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EX-POST COST/BENEFIT ANALYSIS OF FOUR FRDC-FUNDED PROJECTS

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

In this study four completed research projects were evaluated using the techniques of cost/benefit analysis. A range of different types of projects was chosen to span all FRDC program areas. Also, projects had to be completed (preferably several years ago) and, for logistical reasons, to be undertaken by organisations based in eastern Australia.

A brief summary is given below of the results of the analysis of each project. Table 1e identifies the costs and estimated research benefits for each project.

1. Project No: 92/71 "Live Transport of Crustaceans in Air: Prolonging the Survival of Spanner Crabs"

This project was undertaken by the International Food Institute of Queensland. The purpose was to develop new in-transit storage methods for live spanner crabs destined for export markets with a view to prolonging their survival. Research revealed that changes in storage methods (during transport to export markets) made little difference to the mortality rates of the crabs, and that the underlying problem was that crabs were already highly stressed by poor handling on fishing vessels.

The project was extended to examine the effects of alternative on-board handling techniques on crab mortality rates, and to hold a workshop to disseminate the results. It was found that significant improvements in crab survival resulted from holding the crabs in cool, moist conditions on-board the fishing vessel, compared to the industry practice of holding the crabs on deck in baskets.

Although this result was widely disseminated to industry, there was little change in industry practices with respect to on-board crab handling. This was mainly because the limited entry and competitive TAC management regime in place in the fishery provided little incentive for fishers to deliver quality products. As a result, there have been no tangible benefits from the research. However, a forthcoming change to ITQ management will probably provide the necessary incentive to operators to accept the research advice and modify their crab handling practices.

2. ***Project No: 92/125.32 "Improving Packaging Technology, Survival and Market Options for Kuruma Prawns"***

This project was undertaken jointly by the Centre for Food Technology and the Bribie Island Aquaculture Research Centre in Queensland. There were two components to this research. The first was to develop new packaging to reduce in-transit mortality rates of kuruma prawns destined for the Japanese market. The second component was to examine whether kuruma prawns (normally grown in southern Queensland) could be successfully produced and exported, or sent south for climatic agistment, from northern Queensland prawn farms. Faster growth rates and the possibility of two crops per year provided incentive for investigation of the potential for the kuruma prawn industry in northern Queensland.

The study showed that year-round production from northern Queensland sites is infeasible due to the effects of high ambient pond temperatures on prawn mortality. However, production in northern Queensland during the colder months, possibly followed by climatic agistment in more southerly sites, was considered worthy of commercial trials. As nothing has yet come of this research finding, no benefits are attributed.

A new package, with enhanced temperature control features, was successfully developed for the airfreight of live kuruma prawns to the Japanese market. Its adoption by farmers was expected to deliver improved prawn prices as a result of lower in-transit prawn mortality and because of increased market confidence in the Australian product. However, farmers have not used the new packaging, nor do they apparently intend to do so. This is because the mortality rates reportedly being achieved with existing, cheaper packaging are quite satisfactory, being consistently less than 5%. Moreover, farmers believe that the residual mortalities have more to do with the mistaken selection of weak prawns for packing rather than with poor temperature control.

As there has been no adoption of the new packaging, there are no apparent benefits arising from the research.

3. Project No: 94/128 "Assessment of the Impact of Environmental Factors and New Technology on the Northern Prawn Fishery"

This project was carried out by CSIRO's Division of Fisheries in Cleveland. The purpose was to investigate two issues which create uncertainty about the assessment of the tiger prawn stocks in the NPF. Specifically, the effects of environmental variables on fluctuations in prawn abundance, and the effect of the introduction of GPS on the effectiveness of fishing effort were to be estimated.

The study failed to discover any environmental factors that explained inter-annual variation in catches of tiger prawns throughout the NPF, although analyses suggested the existence of relationships in some areas of the fishery. Little confidence was placed on these results and, as no use have been made of them in stock assessment, no benefits are attributed.

The research on the impact of GPS on the effectiveness of fishing effort indicated that effective fishing effort had grown by 12% after three years of use. It was recommended that an annual rate of increase of 5% continue to be used to account for additional components of effective effort growth. This result effectively "drives" the stock assessment model which indicates that fishing mortality on tiger prawn stocks is too high and that effort should be reduced substantially in the fishery. While the 5% figure was used in previous stock assessments, it was argued that industry support for continued use of this assumption was wavering until the results of this research were made available.

Increased industry confidence in the stock assessment, resulting from this research, facilitated negotiations between AFMA and industry on the development of an effort reduction programme. It was agreed that the programme would be implemented in 1999. According to AFMA and the principal stock assessment scientist, gaining industry agreement to the programme in the absence of the research results would have taken at least one more year. The benefits of the research are, therefore, estimated as the discounted difference in the profits of the fleet under (the same) effort reduction programme starting in 1999 and 2000, respectively.

The earlier effort reduction programme generates substantially more economic benefits than the alternative, starting only one year later. This is because "effort creep" increases the fishing costs of the fleet during 1999, eroding in advance the potential gains from the 2000 effort reduction programme.

4. Project No: 94/053 "An Assessment of the Impact of Offshore Recreational Fishing in New South Wales Waters on the Management of Commercial Fisheries"

This project was undertaken by the NSW Department of Fisheries. The purpose was to estimate the total harvest and fishing effort of recreational anglers fishing NSW offshore waters, and to relate these results to the allocation of fish resources between recreational and commercial users.

Data was collected mainly using a large scale boat ramp survey and supplemented with data from vessel movement logbooks kept by the Coastguard and Coastal Patrol. One of the main findings was that recreational fishers collectively harvest large quantities of many species shared with the commercial sector. It was recommended that the recreational and charter boat sectors become subject to enhanced monitoring, that the data be used in stock assessments and for inter-sectoral resource allocations, and that recreational fishers be given greater input to management decision-making on shared resources.

An indication of the value placed on the research is that a "Recreational Fishing Research Group" was established by the Fisheries Department to implement fully the recommendations of the study. One of the main outcomes of the research has been the establishment of seven regional recreational fishing advisory bodies to provide management advice to the Department. These groups, together with their commercial counterparts, were able to negotiate a set of 100 beach closures to commercial "netters", offset by the provision of priority access rights to commercial fishers in other locations. These closures have been implemented by the Department, which indicated that this resource allocation would have been much more difficult to accomplish in the absence of the new institutional framework.

It is difficult to ascribe monetary benefits to this project in terms of changes in commercial harvesting profits and angler satisfaction. Nonetheless, this should not be interpreted to imply that the research was without value. It is our opinion that the research did produce significant non-quantifiable benefits in terms of facilitating conflict resolution between the commercial and recreational sectors (through the collection of catch data and the development of a new institutional framework). Overtime, this should increase the probability of more rationale resource allocations and, in turn, result in quantifiable economic benefits.

Table 1e: Summary of research costs and estimated benefits across four selected projects

Project	Total cost	FRDC cost	Total benefits	Benefits from FRDC funding	FRDC benefit/cost ratio	Future benefits
1. Survival of spanner crabs	$275,749	$100,832	$0	$0	nil	Probable
2. Packaging for kuruma prawns	$194,750	$33,750	$0	$0	nil	Possible
3.Environment and technology in the NPF	$171,251	$67,237	$3,267,000	$1,282,700	19:1	Probable
4. Offshore recreational fishing in NSW	$651,463	$183,565	Significant non-quantifiable benefits	Significant non-quantifiable benefits	unknown	Probable

Summary comment

In order to improve the effectiveness of research investment, it may be worthwhile for the FRDC to insist that research applicants provide a more formal analysis of expected net benefits. This would be particularly useful for "industry development-type" projects, such as the spanner crab and kuruma prawn projects considered in this report. We are not suggesting a costly and detailed cost-benefit analysis should be attached to each research application; but rather, taking the kuruma prawn project as an example, we think that an explicit outline of expected costs and benefits (involving researchers and farmers) would likely have raised serious questions about future net economic benefits. After all, anyone interested in acquiring a business loan from a bank is requested to layout explicitly the estimated economic costs and benefits prior to loan approval.

Postscipt

Comments were received from NSC on the analyses in the draft report relating to project number 2 (spanner crabs) and number 3 (kuruma prawns). While agreeing with the outcome of both analyses, the NSC expressed differing views on the potential benefits arising from the kuruma prawns study. In particular, the NSC suggested that some prawn farmers continued to experience substantial, temperature related mortalities, that the cost differential between the new box and existing packaging was only about $1 per unit and, as a result, there are significant potential gains for farmers from using the new box. The non-adoption of the new box is perceived by NSC to be more the result of poor business decision-making by farmers rather than of a lack of real economic incentive to use the box.

The fact that one farmer recently sent two shipments using the new boxes provides some support for this assertion, particularly as the farmer reported that the survival rate of the prawns was better than in previous, end-of-season shipments (using ordinary packaging) and that the Japanese buyers showed no resistance to the new box. Notably, this particular farmer had previously stated that he had no intention of using the new box.

In these circumstances, it is unclear whether kuruma prawn farmers are likely to use the new box in coming seasons. The limited adoption to date and the equivocal attitude displayed by the industry toward the new box underlines the point made in the concluding comments that researchers should be required to put more effort into defining the potential net benefits from their proposed research, and gaining explicit industry support and involvement in the project.

EX-POST COST BENEFIT ANALYSIS OF FOUR FRDC PROJECTS

1. A Brief Outline of Cost Benefit Analysis

First consider the cost/benefit approach followed in evaluating each of the four projects. There are two major components of net economic benefit in cost/benefit analysis - producer's surplus and consumer's surplus. Producer's surplus is a measure of net economic benefits created in the harvesting and processing sector from a specific research project. Although somewhat of a simplified explanation, producer's surplus can be thought of as additional profits generated. As well, if the research findings induce increases in production and employment, then to the extent that previously unemployed labour is employed, the associated wages would also be included as a benefit in producer's surplus.

Consumer's surplus is a measure of net economic benefits to consumers. For example, if a research project induces an increase in production and that in turn results in a decline in prices on the domestic market, then domestic consumers would be better off. Consumer surplus is simply a measure of this improvement in consumer well-being.

In an effort to keep technical jargon to a minimum, economic benefits related to each of the four projects will be discussed in terms of increased profits, wages and other familiar concepts. As well, consumer's surplus is not particularly relevant for any of the four projects evaluated. This is because three of the projects are concerned with products that are mainly exported so any possible gains in consumers surplus will be derived by foreigners. The remaining project is concerned with generating data on the catch of recreational fishers, and has few immediate implications for consumer's surplus. Consumer's surplus is not further considered in this study.

2. Project No: 92/71 Live Transport of Crustaceans in Air: Prolonging the Survival of Spanner Crabs

Research Agency: **International Food Institute of Queensland**

FRDC program: **Industry development**

2.1 Objectives

- To increase knowledge of the techniques required for successful live transport of crabs destined for export or domestic markets.
- To put this knowledge to commercial practice in developing guidelines and protocols.

2.2 Background

The spanner crab fishery commenced in the late 1970s in the Mooloolaba-Caloundra area as an addition to the mud and sand crab fisheries. In the mid-1980s, the fishery expanded into northern New South Wales, with landings from Queensland and NSW totaling roughly 300 tonnes. After landing, crabs were prepared by cooking for the domestic market and, later for the Taiwanese market.

The spanner crab fishery underwent rapid change at the beginning of the 1990s. A live export market to Asia (primarily Taiwan) was developed, significantly increasing the price received by fishers. New fishing grounds around Bundaberg were discovered. High catch rates and prices encouraged the entry of many more vessels, boosting harvest levels from 880 tonnes in 1991 to almost 2,400 tonnes in 1993.

The International Food Institute of Queensland was heavily involved in the initial development of the live export market, making trial shipments of live crabs to Japan and advising commercial operators on live transport and handling techniques. From the outset, a major factor inhibiting realisation of the live export market's full potential was the sometimes high and variable mortality experienced by spanner crabs during transportation and soon after reaching their final destination.

In the early 1990's, the post-harvest handling methods used by fishers and processors were fairly rudimentary. After harvest, crabs were stored dry in baskets on the deck of boats until returning to shore where the crabs were transferred to live storage tanks in the premises of the crab processors. The crabs were then cooled and stored overnight, prior to packing for export, usually the next day. Therefore, crabs were stored in air twice after harvest: first while on the boat (and sometimes during land transport to processors), and then when shipped by air to export markets.

In response to the live-market mortality problem, FRDC funding was made available initially to study various issues related to spanner crab tolerance when stored in air, with a view to prolonging their survival by developing new in-transit (via air freight) storage methods. The project was subsequently extended to examine the effects of on-board handling on crab mortality and to hold a workshop in late 1993 on harvesting and post-harvest handling of live spanner crabs.

2.3 Research Findings

The research had three components: testing the effects of a buffer formulation during controlled trials and commercial shipments; physiological tests to study the effects on the blood chemistry of the crabs of the buffer and of increased oxygen concentration during shipment; and an examination of the effects on crab survival of changes in post-harvest handling of crabs on vessels and at the premises of processors.

General finding

Initially, attention focused on improving crab survival by improving conditions during air transport. However, as the research progressed, it was thought that on-vessel conditions were probably the major cause of subsequent mortalities. Specifically, the research indicated that, contrary to common perceptions, spanner crabs became quickly stressed when they arrived on deck, and that crabs accumulate large amounts of metabolic waste quickly after leaving the water – their blood pH fell rapidly - a symptom called acidosis.

Air storage during export to market

Two approaches to improving crab survival during air transport were tested. One involved attempts to control the immediate environment of the animals by increasing the oxygen concentration in the pack; and the other, by dipping the crabs in a bicarbonate buffer solution. It was found that an oxygen-rich atmosphere did not help crabs survive any longer, and may actually reduce survival. With respect to the use of the bicarbonate buffer, it was found that the dip had no significant effect on crab survival.

Air storage after harvest but before processor storage

Crabs were stored on-board vessels using three different methods (in baskets on deck, in cold air, and in live wells) and subsequently held for several days in a recirculating sea-water storage tank to monitor crab survival.

It was found that the use of aerated live wells did not reduce mortality over storing crabs in air. It was suspected that crabs in live wells were more active and, since claws were not bound, fighting led to infections. Crabs that were stored on-board in dry and cool (20°C) conditions showed the best survival. After four days in the storage tank, the mortality of these crabs was roughly 25%, compared to an approximate 56% mortality for crabs stored in baskets on deck.

While not undertaken on vessels, a study was also made of the impact of spraying seawater over crabs stored in air. Results in terms of reduced mortality were not provided, however spraying was found to reduce the fall in blood pH and blood lactic acid concentration. Many boats do not unload at the export premises so a period of road transport is necessary. The research found that while metabolic waste accumulation did not increase as a result of transport, mortality levels did increase from an average of 40% after 4 days without trucking to 65% with trucking.

2.4 Research Recommendations

- Spanner crabs should be stored on boats or transported by road in cool, moist conditions (temperature 16-20°C, 100% relative humidity)
- A practical way should be found to restrain spanner crabs after capture to reduce physical injury when crabs are crowded together - in particular, by banding the claws.

- That crabs stored on-board be subjected to seawater sprays, and that a study should be conducted on the physiological effects of refrigerated seawater sprays when storing crustaceans for long periods because of the questions raised in this study.

2.5 Cost Benefit Analysis

FRDC expenditure: $100,832
Total research cost: $275,749

In simple terms, to undertake the cost benefit analysis, we need to estimate any economic benefits that flow from the research findings. Benefits are then compared to the financial cost of the research, plus any economic costs that are required to capture the benefits.

2.5.1 Potential benefits

The potential benefits from adopting practices that reduce crab mortality are in the form of increased sales and/or increased price. Increased price may result directly from lower mortality in transit or from an improved ability of exporters to "play" the market (as crabs could be held longer in storage) through building up or depleting processor inventories as conditions dictate. A second type of benefit would be in the form of increases in wages earned by fishers and processors that resulted from increased production or increased prices.

2.5.2 Realisation of benefits

Clearly, benefits can only arise if fishers or processors, as a result of the research, change their practices with respect to handling and transporting crabs destined for the live export market. As there are no research recommendations relating to the storage, handling or transportation of crabs by processors, any research benefits must arise as a result of changes in the way that fishers handle their catch.

As noted in Section 2.4, the recommendations of the research are that fishers change from the practice of holding crabs on deck in baskets, to a system under which the crabs are held either in cool, moist air, or in a live well with their claws banded, or under cool seawater sprays. These recommendations were disseminated to industry via a workshop, held in late1993.

Discussions were held with fishers in the Caloundra-Mooloolaba area of the fishery and with a processor located in Bundaberg to ascertain the extent to which industry has adapted its practices as a result of the research. It appears that most fishers have made only minor changes to their crab handling practices since the early 1990's. Most vessels still carry their crabs on deck, stored in baskets, although they are now often covered with sacking in an attempt to keep the crabs from drying out. In contrast, most of the larger vessels in the fleet, of 45 feet or more, either store their catch in deck boxes or fish holds with ice, or in refrigerated fish holds. However, such vessels comprise only about 10% of the fleet, account for perhaps 15% of the total catch and are concentrated in the northern, Bundaberg area of the fishery. At present, there are no vessels using live wells or cool seawater sprays to maintain the quality of their crabs.

Fishers indicated that the main problems with crab quality arise during the summer months when air temperature is relatively high, and which also coincides with the time when the crabs are weakened as a result of moulting. At these times, a significant proportion of their catch may be judged unsuitable for the live export market and purchased either for freezing "green" or for cooking and export. Fishers in the Mooloolaba area receive about $1/kg less for these crabs than for the crabs that can be exported live. In the Bundaberg area of the fishery, fishers receive only one price for their crabs, irrespective of quality.

The lack of significant changes in crab handling practices by most operators probably reflects both the small average size of the vessels (most are less than 10m) and the associated lack of covered storage space and, importantly, the disincentives for producing high quality product resulting from the limited entry and competitive TAC based management regimes which have been in place in the fishery. Fishers have had incentive to produce quantity rather than quality, and under the current regime have a daily catch limit measured in baskets of crabs – providing incentive to force as many crabs into a basket as possible. Moreover, with increasing amounts of the year being closed to fishing and daily catch limits being relatively small compared to historic catches, fishers have been "squeezed" financially. This has not been a management "climate" in which investments by fishers to improve crab quality would be likely to take place.

Reinforcing these adverse incentives is the price structure for crabs in the Bundaberg area of the fishery that produces most of the catch. Why bother to look after your catch if you fail to receive a price premium for good quality? Many of the larger vessels, which use ice or refrigerated cool storage, are owned by the processors.

The main crab processor in the Bundaberg area (accounting for around half of live crab exports) stated that the average quality of the crabs coming off the boats has deteriorated since the early 1990's, and that a lower proportion of the catch is now fit for live export. He attributed this quality deterioration to the entry of large numbers of unskilled operators to the fishery since 1991 and to the disincentives and cost pressures faced by industry under the competitive TAC management regime. He did, however, identify that the catches of some operators, using ice or refrigeration were of consistently good quality. But, it was suggested that these vessels would probably have used ice or refrigeration to produce good quality produce in the absence of the research results.

Although there may have been some adoption of the results of the research amongst the larger vessels in the fleet, there would appear to have been few, if any, direct benefits flowing back to these operators due to the single price structure for crabs. Processors may have achieved some benefits by being able to export a higher proportion of crabs than would otherwise have been possible. However, this is unclear, as there has been no overall increase in the proportion of the catch sold on the live export market. Nor has there been any increase in price which might indicate an improvement in the average quality of the crabs being exported. The average in-transit mortality rate for crabs has, apparently, remained around the 5% level since the early 1990's, and there is no apparent improvement in the ability of processors to play the market through holding the crabs longer.

2.5.3 Costs

The total research cost of the project was $275,749, of which $100,832 was contributed by FRDC. Other potential costs are the expenditures by fishers and processors relating to the implementation of research recommendations. Specifically, these are the costs of installing cold storage facilities, live wells or seawater spraying equipment, plus ongoing costs of ice or refrigerant.

As noted above, although some vessels use deck boxes or fish holds to cool their crabs, many of these vessels already had the necessary storage (for other fisheries in which they were involved), and of those that did not, some would have installed cool storage independently of the results of the research. Remaining expenditures, attributable to the research, are assessed to have been minimal.

2.5.4 Net benefits

The net benefits of this project are assessed as being negative. Overall, it appears that the research has been of little direct benefit to fishers or processors as there has been little adoption of the research findings. This outcome has been driven largely by the lack of incentive for fishers to take care of their catches under the current and previous management regimes.

However, an ITQ system is about to be introduced in the fishery. Both fishers and processors expect that substantial improvements will occur under ITQs with respect to the way in which fishers handle their catches. An anticipated contraction in the fleet, together with an increase in the average size of vessel being used, is likely to lead to greater use of cool storage, either with ice or refrigeration. It was also suggested that live wells would be fitted to some boats, with crabs being held in small baskets in the wells, in a similar fashion to their storage in holding tanks in the premises of processors. Therefore, the introduction of ITQs is likely to lead to greater adoption of the research results and the generation of significant benefits to both fishers and processors. An evaluation of the results of this research project undertaken in, say, five years time might well indicate a significantly different result.

3. Project No: 92/125.32 Improving Packaging Technology, Survival and Market Options for Kuruma Prawns

Research Agency: **Centre for Food Technology & Bribie Island Aquaculture Centre**

FRDC program: **Industry development**

3.1 Objectives

- To evaluate the temperature stability of a technically advanced live prawn (seafood) package design (prototype and finished item), under a range of storage, transport and climatic conditions.
- To ascertain/confirm the upper lethal temperature limit for Kuruma prawns.
- To determine if modifications to preparation and packaging operations are likely to improve the survival rate of packaged prawns from high ambient temperature growout conditions.
- To establish the potential feasibility of transporting live Kuruma prawns from one location to another to optimise growout conditions and optimise quality through climatic agistment.

3.2 Background

The aquaculture industry producing kuruma prawns in Australia has developed since the late 1980's when the International Food Institute of Queensland (IFIQ) initiated research on the production, packaging and handling of live kuruma prawns for export to Japan. The techniques developed through this research led directly to the development of the Australian kuruma prawn industry. Industry production has grown from 20 tonnes in 1993 to an expected 250 tonnes in 1998, worth around $15 million. A report, in late 1995, on the Kuruma prawn industry by a Austrade official suggested that through increases in quality, appearance and extensions in the harvesting season, Australian exports could total $100M (1,000 tonnes) by the year 2000.

The original IFIQ research was part funded by FRDC. A cost benefit analysis of this project by ABARE in 1995 indicated that over a 20 year period substantial net economic benefits were likely to be achieved. By the end of 1993-94, the research had already generated benefits equivalent to nearly 90% of research costs.

Until 1995, Australian kuruma prawns consistently attracted high prices (around 80% of those paid for the wild caught Japanese kuruma prawn), attracting new farmers to the industry and leading to increased production. Most of these farms were clustered around the Moreton Bay area, reflecting the fact that the kuruma prawn is a temperate water animal. However, in 1995 a farm in northern Queensland, around Ayr, entered the industry and exported shipments of prawns to Japan. These prawns experienced high mortality rates in transit, damaging the Australian reputation in the Japanese market, and resulting in significantly lower prices for all Australian produced kuruma prawns. Although the northern Queensland farm stopped producing kuruma prawns, prices have remained depressed, although this probably now has more to do with the state of the Japanese economy.

The continued growth in kuruma prawn production, and live export trade, is claimed to be directly linked to in-transit survival and increased production, possibly through the use of more northern Queensland production sites where higher ambient temperatures promote rapid prawn growth. With respect to in-transit survival it is suggested that prices decline if in-transit mortality is greater than 5%. Following the loss in market confidence in the quality of Australian kuruma prawns, a meeting of kuruma prawn farmers in early 1996 agreed on the need for Australian producers to be technically advanced and identified on a country basis as a supplier of quality produce.

In response to concerns about the need to ensure consistent in-transit survival and re-establish market confidence, and to the question of whether northern Queensland sites could be successfully used for kuruma prawn production, IFIQ proposed the research project with the objectives outlined above.

3.3 Research Findings

There are essentially two components to the research. The first is to develop and test an improved package for the airfreight of kuruma prawns. Second is an examination of whether kuruma prawns can be successfully produced and exported, or send south for climatic agistment, from northern Queensland farms.

Development of an improved live prawn package design

In contrast to the packaging currently used in the industry that comprises a cardboard outer carton lined with seven separate sheets of polystyrene, the new packaging is a single polystyrene unit. It is compact, has superior insulation, greater capacity for coolant adjustments, and is readily identifiable (being both different in nature and coloured blue).

The testing program focused on monitoring temperature changes for various modifications to the prototype package. To test the final prototype, in terms of the effects on prawn survival, five shipments of prawns were dispatched to Japanese markets.

The final prototype was found to have a number of advantages over existing packaging. It can be split into two 3kg units (with suggested marketing advantages), the thermal properties of the package were improved (presumably improving quality and survival) and the general aesthetics of the package were improved (enhancing market acceptability). It was shown to be possible, by adjusting coolants in the package, to compensate for changes in environmental conditions in Japan and Australia, due to seasonal differences between the countries (presumably improving quality and survival).

Determine upper lethal temperature limit for Kuruma prawns

The aim of this part of the study was to determine whether temperatures equivalent to those experienced in ponds located in northern Queensland affected Kuruma prawn survival. The first step was to determine the upper lethal growout temperature. To do this, kuruma prawns were maintained in laboratory scale tanks and subjected to experimental temperatures of 28°C to 36°C over a four week period.

The study found that, using a laboratory scale system, mortality did not increase significantly until temperatures exceeded 32°C. However, for a number of reasons, the report suggests that temperatures greater than 28°C may cause difficulties. "It is a common experience that Kuruma prawns harvested from ponds in southern Queensland under high temperature conditions (pond temperatures over 27°C) exhibit higher mortalities during live transport than prawns taken from 23°C ponds." The study also found that the breakdown of moult synchronisation as a result of increasing pond temperatures (above 28°C) may have a major bearing on high levels of mortality.

These results cast considerable doubt about the feasibility of producing kuruma prawns in northern Queensland sites where pond temperatures consistently exceed 28^{0}C during the summer months.

Determine if modifications to preparation and packing can improve the survival rate with respect to high ambient temperature growout conditions

The second step in determining the acceptability of northern Queensland ponds was to examine the potential to modify preparation and packing methods to improve survival from high ambient growout temperature conditions.

The analysis showed a significant decline in post-packing survival as pond temperatures increase from ambient 20°C to 31°C. Survival rates for 20°C and 31°C were 83% and 61%, respectively, on unpacking after 36 hours in dry storage. In an attempt to increase survivability at high ambient temperatures, three preparation and packing modifications were examined. All were thought to be unsuccessful.

Determine the feasibility of transporting live kuruma prawns from one location to another to optimise growout and survival

As an option to increasing in-transit survival of kuruma prawns from warmer climatic conditions, experiments were undertaken to determine the feasibility of transporting prawns in bulk to alternative sites in cooler areas for optimum growout and "conditioning" prior to export.

Even without control of water temperature or quality, the transport trials, involving 12 hour shipments of kuruma prawns, resulted in 100% survival for all treatments studied. This indicated the technical feasibility of moving the prawns from northern to southern locations for climatic agistment.

3.4 Research recommendations

These "recommendations" are implied from the stated research benefits.

- That the new package be used to commercially airfreight kuruma prawns.
- That year-round production and export from northern Queensland farms is infeasible due to the effects of high ambient pond temperatures on prawn in-transit mortality.
- That production of kuruma prawns in northern Queensland sites during the cooler months, followed by climatic agistment in more southerly sites, is considered for commercial trials.

3.5 Cost Benefit Analysis

FRDC expenditure: $33,750
Total research cost: $194,750

3.5.1 Potential benefits

The new packaging, if used by farmers, could potentially generate benefits to farmers in two ways: in the form of higher profits from increased prices resulting from lower in-transit prawn mortality and growth of market confidence; and through higher wages to farm workers from a prolonged harvesting season. The latter potential benefit would result from farmers being able to take advantage of the improved thermal properties of the packaging to lower in-transit mortality to acceptable levels late in the harvesting season when the ambient temperature difference between Queensland and Japan is greatest.

Re-estabishing Australian kuruma prawns, as a consistently high quality product in the Japanese market appears to be a central underpinning of the project. Along these lines, it is stated in the report that "the Australian product needs to be identifiable as superior and reliable", and that "a technically advanced, universally adopted package which helps guarantee in-transit temperature stability will have a major influence in insuring a stable market position for Australian producers". It was also suggested that the smaller pack size (6kg or 8kg instead of 10kg) would allow access to a greater range of buyers, with the prospect of price increases.

Another potential benefit of the new packaging is through the scope it provides for extending the length of the harvesting season in Australia to take advantage of the higher prices on the Japanese market during the northern summer months. At present, Australian harvests and exports commence around the end of April and continue through to the end of June. Export prices tend to be relatively low at the start of the season and increase toward the season end. Towards the end of the season, cooler harvesting conditions in Queensland coupled with the higher ambient temperatures in Japan often result in relatively high levels of in-transit prawn mortality. Researchers suggested that in-transit prawn mortality of 20-30% was not uncommon at this time. It was suggested that the improved thermal properties of the new packaging should be able to counteract the effects of the international temperature difference and allow the harvesting season to be extended, with farmers benefiting from increased prices.

With respect to the research on the feasibility of kuruma prawn production in northern Queensland, the potential benefits of the research are somewhat long term in nature. First, commercial trials would have to be carried out of growing kuruma prawns in the cooler months in northern Queensland, followed by climatic agistment in southern Queensland and export. If these trials indicated that the practice is economically viable, and if followed by industrial development in northern Queensland, benefits would be generated in the form of profits of the new enterprises and in wages paid to workers.

extra cost of box disposal), it is apparent that their reaction is a strong disincentive for these particular farmers to use the new box.

Although some farmers have apparently attempted to extend the harvesting season to take advantage of higher end of season prices, such trials have been based on the use of current packaging.

3.5.1.2 Costs

The total cost of the research amounted to $194,750, of which FRDC contributed $33,750. As there have been only trial shipments of kuruma prawns using the new box, additional costs are negligible.

3.5.1.3 Net benefits

The estimated net benefits of the project are negative. The lack of benefit is in some ways not surprising, as there does not appear to have been a compelling reason to undertake the box development work in the first place.

It is, however, worthwhile to note that the initial results on the technical prospects for climatic agistment of kuruma prawns grown in northern Queensland might form the basis for future industrial development.

4. Project No: 94/128 "Assessment of the Impact of Environmental Factors and New Technology on the Northern Prawn Fishery"

Research Agency: **CSIRO Division of Fisheries, Cleveland.**

FRDC program: **Ecosystem protection / resource sustainability**

4.1 Objectives

- To identify and quantify possible environmental factors (from meteorological records and satellite-derived data) that might explain the year-to-year variation in catches of the two species of tiger prawn in the NPF.
- To estimate the impact that GPS has had on the effectiveness of fishing effort in the NPF.

4.2 Background

There has been a great deal of speculation about whether tiger prawns in the NPF are over-fished. Two issues that create uncertainty about the current status of stocks relate to environmental factors and the measurement of fishing effort. For example, changes in the environment (such as rainfall) can impact on prawn availability and abundance.

With respect to fishing effort, growing use of global positioning systems (GPS) and plotters can in turn enhance the ability of the fleet to locate and catch prawns. Changes in catch per unit of effort are used as a measure of stock abundance in the NPF. In essence, if vessels are catching more per day than in the past, this is assumed to be an indication that prawn abundance is higher. There are a number of difficulties with using catch per unit of effort (CPUE) as an abundance indicator. For example, if *measured* fishing effort is constant or increasing at a slower rate than *actual* fishing effort, while at the same time catches are increasing, CPUE may falsely indicate that prawn abundance is increasing. Therefore, it is important to obtain a measure of effective fishing effort which is, of course, influenced by the use of new technologies such as GPS and plotters.

Since the NPF is managed using input controls, whereby harvest levels are constrained through area and seasonal closures, and restrictions on gear usage and number and size of vessels, increases in fishing effort are, from a management perspective, undesirable and contrary to AFMA's economic efficiency objective. Therefore, information on changes in the level of effective fishing effort are useful to AFMA in meeting this objective.

4.3 Research Findings

- No environmental factors were identified that explain the inter-annual variation in catches of the two species of tiger prawn throughout the NPF. There were, however, significant correlation between recruitment indices and environmental factors in some regions of the NPF for both species of tiger prawns.

- The GPS and plotter system increased the effectiveness of fishing effort in the NPF by 12% after three years of use.

4.4 Research Recommendations

- That a review of the fishing power of NPF vessels be conducted on a regular basis.
- That nominal effort continues to be adjusted by the rate of annual change in fishing power in all future stock assessments.
- That the assumed rate of increase in fishing power remains at 5% per annum.
- That further research is conducted on environmental effects on tiger prawn recruitment by combining the effects of fishing effort in the analysis.

4.5 Cost Benefit Analysis

FRDC expenditure: $67,237
Total research cost: $171,251

4.5.1 Potential benefits

Transforming nominal (measured) fishing effort into effective fishing effort is essential for stock assessment in the NPF. In fact, the results of this transformation essentially "drive" the whole stock assessment model. Specifically, the fact that tiger prawn stocks are thought to be over-exploited is linked directly to increases in effective fishing effort, as nominal fishing effort has been static or declining over recent years.

Given the estimated growth of effective effort of 5% per year (from this research), it is estimated that the fishing mortality on tiger prawn stocks will, by 1999, be 25% higher than the target level that should permit the maximum sustainable yield from the tiger prawn fishery. (While the 5% figure was used in previous stock assessments, it was argued that industry support for continued use of this assumption was wavering until the results of this research were made available.) So, one potential benefit from the research is the economic benefit flowing from increased tiger prawn catches, if effective effort were to be reduced to the target level allowing the tiger prawn stocks to rebuild. It is estimated that total tiger prawn catch could increase by around 4% compared to the current level in the medium term. At 1996-97 average prices, this would result in an increase in fishery revenue (and profit) of around $2.4 million per year.

Potentially, this is a substantial under-estimate of the benefits of an effort reduction programme in the fishery. This is because the estimate is based only on changes in the total revenue stream from fishing due to an increase in prawn abundance, and does not include the cost savings resulting from a lower level of fishing effort. Specifically, if the number of vessels were to be reduced, or if vessels were to fish less intensively, total fishing costs should fall. Such cost reductions would add to the economic benefits of the research.

4.5.2 Realisation of benefits

In 1999, AFMA intends to implement an effort reduction programme in the NPF, based on the results of the current assessment of the tiger prawn stocks. Discussions with stock assessment scientists and the AFMA Manager of the fishery indicate that the results of this research project were pivotal in assisting AFMA gain industry agreement to the effort reduction programme. Until this research was concluded, industry could not agree on the extent to which effective effort was increasing. Although a previous estimate of effective effort growth, based on data from 1979 to 1986, had indicated a rate of 5% per year, the introduction in the late 1980's of more constraining fishery management measures prompted industry to question the current relevance of this earlier estimate.

As a major effort reduction programme was concluded in the fishery only five years ago, fishers were naturally reluctant to commit to another expensive and disruptive effort reduction. Firming up the estimate of the increase in effective effort gave industry greater confidence in the value of the proposed programme and enabled AFMA to gain their agreement. According to the AFMA Manager and the principal stock assessment scientist, in the absence of the research results, the process of gaining industry confidence in, and agreement to, the proposed effort reduction programme would probably have taken at least one more year. Therefore, it is assumed that the benefits of implementing the effort reduction programme one year earlier than otherwise, are attributable to the research.

As noted above, there are potentially two types of benefits that may be derived from the effort reduction progamme. The first is from increased income resulting from higher catches as the rate of fishing mortality on the stocks is reduced to the target level. The second is through reductions in the total costs of fishing.

Under the current and proposed management arrangements for the fishery, it is unlikely that the stock will get the opportunity to rebuild and deliver higher annual catches. This is because effective fishing effort will keep increasing, following the implementation of the effort reduction programme. The AFMA Manager estimates that in the short term, an increase of 5% per year is likely to be maintained. Operators will be able to intensify their fishing effort by towing their gear faster (particularly as the amount of gear per vessel has been reduced and the limit on engine size removed) and by spending slightly more time at sea (there is scope for operators to increase their fishing time by an average of around 5% per year). The probable outcome is that the rate of fishing mortality on tiger prawn stocks will grow quickly back to current levels before stocks can rebuild. Consequently, no increases in catches and, hence, revenues are included in this study as research benefits.

However, economic benefits are likely to arise from the reduction in fishing effort. This is because while fishing costs are likely to fall, revenue probably will not as it is estimated that the proposed effort reduction (12.5%) will have no impact on the size of prawn catches (D. Die, personal communication). That is, the same catch could probably be taken with the lower level of effort.

The scale of reductions in the total costs of fishing will depend on the response of the fishing industry to the effort reduction programme. If fishers respond by consolidating their holdings of gear units through purchases from other fishers (the reduction involves a change from A units to gear units and a 10% reduction in the total number of gear units, as well as some additional seasonal closures), it is likely that a number of vessels will leave the fishery. Already, some vessels have been "bought out" of the fishery and it likely that more will exit before the start of the 1999 season. The AFMA Manager indicates that at least three vessels are likely to leave the fishery prior to 1999, and that three or more vessels will probably leave over the following two years.

Although the departure of these vessels from the NPF would result in a reduction in both the levels of fixed and variable costs in the fishery, there are unlikely to be real savings in fixed costs (unless the vessels are sold overseas or scrapped). As most Australian fisheries are over-capitalised, the opportunity costs of most vessels is close to zero. That is, their redeployment in another fishery is unlikely to increase overall productivity from the resource, so there is no industry-wide benefit from so doing. Therefore, only savings in variable costs will be considered in this assessment.

The variable cost savings are simply the products of the variable costs per vessel in 1996-97, as estimated by ABARE, and the number of vessels which leave the fishery. However, this saving is offset by the additional costs of increasing fishing effort amongst the smaller fleet. As before, effective effort is assumed to rise at 5% per year, increasing some variable cost factors. Specifically, fuel usage is assumed to increase by 5% per year and repairs and maintenance by 2.5%.

As shown in Table 1, the reductions in variable costs resulting from the exit of six vessels results initially in significant increases in fleet profitability. However, these gains are rapidly dissipated by the steady rise in variable costs associated with the growth of fishing effort. Over a five year period, the fishery ends up less profitable than it started in 1998.

However, in the absence of the research, fleet profitability would have been lower still. As shown in Table 2, delaying the implementation of the effort reduction programme for one year (as a result of more protracted negotiations with industry) would have eliminated any prospect of real cost savings compared to the 1997-98 level. This is because the rise in effort in the intervening year more than offsets the cost reductions due to vessels leaving the fishery. Therefore, the estimated economic benefit of the research project is estimated as the difference between the discounted streams of fishery profits under an effort reduction programme commencing in 1999 and 2000, respectively.

4.5.3 Costs

The total cost of the research was $171,251, of which the FRDC contributed $67,237. There are also costs associated with implementing the effort reduction programme. These relate to additional NORMAC meetings and consultancies amounting to $91,000 over two years for the 1999 effort reduction programme. Delaying the programme one year is assumed to result in additional negotiation expenses of $22,000.

4.5.4 Net benefits

Implementing the effort reduction programme one year earlier than might otherwise have been possible is estimated to result in substantial improvements in industry profitability. Summary statistics are given in Table 3.

Table 3: Summary of research costs and benefits for "Assessment of the impact of environmental factors and new technology on the northern prawn fishery"

Summary results

NPV of research benefits	$3,267,000
Gains from FRDC investment	$1,282,700
Benefit/cost ratio	19:1

Specifically, discounted economic benefits in excess of $3 million are estimated over the seven year period following the completion of the research. Nearly $1.3 million of these gains are attributable to the FRDC investment. This is equivalent to a benefit/cost ratio of 19:1.

Table 1: Estimated changes in economic returns in the NPF with the research

Year	1995	1996	1997	1998	1999	2000	2001	2002
No. of vessels			127	127	124	122	121	121
Revenue[1]			130,000,000	130,000,000	130,000,000	130,000,000	130,000,000	130,000,000
Total costs			95,097,600	95,097,600	94,176,450	94,026,480	94,681,399	96,178,429
Fleet "profit"			34,902,400	34,902,400	35,823,550	35,973,520	35,318,601	33,821,571
Fleet gains			0	0	921,150	1,071,120	416,201	-1,080,829
Research costs	87,351	83,900						
Implementation costs			69,000	22,000				
Net economic gains	-87,351	-83,900	-69,000	-22,000	921,150	1,071,120	416,201	-1,080,829
NPV of research benefits	991,082							

Table 2: Estimated changes in economic returns to the NPF in the absence of research

Year	1995	1996	1997	1998	1999	2000	2001	2002
No. of vessels			127	127	127	124	122	121
Revenue			130,000,000	130,000,000	130,000,000	130,000,000	130,000,000	130,000,000
Total costs			95,097,600	95,097,600	96,454,913	95,567,897	95,463,890	96,178,429
Fleet "profit"			34,902,400	34,902,400	33,545,088	34,432,103	34,536,110	33,821,571
Fleet gains			0	0	-1,357,313	-470,297	-366,290	-1,080,829
Research costs	87,351	83,900						
Implementation costs			69,000	22,000	22,000			
Economic gains	-87,351	-83,900	-69,000	-22,000	-1,379,313	-470,297	-366,290	-1,080,829
NPV of research benefits	-2,275,963							

1. Revenues are assumed to be unaffected by the adjustment program.