Final Evaluation Report

Your Details	
Full Name	Cecilia Cerrilla
Project Title	Evaluating the biology, population trends, threats and conservation interventions for South Africa's most threatened migratory freshwater fish
Application ID	35448-1
Date of this Report	26-Oct-2022

1. Indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.

Objective	Not achieved	Partially achieved	Fully achieved	Comments
Objective 1. To chronicle and document the early life history stages of Clanwilliam sandfish by 1) photographing egg developmental stages from fertilisation to hatching and 2) ageing larval and juvenile sandfish by counting otolith growth increments				**Egg development**. We were unable to acquire the full sample of eggs required to run the detailed egg development study, as the sex ratio of captured fish was overwhelmingly skewed towards males. Only four out of 31 captured fish were females, and none yielded sufficient eggs. We decided to halt efforts to capture a suitable female to prevent further disruption of the migrating fish prior to spawning. Instead, we collected a small sample of naturally fertilised eggs (seven) from the spawning riffle after a spawning event and ran a pilot development study with the adjusted small sample size. **Larval/juvenile development**. We successfully collected 200 larval and juvenile sandfish from the Biedouw River in October 2021. While the analysis of growth rings was originally scheduled for January-June 2022, we have had to delay this to January-June 2023. The Biedouw River remained wet 3 months longer than expected due to higher than average rainfall during the 2021 winter, requiring me to extend my field season until March 2022 (rather than December 2021 as planned) in order to complete my visual surveys (objective 2).
Objective 2. To assess movement and habitat use of sandfish in the Biedouw River at different life stages.				Between August 2021 and March 2022, we carried out nine comprehensive visual surveys at each of 30 pools in the lower 15km of the Biedouw River, recording location, species, number, size class and behaviour whenever a fish was spotted. These surveys spanned several life histories stages: migrating adults in August, larval sandfish in September, and juvenile sandfish from October to March. We also carried out three detailed habitat surveys

				during the spawning, larval, and juvenile periods. During the visual and habitat surveys, relevant environmental data were collected. Together, these data have helped us to build a picture of specific environmental requirements of sandfish at each life stage.
Objective 3. To carry out surveys of the Doring River and key tributaries in order to determine the sandfish's current range and assess population trends when compared with historical data.				In November 2021 we carried out a survey of 10 historically sampled sites on the Doring River. Between March and April 2022, we carried out a survey of six key tributaries in the Doring catchment. Both surveys yielded critical information about the current distribution of sandfish, their size distribution at different sites and population estimates based on catch per unit effort, helping to prioritise and focus our conservation efforts.
Objective 4. To characterise the trophic niches of sandfish, bluegill sunfish and spotted bass using stable isotope and gut content analyses.				Juvenile sandfish tissue samples were collected in October 2021 (originating from the same individuals that were collected for otolith analysis) and adult fin clips taken in September 2022. Twenty-one bluegill sunfish and seven spotted bass were collected in January 2022, with further collections planned for November/December 2022. Gut content and stable isotope analyses are scheduled for January-June 2023.
Objective 5. To monitor and evaluate the efficacy of the rescue-rear-release conservation intervention by 1) releasing 1,500 nursery-reared sandfish into the Biedouw River, 2) monitoring the released sandfish in the Biedouw and Doring Rivers and 3) translocating 10,000 juvenile sandfish from the Biedouw to three nursery dams.				**Release of dam-reared fish.** In August/September 2021, we released 1,277 nursery-reared fish into the Biedouw River, 994 of which were PIT-tagged. There were two limiting factors preventing us from reaching our goal of 1,500 PIT-tagged releases: Firstly, many of the nursery-reared fish measured less than 14cm when captured for release; we returned many of the smaller fish to their respective nursery dams so that they would be able to be released the following year once they had grown to a "predator-proof" size of >20cm. Second, after the first four days of tagging, we started to get diminishing returns on our efforts; whereas the first days yielded hundreds of fish per sampling night, subsequent sampling efforts yielded very few (five in one instance). We therefore

				decided to pivot our efforts to visual and habitat surveys (as these also had to take place during the spawning migration). **Monitoring of released fish.** Upon receiving a second grant that allowed us to purchase a passive PIT-tag reader, we decided to adjust the original monitoring methodology. The passive PIT-tag reader consists of an antenna array that is placed across the channel and powered by solar energy. The unique ID code of any PIT-tagged fish that swims over the array is recorded by the reader, allowing us to determine the number of tagged 2021 releases that returned as part of the 2022 spawning migration. We installed this antenna array in the lower Biedouw 2 weeks prior to the 2022 spawning migration and recorded 77 PIT-tagged returnees, indicating that the rescue-rear-release intervention had been successful. **Translocation of young sandfish to nursery dams**. Between November 2021 and March 2022, we rescued 7,396 young sandfish from the Biedouw River and translocated them to five nursery dams. We fell short of our goal of 10,000 rescued fish due to the limited survival of young sandfish in the Biedouw River during this time. Although we maximised our rescue efforts, continuing well into 2022, predation pressure by alien fish and shrinking pools limited the number that survived long enough to be rescued. Despite this, we were able to add two farm dams to our network of nurseries.

2. Describe the three most important outcomes of your project.

a) The detection of 77 of our 2021 PIT-tagged releases in August/September 2022 provides the first evidence that the rescue-rear-release intervention has been successful in boosting the numbers of young sandfish recruiting into the spawning size classes. Not only is this an indication that nursery-reared sandfish are able to survive at least 1 year in the wild but also demonstrates that they joined the spawning migration in the year following their release. We also recaptured a single PIT-tagged male that had grown from 19cm at release to 31cm at recapture and that was ripe and running, indicating that returning dam-reared males were contributing to spawning 1 year after their release. Analysis of these data in the coming months will reveal the factors

that best predict the likelihood of return for released fish, such as size at release, release date, release location, and nursery dam origin. This information will shape future decisions regarding this intervention, maximising the numbers of dam-reared sandfish surviving in the wild and contributing to future spawning events.

b) Our survey of the Doring River confirmed that the population of sandfish in the Doring mainstem is ageing, and that there is extremely limited recruitment taking place. A total of 116 sandfish were recorded at only five of the 10 survey sites. In contrast, non-native fish were recorded at all 10 sites, and two novel non-native species were recorded for the first time in the Doring River System: common carp and Mozambique tilapia. Only one sandfish measuring less than 25cm was recorded in the entire survey, with 72% of sampled sandfish measuring between 40 and 60cm. These results confirm was freshwater scientist have long suspected: that young sandfish are not surviving long enough to recruit into the spawning size classes. This survey will serve as the baseline against which to compare future surveys following years of releases from our nursery dams.

c) Detailed habitat and visual surveys paired with the collection of environmental data have revealed that adult sandfish use very specific flow and temperature cues to trigger their migration into tributaries and the onset of spawning. These data are especially valuable given that climate change models predict that drought intensity and frequency will increase across the Western Cape in the coming years, with the highest drought frequency occurring over the Olifants-Doring River catchment (Naik & Abiodun, 2019). By pinpointing the flow and temperature requirements of sandfish at different vulnerable life stages, especially during spawning, we can better tailor future conservation interventions.

3. Explain any unforeseen difficulties that arose during the project and how these were tackled.

Egg development. We were unable to acquire the full sample of eggs required to run the detailed egg development study as planned. The capture of the donor fish required disturbance of migrating adults, either by capturing them overnight in a fyke net, or by capturing them actively using a seine net. We attempted to capture a gravid female twice and were not successful. The sex ratio of captured fish was overwhelmingly skewed towards males: only four out of 31 captured fish were females, and none yielded sufficient eggs to run a reliable study. We ultimately decided to halt our efforts to prioritise the wellbeing of migrating adults during the spawning period. Instead, we collected a small sample of naturally fertilised eggs (seven) from the spawning riffle after a spawning event and ran a pilot development study with the adjusted small sample size. While not ideal, this pilot study still yielded valuable insights. We were able to field test our rearing setup, which was successful in rearing all seven wild caught eggs from the early embryo stages through to hatching. We were also able to photograph several embryonic stages and the earliest larval stage.

Translocation of young sandfish to nursery dams. Between November 2021 and March 2022, we rescued and translocated 7,396 young sandfish. We fell short of our goal of 10,000 rescued fish due to the limited survival of young sandfish in the Biedouw River during this time. Although we maximised our rescue efforts, dedicating 11 days between November 2021 and March 2022 to rescuing and relocating young sandfish (a significant increase in effort compared to 2020), predation pressure by alien fish and shrinking pools limited the number that survived long enough to be rescued. Despite this, we were able to add two farm dams to our network of nurseries, increasing our capacity for future rescues.

Release of dam-reared fish. In August/September 2021, we released 1,277 nursery-reared fish into the Biedouw River, 994 of which were PIT-tagged. There were two limiting factors preventing us from reaching our goal of 1,500 PIT-tagged releases: Firstly, many of the nursery-reared fish measured less than 14cm when captured for release; we returned many of the smaller fish to their respective nursery dams so that they would be able to be released the following year once they had grown to a "predator-proof" size of >20cm. Second, after the first 4 days of tagging, we started to get diminishing returns on our efforts; whereas the first days yielded hundreds of fish per sampling night, subsequent sampling efforts yielded very few (five in one instance). We therefore decided to pivot our efforts to visual and habitat surveys (as these also had to take place during the spawning migration).

Extension of 2021/22 field season. During winter of 2021, the Biedouw catchment received above average rainfall, resulting in the river remaining wet several months into 2022. I had originally planned to halt my visual surveys by December 2021, assuming that the river would be dry by then. However, I was compelled to extend my visual surveys until April 2022 due to the longer wet period. This resulted in my having to shift otolith analyses from January-June 2022 to January-June 2023. Despite the slight setback, the prolonged wet season allowed me to collect valuable data on juvenile sandfish up to 7 months in age.

Mortality event at Enjo nursery dam. In March 2022, there was a mortality event at one of our nursery dams: Enjo dam. We were surveying the dam using fyke nets, which capture fish in a large chamber overnight, and upon retrieval of the nets the following morning learned that 123 sandfish had died in the nets. We theorise that the sandfish had been trapped in an anoxic pocket of water and were unable to move to a more oxygen-rich part of the dam due to the nets. The aquatic vegetation is extremely prolific at Enjo dam, which means that overnight there is a large amount of respiration taking place, creating hypoxic (and potentially anoxic) conditions in certain areas of high vegetation concentration. We also later learned that the pump that brings spring water into the dam had failed over a week prior to the mortality event, limiting the input of oxygenated water in the days leading up to the sampling event. The pump was fixed, and we have since employed members of the Heuningvlei community to clear about half of the aquatic vegetation from the dam and are in the process of acquiring sterile grass carp to ensure that the vegetation is controlled in the future. Following the incident, we have been mindful of placing fyke nets in strategic locations away from aquatic vegetation, as well as sampling when water temperatures are cooler (and therefore there is more dissolved oxygen available to fish overnight). The incident has not been repeated.

4. Describe the involvement of local communities and how they have benefitted from the project.

Four members of the nearby remote community of Heuningvlei were recruited and employed to assist with the rescue efforts. They were compensated monetarily and were also trained and upskilled in rescue techniques. Members from the same community were again recruited to carry out maintenance of one of our nursery dams, which took place in mid-October 2021. We will continue to work with and employ members of this community in future rescue efforts.

Over the course of this project, we have eradicated alien fish (common carp and bluegill sunfish) from six farm dams belonging to five sets of landowners and converted them into nursery dams for sandfish. We provided all personnel, material, and running costs required to clear these dams. Several of these landowners have also received basic training to monitor the sandfish populations in their dams, and they occasionally assist with release efforts. Several landowners with nursery dams (many of which are in the tourism industry) have received educational signs describing the sandfish conservation project and are thus able to showcase their involvement with a popular conservation initiative.

5. Are there any plans to continue this work?

This project, led by the Freshwater Research Centre, is planned to continue into the foreseeable future, funded by a combination of grants and donations. We plan to continue several cycles of the rescue-rear-release intervention, monitoring returning tagged fish with the use of the antenna array during each year's spawning migration. Results from the work that has been carried out thus far will be analysed as part of my PhD dissertation.

6. How do you plan to share the results of your work with others?

Scientific community: We plan to publish several manuscripts into the peer-reviewed literature detailing findings resulting from this project. We are currently working on a manuscript detailing the preliminary results from the first cycle of returning nursery-reared fish. I will also be presenting these results in Scottburgh, South Africa during The Conservation Symposium in early November and plan to present at several other conferences in the coming years as I continue my PhD.

General public: Our efforts have been documented by Drs Jeremy Shelton and Otto Whitehead of Fishwater Films from the inception of the project, with four "Saving Sandfish" episodes already available on YouTube, and several more in the pipeline. A feature film, also produced by Fishwater Films, is also planned. Over the past year, I have participated in two radio interviews centred on the project and published a popular science article in The Conversation. In March 2022 a National Geographic story featured our project, and several other online magazines have also published stories regarding our research and conservation efforts. In the coming months we will be placing a series of informative sandfish signs in and around the Biedouw River valley. These signs will include a QR code which will link to a website with further

information on the Saving Sandfish project. As we continue with this project, we will prioritise the sharing of exciting results and milestones through popular science media.

7. Looking ahead, what do you feel are the important next steps?

In the coming years we will continue rescuing and releasing young sandfish, helping to boost the population of subadults recruiting into the spawning size classes. Monitoring of our efforts will continue using the PIT-tag antenna reader, which will inform whether PIT-tagged releases continue to migrate into their natal river in the years following their release.

Over the next 2 years I will analyse data related to this conservation initiative, the results of which will inform future rescue and release efforts by revealing the best predictors of success. I will also be producing updated distribution maps which will inform the next IUCN Red List assessment for the species.

We are currently evaluating the feasibility of several river restoration initiatives which will reclaim and reconnect critical sandfish habitat in the Doring catchment. These initiatives include the clearing of alien fish and thirsty alien vegetation from a 5 km reach of the upper Biedouw River and installing a fish ladder on a large weir that blocks movement of indigenous fish, including sandfish, in the Doring River.

8. Did you use The Rufford Foundation logo in any materials produced in relation to this project? Did the Foundation receive any publicity during the course of your work?

The Rufford Foundation was mentioned as a funder of the project in the following online publications:

- South Africa's sandfish are on the brink of extinction: how farmers are helping rescue them. The Conversation. 5 July 2022.
- Mother Earth Day: Saving endangered sandfish. University of Cape Town News. 22 April 2022.
- Saving South Africa's most threatened fish. Getaway. 13 April 2022.

The Rufford foundation logo will be displayed along with other funders on the title page of my upcoming presentation at The Conservation Symposium in Scottburgh, South Africa (Oct 31 – Nov 4). The title of my presentation is: Evaluating a rescue-rear-release intervention for South Africa's most threatened migratory freshwater fish.

9. Provide a full list of all the members of your team and their role in the project.

Member	Role
Dr Jeremy Shelton	Supervisor (Freshwater Research Centre), Saving Sandfish Project lead, photographer/filmmaker
Dr Charles Griffiths	Academic supervisor (University of Cape Town)

Dr Cecile Reed	Academic supervisor (University of Cape Town)
Dr Otto Whitehead	Photographer/filmmaker, field assistance
Dr Bruce Paxton	Key advisor in planning research activities, field assistance, Doring Survey lead
Dean Impson	Field assistance, alien eradication activity lead (nursery dam creation)
Riaan van der Walt	Field assistance, local community involvement lead, tributary survey co-lead
Mohammed Kajee, Lloyd Huntley van Noord, Josh Dwyer-Thiem, Kathryn Gardner, Christina Arnoldy, Caitlin Allison	Field assistance

10. Any other comments?

I sincerely appreciate the financial support of RSG in making this project possible. With this support, we were able to successfully tag and release hundreds of dam-reared sandfish that returned as part of the spawning migration this year. Without the financial support of RSG, which we used to purchase the PIT tags, monitoring of released fish would not have been possible and the success of the conservation intervention would have been extremely difficult to evaluate. I also appreciate the flexibility and understanding shown when I requested to adjust the budget. I look forward to future collaborations with The Rufford Foundation.