Empowering Industry R&D: Trials of gear modifications to reduce bycatch in freshwater fyke nets

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Empowering Industry R&D: Trials of gear modifications to reduce bycatch in freshwater fyke nets

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OBJECTIVES:

1. To trial modified fyke nets for effectiveness in reducing bycatch of protected wildlife
2. To communicate results to the community, industry and management
3. To establish and apply an industry code of practice based on 1 & 2

NON TECHNICAL SUMMARY:

OUTCOMES ACHIEVED TO DATE

A number of important outcomes were achieved from this project.

Fyke nets with modified codends were found to minimise the retention of some protected wildlife species, notably platypuses, while continuing to effectively catch eels. Platypuses were observed to escape within a short time of entering the modified nets, which is expected to reduce the stress of capture in these nets for this species. Other species, such as tortoises, although apparently unable to escape from the nets, remained alive in the nets until release. Fyke nets containing escape tubes were found to significantly reduce the incidental catch of small fish species, but the quantity of eel catch was also reduced.

The modified fyke nets can be used in locations where the incidental bycatch of protected wildlife may occur, such as in wildlife reserves, to improve the management of bycatch while still enabling commercial eel catches to be made.

Limitations to the gear trialled in this project include the restriction of use in shallow (about 1m depth) water, the bulky size of the nets restricts the number which can be used effectively by a single operator, and the ease with which modified nets can be cleared of catch requires improvement. Further refinement and development of this gear is required to improve the likelihood of uptake of the technology in the fishery.

The use of escape tubes in fyke nets will reduce the bycatch of small fish species, but will also permit escape of eels less than about 600g in weight. Such eels are generally less suitable for prime export markets or for processing as smoked product, and are normally retained for restocking into highly productive waters for further ongrowing. Thus escape tubes are likely to have application only in waters which are restocked, or may permit the development of commercial eel fishing in waters currently not fished for eels, but which may contain protected fish species.

Eel fishers are now better equipped to operate in areas where an increased likelihood of interaction with protected wildlife species may exist. The potential impact of fishery-wildlife interactions and community perceptions relating to bycatch in the fishery are now able to be improved by informing the public that fishers are addressing the issue through the selective use of modified gear under appropriate conditions.

The Victorian eel fishing industry has historically been proactive in the reduction of bycatch in the fishery, developing and utilising a range of bycatch reduction devices and practices over many years. Formal assessment of the ecological risks to bycatch species in the Victorian Eel Fishery has found the ecological risks associated with the eel fishery are low, and that current management is adequate to manage the level of risk posed by the industry. Furthermore, the fishery was granted the maximum (5 year) exemption from export controls following evaluation of the ecological sustainability of the fishery by the Department of Environment and Heritage (DEH) under the *Environment Protection and Biodiversity Conservation* (EPBC) *Act 1999*. However, the industry recognises that a degree of social unacceptability exists in relation to the bycatch of some species, notably protected fauna such as platypuses and water birds. Consequently, industry has further developed fishing equipment and modifications to existing fishing gear, specifically to reduce the risk of interaction with protected wildlife and other fauna in the fishery, and is now at a stage of trialling different gear types and further developing prototypes.

A number of bycatch reduction devices and practices are presently used routinely in the Victorian Eel Fishery. Examples include: (1) plastic grills at the entrance to fyke nets to reduce the catch of large fish and aquatic fauna, (2) escape tubes which release small fish and (3) setting nets with the cod ends out of the water to allow aquatic fauna to breathe. There is however a need to implement cost-effective strategies to further reduce bycatch and demonstrate to the wider community the environmental responsibility with which the Victorian eel fishing industry operates.

The gear trialled in this project was designed to allow the escape of bycatch, particularly protected wildlife and small fish, from commercial fyke nets while retaining the target eel catch. The modified gear trialled in this project includes two types of modified codends, (i.e. (1) a rigid, PVC-framed steel mesh box and (2) a collapsible nylon mesh box supported with stakes), and a standard fyke net containing an escape tube. Trials were undertaken in three, two-week sampling events at a number of sites in Victoria, most of which are commercially fished for eels. These locations are known to contain populations of protected wildlife, including many water bird species, tortoises, platypuses, water rats, and/or abundant small fish species.

The research found that there was no significant difference in the eel catch between the modified nets, and the standard commercial fyke nets, which indicates that the use of the modified gear has no negative effect on the commercial eel catch. No significant difference in fish bycatch was observed between fyke nets with modified cod ends and standard commercial fyke nets, but fyke nets containing escape tubes caught significantly fewer eels and significantly less fish bycatch than standard commercial fyke nets. This indicates that while escape tubes will allow small fish to escape, eels smaller than about 600 g may also escape through the escape tubes.

No significant difference in the catch of freshwater tortoises was observed between modified and standard fyke nets. However, the design and function of the modified nets provided greater access for tortoises to the water surface thereby reducing unacceptable stress to tortoises in modified fyke nets.

Significantly more platypuses were recorded in standard fyke nets than in modified fyke nets. However it was observed that platypuses were able to exit the modified nets shortly after being caught by climbing up the mesh walls of the cage and dropping over the cage side into the water. Thus the modified nets provide a distinct advantage by permitting platypuses to escape from the nets in a timely manner, thereby reducing stress and the risk of injury or mortality to this species.

Clearing the catch from the rigid framed nets was considerably easier than from the collapsible nets; however the nets with rigid steel mesh cod ends attached were bulky to carry on board commercial eel boats. Conversely, the nylon mesh nets are more flexible and can be folded and stacked flat on the floor of a boat, allowing a larger number of collapsible nets to be carried at once. The main disadvantage with the collapsible nets is the difficulty in clearing the catch from the nets.

The gear modifications trialled in this project may provide opportunities for the use of modified fyke nets in waters which may otherwise be closed to eel fishing, such as wildlife reserves not presently fished commercially for eels, or in eel fisheries where fyke nets are not presently used to catch adult eels (e.g. Queensland and New South Wales). Furthermore, there is scope for escape tubes to be used in waters not presently fished for eels, but which may contain threatened fish species. This would provide a commercial opportunity through the selective harvest of marketable eels, while allowing small eels to escape and minimising any impact on non target fish species.

The project has identified a number of opportunities for the further development of gear modifications to improve the efficiency of gear operation, and therefore increase the likelihood of uptake by industry. Such developments will need to be made to take full advantage of the findings of this project.

KEYWORDS: **Eel fishery, fyke nets, gear modifications, bycatch, protected wildlife**

ACKNOWLEDGEMENTS

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BACKGROUND

The Victorian eel fishing industry has historically been proactive in the reduction of bycatch in the fishery, developing and utilised a range of bycatch reduction devices and practices over many years. However, detailed knowledge of bycatch issues associated with the Victorian Eel Fishery has been identified in the Victorian Eel Fishery Bycatch Action Plan (BAP) and Eel Fishery Management Plan (EFMP) as being deficient (McKinnon 2002; Leporati and McKinnon 2006), and recommendations were made to commence fishery dependent and independent monitoring of bycatch in the fishery.

Formal assessment of the ecological risks to bycatch species in the Victorian Eel Fishery, as recommended in the BAP, has found the ecological risks associated with the eel fishery are low, and that current management is adequate to manage the level of risk posed by the industry (Anon. 2007). Furthermore, the fishery was granted the maximum (5 year) exemption from export controls following evaluation of the ecological sustainability of the fishery by the then Department of Environment and Heritage (DEH) under the *Environment Protection and Biodiversity Conservation* (EPBC) *Act 1999*. However, the industry recognises that a degree of social unacceptability exists in relation to the bycatch of some species, notably protected fauna such as platypuses and water birds. Consequently, industry has further developed fishing equipment and modifications to existing fishing gear, specifically to reduce the risk of interaction with protected wildlife and other fauna in the fishery, and is now at a stage of trialling different gear types and further developing prototypes.

This project addresses Strategic Challenge One of the FRDC's priorities for Research, Development and Extension by focusing on the reduction of interaction with protected wildlife in eel fishing, thereby reducing the potential impact on species and ecological communities and ensuring their sustainability.

The project has been discussed formally among industry and management representatives through bimonthly meetings of the Victorian Eel Fishers' Association and prepared in consultation with the VEFA and with Fisheries Victoria, both of whom support the project in principle.

Consultation

This project has been developed as part of the Empowering Stakeholder R&D initiative in close consultation with stakeholders. The Victorian EFMP (McKinnon 2002) recommended the BAP be developed as a high priority and both the EFMP and BAP were prepared following extensive consultation with industry and management. An ecological risk assessment has been completed for the fishery as recommended in the BAP, again following close consultation with stakeholders.

Fisheries Victoria has provided in-principle support for the project, encouraging industry in the development of improved fishing gear.

NEED

Fyke nets are used exclusively in the Victorian Eel Fishery and, although potentially large quantities of bycatch are encountered in the fishery, the ecological risk of using fyke nets is low as fishing operations are undertaken so as to minimise bycatch in the first place and, where bycatch does occur, it is generally released from fyke nets unharmed. A number of bycatch reduction devices and methods are presently used routinely in the Victorian Eel Fishery, including plastic grills at the entrance to fyke nets to reduce the catch of large fish and aquatic fauna, escape tubes which release small fish and setting nets with the cod ends out of the water to allow aquatic fauna to breathe. However, these methods have a number of limitations. The use of grills excludes large marketable eels as well as bycatch, and escape tubes also release small eels which are often kept for stock enhancement of other selected waters. Setting nets with raised cod ends limits the ability to set fleets of nets to improve fishing efficiencies, and in deep water may cause the internal funnels of the net to collapse. Furthermore, when large catches are made, raised cod ends may become submerged under the weight of the catch.

An ecological risk assessment (Anon. 2007) has been undertaken on the impact of eel fishing on bycatch, including fish and protected fauna, and the risk has been determined to be low. For some sectors of the community however, the bycatch of protected species such as native water birds, tortoises and platypuses is considered to be unacceptable. There is therefore a need to implement cost-effective strategies to further reduce bycatch and demonstrate to the wider community the environmental responsibility with which the Victorian eel fishing industry operates.

The BAP recognises that the development of efficient Bycatch Reduction Devices (BRDs) is expected to aid in the reduction of capture and/or mortality of endangered, threatened or protected species.

This project addresses the recommendations of the BAP to develop new methods of reducing bycatch in sensitive water bodies, such as wildlife reserves and dams where commercial eel fishing is permitted. This is consistent with the overarching objective of the Victorian Eel Fishery Management Plan to establish a management framework for the ecologically sustainable development of the fishery.

Without this project, the community perceptions that the commercial eel fishery is not managing bycatch adequately are likely to be perpetuated. This may ultimately lead to reactive management impositions upon the fishery, rather than proactive bycatch management and responsible fishing practices by industry which this project will propagate.

OBJECTIVES

1. To trial modified fyke nets for effectiveness in reducing bycatch of protected wildlife
2. To communicate results to the community, industry and management
3. To establish and apply an industry code of practice based on 1 & 2

METHODS

SITE DESCRIPTION

Trials were undertaken at a number of sites in Victoria which are commercially fished for eel, including the Aire River, lower Barwon River and in billabongs on private land in Gippsland (Figure 1). These locations are known to contain populations of protected wildlife, including many water bird species, tortoises, water rats, and/or abundant small fish species. A fourth location on the Barwon River (West Branch), which is not open to commercial eel fishing, was also sampled as part of the project, as this area is known to contain large platypus populations and would be expected to increase the likelihood of interaction with this species in order to more fully test the gear in terms of managing bycatch of high-profile protected wildlife.

Originally, all trials of modified gear were to be undertaken at the Aire River site only during three discrete periods within one fishing season (generally October-April) in order to test for any effect of seasonality on the performance of net design in bycatch reduction. During the first round of surveys no protected wildlife species were caught as bycatch, despite the obvious local abundance of numerous waterfowl species, water rats and platypuses. A decision was made to undertake the remaining surveys at other locations where it was considered more likely that interaction with protected wildlife species would be observed. The sampling dates and locations are summarised in Table 1.

GEAR DESCRIPTION

The gear trialled in this project was designed to allow the escape of bycatch, particularly protected wildlife and small fish, from commercial fyke nets while retaining the target eel catch. Similar gear modifications have been successfully applied in other net fisheries to reduce incidental capture of protected or unwanted species.

Commercial fyke nets commonly comprise a single wing (although up to 3 wings may be used in the commercial eel fishery) which may be up to 46 m in length, but a wing of less than 10m is more commonly used. The wing leads into a 4-6 m long collapsible conical net constructed of nylon mesh between 1.5 and 3.9 cm, and which contains at least 2 internal funnels (Figure 2).

The modified gear trialled in this project includes:

- two types of modified codends, i.e., (1) a rigid, PVC-framed steel mesh box and (2) a collapsible nylon mesh box supported with stakes)
- a standard fyke net containing an escape tube.

The steel mesh cod end was 550 mm wide x 910 mm long x 1,100 mm high (Figure 3); the nylon mesh cod end was 700 mm wide x 1,300 mm long x 1,200 mm high (Figure 4). In each case the cod end was attached to an otherwise standard fyke net of 2.0 m length with a single wing of 6.0 m length. The escape tube was a short (150 mm) length of PVC pipe of 40 mm diameter, flared at each end and attached to the cod end of a standard commercial fyke net (Figure 5).

Table 1. Site locations and dates sampled

Site	Location	Dates sampled
Aire River	38.7064ºS; 143.541 ºE	13-17 Oct. & 27-31 Oct.2008
Thomson River billabongs	38.0092ºS; 146.918 ºE	5 Jan.-9 Jan.2009
Barwon River (west branch)	38.4746ºS; 143.689ºE	17-21 Feb. & 27 Apr.-1 May 2009
Lower Barwon River	38.231ºS; 144.422 ºE	4-8 May 2009

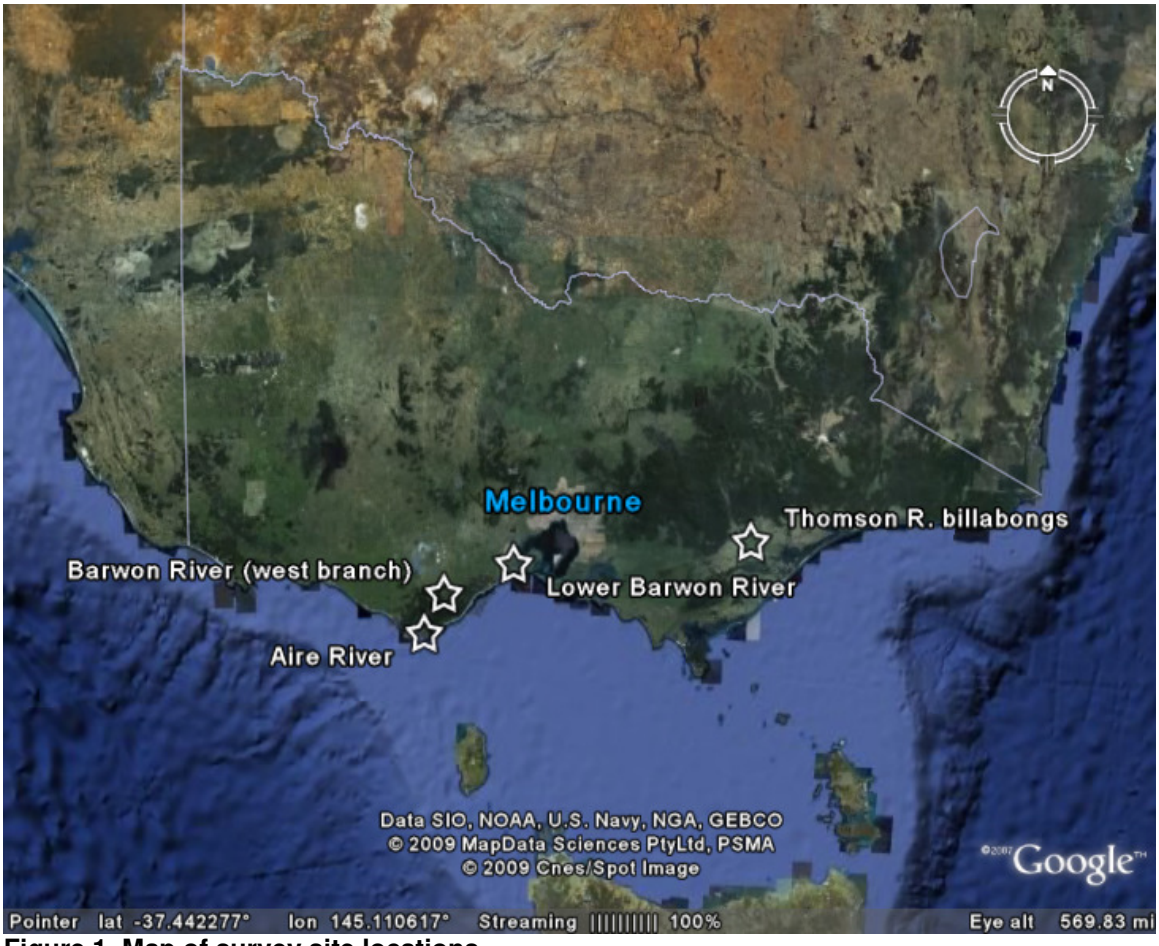

Figure 1. Map of survey site locations.

EXPERIMENTAL DESIGN

In order to determine the appropriate number of different net types and the associated sampling design for the project, existing eel catch and bycatch data from the area in which gear trials are to be undertaken were used to provide estimates of the effect size likely to be detected, as described below. Data collected from the first week of surveys were used to improve these estimates and refine the sampling design.

Existing eel catch data for the Aire River were used to calculate the mean and standard deviation of the number of shortfin eels caught per net. Previously recorded commercial catch data from another area, Lake Bolac, were used to calculate the expected correlation in catch between pairs of nets set in the same location. This correlation was found to be between 0.95 and 0.99. At a correlation of 0.99, it is estimated that four pairs of nets would be required to detect a 40% difference between mean catches with a power of 80% and three pairs will detect a 50% difference in catch.

Using existing eel fishery bycatch data for protected species (Anon. 2007), eight nets in total were required to enable a 50% chance of catching at least one protected non-fish species in a fyke net. This enabled minimum paired comparisons between nets to be made as follows:

- Steel mesh modified net vs Standard fyke net
- Nylon mesh modified net vs Steel mesh modified net
- Nylon mesh modified net vs Standard fyke net
- Escape tube vs Standard fyke net

The cod-ends of standard fyke nets were always set above the water surface to ensure that potential entrapments of wildlife did not result in any mortality or unacceptable harm. The results from the first round of surveys found that there was no significant difference (α=0.05) in the catch of eels between nets with steel mesh cod ends and nets with nylon mesh cod ends. The two modified net designs were therefore treated as the same type of net for the purposes of improving replication in the field. Paired comparisons between gear types were therefore made as follows:

- Modified fyke net vs Standard fyke net
- Escape tube vs Standard fyke net

Analysis of variance (ANOVA) with repeated measures was used to identify gear that showed significant difference at α=0.05 between catches of each species. The ANOVA was performed on pairs of nets as follows: nets with modified cod-ends (including both steel and nylon mesh) and standard commercial fyke nets (standard nets); and nets containing escape tubes in the cod-end and standard nets. The catch rate was transformed (double square root) to satisfy the homogeneity of variance assumption.

Monitoring of fyke nets included visual observation where possible, to observe interactions between protected fauna and different gear types and to ensure that potential entrapments of wildlife do not result in any mortality or unacceptable harm.

Figure 2. Standard commercial fyke net.

Figure 3. Modified fyke net with rigid frame cod end.

Figure 4. Modified fyke net with collapsible cod end.

Figure 5. Standard fyke net cod end containing escape tube.

RESULTS/DISCUSSION

FIRST ROUND OF SURVEYS

The first round of field surveys was completed on 31 October 2008. Two sampling trips were undertaken in October to the Aire River (Table 1), which is allocated for commercial eel fishing under the Eel Fishery Access Licence owned by the Principal Investigator.

The results showed that there was no significant difference in the catch of eels between modified nets with steel mesh cod ends and modified nets with nylon mesh cod ends. Both types of modified nets were therefore treated as the same type of net for the purposes of improving replication in the field, and data from both types of modified nets were consequently pooled for analysis. There was no significant difference in the eel catch between the modified nets, containing either steel or nylon mesh codends, and the standard commercial fyke nets, which indicates that the use of the modified gear has no negative effect on the commercial eel catch (Figure 6).

A summary of results from the first round of surveys is presented in Table 2. Shortfin eels (*Anguilla australis*) comprised the vast majority of the catch, with flatheaded gudgeons (*Phylipnodon grandiceps*), sea mullet (*Mugil cephalus*), Australian salmon (*Arripis trutta*), black bream (*Acanthopagrus butcheri*) and brown trout (*Salmo trutta*) comprising the bycatch (Table 2). No protected wildlife bycatch was caught during the surveys in the Aire River, although many waterbird species were present and platypuses were observed in the vicinity of the sampling operations. There was no significant difference in the catch of the bycatch fish species between modified and standard gear (Figure 6). The eel catch in standard gear was however significantly greater than in gear with escape tubes ($F_{1,6}$=7.97; P=0.03; R^2=0.86). There was no significant difference in the catch of the bycatch fish species (all fish species combined) between standard gear and gear with escape tubes (Figure 6).

Table 2. Total catch (number) and effort by species and gear type from the Aire River, 13-17 October & 27-31 October2008

Gear Type	Escape Tube[1]	Modified[2]	Standard[3]
No. Net Nights	13	32	37
Eels	61	412	838
Sea mullet	4	9	37
Australian salmon	8	5	14
Black bream	2	9	12
Flatheaded gudgeon	16	1	44
Brown trout	0	0	1

[1]Standard fyke net cod end containing escape tube; [2]Modified fyke net with (a) rigid frame cod end or (b) collapsible cod end; [3]Standard commercial fyke net

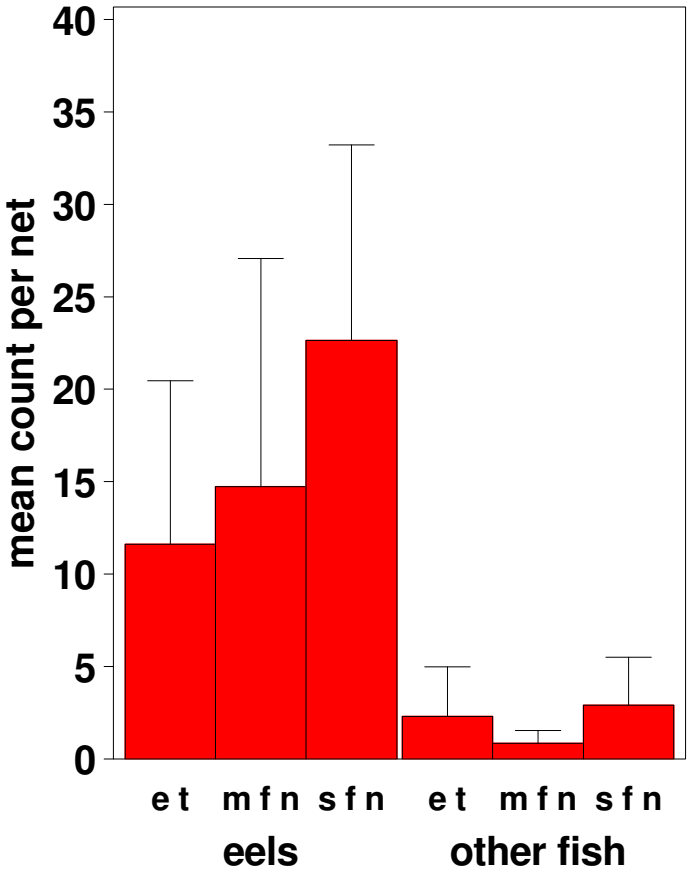

Figure 6. Mean number caught per net by species and gear from the Aire River, 13-17 October & 27-31 October 2008. The catch of all fish other than eels is combined. The bar indicates the upper 95% confidence level. Gear codes are: et: Standard fyke net cod end containing escape tube, mfn: Modified fyke net with (a) rigid frame cod end or (b) collapsible cod end, sfn: Standard fyke net cod end.

SECOND ROUND OF SURVEYS

The second round of field surveys was completed on 21 February 2009. Field sampling locations were changed to increase the likelihood of interaction with protected wildlife species, in order to more fully test the effect of the modified fishing gear on these potential bycatch species. The waters commercially fished in Gippsland contain large numbers of eastern snake-necked tortoises (*Chelodina longicollis*)—a protected wildlife species that may be encountered in commercial eel fishing operations. One sampling trip was undertaken in January 2009, to billabongs in the Thomson River catchment around Maffra (Gippsland) and one sampling trip was undertaken to the Barwon River (west branch), where platypuses (*Ornithorhynchus anatinus*) are known to commonly occur, in February, 2009 (Table 1).

A summary of results from the second round of surveys is presented in Table 3. In the surveys undertaken in Thomson River billabongs, large numbers of eastern snake-necked tortoises and eels were caught in both standard fyke nets and in fyke nets with modified cod-ends (Table 3) and there was no significant difference in catch of either species observed between standard and modified nets (Figure 7). However, the modified nets have a greater advantage over standard nets in terms of management of tortoise bycatch. The large volume of the cage cod end of the modified nets increases the volume available for the total catch and enables tortoises to breathe, thus preventing the accidental drowning of this species (Figure 2).

Other bycatch species recorded in the Gippsland surveys included the introduced carp (*Cyprinus carpio*), goldfish (*Carassius auratus*) and one platypus, each of which were recorded in relatively low numbers (Table 3). Catch rates of these species were not significantly different between gear types (Figure 7).

The catch rate of eels in standard gear was significantly higher than in the gear containing an escape tube ($F_{1,3}$=3.48, P<0.01, R^2=1.0). This is to be expected as the escape tubes will allow commercially undersized eels to escape from the nets, as well as small bycatch fish species. Too few small bycatch fish species were caught in Thomson River billabongs survey to enable a meaningful comparison in catch of small fish species to be made between standard fyke nets and fyke nets containing escape tubes (Figure 7, Table 3).

During the Barwon River surveys, no significant difference in the catch of eels was observed between standard fyke nets and modified fyke nets, however significantly more platypuses were recorded in standard nets than in modified nets ($F_{1,3}$=3.79, P=0.04, R^2=0.66) (Figure 8). There is no apparent reason why the modified nets would catch fewer platypuses than standard nets, as the modifications to the nets occur at the cod-end, or "holding" part of the net. The "catching" part of the net (wing and funnels) is identical to that of standard nets, which explains the fact that there is no significant difference between catch of other species, including eels, between nets with modified cod-ends and standard fyke nets. It became apparent that the modified fyke nets were in fact catching platypuses, but this species was able to exit the modified nets shortly after being caught by climbing up the mesh walls of the cage and dropping over the cage side into the water. In designing the modified gear, it was anticipated that platypuses may be able to escape, although it was thought that additions to the cages, eg an escape "ramp", or similar device, may be required to be developed to assist in this regard. It appears however that platypuses are able to escape from the nets in a timely manner, without the requirement for further modification to the gear as is evident from video footage of platypuses escaping from both modified net designs obtained during this project. An example of the platypus' ability to escape from the modified fyke nets is shown in the DVD video.

Successful modifications to gear have been made in the NSW commercial eel trap fishery specifically to reduce platypus mortality in the fishery (Grant et al. 2004). Such modifications do not allow the escape of platypuses from the nets, but provide airspace for platypuses to move into for subsequent release. Such a method provides a similar result to raising fyke net cod ends in the Victorian eel fishery. The modifications trialled in this project however, provide a distinct advantage by permitting platypuses to escape from the nets in a timely manner, thereby reducing stress and the risk of injury or mortality.

Other bycatch species recorded in the Barwon River surveys included the introduced redfin (*Perca fluviatilis*), brown trout (*Salmo trutta*), the native blackfish (*Gadopsis marmoratus*) and spiny crayfish (*Euastacus yarraensis*), all of which were recorded in relatively low numbers (Table 3). Catch rates of these species were not significantly different between gear types (Figure 8).

In the Barwon River surveys, no significant difference was observed in the catch of eels or of bycatch species between standard nets and nets with escape tubes (Figure 8). Once again, too few small fish species were observed in the nets during the second round of surveys to make a meaningful comparison between gear types.

Table 3. Total catch and effort by gear type from Thomson River billabongs and the Barwon River (West Branch), 5-9 January 2009 and 17-21 February 2009, respectively.

Thomson River billabongs				Barwon river (west branch)			
Gear type	Escape tube[1]	Modified[2]	Standard[3]	Gear type	Escape tube[1]	Modified[2]	Standard[3]
No. Net nights	4	16	20	No. Net nights	8	16	24
Eels	2	180	212	Eels	4	25	25
Carp	0	6	9	Brown trout	1	4	6
Goldfish	0	4	0	Redfin	0	12	9
Tortoise	0	187	170	Spiny Cray	0	1	5
Platypus	0	0	1	Platypus	0	1	15
				Blackfish	0	2	2

[1]Standard fyke net cod end containing escape tube; [2]Modified fyke net with (a) rigid frame cod end or (b) collapsible cod end; [3]Standard commercial fyke net

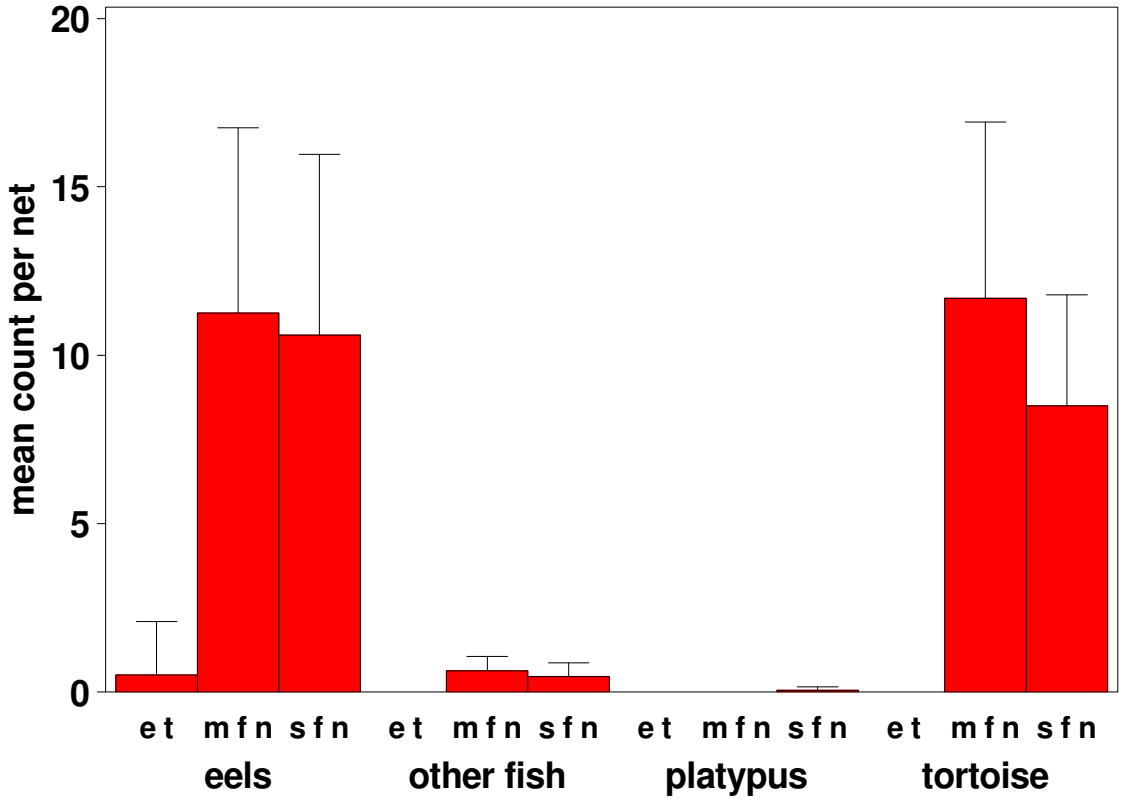

Figure 7. Mean number caught per net by species and gear from Thomson River billabongs, 5-9 January 2009. The catch of all fish other than eels is combined. The bar indicates the upper 95% confidence level. Gear codes are:
et: Standard fyke net cod end containing escape tube, mfn: Modified fyke net with (a) rigid frame cod end or (b) collapsible cod end, sfn: Standard fyke net cod end

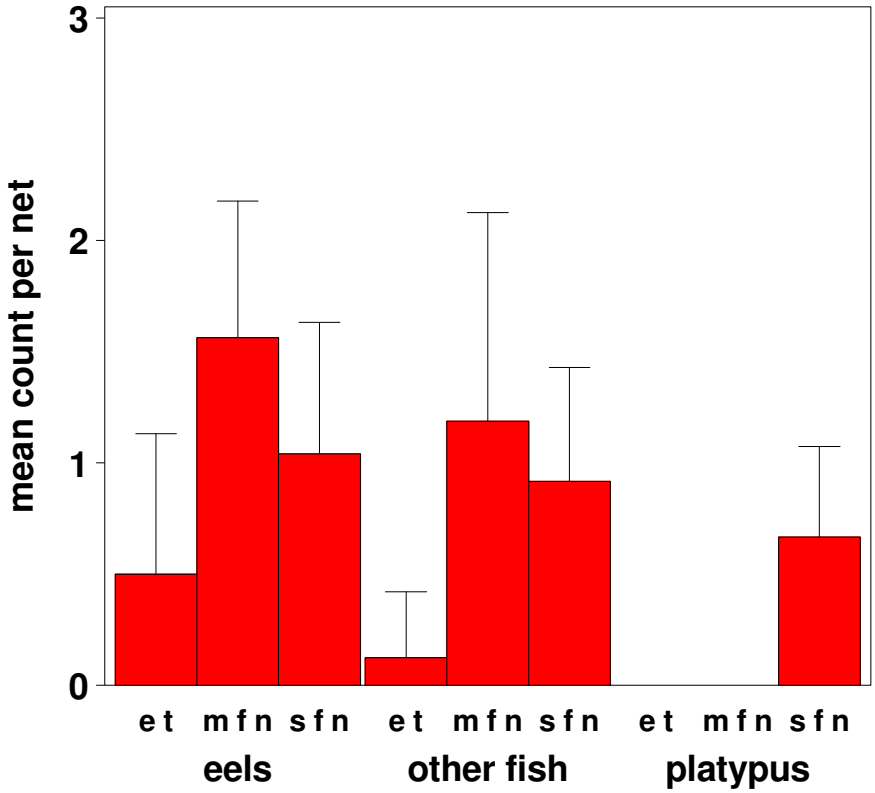

Figure 8. Mean number caught per net by species and gear from the Barwon River (west branch), 17-21 February 2009. The catch of all fish other than eels is combined. The bar indicates the upper 95% confidence level. Gear codes are: et: Standard fyke net cod end containing escape tube, mfn: Modified fyke net with (a) rigid frame cod end or (b) collapsible cod end, sfn: Standard fyke net cod end

FINAL ROUND OF SURVEYS

The third and final round of field surveys was completed on 8 May 2009. Field sampling locations were selected to further increase the likelihood of interaction with protected wildlife species and small non-target fish species, in order to more fully test the effect of the modified fishing gear on these potential bycatch species. One sampling trip was undertaken to the lower Barwon River, near Geelong, and one sampling trip was undertaken to the Barwon River (west branch) (Table 1). The lower Barwon River contains a large diversity of fish species which are likely to be encountered in the commercial gear while eel fishing and, the potential for interaction with platypuses is high in the west branch of the Barwon River.

A summary of results from the final round of surveys is presented in Table 4. In the lower Barwon River surveys, large numbers of small fish species and eels were caught in both standard fyke nets and in fyke nets with modified cod-ends (Table 4), but there was no significant difference observed between catches of any species in standard or modified nets (Figure 9). The fyke nets with modified cod-ends continued to catch similar quantities of eels to the standard nets, as was demonstrated in the first and second rounds of field surveys.

A wide range of non-target fish bycatch species was recorded for all gear types in the lower Barwon River. In addition to shortfin eels, 16 fish species were recorded in the lower Barwon, including primarily King George whiting *Sillagnoides punctata*, Australian salmon and sea mullet (Table 4).

The catch rate of eels in standard gear was again significantly higher than in the gear containing escape tubes ($F_{1,1}$=332.48; P=0.035; R^2=0.68) (Figure 9). Once again, this is to be expected as escape tubes will allow commercially undersized eels to escape from the nets, as well as small bycatch species. The catch of non-target fish species (all species combined) in nets containing escape tubes was significantly less than in standard fyke nets ($F_{1,1}$=815.95; P=0.022; R^2=0.28) (Figure 9). This result shows clearly that escape tubes will reduce the overall quantity of fish bycatch, however the concomitant significant reduction in eel catch in nets containing escape tubes may be a constraint to the commercial application of such devices.

Escape tubes are widely used in stock-enhanced eel production waters ("culture waters"), where small and poorly conditioned eels are stocked and routinely harvested when greater than about 600 g. In other waters however, the use of escape tubes will preclude the harvest of small eels for the purpose of restocking culture waters. Although the use of escape tubes limits the commercial eel catch, there is scope for escape tubes to be used in waters not presently fished for eels which may contain threatened fish species. This would provide a commercial opportunity through the selective harvest of marketable eels, while allowing small eels to escape and minimising any impact on non target fish species.

During the final round of surveys in the Barwon River (west branch), catch rates of all species were very low (Table 4). However, no significant difference in the catch of eels was observed between standard fyke nets and fyke nets with modified cod-ends, as had been observed during previous surveys (Figure 10). One platypus was observed escaping from a modified net in the final round of surveys in the Barwon River (west branch). It is not clear why substantially fewer platypuses were caught in the Barwon River during the final round of surveys than during the second round of surveys. Juvenile platypuses generally emerge from nursery burrows around mid-February, which may explain the relatively large numbers caught in the second round of surveys, however due to population pressure, some juveniles are likely to have left the area by April/May when the final round of surveys were undertaken, and any remaining would have been considerably more alert than they were two months earlier and hence less likely to be trapped (Dr. M. Serena, Australian Platypus Conservancy, personal communication).

Other bycatch species recorded in the Barwon River surveys included the introduced redfin, brown trout and blackfish, all of which were recorded in relatively low numbers (Table 4). Catch rates of these species were not significantly different between gear types (Figure 10).

Table 4. Total catch and effort by gear type from the Lower Barwon estuary and the Barwon River (West Branch), 4-8 May 2009 and 27 April-1 May 2009, respectively.

Lower Barwon River				Barwon River (West Branch)			
Gear Type	Escape Tube[1]	Modified[2]	Standard[3]	Gear Type	Escape Tube[1]	Modified[2]	Standard[3]
No. Net Nights	10	12	23	No. Net Nights	8	14	24
Eels	2	146	270	Eels	0	1	7
Mullet	8	13	59	Brown trout	3	2	3
Australian salmon		2	8	Redfin	2		6
King George whiting		14	45	Flatheaded gudgeon			1
Cobbler	1	2	3	Platypus		1	
Crab	1	7	20	Blackfish			2
Black bream		3	12				
Sandy sprat		1	8				
Flatheaded gudgeon		3					
Bridled goby		1	20				
Old wife		1					
Tupong		1	7				
Greenback flounder		1	10				
Silver trevally			1				
Toadfish			1				
Leatherjacket			1				

[1]Standard fyke net cod end containing escape tube; [2]Modified fyke net with (a) rigid frame cod end or (b) collapsible cod end; [3]Standard commercial fyke net

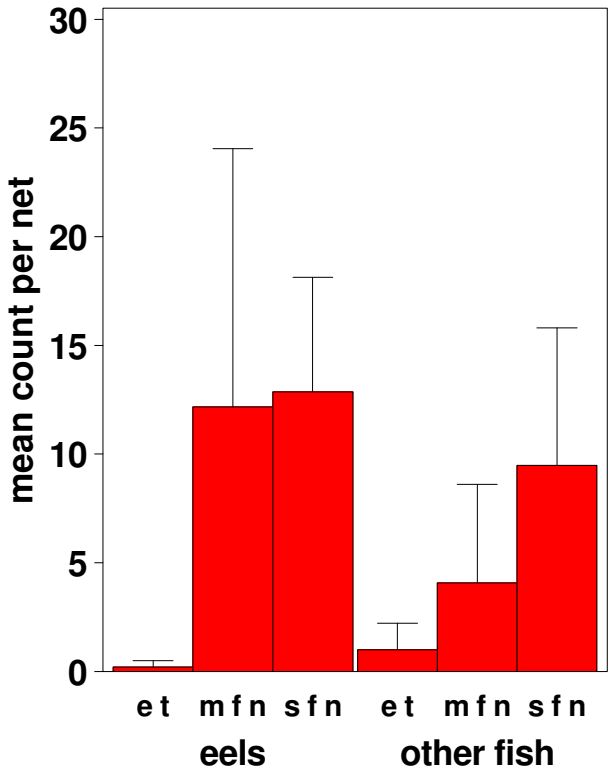

Figure 9. Mean number caught per net by species and gear from the lower Barwon River, 4-8 May 2009. The catch of all fish other than eels is combined. The bar indicates the upper 95% confidence level. Gear codes are: et: Standard fyke net cod end containing escape tube, mfn: Modified fyke net with (a) rigid frame cod end or (b) collapsible cod end, sfn: Standard fyke net cod end

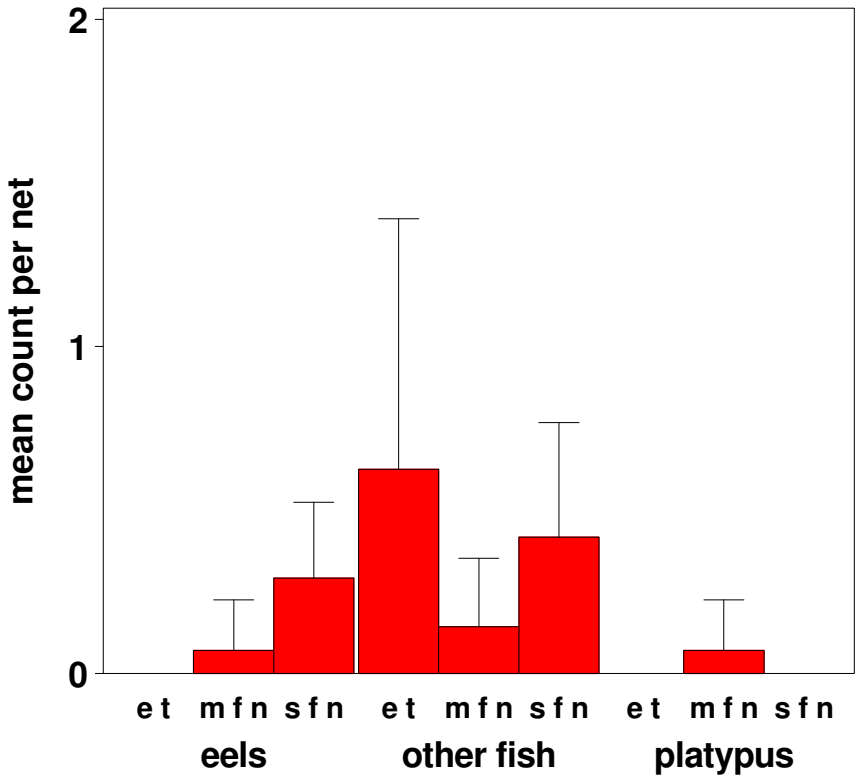

Figure 10. Mean number caught per net by species and gear from the Barwon River (west branch), 27 April - 1 May 2009. The catch of all fish other than eels is combined. The bar indicates the upper 95% confidence level. Gear codes are: et: Standard fyke net cod end containing escape tube, mfn: Modified fyke net with (a) rigid frame cod end or (b) collapsible cod end, sfn: Standard fyke net cod end

EFFECT OF MODIFIED GEAR ON COMMERCIAL EEL CATCH

As discussed above, in each round of surveys no significant difference in the total catch of eels was observed between nets with modified cod ends and standard nets. Furthermore, no significant difference (α=0.05) in maximum, minimum or mean eel weight was observed between modified nets and standard nets (Table 5). Thus modified nets will continue to perform as well as standard fyke nets from a commercial perspective. This is important in terms of industry uptake of the modified net technology, as lower eel catches in modified gear would reduce the likelihood of industry adopting the modified gear for use in commercial fishing operations.

Mean weight of eels caught in nets with escape tubes however, was significantly greater than that of eels caught in either modified or standard nets ($F_{2,13}$ = 8.39; R^2 = 0.60; p = 0.006). The minimum weight of eels retained in nets containing an escape tube was 657 g, whereas that of modified nets and standard commercial fyke nets without escape tubes were 56 g and 89 g respectively (Table 5). This demonstrates that while escape tubes will allow small fish to escape, eels smaller than about 600 g may also escape through the escape tubes. The Victorian eel fishery generally aims to market eels greater than 600 g, as eels greater than this size achieve a significantly higher price as live or frozen product and are also more suitable for smoking. However, eels smaller than 600 g are required from the fishery to stock specified Crown and private waters, which are highly productive, for ongrowing to marketable size. Thus escape tubes are likely to have application only in waters which are restocked, in order to avoid the repeated recapture of stocked eels, or may permit the development of commercial eel fishing in waters currently not fished for eels, but which may contain protected fish species.

Table 5. Mean, maximum and minimum weights of eels caught using each gear type.

Gear type	Mean (g)	Max (g)	Min (g)
Fyke net with Escape tube	1,094	1,425	657
Modified fyke net	532	1,684	56
Standard fyke net	369	1,379	89

BENEFITS AND ADOPTION

The flow of benefits from this project was identified in the project proposal as 100% to the commercial sector (Victoria – 90%, Tasmania – 10%). The benefits of improved bycatch management using modified fyke nets may also apply to eel fisheries in NSW and Queensland where fyke nets are not used. In addition, the outcomes of the project will also provide benefits to the wider community through the dissemination of project outputs (code of practice and DVD) which will inform the community that the perceived risks associated with protected wildlife in the eel fishery are being addressed.

It is expected that the use of the modified gear will be adopted by industry for use in specific situations where the potential for interaction with protected wildlife may be high. Such situations would include for example, wildlife reserves and other waters which may not have been commercially fished for eels previously. Industry may adopt the modified nets for use in waters which are currently fished for eels; however it is not proposed that the modified gear be enforced for use in existing waters, as the risk to bycatch in the fishery has been identified as being low.

The use of escape tubes in the eel fishery is commonplace in waters which are stock enhanced with small eels. Although the use of escape tubes limits the commercial eel catch, there is scope for the development of commercial eel fishing, using escape tubes, in waters not presently fished for eels but which may contain threatened fish species.

FURTHER DEVELOPMENTS

The project has identified a number of opportunities for the further development of gear modifications to improve the efficiency of operation, and therefore increase the likelihood of uptake by industry. A number of advantages and disadvantages with each of the gear types trialled in the project, and recommended initiatives for further trial, have been identified and are summarised in Table 6.

Clearing the catch from the rigid framed nets was far easier than from the collapsible nets. However, the nets with rigid steel mesh cod ends attached were bulky and therefore cumbersome to carry on board commercial eel boats. Only two nets could be carried at once in a small (4 m) punt, which is a vessel commonly used in the Victorian Eel Fishery. These factors may limit the efficient use the rigid framed nets from most commercial eel boats, although it is practical to walk the rigid modified nets in from the shore where the situation allows.

Conversely, the nylon mesh nets are more flexible and can be folded and stacked flat on the floor of a boat, allowing a larger number of collapsible nets to be carried at once. The main disadvantage with the collapsible nets is the difficulty in clearing the catch from the nets (Table 6). The development of a lightweight, collapsible frame to support the modified cod end is seen as a key area for further development of the gear in order to increase the likelihood of uptake by industry. Both rigid and collapsible modified nets may only be used in water of about 1 m maximum depth; however it may be possible to further develop the gear to operate in deeper water.

The limitations of escape tubes have been described above, however it may be possible to reduce the diameter of escape tubes to increase the commercial eel catch while maintaining a reduced bycatch of small fish species.

It will be necessary to further develop the gear trialled in the project to improve its ease and efficiency of operation to maximise its uptake by the commercial sector, thereby taking full advantage of the findings of this project.

Table 6. Advantages, disadvantages and suggested improvements to modified gear

Modification	Advantages	Disadvantages
Rigid, steel mesh cod end	• Lightweight • Cheap construction • Easy to set and clear	• Bulky to transport • Needs additional anchoring • May only be used in shallow water (1m)
Collapsible, nylon mesh cod end	• Compact, may transport many units • Moderately lightweight • Moderately cheap construction	• Time consuming to set • Difficult to clear • May only be used in shallow water (1m)
Escape tube	• Allows small fish to escape	• Allows some eels to escape
Suggested improvements and further development	• Need to develop lightweight, collapsible modifications to codend, e.g. collapsible carbon fibre or aluminium frame with inbuilt anchoring system • Trial reduced- diameter escape tubes • Examine potential for combining modified cod end with escape tube • Adapt modified gear for use in deeper water	

PLANNED OUTCOMES

The project and its associated outputs, including the DVD and reports provide immediate benefits to commercial eel fishers, scientists, fishery managers and the wider community through having achieved the following outcomes:

- Commercial eel fishers now have knowledge and designs for commercial eel fishing gear which minimises the incidental catch of protected wildlife species, and which may be further developed to improve its user-friendliness.
- The existing code of conduct for managing bycatch in the Victorian eel fishery will be updated to incorporate new findings anticipated from this project, and their application in commercial eel fishing.
- Community perceptions relating to bycatch of protected wildlife in the fishery are now able to be improved by informing the public through the DVD and report, that fishers are addressing the issue through the development of gear modifications to improve bycatch management in the fishery.

The Code of Practice is a key output of this project and is presently being reviewed by industry. The Code of Practice will be completed following comment and input from the Victorian Eel Fishermen's Association.

CONCLUSION

Gear modifications to fyke nets enable improved management of protected wildlife in fyke net fisheries while maintaining commercial catch rates of eels. Such gear modifications may provide opportunities for the use of modified fyke nets in waters which may otherwise be closed to eel fishing, such as wildlife reserves not presently fished commercially for eels, or in eel fisheries where fyke nets are not presently used (e.g. Queensland and New South Wales). The use of escape tubes in fyke nets will reduce the bycatch of small fish species although the commercial eel catch may also be reduced. The application of escape tubes may be best suited to commercially stock enhanced eel waters and for the development of eel fishing in waters presently not commercially fished for eels where threatened fish species may occur.

Opportunities exist to further develop the gear to enable improved operational efficiency. This is important in maximising the degree of uptake of such gear modifications in the commercial eel fishery.

Broader community perceptions relating to the bycatch of protected wildlife in the commercial eel fishery are now able to be improved by informing the public that fishers are addressing the issue through active development of fishing gear for the improved management of bycatch.

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APPENDIX 1. INTELLECTUAL PROPERTY

The DVD produced by the project is cited as:
McKinnon, L.J. and Milner, G.L. (2009). Empowering Industry R&D: Trials of Gear Modifications to Reduce Bycatch in Freshwater Fyke Nets. Fisheries Research and Development Corporation, Canberra. DVD production. Accent IT Pty Ltd., Geelong. FRDC Project 2008/17. ISBN 978-0-646-52242-5. Copyright Australian Government 2009.

APPENDIX 2. PROJECT STAFF

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