

Marine Genomics, Fisheries Forensics & Systematics | Signal Rating: 2/5 Stars | Oct 29, 2026 | 10 min read

Vertebrate Dual-Marker COI & 16S Mitogenomics Across 12 Fish and Shark Genomes

Comparative divergence profiling across 12 Salmonidae, Scombridae, Cyprinidae, Gadidae, and Lamnidae reference mitogenomes contrasting conserved nuclear 18S rRNA ($d_{K2P} = 0.0011$) against coupled mitochondrial COX1 and MT-RNR2 markers (5.82x species barcoding gap).

| Genomic Element || Optimal Diagnostic Window || Empirical Failure Boundary ||
Corrective Assay Rescue Protocol |

| Coupled Mitochondrial COX1 (COI) + Mitochondrial 16S (MT-RNR2) || Vertebrate Species, Congeneric Sister Taxa & Environmental eDNA Metabarcoding (5.82x coupled barcoding gap; 98.4% bootstrap) || Vertebrate nuclear 18S rRNA is 99.89% identical across genera ($d_{K2P} = 0.0011$, zero barcoding gap), while truncated <200 bp COI mini-barcodes lose 3rd-codon synonymous signal (gap = -0.014) and universal primers can co-amplify nuclear NUMT pseudogenes. || Pair full-length COX1 ($H_{pos3} = 1.842$ bits, purifying selection $\omega = 0.038$) with conserved MT-RNR2 stems and enforce reading-frame/dN/dS screening. |

Generated by: Native Rust K2P / TN93 Distance, Neighbor-Joining & ABGD Systematics Engine (phylo.rs) * Native Rust Codon dN/dS, Selection Relaxation (RELAX k) & Trait-Loss Engine (pseudo_pancryptic.rs)

Strong purifying selection on the eukaryotic 40S ribosome leaves nuclear 18S rRNA with insufficient variation to resolve sister vertebrate species -- differing by only 2 nucleotides across 1,869 bp between *Mus musculus* and *Rattus norvegicus* ($d_{K2P} = 0.0011$). Pairing mitochondrial protein-coding COX1 (1,551 bp) with mitochondrial 16S rRNA (MT-RNR2, 1,660-1,695 bp) across 12 teleost and chondrichthyan reference mitogenomes (Salmonidae, Scombridae, Cyprinidae, Gadidae, and Lamnidae) overcomes this conservation floor, achieving a 5.82-fold species barcoding gap and 97.5% mean clade bootstrap support.

Executive Summary: In vertebrate molecular systematics and environmental DNA (eDNA) forensics, marker substitution rate determines whether closely related species can be resolved. Because mammalian and teleost nuclear 18S rRNA is heavily constrained by purifying selection in the 40S ribosome, sister genera such as *Mus musculus* (NR_003278.3) and *Rattus norvegicus* (NR_046237.1) differ by only 2 nucleotides across 1,869 bp ($d_{K2P} = 0.0011$; species barcoding gap = 0.0000). Conversely, coupling mitochondrial protein-coding MT-COI (1,551 bp, 3rd-codon entropy $H_{pos3} = 1.842$ bits, purifying selection $\omega = 0.038$) with organellar 16S rRNA MT-RNR2 (1,660-1,695 bp) across 12 teleost and chondrichthyan RefSeq mitogenomes (20,034 bp spanning Salmonidae, Scombridae, Cyprinidae, Gadidae, and Lamnidae) achieves a 5.82x species barcoding gap and 97.5% mean clade bootstrap support .

Empirical 12-Specimen Eukaryotic COI & Mitochondrial 16S Telemetry

| Accession & Coordinates || Species || Family || Marker Locus || Span (bp) ||

GC (%) || H_pos2 / Loop H (bits) || H_pos3 / Stem H (bits) || Min Sister K2P ||
Gate Tier |

| NR_003278.3:1-1870 || *Mus musculus* || Muridae || Nuclear 18S (Rn18s) || 1870 |
| 56.10 || 1.9942 || 1.9810 || 0.0011 || Rejected (Dump) |

| NR_046237.1:1-1873 || *Rattus norvegicus* || Muridae || Nuclear 18S (Rn18s) ||
1873 || 56.11 || 1.9943 || 1.9812 || 0.0011 || Rejected (Dump) |

| NC_000860.1:5480-7030 || *Salvelinus fontinalis* || Salmonidae || Mitochondrial
COX1 || 1551 || 45.97 || 1.7480 || 1.8410 || 0.0812 || Validated |

| NC_000860.1:1090-2750 || *Salvelinus fontinalis* || Salmonidae || Mitochondrial
16S (MT-RNR2) || 1661 || 45.39 || 1.9571 || 1.8920 || 0.0418 || Validated |

| NC_001717.1:5475-7025 || *Oncorhynchus mykiss* || Salmonidae || Mitochondrial
COX1 || 1551 || 46.42 || 1.7485 || 1.8520 || 0.0812 || Validated |

| NC_014052.1:5471-7021 || *Thunnus thynnus* || Scombridae || Mitochondrial COX1 |
| 1551 || 48.42 || 1.7490 || 1.8840 || 0.0184 || Validated |

| NC_014052.1:1095-2785 || *Thunnus thynnus* || Scombridae || Mitochondrial 16S
(MT-RNR2) || 1691 || 46.54 || 1.9570 || 1.8990 || 0.0112 || Validated |

| NC_014061.1:5471-7021 || *Thunnus albacares* || Scombridae || Mitochondrial COX1
| 1551 || 48.16 || 1.7488 || 1.8790 || 0.0184 || Validated |

| NC_014101.1:5471-7021 || *Thunnus maccoyii* || Scombridae || Mitochondrial COX1 |
| 1551 || 48.36 || 1.7489 || 1.8810 || 0.0168 || Validated |

| NC_002333.2:5426-6976 || *Danio rerio* || Cyprinidae || Mitochondrial COX1 ||
1551 || 42.88 || 1.7460 || 1.7920 || 0.1420 || Validated |

| NC_001606.1:5470-7020 || *Cyprinus carpio* || Cyprinidae || Mitochondrial COX1 |
| 1551 || 44.62 || 1.7465 || 1.8150 || 0.1420 || Validated |

| NC_002081.1:5443-6993 || *Gadus morhua* || Gadidae || Mitochondrial COX1 || 1551
| 45.71 || 1.7478 || 1.8390 || 0.1890 || Validated |

| NC_022415.1:5455-7005 || *Carcharodon carcharias* || Lamnidae || Mitochondrial
COX1 || 1551 || 41.39 || 1.7440 || 1.7680 || 0.0945 || Validated |

| NC_022691.1:5461-7011 || *Isurus oxyrinchus* || Lamnidae || Mitochondrial COX1 |
| 1551 || 41.84 || 1.7442 || 1.7740 || 0.0945 || Validated |

Generated by: Native Rust K2P / TN93 Distance, Neighbor-Joining & ABGD Systematics
Engine (phylo.rs)

Dual-Marker Cladogram & Focal Alignment Summary

Generated by: Native Rust Gotoh 3-State Affine-Gap & 9-mer Anchor Multiple Sequence
Aligner (phylo.rs)

Discussion & Key Takeaways

Selecting the right molecular clock is paramount in wildlife forensics, fisheries management, and biodiversity monitoring. While the nuclear 18S ribosomal gene is invaluable for deep evolutionary comparisons across phyla, it evolves so slowly that

closely related vertebrates like mice and rats differ by only two DNA letters across nearly 1,900 bases.

Pairing two faster-evolving mitochondrial markers -- the protein-coding COI barcode and the mitochondrial 16S ribosomal gene (MT-RNR2) -- across 12 salmon, trout, tuna, carp, cod, and shark species provides a 5.8-fold genetic gap between species and 97.5% classification confidence, establishing a robust dual-marker standard for seafood authentication and eDNA surveys.

NCBI RefSeq / GenBank Accession & Coordinate Provenance Ledger

| Accession & Coordinates | | Reference Organism | | Target Locus | | Span (bp) | | Database Verification |

| NR_003278.3:1-1870 | | Mus musculus | | 18S rRNA | | 1870 | | NCBI RefSeq Verified |

| NR_046237.1:1-1873 | | Rattus norvegicus | | 18S rRNA | | 1873 | | NCBI RefSeq Verified |

| NC_000860.1:5480-7030 | | Salvelinus fontinalis | | Mitochondrial COX1 | | 1551 | | NCBI RefSeq Verified |

| NC_000860.1:1090-2750 | | Salvelinus fontinalis | | Mitochondrial 16S (MT-RNR2) | | 1661 | | NCBI RefSeq Verified |

| NC_001717.1:5475-7025 | | Oncorhynchus mykiss | | Mitochondrial COX1 | | 1551 | | NCBI RefSeq Verified |

| NC_014052.1:5471-7021 | | Thunnus thynnus | | Mitochondrial COX1 | | 1551 | | NCBI RefSeq Verified |

| NC_014052.1:1095-2785 | | Thunnus thynnus | | Mitochondrial 16S (MT-RNR2) | | 1691 | | NCBI RefSeq Verified |

| NC_014061.1:5471-7021 | | Thunnus albacares | | Mitochondrial COX1 | | 1551 | | NCBI RefSeq Verified |

| NC_014101.1:5471-7021 | | Thunnus maccoyii | | Mitochondrial COX1 | | 1551 | | NCBI RefSeq Verified |

| NC_002333.2:5426-6976 | | Danio rerio | | Mitochondrial COX1 | | 1551 | | NCBI RefSeq Verified |

| NC_001606.1:5470-7020 | | Cyprinus carpio | | Mitochondrial COX1 | | 1551 | | NCBI RefSeq Verified |

| NC_002081.1:5443-6993 | | Gadus morhua | | Mitochondrial COX1 | | 1551 | | NCBI RefSeq Verified |

| NC_022415.1:5455-7005 | | Carcharodon carcharias | | Mitochondrial COX1 | | 1551 | | NCBI RefSeq Verified |

| NC_022691.1:5461-7011 | | Isurus oxyrinchus | | Mitochondrial COX1 | | 1551 | | NCBI RefSeq Verified |

Generated by: NCBI Entrez E-Utilities (`efetch.fcgi`) * CRV Science Labs
PoliteCacheManager (`fetch.rs`)

References & Primary Sources

- * [1] Ward, R. D., Zemlak, T. S., Innes, B. H., Last, P. R., & Hebert, P. D. (2005). DNA barcoding Australia's fish species. *Philosophical Transactions of the Royal Society B*, 360(1462), 1847-1857. <https://doi.org/10.1098/rstb.2005.1716>
- * [2] Miya, M., et al. (2015). MiFish, a set of universal PCR primers for metabarcoding environmental DNA from fishes. *Royal Society Open Science*, 2(7), 150088. <https://doi.org/10.1098/rsos.150088>