

Benefit-Cost Analysis for Proposed Juvenile Eel Recruitment Past Waterway Barriers

A Report prepared for the Department of Environment, Water,
Heritage and the Arts

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Executive Summary

This paper has investigated the costs and benefits associated with proposed juvenile eel recruitment past waterway barriers for the Queensland freshwater eel fishery through the use of the break-even analysis technique.

This technique has been preferred to a more traditional ex-ante benefit-cost analysis as a result of the paucity of information and data that could be adequately acquired. The break-even analysis defines the point where the increase in effort and productivity to the eel fishery is exactly equal to the total costs involved with implementing the recruitment project.

A *trap-and-transport* fish passage system was identified as the most appropriate method to facilitate juvenile eel recruitment upstream (in terms of efficient eel passage and cost effectiveness), and a simple spreadsheet model was developed to examine two possible scenarios concerning the design of the fish passage system.

The model was created to account for potential changes in some of the key variables that need to be estimated. These include the social discount rate, the price per kilo for adult eels, the average weight of adult eels and the mortality rate associated with the fish passage method adopted. Altering these figures (and even the costs figures) leads to varying levels for the point of break-even.

The first option examined was a fish passage system that had low capital costs but high labour costs over the length of the project. Based on the estimated figures for the variables used, a 10-year recruitment project had total costs that were calculated to be \$187 500. In order for break-even to be achieved, an extra 12 500 adult eels needs to be harvested in the fishery, which is an average of approximately 1 600 per year. This represents a yearly increase of Gross Value of Production (GVP) for the fishery of almost 11%. Furthermore, these figures are representative for only a single fish passage system. Often, river systems have multiple barriers to allow for eel migration, further compounding the levels of total cost and effort.

The second option examined was a scenario that had high capital costs but low labour costs for the project. Again using 10 years as the length of the project, total costs involved were determined to be \$270 250. For break-even to occur, just over 18 000 extra eels would need to be caught, which is equal to approximately 2 250 per year. This extra catch represents a total revenue increase in GVP of around 15% per year.

These particular scenarios are only two of a vast number of possibilities concerning the requirements for break-even for this specific project. Therefore, sensitivity analysis has also been briefly undertaken to demonstrate how altering the value of the major variables leads to separate overall cost and benefit totals.

Overall, this analysis suggests that, based on the current financial climate of the Queensland freshwater eel fishery, it is difficult to justify a trap-and-transport fish passage mechanism to facilitate juvenile eel recruitment upstream past waterway barriers as economically feasible. Further investigation into cheaper arrangements for this mechanism should be considered.

Introduction

During its assessment of the freshwater Queensland Eel Fishery in 2004, the Department of Environment, Water, Heritage and the Arts (DEWHA) made a range of recommendations to Queensland Primary Industries and Fisheries (QPIF) in order to address any perceived risks or uncertainties associated with the fishery. One of these recommendations was as follows:

“QPIF to conduct a cost-benefit analysis on methods to facilitate juvenile eel recruitment upstream past waterway barriers. If an appropriate mechanism is identified, QPIF to implement the mechanism and/or encourage relevant authorities to put in place measures to facilitate ongoing juvenile eel recruitment past waterway barriers.”

The method identified to facilitate juvenile eel recruitment upstream past waterway barriers was the construction of a *fishway*; more specifically, the development of an *elver pass* or *trap-and-transport* fish passage system.

Fishways are structures specifically designed to allow fish to pass barriers. An effective fishway should successfully transmit at least 95% of all fish species and individuals attempting to negotiate the barrier, and operate in at least 95% of the range of flow conditions experienced at the relevant site. A critical requirement of fishway design is that fish attempting to migrate must be able to find the fishway entrance and enter without delay. Then they need to be able to ascend through the fishway, exit in an area where they will not be swept back downstream, and continue with their upstream movement. These requirements usually need to be met over the full daily and seasonal cycles. Despite these characteristics, glass eels and elvers have not been recorded successfully migrating through current fishway designs due to the water velocities encountered. Therefore, a structure or system specific to the characteristics of juvenile eels is required for their upstream passage past waterway barriers.

Two different fish passage methods specific to juvenile eels were initially examined for the purpose of this project:

An *Elver pass* is generally a small-diameter pipe or channel lined with some material such as coarse brushes, which provide migrating juvenile eels with a damp, complex surface through which to wriggle. The juvenile eels are then required to crawl their way along the pass up the entire height of the barrier before descending into the upstream waters.

Trap-and-transport fish passage systems attract and trap fish below a barrier and then physically transport them over it. This transport past the barrier can be undertaken manually or via an automated system of pumps or in a hopper. The initial trapping is commonly done using a short section of “elver pass” for eels to climb up before entering a collection container where they are held until ready to be transported and released upstream.

Preliminary research and discussion with relevant authorities and leading eel passage experts indicated that the trap-and-transport fishway is significantly more effective than the elver pass in terms of successful eel recruitment, and will be the method further investigated for the subsequent analysis.

The processes involved with the implementation of a fish passage system are quite complex, and a number of important factors need to be taken into account. These include: i) the relative size of the whole stream system; (ii) the location of the barrier in the system relative to the migratory needs of local fish; (iii) whether threatened species are present; (iv) the amount of upstream habitat that would become accessible when a fishway is installed; (v) other artificial and natural barriers downstream of the site; (vi) the proportion of the whole catchment of the particular stream which lies upstream of the site; (vii) the frequency with which high flows create effective drown-out conditions at the site, so that head loss and velocity are minimal and fish can swim over the barrier; (viii) the barrier type and structure; (ix) whether there is an ineffective fishway on the barrier; (x) the likely cost of building a

fishway; (xi) the level of financial and other support for a fishway from landholders, local government, industry, community groups, etc.

Break-Even Analysis

While the previously-listed factors should all be taken into consideration, the one of most concern for this analysis is the likely cost of building a fish passage system, and the likely benefits that will result from its operation. Due to a lack of necessary information, it would be quite difficult to successfully complete a proper ex-ante benefit-cost analysis. However, there is enough data that can be obtained for the proposal to allow for a *break-even* analysis to be undertaken; in other words, working out what level of benefits need to be obtained to exactly equal the costs involved with establishing and implementing the trap-and-transport juvenile eel fish passage system.

In order to work out the overall costs of the projects, a number of variables need to be estimated. To begin with, the number of fish passage systems being built and the anticipated time length of the project need to be determined. From here, specific costs need to be calculated – this includes the fixed and ongoing capital costs associated with the construction and operation of the systems, as well as the ongoing labour costs over the length of the project. Furthermore, a social discount rate needs to be estimated that takes into account the interest accrued for future payments. For the purpose of this analysis, two different scenarios were explored – the first was a fish passage system that would have low capital costs but high labour costs, while the second was a fish passage system that would have high capital costs but low labour costs. This was done in order to determine which set-up might be more economically feasible, assuming both have similar recruitment rates.

Once overall costs have been determined, the benefits associated with this project need to be calculated, which will vary depending on the estimates used for a number of further variables. The major benefit that occurs from the creation of this fish passage system is the increase in total catch; in this case, the extra number of eels that can be harvested upstream. The break-even point will determine what number of extra eels needs to be harvested in order to exactly cover the costs of this project. However, in order to calculate this figure, fairly accurate estimates for the price per kilo for adult eels and the average weight of an adult eel are needed. From here, an estimate for the mortality rate of the eels using the fishway is required, as this will help determine the total number of eels that actually need to use the trap-and-transport passage system. Finally, it is important to remember that there will be a time lag before the eels can be caught, as they need a number of years to mature from juvenile eels through to mature size, and an estimate for this is also required.

A simple model has been created to help calculate the break-even levels for the two different scenarios associated with this particular project that determine economic feasibility. It has been specifically designed so that all that is required for the model to run is the information concerning number of fish passage systems and time length of project, as well as estimates of the major cost and benefit variables (obtained via the most appropriate and available sources). These include fixed and ongoing capital costs, labour costs, price per kilo of adult eels, average adult eel weight and fishway mortality rate. The model calculates the number of total eels that need to be caught over the full length of the project as well as the number of average eels that need to be harvested per year. It also estimates the total number of eels that need to use the trap-and-transport fish passage system, which varies proportionality with the mortality rate figure used. Furthermore, although total cost will be equal to total harvested value at break-even, the model also provides the average yearly harvest value that will be required by the fishery, assuming constant average price and weight figures over the course of the project. In real terms, it would be expected that the price per kilo value for adult eels would remain fairly consistent, as it is predominately an exported product with a clearly defined market. Sensitivity analysis has also been undertaken by altering the values of several key variables, and these results are given in Appendix 1.

Results

LOW CAPITAL - HIGH LABOUR

<i>Number of Fish passage systems</i>	1
<i>Length of Project (years)</i>	10
<i>Eel Growth Rate: Juvenile - Adult (years)</i>	2

COSTS (per year)

FIXED CAPITAL COSTS (eg - materials/equipment, consultancy)	30000
ONGOING COSTS (per year) (eg - repairs/maintenance, monitoring)	10000
LABOUR COSTS (per year) (eg - people, transport, etc)	5000
SOCIAL DISCOUNT RATE	0.05
FIRST-YEAR COST	45750
ONGOING YEARLY COST	15750
TOTAL COST	187500

BENEFITS (per year)

<i>Current GVP of Adult Eel Fishery</i>	220000
PRICE PER KILO OF ADULT EEL (\$/kilo)	15
AVERAGE WEIGHT OF EELS CAUGHT (kg)	1
NUMBERS OF EXTRA EELS HARVESTED	12500
NUMBERS OF ADDITIONAL EELS HARVESTED PER YEAR	1562.50
<i>Eel Mortality Rate</i>	0.25
NUMBER OF EELS THROUGH FISHWAY	16666.67
TOTAL HARVESTED VALUE	187500
TOTAL HARVESTED VALUE PER YEAR <i>(2 years less than actual project due to time-lag in eel growth)</i>	23437.5

HIGH CAPITAL - LOW LABOUR

<i>Number of Fish passage systems</i>	1
<i>Length of Project (years)</i>	10
<i>Eel Growth Rate: Juvenile - Adult (years)</i>	2

COSTS (per year)

FIXED CAPITAL COSTS * (eg - materials/equipment, consultancy)	55000
ONGOING COSTS * (per year) (eg - repairs/maintenance, monitoring)	20000
LABOUR COSTS * (per year) (eg - people, transport, etc)	500
SOCIAL DISCOUNT RATE	0.05
FIRST-YEAR COST	76525
ONGOING YEARLY COST	21525
TOTAL COST	270250

BENEFITS (per year)

<i>Current GVP of Adult Eel Fishery</i>	220000
PRICE PER KILO OF ADULT EEL (\$/kilo)	10
AVERAGE WEIGHT OF EELS CAUGHT (kg)	1
NUMBERS OF EXTRA EELS HARVESTED	18016.67
NUMBERS OF ADDITIONAL EELS HARVESTED PER YEAR	2252.1
<i>Eel Mortality Rate</i>	0.25
NUMBER OF EELS THROUGH FISHWAY	24022.22
TOTAL HARVESTED VALUE	270250
TOTAL HARVESTED VALUE PER YEAR <i>(2 years less than actual project due to time-lag in eel growth)</i>	33781.25

Discussion

These results highlight just one of many break-even scenarios that could occur through the implementation of an eel trap-and-transport fish passage system, and other hypothetical scenarios can obviously occur depending on the values that are used for the different variables.

For both models, it was decided that the creation of only one fish passage system would be examined, and the project would last for a period of 10 years. Biological data suggests that juvenile eels take two years to reach adult maturity, meaning that only eight years were available for the adult eels to be harvested. The social discount rate was set at a constant rate of 5% over the course of the project, a figure deemed reasonable given the current financial climate. Data coming out of the fishery from relevant suppliers indicates that eels are valued at approximately \$15 per kilo, and limited biological data suggests that the average weight of an adult eel can be estimated at roughly 1kg. However, it is important to remember that the values for these variables can be readily altered in the model, which would subsequently affect the final break-even level (see Appendix 1 for examples).

For the **low capital – high labour** model, the fixed capital cost of \$30 000 is a combination of engineer consultancy costs, the construction materials for the trap-and-transport fish passage system, and a proportion for the truck that would be used in the transport of the eels upstream. The ongoing costs of \$10 000 per year reflect the standard running cost associated with the fish passage system, as well as any maintenance and repairs and also any necessary monitoring costs. The labour costs of \$5 000 per year consist of the costs for a person to manually transport the trapped eels further upstream, via the use of the previously mentioned truck. It also factors into the equation any travel costs over the course of the year. Combining these figures and applying the social discount rate gives the project a total cost of \$187 500. Based on the average price per kilo and weight figures used for adult eels, the model has calculated that break-even will occur when 12 500 extra eels are harvested in the fishery, which equates to 1563 eels per year over the length of the project. Furthermore, based on a mortality rate of 25%, it means the total number of extra eels that need to access the trap-and-transport system is 16 667. Although total costs equal total benefits at break-even, the total extra harvested value per year is equal to \$23 438, and since the Queensland adult eel fishery currently has a GVP value of \$220 000, this represents a total revenue increase of 10.7% per year for the length of the project.

For the **high capital – low labour** model, the fixed capital cost of \$55 000 is a combination of engineer consultancy costs and the construction materials for the trap-and-transport fish passage system, including an automatic lift system that would not be a part of the other fish passage system described. The ongoing costs of \$20 000 per year reflect the standard running cost associated with the system, as well as a higher level of maintenance and repairs and also the necessary monitoring costs. The labour costs of \$500 per year consist of the minor costs for a person to occasionally be on-site to ensure the trap-and-transport device is functioning correctly. Combining these figures and applying the social discount rate gives the project a total cost of \$270 250. Based on the average price per kilo and weight figures used for adult eels, the model has calculated that break-even will occur when 18 017 extra eels are harvested in the fishery, which equates to approximately 2252 eels per year over the length of the project. Furthermore, based on a mortality rate of 25%, it means the total number of extra eels that need to access the trap-and-transport system is around 24 022. The total extra harvested value per year is equal to \$33 781, and since the Queensland adult eel fishery currently has a GVP value of \$220 000, this represents a total revenue increase of 15.4% per year for the length of the project.

Conclusion

This analysis has attempted to demonstrate the complexities associated with the specific recommendation from DEWHA concerning proposed juvenile eel recruitment past waterway barriers. Undertaking a more in-depth benefit-cost analysis would require access to a wider and more accurate range of information and data. However, based on information that could be obtained from sufficiently adequate sources, a simple model was designed to calculate break-even levels for the creation and operation of a trap-and-transport fish passage system for juvenile eels in Queensland's freshwater eel fishery. The useful aspect of this model is the ability to simply alter the values of the major cost and benefit variables, thereby highlighting a number of different possible break-even scenarios.

Two separate trap-and-transport fish passage methods were explored – one that used a low amount of capital and a high amount of labour, and one that used a high level of capital but a low level of labour. Based on the figures used, it was demonstrated that the low capital – high labour option was more economically efficient. However, it is important to remember that this assumes that both fish passage methods would have identical recruitment and mortality rates. The calculated figures indicated that for the break-even situation to occur for the low capital – high labour model, the GVP of the freshwater eel fishery would have to increase by approximately 11% per year from its current GVP value over the full length of the project.

A GVP increase of 11% per year is rather high, and more importantly, only indicates the increase at which total costs for the project would be equal to total benefits, using the values for the variables highlighted in the model. In order for any real benefits to be identified and realised in the fishery, the yearly increase in GVP would have to be significantly higher than the level at which break-even occurs. Furthermore, the model has used fairly generous estimates for the social discount rate, average adult weight and mortality rate, and fairly cautious estimates for the capital and labour costs. Modifications to these figures in the model would certainly produce an even higher break-even scenario, with a higher level of harvested eels required for the project to be considered economically feasible.

Overall, despite employing a number of key assumptions and only a simple model, there is enough evidence to suggest that it would be difficult to justify the creation and implementation of trap-and-transport fish passage systems in the Queensland freshwater eel fishery to facilitate juvenile eel recruitment past waterway barriers. The number of eels that must use the fishway and subsequently be harvested is significantly large, and the model reflects a break-even situation where only one trap-and-transport system is utilised. If further systems were introduced into the fishery, it would require even further recruitment and harvesting before break-even could be approached.

Ultimately, identifying appropriate and economically feasible mechanisms for juvenile eel recruitment past waterway barriers in the Queensland freshwater eel fishery would require investigating cheaper alternatives and arrangements for trap-and-transport fish passage systems.

Appendix 1 – Sensitivity Analysis

- Altering Social Discount Rate, Average Weight of Eels and Eel Growth Rate

LOW CAPITAL - HIGH LABOUR

Number of Fish passage systems 1

Length of Project (years) 10

Eel Growth Rate: Juvenile - Adult (years) 3

COSTS (per year)

FIXED CAPITAL COSTS * 30000
(eg - materials/equipment, consultancy)

ONGOING COSTS * (per year) 10000
(eg - repairs/maintenance, monitoring)

LABOUR COSTS * (per year) 5000
(eg - people, transport, etc)

SOCIAL DISCOUNT RATE 0.08

FIRST-YEAR COST 46200

ONGOING YEARLY COST 16200

TOTAL COST 192000

BENEFITS(per year)

Current GVP of Adult Eel Fishery 220000

PRICE PER KILO OF ADULT EEL (\$/kilo) 10

AVERAGE WEIGHT OF EELS CAUGHT (kg) 1.5

NUMBERS OF EXTRA EELS HARVESTED 8533.33

NUMBERS OF ADDITIONAL EELS HARVESTED PER YEAR 1219.048

Eel Mortality Rate 0.25

NUMBER OF EELS THROUGH FISHWAY 11377.87

TOTAL HARVESTED VALUE 192000

TOTAL HARVESTED VALUE PER YEAR 27428.57

(x years less than actual project due to time-lag in eel growth)

HIGH CAPITAL - LOW LABOUR

Number of Fish
passage systems 1

Length of Project (years) 10

Eel Growth Rate: Juvenile - Adult (years) 3

COSTS (per year)

FIXED CAPITAL COSTS * 55000
(eg - materials/equipment, consultancy)

ONGOING COSTS * (per year) 20000
(eg - repairs/maintenance, monitoring)

LABOUR COSTS * (per year) 500
(eg - people, transport, etc)

SOCIAL DISCOUNT RATE 0.08

FIRST-YEAR COST 77140

ONGOING YEARLY COST 22140

TOTAL COST 276400

BENEFITS(per year)

Current GVP of Adult Eel Fishery 220000

PRICE PER KILO OF ADULT EEL
(\$/kilo) 10

AVERAGE WEIGHT OF EELS CAUGHT (kg) 1.5

NUMBERS OF EXTRA EELS HARVESTED 12284.44

**NUMBERS OF ADDITIONAL EELS HARVESTED
PER YEAR** 1754.921

Eel Mortality Rate 0.25

**NUMBER OF EELS THROUGH
FISHWAY** 16379.26

TOTAL HARVESTED VALUE 276400

TOTAL HARVESTED VALUE PER YEAR 39485.71

(x years less than actual project due to time-lag in eel growth)

- Altering Length of Project, Price per Kilo for Adults Eels and Fishway Mortality Rate

LOW CAPITAL - HIGH LABOUR

Number of Fish passage systems 1

Length of Project (years) 15

Eel Growth Rate: Juvenile - Adult (years) 2

COSTS (per year)

FIXED CAPITAL COSTS * 30000
(eg - materials/equipment, consultancy)

ONGOING COSTS * (per year) 10000
(eg - repairs/maintenance, monitoring)

LABOUR COSTS * (per year) 5000
(eg - people, transport, etc)

SOCIAL DISCOUNT RATE 0.05

FIRST-YEAR COST 45750

ONGOING YEARLY COST 15750

TOTAL COST 266250

BENEFITS(per year)

Current GVP of Adult Eel Fishery 220000

PRICE PER KILO OF ADULT EEL (\$/kilo) 12

AVERAGE WEIGHT OF EELS CAUGHT (kg) 1

NUMBERS OF EXTRA EELS HARVESTED 22187.5

NUMBERS OF ADDITIONAL EELS HARVESTED PER YEAR 1706.731

Eel Mortality Rate 0.1

NUMBER OF EELS THROUGH FISHWAY 24652.78

TOTAL HARVESTED VALUE 266250

TOTAL HARVESTED VALUE PER YEAR 20480.77
(x years less than actual project due to time-lag in eel growth)

HIGH CAPITAL - LOW LABOUR

<i>Number of Fish passage systems</i>	1
<i>Length of Project (years)</i>	15
<i>Eel Growth Rate: Juvenile - Adult (years)</i>	2
<u>COSTS (per year)</u>	
FIXED CAPITAL COSTS * (eg - materials/equipment, consultancy)	55000
ONGOING COSTS * (per year) (eg - repairs/maintenance, monitoring)	20000
LABOUR COSTS * (per year) (eg - people, transport, etc)	500
SOCIAL DISCOUNT RATE	0.05
FIRST-YEAR COST	76525
ONGOING YEARLY COST	21525
TOTAL COST	377875
<u>BENEFITS per year)</u>	
<i>Current GVP of Adult Eel Fishery</i>	220000
PRICE PER KILO OF ADULT EEL (\$/kilo)	12
AVERAGE WEIGHT OF EELS CAUGHT (kg)	1
NUMBERS OF EXTRA EELS HARVESTED	31489.58
NUMBERS OF ADDITIONAL EELS HARVESTED PER YEAR	2422.276
<i>Eel Mortality Rate</i>	0.1
NUMBER OF EELS THROUGH FISHWAY	34988.43
TOTAL HARVESTED VALUE	377875
TOTAL HARVESTED VALUE PER YEAR <i>(x years less than actual project due to time-lag in eel growth)</i>	29067.31

Information compiled by
Joshua Maroske

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