THE SECRET LIFE OF GOLDEN PERCH

BRENTON ZAMPATTI SHARES WORK HE IS DOING WITH OTHER 'FISH DETECTIVES', TO INVESTIGATE HOW GOLDEN PERCH OTOLITHS (EARSTONES) HOLD THE KEY TO UNDERSTANDING THE INFLUENCE OF FLOW AND HABITAT ON POPULATION DYNAMICS.

River regulation simplifies and fragments aquatic habitats, leading to population decline and a loss of biodiversity. Degradation of aquatic habitat is considered a primary cause of the decline of native fish populations in the Murray–Darling Basin (MDB) and habitat restoration is seen as a means of redressing this. Habitat requirements, however, are often considered from the perspectives of individual fish. For example, most anglers and biologists know that Murray cod love snags, but while specific habitats may sustain individuals, what habitats are required to sustain populations, or indeed promote population growth?

Population growth is a function of births, deaths, immigration and emigration. Fundamental to this equation is an understanding of the habitats that support these processes, the spatial scales over which they operate, and the importance of connectivity between habitats. In large and complex river systems like the MDB, specific regions may act as sources and sinks of particular life stages, and connectivity between these locations may influence population structure at discrete locations. Understanding where these locations are, and their habitat characteristics (including hydrodynamics) and hydrology, is essential to rehabilitating native fish populations.

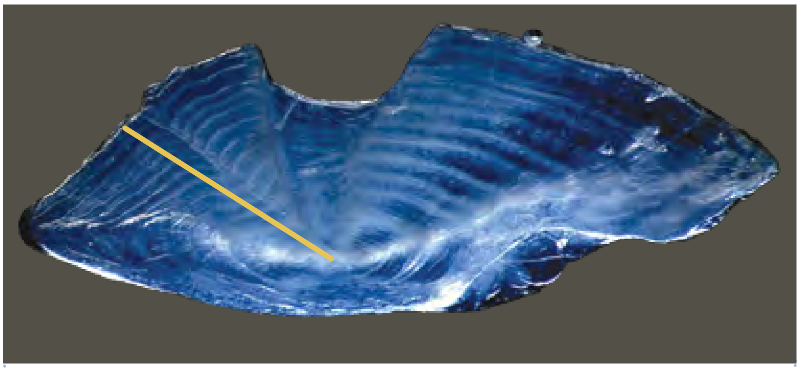
Over the past few years, researchers from the South Australian Research and Development Institute, the Arthur Rylah Institute Victoria, Fisheries NSW and Charles Sturt University have been working together to investigate the spawning, recruitment and movement of Golden perch in the southern MDB. A key question has been to understand the demographics (i.e. age structures) of populations in specific regions, and retrospectively determining where these fish were spawned and what regions of the MDB they occupied during certain life stages (e.g. juveniles).

By knowing *where* a fish was, and *when* it was there, we can determine the flow and habitat characteristics of these regions.

To retrospectively determine where juvenile and adult Golden perch were spawned, and the regions of the southern MDB they have inhabited, we have used fish otolith (earstone) structure (daily and annual growth increments like the rings of a tree trunk) and chemistry. Fish otoliths are formed by the sequential addition of layers of calcium carbonate from birth to death. The chemical composition of the otolith reflects, at least in part, the chemistry of ambient water at the time of deposition. Consequently, the migration history of a fish, including its place of birth and death, can potentially be determined by comparing geochemical signatures in otoliths with ambient signatures in water. This only works when there is geographic variability in water chemistry.

Dissolved strontium isotope ratios ($^{87}Sr/^{86}Sr$) in rivers and streams are an artefact of catchment geology and can provide a geographically distinct natural marker in fish. Importantly, strontium isotope ratios are not biologically modified; therefore the values measured in otoliths are generally similar to those measured in ambient waters. As a result, spatio-temporal 'isoscapes' of dissolved $^{87}Sr/^{86}Sr$ in water can provide a template for determining the spatial origin of freshwater fish. By combining otolith chemistry and chronology a fish can be retrospectively positioned in space and time throughout its life.

Figure 1. A section of a Golden perch otolith showing annual growth increments (analogous to tree growth rings) and the plane of a laser ablation (LA-ICPMS) transect (gold line) to determine strontium isotope ratios across the fish's life time.



FOR FURTHER INFORMATION

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To determine where Golden perch were born, and the habitats they had used throughout their life, we first needed to measure strontium isotope ratios in various rivers of the southern MDB to create a strontium 'isoscape'. We have now collected these data over several years and have established that, in some rivers, $^{87}Sr/^{86}Sr$ is stable over time (for example, the Darling River, Goulburn River and upper Murray River) and in others, $^{87}Sr/^{86}Sr$ is temporally variable, particularly in rivers which have numerous tributaries and hence a constantly varying water source (for example, the mid and lower Murray River). This isotope map was then used as a basis to compare the isotope ratios in the otoliths of Golden perch sampled from locations throughout the region. Laser ablation-inductively coupled plasma mass spectrometry (LA-ICPMS) was used to measure $^{87}Sr/^{86}Sr$ along a transect from the otolith core (time of birth) to the edge (time of death), providing an environmental chronology for each fish (Figure 1).

One of the key findings from our research was that the Golden perch populations sampled in early 2014 in the lower and mid-Murray River, Darling River and Edward–Wakool system were dominated by 4-year-old fish that had otolith core strontium isotope signatures characteristic of the Darling River. This meant that these fish were spawned in the Darling in early 2010 in association with a bank-full flow. Incidentally this was during a time when the MDB was still in the grip of the Millennium drought, and flows in the Murray were at record lows. When we subsequently looked at transects of strontium isotope ratios from the otolith core to edge, we saw a transition in $^{87}Sr/^{86}Sr$ when these fish were either young-of-year (YOY, age 0+) or age 1+, as they moved down the Darling and into the Murray (Figure 2). Many of the 1-year-old Golden perch migrated down the Darling in association with widespread flooding in the southern MDB in late 2010 to early 2011.

Our recent research demonstrates that in the southern MDB, larval, juvenile and adult Golden perch move passively and actively over hundreds to thousands of kilometres, including between the lower Darling River and lower and mid-Murray River (at least up to Torrumbarry Weir), and into tributaries of the mid-Murray such as the Edward–Wakool system.

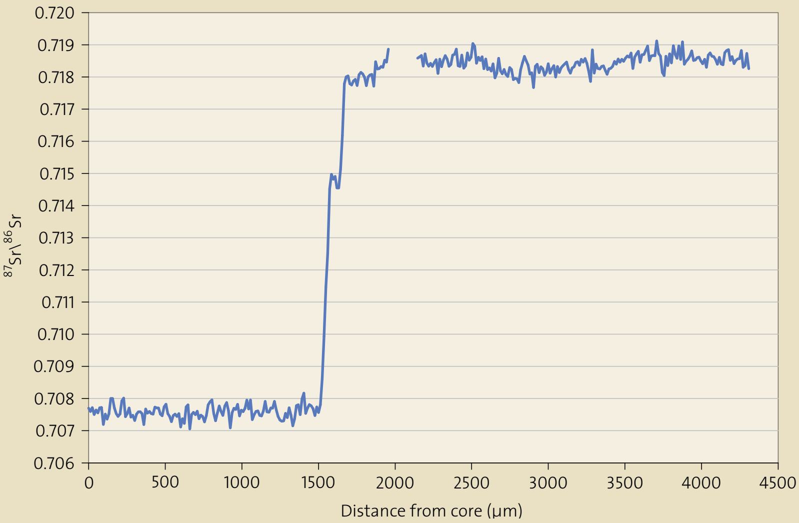

Figure 2. $^{87}Sr/^{86}Sr$ measured along a transect from the core to the edge of an otolith from an age 4+ Golden perch collected in the mid-Murray River at Cohuna. This profile shows the transition (at ~1500 μm from the otolith core) from the $^{87}Sr/^{86}Sr$ ratio of the lower Darling River (~0.7075) to the $^{87}Sr/^{86}Sr$ of the mid-Murray (i.e. ≥0.7180). This transition occurred when the fish was age 1+, in conjunction with widespread overbank flooding in the Murray and Darling Rivers in 2010–11.

We have also found that variability in within-channel and over bank flows, in conjunction with appropriate water temperature, can promote Golden perch spawning.

Nevertheless, in some regions of the southern MDB this may not lead to *in situ* recruitment of fish. For example, while Golden perch spawning (as demonstrated by the collection of eggs and larvae) may occur in the lower Goulburn River and the Murray River at Barmah, recruitment of these early life stages to YOY is uncommon, and there is emerging evidence to suggest that immigration of adult and potentially juvenile fish may have a substantial influence on population dynamics in these regions.

Golden perch age structures in any one region of the southern MDB may be dependent on spawning and movement and/or dispersal from regions hundreds of kilometres away, reinforcing the importance of hydrological and biological connectivity and the need for a river-scale perspective for the management of flow and habitat for Golden perch. Importantly, adult Golden perch may have inhabited numerous river systems and habitats, from birth to maturity, so maintaining connectivity between these habitats is essential for the growth of Golden perch populations in the southern MDB.

This novel research is now being used to guide flow management and environmental water delivery across the southern MDB to promote growth in Golden perch populations. It also forms an integral part of monitoring programs to robustly measure response to flow restoration.

Figure 3. Map of the southern Murray–Darling Basin. Blue shading indicates the spatial extent of a dominant cohort of age 4+ Golden perch (captured in 2014). Age 4+ Golden perch from across this region were spawned in 2009/10 and had otolith core strontium isotope ratio indicative of the Darling River. Gold stars indicate potential spawning regions, upstream and/or downstream of the Menindee Lakes.