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Stocky Galaxias – translocation strategy, Snowy 2.0

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Caveat: This report was completed in October 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 selection of options and preparation of various aquatic Management Plans required as part of the NSW and Commonwealth approvals for the Snowy 2.0 project. This report provides an outline for a translocation strategy for Stocky Galaxias (*Galaxias tantangara*). It sets out objectives and potential translocation activities aimed at improving the security and resilience of the species, given its current low abundance and limited distribution. Given the long-term nature of such an endeavour, its value and relevance will extend beyond the Snowy 2.0 Management Plans.

This translocation strategy for Stocky Galaxias is based on relevant literature including results and knowledge gained from undertaking galaxiid translocations in Victoria since the early 2011 as part of galaxiid recovery plans (Raadik et al. 2010, Ayres et al. 2012a, b). Similar translocation/stocking is also currently part of the conservation management of seven additional, narrow range, threatened galaxiid species in eastern Gippsland, Victoria (Raadik 2019 a, b). This strategy has also taken into consideration relevant components of the following:

- National Policy Guidelines for the Translocation of Aquatic Animals (DAWE 2020).
- NSW Freshwater Fish Stocking Fishery Management Strategy (NSW DPI 2005).
- NSW Translocation Operational Policy (DPIE 2019).
- Conservation Translocation Handbook for New South Wales Threatened Freshwater Fish (Zukowski et al. 2021).

Translocation is defined as the deliberate movement of living organisms from one area to another (IUCN 1987, Armstrong and Seddon 2008), and conservation translocations are those undertaken by humans with the intention of a measurable conservation benefit at the individual, population, species, and ecosystem level (IUCN 2013). The term stocking has also been loosely used instead of translocation, though this more commonly refers to the placement of captive-bred native or non-native species into an area where they are already present, or into new locations for commercial or recreational benefit. Herein, we follow the terminology of IUCN (1987, 2013) for conservation translocations.

Two types of conservation translocations are recognised, based on release of individuals either inside or outside of an organism's indigenous range, with two activities recognised in each (IUCN 2013):

- Population restoration – within an organism's indigenous range.
    - Reintroduction – the intentional movement and release of organisms into part of its native range from which it has disappeared.
    - Reinforcement (restocking) – the intentional movement and release of organisms into an existing population of conspecifics.
- Conservation introduction – outside of an organism's indigenous range.
    - Assisted colonisation – the intentional movement and release of organisms outside its indigenous range to avoid extinction of populations of the focal species.
    - Ecological replacement – the intentional movement and release of organisms outside its indigenous range to perform a specific ecological function.

In each case, and depending on the situation, the source of organisms can be captive-bred or wild-caught stock. In Australia, there is a long history of conservation translocations for freshwater fish involving both wild-to-wild and hatchery-based translocations (Lintermans et al 2015).

For Stocky Galaxias, the first three activities (reintroduction, reinforcement, and assisted colonisation) are relevant. The fourth translocation activity is not relevant, as its aim is to fill a vacant ecological niche, e.g. a closely related, ecologically similar species of galaxiid is introduced to outside of its indigenous range into a catchment in place of a former species which has become extinct.

This translocation strategy follows the IUCN guidelines (IUCN 2013), which have been used in previous threatened galaxiid conservation actions (Ayres et al. 2012a, b), and Zukowski et al. (2021). The strategy will need to be adaptive, as it will depend heavily on outcomes from other activities including species monitoring, catchment survey, captive breeding, pest fish monitoring and on improvements in knowledge of Stocky Galaxias biology/ecology from this work (Raadik and Lintermans 2022a, b, c.).

1.1 Relevance to priority conservation actions

Priority actions identified by NSW DPI (2017) that are relevant to this strategy include:

- Undertake emergency rescues of Stocky Galaxias in response to droughts, oil spills/ pollution, detection of biosecurity threats (e.g. disease or pests), or to avoid other detrimental impacts. (high priority)

- Prevent salmonid stocking into Stocky Galaxias habitat areas, including above the delimiting waterfall which is currently the only natural barrier for invasion to the habitat of the Stocky Galaxias. (high priority)

- Ensure important populations and locations are protected from stocking of trout. (high priority)

- Implement the NSW Freshwater Fish Stocking Fishery Management Strategy to prevent significant impacts from stocking on Stocky Galaxias populations. (high priority)

- Identify potential candidate sites for possible future translocation of Stocky Galaxias. (medium priority)

Although physical translocation back into the wild has not been identified as a priority action for the species by NSW DPI (2017), it is a valuable and logical next action after the identification of candidate sites for future translocations, and is addressed below (NSW FSC 2019, TSSC 2021).

The following priority actions identified by the NSW FSC (2019) and included in the federal conservation advice for Stocky Galaxias (TSSC 2021) are also relevant to this strategy:

- Identification of streams suitable for trout barrier installation (or augmentation).

- Undertake predator (trout) removal, if present, from potential translocation sites.

- Population genetic analysis of current and new populations, to inform translocation plan and specific population management.

- Formulation of a detailed translocation plan and undertake translocations to establish additional, viable populations to spread extinction risk.

2 Translocation strategy

2.1 Objectives and rationale

The objective of the translocation strategy is to:

- Improve the conservation status of Stocky Galaxias in the wild to ensure enough viable populations with evolutionary potential exist to support long term persistence.

Actions to address this are:

- Investigating and prioritising options to enhance the condition and resilience of the current population.
- Establish a translocation procedure to enable the harvesting and translocation of Stocky Galaxias (wild-to-captivity, captivity-to-wild, and wild-to-wild) to act as brood stock for a captive breeding program, to establish additional wild populations, and where required, for emergency extraction (post-fire, predator incursion, etc.).
- Translocate individuals to establish a captively maintained population in the short term, as insurance against the loss of the species in the wild.
- Increase the number of wild populations, and therefore decrease the risk of extinction of the species by establishing additional populations to the only one presently known.

Currently, Stocky Galaxias is confirmed to exist as a highly threatened species in a single, small population in a short reach of stream (NSW FSC 2016, Raadik 2014, Allan and Lintermans 2019, Lintermans and Allan 2019, Raadik and Lintermans 2022a, TSSC 2021). A second, recently discovered, location (Lintermans, Raadik, Unmack unpublished data) is currently undergoing investigation to ascertain whether it is a pure or hybrid population between Stocky Galaxias and Mountain Galaxias (*Galaxias olidus*). From a conservation perspective, species which persist as a single, small, population have a very high extinction risk (Furlan et al. 2016, Brown et al. 2022). This is from various threats such as sudden stochastic events in the catchment (e.g. drought, fire, instream sedimentation, disease, etc.), which lead to loss of population/species resilience due to loss of genetic diversity and inbreeding (Reed 2004, Frankham 2005, Frankham et al. 2010, Smith et al. 2014, Frankham 2015). Further, Stocky Galaxias is a small species with a limited dispersal ability, additional traits which make it vulnerable to extinction (Olden et al. 2007, Kopf et al. 2017, Todd et al. 2017).

Comparatively, threatened species with multiple populations that are distributed over a large geographical range have a lower extinction risk, as the likelihood of a stochastic event affecting all populations is reduced., more populations usually represent a greater number of individuals and greater genetic diversity. For Stocky Galaxias, establishing a greater number of populations as an immediate priority would also provide more individuals for wild-to-wild or wild-to-captive translocation events, and therefore less risk of potential impact from harvesting stock for translocation on donor populations.

As a result of the high risk of extinction for Stocky Galaxias, a triage approach would justify immediate conservation measures to reduce and spread extinction risk (TSSC 2021) due to only a single, small, confirmed population persisting. Failure to act quickly can have irreversible consequences (Martin et al. 2012).

Standard threatened species recovery actions to reduce high extinction risk include increasing the number of individuals within and between populations, the number and extent of populations, and the genetic fitness of individuals/populations. These can all be achieved by translocation, though for Stocky Galaxias, this will be hindered to a degree by the low starting point of a single, small population which imposes limitations on the number of individuals available for wild-to-wild translocations.

Therefore, regardless of the outcome of the Catchment Survey Program, translocation of a sufficient number of individuals to a facility for ex situ management and for captive breeding, is a vital, complementary activity (Canessa et al. 2016), to establish two populations, one as an insurance policy against the extinction of the species, and the second to generate additional, genetically healthy, stock for translocations. This is particularly important in the early phase of recovery until additional, viable populations in the wild can be established. A small population of Stocky Galaxias is currently in captivity, having been extracted from Tantangara Creek in response to the 2019/20 fires, however, due to decline in numbers, is not considered suitable as an insurance population or for large-scale captive breeding (see 2.2.2, below). Consequently, establishment of an insurance population, following appropriate biosecurity processes, is still required. The

separate, small number of captive fish still have value from an experimental perspective and can be used to trial aspects of captive breeding for the species.

The number of viable populations required to sufficiently reduce the extinction risk to Stocky Galaxias is unknown, and this field of conservation translocations is under debate (Sanderson 2006, Traill et al. 2010, Flather et al. 2011). However, in the short-term, increasing the number of populations above one is critical, and > 3 geographically spread populations may be a manageable target depending on the outcomes of the Catchment Survey. Given the risk of unexplained and often sudden loss of populations during the early phase of new population establishment (Lintermans et al. 2015), a long-term target of 6–8 populations would be preferable, to allow for redundancy. However, this number may need to increase if many new populations discovered are geographically close, and therefore at equal risk of impact from a stochastic event compared to populations spread more widely across a broad geographic area. Whilst a target of 6–8 geographically spread populations is an ultimate conservation target, it is acknowledged that this may be constrained or delayed by other factors such as limited suitable translocation sites, reduction in the size of source populations preventing harvesting of individuals, failure or delays in establishing captive breeding techniques, etc.

Measures to establish captive breeding of Stocky Galaxias, to support potential translocations, will be addressed in a separate Captive Breeding Strategy.

2.2 Strategy details

Actions and decisions for a long-term translocation strategy are outlined in Figure 1, including linkages with population monitoring and future captive breeding research and activities. Other important components are detailed below.

2.2.1 Optimal translocation plan

Once options for translocations are known, specific translocation activities should follow a detailed translocation plan which addresses aims, methods, feasibility, genetic considerations, measures, and timeframe for assessing success (George et al. 2009, Galloway et al. 2016, Zukowski et al. 2021). Key in this is knowledge of the source population(s) and translocation site(s) and type of translocation to be undertaken (i.e. hatchery-based or wild-to-wild). This should also consider an assessment of risks (e.g. unintended consequences) from the translocation, and controls to ensure activities to minimise potential impacts. This is an important step which is also addressed in the REF (see above) as part of the translocation approval process.

Genetic assessments are a crucial component of any plan to guide translocations to maximizes genetic diversity, adaptability, and resilience of populations (e.g. Weeks 2014, Attard et al. 2016, Flanagan et al. 2018). This assessment would be based on genetic data from the target organism (Stocky Galaxias) and size and number of available translocation sites with the aim to preserve genetic diversity at the establishment phase, while giving populations the opportunity to evolve and adapt independently from one another.

For Stocky Galaxias, this is highly important as the species is only known at present to persist as a single pure population in the wild, individuals from which will be used for reintroductions, reinforcement, and if needed, assisted colonisation. An optimal plan will also benefit from a genetic and demographic monitoring protocol to assess reintroduction success and establishment and help guide adaptive management of populations (sensu McCarthy and Possingham 2007). This may also include development of a genetic simulation program for determining the genetic trajectory of reintroduced populations based on real demographic and genetic data.

Such a plan can inform optimal genetic diversity targets, numbers of individuals for types of translocations and post translocation monitoring activities, particularly genetic monitoring (Weeks 2014). This will also be invaluable to a captive breeding program.
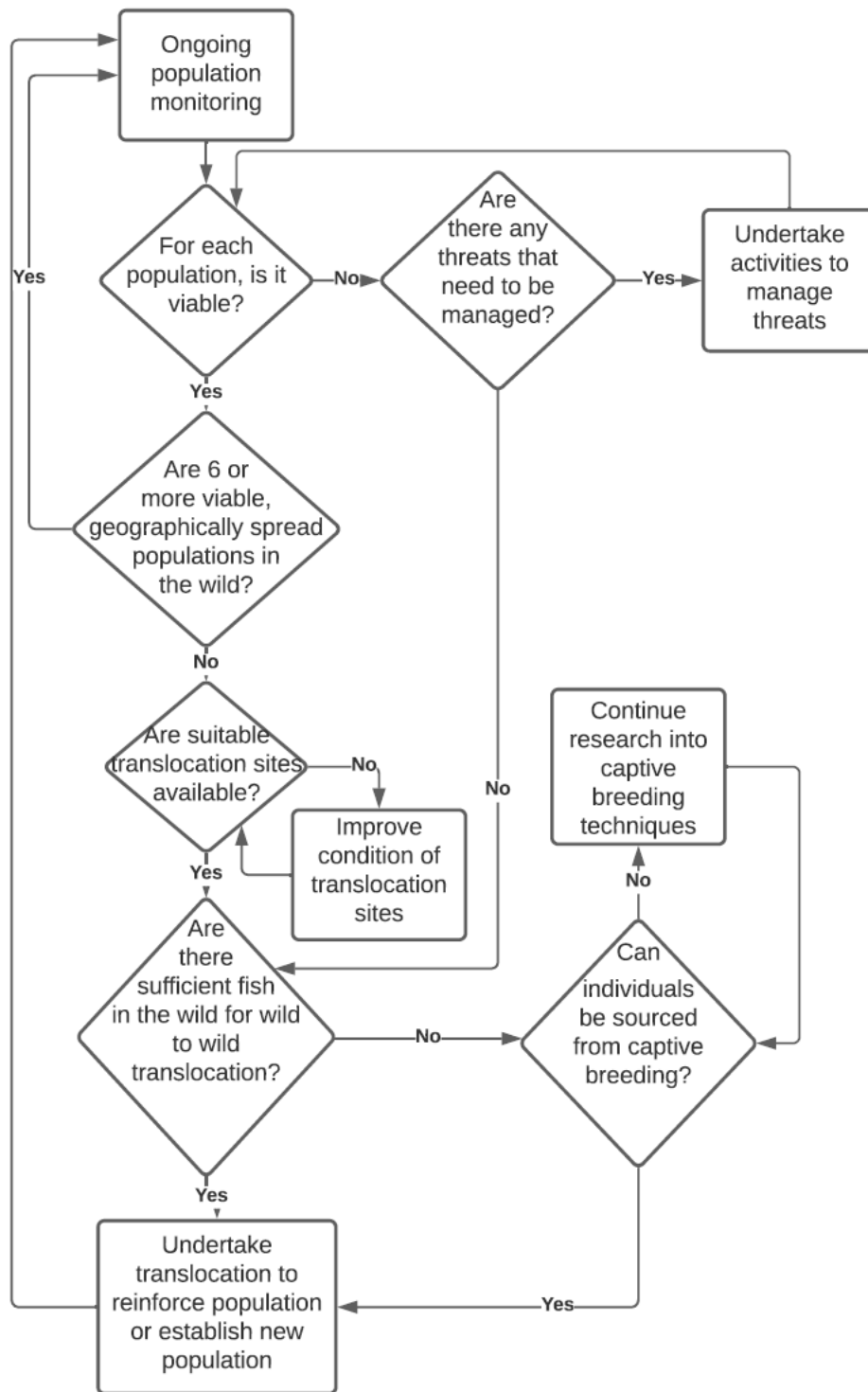
Figure 1. Flow chart of decisions (diamond box) and actions (square box) to guide translocations for Stocky Galaxias.

As establishment of viable new populations is reliant on population genetic data, this needs to be gathered before large scale captive breeding or translocations can be conducted. This genetic assessment could occur using existing available genetic material collected in 2020 (M. Lintermans and H. Allan, pers. comm.) that is expected to be analysed shortly (Luke Pearce, pers comm.) or from samples collected during population monitoring activities. Until sufficient genetic assessment of known populations occurs and suitable translocation sites are identified, the specific details for a Translocation Plan for Stocky Galaxias cannot be determined.

2.2.2   Translocation prerequisites and triggers

Simplistically, conservation translocations are reliant on three prerequisites:

- A justifiable reason to shift individuals (threat monitoring or reduction of extinction risk (single population)).

- Individuals available to shift (donor location(s)).

- Suitable location(s) to receive individuals (recipient location(s)).

For stocky Galaxias, the first two criteria are met: single confirmed, small population and high risk of extinction and one available population. Recipient locations are currently unknown besides a captive population as insurance against the loss of the species in the wild. From a future-proofing perspective, translocation to manage increasing fire/drought impacts should also be considered (Sgro et al. 2011, Shanke et al. 2017).

Some potential candidate recipient locations have been preliminarily identified (e.g. Kiandra Creek (Allan and Lintermans 2019)) but additional information is required on these and other potential locations. A comprehensive survey for potential wild recipient locations (translocation sites) will be addressed as part of a Catchment Survey (Raadik and Lintermans 2022c).

Prior to any activities to translocate Stocky Galaxias the following activities would be required to maximise the potential for success and minimise the potential for adverse outcomes:

- Translocation site identification and suitability assessment.

- Genetic modelling and assessment of the donor and recipient populations.

- Undertake Environmental Assessment and obtain necessary permits and approvals.

- Population modelling (if available data allows) and assessment.

- Pre-release translocation site monitoring.

Genetics

One of the key activities to meet the objective of the translocation strategy is to ensure the persistence of enough viable populations with evolutionary potential (3.1 above). As such, the genetic condition of each wild source population, or captive bred stock, is critical to understand prior to translocations being undertaken. This information is crucial to guide decisions regarding translocation, whether wild-to-wild, wild-to-captive or captive-to-wild, to set genetic targets for translocations to increase establishment probability in the short-term, and evolutionary potential and persistence in the long-term. Population/species genetic data is the key to improving translocation success, and overall conservation management, as it provides information to address many critical conservation considerations (e.g. Weeks et al. 2016, Pavlova et al. 2017, Hoffman et al. 2020, Bragg et al. 2021).

Genetic analysis of the Tantangara Creek population is planned by NSW DPI currently (Luke Pearce, pers. comm.) and could continue as part of the Monitoring Program (Raadik and Lintermans 2022b). This would extend to any new populations which may be discovered during the Catchment Survey Program. Understanding the genetics of captive bred stock, ready for translocation, will be an integral part of any future captive breeding activities for broodstock and offspring.

Permits

Relevant permits to undertake the collection and translocation of fish will need to be organised well in advance. These are, but may not be restricted to, the following.

- Scientific Collection Permit – authorises the taking and possession of fish for the purpose of research, under section 37 of the NSW *Fisheries Management Act 1994*, and threatened species under the *Biodiversity Conservation Act 2016*. Available from the NSW Department of Primary Industries.

- Scientific Licence – authorises research in the National Parks and Wildlife Service reserve system, authorised under section 132C of the NSW *National Parks and Wildlife Act 1974*. Available from the NSW Office of Environment & Heritage.

- Animal ethics approval – for sampling of fish, and collection of voucher material (either NSW or institutional).

- Broodstock Collection Permit – authorises the take or possession of fish, under section 37 of the NSW *Fisheries Management Act 1994*. Available from the NSW Department of Primary Industries. (This is required only if broodstock collection was not included in the Scientific Collection Permit.)

- Stocking Permit – authorises the release of live fish into waters of New South Wales, under section 216 of the NSW *Fisheries Management Act 1994*. Available from the NSW Department of Primary Industries.

Before permits can be issued, an assessment of the merit and risks of conservation translocations would need to be undertaken by the proponent through a Review of Environmental Factors (REF), approved by the NSW DPI Fisheries Threatened Species Unit, which is a requirement of the NSW Freshwater Fish Stocking Fishery Management Strategy (Zukowski et al. 2021). The REF is assessed as part of a Threatened Species Conservation Stocking Approval, and if approved, the details of each translocation would be notified to NSW DPI Fisheries through a Conservation Stocking Verification Form.

The NSW Freshwater Fish Stocking Fishery Management Strategy (FMS) outlines the rules, regulations and programs that are designed to manage the activity of fish stocking (i.e. translocation) in future, including the introduction of an appropriate management regime to minimise the environmental risks of stocking. As such, it is an important document guiding the NSW approach to both recreational and conservation stocking and guides activities from species and waters to be stocked, hatchery protocols, sufficient targeted research pre and post stocking, compliance and education and information management.

Wild-to-captivity translocation

A clear trigger for the translocation of Stocky Galaxias into captive management is already present; an extremely high risk of extinction to the species due to potential impacts on its only known, small population (Bowkett 2009, Dolman et al. 2015). Whilst 140 individuals, taken into captivity in January 2020 due to fires (see Raadik and Lintermans 2022a), and juveniles collected in early 2021 (M. Lintermans unpublished data), are being managed within captivity, this is not being informed by a captive management or breeding strategy.

Any learnings regarding captive care or reproduction from the captive husbandry of the fire-rescued fish will be incorporated into the proposed captive breeding strategy. However, losses of these fish since the rescue to less than 50 individuals, some of which are juveniles, suggests that there is currently an insufficient number of individuals on which to base an insurance population (i.e. one from which the species could be recovered if extinction in the wild occurs). The small number of remaining individuals, albeit collected from two locations in Tantangara Creek, is considered too small to be representative of the wild population and will likely experience a higher coefficient of inbreeding. Larger effective population sizes (e.g. >50 individuals) is usually accepted as the minimum to combat inbreeding. Further, the effective population size is always smaller than the actual population size, as not all members will be able to breed, and therefore the size of the captive population should also accommodate this consideration. Further, these fish were exposed for a time to river water from a different catchment and are now considered to be a potential biosecurity risk if returned to Tantangara Creek. Any offspring of these fish could be considered suitable for release if appropriate biosecurity measures are maintained during the captive breeding process.

Other scenarios which could trigger this type of translocation of Stocky Galaxias are as follows:

- An identified active or imminent threat to any existing population

- Insufficient individuals in the wild to support wild to wild translocation – requires translocation of some individuals to a facility for a captive breeding program to support reintroduction, reinforcement or assisted colonisation.

- Less than six evolutionarily viable populations exist in the wild – requires translocation of individuals (wild-to-wild and/or hatchery-to-wild) to establish additional populations (reintroduction or assisted colonisation).

- Population decline or evidence of recruitment failure in an existing wild population. If pre-established trigger levels are reached during population monitoring (see Trigger Action Response Plan in Raadik and Lintermans 2022b) including issues such as recruitment failure, genetic decline, predatory fish invasion, decline in fish condition, fire, drought, instream sedimentation, or declines in water quality, translocation activities may be required. These could include translocation to captivity, between populations (reinforcement), reintroduction or assisted colonisation

Wild-to-wild or captive-to-wild translocation

Specific situations that could trigger the translocation of individuals from one wild population to another location in the wild, or from captivity (e.g. hatchery or temporary captive management) to a wild location include:

- To safeguard against an imminent threat or reproductive issue as identified in the Trigger Action Response Plan (TARP) associated with the source population (in the case of wild-to-wild).

- If population enhancement by adding more fish or genetic diversity at the recipient location is required and sufficient numbers occur (and the genetic assessment considers them suitable) at the donor population or in captivity (wild-to-wild, or captive-to-wild).

- If genetic assessment considers that population 'fitness' can be improved via wild-to-wild translocation or from captive-to-wild translocation.

- If the opportunity to establish a new, or expand the range of the existing, population has been identified during a catchment survey.

2.2.3   Fish collection

The following section is based on a protocol developed for the similar Barred Galaxias (Ayres et al. 2012a, b), and experience of the 2020 and 2021 collections of Stocky Galaxias (M. Lintermans unpublished data).

Once the need for collection of Stocky Galaxias from the wild for translocation has been established, this should be undertaken by backpack electrofishing (see Raadik and Lintermans 2022b,c). Fish collection should be spread along an appropriate length of the stream (e.g. 200–400 m), to increase the probability of selecting enough unrelated individuals representing the spread of genetic diversity within the population (Furlan et al. 2012); favouring variation over uniqueness (Weeks et al. 2016). Multiple (repeated) electrofishing runs could be undertaken if needed, and sampling can be targeted to discontinuous reaches to minimise depletion effects in localised areas.

Individuals for translocation should be selected from across all sexually mature size classes and both sexes (if sex is known), aiming for an equal sex ratio if possible. This will maximise the translocated population's likelihood of reproducing within the first year, however, must not overly deplete the wild source populations' reproductive potential. This can be informed by a stochastic population model (see below), however, in the absence of one, a conservative, qualitative target for annual harvest may be set at 15% or less of the adult population. The distance sampled and average stream width should be recorded at collection sites to enable additional estimates of fish abundance/density, if collection is not undertaken during an annual monitoring event. All fish should be visually inspected for disease, parasites and injury, and only healthy fish translocated. All selected fish should be fin-clipped for later genetic analysis and measured for weight (g) and total length (mm) (as per Raadik and Lintermans 2022b) and externally sexed (if possible).

The optimum timing of Stocky Galaxias capture, and translocation for population restoration (reinforcement, reintroduction) or conservation introduction (assisted colonisation) is late summer to autumn: this could possibly be timed to coincide with population monitoring (Raadik and Lintermans 2022b). This takes into consideration the amount of time before the next spawning season to ensure fish are translocated early enough to allow them to breed. Fish shifted at an advanced stage of reproductive development may not breed due to potential stress associated with the translocation event, or unfavourable habitat conditions at the release site. Further, increased water temperatures during summer, or high flow conditions during winter, may create unfavourable habitat conditions for translocation and cause unnecessary stress on translocated individuals.

Obviously, if fish require translocation as part of a fish rescue (e.g. due to a trigger identified in the Trigger Action Response Plan (Raadik and Lintermans 2022b) or an identified active or imminent threat), seasonal timing will probably not be as important as the risk from the threat, and translocations should proceed rapidly.

General site characteristics such as GPS coordinates, date and time, and digital images should also be recorded prior to collection of individuals from sites in the wild, in addition to water parameters at the source site, i.e. electrical conductivity, temperature, dissolved oxygen (mg/l and % saturation), pH and turbidity. All procedures applied during the translocation process must comply with conditions stipulated by the translocation permit, and those applied during all activities must minimise stress and avoid injury or illness to the fish.

2.2.4   Biosecurity and fish health

Processes to ensure aquatic fieldwork hygiene should follow NSW DPI (2017) and any other relevant Biosecurity guidelines. Specific measures and controls should be determined during planning for the activity. These include, but may not be limited to, pre-departure and end of fieldwork inspection and removal of debris, cleaning, disinfecting and drying equipment, specific hygiene for aquatic fieldwork equipment and PPE, and destruction, disposal, and investigation of suspected aquatic disease/pests.

During capture of fish for translocation, or before release at a translocation site, all fish will be visually assessed for signs of disease or damage. Very sick fish with poor potential for recovery will be euthanased. Similarly, all fish leaving a holding or aquaculture facility will first be checked by a veterinarian for visible

signs of disease, damage, or aberrant behaviour. During the translocation process at a site, all source water will be disposed of well away from the waterbody (see below).

2.2.5   Fish transport

Fish may need to be transported from the site of collection to a facility for captive management or breeding (wild to hatchery), to the wild from a hatchery, or between sites in the wild. During transportation, care will be required to minimise harm and stress to fish. Specific measures and controls should be determined during planning for the activity. The following sections provide detail on controls for fish transport that are currently considered 'best practise' (NSW DPI 2005, Zukowski et al. 2021).

Between capture location and transport vehicle.

The transfer of fish between a capture location and a transport vehicle is similar in either direction. However, see 'Release of Fish' below.

- If vehicle is close to site of capture (< 200 m) shift fish in temporary transport containers (e.g. fishing buckets with lids). Ensure water is exchanged with fresh source water before shifting.

- If vehicle is far from the site of capture (> 200 m), fish may need to be shifted in temporary transport containers (e.g. fishing buckets with lids), other suitable container carried inside a hiking pack, or carried in a container specifically attached to a hiking frame. In that case:
  – Add fresh source water before shifting.
  – Provide adequate aeration (e.g. high powered, rechargeable battery, portable air pumps and air-stones).
  – Provide insulation around containers if required.
  – Check fish periodically (e.g. every 30 minutes).
  – Replace transport water if necessary (and possible).

Consider the transfer of fish between transport vehicle and capture/release site using helicopter if capture/release locations are very remote or difficult to drive to (e.g. rough terrain) and there is a high risk of fish mortality (i.e. Gooch and Roberts 2021).

Within transport vehicle

- Transport containers should be large enough to hold the number and size of fish requiring transport and insulated to minimise water heating during transport. They should also be filled to just below the brim to reduce water movement during transport to avoid physical damage to fish.

- Animals should be transported in source water, which is at the lower end of the species' preferred temperature range to reduces metabolic activity to reduce waste production which can have consequences for water parameters and therefore animal condition (Sampaio and Freire 2016). Decrease temperature of water containing animals slowly to avoid shock (i.e. not more than 2°C/h and ≤ 10°C/day; Johnston and Jungalwalla 2004).

- Transport water should be treated with a prophylactic additive such as Protech (Aquasonic Pty Ltd) to counter loss of protective outer mucus layer on fish due to capture, handling, and transport, and Amguard™ (Seachem) to reduce exposure of animals to toxic free ammonia released during transport.

- Each transport container should be fitted with adequate aeration, and water chilling (if required), to prevent adverse water quality changes, and to meet the physiological requirements of the animals over the time they are being transported.

- Regular checks, at least once hourly, should be undertaken to ensure water parameters remain within the species' range, and that aerators and chillers remain functional.

- Spare equipment, necessary for the life support of individuals (e.g. aerators, air-stones, plastic tubing and connectors, and chillers), is also necessary to rapidly rectify breakdowns.

- All animal transport containers should be secured to the transport vehicle.

2.2.6   Identify suitable release sites

Potential translocation sites must be identified in advance and the habitat must be considered able to sustain a new population. These sites may be identified as part of the Stocky Galaxias Catchment Survey (Raadik

and Lintermans 2022c), or from other management or research projects in the area. Features considered necessary for a translocation site for Stocky Galaxias include:

- High degree of water permanency (ability to support fish).
- > 1 km, preferably > 2 km of potentially permanent wetted habitat to sustain a population of sufficient size.
- One or more instream barriers to prevent the upstream incursion of predatory fish (trout).

The additional option of using constructed/artificial habitat (ponds, dams, connecting streams) as an alternative to natural habitats should also be considered if natural locations are unavailable.

Predator removal

If predators (trout) are present at a site with good conditions for fish persistence (e.g. effective barriers present, good habitat and water security), the removal of all trout will enable the location to meet the criteria to be considered a potential translocation site for Stocky Galaxias. These sites should be assessed for the feasibility of fish removal, based on the following:

- Area (length x width) of stream to be treated.
- Stream complexity (e.g. single channel, braided channel, multiple tributaries).
- Water depth and complexity of instream habitat (with respect to difficulty of detecting fish/efficacy of removal treatment to be applied).
- Site accessibility (remoteness from vehicle access points).
- The time of year.
- Applicability of mechanical (physical removal via electrofishing) or chemical (piscicide) removal.

A short reach, or short reaches between multiple barriers, of a single stream channel will be easier and more effective to treat than long continuous reaches or complex channels and tributaries. Similarly, effort will increase with increasing water depth and habitat complexity, as well as distance from access, particularly to achieve full effectiveness, which is a 100% removal of predatory fish. The time of year relates to fish detection, as fish recruited from the previous breeding period are the largest, and more easily detected, in autumn just before the next breeding season.

The amount of effort can also be influenced by the efficiency of the removal technique (mechanical or chemical), and whether it needs to be repeated. For example, chemical removal can be undertaken efficiently in one treatment if the stream channel is not braided, whereas successive electrofishing runs will need to be undertaken to maximise fish detection and removal, usually to three successive runs of zero detection to be confident (Raadik et al. 2015; Raadik 2017). If removal has been less than 100%, additional removals would need to be undertaken, and any fish left in the system over winter may spawn and increase the number of fish requiring removal the following year; small individuals (< 140 mm in length) are more difficult to detect than older, larger individuals. Each method has its benefits and limitations.

Instream barriers

Instream barrier to the upstream movement of fish is important to protect a translocation site for Stocky Galaxias from the incursion of predatory trout. This may involve augmentation of existing barriers or construction of new barriers.

If a barrier, or barriers, are present, but are found to be only partially or totally ineffective, they should be assessed to see if they can be modified to improve their ability to prevent fish passage. The specific attributes which make the barrier ineffective should be identified (see Raadik and Lintermans 2022c) to understand the nature of modification required, and engineering solutions sought. This may entail increasing the height of an existing barrier (or low section on a barrier), removing material from the face of a barrier to increase its vertical angle, removing a control point of a large, deep pool on the downstream side to remove or decrease pool level, removal of large obstructions on the downstream side to increase water flow and drainage during flood events, infilling of low-flow channels adown the barrier face to eliminate potential fish passage pathways, etc.

Where barriers do not exist, an alternative is to construct one or more artificial instream barriers. These can be made of reinforced concrete, or other material which prevent fish movement, and depending on the physical characteristics of the location, may need to be small or large in width and/or height, and either constructed onsite, or prefabricated off-site, delivered and installed. As artificial barriers can be expensive, and difficult to construct in remote areas, optimal site characteristics, which also achieve the necessary

barrier characteristics required to be effective in preventing upstream fish passage are needed to make them feasible. These can include:

- A narrow, steep valley – reduces barrier width.

- Relatively steep stream gradient – reduces barrier height required.

- Stable substrate such as bedrock.

- Ease of access for construction.

If these were to be optimised, a single artificial barrier may be sufficient. However, the remoteness of much of the terrain in the project area may constrain barrier design (technical feasibility) and construction (access logistics). As such, depending on options and an assessment of the criteria above, an alternative may be to install more than one barrier along a less-optimal reach.

2.2.7   Fish release

Release considerations for translocated fish can be as important as transport considerations (Faira et al. 2010). As with transport, specific measures and controls for fish release should be determined during planning for the activity. The following measures are detailed in Zukowski et al. (2021) and are currently considered 'best practise':

- Inspect fish and remove any showing signs of distress or damage: euthanise and voucher these.

- Do not release any source water into the release water. Any water removed from the transport container during the release process must be decanted away from the release water, preferably well away from the waterbody and into a vegetated area.

- Commence diluting the source water in the transport container with successive amounts of release water, discarding the source water, as above. This water temperature equilibration must be undertaken slowly to avoid shock from increasing or decreasing water temperature (e.g. not more than 2°C/hr and ≤ 10°C/day).

- Fish release can commence once all source water has been replaced by release water. Shift fish into smaller bucket with handle that contains release water.

- Release fish into a stream reach, preferably a pool or backwater and with instream habitat, by capturing and lifting fish out of the bucket using a soft, fine mesh, aquarium dipnet, immediately immersing the dipnet and allowing fish to swim out.

- Record all details onto a site datasheet: date, waterbody name, location, decimal Latitude and Longitude, staff, time of release, release site water quality parameters, numbers of fish released and euthanased, details of release reach (e.g. distance).

2.2.8   Post-release monitoring

Ongoing monitoring of translocated populations is crucial for documenting establishment success (Saddlier et al. 2013), informing translocation failure, identifying the need for additional interventions and to identify opportunities for improvement for future activities. Such monitoring is usually poorly undertaken (Lintermans et al. 2015) and requires careful planning (Lindenmayer et al. 2013). As a minimum, monitoring of translocation sites should be undertaken annually, unless immediate threats are identified (Ayres et al. 2012). Monitoring could also be seasonal in the year following translocation, which will provide rapid evidence of continued survival or mortality, possible factors that caused failure, or if additional translocations or other interventions are required in the same season (Zukowski et al. 2021).

Whilst success of translocations is poorly defined (Robert et al. 2015), IUCN Red List criteria can be used, such as 10 years or three generations (i.e. 9 years for Stocky Galaxias), before a translocated population could be considered to have established and be viable. This is potentially enough time for the effective population size to exceed 1000 individuals (Willi et al. 2006, Weeks et al. 2011). The objective of monitoring is to assess the success of translocation events and to facilitate rapid intervention if undesirable outcomes are detected (e.g. poor survivorship, inbreeding depression, and habitat changes) (Ayres et al. 2012). Consequently, post translocation monitoring should focus on physical (e.g. fish survivorship, natural spawning/recruitment, etc.). and genetic (genetic diversity, inbreeding, etc.) parameters (Frankham 2015).

Monitoring activities should follow the methods set out in the Monitoring Plan (Raadik and Lintermans 2022b). However, the potential spread of fish from the translocation site should also be monitored and likely require additional monitoring sites at suitable distances upstream and downstream from the release site. The

distance downstream will be delineated by the location of the instream barrier to fish movement which will be protecting the translocation site from trout incursion.

2.2.9 Species stochastic population model

Population models are a useful method for collating knowledge of a species and for testing hypotheses and comparing management options (Freckleton 1999, Caswell 2001). Furthermore, they allow an assessment of the value and likelihood of success of management activities designed to assist in the recovery of a species (Koehn and Todd 2012; Todd and Lintermans 2015), and in doing so, provide a framework for proactive management of populations.

Development of a population model for Stocky Galaxias, incorporating data on its biology and ecology, may also be informative in guiding translocations to improve success, like with translocations of Macquarie Perch (*Macquaria australasica*) and Trout Cod (*Maccullochella macquariensis*) in Victoria and ACT. However, as relatively little is currently known about the ecology of the existing Stocky Galaxias population (Raadik and Lintermans 2022a), and only a single population is known, the model would be considered somewhat deficient, with relatively high uncertainty, until at least 2 years of monitoring generates data to improve its precision (e.g. strength of recruitment, population size/density variability over time. Some key data is already available, such as length-fecundity and limited length-frequency (Allan et al. 2021; Lintermans unpublished data), however age-length (and age-fecundity), and egg, larval and juvenile survivorship rates (age-specific survival rates) are unavailable. The analysis of specimens sacrificed for the study of reproductive ecology in Stocky Galaxias (Allan et al. 2021) would potentially provide data on age-length relationships.

2.2.10 Research

The overall conservation management, including the translocation component, of Stocky Galaxias will also benefit from research into ecological and evolutionary (genetic) factors which can improve translocation success (Lande 1988), such as optimal time of year to translocate, how translocated fish interact with any resident fish of other species, if present, and the adaptability of the species if it were to be translocated outside of its natural range to lower elevations, etc. This specific research will, however, by necessity take several years, and is potentially more suited to student research, which can then be incorporated into the conservation of Stocky Galaxias.

2.3 Measures of success

A hierarchy of criteria to assess the success of translocated populations of Stocky Galaxias should be developed involving short and long-term measures (Lintermans 2013).

Short-term (1–3 years) success of translocation can be measured by the following for each of the three types of translocations:

- Survival – stocked larvae, juveniles or adults are still detected after one year or longer.

- Dispersal – fish spread from point of translocation into other sections of available habitat (reintroduction, assisted colonisation).

- Successful recruitment – fish smaller than those originally translocated are found one year or longer following translocation; (reintroduction, assisted colonisation).

- Improvement in population abundance – length/age cohorts increasing, fish abundance increasing (reinforcement).

- Improving genetic fitness – stabilising or increasing genetic diversity, declining level of inbreeding) (reintroduction, reinforcement, assisted colonisation).

- Persistence of fish –length/age structure of individuals in population improves, and a healthy structure begins to be maintained (reintroduction, reinforcement, assisted colonisation).

Long-term (4– >10 years) success of translocation can be measured by the following for each of the three types of translocations:

- Continuing persistence of fish (reintroduction, reinforcement, assisted colonisation).

- Continuing regular recruitment (reintroduction, reinforcement, assisted colonisation).

- Relatively stable population length/age structure and abundance (reintroduction, reinforcement, assisted colonisation).

- Stable genetic fitness (e.g. continuing low level of inbreeding, stable genetic diversity, etc.) (reintroduction, reinforcement, assisted colonisation).

- Fish distributed over all available, suitable habitat within site (reintroduction, reinforcement, assisted colonisation).

2.4   Risk assessment

Various actions in the translocation strategy are heavily reliant on outcomes from ongoing population monitoring, catchment survey, genetic assessments and future developments regarding captive breeding, and have inherent risks (Table 1). For many of these there are no alternative options as they are critical, fundamental actions, though the risk may be able to be reduced by refining strategies, protocols, or actions.

Table 1. Risk assessment for translocation activities, including potential options to reduce risk and their difficulty

Action	Risk	Alternative Options	Difficulty of managing risk and risk controls	Dependencies
Initial translocation of a portion of Stocky Galaxias from Tantangara Creek into captive management (wild-to-captive).	Impact on donor population. Loss of captive stock.	Minimising the number of fish removed from the donor population.	Risk reduced by guidance of a detailed translocation and captive management plans for the activity, incorporating genetic data and targets.	• Decision on minimum number required and collection localities • Assessment of source population abundance and genetics. • Establishment of captive management facilities.
Using Tantangara Creek population as source of fish for wild-to-wild translocations.	Impact on donor population. Extinction of the species.	Establish a captive insurance population. Develop captive breeding plan and breed fish for translocation. Establish new populations (reintroduction) and bolster Tantangara population when required (reinforcement). Use reintroduced populations as wild hatcheries for additional translocations.	Moderate, but required; high risk until established Moderate, but required. Moderate to high; but critical to achieve. Relies on effective translocation strategy and captive breeding plan. Low to Moderate; depends on how quickly viable populations establish.	• Assessment of source population abundance. • Establishment of translocation sites • Number of individuals required (based on genetic guidance)
Transporting and handling fish for translocation (wild-to-wild, captive-to-wild, wild-to-captive).	Fish mortality. Biosecurity issues.	None.	Low; established protocols in place. Improve protocols if needed. Low; established protocols in place. Improve protocols if needed.	• Appropriate equipment sourced and detailed protocol established.
Post-translocation monitoring.	Decline in source population. Failure of translocation (mortality of released fish).	If fish releases are failing, consider new translocation locations, different donor fish source (either captive bred or wild stocks), different donor fish size (from wild populations), or time of release.	Moderate; failure of translocation could still occur in some years. Increase regularity of monitoring or refine monitoring targets.	• Pre-translocation monitoring data on source population. • Continuation of monitoring program • Pre-translocation knowledge of characteristics (e.g. water and habitat quality, etc.) of translocation sites as baseline for comparison. • Monitoring program ready for translocated population.

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