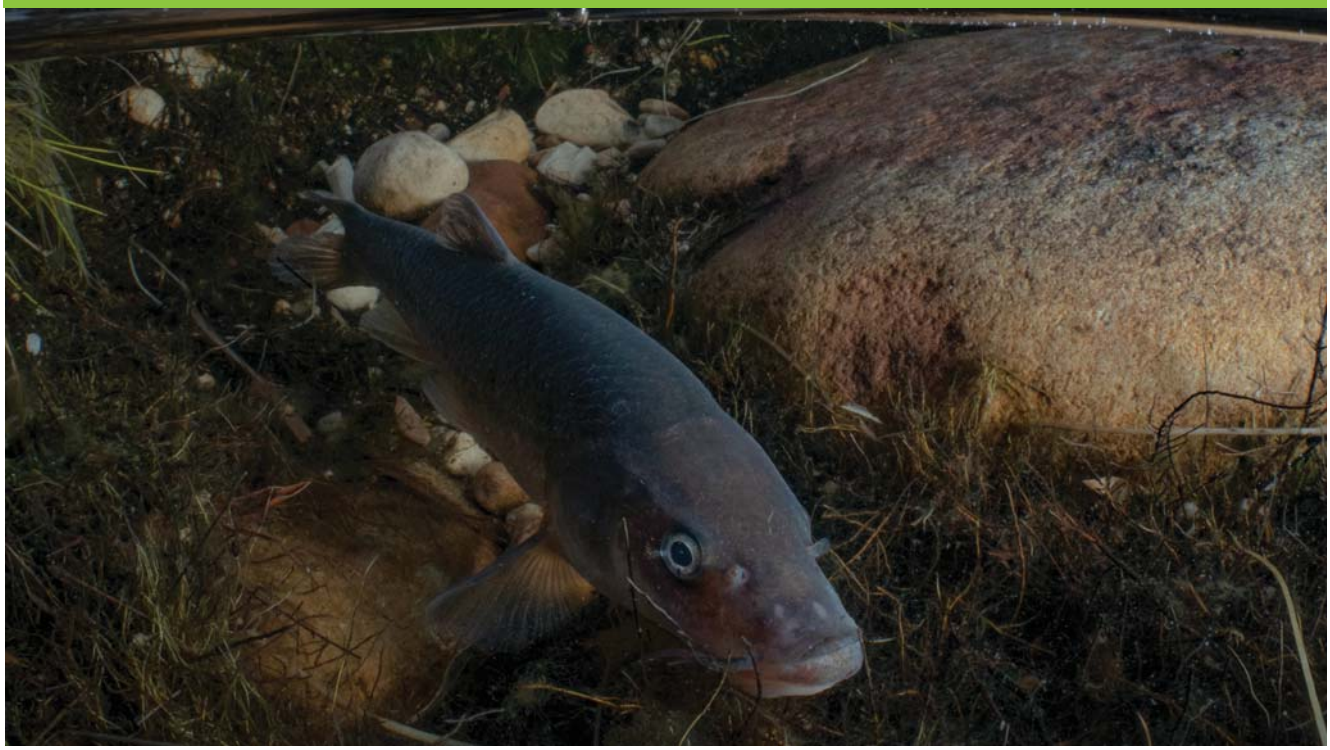
FRESHWATER FISH

FBIS – helping to collate quality data for the preservation of SA's freshwater biodiversity

The Freshwater Biodiversity Information System (FBIS) is proving its worth in supporting data-driven decision-making for managing rivers, wetlands and protected areas. Article by Sue Matthews.



Jeremy Shelton

When the recipients of the annual 'Science Oscars' were announced in July last year, it probably came as no surprise to anyone in the freshwater research and management field that the Cape Town-based Freshwater Research Centre (FRC), together with technical partner Kartoza, won the Data for Research Award for their groundbreaking Freshwater Biodiversity Information System, better known as FBIS. This open-access, online platform for hosting, visualising and sharing freshwater biodiversity data was developed in consultation with a wide range of end users, who have seen how FBIS facilitates their own work.

Executive Director of the FRC, Dr Helen Dallas, already had a good idea of what was required at the project's inception in mid-2016 because of her experience in developing the BioBase during the 1990s and the Rivers Database in the 2000s. These databases were primarily focused on invertebrates, the latter having been the repository for SASS data from the national River Health Programme – since replaced by the River Eco-status Monitoring Programme (REMP) – but they had not been maintained and were no longer readily accessible. With fish specialist Dr Jeremy Shelton on the FRC staff, the intention was always to include fish too, but the project nevertheless began with a needs analysis and then a stakeholder workshop involving representatives from academia, key parastatal organisations and environmental consultancies.

"It was very much designing backwards, finding out what the

end users wanted and then designing a system that's visual, appealing and easy to use," says Dallas. "And, of course, it was teaming up with Kartoza that made our vision a reality."

Collating data to populate FBIS was a mammoth task. Dallas, Shelton and other senior FRC staff drew upon their personal contacts to solicit contributions, while a team of postgrads, interns and junior staff trawled though scientific papers, reports and theses, finding data that could then be checked and verified by specialists. The BioBase and Rivers Database were pulled in, as was any relevant data in GBIF – the Global Biodiversity Information Facility – where organisations such as the South African Institute of Aquatic Biodiversity (SAIAB) and the Albany Museum make data available once it has been used in publications.

By July 2020 – the end of the first project phase supported by a grant from JRS Biodiversity Foundation – data for freshwater invertebrates, fish and algae were accessible on FBIS through user-friendly maps and dashboards. But another JRS grant for a second phase, which ends in April 2024, allowed FBIS to be expanded to include anurans (frogs and toads), wetland plants, algae and invertebrates, as well as water temperature and other physico-chemical data. Today there are some 734 000 occurrence records of approximately 10 000 taxa, and data continues to trickle in as users upload their data.

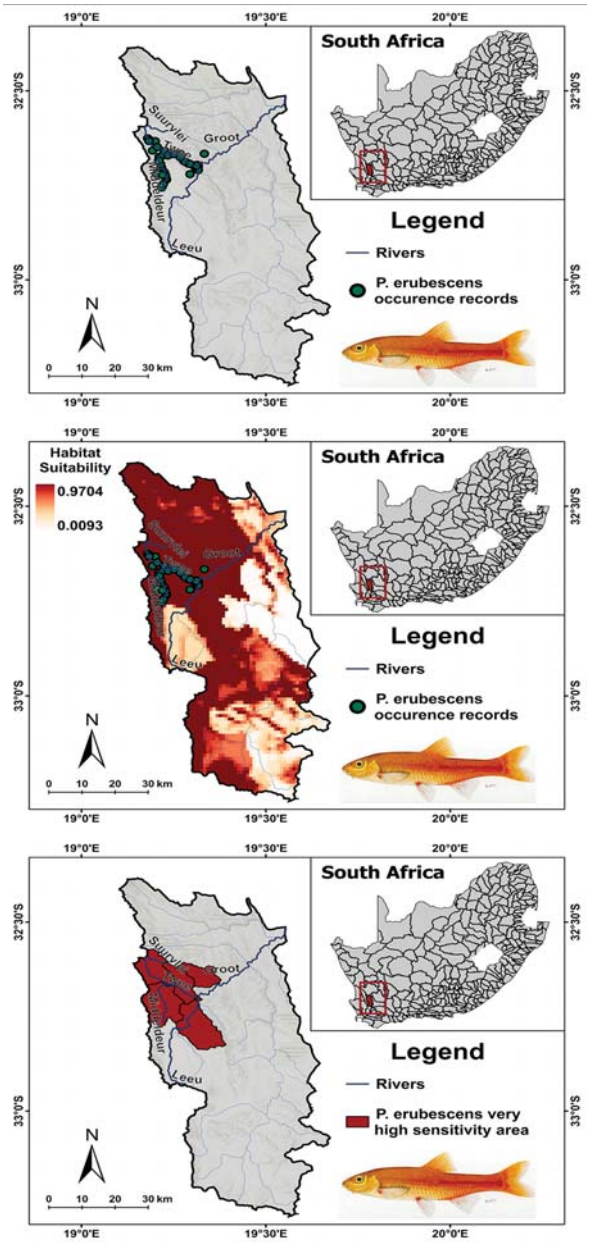
"We also bring in available citizen science data by pulling down any research-grade i-Naturalist data that's been published to GBIF," says Dallas. "Observations submitted to i-Naturalist are classed as research-grade data once identifications have been confirmed by three subject specialists. Likewise, citizen science data in the Virtual Museum's FrogMAP and OdonataMAP are verified before being pulled into FBIS. With the lack of resources for doing monitoring in this country, it's fantastic that citizen scientists can bolster data collection!"

The Virtual Museum, originally developed by the Animal Demography Unit at the University of Cape Town (UCT), is now hosted by UCT's FitzPatrick Institute of African Ornithology. Dallas points out that it's largely thanks to citizen scientists photographing dragonflies with their cellphones that FBIS currently has almost 100 000 adult odonate records of 191 taxa at more than 12 000 sites countrywide.

"During the second phase, apart from developing the new modules and a mobile app for use in the field, we set out to embed FBIS in key decision workflows," says Dallas. "So FBIS is now becoming the accepted freshwater resource for data that will feed into the National Biodiversity Assessment, the IUCN red listings, the REMP and so on. It has already been really valuable in developing freshwater fish sensitivity layers for the EIA screening tool."

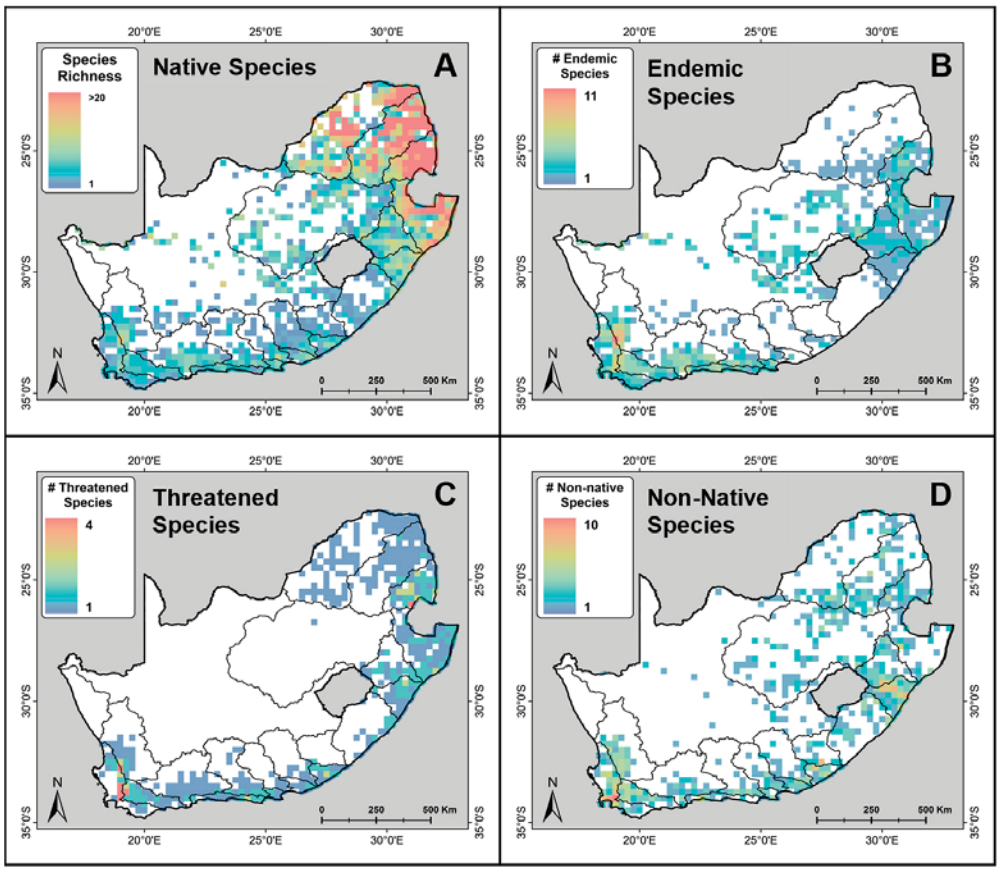
She explains that environmental impact assessments typically identify areas of concern using model outputs or expert knowledge, but the fish sensitivity layers in the Department of Forestry, Fisheries and the Environment's national web-based environmental screening tool rely on hard data that has been verified by experts. The tool allows landowners, developers and their environmental consultants to screen sites for any environmental sensitivity before applying for environmental authorisation in terms of the EIA regulations.

A PhD student co-supervised by Dallas and Shelton, Mohammed Kajee, did a lot of the grunt work behind the development of the fish sensitivity layers and is the lead author of an open-access paper describing the process in the journal ***Frontiers in Environmental Science***, but it was very much a collaborative effort involving several stakeholder organisations. Essentially, occurrence records in FBIS were extracted for 34 threatened



The output from the DFFE screening tool for the critically endangered Twee River redfin, Pseudobarbus erubescens, showing occurrence records (top), the species distribution model (middle) and the very high sensitivity area located in tertiary catchment E21 (bottom).

Kajee et al. 2023, 8, 571.



Species richness per QS grid cell for all native, regionally endemic, threatened and non-native species within South Africa's primary catchment areas.

freshwater fishes, representing 27 formally described species that have been classified as vulnerable, endangered or critically endangered according to the IUCN Red List, plus seven genetically distinct lineages that had as yet not been formally described and had only been assessed nationally for SANBI's Red List of South African species.

Taxon specialists around the country then verified these records, with erroneous ones removed and missing data sets added. The final 'cleaned' data set of 6 660 records was used to generate updated distribution maps that were checked again before the sensitivity layers were developed. The very high sensitivity layer applies to the six critically endangered fish taxa, reflecting all pre-2002 and post-2002 occurrence records, while the high sensitivity layer represents post-2002 occurrence records of taxa assessed as vulnerable or endangered. For both layers, the occurrences were intersected with the sub-quaternary catchment layer from the National Freshwater Ecosystem Priority Areas (NFEPA) project to create polygons indicating the presence of a threatened fish in that catchment.

The medium sensitivity layer also represents vulnerable and endangered taxa, but in this case the records were combined with a suite of environmental and hydrological variables to develop species distribution models used to predict geographic ranges. This layer covers a total catchment area of 251 264 km^2 and spans almost 50 000 km of river – vastly more than the 5 992 km^2 area and 1 024 km river span of the very high sensitivity layer.

The authors note that the screening tool should help prevent further destruction of critical freshwater habitats, which would support the conservation of threatened freshwater fishes, particularly where they occur outside formal protected areas.

In a subsequent paper published in the MDPI journal ***Fishes*** in November 2023, Kajee and co-authors investigated the extent to which threatened freshwater fishes fall outside such formal protected areas. After downloading 57 485 records for freshwater fishes from FBIS and undertaking a data-cleaning exercise, they were left with a final data set made up of 50 927 records for native fishes and 4 288 records for non-native fish, covering the 184-year period from 1839 to 2023. The 129 species represented in the data set comprised 105 (81%) native and 24 (19%) non-native species. Species richness maps were then produced at a quarter-degree square (QDS) spatial scale for all native, non-native and threatened species.

"Areas of relatively high density of occurrences (>100 records per QDS grid cell) were in the northeast (Limpopo, Olifants, Komati, Mfolozi, Tugela and Mkomazi Primary Catchments) and southwest (Olifants/Doring, Berg, Breede and Gourits Primary Catchments) of South Africa," report the authors. "Conversely, large areas with no records were observed within the central (Orange and Vaal Primary Catchments) and western (Buffels Primary Catchment) parts of the country. On a finer scale, there were noticeable gaps in data in the northern part of the Olifants Doring, Gourits, Mzimvubu and Limpopo Primary Catchments, respectively."

Native species richness followed a similar pattern, while endemic species richness was highest in the Western Cape (Olifants/Doring, Berg and Bree Primary Catchments) and along the south coast of the Eastern Cape (Swartkops, Kromme and Gamtoos Primary Catchments). Worryingly, the same Western Cape catchments contained the highest concentration of both threatened species and non-native species.

What's more, of the 5 740 records of threatened species countrywide, only 1 060 were from a formally protected area, although a further 2 216 fell within a conservation area such as a biosphere reserve, conservancy or botanical garden. More than a third of the records for non-native species were located within these protected and conservation areas.

The authors point out some limitations of the methodology and important caveats, but note that the patterns of species richness, endemism and threatened species broadly agree with previously published descriptions of South Africa's freshwater fish diversity.

"It is thus recommended that all QDS grid cells identified as having high levels of species richness, endemism and threatened species be prioritised for resampling and monitoring, to better inform the conservation interventions required in these catchments. Focusing effort and resources in this targeted manner could provide the most efficient use of the limited national, provincial and scientific resources available in the country."

They add that their findings lend further evidence to the growing body of research that considers South Africa's protected area network to provide inadequate protection for sensitive freshwater species. Fortunately, the Fish Sanctuaries, Fish Support Areas and Upstream Management Areas identified in the NFEPA layers, as well as the freshwater sensitivity layers in the DFFE screening tool, may provide some additional protection.

Clearly, FBIS is very useful in such studies, and there has been considerable interest in the system from beyond South Africa's borders, with instances of FBIS already set up in Rwanda and Botswana, and work under way on a more advanced version to replace Europe's Freshwater Information Platform (FIP) data portal. A system is also being developed for SANParks to include freshwater, marine and terrestrial biodiversity within its national parks and marine protected areas, and the FRC is seeking funds in partnership with NGOs such as WWF, African Parks, Wild Bird Trust and The Nature Conservancy to develop an Africa-wide freshwater biodiversity platform.

The FRC and Kartoza team have therefore implemented a multi-tenant model to ensure the longevity of FBIS and other information systems beyond the JRS-funded project. By sharing costs, the resilience of all platforms will be increased.

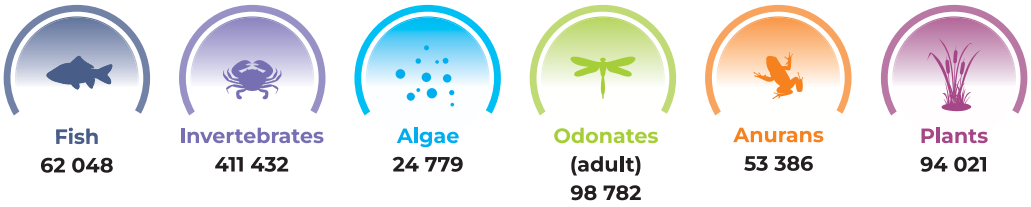
"In the multi-tenant model, there'd be one cloud host with one database, but every tenant would have their own entry point," explains Dallas. "The South African FBIS would look much the same, but any improvement made in one instance would get rolled out to all of them. Each tenant would contribute to hosting and support, but if any instance has a gap in funding, it will be able to piggyback off the projects that do have funds and will just keep ticking over."

"So by spreading the funding requirements across countries and organisations in and out South Africa, we're hoping that it will be a sustainable solution, allowing the FRC and Kartoza to continue providing technical support," she says. "Truth be told, we've become very attached to FBIS and we're super proud of it. From inception six years ago to where it is now, it's been really exciting stuff!"

The Freshwater Biodiversity Information System (FBIS) can be accessed at https://freshwaterbiodiversity.org/

A short video, The Life of a Data Point, produced to raise awareness about the importance of sharing data and to encourage researchers and postgraduate students to upload their data to FBIS, can be viewed on the Freshwater Research Centre's YouTube channel.

The number of records on the FBIS system



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