Department of Agriculture, Fisheries and Forestry

Habitat preferences of small bodied native fish

Final Report

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Habitat preference of small fish species

Background

In the 2011 annual report to the Condamine Alliance (Norris *et al.* 2011) it was noted that small fish species had declined at a number of sites, including Oakey and Myall Creeks. This was in part attributed to major flooding scouring out preferred macrophyte habitats. It was also noted that in-spite of Murray cod stocking, very few juvenile cod had been captured in follow up surveys. The report suggested that introducing habitat for small fish species and the juveniles of large bodied species could be a worthwhile intervention activity to boost diversity of native fish in the intervention sites and to improve recruitment of large bodied species.

This is part of a holistic approach to habitat, where to maximise outcomes, restoration of habitat for all phases of the life-history is essential. Adult feeding and resting habitats, spawning habitat and juvenile nursery habitat and the connections between them are all considered (Figure 1) in this approach. Increasing the capacity to support small bodied native fish should also have flow on benefits to larger bodied species such as Murray cod (Figure 2).

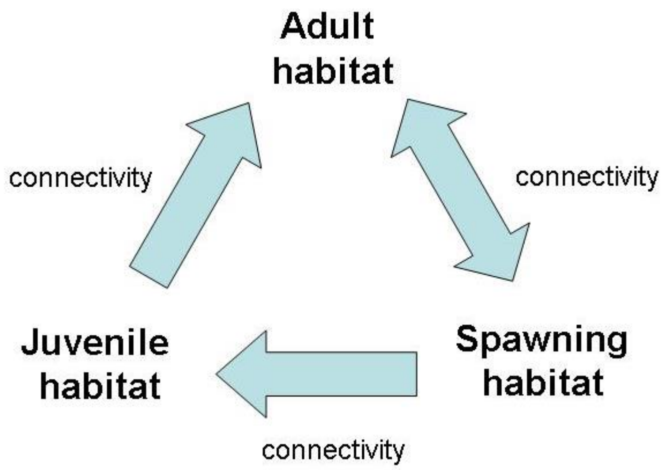

Figure 1: Conceptual diagram for the importance of different habitats throughout the life-history of a fish.

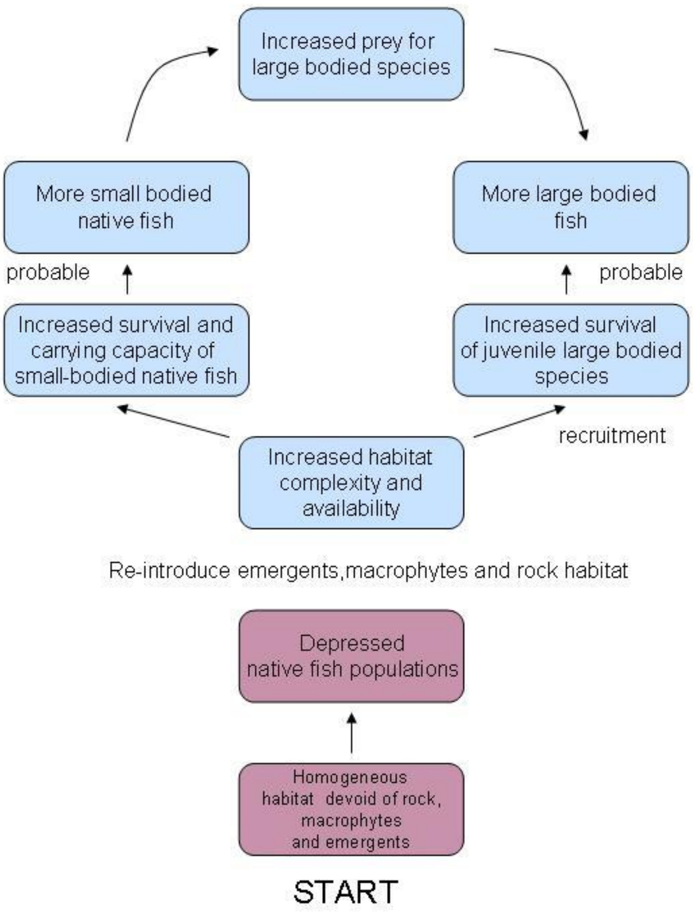

Figure 2: Conceptual diagram for the importance of habitat for small bodied species

A series of tank-based habitat preference experiments were designed to guide potential options for small bodied and juvenile fish habitat introduction. The results of this work are presented in this report.

Methods

Habitat preferences were tested in eight gel-coated fibreglass troughs, with dimensions of 120 cm long, by 30 cm wide and 30 cm depth. These provided eight replicate tests for each habitat preference combination. The base of each trough was filled with a 3 cm deep layer of filter sand. An acrylic divider on a draw string was suspended above the centre of each trough. This could be lowered through tracks to divide each trough into half. Each half of a trough was provided with a separate habitat choice (see Table 1 and Figure 3). For each habitat pair the ends at which the habitat was situated was alternated between troughs to eliminate end bias (due to room lighting etc.) that may have otherwise skewed results.

Table 1: Habitat preference combinations tested in troughs. Macrophyte consisted of a mixed planting of *Hydrilla* and *Vallisneria* over sand. Both Hydrilla and Vallisenaria occurred in Oakey Creek at Bowenville Reserve prior to major flooding in 2010/11. Rock consisted of granite 15 to 25 cm diameter piled together. The emergent plant used was common reed *Phragmites australis* planted in sand. *Phragmites australis* is also native to the Condamine Catchment.

Habitat combination	Habitat choice 1	Habitat choice 2
1	sand	rock
2	sand	macrophyte
3	sand	emergent (reed)
4	rock	macrophyte
5	rock	emergent (reed)
6	macrophyte	emergent (reed)

Habitat preferences of Murray-Darling rainbowfish, carp gudgeons, un-specked hardyheads, olive perchlets, juvenile Murray cod, juvenile golden perch and juvenile silver perch were examined. Juvenile fish were in the 35 to 60mm size range. It was planned to look at habitat preferences of juvenile spangled perch as well, however it was not possible to collect sufficient numbers of these to use in the preference trials.

For each habitat preference test, 12 individuals of the species being examined were introduced into the centre of each test trough . The fish were left for two hours and could move to any part of the trough. At the end of that time the barriers were lowered simultaneously in all troughs by releasing a bank of drawstrings. The number of fish on each side of the barrier in each trough was then counted (Figure 4) to give an indication of habitat preference. A generalised linear model of binomial proportions with logit link function was run in Genstat ™ (version 14.2) for each species and each habitat combination. The predict function was used to calculate back transformed mean proportions of habitat use and standard error of the mean (SEM) values. The null hypothesis of no significant difference from a predicted 0.5 (equal use of either habitat) was tested for each habitat pair using a two tailed t test. The value of t was calculated using the formula $(0.5-\bar{x})/SEM$. Probability levels were calculated using seven degrees of freedom.

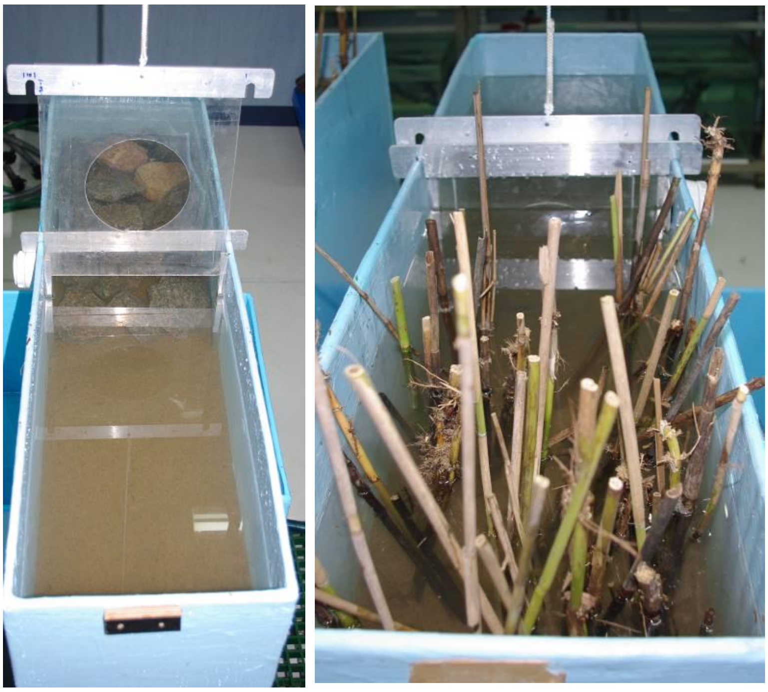

Figure 3: Habitat preference troughs with choice of sand and rock (left) and *Phragmites* and sand (right). Note the acrylic divider suspended on a draw string. The one on the right has been lowered. The apparent hole in the divider is sealed with a thin sheet of acrylic. *Phragmites* have been trimmed

Figure 4: Counting unspecked hardyheads at the end of a preference trial with the habitat choices of sand and macrophyte. Note the barrier is lowered. At the end of the experiment fish were returned to aquaria.

Results

The results of the habitat preference trials are presented in Tables 2 to 7.
Juvenile Murray cod and golden perch showed a significant preference for rock over sand, whereas unspecked hardyheads showed a significant preference for sand over rock. Olive perchlets, Murray-Darling rainbowfish and silver perch showed no significant preference for sand or rock compared to an expected value of 0.5 (Table 2).

Table 2: Mean proportions of adult small native fish and juveniles of large species in rock and sand habitats in preference troughs. t-test probabilities were compared against an expected mean of 0.5. Errors are one standard error of the mean. Mean values in bold indicate a significant preference for that habitat type at the 5% level. Number of replicates = 8 for each species.

Species	Rock	Sand	p
Rainbowfish	0.3854 ± 0.146	0.6146 ± 0.146	>0.05
Carp gudgeon	0.6562 ± 0.077	0.3438 ± 0.077	>0.05
Olive perchlet	0.5833 ± 0.100	0.4167 ± 0.100	>0.05
Unspecked hardyhead	0.1979 ± 0.072	**0.8021** ± 0.072	**<0.005**
Murray cod juveniles	**0.9896** ± 0.008	0.0104 ± 0.008	**<0.001**
Silver perch juveniles	0.5729 ± 0.168	0.4271 ± 0.168	>0.05
Golden perch juveniles	**0.9062** ± 0.037	0.0938 ± 0.037	**<0.001**

Murray-Darling rainbowfish showed a significant preference for sand over macrophyte, whereas carp gudgeon, olive perchlets, juvenile Murray cod and juvenile golden perch all showed a preference for macrophyte over sand. Unspecked hardyheads trended towards increased use of macrophyte compared to sand, but standard error values were too high for this to be significant at the 5% level. Silver perch showed no significant difference to the expected value of 0.5 (Table 3).

Table 3: Mean proportions of adult small native fish and juveniles of large species in macrophyte and sand habitats of preference troughs. t-test probabilities were compared against an expected mean of 0.5. Errors are one standard error of the mean. Mean values in bold indicate a significant preference for that habitat type at the 5% level. Number of replicates = 8 for each species.

Species	Macrophyte	Sand	p
Rainbowfish	0.1354 ± 0.041	**0.8646** ± 0.041	**<0.001**
Carp gudegon	**0.9167** ± 0.040	0.0833 ± 0.040	**<0.001**
Olive perchlet	**0.8958** ± 0.049	0.1042 ± 0.049	**<0.001**
Unspecked hardyhead	0.6875 ± 0.145	0.3125 ± 0.145	>0.05
Murray cod juveniles	**0.9792** ± 0.013	0.0208 ± 0.013	**<0.001**
Silver perch juveniles	0.5208 ± 0.125	0.4792 ± 0.125	>0.05
Golden perch juveniles	**0.7500** ± 0.027	0.2500 ± 0.027	**<0.001**

Neither Murray-Darling rainbowfish, olive perchlets, unspecked hardyheads nor juvenile silver perch showed a preference for sand or *Phragmites*. They all used both habitats in similar proportions to the expected 0.5 level. Carp gudgeons, juvenile Murray cod and juvenile golden perch strongly preferred *Phragmites* to open sand (Table 4).

Table 4: Mean proportions of adult small native fish and juveniles of large species in *Phragmites australis* and sand habitats of preference troughs. t-test probabilities were compared against an expected mean of 0.5. Errors are one standard error of the mean. Mean values in bold indicate a significant preference for that habitat type at the 5% level. Number of replicates = 8 for each species..

Species	*Phragmites*	Sand	p
Rainbowfish	0.4583 ± 0.124	0.5417 ± 0.124	>0.05
Carp gudgeon	**0.8021** ± 0.060	0.1979 ± 0.060	<**0.002**
Olive perchlet	0.5312 ± 0.137	0.4688 ± 0.137	>0.05
Unspecked hardyhead	0.4271 ± 0.177	0.5729 ± 0.177	>0.05
Murray cod juveniles	**0.9375** ± 0.024	0.0625 ± 0024	<**0.001**
Silver perch juveniles	0.5104 ± 0.187	0.4896 ± 0.187	>0.05
Golden perch juveniles	**0.8229** ± 0.062	0.1771 ± 0.062	<**0.002**

Unspecked hardyheads showed no significant preference for rock or *Phragmites*, with mean use values close to the expected 0.5. All other species preferred rock over *Phragmites*. This preference was very strong in juvenile Murray cod (Table 5).

Table 5: Mean proportions of adult small native fish and juveniles of large species in *Phragmites australis* and rock habitats of preference troughs. t-test probabilities were compared against an expected mean of 0.5. Errors are one standard error of the mean. Mean values in bold indicate a significant preference for that habitat type at the 5% level. Number of replicates = 8 for each species.

Species	*Phragmites*	Rock	p
Rainbowfish	0.2396 ± 0.068	**0.7604** ± 0.068	<**0.01**
Carp gudgeon	0.1875 ± 0.053	**0.8125** ± 0.053	<**0.001**
Olive perchlet	0.2083 ± 0.056	**0.7917** ± 0.056	<**0.001**
Unspecked hardyhead	0.5521 ± 0.136	0.4479 ± 0.136	>0.05
Murray cod juveniles	0.0000 ± 0.000	**1.0000** ± 0.000	<**0.001**
Silver perch juveniles	0.2500 ± 0.044	**0.7500** ± 0.044	<**0.001**
Golden perch juveniles	0.2708 ± 0.049	**0.7292** ± 0.049	<**0.005**

Olive perchlets and juvenile silver perch showed a preference for submerged macrophytes over *Phragmites,* but all other species showed no significant difference to the expected mean useage value of 0.5. However the trend was for use of macrophyte to be marginally higher than use of *Phragmites* (Table 6).

Table 6: Mean proportions of adult small native fish and juveniles of large species in *Phragmites australis* and macrophyte habitats of preference troughs. t-test probabilities were compared against an expected mean of 0.5. Errors are one standard error of the mean. Mean values in bold indicate a significant preference for that habitat type at the 5% level. Number of replicates = 8 for each species.

Species	*Phragmites*	Macrophyte	p
Rainbowfish	0.3854 ± 0.096	0.6146 ± 0.096	>0.05
Carp gudgeon	0.3958 ± 0.106	0.6042 ± 0.106	>0.05
Olive perchlet	0.1250 ± 0.040	**0.8750** ± 0.040	**<0.001**
Unspecked hardyhead	0.3750 ± 0.143	0.6250 ± 0.143	>0.05
Murray cod juveniles	0.3229 ± 0.078	0.6771 ± 0.078	>0.05
Silver perch juveniles	0.1771 ± 0.096	**0.8229** ± 0.096	**<0.02**
Golden perch juveniles	0.4687 ± 0.092	0.5313 ± 0.092	>0.05

Juvenile Murray cod, juvenile silver perch and carp gudgeons all showed a preference for rock over macrophytes. In all other species use of rock and macrophyte was not significantly different from the expected 0.5 level. Rainbowfish and unspecked hardyheads showed some tendency for increased use of macrophyte, but standard error values were too large for this to be significant at the 5% level (Table 7).

Table 7 Mean proportions of adult small native fish and juveniles of large species in macrophyte and rock habitats of preference troughs. t-test probabilities were compared against an expected mean of 0.5. Errors are one standard error of the mean. Mean values in bold indicate a significant preference for that habitat type at the 5% level. Number of replicates = 8 for each species.

Species	Macrophyte	Rock	p
Rainbowfish	0.6250 ± 0.077	0.3750 ± 0.077	>0.05
Carp gudgeon	0.2604 ± 0.066	**0.7396** ± 0.066	**<0.01**
Olive perchlet	0.4583 ± 0.128	0.5417 ± 0.128	>0.05
Unspecked hardyhead	0.6563 ± 0.177	0.3437 ± 0.177	0.058
Murray cod juveniles	0.1042 ± 0.052	**0.8958** ± 0.052	**<0.001**
Silver perch juveniles	0.0208 ± 0.016	**0.9792** ± 0.016	**<0.001**
Golden perch juveniles	0.4167 ± 0.042	0.5833 ± 0.042	>0.05

Discussion

These preference tests only used adult fish for the smaller species (rainbowfish, unspecked hardyheads, olive perchlets and carp gudgeons). It is possible that juveniles may have different habitat preferences to adults. For example, Murray-Darling rainbowfish showed a preference to sandy substrate over macrophyte, and showed no significant difference in use of rock and sand or rock and *Phragmites*. However juvenile rainbowfish might be more inclined to use macrophytes or other cover as a predator avoidance strategy. Murray-Darling rainbow fish spawn amongst aquatic plants (Lintermans 2009) or in the vicinity of vegetation (Moffatt and Voller 2002), therefore aquatic plants are still likely to be important for part of the life history of this species. Furthermore these tests were conducted when there was no threat of predation. The preferences therefore indicate habitats the adult fish may prefer to use when not under duress. For some of the larger species, such as golden perch and Murray cod, adult habitat preferences are fairly well known (Boys and Thoms 2006, Crook *et al.* 2001, Koehn 2009a; Koehn 2009b) but little is known of the juvenile habit preferences. This series of experiments has provided some useful information to guide habitat rehabilitation works for juveniles of larger species and the adult stages of small species.

Rainbowfish

It would appear that adult rainbowfish are comfortable in open water habitats. They preferred sand to macrophytes and did not show any significant difference in use of sand compared to the other habitats. This conforms to some field observations we have made when electrofishing. It is not unusual to catch rainbowfish in open water well away from the river bank. We also have observed rainbowfish in association with sticky snags covered in filamentous algae and root mats.

Rocky habitats may be of some value to rainbowfish. Rainbows showed a preference for rock over *Phragmites*, but there was no significant preference for rock over any of the other habitats.

Even though rainbowfish adults did not display any preference for macrophytes, this habitat is still known to be important for rainbowfish breeding (Moffatt and Voller 2002; Lintermans 2009). Therefore regeneration of macrophytes is still likely to benefit rainbowfish populations. Although adult rainbowfish use open water habitats, if these habitats are adjacent to structure such as macrophytes, then they would have a refuge area available should predators threaten them.

Carp gudgeons

In contrast to rainbow fish, adult carp gudgeons showed a preference for use of cover over open sand. Both submerged macrophyte and *Phragmites* were preferred to open sand. Use of rock was not significantly preferred compared to sand, however there was a trend towards use of rock. When given a choice of rock and *Phragmites* or rock and macrophyte, carp gudgeon showed a significant preference for rock. Given the results for the pairings of *Phragmites* and sand and macrophyte and sand, this does suggest that carp gudgeons are attracted to rocky habitat. When given a choice of *Phragmites* and macrophyte, the result did not differ significantly, suggesting carp gudgeons are comfortable in both habitats.

Carp gudgeon should benefit from establishment of *Phragmites*, submerged macrophytes and introduction of rocky rubble habitats. In some control sites and reference sites in the Dewfish Demonstration Reach where *Phragmites* beds have established we have observed carp gudgeons in the *Phragmites* during electrofishing surveys.

Olive perchlets

Olive perchlets showed a strong preference for macrophyte over sand and over *Phragmites.* However there was no significant difference for the rock and macrophyte pairing. Rock was preferred over *Phragmites,* but none of the other habitat pairings differed significantly.

Olive perchlets have declined over much of the Murray Darling Basin (Lintermans 2009). They have rarely been collected in the Dewfish Demonstration Reach intervention sites to date (Norris *et al.* 2012). However they have been collected in reasonable numbers in reference and control sites in the Charlies Creek catchment (Norris *et al.* 2012). Macrophytes are still in reasonable condition in parts of the Charlies creek catchment. It is quite likely that the presence of macrophytes has favoured persistence of olive perchlets. The preference experiments from this study support the concept that macrophytes are important for olive perchlets. Re-establishment of olive perchlets in the Dewfish Demonstration Reach should be assisted by introduction of macrophytes. Several publications report the association of olive perchlets with aquatic plants (Allen 1996, Lintermans 2009, Moffatt and Voller 2002, Pusey *et al.* 2004). Olive perchlet eggs are adhesive and attach to aquatic vegetation and rocks (Allen 1996, Lintermans 2009). In the Brisbane River eggs of olive perchlets have been observed attached to *Vallisneria* and *Nymphoides* (Milton and Arthington 1985). Therefore macrophytes are not only important for adult olive perchlets, but for the early life stages as well.

Unspecked hardyheads

Unspecked hardyheads did not display many strong habitat preferences in the current series of experiments. The only significant result was a preference for sand over rock . There was also a tendency to favour macrophyte over sand but this was not significant. Prior to scouring of macrophytes at Bowenville Reserve on Oakey Creek, we observed and captured many unspecked hardyheads in and around macrophyte beds. After scouring of macrophyte beds during flooding unspecked hardyhead numbers dropped to low levels. This suggests some dependence on macrophytes. Lintermans (2009) describes the preferred habitat of unspecked hardyheads as still habitats with aquatic vegetation and sand, gravel or mud substrates.

It could be that juvenile stages or early life history stages that were not tested in this series of experiments are more directly dependent on macrophytes than the adults. Specimens of the closely related sub-species *Craterocephalus stercusmuscarum stercusmuscarum* (fly-specked hardyhead) have been observed to lay their eggs on aquatic vegetation in aquaria (Semple 1985).

Juvenile Murray cod
Some past field observations by us suggest that rock may be favoured by juvenile Murray cod. The majority of our captures of juvenile Murray cod in Storm King Dam near Stanthorpe occurred in complex rocky habitats, including crevices in artificial rock wall structures. The current series of habitat preference trials confirms the preference of juvenile Murray cod for rocky habitats. Rock was overwhelmingly preferred over each other habitat type. In the absence of rock, juvenile Murray cod chose both macrophyte and *Phragmites* over bare sand substrates. This clearly demonstrates a preference for cover. When given a choice between macrophyte and *Phragmites,* habitat use did not differ significantly, suggesting both forms of cover will be used if available and the preferred rock absent. There was a tendency toward slightly more use of macrophytes over *Phragmites*, but this wasn't significant.

Based on these results it seems clear that juvenile cod would benefit from the introduction of rocky habitats in the form of boulder piles or rocky reef structures. This may enhance juvenile recruitment or post-stocking survival of juvenile cod. Positioning rock piles or rocky reef type structures near Murray cod breeding structures such as Lunkers, cod pipes or logs could further enhance recruitment success of this species through minimising distances between spawning and nursery habitats.

Koehn (2009a) has observed that juvenile Murray cod (<150mm total length) tend to select high loadings of structural woody habitat in shallower habitats and closer to the bank than adults. We have also observed juvenile cod using complex small woody debris habitats and complex tree root habitats close to the bank in areas where rock was scarce or absent. Formation of these habitats may take time to develop at rehabilitation sites and is dependent on a mature functional riparian zone. Introduction of rock may more rapidly address Murray cod nursery habitat requirements and could be used as a functional habitat while longer term strategies to address riparian condition are being completed. In weir pool habitats, where it is often more difficult to address bankside habitat, use of rock structures set at different depths to account for fluctuating weir water levels could be a way to increase habitat complexity and improve recruitment.

Juvenile silver perch
For juvenile silver perch there was no significant preference between open sandy substrates and any of the more complex habitats (*Phragmites*, macrophyte and rock). This suggests juvenile silver perch may be quite comfortable in open habitats and may in part be related to their schooling behaviour. Schooling behaviour is one strategy used by some fish species to minimise predation risk.

When complex habitats were compared, silver perch preferred rock and macrophyte to *Phragmites* and preferred rock over macrophyte. This result is difficult to explain. If silver perch were seeking these habitats as cover, then it would be expected they would also be chosen over sand, but they were not. All that can be concluded from this is that *Phragmites* may not be important to silver perch juveniles.

Moffatt and Voller (2002) describe the microhabitat use of silver perch as often in open water (which concurs with non-avoidance of the open sandy habitat in our experiments). Moffat and Voller (2002) also report silver perch can be associated with submerged or emergent aquatic vegetation. They do not state whether this is adult or juvenile fish or both.

Most other publications describe only the macrohabitats used by silver perch. Macrohabitats include lowland turbid and slow flowing rivers (Lintermans 2009). Merrick (1996) reports that silver perch occur mainly in fast flowing waters, especially where there are rapids and races.

Silver perch are omnivorous and the diet includes aquatic plants, green algae and also some animals such as snails, shrimps and aquatic insect larvae Merrick 1996, (Lintermans 2009). Some of these animals are often associated with aquatic plants. Therefore aquatic plants may benefit silver perch by being a component of their diet and a habitat for some of their prey species.

Juvenile golden perch

Some past field observations by us suggest that *Phragmites* may be favoured by juvenile golden perch. On a number of occasions, especially during high flow events we have electrofished both juvenile and adult golden perch from *Phragmites* beds. The preference experiments confirmed that *Phragmites* is actively selected by juvenile golden perch over open sandy habitats.

Phragmites has declined in the Murray-Darling Basin, in part due to grazing down by cattle (Roberts 2000). Fencing of the riparian zone may assist in natural recovery of this species at some sites.

Golden perch juveniles also selected rock and macrophyte over open sandy habitat, demonstrating a strong preference for cover. Rock was preferred over *Phragmites*, but no preference was displayed between macrophyte and *Phragmites*, suggesting both habitat types will be used equally. No preference for the use of rock and macrophyte was observed suggesting both are suitable forms of cover.

Habitat restoration options

The main objective of this project was to investigate the habitat preferences of a range of small native fish with respect to options that could be introduced into a waterway for habitat restoration. The results indicate that a range of restoration options need to be considered to address the requirements and preferences of a broad range of species. The most suitable type of habitat to re-introduce will be site specific and dependent upon the existing habitat, species of fish present and the goal of the activity. Very degraded sites may require introduction of a range of habitats, whilst a species specific recovery may only require a single habitat. The following contains application recommendations for each habitat type that was investigated. It should be noted that all habitats also provide some bank stabilisation, sediment trapping and other ecosystem functions that are not discussed.

Rock as a habitat restoration option

It does seem clear that rock could benefit juvenile golden perch and juvenile Murray cod, which all preferred rock over open sand. There was also a tendency for adult carp gudgeons to use rock over sand. Juvenile Murray cod strongly preferred rock over all other habitat choices. Excluding unspecked hardyheads, rock was preferred by most species over *Phragmites.* It was also preferred by juvenile silver perch and adult carp gudgeons over macrophyte.

Therefore there does appear to be merit in introducing rocky habitat. One advantage of rocky habitat would be it is resistant to flooding. When macrophyte beds are swept away, rocky structure would still provide some species of fish with an alternative habitat. The most useful type of rocky structure would be one with overlapping rocks and boulders of various sizes to provide crevices where small fish could hide from predators. The larger boulders should be interlocked with smaller rocks to provide them protection from the current and to prevent them from washing away. It can be expected that rocky habitats will also become covered in biofilm and contribute to the productivity of the river. As suggested above positioning of rocky structures near Murray cod breeding habitats may help enhance recruitment of Murray cod. Rocky habitats would be a useful measure to address lack of juvenile cod habitat. Development of complex root masses and other complex woody habitats suitable for juvenile Murray cod close to the bank will require maturation of the riparian zone. Use of rocky habitats may be one way to ensure good recruitment of Murray cod while the riparian zone is in its recovery phase. Given Murray cod are listed as vulnerable nationally (Lintermans 2009), then actions to improve recruitment of this species will be important.

Macrophytes as habitat restoration options

Restoration of macrophytes should benefit adult carp gudgeon and olive perchlets, and probably also unspecked hardyheads. Murray cod and golden perch also selected macrophytes over open sandy habitat. Based on what is reported in the literature, recruitment of Murray-Darling rainbow fish should also benefit from restoration of macrophytes, as rainbowfish will use macrophytes as spawning habitat. The problem with establishing submerged macrophytes such as *Hydrilla* and *Vallisneria*, even though they may be useful fish habitat, is that they do not grow well in turbid waters. The shallow waters of Oakey Creek is possibly the only area where turbidity levels are consistently low enough for these species to establish at present in the demonstration reach.

Alternatively there are some macrophytes such as Nardoo *Marsilea mutica* water primrose (*Ludwigia peploides*), water snowflake (*Nymphoides indica*), wavy marshwort (*Nymphoides crenata*) and swamp lily *Ottelia ovalifolia* that have considerable underwater structure, but floating leaves. Figure 5 shows an example of floating attached macrophytes in the Durah Creek reference site. This site had good numbers and variety of small native fish species. Floating leaves enable these types of macrophyte to survive in turbid water. These native plants also have the added advantage of being somewhat ornamental, with attractive flowers or leaves. Therefore they may be an appealing planting for urban parkland settings such as Myall Creek, and provide fish habitat values at the same time.

For plantings of macrophytes to succeed ongoing suppression of carp numbers may be necessary as carp are known to uproot and damage some macrophytes (Roberts *et al.* 1995, Miller and Crowl, 2006, Gilligan and Rayner 2007). Continued suppression of carp numbers may also be necessary to promote natural regeneration of *Vallisneria* and *Hydrilla* at Bowenville reserve. Suppressing carp may also assist in preventing resuspending of sediments that contribute to turbidity.

Figure 5: Floating attached macrophytes at the Durah Creek reference site, including *Marsilea mutica* and *Ottelia ovalifolia*. Note the fine mesh fyke net set in this habitat.

Phragmites **as a habitat restoration option**

Phragmites australis was selected over open sandy habitat by carp gudgeon, juvenile Murray cod and juvenile golden perch. Most species preferred rock over *Phragmites*, but when compared to macrophyte there was no significant preference. The exceptions were olive perchlets and silver perch juveniles. Although for some species such as unspecked hardyheads, silver perch and olive perchlets *Phragmites* is not a preferred option for several other species it is potentially useful habitat that provides cover and feeding opportunities. During strong flow events we have observed a number of species amongst *Phragmites*, including golden perch and Bony bream (Figure 6).

Figure 6: Stunned golden perch following electrofishing in *Phragmites australis* beds in the Balonne River near St George.

Phragmites provides some protection from rapid flow. *Phragmites* should also be more resilient to surviving flooding than other aquatic plants and should be able to recover rapidly if protected from grazing. It can provide alternative habitat to macrophyte beds for some fish species until macrophyte beds recover.

Phragmites can be encouraged to establish by excluding or minimising access by cattle to the river bank. It can also be relatively easily propagated from seed grown from cuttings, clumps and rhizomes, but this is less successful than using seed (Parr 1987, Pistillo and Heritage 1996). Propagated plants can be planted into the shallow margins at the edge of the bank. Propagation of *Phragmites* may be a task suitable for community groups and help engender greater ownership of inland waterways and the issues affecting them.

Acknowledgements

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