

Section 4 Summary actions for conservation

Conservation of South Australian freshwater fishes requires recognition of current and future threats and actions to ameliorate them. Proactive measures are likely to be most effective in preventing further serious fish declines and minimising potential threats. Effective fish conservation is also most likely to be achieved when an ecosystem level approach is taken to ensure the survival of groups of species by protecting underlying habitat and environmental functions (flows). With historic neglect, ever increasing pressures from human development, and over half the States freshwater fishes already threatened with extinction, the reality is that urgent reactive measures are required in many cases involving hard decisions and decisive actions to prevent population or species loss.

Specific threats to species and counter actions have been detailed in species Recovery Outlines (Sections 2), and Table 5 provides example actions which could be used against the broader threats detailed in Section 3. This section provides a combined perspective of proactive and reactive measures, with an overall summary of higher recommendations for stakeholder consideration and involvement.

Table 5. List of possible actions against potential threats to freshwater fishes in South Australia.

Threat category	Examples Actions
1. Hydrological (flow) alteration	
a) Loss of water from a system/habitat	Adequate and proactive Water Allocation Planning (environmental water provisions); improved hydrological knowledge; government and community flow restoration programs; NRM/Catchment Management plans; improved Legislative Protection
b) Altered flow seasonality and variability	
2. Habitat loss and degradation	
a) Removal and alteration of habitat (broad)	Catchment scale restoration projects; flow restoration; targeted stream improvements of riparian and instream habitat (e.g. stock control, revegetation, resnagging, stormwater treatment); improved and considered environmentally sustainable development guidelines; tighter habitat protective measures (legislation and local planning); NRM/Catchment Management plans
b) Removal and damage of riparian vegetation	
c) Loss of instream cover	
d) Artificial barriers to fish movement and gene flow	
3. Lowered water quality	
a) Fish kills	Improve and protect environmental water provisions; increase stormwater treatment and industrial safeguards (e.g. winery waste disposal, saline water discharge, chemical spills); promote best catchment management practices (e.g. reinstating riparian buffers and revegetation, minimise agricultural runoff and nutrient/sediment inputs). Prompt reporting and action.
b) Sub-lethal responses (e.g. reduced spawning or feeding ability)	
c) Reduced habitat quality	

Table 5 continued....

Threat category	Examples Actions
4. Alien species & stocking (biological pollution)	
a) Biological impacts (competition, predation, aggression, habitat modification)	Identify and control impacts in key areas and habitats through physical removal, control of stocking or environmental manipulation/restoration; promote the environmental requirements of native species to increase their resilience; legislation and education for proactive measures to prevent new introductions or expanded translocations); develop a sound translocation policy
b) Transfer of disease and parasites	Research to increase understanding of the occurrence, frequency and impacts of disease and parasites in wild populations; develop a process for routine and responsive disease testing of native and introduced fish (wild and translocation); education to prevent aquarium fish discards; assess quarantine procedure and risk (importation of fish, movement of equipment); prevent inter-basin transfer of organisms (e.g. alternate water supplies/transport methods, water treatment, screens)
c) Genetic impacts	Develop a sound translocation policy and legislation; education within government and the community to improve awareness of impacts (preventative control)
5. Exploitation	
a) Reduced abundance and reproductive potential	Carefully research and regulate sustainable harvest; promote community ownership and involvement to prevent overfishing, ecosystem impacts and illegal harvest
b) Trophic cascades and altered states	
6. Population decline	
a) Loss of genetic diversity & reduced ability to adapt to change	Recognise and protect threatened species and populations; minimise threats to already restricted population (reactive and proactive); undertake flow and habitat restoration to allow natural expansion; devise contingency plans for urgent conservation measures if required (e.g. captive maintenance)
b) Restricted range and/or small populations	
c) Failure to include fishes in management and planning	Improve awareness of the presence, plight and requirements of freshwater fishes; promote and distribute Action Plan information and recommendations for incorporation into the activities and thinking of those undertaking activities (doers), decision makers, researchers and funding bodies;
7. Climate change	
a) Change in habitat and flow	Encourage and promote appropriate renewable energy sources; act to reduce energy and water consumption; build resilience to native populations through water allocation planning and habitat improvement

4.1. SOME IMPORTANT FIRST STEPS

Systematic frameworks A prerequisite for conservation, research and management of threatened species is a sound systematic framework which involves an understanding of species boundaries and spatial genetic structure. Freshwater fishes in general show high levels of cryptic species (i.e. species awaiting detection) and genetic diversity. Undetected species have the potential to confound biological information or worse result in the loss of species yet to be recognised. There are several examples of recent studies demonstrating multiple species either at one location or within distinct aquatic systems of South Australia: Carp Gudgeons, Smelt, Southern Pygmy Perch (see Figure 17), and Golden Perch^{13,16,269,270}. Spatial genetic structure and information on species/population genetic diversity helps to determine the scale and priorities for management and thus protect distinct or unique evolutionary or management units (e.g. stream catchment, wetland or spring system, Drainage Divisions)²⁷¹. The few freshwater fishes in South Australia so far investigated show strong patterns of spatial genetic structure (River Blackfish, Southern Pygmy Perch, Yarra Pygmy Perch, Mountain Galaxias, Smelt^{13,16,55,130}).

Systematic frameworks should be investigated for all freshwater fish species in South Australia, even for 'common' species that may actually have more complex genetic patterns. Section 2 contains priority recommendations for threatened species including resolving taxonomic relationships with species and populations interstate. Taxonomic research is urgently required to describe and provide characters to distinguish cryptic species particularly as it forms a critical link to field identification, research and conservation management.

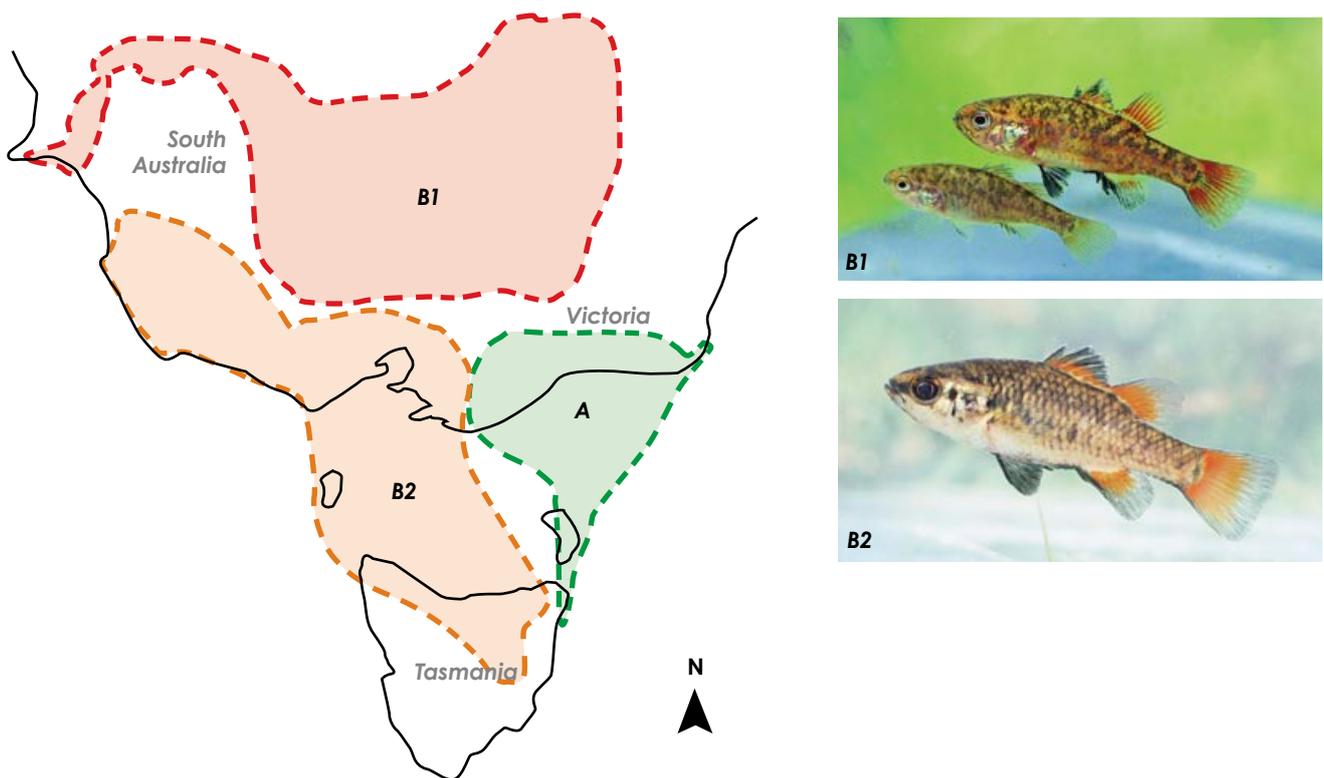


Figure 17. Systematic framework for Southern Pygmy Perch in south eastern Australia. Formerly considered a single wide-spread species, we now know that two distinct species exist. An eastern species (A) occurs in Gippsland, Flinders Island and north eastern Tasmania. The western species has two distinct genetic and geographic groups (likely sub-species): (B1) Murray-Darling Basin including the Mount Lofty Ranges and (B2) south east South Australia, western Victoria and northern Tasmania. Hence the new systematic framework identifies several different manage units in South Australia, with special relevance to declining population in the lower River Murray region^{13,22}.

Distributional data Information on the number of fish species and their distribution is critical to assess priorities for management and planning, and also links to assessing population trends. Freshwater fishes have been poorly surveyed in many areas of South Australia. For example, we know very little about the species occurring in the River Torrens that runs through the heart of Adelaide. Only opportunistic historic records occur, and early cataloguing and modern programs such as biosurveys across the State did not include fishes. Most of the available data is thus from more recent specialised fish surveys (see Section 1 and Appendix 3). A readily searchable database of State wide distributional information is required to incorporate existing data and highlight knowledge gaps.

Examples of data gaps include:

- Southern Fleurieu Swamps and waterways (only broad scale assessment conducted to date).
- Western Mount Lofty Ranges - survey intensity is patchy but it is an important region considering the amount of habitat present and levels of development.
- North Eastern Mount Lofty Ranges.
- River Murray wetlands – still a number of areas to be sampled for smaller species, especially with wetland drying occurring.
- Flinders Ranges – important refuge habitats and species to be mapped.
- Eyre Peninsula - limited data for systems including Todd River.
- Lake Eyre Basin – many regions need to be mapped and compared to historic data, especially important dry period refuges in the Cooper Creek and review of status of mound spring habitats and fishes.

Urgent conservation measures Many species with restricted and/or severely fragmented distributions and numerous near and present threats will require immediate action to secure sustainable populations into the future. The potentially short lifecycles of smaller species also heightens the need for action as one or successive years failed recruitment could have serious impacts. Species such as Yarra, Southern and Variegated pygmy perch, Flinders and Southern purple-spotted gudgeon, Murray Hardyhead and River Blackfish appear particularly at risk. The range of urgent conservation measures available will be specific to the location and habitat conditions locally and the broader catchment but could include:

- Special Environmental Water Provisions.
- Localised habitat management such as fencing or engineering works.
- Temporary captive maintenance or translocation to other suitable habitat²⁷².
- Regular monitoring.

Targeted awareness raising Given the low level of current available knowledge and awareness surrounding native fishes, some information should be targeted to highlight the presence and requirements of key threatened species or populations to ensure that relevant stakeholders are fully aware of their presence and implications of their actions/in-action. To some extent this has occurred through the invitation of input from key stakeholders on draft versions of this document. Regional or species workshops would be a valuable way to bring stakeholders together, present background information and build capacity to identify species, their conservation requirements, and scope and initiate actions and resources.

More general publicity of the plight of native fish could also generate some initial actions that can create momentum behind a more comprehensive approach to future protection, and may also help to engage the community and managers to provide new information to their knowledge of threatened species.

4.2. ADDRESSING HYDROLOGY, HABITAT AND WATER QUALITY

Environmental Water Requirements and Provisions Water is a primary consideration for securing threatened freshwater fish species. If appropriate hydrology is provided so that water is not a limiting factor, a sound platform for other restoration and conservation is secured. Management of surface and groundwater sources can take two basic approaches: (a) proactive or preventative measures to secure existing water sources (especially for unregulated systems like Coopers Creek and for catchments, sub-catchments or wetlands with less altered hydrology), and (b) restorative measures which is typically the more difficult task of returning environmental water to systems with heavy water resource development (e.g. areas with lots of farm dams or plantations, large reservoirs, high groundwater use and those that have been drained).

Options for returning environmental water include specific allocations in larger systems such as the River Murray and from reservoir releases in the Mount Lofty Ranges. For smaller systems, the management of farm and irrigation dams (e.g. adjusting overall capacity and adding low flow diversion), careful forestry planning and regulation/management of groundwater use are the main avenues. It is important that the methods of water return are not simplified to focus on flow volume alone, but should consider various other aspects of natural flow regimes (e.g. smaller flows over summer which are critical for protection of core refuge habitats, flow events with the appropriate timing and duration to allow fish migration, or flood peaks which mimic the natural rates of rise and fall).

Environmental Water Requirements (EWR) are delivered as provisions through the Water Allocation Planning (WAP) process. In the past, arbitrary and often small targets have been set for the amount of water to be retained or provided for the environment (10-30% of natural runoff or volume). However, studies investigating flow components and related processes required to meet environmental objectives (e.g. self sustaining fish populations, protection of core refuges) are likely to be much more appropriate and effective. Key challenges for future EWR assessments and reviews of existing WAPs will be to protect critical flows or refuges and to incorporate climate change scenarios as part of changing human and environmental needs in the future.

The establishment of truly effective environmental water provisions is likely to require an improved understanding of our freshwater ecosystems, freshwater fish biology/ecology, hydrological interactions between surface and groundwater sources, and models which account for variable South Australian climates (e.g. identify critical lows). Programs will require sufficient resources for education and enforcement, and importantly, water allocation planning requires support and commitment from community groups, business and government. Effective environmental water provisions can only be achieved if there is greater awareness of the problems facing our rivers and native fishes (see Brisbane Declaration below). An appreciation of the cultural, recreational, environmental and commercial importance of freshwater fishes is also needed to ensure a concerted commitment is made towards their conservation.

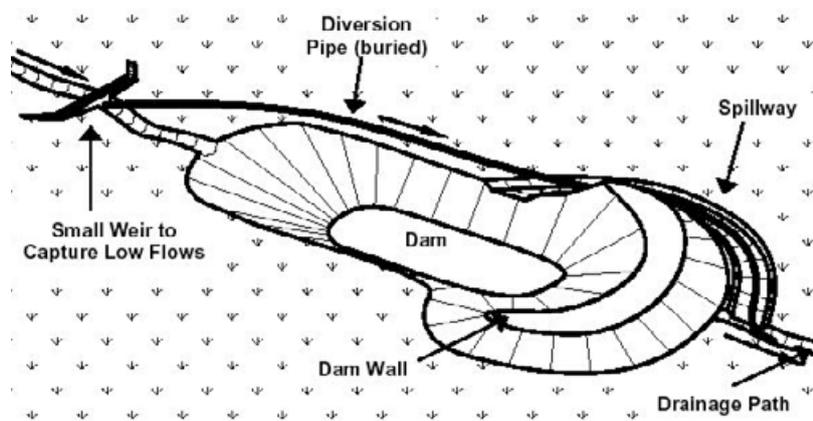


Diagram of a low flow diverter – designed to pass smaller flows critical to sustaining aquatic systems

The Brisbane declaration is a succinct summary of the need for understanding and providing Environmental Water Requirements. It is derived from summary findings and a global action agenda that address the urgent need to protect rivers globally, as proclaimed at the 10th International River symposium and International Environmental Flows Conference, held in Brisbane, Australia, September 2007. The conference was attended by more than 750 scientists, economists, engineers, resource managers and policy makers from more than 50 countries.

The Brisbane Declaration: Environmental Flows are Essential for Freshwater Ecosystem Health and Human Well-Being, key findings include:

- **Freshwater ecosystems are the foundation of our social, cultural, and economic well-being.** Healthy freshwater ecosystems – rivers, lakes, floodplains, wetlands, and estuaries – provide clean water, food, fiber, energy and many other benefits that support economies and livelihoods around the world. They are essential to human health and well-being.
- **Freshwater ecosystems are seriously impaired and continue to degrade at alarming rates.** Aquatic species are declining more rapidly than terrestrial and marine species. As freshwater ecosystems degrade, human communities lose important social, cultural, and economic benefits; estuaries lose productivity; invasive plants and animals flourish; and the natural resilience of rivers, lakes, wetlands, and estuaries weakens. The severe cumulative impact is global in scope.
- **Water flowing to the sea is not wasted.** Fresh water that flows into the ocean nourishes estuaries, which provide abundant food supplies, buffer infrastructure against storms and tidal surges, and dilute and evacuate pollutants.
- **Flow alteration imperils freshwater and estuarine ecosystems.** These ecosystems have evolved with, and depend upon, naturally variable flows of high-quality fresh water. Greater attention to environmental flow needs must be exercised when attempting to manage floods; supply water to cities, farms, and industries; generate power; and facilitate navigation, recreation, and drainage.
- **Environmental flow management provides the water flows needed to sustain freshwater and estuarine ecosystems in coexistence with agriculture, industry, and cities.** The goal of environmental flow management is to restore and maintain the socially valued benefits of healthy, resilient freshwater ecosystems through participatory decision making informed by sound science. Ground-water and floodplain management are integral to environmental flow management.
- **Climate change intensifies the urgency.** Sound environmental flow management hedges against potentially serious and irreversible damage to freshwater ecosystems from climate change impacts by maintaining and enhancing ecosystem resiliency.
- **Progress has been made, but much more attention is needed.** Several governments have instituted innovative water policies that explicitly recognize environmental flow needs. Environmental flow needs are increasingly being considered in water infrastructure development and are being maintained or restored through releases of water from dams, limitations on ground water and surface-water diversions, and management of land-use practices. Even so, the progress made to date falls far short of the global effort needed to sustain healthy freshwater ecosystems and the economies, livelihoods, and human well-being that depend upon them.
- **Environmental flows describe the quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems.**

Habitat protection and rehabilitation Options for habitat protection and rehabilitation are essentially limited only by the ideas and capacity of groups and individuals involved, but it is important that some basic principles are followed. Many of our ecosystems have adapted to change, and are now relying on altered conditions (e.g. Murray Hardyhead in salt evaporation basins, River Blackfish and Willows). Essentially this means that the objectives and implications (positive and negative) of any planned restoration should be carefully assessed at the outset. The same considerations apply to changes in land use or management regimes.

Given that much of our knowledge on freshwater ecosystem restoration is in its infancy, it's important that any restoration program include sufficient monitoring to identify if restoration targets have been met. By monitoring sites before, during and after restoration activities have occurred, it enables an adaptive management approach to future design and implementation of restoration programs.

Although often aiming to assist in the recovery of single threatened species, restoration programs should adopt an ecosystem approach, which may include managing fish communities. Ideally, actions should be aligned within broader plans (e.g. NRM/Catchment Management) and consider the catchment scale approach²⁷³. There are various guidelines available that may be of use in design and implementation of on-ground works^{274,275,276}.

Some fish related management programs and works that could relate to species recovery include:

- Environmental water provisions will help to maintain or increase the diversity of physical and biological habitat types.
- Strategic revegetation to increase suitable stream bank vegetation cover and related instream cover (shade, snags, leaf litter etc), provide a buffer from terrestrial impacts (edge effects such as runoff), and to upper catchment areas and swamps to help restore a flow energy balance (reduce incision) and improve water holding capacity for later release as low flow or springs.
- Instream works to improve habitat availability including options to stabilise stream geomorphology (e.g. banks), add cover (e.g. resnagging, rock banks, aquatic plants) and remove artificial structure or invasive species.
- Stock exclusion will help to minimise trampling of sensitive edge habitat and improve water quality. Even reducing stocking rates or limiting stock access during very wet and dry times could improve the condition of important stream edge or wetland habitat.
- Refuge sites should be targeted for habitat protection and restoration measures, with works expanding out from these points to encourage natural recolonisation.
- Siltation impacts should be targeted with revegetation and other physical control such as stormwater treatment especially for new developments (part of ESD guidelines –see later).
- Fish passage at artificial barriers (physical and biological) should be provided across the size spectrum of local species using modern or novel engineering solutions (but need to check and consider the impacts to species isolated upstream especially in reference to introduced predators).

On ground works such as fencing, revegetation and the provision of alternate watering points will not only help protect and expand populations of native fish, but also offer a wide range of other benefits such as:

- Improved water quality - for the environment and stock (less parasites and disease risk).
- Stock management benefits – e.g. easier to move.
- Possible financial gains - through efficient management, reduced erosion and loss of land.
- Biodiversity benefits - through the return of native birds and other wildlife.
- Aesthetics (visual) improvement - as green healthy areas look good!
- Social benefits - provides a sense of achievement and ownership.

Water quality Maintaining and improving water quality is essential for conserving our freshwater fishes. Water quality is heavily linked to environmental water provisions (e.g. for dilution and oxygenation), but the control of point source and diffuse pollution in rural, industrial and urban environments is also required. It is important that preventative measures are taken to ensure low or no levels of deleterious or toxic substances reach aquatic systems. As for habitat protection and restoration, many options for exist for improving water quality across South Australia, with many of the options covered under Environmental Protection Authority (EPA) guidelines or other action plans (e.g. salinity). Examples of water quality improvement methods include:

- Provide effective and monitored stormwater treatment for suspended solids (turbidity), nutrients and toxic substances (e.g. heavy metals, ammonia).
- Greater consideration for developments along side water courses to minimise stream bank disturbance, silt laden runoff and dust settlement (and include contingency for flooding).
- Identify and minimise risks from industrial pollution, especially in sensitive areas.
- Prevent saline discharge into sensitive aquatic habitats (e.g. drainage).
- Improved design in road infrastructure that discourages pigeon roosting (to reduce faecal matter entering the system).
- Riparian (stream edge) buffers to help filter nutrient and silt runoff and to protect against bank erosion.



A restored section of Mosquito Creek, SESA with healthy edge and instream vegetation, improved water quality, stable banks and developing canopy

4.3. MANAGING ALIEN (INTRODUCED) FISH

Preventative measures The easiest and cheapest way to control the impacts of alien fish is to prevent their establishment in the first place. Hence, reducing avenues of introduction (Section 3.4) should be the target of review, education and legislation to limit chances of additional species and disease entering our aquatic habitats²⁷⁷. This is of particular importance for areas which currently have few or no alien species established such as arid zone Springs, Cooper Creek and other central waterways, the Upper South East and parts of the Southern Fleurieu Peninsula and Mount Lofty Ranges.

Some primary recommendations include:

- Increased education within the community and government to improve awareness of the impacts of alien species (thus increasing the level of preventative control). Promote the fact that native fish occur in many waterways and that they play an important role in the functioning of such ecosystems.
- Review and possibly regulate fingerling sales to the public from local and interstate hatcheries. The aim of this initiative would be to further reduce the potential for inappropriate releases of alien (including non endemic) fish species.
- Develop a freshwater fish translocation and stocking policy (see below).
- Inform the community on the impacts of aquarium escapees and engage with the aquarium trade to spread the message and divert unwanted fish (and plants) to alternate sources.
- Encourage greater community involvement in conservation programs.
- Identify and engage groups likely to release alien for cultural reasons.
- Respond quickly to new incursions to prevent spread and develop the contingency and capacity to respond (including remote locations).

Preventative measures of course do not deal with the significant issue of already established species, although several principles could help minimise their spread and control, with topics on control explored below.

Environmental management By managing the environment, the impacts to native fish posed by introduced species can be reduced in two general ways:

- To promote the environmental requirements of native fishes to increase their population size, health and hence resilience to the impacts of introduced species. For example, increasing habitat complexity (e.g. fencing to protect sensitive riparian vegetation and resnagging) may lessen direct interactions between alien and native species; environmental flows may maintain habitats as a refuge for native species; or combined suitable habitat and flows may allow strong native fish recruitment and subsequent larger populations to help negate the effects of predation and competition. Furthermore, healthy native fish populations, with naturally occurring larger predators such as Murray Cod, may in fact help restore a natural balance through their feeding on introduced fish.
- Provide environmental conditions which discourage or impact introduced species via protection of natural conditions (less disturbed environments) and manipulation or restoration in more disturbed areas. Several studies have found that regulated environments in the Murray-Darling Basin can favour the recruitment and establishment of species such as Goldfish, Carp, Redfin and *Gambusia*^{25,240,278} whilst natural environmental extremes such as flood and drought limit the distribution and success of species like *Gambusia*, trout and Redfin^{3,118,279,280}. Hence, within Environmental Water Requirement studies and provisions, seeking naturally variable flow regimes (e.g. floods, water level fluctuations) and water quality conditions (e.g. temperature and salinity) may contribute to managing introduced species.

Translocation and stocking Current attitudes and practices in regard to fish stocking and translocation in South Australia are in contrast to those of other vertebrate groups. For example, it is

not legal to release the introduced Red Fox and in fact, extensive programs of control exist across the country to mitigate their impact on the natural environment. However, it is still permitted to release a comparably significant exotic predator, trout, into waterways and areas that contain threatened fish species, even though it may directly impact on the survival of native species. While active stocking of exotic species might only be a part of the problem that native fish face, it is an area which can be controlled and is currently something which sends a disappointing message about our commitment to the conservation of our unique native fish species.

A formal policy for introduction, translocation and stocking in South Australia, supported with a legislative and administrative framework, is required to identify and minimise risks of incursions to artificial and natural waterways. Ideally, the policy should align with that for other vertebrates in South Australia²⁷², as well as the National Policy for the Translocation of Live Aquatic Organisms (1999). Such a policy would also raise awareness about the impacts of both exotic and Australian native species outside their natural range, and define the appropriate methodology to minimise or prevent risk to wild fish populations and ecosystems.

Some key elements may include:

- Risk assessments for local environments and species.
- Developing environmental safeguards for the timing and nature of any remaining stocking, especially related to threatened species and during periods of environmental stress.
- Developing understanding of genetic structure in native fish populations to facilitate appropriate management and breeding of genetically appropriate stocks to supplement wild populations.
- Ensure strong protocols and procedures are maintained to minimise the risk of introducing disease and parasites to wild populations.
- Coordination with interstate agencies for shared catchment areas.

For translocations to artificial habitats (e.g. dams), a range of factors should be considered in species selection²⁵¹:

- Wetland position – can species escape? If so it may then be appropriate to limit the release options to those species which occur naturally in the local area to limit the ecological impact and genetic contamination.
- Accurate recent information on local native fish and other important ecological assets and their distribution.
- Biological characteristics of target species to ensure the broader wetland environment is conserved.
- Collection of broodstock from the wild should not threaten the viability of the source population.

Other control options Control of alien species is difficult once firmly established but there are several methods and emerging technologies aimed at suppressing or removing introduced species. Control should be targeted to areas where it is likely to have the greatest benefit and where identified/predicted impacts are high or of significant consequence.

In small systems, simple physical control such as angling or permitted physical removal including netting may help to provide habitat for native fish to colonise²⁶¹ or lessen the impacts to restricted native fish populations (e.g. removal and community fish outs of Redfin surrounding Pygmy Perch habitat²²). Outright control with fish poisons may be possible in small areas, but great care is needed to ensure care of the general environment²⁸¹.

Identifying biological weaknesses of alien species (such as key spawning requirements, movement patterns or tolerances) may then provide management options that can be targeted for engineering solutions or environmental manipulation. For example, Carp separation cages are a new technology which targets a specific behaviour to enable selective harvest at places such as fishways²⁸². Barriers have also been built to protect small pockets of refuge habitat for native fish and prevent upstream movement of trout in Victoria²⁸³. Biological control (disease agents) and gene technology are being trialled as potential control methods for Carp and one day may also be available for use in the control of *Gambusia*.

Minimising disease risk Currently live fish can only be brought into South Australia if they have been certified free of disease. However, as many pathways exist, disease risk should be reviewed concurrently with any introduction as a proactive measure (i.e. incorporated into a translocation and stocking policy). This will help prevent potentially costly and devastating disease outbreaks. Any proposal to release fish to the wild should specifically include a review of quarantine procedures (including the movement of equipment), and other potential disease pathways such as interbasin water transfer (e.g. alternate water supplies/transport methods, water treatment, screens). Reducing the opportunity of new diseases and parasites is the most cost effective way to ensure the protection of freshwater fish in South Australia.

Research to improve our knowledge of current and potential diseases and parasites of wild freshwater fish in South Australia is required. A program to receive enquires, diagnose noticed problems, and routinely monitor for new outbreaks needs to be developed. Importantly, this is beginning to be addressed through initiatives such as the Australian Wildlife Health Network, a network that has been designed to capture information and investigate occurrences of existing and emerging diseases.

4.4. NEW DIRECTIONS IN FISH CONSERVATION

State of the art research and management Developing a better understanding of the role and response of fishes within ecosystems, as well as the response of fishes to various management regimes, will greatly aid in the protection of threatened species and communities in general. Sound research and management strategies are required in fields such as development and planning (in particular Water Allocation Plans and Environmental Water Requirements), habitat restoration, alien species management and tackling climate change. The careful monitoring of our fish populations is likely to play a pivotal part in ensuring adaptive management frameworks are available.

The triple bottom line Increasing awareness of fishes, biodiversity and natural systems will help to increase their value and give them greater consideration within the community, business, planning and development, and the day to day activities of government. Increased understanding and appreciation of the benefits provided by our native animals and habitats is needed to better align their conservation value with economic and social values. This will better enable their true conservation benefit to be fully realised. Ecologically sustainable development (ESD) is seen as way of harnessing natural resources whilst protecting their existence and function, whilst in reality, many changes in land use and development will have some form of negative environmental impact. It is therefore critical to ensure that when development impacts are identified, the effects are minimised and clear efforts are made to incorporate habitat protection and restoration with any proposal. ESD underpins many pieces of legislation in South Australia, however, greater emphasis on this philosophy is required within planning, policy and development guidelines to accurately reflect the needs of fishes and aquatic habitats.

Monitoring habitat and flow restoration The key to any successful restoration program is the development of detailed plan at the outset, including a detailed monitoring strategy and good documentation. Programs should include S.M.A.R.T. (specific, measurable, achievable, realistic and time-bound) targets to enable progress to be readily assessed and to utilise resources most effectively. This approach allows for adaptive management, enabling past experiences to be incorporated into programs, rather than acting in isolation or repeating previous mistakes.

The restoration of South Australia aquatic habitats has seldom included objectives relating specifically to fish, although there are some significant recent examples in the River Murray system such as the Fishways Program, and an increase in the occurrence of Environmental Water Requirement studies. Hence, while actions such as fencing and exotic plant control in theory provide benefits for fishes, this is often not supported with data showing the response by fish as key environmental indicators. In some areas, restoration efforts aimed to enhance aquatic diversity will be severely hampered by the high abundance of exotic predatory fish and this requires specific recognition within broader catchment management programs.

A key recommendation to underpin both environmental restoration and risk assessment is the undertaking of routine monitoring to identify risks and examine fish community and habitat state before, during and after actions.

Tackling and preparing for climate change The ability of fishes and other biota to cope and ultimately adapt to climate change will depend on the characteristics of particular species and ecosystems, some level of management and probably in many cases, chance. In a sense, we currently have a small window of time to repair damaged systems and ensure populations are as healthy as possible in the lead up to any change. The best prescription for climate change is to sensibly manage and protect systems from external influences (e.g. habitat damage). Emphasis on adequate environmental water allocations will ensure healthy habitats and strong populations exist to face any future change. Research to understand tolerances and requirements of native fish will also help to identify key areas of impact and hence targets for action.

The other aspect of tackling climate change is reducing use of and reliance on carbon. There is an increasing awareness of things that individuals, businesses and governments can do to reduce environmental impacts, such as switching to renewable energy, using less energy for transportation and living, minimising consumption, packaging and waste. Environmentally sensitive plantation (i.e.

not impacting stream flows) and revegetation is a growing consideration, particularly with the rapid increase in carbon credit and carbon offset initiatives.

Fishways Fishways or fish ladders provide a physical conduit for species to scale and pass artificial physical barriers. Recent research and thinking on fishways has resulted in improved design, with structures now engineered to cater for local conditions, the swimming ability of native species, and also their biology and behaviour^{151,284,285}. Fishways can range from significant engineering works to small modifications or alternate movement pathways such as artificial creeks. Improving fish passage has been a major focus in the Murray-Darling Basin, with fishways on the Barrages and weirs along the Murray proving effective at allowing passage to a variety of species and sizes of fish during low flows (which now predominate in the system conditions¹⁴²). Fishways have also recently been installed at the mouth of the River Torrens, and also as part of a restoration program to restore water levels in the Piccaninnie Ponds area.

Recommendations relating to continued progress in restoring fish passage include:

- An inventory of barriers on waterways in South Australia ranging from major obstacles to critical local obstacles such as road culverts²⁸⁶.
- Monitoring to assess impacts of barriers to help prioritise actions. This includes assessing fish populations that may be conversely protected by barriers (e.g. limiting introduced fish access).
- Remove or construct appropriate fishways on priority barriers that inhibit migration.
- Potential new barriers (e.g. flood mitigation dams and gauging weirs) must include fishways.
- Monitor the effectiveness of fishways including fish movement and upstream community change. The modification of structures may be required in some instances.



A new fish ladder (circled above) at the mouth of the River Torrens allowing movement of fish from the sea into freshwater over the Breakout Creek weir

Fisheries Within fisheries legislation and management there is a move toward ecosystem based fisheries. This includes the recognition of the need for healthy habitats and ecosystems that can then provide for ecologically sustainable development (harvest) of wild fishes. Under this premise, harvest and management of fishes needs to reflect the highly variable nature of aquatic environments in South Australia and heavy alteration of flow regimes and habitats. For example, for some species that are highly threatened, harvest in the short-term is not sustainable and management regulations may need to have sliding scales to protect important breeding stock during times of natural or induced drought (e.g. Lake Eyre Basin Golden Perch and Murray Cod). A benefit of proper ecosystem based fisheries is that the recreational, commercial and cultural values of fisheries will provide awareness and promote better environmental management and health to support human values and needs. Conversely the approach invokes the responsibility of stakeholders to ensure that their activities are both sustainable to the species and ecosystems they target. This obviously requires good communication, awareness and involvement of the various stakeholders across conservation, natural resource development, recreation and heritage.

Positive new directions in fisheries also include a growing 'catch and release' ethic which, if supported with careful handling and treatment of fish, promotes sustainable recreation. Some fishing groups are realising the importance of healthy aquatic habitat and flows in protecting fish stocks and are getting involved with local habitat improvement initiatives or providing input and support to environmental water provisions.

Captive management Maintaining threatened species in captivity for short or long time periods should be seen only as a last resort effort to protect against catastrophe such as potential local extinction. A capacity for maintaining fish in captivity should not be cause for reducing efforts to conserve species in the wild. There are also high level of risks associated with captive maintenance, such as potential fish losses, maintaining genetic variation and fitness, and disease contamination²⁸⁷. Maintaining fish in captivity is costly (i.e. time consuming work for a long period) and places greater responsibility on individuals and management for species survival.

The method can however provide an important backup under extreme scenarios and has value in education on the plight of species. There may be different goals for captive fish including:

- Temporary captive maintenance – fish are held temporarily until suitable conditions occur and are then returned to the point of capture.
- Establishment of an ex-situ population – fish are maintained, spawned and reared in captivity as a backup in case of catastrophe and as a resource for conserving the wild population.
- Population supplementation or re-introduction program – major local declines or extinctions can drive captive breeding initiatives to supplement or re-establish a population with fish bred in captivity (usually from original broodstock).

Each of the above goals, and indeed species, can require a different approach to captive maintenance (e.g. temporary care of adults versus providing space and conditions for spawning and rearing juveniles) and therefore programs must be mindful of different variables such as the potential short life span of some smaller species. Re-stocking and sustaining captive populations requires consideration of genetic issues to avoid negative impacts from reduced genetic diversity. Re-stocking initiatives must be done in conjunction with the maintenance and/or restoration of habitat, utilising avenues such as environmental water provisions, habitat restoration and engineering solutions to do this. Timing of a decision to undertake captive maintenance is also important as it may be too late once a species is already on the edge of extinction¹¹⁹. Recent examples of captive maintenance include Yarra Pygmy Perch from Lake Alexandrina and Southern Purple-spotted Gudgeon^{113,119,129}.

4.5. IMPROVING PROTECTION

Legislation There is currently a cross-match of legislation available to protect fish species and habitats in South Australia, with the best opportunities to improve its effective use being through a greater focus on developing or strengthening specific policy and coordination between government agencies. As with most legislation, increased community awareness (and hence community support) is needed to recognise and respond to what may constitute a potentially significant impact (e.g. page 167). Some aspects of government policy, such as permitted release of exotic species, conflicts with other legislation including "No Species Loss" and habitat restoration initiatives (e.g. Naturelinks), and a review to identify and address such perverse incentives would be a major advance in fish conservation in this state.

A very brief synopsis of the objectives and application of the relevant legislation is provided below, but for more information consult the Acts in detail (www.austlii.edu.au) or contact relevant government departments:

- **EPBC Act 1999:** provision for protecting nationally listed species (8 of which occur in South Australia) and ecological communities (Desert Mound Springs and Southern Fleurieu Swamps): 'avoiding, remedying or mitigating any adverse effects of activities on the environment and to prevent, reduce, minimise and, where practicable, eliminate harm to the environment'. The list of federally threatened species and ecological communities now warrants a review, primarily to incorporate new information available on South Australian fishes and freshwater ecosystems. It is likely the several additional South Australian freshwater ecological communities are eligible for listing under the *EPBC Act* (e.g. Lower South East rising spring habitat).
- **Natural Resources Management Act 2004:** the most holistic legislation relating to protection of ecosystems, ecological drivers (flow and habitat) and species with an overall aim to assist in the achievement of ecologically sustainable development. Objectives are wide ranging and cover many important aspects such as: recognising and protecting the intrinsic values of natural resources; biodiversity conservation; protecting, restoring and managing ecological systems or catchments, prevention or control of impacts caused by pest species; and education and capacity building. Incorporates the Water Resources Act 1997.
- **National Parks and Wildlife Act 1972:** provision for the official listing of conservation status of threatened species and the protection and management of species within reserves. Fish have been considered for future specific inclusion^{38,286}, but this must be formalised to provide an official conservation list.
- **Fisheries Management Act 2007:** ensuring, through proper conservation, preservation and fisheries management measures, that the living resources of South Australian waters are not endangered or overexploited. Main application has been: 'Protection' of species from exploitation, regulation of take (e.g. commercial and recreational fisheries), and controls on exotic species.
- **River Murray Act 2000:** aims for a healthy River Murray with specific river health, environmental flow and water quality objectives including that the key habitat features in the River Murray system are to be maintained; wetlands of national and international importance are to be protected and restored to enhance ecological processes; barriers to the migration of native species of animal are to be avoided or overcome; the extinction of native species of animal and vegetation associated is to be prevented.
- **Environmental Protection Act 1993:** designed to safeguard the life-supporting capacity of air, water, land and ecosystems within an ESD framework and has a mandate for avoiding, remedying or mitigating any adverse effects or harm of activities on the environment.
- **Development Act 1993:** regards all matters of resource management with aims that include to facilitate sustainable development and the protection of the environment and to encourage the management of the natural and constructed environment in an ecologically sustainable manner.



TOP Angas River major instream earthworks near Strathalbyn
 BOTTOM LEFT Bremer River dammed and filled with silt as part of road works at Harrogate
 BOTTOM RIGHT Finnis River dammed, flooding small pool habitat and blocking fish passage

Examples of recent (after 2002) habitat destruction in threatened species habitats in the Eastern Mount Lofty Ranges undertaken by a developer, local council and landholder respectively. Greater legislative protection and enforcement is required to provide sufficient deterrent to prevent such destructive actions, combined with a greater awareness of the presence and requirements of fish within regional planning, government bodies and the wider community.

Links to other plans There is a plethora of existing plans and programs which have the potential to consider and incorporate fish information or actions to help towards species recovery and improved awareness. Some plans have specific targets that directly benefit threatened native fish (e.g. MDBA Native Fish Strategy²³⁶) and compliment the objectives of this Action Plan. However, other broadly related plans often have a tailored framework that focuses on their relevant topic, with significant gaps in objectives and information relating to native fish. For these and developing plans, especially regional NRM plans, the presence of a specific freshwater fish Action Plan provides an information source and avenue for holistic treatment and identifying relevant threats and actions. Table 6 provides an initial list of relevant plans that can assist in delivering positive outcomes for South Australian native fish.

Table 6. Synopsis of plans relevant to the conservation of freshwater fishes in South Australia.

Plan	Application
National	
Native Fish Strategy for the Murray-Darling Basin 2003-2013	A comprehensive document aimed at rehabilitating native fish communities back to 60 per cent of their estimated pre-European settlement after 50 years of implementation. A series of overarching objectives relating to healthy native fish communities and habitats, threatened species conservation and alien fishes. Drives coordinated cross jurisdictional action and provides an excellent framework for the SAMDB, that could be adapted to other regions.
Living Murray initiative (current phase 2004-2009)	A program established in response to declining health of the River Murray system, being a partnership of the Australian and State/Territory governments. A first step focuses on recovering 500 gigalitres of water for the River Murray by 2009, specifically for the benefit of plants, animals and humans it supports, and improving at six icon sites (SA has Chowilla, the Murray channel and Lower Lakes).
Action Plan for Australian Freshwater Fishes (1993)	The seminal document providing baseline coverage for threatened fish issues and potential actions for Australia, although now is in need of review. Contains Recovery Outlines for several species occurring in South Australia.
Ramsar Convention on Wetlands (signed 1971)	The Ramsar Convention is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. Australia is one of 156 contracting parties, with six Ramsar listed wetlands in South Australia. The South Australian Government is preparing management plans for Ramsar Wetlands based on the wise use and the protection of waterbirds and their habitats...(need to be holistic).
National Plan for Water Security (2007), also a new Basin Plan in development	Relevant objectives include to: address over-allocation in the Murray Darling Basin, develop new governance arrangements for the MDB, set and administer a new cap in the MDB, continue the restoration of the Great Artesian Basin.
National Action Plan for Salinity and Water Quality (2002-2008)	A commitment by the Australian, State and territory governments to jointly fund actions tackling two major natural resource management issues facing Australia's rural industries, regional communities and our unique environment.

Table 6 continued...

Plan	Application
Australia's Biodiversity Conservation Strategy 2010–2020,	Developed through a Review Task Group that reports to the National Resource Management Ministerial Council (NRMMC). The Draft Strategy includes six priorities for change: building ecosystem resilience; mainstreaming biodiversity; knowledge for all; getting results; involving Indigenous peoples; and measuring success.
National Threatened Species Recovery Plans	Recovery plans are developed for EPBC Act 1999 listed fish species, several of which occur in South Australia. Incorporation of South Australian information and objectives into reviews and new plans is required.
National Recovery Plans for threatened ecological communities	Recovery Plan initiated for Swamps of the Southern Fleurieu by the Conservation Council of SA with a Recovery Team established. Could further incorporate the requirements and thinking on fish such as Southern Pygmy Perch
Regional Recovery Pilot Project – Adelaide and Mount Lofty Ranges	The Commonwealth Government is investigating multi-taxa regional recovery planning options for threatened species and communities. The Regional Recovery Project will pilot the development of a Regional Recovery and Threat Abatement Plan in the Adelaide and Mount Lofty Ranges Region.
Australian Pest Animal Strategy (2007)	A vision that 'Australia's biodiversity, agricultural assets and social values are secure from the impacts of vertebrate pest animals' - to address the undesirable impacts caused by pest exotic vertebrate animals mammals, birds, reptiles, amphibians, and prevent the establishment of new pests. Links to alien fish management. A Strategic Approach to the Management of Ornamental Fish in Australia Aims to provide a framework for identify and regulating noxious species in the Aquarium trade which could cause environmental harm in the natural environment.
South Australia	
No Species Loss - a Biodiversity Strategy for South Australia 2006-2016	Provides a framework to act to halt species decline – 'all threatened species and ecological communities must be improved and where possible restored, requiring long lasting, strategic and creative partnerships of community, industry and government'. Freshwater fishes must be brought into the thinking and implementation of this strategy.
State NRM Plan (2006)	Seeks to integrate NRM across all public and private lands, in partnership with government, industry and community. Objectives associated with water allocation and planning, habitat protection and restoration (e.g. wetlands), biodiversity conservation and invasive species provide key links to freshwater fish conservation. Regional Recovery Plan for Threatened Species and Ecological Communities of Adelaide and the Mount Lofty Ranges A national trial for multi-species recovery, includes including the 203 species profiles: follow the links at: http://www.environment.sa.gov.au/biodiversity/threatened-species/regional-recovery-pilot.html
Regional NRM Plans and Investment strategies	Identifies resource condition targets, threats, environmental objectives and priority actions. These Plans are in development, so it is an ideal time to incorporate fish information and priorities in different regions. Updates and incorporate Catchment Plans. A range of plans are being developed for the Lower Murray Region in reponse to critical drought conditions (e.g. Murray Futures).
Regional biodiversity plans	Plans developed for various regions of the State, generally limited information and priority on fish issues (should be improved).

Table 6 continued...

Plan	Application
Parks Management Plans (State Reserve system)	Provide an information base and management direction within various lands in the State Reserve system. Fish are infrequently mentioned and considered and most plans require updates to this end.
State Water Plan (2000)	Sets out principles for the management of water dependent ecosystems, guides various strategy and policy.
Wetlands Strategy (2003)	Seeks more dedicated and integrated approaches to the management of wetlands in South Australia with a goal to see 'Wetlands recognised and managed as ecological community assets for the benefit of present and future generations'.
Wetland management plans	Management plans for individual wetlands normally devised to guide areas with control structures. Baseline surveying to identify ecological assets and strategies to prevent harm to native fish (e.g. drying of populations) should be important components.
Marine species at risk	Review and recommendations concerning conservation of South Australia's marine bony and cartilaginous fish. Significant overlap with the freshwater fish Action Plan for diadromous and euryhaline taxa.
Management strategy for the sustainable development of recreational fishing (2001)	Review of recreational fishing with a mission to optimise the long term value of, and opportunities for, a sustainable recreational fishery in South Australia, based upon sound management and a healthy environment. Links to recreational catch and effort and utilisation of threatened species.
Biosecurity Strategy for South Australia (2005)	Addresses biosecurity to protect primary industries, the environment and the community, complements the National Biosecurity System, establishing high-level directions for State policy and biosecurity activities. There is a potential link to a translocation and stocking strategy and fish quarantine procedures.
State of the Environment reporting (SA)	The next State of the Environment Report is due out in 2008. The Report will provide analysis of an extensive amount of environmental data across a wide variety of environmental topics and investigate broader issues that need to be considered in creating a sustainable South Australia. Of great interest will be the impact of the current drought on South Australia's environment.
Planning strategy (medium term - 10-15 years).	The Planning Strategy provides direction from the State Government on land use and development. The Strategy contains various maps, policies and specific strategies, covering a full range of social, economic and environmental issues. These provide direction and a resource for Councils undertaking strategic planning processes, including strategic management plans, Development Plan reviews and Development Plan Amendments.
Greenhouse Strategy 2007-2020	South Australia's long-term response to climate change with a series of strategies and an Action Plan for the State to effectively address climate change. The action plan is a framework to guide the activities of government agencies in implementing the strategy for South Australia to meet its commitment to achieve the Kyoto emissions reduction target within the first commitment period of 2008-2012.
Naturelinks Strategy 2002	A program that aims to conserve South Australia's species and habitats in partnership with the community by establishing ecological links across land and sea.

Aquatic protected areas Reserves are one way of protecting areas of habitat, but there are several challenges in defining reserves or protected areas for aquatic species. The connectivity of freshwater systems means that broader issues (such as flow regulation and water loss, fish introductions and exploitation) can often override any site protection program. Therefore, a holistic approach to fish conservation is needed in order to truly be effective. Whilst the State Reserve system in South Australia (e.g. National Parks, Conservation Parks etc) has never been specifically designed for fish, however several parks are notable for fish they contain and can thus offer the opportunity for local habitat and species protection. Dalhousie Springs, Balcanoona Creek, Ewens Ponds, Bool Lagoon, eastern Hindmarsh Island, and Chowilla are notable examples of reserve areas with high fish diversity or key threatened fish populations. South Australia also has Ramsar wetlands which include international obligations for national action for the conservation and wise use of wetlands and their resources namely:

- Coongie Lakes
- Riverland (Chowilla region)
- Banrock Station wetland
- The Coorong, Lake Alexandrina and Lake Albert
- Bool and Hacks Lagoons

To ensure that the State Reserve system effectively caters for both freshwater and terrestrial biodiversity, it would be advantageous to undertake a thorough inventory of fishes and threats within State Reserves. Such information would be valuable to feed into Park Management Plans and for the development of education and awareness programs for community utilising reserves. Increased awareness of aquatic biodiversity within reserves may also ensure that reserves themselves are considered within broader natural resource management issues such as environmental water requirements and assessments of upstream development. A review of Reserve coverage (in regard to fish species and habitat types) may also be useful for reserve planning purposes. Links between terrestrial and marine parks may also help to protect intervening estuarine areas that are significant sites for numerous species.

4.6. WAYS FOR INVOLVEMENT

Who is responsible (major stakeholders) Conservation of fish, especially smaller species, and protection of their habitat has essentially fallen through the gap of traditional threatened species management (terrestrial focus) and fisheries management (focus of larger commercial species). Historically, this has led to a degree of inactivity in regard to freshwater fish conservation, an issue not helped by a relative lack of awareness of this taxonomic group. However, various initiatives by individuals, groups and government has meant that a solid base of information is now available to make significant advances in fish conservation. It is important that a well coordinated State-wide approach be taken to make the most rapid and effective progress. Greater coordination will help engage all stakeholders and provide clearer direction in regard to policy, planning and project initiation. Having an interagency and cross jurisdictional framework to undertake recommendations and actions from this Plan will provide the greatest opportunity for success. Indeed, this will also help harness a new wave of interest in native fish as part of holistic natural resource management.

A second and critical process is the engagement of all stakeholders in implementation of required actions. As mentioned at the outset, this range of stakeholders is diverse, covering decision makers, funders and or doers, and ways for involvement for these groups should become clear from the content and recommendations contained herein. The major stakeholders and their reasonability or potential ways for involvement are outlined in Table 7.

Changes in attitude and awareness Historically, life hidden below the water's surface has been a

Table 7. Outline of major stakeholders that should be involved with implementing the Action Plan.

Who	Example body or group	Role or responsibility
Federal government	DEWHA, MDBA	Nationally listed species/communities and cross jurisdictional coordination of action and funding.
State government	DEH	No species loss, recovery planning, reserve protection (species and habitat).
	DWLBC	Sustainable use of water resources, biodiversity conservation.
	NRM Boards	No species loss, sustainable use of natural resources, habitat protection, threatened species.
	PIRSA	Management and protection of aquatic resources, sustainable use, protected species.
	EPA	Environmental protection/pollution control. Objectives and policy also outline environmental harm including losses of fish.
	Other (e.g. SEWCDB, USE Scheme, Transport SA, ForestrySA)	Ensure the identification, protection and enhancement of existing ecological assets.
	Councils and planners	Key role in ensuring new and existing development and practices alongside aquatic habitats does not jeopardise threatened species, and that their requirements are considered in plans and assessments.
Non-government conservation organisations	TSN, CCSA, Nature Foundation (SA), NFA(SA), Waterfind Environment Fund	Implement onground actions, harness community interest and knowledge. United lobby to influence government decision making and planning.
Community groups	LAPs, Indigenous Communities, Landcare & Catchment groups, Friends of Parks, angling clubs	Consider fish conservation in existing or planned activities, generate awareness and action for species in their area of interest.
Research organisations	Universities, SARDI, SA Museum, CSIRO	Focus on and drive research and monitoring of threatened species and ecosystems.

bit like 'out of sight, out of mind', which in some instances has equated to a lack of care or focus relating to the management of fish populations and their threats. From a social and perhaps political point of view, the value of water resources for human use seemingly far outweighs the intrinsic value of water dependent fauna and flora and, combined with an overall low level of awareness on the existence and plight of freshwater fishes, acts as a major barrier to conservation.

Fortunately, a change in attitude toward the conservation of native fishes and the holistic protection of habitats (e.g. water catchments) is starting to occur. This primarily relates to an improvement in awareness reflected in three key attitudes:

- Identify fishes as an important fauna group that deserve recognition at the same level as other vertebrates in South Australia.
- Recognise the biodiversity value and ecosystem services provided by native fish, in addition to the resource or fisheries value.
- Value native fish higher than exotic species.

In many cases, improved awareness through access to accurate information about species and appropriate planning could avoid many of the impacts on native fish caused by human activities. This document now provides an opportunity for planners to better address the needs of freshwater fishes. Methods to increase community awareness are needed to expose native fish species to the general public, especially in areas where people can be involved in species conservation. Example avenues include:

- Interpretive materials (website content, brochures^{106,121,201,288}, posters, signage).
- Primary school and high school resources (kits, games, colouring stencils, hands on exercises, promote ownership of a species or local patch of aquatic habitat).
- Media and public presentations, public aquaria and displays (e.g. Zoo, schools).
- Promotional events and market image (e.g. Chocolate pygmy perch).



A promotional event with a local chocolate company resulted in a release of a specially labelled chocolate fish to help promote awareness for the recovery of Southern Pygmy Perch. The successful release was accompanied by brochures, posters, colouring competitions and give-aways at schools and community events in the EMLR, within the range of the real pygmy perch. This event was successful in its goal to raise community awareness about this threatened species. Haigh's currently market a chocolate Murray Cod with part proceeds going to native fish conservation.

Role for the community The community play a pivotal role in the conservation of freshwater fishes, both broadly and locally. By adopting best environmental practices in their day to day activities, being a voice for encouraging conservation and sustainable development and by assisting in conservation/research activities, the community can greatly improve the conservation prospects for many of our species. Some more detailed points include:

- **Attitudes and awareness:** one of the main avenues in helping to change attitudes and increase awareness is through word of mouth, involvement in education.
- **Reporting information:** the Government has a Fishwatch free call number (1800 065 522) to report any suspicious or illegal activity. Ideally, other information such as sightings of threatened fish, oral history or habitat threats should also be reported in a similar manner (however a contact point and website would need to be established).
- **Recreational angling:** harness the interest and knowledge of recreational anglers to ensure sustainable harvests (e.g. catch and release ethic) and to protect habitat and smaller species.
- **Waterwatch:** a program involving the community and school children with environmental monitoring (including invertebrates and water quality). This is also an ideal pathway for teaching about local native fish and their requirements.
- **Fish handling:** in research, community monitoring or angling, there is a need for improved understand of how to handle fish safely, to prevent personal injury (e.g. from Freshwater Catfish spines) but also to minimise damage to fish. For example, fish should obviously be out of water for the minimum period possible, kept in the shade, and not be handled directly (as this can damage scales and sensitive mucus coating (use a soft net instead, or at least have wet hands). Larger fish should be cradled in the water rather than lifted to prevent internal and spinal damage.

Research priorities

- Research to underpin effective implementation of onground works and programs (e.g. WAP) is imperative, with research priorities including:
- Systematics and Genetics: Such information is needed to improve our understanding of the number of species, their distribution, conservation units and status.
- Biology and Ecology : This will provide the necessary biological data to inform management (e.g. water requirements, spawning conditions, key habitat, species tolerance information)²⁸⁹.
- Habitat Management/Manipulation: Monitoring the response of fish and habitats to changing conditions and threat abatement activities is needed to feed adaptively into species recovery management plans.
- Climate Change Modelling: Tracking and predicting responses to climate change will assist with the development of appropriate preventative planning and restoration.
- Social Research: To better identify social attitudes to determine S.M.A.R.T. targets for awareness and education.

An important aspect of research must include strong collaborative links, publication and peer review and information sharing to provide a combined front to achieve collective goals. Effective communication and knowledge exchange within management and the community is also vital to generate interest, awareness and further engagement in fish conservation activities. Skill, consistency and verification in fish identification could be improved in South Australia, and procedures for the ethical and safe treatment, handling, and survey design should be incorporated into organisational activities (e.g. minimal impact to threatened species, sterilisation of gear, non-target organism).

An underwater photograph of Ewens Ponds. The water is a deep, clear blue-green. The foreground and midground are filled with dense, vibrant green aquatic plants, likely submerged grasses or sedges. Several large, brown, weathered pieces of driftwood are scattered throughout the scene, some standing upright and others lying horizontally. The lighting is bright, creating a clear view of the underwater environment.

Capacity for action A new wave of interest and involvement in native fish conservation will require specific expertise and capacity within government and community groups and research organisations. Some requirements for building capacity include:

- Higher education and training avenues to produce individuals with the appropriate background in conservation biology, ecology and resource management.
- Contact points for educational and technical information.
- Recognition of funding sources.
- Strong taxonomic base for routine verification and clarification species (e.g. increased capacity, use and accessibility of the SA Museum specimens).
- Body to drive and develop conservation initiatives and dedicated staff to specialise and implement species recovery actions.
- Action leads to action – develop initial projects that build understanding and provide experience, enabling the development and refinement of new projects.

Underwater view of Ewens Ponds– education is required to help remove the barrier between the water's surface and the life occurring below

4.7. MAJOR RECOMMENDATIONS

Securing and restoring habitat and populations:

- **Water:** develop water allocation plans that protect and restore water requirements for sensitive aquatic ecosystems and fish across all regions of South Australia. This will require a strong commitment by stakeholders to ensure freshwater fishes and their habitats remain for future generations.
- **Habitat:** improve riparian and instream condition, vegetation buffers, water quality, and fish passage (past artificial barriers) through well planned and monitored habitat protection and rehabilitation.
- **Protected areas:** improve our understanding of protected areas to provide greater capacity to cater for the conservation requirements of freshwater fishes, including inventory and planning within the existing State Reserve system and investigation of gaps in species or community coverage for future reserve planning.
- **Urgent conservation measures:** undertake actions for high priority species and populations, to protect against existing and potential threats. Implement species recovery plans and regional action plans, encouraging their incorporation into regional Natural Resource Management frameworks.
- **Water quality:** encourage councils, landholders and industry to improve point source and diffuse pollution problems within aquatic habitats (including stormwater).
- **Alien species:** undertake targeted control of alien species to facilitate recovery and improve resilience of impacted native fish populations.
- **Climate change:** plan for the impacts of climate change, especially potential reductions in available surface water during dry periods.

Improving knowledge and awareness:

- **Biodiversity:** develop a sound systematic framework for all freshwater fish species in South Australia, even for 'common' species that may actually have more complex genetic patterns. This work also needs to be supported by taxonomic studies.
- **Accessible data:** build a detailed database of freshwater fish distribution which incorporates existing data and identifies data gaps or areas without recent inventories.
- **Meaningful research:** incorporate research priorities into NRM and funding programs to underpin effective implementation of on ground works, flow restoration programs and conservation biology.
- **Let people know:** develop a broader education and communication strategy to improve stakeholder and community awareness; undertake targeted awareness raising programs to improve the profile of key threatened species and the level of awareness of key threatening processes.
- **Review:** the Action Plan information should be reviewed every five years, and status assessment and Recovery outlines updated every two years.

Policy and management:

- **Collaboration:** initiate engagement of stakeholders through a coordinated body or working group to drive policy, awareness raising and to connect people, agencies and states. Develop recovery teams for threatened fishes.
- **Protection:** work to enhance the legislative framework for protecting species, ecological communities and habitats in South Australia through review, development and strengthening of existing Acts and policy. This process should explicitly consider the conservation requirements of fishes and remove perverse incentives.

- **Status:** review federally listed species and ecological communities to incorporate new information.
- **On the front foot:** Develop a coordinated strategy for proactive protection of flows and habitats with high natural value or minimal disturbance, especially in the Lake Eyre Basin.
- **Biosecurity:** Formulate a 'fish introduction, translocation and stocking strategy' to provide proactive measures to address the problem of existing and potential alien fish and disease.
- **Use:** further promote ecosystem based fisheries which recognise the intrinsic value of all native species, sustainable practice and the protection of wild habitats.
- **The triple bottom line:** initiate significant improvement in the recognition and incorporation of fishes into ecologically sustainable development (e.g. planning).
- **Capacity:** address the need for increased capacity to undertake action in South Australia.