



# IWEG

International Workshop on  
Environmental Genomics

## ADVANCING NATURE ACCOUNTABILITY: FROM MEASUREMENT TO MANAGEMENT

JUNE 13-14, 2024



# Introduction

The 9th annual International Workshop on Environmental Genomics (IWEg) was hosted in St. John's Newfoundland and Labrador, Canada from June 13th – 14th, 2024.

Each year, the Centre for Environmental Genomics Applications (CEGA) hosts the International Workshop for Environmental Genomics (IWEg). IWEg brings together a diverse range of participants, from government and academic researchers to environmental consultants, technology innovators, and industry managers and executives to foster cross-sector discussions and collaboration. By sharing the latest research developments and working together to bridge gaps between research and applications, we aim to increase the application of environmental genomics tools for biodiversity assessment across sectors. The ninth annual International Workshop for Environmental Genomics (IWEg) was held in St. John's, Newfoundland, Canada from June 13th – 14th, 2024.

The 2024 workshop facilitated discussions about how environmental genomics (EG) can be leveraged to help businesses measure biodiversity impacts to support sustainable management of natural resources, with the theme "Advancing Nature Accountability: From Measurement to Management." As part of the coordinated global effort to effectively address and mitigate the biodiversity crisis by 2030, many regulatory bodies and independent organizations are developing frameworks and/or regulations involving biodiversity impact reporting.



# Plenary Talk

The workshop began with a plenary talk by Dr. Kelly Goodwin (NOAA), a co-chair of the United States eDNA Task Team of the Biodiversity Interagency Working Group, which authored the US National Aquatic eDNA Strategy. The US Aquatic Environmental DNA Strategy was developed to meet the growing demand for biodiversity data at the national level.

The goals of the Strategy are to coordinate technical knowledge across sectors to integrate eDNA into decision making, build an effective aquatic eDNA monitoring network, and to continually assess U.S. waters using eDNA. Governments require accurate, widespread, interoperable data on species distributions in order to meet targets for maintaining biodiversity and ecosystem health.

eDNA technologies are well suited to support such needs as sampling methods are non-invasive and sampling can be automated to cover large geographic and spatial scales in a cost-effective manner.

Moreover, eDNA enables the assessment of a range of trophic levels from a single sample, providing incredible value across a wide spectrum of biodiversity applications. However, molecular biology and bioinformatics expertise are not well distributed across federal agencies in the U.S., impeding the development of comprehensive eDNA-based national programs. Effective national coordination and communication are crucial to share technical expertise and ensure eDNA data are collected and interpreted consistently, thereby securing public trust. The National Aquatic eDNA Strategy was released in June 2024. It will provide a framework to apply eDNA to build a better understanding of aquatic life and biological resources. Biodiversity data collected through these credible approaches can be used to inform energy development, nature-based climate solutions, and sustainable bioeconomy strategies.



# Applications for Industry and Conservation

We have seen widespread adoption of eDNA as a tool since the first annual IWEG in 2016. While the use of eDNA metabarcoding for biodiversity assessment and qPCR for single-species detections are becoming quite common, there are several instrumental and methodological innovations that could take a foothold in the field of environmental genomics.

The commercialization of EG analysis is facilitating its use in a wider range of applications beyond academic research. Presenters discussed projects that highlighted advantages of EG over conventional biological surveys for conservation and restoration guidance as well as for environmental permitting monitoring. Environmental consultants shared applications of EG for sensitive species assessments and effluent environmental permitting assessments. EG is well suited to these applications and offers benefits over conventional methods because it is less invasive, provides higher detection sensitivity, and can offer better taxonomic resolution. Representatives from the aquaculture industry presented plans for adding EG into aquaculture management practices. Canadian aquaculture regulation and management is based on biogeochemical-based metrics which are used as a proxy for biodiversity. Studies comparing EG-based assessments of biodiversity to biogeochemical-based estimates of biodiversity can ensure that new indicators are tied to historic results so that trends can be tracked over long timescales. This presents an opportunity for measuring biodiversity directly rather than through proxies.

The EG community is making progress on standardization to increase accessibility to EG approaches and improve public trust. This was demonstrated by the efforts of the International Association of Oil and Gas Producer's Joint Industry Program work to develop standard guidelines for EG applications.

These standards will help the industry to apply EG to evaluate baselines, monitor and respond to species of concern, evaluate remediation activities, and monitor decommissioning effects. The next phase in the Joint Industry Program will involve technology development to improve automation and scaling capacity of EG sampling.

The workshop included presentations on important developments that are expanding the reach of eDNA to meet the large-scale demand for biodiversity data. Much of the work expanding the reach of eDNA is focused on building more expertise among people and building eDNA sampling and analysis infrastructure. Numerous presenters highlighted data that were collected through collaborations between scientists and community groups. This is a good sign that eDNA outreach and education efforts have been successful in expanding the eDNA sampling infrastructure. The reach of eDNA can also be expanded through developing hardware innovations, and by broadening the use cases for EG. Methods are continually being optimized for new applications and new environments. Approaches which combine eDNA collection devices may offer improved sensitivity, and combinations of active and passive sampling devices provide data with varying temporal sensitivity. CEGA now has a ready to deploy protocol for comprehensive biodiversity monitoring of terrestrial and aquatic environments simultaneously.



# Advancements in Molecular Methods

The workshop included several talks highlighting recent advancements in eDNA laboratory analysis. Avery McCarthy, the genomics lead from eDNAtec showcased the service provider's new automated workflows for increased capacity and faster turn-around times. Illumina has improved sequencing accuracy and performance with its new XLEAP-SBS chemistry. The lower cost-per-base and temperature-stable reagents can make this technology accessible to users at lower price points and in regions which currently lack access to reliable cold transport chains. EG technology is also becoming more accessible globally through education and research initiatives such as OceanX, which manages a research vessel equipped with molecular labs for onboard eDNA analysis, collaborates with scientists and governments around the world to collect data from understudied environments. This innovation in mobile laboratory technology paves the way for bringing advanced molecular analysis directly to remote regions, expanding opportunities for in-situ sampling and accelerating the pace of environmental discovery.

A breakthrough molecular method development may soon enable EG to provide quantitative estimates for multiple species simultaneously, advancing both industry and conservation uses. With its scalability and broad taxonomic coverage, EG is already well suited for ecosystem-based-management operations, such as Marine Protected Areas (MPAs). However, MPA management relies not just on species presence and absence information, but also biomass or quantitative information, which EG has historically struggled to deliver until now. While single-species quantitative data can be estimated via qPCR approaches, multi-species NGS metabarcoding data typically do not correlate well with other quantitative estimates. The discrepancy largely stems from biases introduced during as laboratory processing steps. The Centre for Environmental Genomics Applications (CEGA) has developed a quantitative sequencing approach (qNGS) to mitigate biases from lab processing steps, thus enabling quantitative estimates for multiple species from a single environmental sample. Pilot projects using this qNGS approach are in planning stages.

# Expanding Data Applications

As EG has seen explosive growth in the past decade, we have a growing resource of EG datasets. Uncovering new ways to analyze EG data can help us discover new insights from existing EG data expand use cases for future EG applications. Andrew Riley (University of Guelph) demonstrated that DNA metabarcoding data collected for community-level assessments can be reanalyzed to evaluate within-species diversity patterns. This type of population-level information may be useful for establishing earlier metrics of environmental impacts, because shifts at the population level are likely to precede community-level changes.

Workshop members expressed a lot of interest in combined approaches and the potential for using EG to add sensitivity to other data types, and some presentations. EG can be linked with other assessment approaches can improve the scope and quality of data. Maxime Geoffroy () and Dave Cote () highlighted a project that applied EG to ground truth hydroacoustic signals to study pelagic ecosystems. Donald Baird () presented case studies which combined EG data with geodata to develop predictive models to guide conservation strategies for protecting ecosystem function. EG to effectively monitor biodiversity and associated ecosystem function and services.

# Panel Discussion

The discussion, moderated by Donald Baird, convened a distinguished group with expertise in research, environmental consulting, technology, and industry management. The session included panelists who are taking active roles in applying EG to nature management in a variety of industries. Jennifer Wollenberg (Integral Consulting) and Angela Martinez Quintana (Fugro) provided perspectives on how EG can be applied to permitting compliance. Mia Parker (Mowi) provided perspective on how EG can support aquaculture productivity and mitigation strategies. Nicolas Tsesmetzis (Shell International Exploration and Production Inc) was able to speak on the progress oil and gas producers are making to utilize EG for assessments and reporting. Mehrdad Hajibabaei (eDNAtec; University of Guelph) provided input about steps the international community of scientists are taking to develop robust standardised EG approaches.

When discussing how eDNA can support corporate nature-related financial disclosures under biodiversity frameworks, panelists noted that different sectors may be better positioned than others to adopt this technology. Certain industries, such as aquaculture, have direct and visible dependencies on environmental health, and are well-positioned to integrate EG. These companies often already invest in environmental monitoring to meet sustainability certifications and can leverage existing infrastructure and expertise to add EG into their monitoring operations to fulfil new disclosure obligations. In contrast, sectors with predominantly indirect reliance on biodiversity stability may find it more challenging to justify investment in biodiversity monitoring schemes. These industries often have more indirect supply chains, making it harder to trace and monitor biodiversity impacts. Implementing eDNA monitoring, and biodiversity monitoring more generally, in such sectors may require significant time and resources, potentially diverting attention away from the core business activities. Presenting these companies with cost effective and scalable tools for biodiversity monitoring will facilitate the implementation of nature reporting.

Biodiversity disclosure frameworks are designed to drive continuous improvement, but currently lack clear, standardized methods measuring biodiversity. Panelists emphasised the need to engage regulatory bodies to ensure future guidance is scientifically grounded and technically robust. With biodiversity loss and climate change accelerating, the moment calls for urgent action. Advancing EG as a standardized, commercial-scale solution presents an opportunity to forge cross-sector partnerships, establish robust monitoring networks, and embed nature accountability into business practices.

The scale at which management decisions are made is important when considering how biodiversity should be measured. Panelists highlighted several examples of EG successfully applied to local assessments, point-source effluent assessments and farm-scale aquaculture biodiversity impacts, however they noted that broader geographic applications present challenges. Certain environment types may pose greater barriers to applying EG analysis at large spatial scales because system complexity can influence detection probabilities in unpredictable ways. Uncertainty around the spatial and temporal resolution of eDNA samples in different environments presents a challenge to scaling the technology for management purposes. However, these challenges may be addressed through conducting studies with varying levels of sampling effort to calibrate the data models. By improving standardization in EG data collection and analysis methods, we may build opportunities to combine projects from discrete areas over large geographic and temporal scales.

There was unanimous agreement among panelists that recognized standards for eDNA must underpin any management application. The ongoing efforts to develop international eDNA standards through ISO and the International eDNA standards Task Force (<https://iestf.global/>) represent an important step forward in standardization efforts.

Following standard practices for eDNA collection and analysis and introducing data sharing infrastructure will open up new possibilities for large-scale biodiversity monitoring. For example, eDNA data collection stations could be incorporated into national and international sensor networks. While panelists acknowledged the challenges of democratizing data in such systems, they emphasized the importance of balancing accessibility with the protection of proprietary information.

The potential benefits of large-scale EG application are significant. Environmental genomics can enable us to make swift decisions and raise early warnings for environmental threats. This is particularly valuable in sectors tightly linked to environmental conditions like aquaculture and invasive species management. By detecting pathogens in local environments through eDNA analysis, aquaculture managers make informed decisions and proactively gather resources for early treatment, potentially mitigating the severity of outbreaks and reducing the need for extensive interventions. The high sensitivity of eDNA allows for early detection of invasive species in sensitive areas and the ease of deployment can support invasive species monitoring networks. This can support timely implementation of management actions, potentially preventing non-native species from establishing a foothold and causing significant ecological damage.

There are challenges when seeking approval to add eDNA to management strategies within organizations. Study design to adjust from conventional approaches to EG methods must be validated on a case-by-case basis, and that slows down the uptake of this method. Additionally, it can be difficult to make the case for using eDNA, when it is not mandatory or when companies need to meet standards defined within a regulatory framework that does not currently list eDNA as an accepted method. There are concerns about the high sensitivity of the technology being incomparable with older surveys, as well as with concerns about rates of false positives and false negatives.

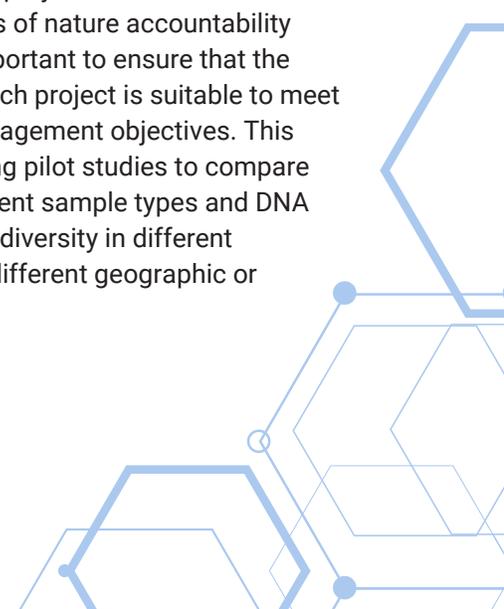
Traditional methods are usually not subject to the same scrutiny as eDNA, and we don't always have good estimates of false positive or false negative rates for conventional surveys either. There are data modeling tools to estimate false positive and false negative rates with eDNA based on replicate sampling that can provide explicit estimates, which are not available for many conventional methods. The panelists see the most value in EG data serving as one line of evidence to be combined with other lines of evidence.

## Interactive Session

The workshop included an interactive session where participants discussed the application of EG to fulfill biodiversity reporting requirements. The objectives of this session were to (1) identify gaps in deploying eDNA alongside other tools for biodiversity monitoring to support nature accounting and reporting initiatives, and (2) to determine what steps or actions can be taken to fill the identified gaps. We identified seven broad categories for discussion: capacity and scaling, measurement and data collection, analysis and metrics, combining new and old data types, validation, data management, and communications and education.

## Measurement & Data Collection

As new biomonitoring projects are initiated to meet the requirements of nature accountability reporting, it will be important to ensure that the sampling design of each project is suitable to meet the reporting and management objectives. This may involve conducting pilot studies to compare the suitability of different sample types and DNA markers to assess biodiversity in different environments and at different geographic or temporal scales.



This may also involve developing guidelines for sampling design to ensure the samples collected will have enough statistical power to detect changes at the scale necessary for appropriate management. Standardization of data collection methods is absolutely required in order to advance trust in EG. While flexibility is necessary to work within environmental constraints, standard procedures with clear guidelines and minimum requirements that address common challenges in a variety of environment types will improve the usability and interoperability of EG data while still allowing for flexible applications. Standardized approaches tailored to precise management goals will ensure that the data collected are both meaningful and actionable, providing valuable insights into biodiversity and environmental health.

## Capacity & Scaling

The EG industry would need increase capacity to collect, process, and interpret eDNA and biodiversity data to enable monitoring at the spatial and temporal scales required for international nature reporting frameworks. With tens of thousands of companies expected to be affected, the demand for biodiversity data will be large. The scale of field operations can be expanded by applying automated and passive sampling technologies, evaluating surveys that use more than one sample type to determine efficiencies, and engaging with community-based monitoring. At the same time, capacity of laboratory operations can be improved by using more automated sample processing systems and by continuing work to develop ISO standards so that more laboratories can be capable of processing EG samples.

## Analysis & Metrics

EG analysis provides several unique metrics that can revolutionize monitoring and management objectives. Beyond the commonly used species presence and absence metrics, there is progress toward addressing the lack of quantitative data by establishing reliable ways to maximize the data acquired from eDNA samples. For example, there are new methods to use sequence abundance as a proxy for biomass or population sizes. Furthermore, Genetic diversity within and between species may be used to aid assessments of ecosystem health and resilience and to track changes to distributions of genotypes, addressing the current gap in understanding how populations are adapting to environmental stressors over time. Other metrics such as those derived from RNA and functional gene analysis offer potential to describe ecosystem processes and functions, helping fill gaps in our ability to assess not just what species are present, but how ecosystems are functioning and responding to change.

## Combining Data Types

EG approaches may be substituted for other biodiversity assessment methods or may be combined with other data types for impact assessments. We cannot use combined approaches to compare eDNA results to previous metrics in every use case because there are limited resources, and it can be difficult to interpret conflicting results. To overcome this, generalized guidance could be established to support the transition from conventional biodiversity data types to new data types while maintaining interoperability for datasets collected over long time scales. This can include considerations about how to handle data that are resolved to different taxonomic levels, how to use replication to evaluate detection probabilities for new sampling methods, and how to handle multiple data types with differing temporal resolutions. Additionally, we may want to consider leveraging other forms of data such as remote sensing or acoustic data to add resolution to a dataset or improve prediction capabilities.

## Validation

New metrics will need validation so that we can appropriately communicate error rates and assumptions of the data. This will facilitate better cross-comparison of eDNA data with existing time series and support management actions. One common issue faced in interpreting results from EG projects is estimating the rates of false positive detections and false negative detections.

Database completeness and database accuracy can influence these incidents. More funding and effort could be directed toward building up databases and ensuring accuracy. This should include additional genome skimming and whole genome sequencing as well as additional barcode sequencing of populations and hybrids, and geolocation information for database records can be leveraged to improve confidence in results. Positive controls with known assemblages can be developed and commercialized to validate processes for various environmental sample types. Ultimately, an EG accreditation agency should be established to ensure consistent results across laboratories and to maintain a directory of such laboratories.

## Communications & Education

The EG community will need to build public trust as well as increase trust from regulators, managers, and users. We can meet the need for more widespread communication by engaging with science journalists, teachers, and community groups to create more public knowledge of eDNA. Teachers and journalists can help make media interactive and communicate using accessible language. It is important to also consider partnerships with social media “science influencers” to produce accessible (closed captioned) educational video content for a broader audience. We can build public trust by communicating limitations and confidence levels for the data.

Additionally, we must bridge the gap across sectors and between scientists and decision makers. We can create meaningful data presentations to support management, including story maps and “toolkits” which streamline messaging to highlight case studies that showcase the benefits of using eDNA.

## Data Management

If EG is to be applied to nature accountability reporting for numerous transnational corporations, companies may require substantial investment in data storage infrastructure. Additionally, we will need to address interoperability and ownership of data and determine what metadata is required alongside biodiversity data. We will need to determine minimum requirements for data lifespans so that long-term comparisons are possible. Next steps for effective EG data management include, establishing interoperable data formats, defining data ownership frameworks, establishing standardized metadata requirements, setting minimum data retention standards, and developing secure, scalable infrastructure to manage storage, processing, and sharing at a global scale.



# Appendix A

Workshop agenda.



**2024 INTERNATIONAL WORKSHOP ON ENVIRONMENTAL GENOMICS:**  
**Advancing Nature Accountability: From Measurement to Management**

*St. John's Convention Centre* 50 New Gower St – 'Bannerman Ballroom'  
St John's, Newfoundland and Labrador, Canada  
June 13th and 14th, 2024



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## AGENDA

### DAY 1 - THURSDAY, JUNE 13th, 2024

08:30 – 09:00	Registration
09:00 – 09:30	Welcome & Introductions
09:30 – 10:15	<b>Kelly Goodwin (National Oceanic and Atmospheric Administration)</b> , Plenary Speaker <i>United States National Aquatic eDNA Strategy</i>
10:15-10:45	<i>Coffee Break</i>
10:45 – 12:15	SESSION 1 – Industrial case studies and applications
	<b>Jennifer Wollenberg (Integral Consulting)</b> <i>Applications of eDNA monitoring for site assessment, management, and regulatory compliance</i>
	<b>Mia Parker (Mowi)</b> <i>Management context for Environmental Genomics in (Resource) Decision Making</i>
	<b>Nicolas Tsesmetzis (Shell International Exploration and Production Inc)</b> <i>IOGP-JIP34 current progress and future directions on the use of eDNA in the Energy sector</i>
12:15 – 13:15	<i>Lunch Break</i>
13:15 – 14:45	Panel Discussion
14:45 – 15:15	<i>Coffee Break</i>
15:15 – 16:15	SESSION 2 – Case studies continued: Industry and conservation
	<b>Dave Cote (Memorial University, Ocean Sciences Centre)</b> <i>Challenges and opportunities of using eDNA metabarcoding in protected area monitoring in Newfoundland and Labrador, Canada</i>
	<b>Beverly McClenaghan (CEGA)</b> <i>Expanding the reach of eDNA to meet large scale demand for biodiversity data</i>
16:15-16:45	Day 1 Wrap-up
18:30 – 21:30	<b>Special Event at EMERA INNOVATION EXCHANGE</b> <i>Reception</i>

Please join us for a **Cocktail Reception at Emera Innovation Exchange**  
Reception: 6:30 PM – 9:30 PM

## **DAY 2 - FRIDAY, JUNE 14th, 2024**

09:00 – 10:30	SESSION 3 – Harnessing metadata for biodiversity management
	<b>Mohamed Ahmed (ESRI)</b> <i>Mapping the Gap</i>
	<b>Donald Baird (Environment &amp; Climate Change Canada)</b> <i>Linking geodata and eDNA biodiversity to support improved nature management</i>
10:30 – 11:00	Coffee Break
11:00 – 12:00	SESSION 4 – Technological advancements
	<b>Jeffrey Gross (Illumina)</b> <i>Illumina's XLEAP Chemistry Unlocks Accessibility to Sustainable Environmental Genomics Assays</i>
	<b>Avery McCarthy (CEGA)</b> <i>High Throughput Innovation at eDNAtec: Automation and Enhanced Next Generation Sequencing Workflows in the Centre for Environmental Genomics Applications (CEGA)</i>
12:00 –	Lunch Break
13:00 – 13:00	SESSION 5 – Discovery and notes from the field
– 14:30	<b>Larissa Fruehe (OceanX)</b> <i>Navigating the Future: Leveraging Onboard Sequencing for Sustainable Ocean Management</i>
	<b>Andrew Riley (University of Guelph)</b> <i>Large scale analysis of within species diversity using DNA metabarcoding data</i>
	<b>Maxime Geoffroy (Fisheries and Marine Institute of Memorial University)</b> <i>Groundtruthing hydroacoustic signals with environmental DNA in coastal and offshore environments</i>
14:30 – 16:15	Interactive session
16:15 – 17:00	Closing Remarks

**Thank you for Attending IWEG 2024**

## Event Location:

**ST. JOHN'S CONVENTION CENTRE**  
50 News Gower Street  
St. John's, NL Canada



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## Reception Location:

**Emera Innovation Exchange**  
100 Signal Hill Road  
St. John's, NL Canada



<https://www.mun.ca/signalhill/mera-innovation-exchange/>

