Meeting Energy Industry Biodiversity Challenges through the Environmental Genomics Joint Industry Program

Michael Marnane

Industry Co-Chair – Environmental Genomics JIP

Chevron Corporate HSE Function
Adjunct Professor, Curtin University

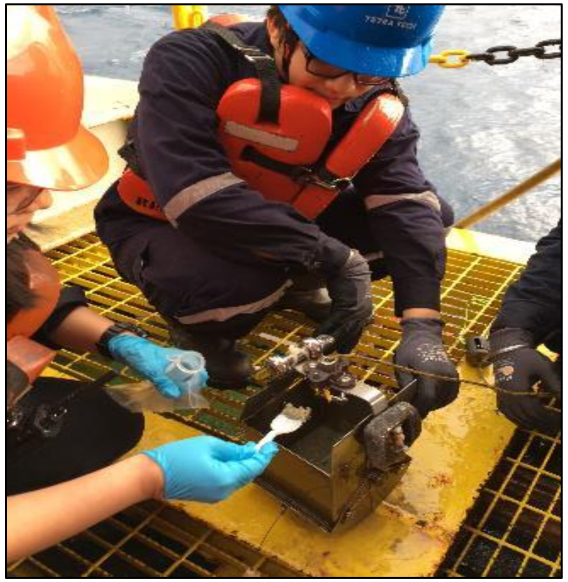
Nicolas Tsesmetzis, Jordan Angle, Gustavo Estrada, Sonja Kaulbarsch, Anita Skarstad, Ane Kjølhamar, Thomas Merzi, David Wyker, Ezzaini Ramli, Harvey Johnstone

UN Ocean Decade Contribution

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Energy Industry Biodiversity Monitoring

Environmental Baselines



Images courtesy of Chevron

Requirements

- Detecting species presence and distribution at new project sites
- Data for Environmental Impact Assessment (EIA) and Approvals
- Baseline data for the unlikely event of an oil spill

Opportunities for eDNA use

- Large reduction in field time (costs, safety risk)
- eDNA provides holistic data on entire assemblages

Challenges for eDNA use

- Many regulatory agencies do not yet prescribe or accept eDNA for baselines
- eDNA still viewed by industry as an additional method/cost, not a replacement
- New geographies = limited reference sequences

Energy Industry Biodiversity Monitoring

Impact Assessments and Compliance Monitoring

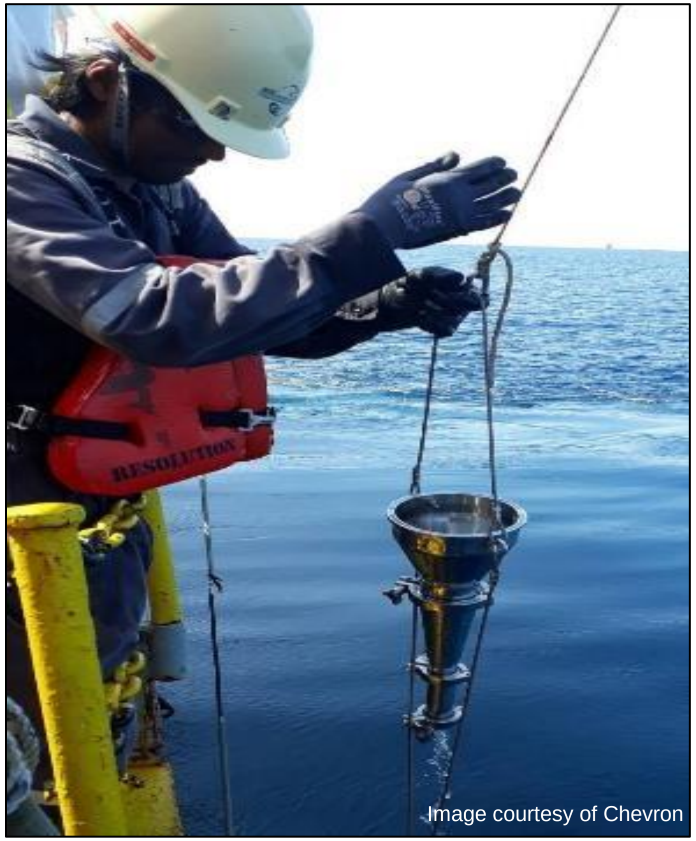


Image courtesy of Chevron

Requirements

- Assess impacts from construction of projects (EIA)
- Provide routine data for compliance monitoring and reporting

Opportunities for eDNA use

- Increased power to detect changes in biological communities

Challenges for eDNA use

- Data needs to stand up to regulatory and legal scrutiny
- Lack of standard methods for assessing and reporting error in eDNA data
- Limited validation of spatio-temporal variation in eDNA
- Limited measures of abundance or condition

Energy Industry Biodiversity Monitoring

Species of Interest or Concern

Images courtesy of Chevron and Curtin University

Requirements

- Monitoring and management of impacts to rare, threatened or endangered species or species that are difficult to monitor (e.g. cryptic, subterranean)
- Detection of invasive species

Opportunities for eDNA use

- Improved detection rates (e.g. low numbers, juveniles, rare, cryptic species)
- Powerful when combined with geospatial data to map distributions
- Can be deployed by non-specialist staff

Challenges for eDNA use

- Understanding levels of false positives and negatives
- Turnaround times (critical for invasive species)
- Detection of species in arid environments

E&P ENVIRONMENTAL GENOMICS RESEARCH PROGRAMME

IOGP International Association of Oil & Gas Producers

Energy Industry Biodiversity Monitoring

Decommissioning, Remediation & Restoration


Images courtesy of Chevron and Curtin University

Requirements

- Demonstrating biodiversity benefits and risks associated with decommissioning
- Assessing recovery of soil communities impacted by contamination
- Assessing site restoration success and driving factors

Opportunities for eDNA use

- Holistic data on assemblages can provide additional insights into biodiversity value, ecosystem condition, factors driving success

Challenges for eDNA use

- Applications relatively new and evolving
- Uptake by industry and acceptance by regulators a work in progress

Energy Industry Biodiversity Monitoring

Nature Reporting, Nature-Positive, Nature-based Solutions

Image courtesy of Chevron

Requirements

- Nature-related financial disclosures (e.g. EU CSRD, TNFD)
- Demonstrating Nature-Positive Impacts
- Demonstrating Biodiversity Co-benefits of Nature-based Solutions (NbS)

Opportunities for eDNA use

- Ability to cost-effectively scale biodiversity monitoring
- Can provides data on target species as well as holistic data on entire assemblages

Challenges for eDNA use

- Integrating eDNA with other data sources and comparing data through time
- Agreement on metrics and indicators of ecosystem condition provided by eDNA

Addressing eDNA Challenges through the Environmental Genomics Joint Industry Program

Goals:

- Mutualize R&D efforts to accelerate the use of environmental genomics for environmental management applications in the energy industry

- Develop environmental genomics guidance applicable to all phases of energy industry activities, study objectives and environments

Chevron
eni
ExxonMobil
TotalEnergies
equinor
BR PETROBRAS
Woodside Energy
bp

E&P ENVIRONMENTAL GENOMICS RESEARCH PROGRAMME

IOGP International Association of Oil & Gas Producers

Development of Energy Industry eDNA Guidance

Objectives:

- Allow standardization of approaches and reproducibility of results
- Leverage existing guidance and publications (do not re-invent the wheel)
- Facilitate regulatory input to guidance to improve alignment on expectations
- Ensure guidance is evergreen and regularly updated as the field evolves

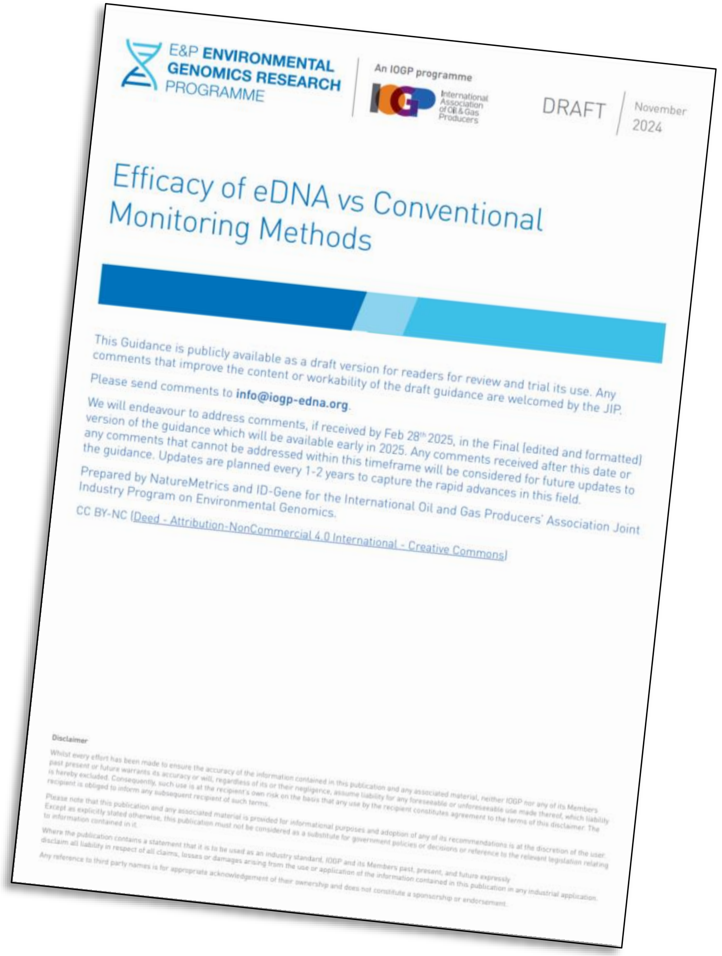
Four comprehensive guidance chapters drafted (400+ pages):

Chapter 1: *Efficacy of eDNA versus conventional monitoring methods*

Chapter 2: *Sampling guidelines and considerations for industry applications*

Chapter 3: *Laboratory analysis guidelines*

Chapter 4: *Bioinformatics, data analysis and interpretation guidelines*


E&P ENVIRONMENTAL GENOMICS RESEARCH PROGRAMME

An IOGP programme

International Association of Oil & Gas Producers

DRAFT | November 2024

Efficacy of eDNA vs Conventional Monitoring Methods

This Guidance is publicly available as a draft version for readers for review and trial its use. Any comments that improve the content or workability of the draft guidance are welcomed by the JIP.

Please send comments to **info@iogp-edna.org**.

We will endeavour to address comments, if received by Feb 28th 2025, in the Final (edited and formatted) version of the guidance which will be available early in 2025. Any comments received after this date or any comments that cannot be addressed within this timeframe will be considered for future updates to the guidance. Updates are planned every 1-2 years to capture the rapid advances in this field.

Prepared by NatureMetrics and ID-Gene for the International Oil and Gas Producers' Association Joint Industry Program on Environmental Genomics.

CC BY-NC (Deed - Attribution-NonCommercial 4.0 International - Creative Commons)

Disclaimer

NATURE METRICS
DNA-BASED MONITORING

Guidance Chapter 1:
Efficacy of Genomic versus Conventional Monitoring Methods

- Compares the efficacy of environmental genomic versus conventional monitoring methods for a range of industry objectives, taxa and habitats, through a meta-analysis of published literature
- Presents decision trees that guide environmental practitioners and contractors on when, where and how to apply genomic methods
- Summarizes the current state of readiness of genomics for a range industry applications (evergreen, to be updated regularly)


Images courtesy of Chevron

E&P ENVIRONMENTAL GENOMICS RESEARCH PROGRAMME

International Association of Oil & Gas Producers

Guidance Chapter 1:
Efficacy of Genomic versus Conventional Monitoring Methods

Habitat	Target community	eDNA methods	Conventional methods	Recommended use	Phase of operation
Marine	**Benthic sediment**	Sediment sample; Macrofauna sample	Macrofauna sample; Benthic imagery; Active acoustics	CA with further validation	B; E&P; OSR; R
	Benthic hard substrate	Surface scrape; Surface swabs; Surface suction	Surface scrape; Benthic imagery; Active acoustics	CA in combination	B; E&P; OSR; D; R
	Fish	Water filter	Netting; Benthic and aerial imagery; Active acoustics	Stand-alone CA & SD	B; E&P; OSR; D; R
	Broad vertebrates	Water filter	Visual observations; Passive acoustics; Aerial imagery	CA & SD in combination	B; OSR; R
	Zooplankton & Phytoplankton	Water filter; Bulk net sample	Water sampling; Netting; Active acoustics; Aerial imagery	CA in combination, and SD stand-alone	B; OSR; D
Freshwater	**Fish**	Water filter	Netting; Electrofishing	CA in combination and SD stand-alone	B; E&P; OSR; D; R
	Aquatic Invertebrates	Water filter; Bulk sampling	Kicknet; Traps	CA with further validation and SD stand-alone	B; E&P; OSR; R
	Phytobenthos	Biofilm sampling	Biofilm sampling;	CA with further validation	B; E&P; OSR; R
Terrestrial	**Broad vertebrates**	Water filter; Air DNA; Surface swabs; iDNA	Visual and auditory; Camera traps; Vertebrate traps; Artificial cover	CA and SD in combination	B; OSR; D; R
	Invertebrates	Invertebrate traps; Air DNA; Surface swabs	Invertebrate traps	CA in combination	B; OSR; D; R
	Soil	Soil sampling	Soil sampling	CA with further validation	B; E&P; OSR; R

Key: **Recommended use:** CA = Community analysis; SD = Species detection
Phase of operation: B = Baseline; E&P = Exploratory and production; OSR = Oil spill and remediation; D = Decommissioning; R = Restoration

Guidance Chapter 2:
Development of eDNA Sampling Standards and Guidelines

- Presents critical considerations for industry practitioners and contractors when designing genomics sampling programs
- Provides recommendations that improve robustness of sampling, representation of taxa and reproducibility of results
- Identifies critical knowledge gaps that need to be addressed to improve confidence in sampling and data obtained

Stantec NATURE METRICS DNA-BASED MONITORING

E&P ENVIRONMENTAL GENOMICS RESEARCH PROGRAMME

IOGP International Association of Oil & Gas Producers

Stantec NATURE METRICS DNA-BASED MONITORING

Guidance Chapter 2: Development of eDNA Sampling Standards and Guidelines

Factors influencing a false result introduced during eDNA field sampling or laboratory analysis, with the potential for mitigation based on study design

(modified from Burian et al., 2021)

False Result		Error Description	Mitigation Potential
Field	False Positive	**Contamination during sampling** (accidental eDNA across site transfer)	Very High
		***Sampling independent contamination** (e.g., by birds, predator feces, ballast water or other human activities)	Intermediate
		***Vertical transport** (e.g., downstream eDNA along river networks influenced by hydrology	Intermediate
		***eDNA persistence** (e.g., historical eDNA introduced to sample)	High
	False Negative	**Inappropriate sampling method** (wrong habitats within sites or insufficient media quantities are sampled)	Very High
		Environmental heterogeneity (of environment and populations)	Intermediate
		eDNA persistence (high microbial activity leads to rapid eDNA degradation and low concentrations)	Intermediate
		Physiological factors (e.g., seasonality in activity patterns)	High
		Environmental drivers (e.g., rain events can flush out eDNA)	Intermediate
Laboratory	False Positive	**Technical contamination** (contamination across samples due to inappropriate lab procedures or mislabeling of samples)	Very High
		Insufficient specificity (non-target eDNA is amplified)	High
	False Negative	**Inhibition** (amplification of target DNA is inhibited by co-extracted compounds)	Intermediate
		Inadequate extraction protocol (low extracted DNA concentrations)	Very High
		Inadequate sample preservation (if extraction is delayed)	Very High
		Low sensitivity (low amplification efficiency, high limit of detection)	Very High
		Insufficient specificity (assays fails to detect certain haplotypes)	High

Guidance Chapter 3:
eDNA Laboratory Analysis Guidelines

- Recommends minimum laboratory analysis requirements that allow industry practitioners to confidently rely on genomics data
- Provides recommendations that are relevant to a range of study objectives, sample substrates, environments and taxa
- Identifies critical knowledge gaps that currently introduce uncertainty or bias during laboratory analysis

Image courtesy of eDNATec

Guidance Chapter 3:
eDNA Laboratory Analysis Standards

Guidance on meta-barcode primer selection

Gene region	Target Taxa	Example Marker	Mean amplicon length (bp) including primers	Taxonomic Resolution
12S	Fish	MiFishU (Miya et al., 2015) F: NNNNNNGTCGGTAAAACTCGTGCCAGC R: NNNNNNCATAGTGGGGTATCTAATCCCAGTTTG	234	Medium
	Vertebrates	12SV05 (Riaz et al., 2011) F: TTAGATACCCCACTATGC R: TAGAACAGGCTCCTCTAG	133	Low
16S	Bacteria	515F–806R (V4 region) (Apprill et al., 2015; Parada et al., 2016) F: GTGYCAGCMGCCGCGGTAA R: GGACTACNVGGGTWTCTAAT	390	Medium
	Mammals	16Smam (P. Taylor, 1996) F: CGGTTGGGGTGACCTCGGA R: GCTGTTATCCCTAGGGTAACT	135	Low
18S	Eukaryotes	18SV4M1 (V4 region) (Stat et al., 2017) F: GCAGTTAAAAAGCTCGTAG R: TCCAAGAATTRCACCTCT	346	Low
COI	Eukaryotes	F230 (Gibson et al., 2015) F: GGTCAACAAATCATAAAGATATTGG R: CTTATRTTRTTTATNCGNGGRAANGC	281.5	High
	Metazoans, Macroalgae	Leray XT (Wangensteen et al., 2018) F: GGWACWRGWTGRACWITITAYCCYCC R: TAIACYTCIGGRTGICCRAARAAYCA	368	High
	Insects	BF3BR2 (Roger et al., 2022) F: CCHGAYATRGCHTTYCCHCG R: TCDGGRTGNCCRAARAAYCA	458	High

Guidance Chapter 4:
Bioinformatics, Data Analysis and Interpretation

- Provides recommended workflows and methods for bioinformatics and data analysis
- Includes interviews with thought leaders on controversial or rapidly-evolving topics
- Improves ease of interpretation, reproducibility of results and greater confidence in using genomics data in management decisions
- Includes status of sequence reference databases for many key regions where the energy industry operates

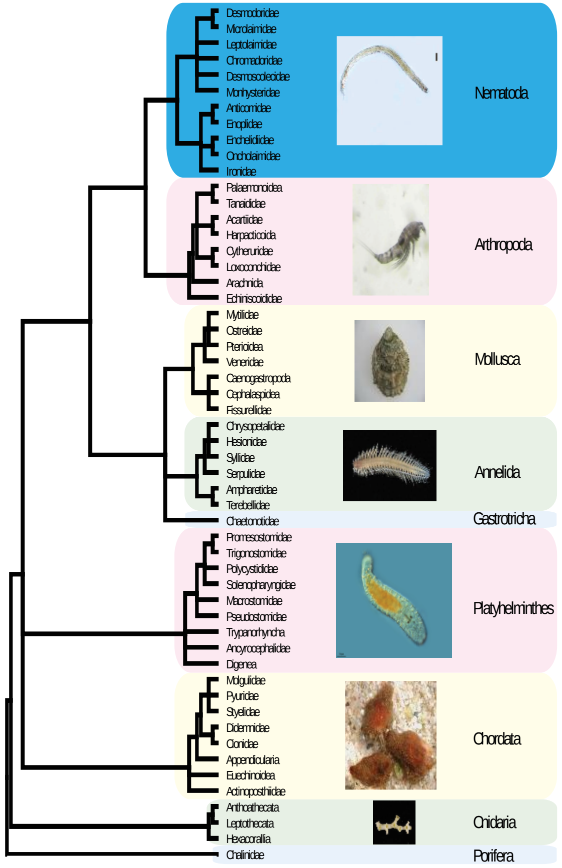
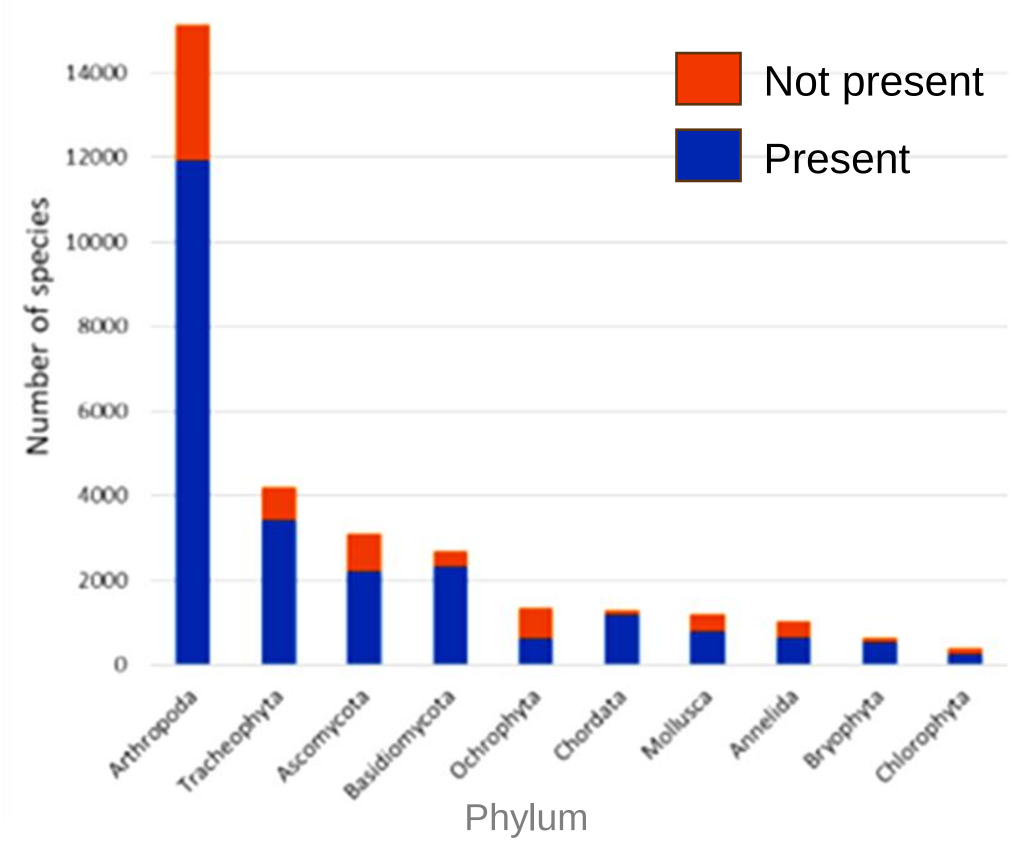


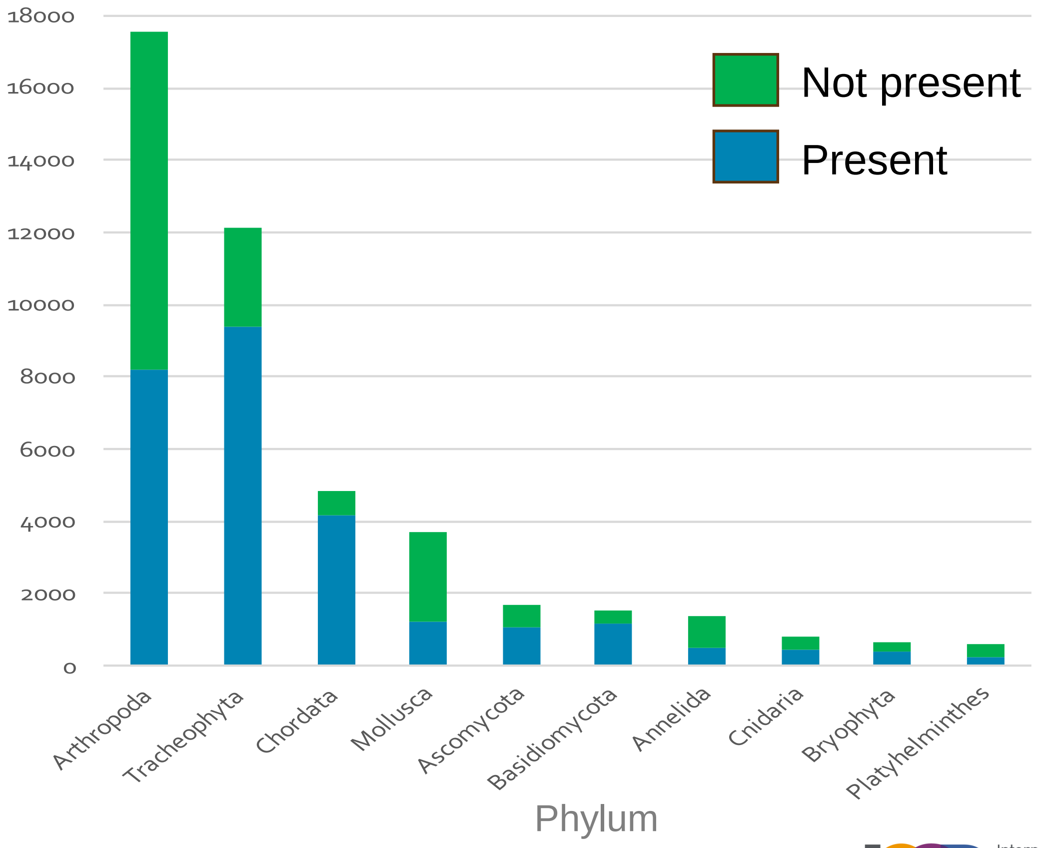
Image courtesy of Curtin University

Guidance Chapter 4:
Bioinformatics, Data Analysis and Interpretation

Sequence Database Completeness:
North Sea



Sequence Database Completeness:
Gulf of Mexico



Data based on number of recorded species for region from GBIF versus Genbank nucleotide database (mid-2023); Figures courtesy of eDNATec

We need your help!

- **Draft guidance** publicly available on JIP website: https://www.iogp-edna.org/publications/

SCAN ME

- Please review and use guidance and provide comments to:

  info@iogp-edna.org

- Comments will be addressed Q1 2025 revision

Chapter 1 - Efficacy of eDNA vs Conventional Monitoring Methods

Chapter 2 - eDNA Sampling Standards and Guidelines

Chapter 3 - Laboratory Analysis Guidelines and Best Practices for Environmental Genomics Applications Relevant to the Energy Sector

Chapter 4 - Industry Guidance on Bioinformatics Analysis Standards and Guidelines for eDNA Data relevant to O&G

E&P ENVIRONMENTAL GENOMICS RESEARCH PROGRAMME

International Association of Oil & Gas Producers

JIP Phase 2 Priorities (2025-2028)

1. **Nature Reporting:** Framework on how to incorporate eDNA methods
2. **Natue-based Solutions (NbS):** Framework on how to incorporate eDNA methods
3. **Estimating and reporting levels of error in eDNA data:** Standardized approach
4. **Extracting greater value from eDNA data:** Guidance and case studies (e.g. using occupancy modelling, relative reads, co-occurrence networks)
5. **eDNA sampling technology development:** Maintain currency of knowledge within industry and outline needs to technology developers
6. **Industry sequence data:** Facilitate sharing for other uses such as conservation or validation of geospatial/AI models
7. **eDNA fluency:** Build fluency among industry, regulators and government agencies
8. **Guidance:** Update industry guidance to capture the rapid evolution of the field

Image courtesy of Chevron

Priorities 1-3: work commenced; outputs due mid-2025
Priorities 4-8: work to commence later in 2025

International Association of Oil & Gas Producers

For more information please contact:

Michael Marnane, Industry Co-Chair MichaelMarnane@chevron.com
Nicolas Tsesmetzis, Industry Co-Chair Nicolas.Tsesmetzis@shell.com
Harvey Johnstone, Environment Director hj@iogp.org

website http://www.iogp-edna.org

IOGP Headquarters

City Tower, 40 Basinghall St, London EC2V 5DE, United Kingdom
T: +44 (0)20 3763 9700
E: reception@iogp.org

IOGP Americas

T: +1 713 261 0411
E: reception-americas@iogp.org

IOGP Asia Pacific

T: +60 3-3099 2286
E: reception-asiapacific@iogp.org

IOGP Europe

T: +32 (0)2 790 7762
E: reception-europe@iogp.org

IOGP Middle East & Africa

T: +1 713 261 0411
E: reception-mea@iogp.org

www.iogp.org