Macquarie Perch – monitoring plan, Snowy 2.0

M. Lintermans, Z. Tonkin, J. Lyon, and D. Gilligan

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Acknowledgment

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Arthur Rylah Institute for Environmental Research
Department of Environment, Land, Water and Planning
PO Box 137
Heidelberg, Victoria 3084
Phone (03) 9450 8600
Website: www.ari.vic.gov.au

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Front cover photo: (clockwise from top) Murrumbidgee River at junction with Tantangara Creek; Macquarie Perch; alpine plain in snow; Stocky Galaxias (Images: Tarmo A. Raadik).

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Arthur Rylah Institute for Environmental Research
Department of Environment, Land, Water and Planning
Heidelberg, Victoria

Macquarie Perch – monitoring plan, Snowy 2.0

Mark Lintermans[1], Zeb Tonkin[2], Jarod Lyon[2] and Dean Gilligan[3]

[1] Threatened Fish Services
PO Box 111, Belconnen ACT 2616

[2] Arthur Rylah Institute for Environmental Research
123 Brown Street, Heidelberg, Victoria 3084

[3] New South Wales DPI – Fisheries
Batemans Bay Fisheries Office, Cnr of Beach Rd & Orient St, Batemans Bay NSW 2536

Caveat: This report was completed in December 2021 and consequently does not contain more recent information which may have become available.

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1 Introduction

Snowy Hydro Limited received approval in 2020 to construct a new large-scale pumped hydro-electric storage and generation scheme (Snowy 2.0), to increase hydro-electric capacity within the existing Snowy Mountains Hydro-electric Scheme. This will involve the connection of the existing Talbingo and Tantangara reservoirs via a series of underground pipes and an underground power generation station. Water will be transferred in both directions between the reservoirs, which are in separate river catchments.

The Arthur Rylah Institute for Environmental Research has been engaged by Snowy Hydro to provide specialist advice that can inform the preparation of various aquatic Management Plans required as part of the NSW and Commonwealth approvals for the Snowy 2.0 project.

This report provides advice for monitoring Macquarie Perch (*Macquaria australasica*) in the mid-Murrumbidgee River catchment. It outlines a process of monitoring relevant to the priority conservation actions for the species and includes objectives and potential activities aimed at understanding population variability and trajectory to inform long term population management. As such, its value and relevance will extend beyond the Snowy 2.0 Management Plans.

The project team have all been involved with survey and monitoring of Macquarie Perch for decades (e.g. Lintermans 2006, 2013a,b, 2016, 2017, Gilligan et al. 2010, Lintermans et al. 2013, Tonkin et al. 2018, 2019, Broadhurst et al. 2020). In the upper Murrumbidgee Catchment (between Burrinjuck and Tantangara reservoirs), Macquarie Perch monitoring programs have previously been designed and implemented in both riverine and impoundment populations (Lintermans 2013a, 2016, Lintermans et al. 2013; Broadhurst et al. 2018, 2020) and so the sampling methodology is well established. This collective knowledge and experience have been used to develop a long-term Macquarie Perch monitoring program specific to the study region.

Macquarie Perch (as currently described) is endemic to the south-eastern reaches of the Murray–Darling Basin and two coastal river systems in NSW. Morphological and genetic differences between Murray–Darling Basin and eastern seaboard Macquarie Perch have resulted in a reconsideration of the taxonomic status of the species, recognising the coastal populations as distinct separate species in the Shoalhaven and Hawkesbury-Nepean basins (Faulks et al. 2010; Pavlova et al. 2017). Macquarie Perch has approximately 12–18 known populations, primarily in the Murray–Darling Basin but also including three translocated populations in coastal systems (Lintermans et al. 2019). A review of threatened species monitoring in Australia found that most current programs were inadequate (Scheele et al. 2019), as they are for freshwater fish (Lintermans and Robinson 2018). When assessed against a suite of nine monitoring metrics, threatened freshwater fish monitoring programs scored well for coverage (how much of a species range was covered), sampling periodicity (how frequently does monitoring occur) and fit-for-purpose methods (were the methods tailored for the focal species and site, rather than just generic) (Lintermans and Robinson 2018). Threatened fish monitoring programs scored poorly for data availability and reporting, demographic parameters, program longevity, and design quality (power to detect trend) (Lintermans and Robinson 2018).

Monitoring can be characterised as either *compliance* (have required actions been undertaken or statutory thresholds breached), *surveillance* (low intensity or generic monitoring (generally long term at set sites) to alert managers that additional management intervention is required) or *intervention* monitoring (monitoring of the efficacy of specific management interventions) (Lintermans 2013c). The monitoring approach used in document is predominantly a surveillance approach, but there are elements of intervention monitoring triggered by a TARP (Trigger Action Response Plan).

Management of threatened species ultimately aims to recover populations and increase abundance and distribution so that the species may eventually be de-listed from threatened species legislation. To reach this endpoint, information is required on how the status of a species and trend of its populations changes through time, and so monitoring is an essential requirement of threatened species management. Monitoring should provide information on a focal population's 'status' (i.e. abundance; distribution and trend); demographics and recruitment; and if relevant, how these metrics respond to management actions. Other non-demographic metrics that may also be included in a monitoring program include identifiable threats; habitat availability and rate of loss; habitat condition and other critical resources needed. This information can then be used to frame, evaluate, and revise or refine management activities (Lintermans and Robinson 2018).

The methods used, attributes monitored, and the frequency of monitoring, should be sensitive enough to allow a detection of change, if it occurs, beyond levels of natural variability. Biological monitoring to determine aquatic condition (or some component thereof, e.g. fish community composition, habitat rehabilitation, flow-regime restoration (environmental flows); river health), almost invariably uses a referential approach (Reynoldson et al. 2001; Wolter et al. 2005; Bain and Meixler 2008; Hawkins et al. 2010) and Australia is no different (Harris and

Silveira 1999; Davies et al. 2010; Lintermans et al. 2013). Having reference sites or defining a reference condition (where reference sites are unavailable), is a key requirement for monitoring and target setting (Hawkins et al. 2010) and there are many factors that influence the selection of reference sites (see Dallas 2013). However, a referential approach will assist in understanding the direction, magnitude and potential drivers of change and change in persistence and will inform the overall conservation status of the species.

The following monitoring advice only relates to the Murray–Darling species. The Snowy 2.0 EIS divides the upper Murrumbidgee Catchment into Upper (upstream of Tantangara Dam) and Mid (between Tantangara Dam and southern Australian Capital Territory (ACT) border; Cardno 2019). This advice relates to the Mid-Murrumbidgee catchment population (as defined above). The Mid-Murrumbidgee population is now only known from the mainstem of Murrumbidgee River, with the current status of historic sub-populations in tributaries of the Murrumbidgee having received little attention (except for the Queanbeyan River sub-population located downstream of the Mid-Murrumbidgee catchment (Lintermans 2006; 2013a)).

The focus of this monitoring approach is on locations where Macquarie Perch recruitment is known to be occurring in the Mid Murrumbidgee River, plus some adjacent river reaches where recruitment may occur in the future (so that expansion of viable sub-populations can be detected). The monitoring program will provide comparable data on the Mid Murrumbidgee Macquarie Perch population, relative to risks such as exotic species incursions, e.g. Redfin Perch (*Perca fluviatilis*) (see Cardno 2019; Tonkin et al. 2022a) and importantly, inform decisions on management interventions such as translocations (Tonkin et al. 2022b), stocking and exotic species control.

Should other sub-populations of Macquarie Perch be detected or established in future, monitoring should be reviewed, and consideration given to including these locations.

1.1 Relevance to priority conservation actions

Priority actions for Macquarie Perch identified by NSW DPI (2015) that are relevant to this document include:

- *Monitor Macquarie Perch populations over time to assess trends in abundance and distribution and to identify emerging threatening processes (High priority).*

2 Monitoring aim and objectives

The overall aim of the monitoring for Macquarie Perch is:

> To provide baseline, comparable data on the Mid Murrumbidgee population, to inform decisions on management intervention for the long-term survival of the population.

Specific monitoring objectives for Macquarie Perch in the Mid Murrumbidgee catchment to meet the overall aim are to provide baseline, comparable data on:

- The persistence of Macquarie Perch (Is the species still present and breeding at sites where recorded since 1998).
- The population trajectory (is the population increasing, stable or decreasing) and variability (significant change from normal).
- The status of the Macquarie Perch population (incorporating measures of abundance, distribution, reproduction and demographics).
- The persistence and establishment of any new translocations of the species into the catchment.
- Incursions of Redfin Perch into the Mid Murrumbidgee catchment.
- Triggers for further investigations and/or identified management interventions to mitigate potential sudden declines because of identified threats (e.g. Redfin Perch fish invasion, drought, fire).

The monitoring advice presented here should be adaptive. If new populations are discovered or established additional sites should be added to the program.

2.1 Design considerations

Table 1 details population and species criteria, including important attributes to be measured. Specific monitoring questions are essential to establish the conceptual basis for monitoring and subsequent interpretation and to facilitate true adaptive management (Lindenmayer and Likens 2009, 2010, Lindenmayer et al. 2013, Lintermans et al. 2013a). Importantly monitoring programs should lead to timely and informed management decisions and should not be an end in themselves (Lindenmayer et al. 2013).

Table 1. Population and species parameters important for monitoring Macquarie Perch

Criterion	Explanation	Life-history parameters
Persistence	Continued presence over space and time	- presence of individuals across the sample range - relative abundance of individuals - individual condition (length / weight condition indices, parasites, disease) - size structure of population (young of year, juveniles, sub-adults, adults) - successful recruitment (abundance and proportion of population); abundance of individuals - level of genetic diversity and effective population size
Trajectory	Direction of change over time	
Variability	Fluctuation over time	
Status	Overall level of extinction risk	

Note: All parameters are relevant to each criterion.

Specific monitoring questions can relate to threats, knowledge gaps, ecological attributes or life phases of the target species (see Lintermans et al. 2013a). Monitoring can also be undertaken to understand outcomes from interventions such as translocations.

The proposed monitoring is framed by the following specific questions:

1. Will there be significant changes over time or between sites in the abundance of Macquarie Perch in the Mid Murrumbidgee catchment (Young-of-Year, juveniles and sub-adults/adults)?
2. Will there be significant changes over time in the distribution of Macquarie Perch in the Mid Murrumbidgee catchment (range expansion or contraction)?
3. Will there be a significant change in annual recruitment in the Macquarie Perch population in the Mid Murrumbidgee catchment relative to reference sites?
4. Will changes in the abundance and distribution of Redfin Perch in the Mid Murrumbidgee catchment lead to changes in Macquarie Perch persistence and status?
5. Will translocated Macquarie Perch survive following release, reproduce, and establish?

The reference sites referred to in Question 2 are a valuable inferential component of robust monitoring programs (Reynoldson et al. 2001; Davies et al. 2010; Lintermans et al. 2013; Broadhurst et al. 2020) but can be problematic for rare or threatened species monitoring. Threatened species often occur as small, fragmented populations (often on different population trajectories) with few populations available to act as a reference. At least one reference population and two sites are required to allow inference of whether changes in trend of the target population is a local response, or if it represents a broader response across the species range (e.g. to climate extremes such as drought). It was the reference site data from the mid Murrumbidgee that clearly identified that a multi-year recruitment failure of Macquarie Perch in Cotter Reservoir was a local rather than regional pattern (Broadhurst et al. 2020). No two sites or streams are directly comparable and ideally data from multiple reference populations would be used to better represent the species trajectory.

Further investigation is required to review and refine reference requirements and availability of comparable sites, but in the interim two potential reference sites are identified within the Abercrombie River Macquarie Perch population. Other options include data collected in other populations in the ACT, NSW or Vic. Of course, in some circumstances reference sites are not suitable to achieve their purpose because the population dynamics and drivers are not reflective of those of the target population. A referential framework is the preferred approach if suitable data is available. This should be reviewed after the first 5 years of data collection. A constructed reference condition is often created for fish communities where pristine reference sites no longer exist (e.g. Davies et al. 2010; Wolter et al. 2005; Belliard et al. 2018) and 5 years of monitoring data at Mid Murrumbidgee and suitable reference sites may allow the creation of such a constructed reference containing life stage abundance (young of year, juvenile, sub-adult adult) and target recruitment metrics.

3 Monitoring Activities

To address the above aims, we have developed five monitoring components, with two assigned as routine surveillance monitoring (long-term, ongoing) (See Section 3.1), and three assigned as response to trigger points under the TARP (see Section 4.1). A summary of recommended activities is provided in Table 2.

3.1 Routine surveillance monitoring

3.1.1 Population monitoring

Purpose: Surveillance population monitoring of most life-history attributes.

Value: Fish presence/absence, distribution, relative abundance, size and condition, recruitment success and collection of tissue samples for genetic analyses.

Timing: Autumn (March/April).

Frequency: Annually (Core distribution and Fringe sites); Additional sampling may be required if triggered by the TARP (Table 5).

Method: Undertaken at all sites in Table 3. Specific suite of methods and level of effort for each of gill netting, fyke netting, boat electrofishing and backpack electrofishing is site specific (see Section 3.1.8). All fish counted, measured for length (mm Total Length or Caudal Fork Length). Macquarie Perch weighed (grams), fin-clipped, visually assessed for external parasites, disease, and PIT tagged. Native species returned alive to site of capture. Water quality and stream characteristics measured at site scale, general threat assessment (instream and riparian zone) undertaken at site scale.

Analysis and Reporting: Annual.

3.1.2 Population genetics

Purpose: Monitoring level of population genetic variation and effective population size.

Value: Documentation of population genetic fitness and estimation of number of breeding adult Macquarie Perch (effective population size) which is not observable from life-history attributes; potential early warning of population genetic collapse or small parental stock.

Timing: Autumn (March/April). Collection of samples can be undertaken during annual population monitoring (Table 3).

Frequency: Every 3 years or when triggered by TARP (Table 5).

Method: Undertaken at all monitoring sites with samples collected every year during population monitoring activities, with samples processed every third year. Collect a small sample of fin tissue from all fish ≥40 mm, clipping all fish up to a maximum of 90 individuals per site into 100% ethanol. If insufficient samples collected in routine monitoring, additional sampling may be required. Collected tissue sent for population genetic analysis including effective population size, genetic diversity, parentage level analysis (using single nucleotide polymorphisms (SNPs) (as per Lutz et al. 2021).

Table 2. Summary of recommended monitoring activities as grouped into either routine surveillance monitoring, or trigger-based monitoring

Sampling Type	Method	Duration/Level of Effort	Parameters measured	Frequency[+]	Location/Area
Routine Surveillance Monitoring					
Population monitoring	Gill net; Boat electrofishing; Fyke net; backpack electrofishing. Suite of methods site specific and to be determined upon initial site visit.	12 fyke nets (16 hr soak); 2 gill nets (6 hr soak); boat efish (min 12 x 90sec shots); bp efish (min 5 x 150 sec shots). Effort for each method site specific and to be determined upon initial site visit.	No. of fish; length; visual assessment for parasites; WQ* and stream characteristics; visual threat assessment.	Annually in Autumn (March/April); 1 day/night sampling per site.	Each monitoring site annually (Core and Fringe sites) Sampling to be conducted in Autumn (March/April).
Includes water temperature monitoring	Installed water temperature loggers, continuous recording.	Initial installation using punt, then data downloaded 6 monthly. 3.5 days required for two-person team for each download in addition to download during routine population monitoring.	Water temperature.	Continuous monitoring once installed	Installed at ~20–30 km intervals across the Macquarie Perch Murrumbidgee River monitoring reach, at the following sites: 1. Upstream Yaouk, 2. Bolaro, 3. Middle Dry Plains 4. Murrells Crossing, 5. Downstream Bredbo, 6. Lawler Road, 7. At one reference site.
Population genetics	Fin clipping.	Fin clips to be collected from up to 90 individuals per site. Up to 30 Young of Year and 30 age 1+ individuals to be sampled at each site; and all adults > 300 mm TL to be sampled each year. Samples collected as part of routine population monitoring.	Using SNP data: genetic diversity; effective population size; parentage analysis.	Collected each year, analysed every three years.	Each monitoring site in each sampling year in Autumn (March/April).
Trigger-based Monitoring					
Spawning monitoring	egg sampling (transects and quadrats) and larval sampling (drift nets).	Eggs: 2 riffles per Core site, 5 sites; 5 transects per riffle, 4 quadrats per transect. Larvae: 2 or 3 drift nets set overnight per site.	egg abundance and developmental stage, larval abundance.	Trigger based in Spring (Mid-October to mid-November). 2 sampling runs separated by 2 weeks	Monitoring sites as specified in TARP.

Sampling Type	Method	Duration/Level of Effort	Parameters measured	Frequency+	Location/Area
		Eggs and larval sampling to occur fortnightly for four trips. 1 night required for 3-person team per site.			
Redfin Perch incursion	Gill net, boat electrofishing, fyke net, eDNA.	Boat electrofisher, nets, eDNA sampling equipment, 5 samples per site at incursion and adjacent (2 sites upstream and 2 sites downstream) monitoring sites. 5 days required for 2-person team per incursion.		Trigger based: (within same year of initial detection) (March–May or Oct–Dec).	Initial eDNA sampling at 5 km intervals radiating from incursion site/s to define the invasion front and then physical sampling at 5 sites within the incursion zone to quantify incursion status.
Fish condition assessment	Backpack electrofishing, fyke net, fine mesh macroinvertebrate net and sample fixing equipment, WQ meter.	*Field* – collection of juvenile fish per site for parasites/disease inspection, retention of voucher specimens for histological analysis; macroinvertebrate sampling and live pick, catchment and water condition assessment – 1 day per site, *Laboratory* – Laboratory identification of stream macroinvertebrate sampled – 1 to 1.5 day per site. Veterinary laboratory identification of internal parasites 2-4 days per site.	Fish length and weight; visual assessment for parasites; WQ and stream characteristics; visual threat assessment, Stream macroinvertebrate collection for diversity and relative abundance. Parasite identification, location and load, and disease type – from histological examination.	Trigger based.	Monitoring sites as specified in TARP.

* Water quality: includes: water temperature, turbidity, dissolved oxygen, pH, conductivity

+ Additional sampling may occur in response to the triggers identified in section 3.2.

3.1.3 Monitoring methods and level of effort

Population monitoring

Population monitoring should use both active (e.g. electrofishing) and passive (e.g. fyke netting) methods to monitor trends in relative abundance, population structure and distribution across the study area. Different methods are typically tailored to suit specific waterways and sites therein. As such, a combination of netting and electrofishing should be used to achieve the objectives of the monitoring program (monitoring questions 2–4) and enable comparison with other programs already underway across the southern Murray–Darling Basin. As such, on the first visit, each site would be assessed for the suitability of each method, then would be sampled using a combination of fyke netting, gill nets, boat-mounted or backpack electrofishing. The final suite of methods and effort of each sampling gear should then be maintained each year for the duration of the program.

Previous studies in the upper Murrumbidgee catchment have determined that fyke netting and gill netting were the most effective at detecting the presence of Macquarie Perch at suite of survey sites, with fyke nets being particularly effective at detecting recruitment (i.e. Young of Year or age 1+ individuals) and gill nets effectively capturing subadults and adults (Lintermans 2013a, 2016). In a multi-method survey across multiple sites and years, fyke nets captured Macquarie Perch at 100% of sites where the species was detected, and gill nets captured the species at 86%. Boat electrofishing captured Macquarie Perch at 43% of sites where the species was detected but captured few Young of Year or juveniles (Lintermans 2016). It was recommended that future sampling for this species should employ fyke and gill nets to adequately characterise population structure (adults, juveniles, YOY), minimise false negatives and detect successful breeding from the previous year (Lintermans 2016).

While fyke and gill nets are most suited to sample pool, or slow-run habitats, sampling of faster flowing habitats or long extensive pools is most suited to electrofishing (boat or backpack), which can cover larger spatial areas thereby, increasing the area that can be sampled (Lintermans et al. 2013, Tonkin et al. 2019, Broadhurst et al. 2020). Electrofishing is the primary method used for most other state (NSW and Victoria) and Basin-wide fish community monitoring programs such as the Murray–Darling Basin Fish Survey (MDBFS), NSW Basin Plan environmental outcome monitoring and Victorian Native Fish Report Card. This would make data collections comparable with these programs.

Annual population sampling of sites should be conducted in early to mid-autumn (March-April). Sampling earlier than this runs the risk of either not detecting or gilling small Young of Year (YOY) in the fine net mesh, and later sampling is prone to episodic high flows which introduces variation in netting catches (e.g. gill nets less efficient).

Details of each gear and method is as follows:

Fyke nets. Twelve single-winged fyke nets (12 mm stretch-mesh) are to be set at each site. Nets are to be attached to the bank at the cod-end and then set at an angle to the bank facing downstream with a weight attached to the wing to hold the net securely. The single wing is attached to the centre of the front ‘D’ of the fyke net. Each fyke net is to have a 150 mm diameter polystyrene float inserted in the cod end to provide an airspace to prevent mortality of non-target animals such as Platypus (*Ornithorhynchus anatinus*). Nets are to be set between 15:30 and 16:30 hrs and left overnight until retrieved between 07:30 and 08:30 hrs the following morning, giving a ~16-hour soak time.

Gill nets. Two braided monofilament gillnets, 50 meshes deep, stretch mesh size of 75 and 100 mm, 33 m length when strung on a float line are to be set across the afternoon and early evening. Nets are set between 15:30 and 16:00 hrs and retrieved between 21:30 and 22:00 hrs, giving a 6-hour soak time (Lintermans 2013a, 2016, 2020, Lintermans et al. 2013b, Broadhurst et al. 2020). Gill nets must be floating, multifilament and essentially unweighted (light weights may be used to ensure the net is not being streamed out by higher flows). Previous research has demonstrated that the 6-hr soak time captured 79% of the number of Macquarie Perch captured using a 16-hr soak time, and that mortality of both target and non-target species was reduced (Lintermans 2013a). One end of each gill net is to be attached to the bank and the other end is to be attached to an anchor mid-stream.

The limited soak time of gill nets also reduces stress or possible mortality of threatened fish species or non-target species such as Platypus and Eastern long-necked turtle (*Chelodina longicollis*). Gill nets will also be patrolled at approximately hourly intervals after dusk with any captured animals (fish or Platypus) removed from the nets. Platypuses should be retained in plastic 60 litre bins (rubbish bins) overnight to prevent recapture, with the bins containing a quantity of leaf litter/grass ‘nesting’ material to allow animals to dry off and minimise stress. Platypuses should then be released at the point of capture after removing fyke nets the following morning.

Electrofishing. Backpack and boat electrofishing should follow the Sustainable Rivers Audit methodology (Davies et al. 2012) to facilitate comparisons with other long-term monitoring data. If a site is deemed

suitable for boat electrofishing, whereby it has extensive pool and run habitats navigable by boat, and boat electrofishing is deemed necessary, it should be sampled using a minimum of 12 x 90 second shots of accumulated power-on time. There are mixed views on the value of boat electrofishing data, with some concerns about its use as a sole sampling technique to adequately monitor some life-history phases (e.g. YOY and juveniles) of Macquarie Perch (Lintermans 2016). Its values lies in its capacity to sample adults in higher flow situations where gill nets are less effective. In sites <10 m wetted channel width (as estimated by sampling teams) or in shallow runs and riffles of wadable depth, backpack electrofishing should be used using 5 - 8 x 150 second shots of accumulated power-on time. Sites with both navigable and wadable habitat types could be sampled by both electrofishing apparatus in proportion to the relative availability of each habitat type within the sampled site. Sampling should begin at a georeferenced starting point and fish in an upstream direction covering all available habitat (with the finish location of the final shot also georeferenced for future replication).

Fish processing

All fish species captured will be identified and measured for length (nearest mm; Caudal Fork Length or Total Length, as appropriate). Weight of each Macquarie Perch captured should also be recorded (nearest gram). All subadults and adult Macquarie Perch should be scanned for a PIT tag, and if a PIT tag is recorded, the code should be recorded in full. If no PIT tag is detected, a tag should be implanted as per standard procedures. All fish should be visually inspected for deformities, injuries (e.g. cormorant strike) and external parasites (e.g. *Lernaea cyprinacea*). A small fin clip should be collected from selected Macquarie Perch (see details below) and preserved in 100% ethanol.

Fish age/maturity can be estimated for all Young of Year and juvenile Macquarie Perch captured based on fish length and previous experience of Macquarie Perch in the upper Murrumbidgee catchment (Lintermans 2016). The first two age cohorts (young of year and juvenile (age 1+) of Macquarie Perch can be confidently estimated for this species, but age of subadults/adults is problematic as sexes mature at different sizes and individual growth rates vary. For example, a 180 mm TL fish could be a mature male or a sub-adult female. (M. Lintermans unpublished data). Following data collection, each fish should be released at the point of capture.

3.1.4 Life-history parameters measured

Population monitoring

Life history parameters to be recorded and reported as part of an annual population monitoring program for Macquarie Perch in the Mid Murrumbidgee River, relative to the reference location, are provided in Table 1. These standard biological attributes are commonly recorded during monitoring programs for threatened fish. These can vary spatially and temporally within a population, and importantly, provide multiple but differing measures of population condition.

The continuing *Presence* of fish over time at a monitoring location provides evidence of the persistence of that species at that location or site. Moreover, when a suite of sites extends across the species distribution, or expected distribution, information is gathered on the populations range and any changes to such. The latter is particularly useful for rare species, where relative abundance measures are often variable and therefore uninformative. However, presence and range of fish alone (particularly for long-lived species such as Macquarie Perch) does not provide data on population health or variability, or small changes to population trajectory.

Relative Abundance, usually from counting all individuals in a sample in a survey reach relative to sampling effort, or in a subsample of age/size classes, provides an indication of population structure and recruitment success and expected fish persistence over time.

Condition, usually measured as individual fish weight relative to length (morphometric condition), and a visual inspection of external parasites or signs of disease, provides a qualitative measure of general fish health. Fish weight/condition can vary depending on the degree of gonad development, and consequently this should be measured when gonad development is minimal (e.g., during summer/autumn) or at a standard time of year (so between year changes are directly comparable). The number of fish visually identified with external parasites or disease indicates the degree of infection of the population and the level of individual infection can give important information on average disease/parasite load.

The *Size Structure*, using length data, of a population is based on length measurements of individuals, and indicates recruitment success, adult (spawning stock) abundance, fish persistence and growth (age/length cohorts) over time.

Spawning and *Recruitment* success is an important indicator of fish persistence and abundance over time, and of successful reproduction. As part of the population monitoring program, the success of spawning and recruitment will be evidenced through presence of an adequate proportion of Young of Year.

For genetic analysis (see below), a small fin tissue sample to be taken and stored in 100% ethanol each year from up to 30 Young of Year and 30 age 1+ individuals from each site, including up to 30 adults > 300 mm TL.

Statistical analysis

At a broad level, using presence data, presented as reporting rates across site as (frequency of detection across a range) will provide a simple descriptive approach of temporal trends in distribution (that can be further refined to juveniles or adult life stages).

Assessing trends in relative abundance through time of all or a subset of the Macquarie Perch population (e.g. adults) can be analysed in several ways and is largely dependent on the sample size of fish recorded during monitoring. Based on recent work, we suggest the use of state-space population models that allow the modelling of both process and observation error variances (Kéry and Schaub 2012, Tonkin et al. 2019). State-space population models provide a more mechanistic process than other methods such as generalised additive models which have been commonly used to analyse population count trends but rely on relatively arbitrary smoothing and do not partition process error from observation error. Loglinear models have also been extensively used to estimate changes between time periods but these do not link temporal steps nor handle missing abundance estimates.

An assessment of changes in Macquarie Perch size frequency will provide important information on annual changes in adult stocks, survival and recruitment. Simple length-frequency histograms will accurately determine the first two age cohorts of Macquarie Perch, thereby informing recruitment dynamics, without any need for destructive ageing (Lintermans et al. 2013a; Lintermans 2016; Tonkin et al. 2017; Broadhurst et al. 2020). In addition to assessing trends in Young of Year or age 1+ (using the state-space model above or other generalised additive models), is a targeted assessment of temporal patterns in fish length and subsequent annual changes in population size structure in relation to any change in relative abundance (CPUE). This provides an indication of the contribution of juvenile fish recruiting into the population versus survival or immigration of existing larger fish in or into the sampled population. For example, a large increase in population size accompanied by a reduction in mean fish length within the lower size range reflects recruitment of Young of Year fish into the population (fish > 1 year of age). Conversely, an increase in population size but with no reduction in the lower size range is more likely to reflect no change in recruitment rates but rather an increase in survival of fish already accounted for in the population, or immigration of fish into the sample sites. To do this, we suggest using a quantile regression analysis to model different percentile lengths relative to estimated ages (see Tonkin et al. 2017, 2020).

3.1.5 Population genetics

Population/species genetic diversity is an important component of population persistence, health, and evolutionary potential. Monitoring a population's genetic structure is now an established technique that provides additional information on population demography and dynamics. Measures such as genetic diversity, level of inbreeding, effective population size, and kinship as determined by genetic analysis of a subset of individuals, are important components to enable an assessment of population persistence, health, and evolutionary potential.

Whilst there is some information published on genetic diversity in the upper Murrumbidgee (Pavlova et al. 2017), this is based on a small number of samples from 1 or 2 sites. Similarly, estimates of effective population size have been published, but again are from limited sample sizes, a small number of sites, and a small number of years (Farrington et al. 2014; Pavlova et al. 2017). As such, non-destructive sampling of genetic tissue collected from individual Macquarie Perch captured is proposed as part of the broader monitoring program.

Statistical analysis

The analysis of genetic data to assess changes in genetic diversity, survival of stocked and translocated offspring, and to identify whether individuals captured are of stocked or natural spawned origin, should follow the methods described in Lutz et al. (2021). In summary this will involve analysis of identity, sibship and parentage using SNP data, including analysis to assign individuals to a translocated or source population, and to generate genetic indices such as proportion of heterozygous loci (PHt), effective population size (*Ne*), levels of heterozygosity (expected and observed), allelic richness and private alleles, etc.). Briefly, all genetic samples should be genotyped using DartSeq™ protocols or equivalent (Kilian et al. 2012). SNP data should be filtered using the dartR package (Gruber et al. 2018) in R. A single biallelic SNP per locus with reproducibility=1 (estimated based on re-processing of ~25% samples) should be retained, and loci missing scores in >10% of individuals removed. Identity analysis and parentage analysis should be performed in CERVUS3 (Kalinowski et al. 2007) with error rate of 0.0001 (justified in Lutz et al. 2021). These will enable identification of translocated individuals and stocked offspring (when both broodstock parents from the breeding program are sampled). Sibship and parentage analyses should also be performed in COLONY2 (Jones and Wang 2010), assuming a polygamous, non-inbreeding, dioecious diploid mating system, with a

locus error rate of 0.0001. Sibship analyses will enable confident identification of full siblings in the monitoring samples, and thus estimation of the number of parental pairs that bred each year in the Murrumbidgee population (provided that the length data for siblings could be used to approximate their age). A PCA and STRUCTURE analysis will enable assignment of non-stocked and non-translocated individuals to the source population, (Pritchard et al. 2000). Individual genetic diversity, expressed as proportion of heterozygous loci (PHt), can be calculated using GENHET in R (Coulon 2010). Together with inferred ages (from length), this will enable monitoring changes of genetic diversity across breeding seasons. Contemporary effective population size (Ne) should be estimated using LDNe (Waples and Do 2008) and implemented in NeEstimator (Do et al. 2014).

3.1.6 Environmental variables

Environmental variables are also important to monitor as part of the population monitoring program, as they may provide qualitative understanding to the life-history parameters above, and to sampling efficiency. Data on environmental variables will be collected as part of the routine surveillance monitoring (Appendix 1).

Standard water quality parameters are water temperature (°C), electrical conductivity (µS/cm), dissolved oxygen levels (mg/L and % saturation), pH, and turbidity (NTU). Water quality should be taken at each sampling site on each sampling event. Data is collected on-site with a portable multimeter. Water temperature and flow are critical environmental variables for fish ecology, particularly for Macquarie Perch spawning, and can provide valuable insight into potential recruitment failure or poor fish condition. Deployment of water temperature loggers will provide continuous water temperature data, and interrogation of existing flow monitoring stations in the Mid Murrumbidgee (Yaouk No 2; Mittagang; Billilingra, Michelago, Chakola) and one site in the Abercrombie (Abercrombie River at Abercrombie No.2; see https://realtimedata.waternsw.com.au/) will provide continuous discharge data. Water temperature loggers should be deployed at six sites on the Mid Murrumbidgee (Upstream Yaouk, Bolaro, Middle Dry Plains, Murrells Crossing, Downstream Bredbo, Lawler Road) and one of the reference sites in the Abercrombie River. Water temperature loggers should be downloaded 6-monthly.

Variables related to the sampled aquatic habitat are also important, particularly to standardise survey data (e.g. abundance, etc.) and to define physical and aquatic changes since the last site visit. These are average stream width and depth (m) calculated from several measurements and water level height (m) at the time of sampling, as a measure of relative change (e.g. measured from a fixed height marker). These should be recorded on each monitoring occasion, at each monitoring site.

3.1.7 Monitoring threats and habitat change

Visual assessment and characterisation of threats at each sampling site will give early warning of potential management issues for Macquarie Perch. For example, is there excessive sediment accumulating in the stream (a threat to refuge pool habitats and spawning habitats), are riparian zones in good condition (providing litter fall and shading); is general vegetative cover adequate (to minimise sediment input), etc. At each sampling site threats will be visually assessed, and habitat conditions scored (Appendix 1). The presence and/or abundance of exotic species such as salmonids, cyprinids and Redfin Perch that present threats such as predation, competition or disease transmission will also be monitored.

3.1.8 Monitoring sites

The known existing distribution of the recruiting population encompasses approximately 95 km of the upper Murrumbidgee River mainstem between approximately the Numeralla River junction (~25 km downstream of Cooma) and Yaouk (Figure 1) (M. Lintermans unpublished data; D. Gilligan unpublished data, Lintermans 2016, 2020). Subadult and adult Individuals are sporadically captured at sites downstream of the Numeralla junction to the ACT border, but these are largely considered likely to be dispersing or vagrant individuals (M. Lintermans unpublished data).

Unpublished Macquarie Perch movement data suggests that some fish from outside the core recruitment area move between core and fringe areas in the spawning season (P. Haantjens unpublished data). Consequently, the monitoring program should encompass the known extent of the recruiting population, as well as sites upstream and downstream (fringe sites) so that distributional expansion of the recruiting population expansion can be detected.

Proposed monitoring sites/reaches, including two potential reference sites, are listed in Table 3 and Table 4 and Figure 1 and 2, and have been selected to give adequate spatial coverage of the core distribution and allow for detection of spatial expansion (an upstream and a downstream fringe site are included). For some sites where public access is readily available precise coordinates can be given, but for other locations where private access and landholder permissions will be required, the centroid of a river reach only is given and further on-ground inspection and access negotiation is required before the site may be used.

The catchment survey may identify additional sites and/or sub-populations/populations which should then be integrated into the monitoring program in accordance with priorities. If a fringe monitoring site is reconsidered as a core site, due to the continual presence of Macquarie Perch, another fringe site further along the river should be established.

3.1.9 Review of Monitoring sites

The number, categorisation (core, fringe etc) and frequency of monitoring of sites should be reviewed following the 5 years of initial monitoring. Additional sites to those identified above will potentially be added based on the outcomes of the catchment survey, and the identification of translocation sites. As a result, some rationalisation or prioritisation of sites may be possible. All the currently designated core sites are priorities for annual sampling, and the first 5 years of monitoring may expand or contract the known core distribution, with sites currently designated Fringe potentially reassessed as core or vice versa.

With an expanded core distribution or increase in the total number of sites to be monitored, it may be appropriate to identify a subset of 'sentinel' core sites (monitored each year) which will provide and annual baseline against which to compare other sites that are monitored less frequently. Currently it is not appropriate to nominate which sites should be sentinel sites, as knowledge of Macquarie Perch status and abundance is not known for all core sites. Given the existing knowledge, some sentinel sites can be nominated based on significant datasets previously collected or currently under collection. Murrells Crossing and Below Yaouk reach are currently sentinel sites (Lintermans 2021) and Kissops Flat also has a long time-series of data (Lintermans et al. 2013, Lintermans 2016, Broadhurst et al. 2020). The Bolaro reach and Mittagang Crossing will also have multiple years of data since 2020 (Lintermans 2021; unpublished data) and are also good candidates for sentinel sites.

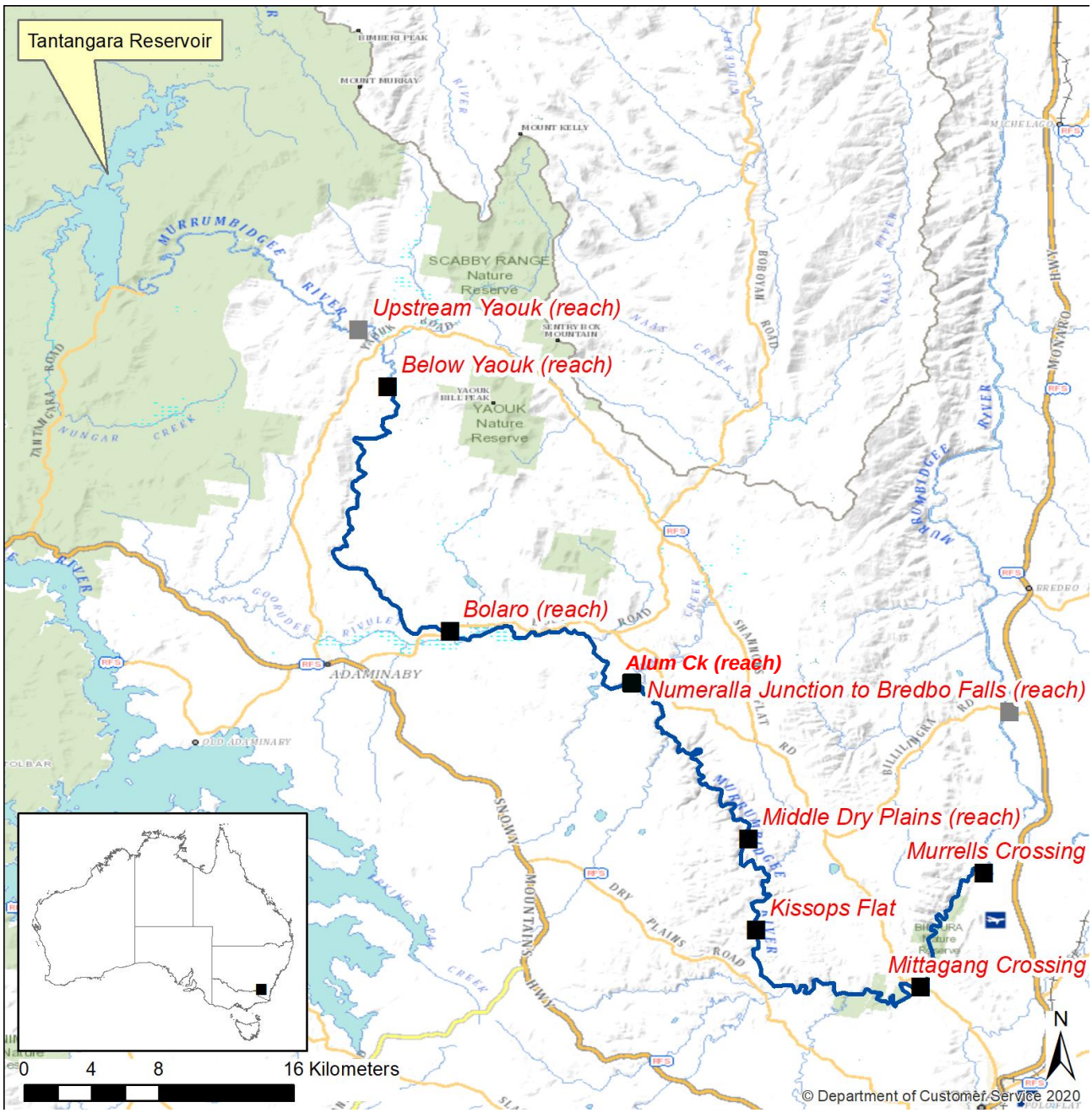

Figure 1. Map of project area and proposed monitoring sites on the Murrumbidgee River

Dark blue line – core reach for Macquarie Perch; Black squares – Core sites; Grey squares – Fringe sites.

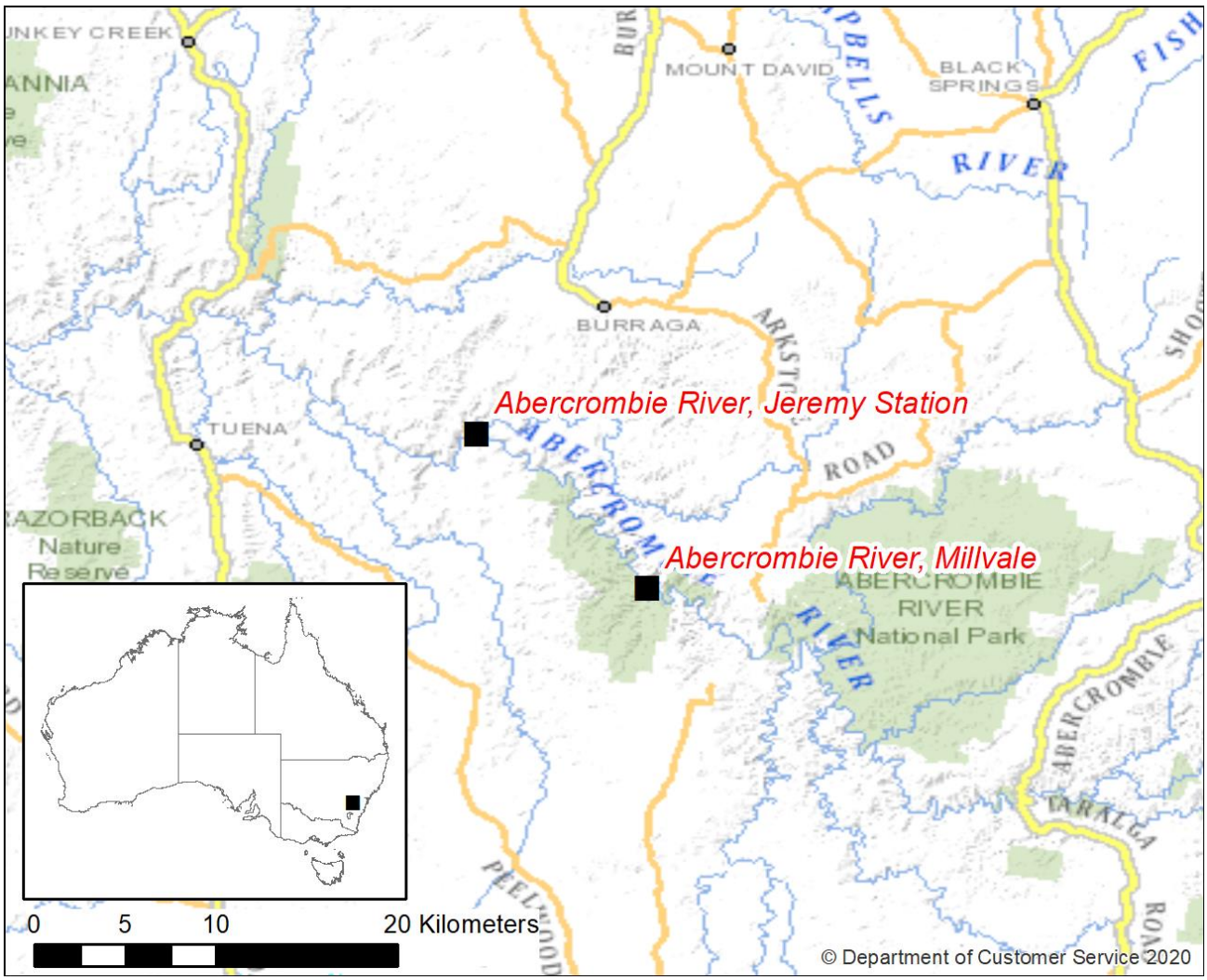

Figure 2. Map of potential reference sites in the Abercrombie River

Table 3. Monitoring sites/reaches in the Murrumbidgee catchment, access, and availability of previous comparable data (utilising fyke and gill nets) and boat electrofishing since 1998. Precise coordinates are given for sites, approximate centroids are given for reaches. Core sites are within the known core population area (reproducing); Fringe sites are areas where population expansion may be detected

[A] South East Local Land Services data; [B] data from Lintermans (2016); [C] data from Icon Water; [D] only fyke net data; [E] NSW DPI Boat electrofishing data, [F]ACT Government boat electrofishing data.

Site/Reach name	Coordinates : Decimal Latitude, Longitude	Macquarie Perch previously recorded?	Core or fringe distribution	Public or private access	Previous comparable fyke and gill net data available? (years)	Boat electrofish data available[E]? (years)
Numeralla Junction to Bredbo Falls (reach)	-36.023571 149.138720	No	Fringe	Public and Private	No	No
Numeralla Junction to Bredbo Falls (reach)	-36.023571 149.138720	No	Fringe	Public and Private	No	No
Murrells Crossing	-36.109373 149.124937	Yes	Core	Public	Yes (1998[B], 1999[B], 2019-2021[A])	Yes[E] (2002-04, 2007, 2010, 2013-18, 2020)
Mittagang Crossing	-36.170377 149.091151	Yes	Core	Public	Yes (1998[B], 1999[B], 2020 [A])	Yes[E] (2004, 2007)
Kissops Flat	-36.139947 149.003230	Yes	Core	private	Yes (1998[B], 1999[B], 2001 [B], 2003 [B], 2004 -2006 [B], 2010-2021[C,D])	Yes[E] (2003, 2014)
Middle Dry Plains (reach)	-36.091389 148.999167	Yes	Core	Private	No	No
Alum Creek (reach)	-36.008944 148.940417	No	Core	Private	No	No
Bolaro (reach)	-35.980471 148.839602	Yes	Core	private	Yes (2021[A])	Yes[E] (2004, 2007, 2018)
Below Yaouk (reach)	-35.849818 148.806370	Yes	Core	private	Yes (1998[B], 1999[B], 2020 [A], 2021 [A])	Yes[E] (2003, 2007)
Upstream Yaouk (reach)	-35.819510 148.790909	No	Fringe	Private	Yes (1999[B])	No

Table 4. Potential reference sites, access, and availability of previous comparable data (utilising fyke and gill nets) and boat electrofishing since 1998

Site/Reach name	Coordinates : Decimal Latitude, Longitude	Macquarie Perch previously recorded?	Public or private access	Previous comparable fyke and gill net data available? (years)	Boat electrofish data available[E]? (years)
Abercrombie River, Millvale	-34.0878 149.55104	Yes	Private	No	Yes[E] 2006, 2008-14
Abercrombie River, Jeremy Station	-34.01125 149.46691	Yes	Private	No	Yes[E] 2006, 2008-10, 2013-14

4 Trigger Action Response Plan (TARP) criteria associated with the potential results of monitoring

A Trigger Action Response Plan (TARP) provides a framework for decision making in response to a deviation from a 'normal' condition in key criteria. For Macquarie Perch, the objective of such a plan is identify threats that may cause a sudden decline in Macquarie Perch and enable an assessment of cause with trigger values being informed by monitoring activities. A TARP for environmental monitoring also has several levels of activity or response, from 1 (normal), 2 (alert/investigation), to 3 (high alert).

Criteria, trigger levels and suggested response activities for Macquarie Perch are provided in Table 4. These have been developed from an understanding of the biology/ecology of the species and key threats (Tonkin et al. 2022a), and key monitoring activities proposed above, including potential monitoring outcomes. Note that specific trigger levels for genetic diversity cannot be defined as the genetic diversity of Macquarie Perch in the upper Murrumbidgee is not well known, with samples previously analysed only for a very small number of sites (Pavlova et al. 2017).

If monitoring indicates an Alert Level 3 for one or more of the criteria in Table 5 below, significant intervention may be required such as the emergency collection of individuals into captivity or restocking of a sub-population from captive breeding. Such an activity will require significant input from NSW DPI. Given that such interventions are often very time sensitive, it is recommended that an emergency intervention procedure is developed if one does not already exist.

As monitoring continues and knowledge of Macquarie Perch in the Mid Murrumbidgee improves, the trigger levels should be periodically reviewed, at least every 5 years, to ensure they are fit for purpose. As the species is relatively long-lived, this period is required for trends to be identified and validated, avoiding unsupported changes to trigger levels if triggers are met too often over shorter timeframes.

4.1 Trigger-based sampling

The Trigger Action Response Plan (TARP) details a decision-making framework for additional sampling in response to deviations from a 'normal' condition in key Macquarie Perch population metrics or other threats identified in the routine surveillance monitoring (see Section 3.5). This trigger-based sampling aims to identify specific processes (e.g. spawning failure) and threats (e.g. Redfin Perch incursion) that may cause a sudden decline in population metrics such as recruitment and survival.

4.1.1 Spawning assessment

Purpose: Monitoring of spawning activity.

Value: Contributes to identifying unsuccessful life-history stage(s) if recruitment failure is detected (e.g. spawning, hatching).

Trigger: Recruitment success or failure (presence and proportion of Young of Year) is determined from the routine surveillance population monitoring activity.

Timing: Mid-October to December.

Undertaken within 'core distribution' (see Table 3 monitoring sites (using the transect and quadrat methodology, and larval sampling method outlined below) along with collection of the routine water quality parameters measured at site scale, and general threat assessment (instream and riparian zone) undertaken at site scale. By undertaking this assessment in the spring following an observed > 30% decline of age 0+ fish over 2 consecutive years or in 3 years out of 5, a repeated failure can be detected as early as possible as well as an investigation into the cause of the decline.

Table 4. Criteria, trigger levels, and suggested response activities, for each alert level for Macquarie Perch

All percentage changes are relative to mean baseline data.

Criteria Alert level	Redfin Perch invasion	Decline or loss of recruitment	Decline in relative population abundance	Decline in fish condition or fish kill/morbidity	Genetic decline	Fire or drought (risk of sedimentation, water loss)
1 (Normal)	Continue monitoring.	Continue monitoring.	Continue monitoring.	Continue monitoring.	Continue monitoring.	Continue monitoring
2 (Alert / investigate)	*Trigger:* Redfin Perch reported or detected in annual monitoring. *Response:* immediate physical sampling (Section 4.1.2).	*Trigger:* Loss or > 30% decline of Young of Year life phases (in 2 consecutive years or 3 years out of 5) at > 2 sites *Response:* investigate spawning and egg hatching in subsequent season to establish the life stage where the failure may be occurring and seek to identify the cause (Section 4.1.1).	*Trigger:* > 20% decline in post-Young of Year life phases in 2 consecutive years. *Response:* investigate additional monitoring of recruitment, disease, survival (spring sampling run) (Section 4.1.1). - trigger levels to be reviewed following 3 years of data.	*Trigger:* > 30% of individuals declined in condition by > 25%; > 25% of individuals at 2 or more monitoring sites with externally visible parasites/disease, OR, fish kill observed or reported *Response:* investigate catchment (sedimentation, , riparian cover, food resources) and flow conditions (Section 4.1.3). - increased disease/parasite monitoring (samples to Veterinary clinic) and/or submission of samples from fish kill to veterinary clinic (Section 4.1.3).	*Trigger:* Loss of genetic diversity, increasing level of inbreeding. *Response:* additional annual analysis (2 years) of collected fin clips (Section 3.1.2) *Note* – specific trigger levels to be defined following first population genetic analysis.	Trigger: > 20% of catchment area burnt or streamflow ceases at nearest upstream flow gauge. Response: - additional monitoring of Macquarie Perch population for evidence of impact (spring sampling run) (Section 3.1.1).
3 (High alert)	*Trigger:* Redfin Perch detection in mid-Murrumbidgee confirmed by sampling (see Biosecurity Plan). *Response:* Immediately notify NSW DPI and enact emergency intervention procedure.	*Trigger:* Loss or > 30% decline in 3 consecutive years. *Response:* Notify NSW DPI and enact emergency intervention procedure to collect potential broodstock for incorporation into captive breeding program.	*Trigger:* > 30% decline in post Young of Year life phases in 2 consecutive years *Response:* Notify NSW DPI and enact emergency intervention procedure to assess need for supplementation of wild population in captive breeding program.	*Trigger:* > 50% of individuals declined in condition by > 25%; > 25% of individuals at 3 or more monitoring sites with externally visible parasites/disease. *Response:* Notify NSW DPI and enact emergency intervention procedure.	*Trigger:* Note – specific trigger levels to be defined following first population genetic analysis. *Response:* If captive breeding program operational, assess need for supplementation of wild population. Notify NSW DPI and enact any emergency intervention procedure to assess need for supplementation of wild population in captive breeding program.	Trigger: High risk of post-fire debris flow/instream sedimentation event, or pools drying. *Response:* Notify NSW DPI and enact emergency intervention procedure to collect potential broodstock for incorporation into captive breeding program. population when risks decline.

Spawning site characterisation and egg sampling

If repeated failure to detect recruitment of Young of Year occurs, it is necessary to investigate at which life phase the failure has occurred (spawning, hatching, larval growth and survival). Determination of whether and where spawning has occurred can be quantified by searching for eggs and spawning sites. To characterise Macquarie Perch spawning habitat in riffles, a suite of habitat variables should be measured along quadrats within transects perpendicular to river flow at several riffles (Tonkin et al. 2016; Broadhurst et al. 2019). Total riffle length is measured and then a series of transects are established at 0, 25, 50, 75 and 100% of the longitudinal length of the riffle at the time of sampling. Physical characteristics of each riffle are assessed in four evenly spaced 0.5 x 0.5 m quadrats placed across each of the transects spanning the entire length of a riffle (giving a total 20 quadrats per riffle). Quadrats are placed at 20, 40, 60 and 80% of the channel width of the transect at the time of sampling. Within each quadrat a range of microhabitat features are assessed (Table 6).

Once habitat parameters are measured for a quadrat, the substrate within the quadrat can be disturbed (by a modified rubber broom; by hand; by foot) and the material collected immediately downstream in a 500µm dip net. Contents of the net can then be immediately washed into a sorting tray where all fish eggs and larvae are removed. In each quadrat the number and developmental stage of fish eggs is then determined (Table 7) with eggs then released at the site of collection. Sampling at each site would occur twice between mid-October to December (2 weeks apart). Sampling to occur at sites with decreased recruitment and at adjacent sites (2 upstream and 2 downstream where available unless there are not 2 routine monitoring sites upstream or downstream (i.e. edge of core distribution).

Larval sampling

To determine hatching success, larval monitoring should be conducted in late November to mid-December. Larval drift nets should be deployed overnight at sites with decreased recruitment and at adjacent sites (2 upstream and 2 downstream , where available) unless there are not 2 routine monitoring sites upstream or downstream (i.e. edge of core distribution). Larval sampling to follow standard procedures using 2–3 larval drift nets per site, set overnight with flow meters (1 day per site to process the 3 nets). Sampling at each site would occur twice (2 weeks apart).

Table 6. Habitat variables used to characterise spawning habitat in riffles

Scale	Metric
Mesoscale	Riffle length and width
	Water Temperature
	Distance from shore
	Water velocity
Microscale	Water depth
	Substrate composition

Table 7. Physical characteristics used to determine Macquarie Perch egg stage (modified from Jones et al. 1978)

Egg stage	Characteristics used to determine stage in field
Unfertilised / early cleavage	transparent or oil globule present
Late embryo	Eye spots, notochord or spine visible
Larvae	Free swimming larvae

4.1.2 Non-native species assessment (TARP triggered)

Purpose: Detection of invasion of Redfin Perch into Macquarie Perch sampling sites.

Value: Early detection of Redfin Perch to facilitate control or other management.

Timing: Trigger based (see **Error! Reference source not found.**).

Frequency: Trigger based (see **Error! Reference source not found.**).

To verify/validate reported incursion, intensive additional sampling is to be undertaken if Redfin Perch are detected in annual sampling or outside report of incursion is received. Conventional sampling using nets, backpack electrofishing and/or boat electrofishing is to be undertaken at the reported incursion location and 2 monitoring sites immediately upstream and downstream of reported incursion location. Subject to access, initial eDNA sampling at 5 km intervals radiating from incursion sites is required to define the invasion front with further physical sampling required for positive detections.

Detection of Redfin Perch invasion

Redfin Perch are a significant threat to Macquarie Perch both through predation of smaller life stages and as a vector of epizootic haematopoietic necrosis (EHN) virus (Langdon 1989; Whittington et al. 2011; Commonwealth of Australia 2018; Hick et al. 2019). As such early detection of the presence of this species is critically important. The routine population monitoring for Macquarie Perch has the capacity to detect the presence of Redfin Perch. However detection of rare species at low abundance is problematic, and so capacity to respond to reports of Redfin Perch incursions is critical.

A pest fish and disease surveillance program is a requirement of the Snowy 2.0 Biosecurity Risk Management Plan.

4.1.3 Fish condition assessment

Purpose: Identification of cause of decline in fish condition, or fish kill/morbidity.

Value: To enable early intervention to reduce or reverse decline in condition or diagnose reason for fish kill/morbidity before impact to Macquarie Perch population occurs.

Timing: Trigger based (see **Error! Reference source not found.**).

Frequency: Trigger based (see **Error! Reference source not found.**).

Method: Undertaken at the relevant sites triggered by observed decline in fish condition metric (fish length/weight relationship or external parasite load) generated from annual monitoring and/or increased parasite load. Depending on the observed decline and catchment conditions consider the following activities:

- Collect sample of juvenile individuals for intensive investigation of internal and external disease/parasite by appropriate Veterinary Clinic.
- Assess instream aquatic macroinvertebrate abundance and diversity.
- Assess catchment conditions for threats likely impacting condition such as aquatic macroinvertebrate condition, (e.g. sediment),water quality or exotic fish incursions.

Consider the need to continue monitoring fish condition and parasite/disease, including standard water quality parameters whilst undertaking investigations.

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6 Appendices

6.1 Example of field survey data form (Victorian data form, Murray–Darling Basin Fish Survey program)

VICTORIAN MDB Fish Survey DATA SHEET

MDB FS datasheet v1.0

OurSiteNo.: ____ - ____ - ____ MDBSiteNo: _____ Date: _____/ _____/ 201___

DrainDivision: IV RivBasin No.: _____ RiverBasin Name: _____

Water Name: _____ Trib. of: _____

Location: _____

_____

_____

_____VICRoads Ref:_____

MapNo:_____ Zone:____ Datum (circle): 84 GDA94

(MGA = as close to 1:25 000 mapped point as possible) LAT/LONG – e.g. – 33.57030 149.25275 (5 decimal places)

D/S: MGA: _ _ _ _ _ 00 E _ _ _ _ _ _ 00 N Lat. --_____'S Long: _____'E

U/S: MGA: _ _ _ _ _ 00 E _ _ _ _ _ _ 00 N Lat. --_____'S Long: _____'E

Alt: _____ m STAFF: _____, _____, _____, Site Photos: YES/NO No._____u/s_____d/s

SITE Ave. Depth (m) Max. Depth (m) SAMPLE RATING(circle): Green / Amber* / Red*

* - provide comment below as to why

WQ: Time:_____ (hrs) EC:_____ @ (circle) WTemp / or 25°C Water Temp. (°C):_____

DO:_____ mg/L _____ %sat. pH: _____ Turbidity.: _____ Secci Disc:_____ m

Gear Codes: BP Backpack; BM Bank Mounted; BT Bait Trap; LB Large Boat; MB Medium Boat; SB Small Boat

Gear Type	EF Op.#	Time Start (24 hr)	Time Finish (24 hr)	Sampling Period (min & sec)	Electro Seconds 90 or 150	Distance Travelled (m)	Wetted Width (m)	Volts	Pulses per sec per sec.	% Duty Cycle	Pulse Width (m/s)	Amps
	1						.					
	2						.					
	3						.					
	4						.					
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	10						.					
	11						.					
	12						.					
BT	-											

(nick)

☐ SHRIMP present ☐ MACROBRACHIUM present ☐ MUSSELS No. _____

☐ Platypus, No._____ ☐ Water Rat No._____ ☐ Unidentifyed Turtle No._____ ☐ Long-neck Turtle No._____

☐ Short-neck Turtle No._____ ☐ Broad-shelled Turtle No._____

Comments:_____

_____

_____More Comments - P.T.O.

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Site No.: _____ - ______ - _______ **Date:** _________/ _________/ 201___ **VICTORIAN MDB – FISH SURVEY**

Gear Codes: **BP** Backpack; **BM** Bank Mounted; **BT** Bait Trap; **LB** Large Boat; **MB** Medium Boat; **SB** Small Boat

CONDITION CODES:

- **D** - Deformity (Skeleton deformities, blindness, asymmetrical etc.)
- **F** - Fin condition poor (broken or eroded)
- **G** - Fungus
- **L** - *Lernaea* (if fish <100 mm TL record number present; if fish >100 mm TL only report if more than three individuals present)
- **O** - Other (eg. gas bubble eye) (photograph and describe)
- **P** - Other visible parasites (eg. encysted metacercariae, leeches, isopods)
- **S** - Lesions (skin abnormality with raised and or discoloured scales)
- **T** - Tumor (localised abnormal growth)
- **U** - Ulcers (redness, skin broken, crater like)
- **W** - Wounds (bird strikes, hook wounds etc.)

Gear	Op. #	Genus	Species	Collected Fish #	# Fish Observ.	Length (mm)	Weight (g)	Condition Code	Sex	Comment (and Tag No.)
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