



POPULAR ARTICLE

Environmental DNA: Finding fish without catching them

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Intricacies of the subject

A river can contain fish that a conventional net survey never catches. Rare species may be present in very small numbers, active at different times, or inhabit deep pools, dense vegetation and rocky areas where sampling equipment is difficult to use. Environmental DNA (eDNA) offers another way to detect such species by collecting water and analysing the genetic traces organisms leave behind through skin cells, mucus, scales, waste and reproductive material. Researchers filter the water, extract the DNA and identify species-specific genetic sequences. However, eDNA detects the presence of genetic material rather than counting individual fish, and DNA may travel through flowing water or persist after an organism has moved away. Therefore, eDNA is best considered a complementary tool alongside conventional surveys. India's fish production reached 197.75 lakh tonnes in 2024–25, according to the Department of Fisheries, but such production figures cannot show which species survive in a particular river stretch or wetland, making local biodiversity monitoring important. It can also help identify changes in species distribution over time and reveal biodiversity patterns that may otherwise remain unnoticed. By combining eDNA with traditional sampling methods, researchers can

develop a more complete understanding of freshwater fish communities and their habitats.

Introduction

Fish continuously release small amounts of genetic material into their surroundings through skin cells, mucus, waste and reproductive products. Some of this DNA remains suspended in water or becomes attached to tiny particles, allowing scientists to collect it without directly capturing the fish. In an eDNA study, researchers collect water samples, pass them through fine filters to concentrate biological material, extract the DNA and examine short genetic sequences that can distinguish different species. The approach gained significant attention after a 2008 study demonstrated that an invasive frog could be detected from DNA present in pond water. Since then, eDNA has developed into a useful technique for detecting rare, elusive and invasive species and for studying aquatic biodiversity.

Two questions, one technology

For a particular species, scientists can use a species-specific test, often quantitative PCR (qPCR). This is useful when checking for a threatened fish or an early invasion. To survey a wider fish community, metabarcoding amplifies a short DNA region shared across



many fishes and sequences the mixture. MiFish primers are a well-known example developed for fish metabarcoding. The resulting species names depend on the quality and coverage of a reference database.

Where it can help fisheries managers?

Rare species: Repeated sampling can reveal a species that gear-based surveys may miss, particularly when capture is undesirable. A detection should be followed by confirmation and site assessment before decisions about local population status.

Invasive species: A targeted test may provide an early warning at a reservoir, river connection or aquaculture escape route, allowing focused follow-up surveys.

Community change: Sampling the same sites through seasons can show shifts in detected fish species around dams, polluted reaches or restoration areas. Comparable methods, timing and effort are essential for a meaningful comparison.

Remote waters: A field team can collect water from hill streams or wetlands that are hard to survey with nets, although filtration, preservation and laboratory analysis still require trained staff and equipment.

Read the signal carefully

A positive eDNA result is evidence that a sequence was detected in the water sample, not proof that a live fish was present at that exact spot. DNA can move downstream, and contamination or DNA from transported fish can create misleading signals. A negative result does not prove absence: the species may shed little DNA, sampling may miss it, or the assay may fail to amplify it. Replicate samples, field and laboratory blanks, suitable reference sequences and confirmation of unexpected findings strengthen interpretation. DNA concentration is also an uncertain measure of

abundance. Shedding, water flow, temperature and degradation all affect the amount recovered. Nets and visual surveys remain necessary when managers need body size, age structure, health or direct catch information. eDNA is most useful when it is planned alongside those methods.

The Indian opportunity

Reliable reference sequences are a practical foundation. Recent barcode work on voucher-identified fishes from the Gomti River illustrates how local genetic libraries can improve species identification. For Indian waters, a sensible programme would begin with a clear monitoring question, selected sites and seasons, validated assays, and a plan for checking surprising results. Repeated surveys could support conservation, rapid response to invasive species and monitoring of restoration.

An example from a hill stream

Suppose a fisheries team wants to check whether a native fish is still detected around a disturbed river reach. It could take replicate water samples above, within and below that reach in the same season, alongside a field blank. The laboratory would use a validated targeted assay and report detections at each site. If DNA appeared only downstream, the team would survey again and examine water flow before deciding where fish may live. This is an illustrative survey design, not a report of actual results.

Conclusion

A bottle of water can reveal fish that are difficult to observe, but its message must be interpreted with care. eDNA adds a sensitive, non-invasive line of evidence to fisheries surveys. Combined with sound field design and conventional observations, it can help managers to ask better questions about where the fish occur and how aquatic communities change.



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