, and Michael O’Brien, from Raptis).

At a more objective level, a survey of 758 licensed Queensland operators was undertaken during the project to obtain information on the level of TED and BRD usage in the Queensland prawn trawl fishery. Comparing the results from this survey to those from a similar survey completed prior to 1997, the number of vessels regularly using TEDs and BRDs increased twenty-fold during the course of the project, albeit from a very low starting level (Table 2).

Table 2: TED and BRD Use by the East Coast Prawn Trawl Fleet 1997-May 1999

	Proportion of fleet regularly using TEDs	Proportion of fleet regularly using BRDs
Prior to 1997	1%	2%
Prior to April 1999	20%	38%

It is unreasonable to expect that the project was the only factor contributing to the increased TED and BRD use. For example, Queensland had announced that the use of TEDs and BRDs would become compulsory in the fishery as from May 1999, and some fishers may have started using the devices to become familiar with their use prior to their becoming mandatory. However, based on the Queensland industry’s very positive perceptions of the

work –it being considered a landmark study - it is reasonable to assume that the project did effect a change in industry attitudes.

No comparable data on TED and BRD usage was collected for the other northern Australian prawn fisheries. However, based on the positive comments received from representatives from the northern prawn fishery, the project seems to have been similarly successful.

c. Potential Benefits

As stated in the project proposal, the research was designed to ‘maintain the economic viability of the commercial trawl fishery while meeting the ecological sustainability required by government and the conservation lobby’. Given this intent, there are two potential benefits arising from the changed industry attitudes that the project induced:

- i) improved ecological performance of the fishery, measured in terms of reduced bycatch. If the amount of bycatch taken in the northern Australian prawn fisheries is lower than it would otherwise have been had the project not been implemented, the benefits associated with this reduced bycatch are attributable to the project;
- ii) industry profitability being higher than it otherwise would have been had the project not proceeded. This could potentially be:
 - market related – such as through improvements in prawn quality (since the prawns in the codend will be subjected to reduced damage and bruising, and since reduced sorting times will enable prawns to be iced or frozen more quickly), reduced fuel consumption (from less drag on the net), savings in labour costs should less crew being required, and increased consumer acceptance - and hence demand - for Australian prawns (either domestically or on export markets); or
 - management related – such as through the use of TEDs and BRDs enabling fishers to maintain access to traditional fishing grounds that might otherwise have been closed to fishing had bycatch levels continued at unacceptably high levels.

d. Realisation of benefits

Improved ecological performance

Of all the bycatch species, the bycatch of turtles was the most sensitive. Given that the death of turtles in trawl nets generates the greatest public concern, it follows that the saving of turtles will generate the greatest public benefit.

A recently completed FRDC-supported project¹ has estimated turtle catch and mortality rates in the NPF with and without TEDs. Results from that work estimate the use of TEDs in the NPF to have saved in excess of 1100 turtles/year (Table 3).

Table 3: Annual Impacts of TEDs on Turtle Catch and Mortality in the NPF

	Turtle catch	Mortality rate	Turtle mortality
Without TEDs	5200	22%	1150
With TEDs	140	22%	31

Source: FRDC project 1998/202

Earlier studies had estimated turtle mortality rates of between 25%-39%². The reduced mortality rate in recent years was considered due to the crew being more aware, and more informed, of improved on-board turtle handling techniques. Although this project would have had some positive influence in supporting skippers/crew improve their handling techniques, a conservative approach is taken in that it is assumed that the reduced mortality rate was due to factors other than this project (such as the turtle handling brochures).

These results are supported by the preliminary findings from a separate FRDC study that indicate the use of TEDs has reduced turtle catch rates in the NPF by 99%³. Other preliminary results indicate a 26% reduction in the bycatch of rays, a 90% reduction in bycatch of sponges, and a 20% reduction in bycatch of sharks⁴.

¹ Robbins, C.M., Goodspeed, A. M., Poiner, I. R. and Harch, B.D. (1992), Monitoring the Catch of Turtles in the Northern Prawn Fishery, FRDC Project 1998/202

² Poiner, I.R, and Harris, A. N. M (1996), The incidental capture, direct mortality and delayed mortality of sea turtles in Australia's northern prawn fishery, Marine Biology 125, 813-825.

³ Assessment and improvement of BRDs and TEDs in the NPF: a co-operative approach by fishers, scientists, fisheries technologists, economists and conservationists (in progress), FRDC Project 2000/173.

⁴ The reduced shark catch rate was based on using TEDs in association with BRDs.

Clearly, TEDs are very effective in reducing the bycatch of large animals. This raises the question of to what extent has the project contributed to the TEDs effectiveness - in other words, would TEDs have been as effective had the project not been implemented?

It is not possible to find a precise answer to this question. However, every fisher, industry representative, government official and researcher contacted during this evaluation expressed the belief that the proactive approach taken by industry was a key factor underpinning the success of the TEDs. Industry's positive approach is considered to have been largely attributable to the change in industry attitude towards TEDs engendered by the project.

- Prior to the project, there was widespread industry resistance - in some cases hostility - to using TEDs. By the end of the project, this hostility was replaced by industry having a sense of ownership over the process, and a responsibility for making TEDs work.

As was noted in the project proposal, 'a legislated approach to the use of bycatch reduction devices will be inefficient and will cause significant conflict between fishing, government and conservation organizations.'

- In the United States, the use of TEDs in their prawn trawling fisheries has been plagued by confrontation and legal action between industry, the government and conservation groups for more than 20 years, and non-compliance involving the intentional disabling of the TEDs while at sea is allegedly widespread.

The United States experience is in direct contrast to the outcomes achieved in Australia:

- In the case of the Queensland east coast fishery, the positive industry attitude allowed government authorities to take a more flexible approach to introducing TED regulations.
- For example, rather than prescribing rigid specifications about the types of TEDs that could be used, the regulations gave the skippers and crew the opportunity to experiment with alternative TED designs in commercial at-sea trials. Fishers had the freedom, and confidence, to test alternative designs, without fear of violating regulations. Over time, fishers developed a variety of TED designs appropriate to – and effective in – the different conditions experienced across the Queensland fishery, which in turn accelerated the adoption of the devices throughout the fleet.

- The positive attitudes from both industry and government enabled both parties to work together to implement TEDs in a constructive rather than confrontational relationship.

It is likely that TEDs would have become mandatory in the northern Australian prawn fisheries at some point in time, irrespective of whether this project was implemented. However, as previously stated, the legislative approach by itself would not have been sufficient to make the TEDs work as effectively as they have - industry support is the critical ingredient to effective TED implementation.

Had the project not been undertaken, it is assumed that industry would have continued to resist TEDs being introduced, adoption rates would have been slower and industry would have been less involved in refining TED designs. These factors would have resulted in TEDs being less effective – and bycatch levels higher – than has been experienced.

In estimating the benefits directly attributable to the project, it is assumed that in the absence of the project, industry compliance with TED requirements would have been deferred by three years. In other words, it is assumed that the project enabled the widespread use of TEDs three years earlier than otherwise would have occurred. Benefits and costs arising from the use of TEDs over these three years are thus attributed to the project.

The impacts of TEDs will obviously continue beyond this three-year timeframe. However, these longer-term impacts are deemed to have been realised regardless of the project and are thus not included in the analysis.

Improved industry profitability

One of the objectives of a current FRDC project is to assess the economic costs and benefits to the NPF industry from the use of TEDs and BRDs⁵. Work on that project is continuing, but preliminary results indicate that:

- i) the use of TEDs and BRDs has resulted in fewer damaged prawns being caught. The benefits of this are estimated at around \$600,000/year;
- ii) benefits associated with reduced fuel consumption and crew costs are negligible;

⁵ Assessment and improvement of BRDs and TEDs in the NPF: a co-operative approach by fishers, scientists, fisheries technologists, economists and conservationists (in progress), FRDC Project 2000/173.

- iii) costs associated with the use of TEDs and BRDs include the manufacture and installation of TEDs and BRDs (estimated at \$300,000/year) and a reduced prawn catch (estimated at 6%, and costing an estimated \$2.7m/year);
- iv) preliminary results from the analysis indicate a financial cost to the NPF industry from the use of TEDs and BRDs of around \$2.4m/year - slightly under 2% of the value of the NPF prawn catch.

The net impact is highly sensitive to the assumed rate of prawn loss. There is considerable uncertainty regarding this true impact of TEDs on catch rates, with estimates ranging from a negligible impact to losses of 10-20%.

It is assumed that there is some reduction in catch attributable to the use of TEDs and that this lost catch at least equals the benefits obtained from the improvements in prawn quality. In other words, the net effect on fishers' incomes from the quality improvements and prawn losses is at best neutral.

Improved market access

The use of TEDs in the NPF has created additional marketing opportunities for Australian prawn exporters through the reopening of the United States market⁶. Though a positive development, the benefit of being able to export to the United States is of strategic rather than monetary value, at least at the present time:

- i) the United States is not an important market for Australian prawns at the present moment, accounting for around 1% of prawn exports valued at around \$3m;
- ii) access to the United States market does give the possibility of developing that market at some time in the future, as well as giving exporters some form of insurance against any future downturns in the Japanese, other Asian, or European markets.

In terms of the domestic market, the earlier introduction of TEDs and BRDs will not have had any positive impact on domestic prawn prices or prawn consumption, such that the project will not have generated any benefit in terms of increased consumer surplus.

⁶ Under US legislation, wild-caught prawns can only be imported from those countries that require vessels operating in their prawn fisheries to use TEDs of at least a similar standard to those required in US prawn fisheries. Australia was thus unable to export prawns to the US prior to the NPF being accredited by US officials in 2000.

Management-related benefits

As previously stated, it is likely that TEDs would have been made mandatory in the northern Australian prawn fisheries irrespective of whether this project was implemented. However, in the absence of this project, industry would have been far less supportive of TEDs, such that the effectiveness of the TEDs in reducing bycatch interactions would have been significantly less. How the management agencies would have responded to a continuing turtle interaction problem is difficult to assess:

- at the very least, the management agencies would have had a difficult compliance problem enforcing the mandatory use of TEDs without industry support. Instead of the cooperation and strengthening of relationships that was experienced, a confrontational atmosphere would have developed between the government and industry over the TEDs issue, with biological, economic and most likely legal and political implications, mirroring the United States experience;
- additional management measures may have been introduced. For example, one of the initial options identified to manage the turtle issue in the Queensland fishery was to designate those areas known to experience high rates of turtle interactions as closed to commercial trawling. Had TEDs not been effective, it is reasonable to expect that the option of additional closed areas would once again been under review. Depending on the areas chosen, the economic impacts on fishers from additional closed areas may have been considerable.
- at the Commonwealth level, continuation of the turtle interaction issue would have been a highly contentious issue in the strategic assessment process required under the Environment Protection and Biodiversity Conservation Act 1999 (the EPBC Act). The act applies to all Commonwealth fisheries, and all State fisheries with an export component – in other words, all the northern Australian prawn fisheries. It is highly likely that the Environment Minister would have required additional management measures to be introduced had there continued to be a significant turtle issue in any of these fisheries.

There is too much uncertainty to predict with any confidence what additional management measures may have been introduced, or to quantify what the likely impact of the restriction would have been on commercial fishers. However, an indication of the likely costs

associated with additional management restrictions, for a given impact on catch, can be estimated without specifying what the particular management measures may have been (Table 4).

Table 4: Foregone profits resulting from additional management restrictions

	Foregone annual revenue ¹	Foregone annual profits ²	Net present value of foregone profits over 10 years
Impact of a management restriction that results in a 1% fall in catch	\$2.34m	\$0.5m	\$3.6m
Impact of a management restriction that results in a 5% fall in catch	\$11.7m	\$2.3m	\$18m
Impact of a management restriction that results in a 10% fall in catch	\$23.4m	\$4.7m	\$36m

1: based on prawn production from the three northern Australian prawn fisheries in 2001/02 valued at \$234m;

2: based on profit margins representing 20% of revenue

Had the management agencies been required to introduce additional restrictions on industry that resulted in a 1% fall in catch – a fairly modest impact - the foregone profits resulting from the lower catch are estimated at \$0.5m/year, and \$3.6m (in net present value terms) over 10 years. Not surprisingly, the larger the impact of the restriction on catches, the greater the foregone profit.

e. Net Benefits

In calculating the benefits attributable to FRDC's investment in the project, it is assumed that the project would not have proceeded without the financial contribution made by each of the parties. In other words, the project would not have proceeded without FRDC's – and the other contributors' – support. The net benefits attributable to the project are therefore allocated to each of the research-funding parties in proportion to their funding contribution. Given that 48 per cent of the research effort was funded by FRDC, just under half of the benefits from the project are attributable to the FRDC investment in the project.

Quantifying the value of the benefits arising from the project is not readily possible:

- while the project is attributed with positively changing industry attitudes regarding TEDs and enabling industry to effectively use TEDs, the bycatch species that have been saved have no commercial value, nor are they significant species for the recreational fishing sector;

- there is too much uncertainty to predict with any confidence what additional management measures may have been introduced had the implementation of TEDs not been so effective, or to attempt to quantify what the likely economic impact of such additional measures would have been on commercial fishers.

While it is not possible to quantify these actual benefits, it is possible to identify threshold values that would justify FRDC's investment in the project.

- considering the reduced turtle mortalities, the hastening of the use of TEDs in the NPF is estimated to have saved around 3300 turtles over a three-year period, 48% of which can be attributed to FRDC's contribution to the project. With the net present value of FRDC's investment in the project in excess of \$1.2m, the almost 1600 turtles saved as a result of FRDC's contribution have each cost around \$780. Viewed from a different perspective, and based on 75% of FRDC's investment in the project having been sourced from the total Australian population of 20 million, the saving of the almost 1600 turtles has cost around 5 cents/person. If the community would be prepared to pay at least 5 cents/person to save these 1600 turtles, FRDC's investment in the project would be justified based solely on the number of turtles saved in the NPF, let alone the saving of turtles in the other northern fisheries and the value to the community from reduced mortalities of other non-market species such as rays and sharks;
- considering the likely impact from additional management measures, in the absence of this project, it is likely that the respective fisheries management agencies would have been faced with a continuing turtle interaction problem and may possibly have introduced additional management restrictions. A restriction that resulted in only a 1% reduction in catch across the northern Australian fisheries would have incurred a cost to industry of foregone profits of around \$500,000/year. The net present value of these foregone profits over a ten-year period is \$3.6m, 48% of which (\$1.7m) can be attributed to FRDC's contribution to the project. With the net present value of FRDC's investment in the project of \$1.2m, FRDC's investment in the project would be justified based on the saving of these foregone profits alone.

Table 5: Summary of research costs and benefits

Research costs and benefits	
Net present value of FRDC investment (in 2003 terms)	\$1.24m
Reduced turtle mortality in the NPF attributed to FRDC investment (no. of turtles)	1584
FRDC investment/turtle saved in the NPF	\$783
Threshold value of saving 1600 turtles/head of population	5 cents
Net present value of foregone profits 'saved' from not requiring an additional management restriction that reduced catch by 1% ^s	\$3.6m
Net present value of foregone profits saved attributed to FRDC investment	\$1.7m

Other non-quantified benefits arising from the project include:

- v) the building of more cooperative relationships between industry, researchers, conservationists and fishery managers - in direct contrast to the confrontational outcomes experienced in the United States – and the saving of management/enforcement/legal costs than may otherwise have been incurred;
- vi) flow-on benefits to prawn fisheries in South Australia and Western Australia;
- vii) the strategic value to Australian prawn exporters from regaining market access to the United States, and from having an improved marketing image for Australian prawns more generally; and
- viii) a strengthening of Australia's international reputation in terms of environmentally sustainable fisheries management.