Population genetic diversity, structure, and connectivity of Euphausiaceae based on COI barcodes: Implications for biodiversity and biogeography

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SCOR MetaZooGene Symposium
Aviva Stadium, Dublin, Ireland - September 23, 2022
COI Barcoding of Zooplankton Diversity

- COI barcodes identify and discriminate species
- Metabarcoding with COI allows species-level analysis of biodiversity
- COI reference barcode database needed to identify species

Barcode gene tree for copepods
Blanco-Bercial et al. (2014) PLoS Currents

COI “Rosetta Stone” for Sargasso Sea zooplankton
Barcoding Euphausiids


Barcodes for 193 individuals of 40 species

N. megalops (4)
T. tricuspidata (3)
Euphausia
Thysanoessa
Nyctiphanes
Meganyctiphanes
Thysanoessa
Euphausia

98
99
100% bootstrap


Peter Wiebe (WHOI); 10-m MOCNESS

Barcodes for 193 individuals of 40 species
Barcoding Euphausiids

- Barcodes for >70 species.
- COI discriminates species
- Reveals cryptic variation in widespread taxa

Variation between species 11% - 17%
Variation within species 1% - 3%
Mistaken species ID
MetaZooGene Barcode Atlas & Database (MZGdb)
Todd O’Brien, NOAA Fisheries (USA)

- Over 218,299 COI sequences for 11,356 species of marine zooplankton
- MZGdb expanded to include 18S rRNA & other gene regions; adding fish & protists
- Data from NCBI GenBank & BOLD (duplicates removed)
- Searchable by taxonomic group and ocean region

http://metazoogene.org/atlas
https://doi.org/10.1007/s00227-021-03887-y

Ann Bucklin, Todd D. O’Brien & MetaZooGene (SCOR WG157) members

- Introduce, explain and promote MZGdb: https://metazoogene.org/MZGdb
- Acknowledge: MetaZooGene (SCOR WG157) and ICES WGIMT

Photos by R.R. Hopcroft and C. Clarke (UAF) and L.P. Madin (WHOI); see http://www.cmarz.org/galleries.html
COI Barcodes for Euphausiids (Krill)

MetaZooGene Barcode Atlas & Database (MZGdb)
- 83 described / accepted species of euphausiids
- 65 (78%) with COI barcodes; 3003 COI sequences
- 28 species (33%) with 18S rRNA barcodes

Euphausiacea barcodes and observations

Blue dots: Species collection records; Red stars: barcoded specimens; http://metazoogene.org/atlas
Nematoscelis megalops

Barcode records with georeferencing:
COI = 28; mt 16S = 2; 18S rRNA = 1; 28S = 2

http://metazoogene.org/atlas
Styocheiron affine
Barcode records with georeferencing:
COI = 17; mt 16S rRNA = 1; 18S rRNA = 1

http://metazoogene.org/atlas

Azofeifa-Solano et al. (2021)
**Stylocheiron affine**
in the Red Sea


**COI variation**
- Within species = 2.8% (SD 3.1%)
- Between species = 16.6% (SD 0.7%)
- S. affine from Red Sea differed 14% from Atlantic & Pacific
- Possible Red Sea cryptic species

Azofeifa-Solano et al. (2021)
Stylocheiron elongatum in Gulf Stream System


- *Stylocheiron* species show low COI variation; little or no population structure.
- *S. elongatum* showed <1% COI variation across all ocean basins, but significant differentiation in NW Atlantic Ocean.
- Position-keeping by deep-living, non-migrating species may prevents mixing along Gulf Stream.
Thysanoessa inermis & T. raschii
Atlantic – Arctic Divergence

COI barcode variation (p-distance): \( T. \textit{inermis} = 0.003 \) vs \( T. \textit{raschii} = 0.025 \)
Euphausiid Barcodes for North Atlantic
MetaZooGene / ICES WGIMT Barcode Atlas
Todd O’Brien (NOAA Fisheries, USA)

- 42 species from North Atlantic
- 41 species with COI barcodes from "any ocean"; total 1,622
- 21 species with COI barcodes from N Atlantic; total 112
- Collaborative effort:
  - SCOR WG157 MetaZooGene
  - ICES WGIMT and WGZE
  - NOAA COPEPOD

https://metazoogene.org/database
- **Time-series sampling:** NOAA NMFS Ecosystem Monitoring (EcoMon) Surveys
- **Taxonomic data from EcoMon:** zooplankton species counts, biomass
- **Spring cruises 2002-2012:** 3 regions; total 26 samples


COI Barcodes to Monitor Euphausiid Diversity
NEFSC EcoMon Time-Series Surveys

Time-series records of euphausiid species:
- Listed in EcoMon records & detected by both counts & COI
- EcoMon listed but not detected by counts or COI
- Detected only by COI metabarcoding

<table>
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<tr>
<th>Species</th>
<th>EcoMon List</th>
<th>Counts &gt;1% FO</th>
<th>COI seqs All</th>
<th>COI Seqs&gt;50</th>
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<td>Total # Species</td>
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Tracing Mesopelagic Food Chain

Identification of euphausiid prey species reveals sources of productivity: surface vs deep

Mesopelagic Fish Predators

*Argyropelecus aculeatus*  
Silver hatchet fish

*Sigmops elongatus*  
Bristlemouth

<table>
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<th>Prey Species by Group</th>
<th>Aa</th>
<th>Cs</th>
<th>Hh</th>
<th>Ns</th>
<th>Sb</th>
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*Photos: Paul Caiger (WHOI)*
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