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Fisheries Economics, Research and Management Pty. Ltd.

EX-POST BENEFIT/COST ANALYSIS

PROJECT No. 93/180

Development of by-catch reducing prawn trawl and fishing practices in NSW prawn trawl fisheries (incorporating an assessment of the effect of increasing mesh size in fish trawl gear)

Prepared for the FRDC

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Research Agency: **NSW Fisheries, Fisheries Research Institute**

FRDC Sub-programme: **Effects of Trawling**

1 RESEARCH OBJECTIVES

- To develop and test a variety of modified prawn trawl gears and fishing practices which maintain catches of prawns at those levels caught by conventional methods but exclude the unwanted by-catch of juvenile fish;

- To determine the most appropriate design(s) of these gears and practice for each of NSWs' estuarine and oceanic prawn-trawl fisheries, recommend their implementation and assist fisheries managers in this implementation.

- To investigate the impact on catches and by-catch due to increasing mesh size in fish trawls from 90mm to 100mm.

2 Background

The prawn fisheries of NSW are the highest value capture fisheries in the state. The fishery is divided into two sectors: the estuarine and the oceanic fisheries. Average reported landings of prawns in these two fisheries over the past 5 years have been around 1,800 tonnes per annum, worth around $15 million. Of this production, landings from oceanic waters contribute around 55% by weight and over 80% by value. There are 262 licences in the oceanic fishery and 312 licences in the estuarine fishery.

In the 1980s, there were concerns that prawn trawlers in both the oceanic and estuarine fisheries were discarding high levels of by-catch, including juveniles of species targeted in other commercial and recreational fisheries. This became a source of conflict within the commercial fishing industry and between commercial and recreational fishers. In response to a need to determine the quantity and species composition of this by-catch, FRDC funded a three year observer study (project no. 88/108), implemented by NSW Fisheries. The study quantified large by-catches of juveniles of commercially and recreationally important species throughout NSWs' estuarine and oceanic prawn trawl fisheries. Key species, regions and times involved in interactions with other commercial and recreational fisheries were identified.

The information generated from this project provided the impetus for a subsequent three year research project to explore methods to reduce these large by-catches (i.e. the project under review), with the objectives described in the preceding section. The main focus of this research was the development of trawl gear modifications and fishing practices to reduce the capture and mortality of finfish by-catch. FRDC also requested that the project study the effects of increasing mesh size in fish trawls.

3 Research Findings

3.1 By-catch reduction devices

Chartered vessels were used to carry out paired comparisons of a conventional net with a modified trawl containing a by-catch reduction device (BRD). In the estuarine prawn trawl fishery, separator-panels that partitioned the catch were found to be the most effective means of reducing by-catch. The effectiveness of different types of separator panels varied according to the location of the fishery (see Table 1). In the oceanic prawn fishery, the use of a composite square mesh panel reduced total by-catch but had no significant effect on prawn catches or by-product (fish that can be sold). Also, a delay of 15 seconds between ceasing to tow and hauling the trawl net allowed large numbers of red spot whiting to escape from the net.

Table 1 Summary of BRD Trials

Location	Gear type	Most effective BRD	Effect on prawn catches	Effect on by catches
ESTUARINE				
Clarence River	Paired tows	Nordmore Grid	No effect	90% reduction
Hawkesbury River	Trouser trawl	Square mesh panel	No effect	49% juvenile mulloway
Hawkesbury River	Alternate trawl	Half square mesh codend	No effect	46% juvenile mulloway
Botany Bay	Alternate haul	100mm and 150mm separator panels	35% reduction in king prawns	58% reduction in by-catch
Hunter River	Paired tows	Nordmore grid with secondary designs	No effect	45-58% reduction
OCEANIC				
Yamba	Paired tows	Long square meshed panel plus haulback delay	No effect	No effect on by-product i.e. fish that can be sold 40% reduction in by-catch
Iluka	Paired tows	Composite square mesh with 100 – 200mm mesh codends	No effect	No effect on by-product. 40% reduction in by-catch
Port Stephens, SW Rocks, Yamba, Ballina	Paired tows	100 mm net	5-14% increase in prawns	32%-41% decrease in total by-catch

3.2 *Damage and mortality of escaping fish*

Laboratory experiments were undertaken to study fish escaping from BRDs. The experiments were carried out with juvenile yellowfin bream, mulloway and whiting using a simulated escape through the guiding panel of a Nordmore grid and square mesh panels. The results showed no negligible damage (less than 4% scale loss) and negligible mortalities compared to the control fish.

3.3 Increasing mesh size in the fish trawl fishery

A study was also carried out on the impact on by-catch of increasing the mesh size of fish trawls (i.e. not prawn trawls) from 90mm to 100mm. Catches of finfish were compared with catches from a conventional fish trawl with a 90mm mesh in the body and codend. Although the 100mm net reduced by-catches of under-size fish (e.g. tiger flathead, rubberlip morwong and cuttlefish) by approximately 50%, it also reduced the catch of retainable individuals by approximately 30% making any increase in mesh size for this fishery quite costly in terms of landings. Increasing the mesh size also increased the catch of john dory at the site where these fish occurred in large numbers. The size frequencies of one of the most common species (tiger flathead) showed that the ranges of sizes retained in both nets were similar, suggesting that these fish have a wide range of selectivity. The study concluded that there was a need for comprehensive selectivity experiments and behavioural observations to determine the most effective trawl designs for this fishery.

4 Benefit/Cost Analysis

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 a simplified explanation, producer's surplus can be thought of as additional profits generated. In addition, 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 product supply that in turn results in a decrease 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 simple terms, to undertake the benefit/cost analysis, it is necessary to estimate all economic benefits that flow from the research findings. Benefits are then compared to the financial cost of research, plus any economic costs that are required to capture the benefits.

4.1 Costs

The total project cost was $745,321 of which FRDC contributed 73%. However, a previous project 88/108 should also be included in project costs, as the information generated by this project was a foundation for the project under review. This project, "Observer-based Survey of By-Catch from Prawn Trawling in New South Wales" had a total cost of $496,376, The breakdown of this between FRDC and NSW Fisheries is not known. It has therefore been assumed that FRDC contributed the same proportion to total project costs as to the subsequent project, equal to $362,355 or 73% of project costs. It is also assumed that payments were evenly spread over the three years, 1990-1992. A summary of total project costs is shown in Table 2.

Table 2 Summary of Project Costs

Project Number	Total	FRDC Contribution
88/108	$ 496,376	$ 362,355
93/180	$ 745,321	$ 543,983
TOTAL	**$1,241,697**	**$ 906,338**

Some costs were incurred by the prawn fishers in modifying their trawl nets. These have been estimated to be around $100 per vessel.

4.2 Potential Benefits

Potential benefits of the use of BRDs in the oceanic and estuarine fisheries include: improvements in prawn product quality; the value of escaped by-catch; fuel savings; higher prawn catches; lower labour costs; increases in consumer well-being stemming from reductions in the market prices of prawns or improvements in quality; and improvements in recreational fishing catch rates.

Improvements in product quality

Improvements in product quality may occur, as prawns in the codend will be less subject to bruising from the weight of unwanted by-catch. These improvements in quality may be translated into a price premium, with economic benefits to fishers.

Value of Escaped By-catch

The results of the project, together with information provided by fishers, indicate that the use of BRDs has resulted in a substantial reduction in by-catches of a range of commercially and recreationally important species. Discards of commercially important species are dominated by stout whiting, snapper, red spot whiting, cuttlefish, smooth bugs and eastern blue spot flathead. There are clearly ecological, as well as economic, potential benefits from by-catch reductions of commercial and recreational species (and non-commercial species). Although such ecological benefits are intangible, their potential significance should not be overlooked. The potential economic benefits of reductions in the bycatch of juvenile fish may also be substantial if these fish are then recruited into the commercial fishery.

Savings in fuel consumption

The use of BRDs may reduce fuel consumption if there is less drag on the net because of lesser quantities of fish in the codend.

Savings in Labour Costs

The reduction in time to sort prawns and by-catch could potentially reduce labour costs if less crew are required on board the vessel.

Increased prawn catches

The research showed that prawn catches increased by 5-14% in some of the oceanic trawls. Therefore a potential benefit of the use of BRDs would be to increase prawn catches throughout the oceanic fishery.

Consumer surplus

As mentioned earlier, consumer surplus is a measure of net economic benefits to consumers. If price of prawns decreases then consumer surplus is increased and vice versa. If product quality increases or choice of products widens then this also provides benefits to consumers. Potential benefits of the project could also be an increase in consumer surplus.

Improvements in recreational catch rates

The reduction in by-catch of recreational species (e.g. snapper, eastern blue spot flathead, mulloway and whiting) in both the oceanic and estuarine fishery through the use of BRDs may have a positive impact on catch rates in the recreational sector. An improvement in the quality of recreational fishing experiences represents an economic benefit from the research.

Another potential benefit from reduced prawn by-catches is a reduction in tension between the recreational and estuarine prawn sectors as recreational fishers become aware that the commercial sector is operating with BRDs.

4.3 Realisation of benefits

As a result of the research project, many fishers in the estuarine and oceanic prawn fisheries voluntarily trialed and adopted BRDs in their normal fishing operations. In July 1999, NSW Fisheries introduced regulations that made BRDs mandatory in the ocean prawn trawl fishery and in the Botany Bay and Port Jackson estuarine fisheries. The introduction of this measure in 1999 is also attributable to the project.

In the oceanic fishery, fishers are required to use one of three designs: a square mesh panel, a Nordmore Grid or a Soft By-catch Reduction Device (or blubber chute), although the mesh size of the BRD is 50mm - lower than the 85mm mesh recommended by the project. Also, the minimum size of the panel is smaller than the BRDs used in the trials. NSW Fisheries has adopted this minimalist approach to "ease" fishers into the concept of using BRDs. However, an estimated 90% of oceanic prawn fishers are using BRDs with larger mesh sizes (75mm) and larger panels than the prescribed minimum. The adoption of BRDs in the three other estuaries (Clarence, Hunter and Hawkesbury) is not mandatory but there are plans for this in draft management plans, and is anticipated that BRDs will become mandatory in these fisheries by 2001.

In estimating benefits of BRDs that are attributable to the project, an important question is whether BRDs would have been introduced if the project had not been undertaken. And, if so, when? Clearly, if the use of BRDs had become mandatory in

NSW fisheries in 1999 irrespective of the research, then the research would have been of little or no value.

Trends in the management of Australian and other international prawn fisheries indicate that BRD introduction would have occurred sooner or later. However, it is reasonable to assume that the project has speeded up the implementation of BRDs in NSW fisheries by a number of years. The trials and extension work carried out under the project have improved fisher awareness of by-catch issues and their acceptance of the use of BRDs. Therefore, in estimating the benefits directly attributable to the project, it is assumed that BRDs would have become mandatory in the fishery by 2004/2005, if the project was not carried out. Therefore, benefits directly attributed to the project cease after 2005, although benefits from the use of BRDs obviously continue beyond this time. This analysis assumes adoption of BRDs is phased at the adoption rates as shown in Table 3.

Table 3: Adoption rates of BRDs used in the analysis

Year	**Oceanic fishery**	**Estuarine fishery**
1996/97	25%	0
1997/98	50%	30%
1998/99	80%	30%
1999/00	100%	40%
2000/01	100%	60%
2001/02 – 2004/05	100%	100%

Improvements in product quality

Fishers in both the oceanic and estuarine fisheries have reported that the use of BRDs improves the quality of prawn catches. However only fishers in the oceanic fishery and Port Jackson and Botany Bay estuarine fisheries report that a price premium is paid for better quality prawns. The premium is said to be approximately 7% or $1/kg at an average price of $15/kg. Not all of the premium is attributable to BRDs; some is attributed to a generally greater awareness amongst fishers of the need for improved product quality and, consequently, improved handling and sorting. In the other estuarine fisheries (Clarence, Hunter and Hawksebury Rivers), discussions with fishers indicate that there is no price premium for higher quality prawns as most product is sold locally, with price driven by seasonality of demand (e.g. school holidays) rather than quality.

Based on these discussions, it is therefore assumed that only half of the price premium (i.e.3.5%) is attributable to BRDs. This results in an estimated benefit to fishers of just under $540,000 per year, assuming that product quality has improved throughout the oceanic, Port Jackson and Botany Bay fisheries, and average annual landings in these fisheries remain at around 1025 tonnes.

Value of Escaped By-catch

The economic benefits of reductions in the bycatch of juvenile fish are difficult to estimate with any reasonable degree of accuracy as this requires, for each species, information on key population parameters such as growth rate, natural mortality rate and exploitation rate. This information is unavailable for most of the by-catch species. However, because of the likely significance of the economic benefits from by-catch reductions, some broad "ball-park" calculations of potential benefits from the use of BRDs for the oceanic prawn fleet have been attempted.

The observer-based survey carried out in the current project estimated that approximately 2,500 tonnes of commercially important species were discarded by approximately half the fleet over two years. This is equivalent to 2,500 tonnes of commercially important species by the whole fleet in one year, assuming that the four sampled ports were representative of all ports in NSW. BRDs reduce bycatch by 50% To estimate the contribution of this reduction, a coarse, aggregate approach has been adopted because of the lack of biological data on individual by-catch species and the multitude of species in the catch. This involves assigning average values for growth, natural mortality and exploitation rate across the by-catch savings as a whole. A wide range of values for each of these parameters was tested within a risk assessment model to account, in part, for the uncertainty surrounding these choices. Specifications for the parameters used are given in Table 4 below.

Benefits of by-catch reduction in the estuarine fishery are not possible to quantify, largely because fishers report that there is great variation in by-catch quantities and species in each of the estuarine fisheries, and in some estuaries (Clarence and Hawkesbury Rivers) little by-catch is caught when targeting prawns. The observer based programme collected data on by-catch rates in Botany Bay and Port Jackson and estimated that by-catch rates may vary between 34 tonnes per year in Port Jackson to 165 tonnes per year in Botany Bay. It was noted that these estimates should be treated with caution, especially as they were based on questionable estimates of fishing effort. Although there are clearly benefits from the use of BRDs in estuarine fisheries, quantification of these benefits has not been attempted.

Savings in fuel consumption

As detailed information on fuel consumption is not available, anecdotal evidence indicates that savings of around 250 litres per vessel per year could be expected in both the oceanic and estuarine fisheries for vessels using BRDs.

Savings in Labour Costs

In neither the oceanic or estuarine fisheries has there been a reduction in the number of crew employed despite a reduction in the amount of time required to sort prawns and by-catches. This is because the same number of crew is required for other activities. Nevertheless, the time saved in sorting has had other intangible benefits such as improved health and safety of crewmembers, due to, for example, less time spent on deck in rough weather and more time spent on watch.

Increased prawn catches

Operators who use BRDs in the ocean prawn and estuarine fisheries have observed that trawl shots can be of longer duration, as the net does not have to be cleared so frequently. As a result, prawn catches are sometimes higher. However, as there is probably effort saturation in these fully exploited fisheries, it is considered very unlikely that the use of BRDs will increase total catches.

Consumer surplus

The Australian market for prawns is segmented and, for the purposes of this study, can be considered as having a high quality segment and a lower quality segment.

Prawn fishers have stated that they receive a price premium for the higher quality prawns they produce when using BRDs. In effect, some prawns can be thought of as having been withdrawn from the lower quality end of the market and replaced by better quality prawns supplied to the higher end of the market. Whether this change has affected consumer surplus depends on whether there has been a noticeable alteration in the total supplies to each market segment and any consequential changes in prices paid by consumers.

At the lower quality end of the prawn market, if prices have increased as a result of a supply reduction, then there is a reduction in consumer surplus. However, if prices have gone down at the high quality end of the prawn market, as a result of an increase in supply of higher quality prawns, then there is an offsetting increase in consumer surplus. Whether there would be a net change in consumer surplus is an empirical issue that cannot be addressed due to lack of information on price elasticities of demand in each segment of the NSW prawn market. However, it seems likely that the net effect on consumer surplus would be marginal.

Improvements in recreational catch rates

These benefits, whilst potentially important, are extremely difficult to quantify and have not been attempted in this evaluation.

Tension between the recreational and estuarine prawn sectors as recreational fishers has been reduced as a result of the project extension campaign and the knowledge amongst recreational fishers that the commercial sector is operating with BRDs.

4.4 Analytical approach

To account for uncertainty in the biological and economic parameters used to estimate benefits of the project, a form of sensitivity analysis has been carried out that allows the values of eight important parameters to vary within certain bounds. These bounds are specified in Table 4. By varying these parameters within these bounds, probabilities of different outcomes can be estimated. This analysis produces no "base case" *per se*, but a range of probabilities on the value of economic benefits generated by the project.

Table 4 Parameter values used in the assessment

Parameter	Unit	Minimum	Most Likely	Maximum
Landings of prawns in the oceanic fishery	Tonnes	800	1,000	1,100
Average prawn prices in the oceanic fishery	$/tonne	13,000	15,000	17,000
Price premium attributed to the use of BRDs	% of average prawn price	0%	3.5%	5%
By-catch of the oceanic prawn fleet without BRDs	Tonnes	2,000	2,500	3,000
Reduction in bycatch from BRDs in the oceanic fleet	% of by-catch	20%	50%	60%
Natural mortality of escaping fish	%	10%		90%
Exploitation rate of escaping fish	% of the harvestable population	10%		50%
Average market price of escaping fish	$/tonne	1,800	2,500	3,500

4.5 Net Benefits

The discounted present values of research costs and estimated benefits are shown in Table 5 using three different discount rates. The mean net present value of economic benefits (after accounting for research costs) ranges from around $2.7 million using a discount rate of 6%, to $1.5 million at 10%. The associated benefit/cost ratios range from 5.8: 1 to 4.6:1.

Table 5: Estimated mean net present values of research benefits

Discount Rate	**6%**	**8%**	**10%**
NPV of net economic benefits	$ 2,707,000	$ 2,007,000	$1,500,000
Mean Benefit/cost ratio[1]	5.8	5.1	4.6

[1]Discounted benefits divided by discounted costs

For example, at a discount rate of 8% there is a 50% chance that the net present value of benefits is less than or equal to $2 m. This is shown in the cumulative probability plot presented as Figure 1. In addition to the mean net present values presented above, the cumulative probability plot provides additional information on the likelihood of the research generating other levels of net economic benefits. For example, there is a 20% probability that the net present value of estimated net benefits would be less than $0.46 million or more than $3.9 m.

It is clear from these figures, that even accounting for uncertainties in the biological and economic parameters, the combined projects are likely to have generated significant economic benefits. The main economic benefits arise from the improvement in prawn prices and the additional weight and value of fish catches as a consequence of by-catch reduction.

Figure 1: Estimated distribution of discounted net economic benefits from by-catch research, using an 8% discount rate