SCCWRP FACT SHEET

eDNA: An approach to monitoring organisms using their genetic traces

Environmental DNA (eDNA) technology is in the process of being incorporated into routine monitoring programs

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One of the key ways that environmental managers evaluate the health of an ecosystem is by monitoring the organisms living in it. These biology-based assessments – or bioassessments – traditionally rely on directly sampling or observing organisms. But some organisms are not feasible to sample or observe because they are:

- » Difficult to identify visually
- » Elusive, rare and/or pass rapidly through their environment
- » Threatened or sensitive, making their capture ecologically destructive

Thus, scientists have developed a complementary approach for monitoring aquatic life that relies on the DNA that organisms shed into their environment, known as environmental DNA (eDNA). By analyzing eDNA in water samples (as well as soil and air samples), managers can detect the organisms that were present and gain insights into ecological health.

A SCCWRP field crew retrieves water samples from a stream to identify the organisms living in it via their eDNA signature.

Insights provided by eDNA monitoring

Targeted analysis

Figure out if one or a handful of specific species is present

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Uses

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Presence/ absence

» ***Example***: Are any Delta smelt present in my sample?

» ***Technology***: DNA barcording

Quantification

» ***Example***: How much steelhead DNA is present in my sample?

» ***Technology***: Quantitative or droplet digital polymerase chain reaction (PCR)

Community analysis

Identify the species present within a major category of organisms (e.g., all bacteria, all fish, all diatoms)

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Use

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Community surveys

» ***Example***: How diverse are the fish communites in my sample?

» ***Technology***: DNA metabarcoding; genomics/meta-genomics

Monitoring programs that are piloting eDNA methods in California

- California Surface Water Ambient Monitoring Program (SWAMP) eDNA Metabarcoding Monitoring and Analysis Project (SeMMAP) + similar regional efforts
- Estuary Marine Protected Area (EMPA) Monitoring Program
- Southern California Bight Regional Monitoring Program
- California Cooperative Oceanic Fisheries Investigations (CalCOFI)
- California Freshwater Harmful Algae Blooms (FHABs) Monitoring

Using eDNA to extend monitoring's reach

In many cases, eDNA monitoring can serve as an effective complement to traditional bioassessment monitoring. But in other cases, eDNA can extend monitoring to places and applications where traditional monitoring isn't viable or effective. Examples include:

Sensitive species and habitats

Species with protected legal status and/or that live in ecologically sensitive habitats are often infeasible to observe or sample. eDNA-based monitoring offers a non-invasive alternative.

California newt, a species of special concern

Invasive and nuisance organisms

Unwanted and nuisance species like harmful algal blooms and invasive fish can go undetected until after they've already harmed ecosystems. eDNA monitoring could provide an early-warning system for these threats.

Harmful algal bloom in a Southern California lake

Community surveys

Often, managers want to survey more than just a handful of species in a community – which can quickly become cost-prohibitive and impractical. eDNA makes it feasible to monitor entire communities at once with just one eDNA sample.

Photo credit: Ian G. Taylor

Pacific hake, one of many common species targeted during regional fisheries stock assessments

Benefits vs. limitations of eDNA monitoring

The science behind eDNA monitoring has evolved rapidly in recent years, giving researchers a clear picture of eDNA's benefits and limitations as a monitoring tool.

Benefits

- **Faster, more accurate results**: Many eDNA processing and analysis steps are automated, reducing human error and producing results in hours to days.
- **Cheaper**: Traditional monitoring methods have high per-sample costs due to the need for a trained taxonomist to manually identify organisms. eDNA methods are a fraction of the cost.
- **More sensitive**: eDNA methods can differentiate closely related species, species that lack distinguishing features, and species present at very low levels.
- **Minimally invasive**: In ecologically sensitive habitats, direct sampling of organisms for bioassessment monitoring is often banned or infeasible. eDNA provides a minimally invasive way to sample in these habitats.
- **More species detectable**: Not all species can be detected via traditional monitoring because of their small size, large home ranges, reclusive behavior and/or transitory nature. eDNA monitoring can detect more species in a given area.

Limitations

Limitations	How limitations are being overcome
No direct observation: Organisms are not directly observed as field samples are collected, potentially introducing false negative and false positive detections.	» Scientists are working to better understand and predict the risks of false positives and false negatives to decrease uncertainty associated with eDNA data.
Estimates, not counts: Although laboratory methods can accurately quantify the amount of eDNA present in a sample, the relationship between DNA concentration and population numbers is not always a simple linear relationship; estimates are required.	» Scientists are studying how to account for variations in eDNA shedding rates when estimating how many organisms are present in a sample.
Complex fate and transport patterns: Once shed, eDNA disperses and degrades over time until it is no longer detectable, at distances and rates that vary based on a range of environmental factors.	» Scientists are studying how temperature, nutrient availability, substrate, flow and other conditions influence eDNA fate, transport and decay rates.
DNA library gaps: Organisms can be identified by their DNA only if this organism-specific genetic information has been published in online DNA libraries.	» Scientists are continuing to build out DNA reference libraries to enable a wider range of organisms to be identified via eDNA.

California's eDNA investments

California has played a national role in advancing eDNA monitoring from a series of experimental, pilot-scale studies, to a rigorously vetted science that is ready for routine monitoring applications.

» The California Water Quality Monitoring Council, a consortium of California environmental management agencies, established a Molecular Methods Workgroup in 2018 to advance use of DNA-based methods – including eDNA monitoring – across a wide swath of environmental monitoring programs statewide.

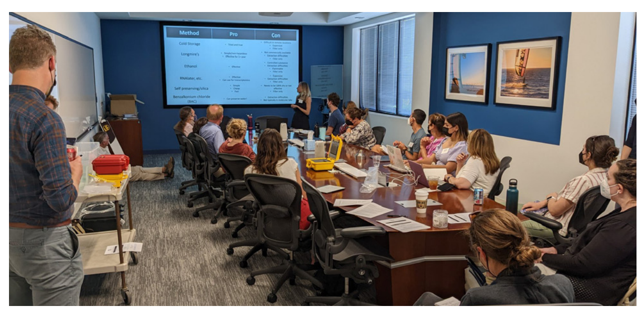
» The workgroup has developed best-practices guidance for facilitating incorporation of eDNA into routine monitoring – guidance that is now helping to inform development of a national eDNA implementation strategy.

Toward a national eDNA strategy

During a national scientific workshop hosted by SCCWRP in 2022, leading experts agreed that eDNA technology has reached a point where it's ready to be incorporated into routine environmental monitoring programs.

» To ensure an efficient, coordinated technology transfer and nationwide comparability of eDNA monitoring data, scientists are developing a national eDNA strategy and implementation roadmap.

» The national strategy is designed to coordinate and unify the many agencies and programs that historically have been working in silos to use eDNA monitoring tools.



National eDNA scientific workshop, hosted in Costa Mesa, CA in 2022

More reading

2nd National Workshop on Marine eDNA summary journal article

Toward a national eDNA strategy for the United States