

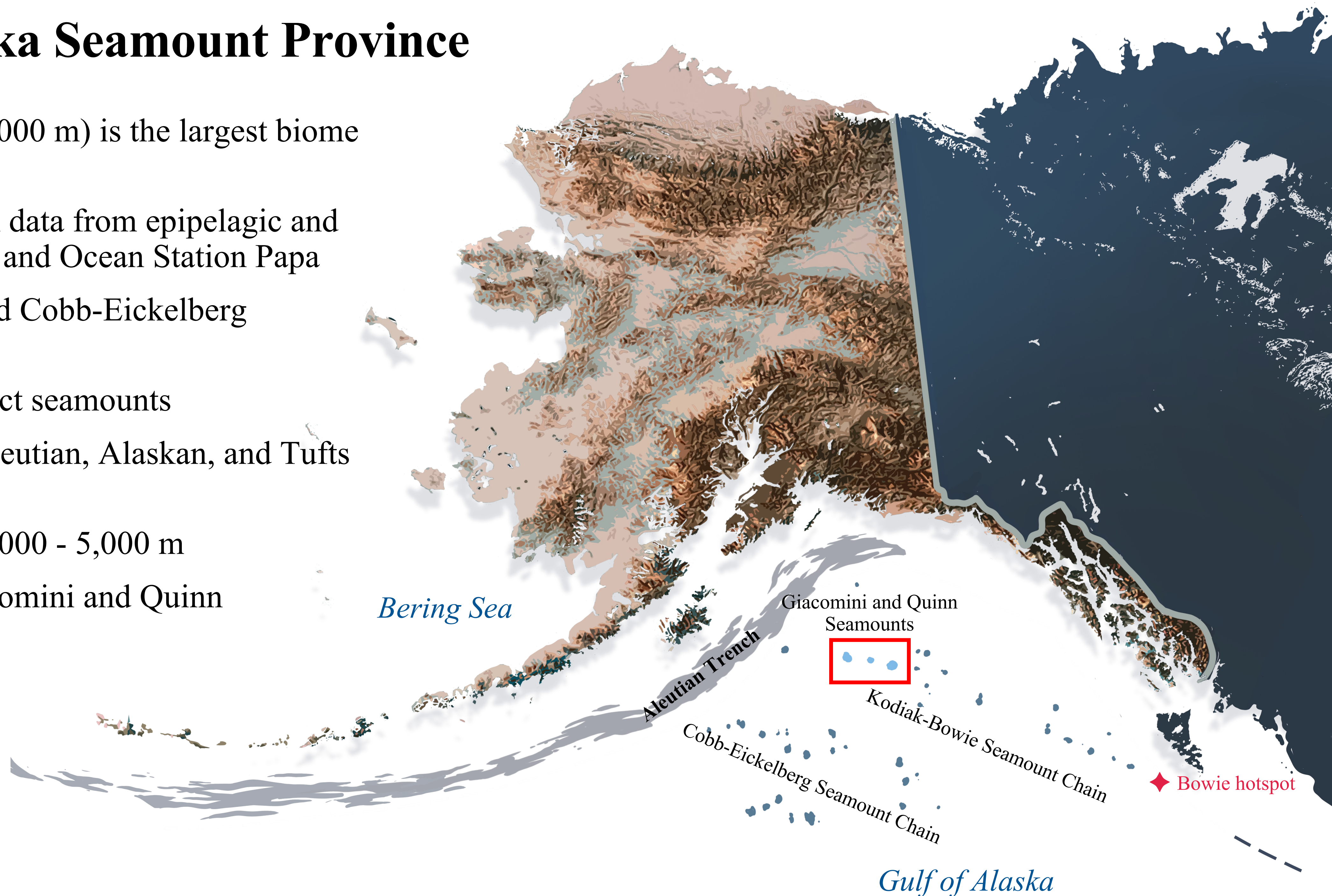
Molecular characterization of the dee-sea zooplankton community from the Gulf of Alaska Seamount Province

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Gulf of Alaska Seamount Province

- The deep sea ($>1,000$ m) is the largest biome yet least studied
- Most zooplankton data from epipelagic and nearshore regions and Ocean Station Papa
- Kodiak-Bowie and Cobb-Eickelberg Seamount Chain
 - Over 100 distinct seamounts
- Lies within the Aleutian, Alaskan, and Tufts abyssal plains
 - Depth range: 4,000 - 5,000 m
- Targeted the Giacomini and Quinn Seamounts



NOAA OER Gulf of Alaska Seamounts Expedition (2019)



Pelagic dives to 3,000 m

ROV Global Explorer

- Rotary carousel suction skid
- Detritus samplers
- UHD 4K & 3D camera systems



Depth-stratified samples to 4,500 m

MOCNESS (505 μm ; left)

- 9-net system
- Net samples split for morphological and molecular analyses

Tandem MultiNet (150 μm ; right)

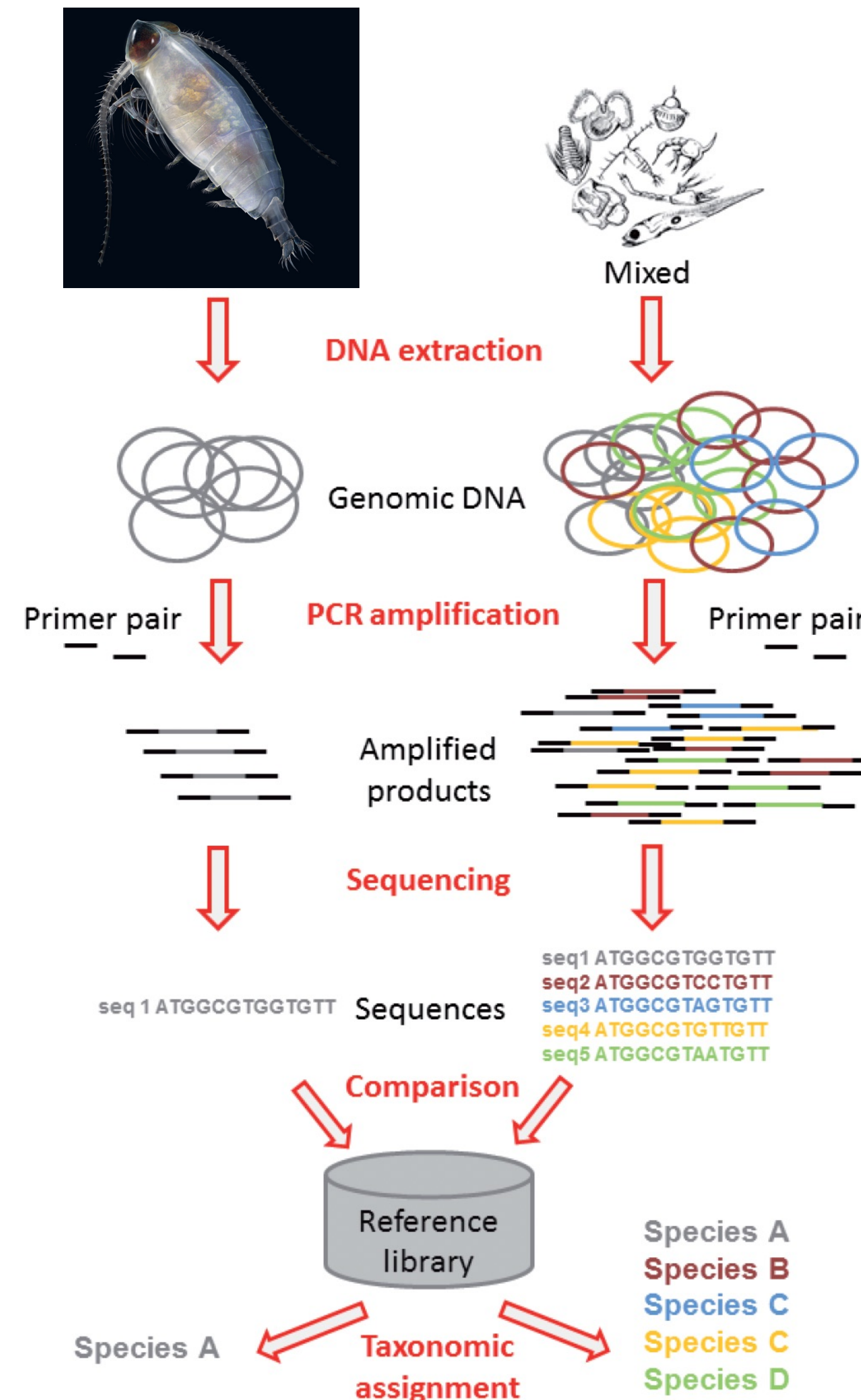
- 5-net system
- back-to-back casts
- Discrete samples for morphological and molecular analyses

Molecular Analyses of Zooplankton Communities

DNA barcoding

- DNA Barcoding is a standardized approach to identification of organisms by fragments of DNA, called DNA barcodes
- Sanger sequencing technology
- Full length COI, 16S, 18S, and 28S
- DNA barcoding on organisms from all sampled stations and depths

Cephalophanes frigidus



Metabarcoding

- Taxonomic identification of organisms from complex environmental samples based on high-throughput sequencing (HTS) using DNA barcodes
- COI (~313 bp fragment)
- V4 18S rRNA (~450 bp fragment)
- Metabarcoding results from MOCNESS and MultiNet samples from GAK13.5 & GAK19

DNA barcoding of Gulf of Alaska Zooplankton

>2,000 formalin and ethanol vouchered organisms

- Each ethanol voucher has a matching formalin voucher
- At sea identifications to best taxonomic resolution
- Photographed many organisms
- Finer-scale taxonomic identifications post-cruise

DNA barcoding performed at Smithsonian NMNH

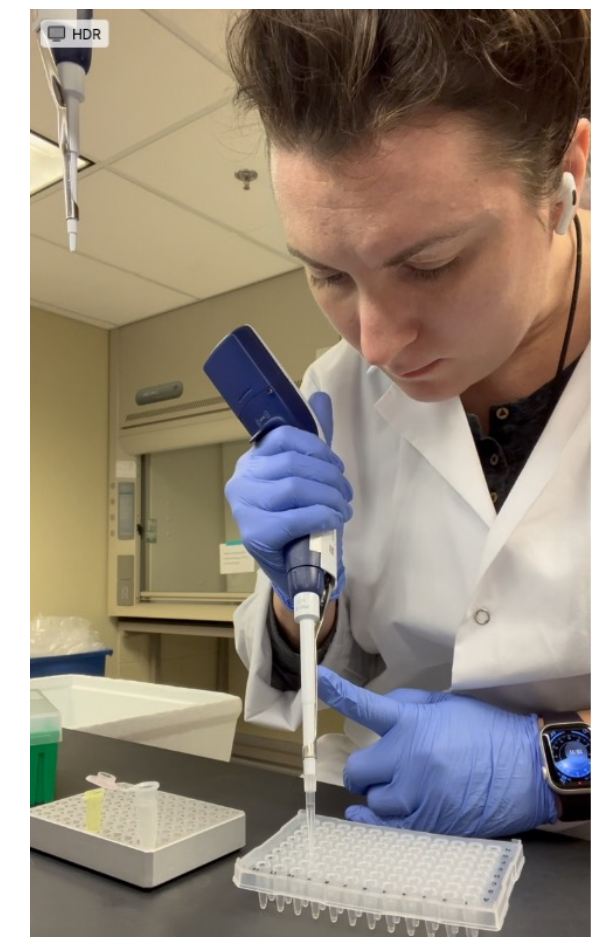
- Cnidarians and Ctenophores (2019)
 - COI, 16S, 18S, and 28S
- Arthropods and other taxa (2022)
 - COI and 18S



C. Smoot, D. Lindsay, and R. Hopcroft

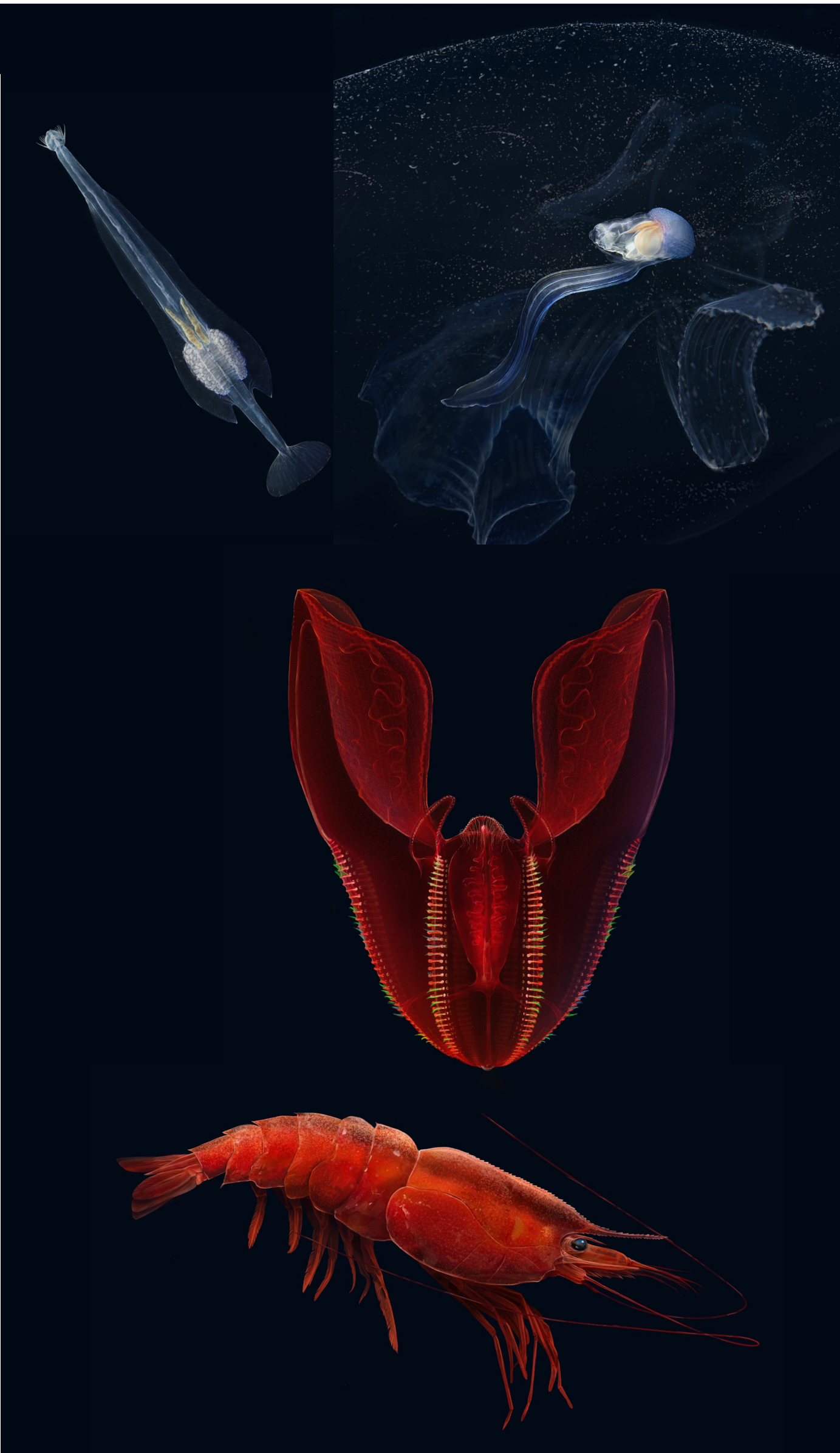
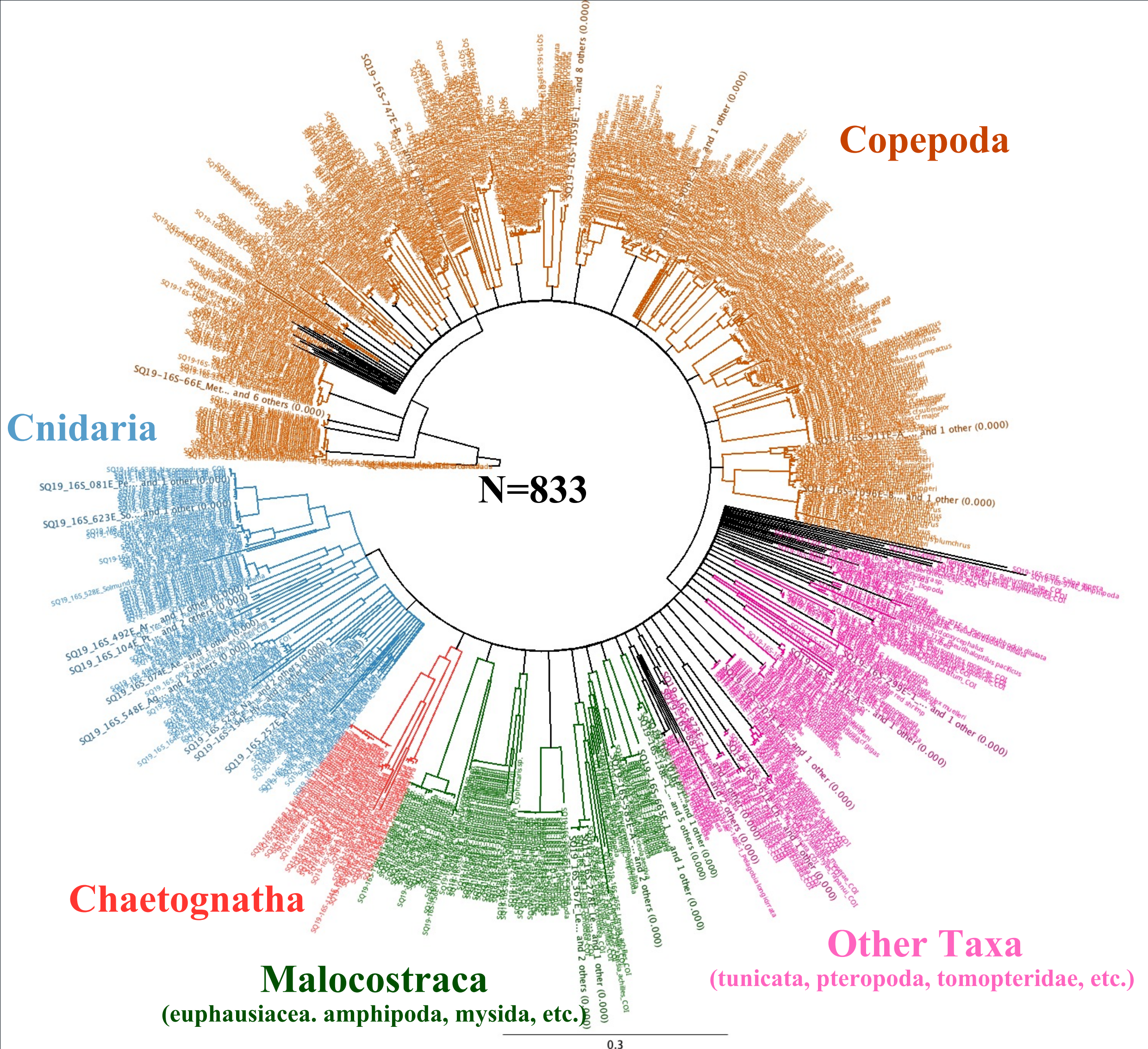


AutoGenprep 965 at Smithsonian



DNA barcoding of Gulf of Alaska Zooplankton

Neighbor-Joining tree for COI barcodes



DNA barcoding of Gulf of Alaska Zooplankton

With the material identified, we have so far...

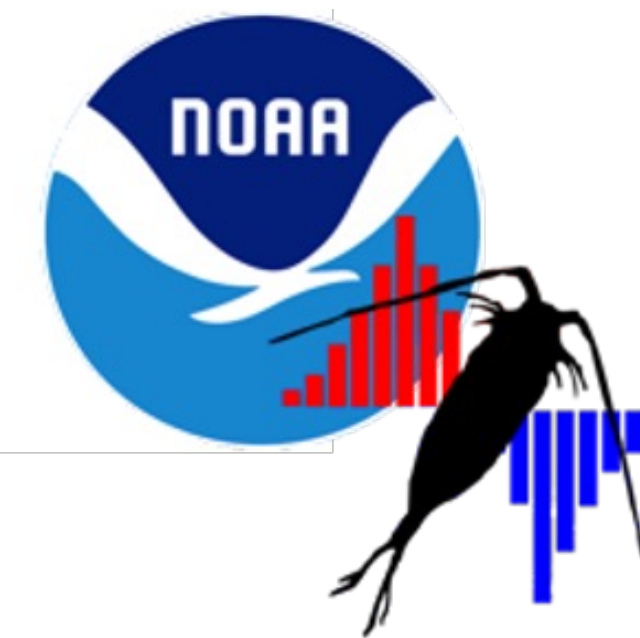
- Generated **>3,500** sequences for 18S and COI for NE Pacific zooplankton
 - **387** new species' barcodes between 18S and COI markers alone
- Recorded multiple **new observations** for species in the NE Pacific (Gulf of Alaska & Ocean Station Papa)
 - (e.g., *Mormonilla phasm*, *Batheuchaeta lamellata*, *Gaetanus paracurvicornis*, *Heterostylites submajor*, *Talacalanus* aff. *greenii*)
- Collected specimens believed to be **undescribed species** (e.g., cnidarians, ctenophores, larvaceans)
- Obtained copepod species **without taxonomic descriptions** for male specimens
 - (e.g., *Bathycalanus* spp.)



SCOR WG157

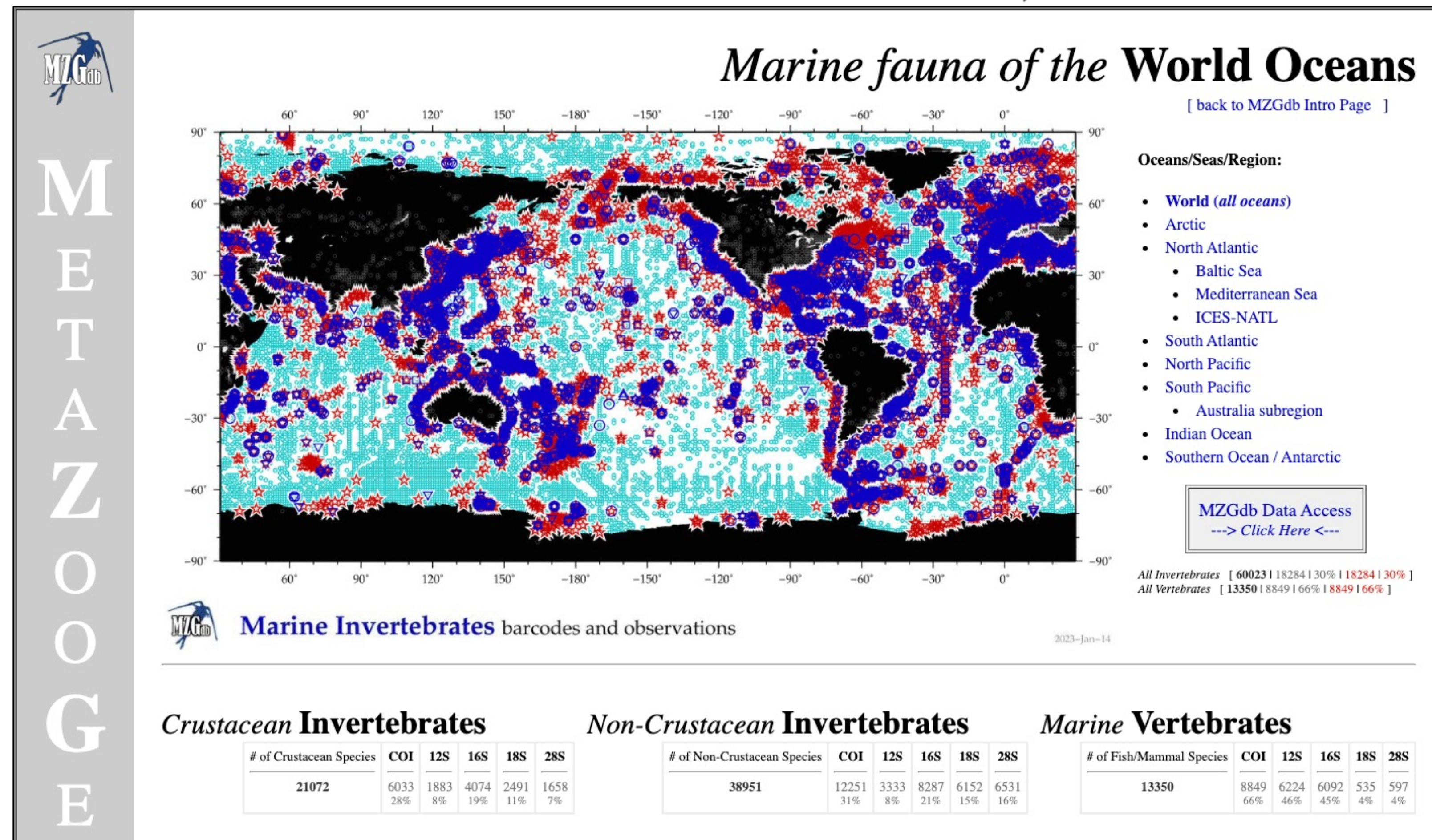
MetaZooGene

Toward a new global view of marine zooplankton biodiversity based on DNA metabarcoding and reference DNA sequence databases.



Todd O'Brien
metazoogene.org

- Stringently QA/QC database for marine metazoans
- Represents 73,373 observed species for 5 genetic markers
 - COI
 - 12S
 - 16S
 - 18S
 - 28S
- Geographic specific databases
- Downloadable files for bioinformatic pipelines



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<https://doi.org/10.1007/s00227-021-03887-y>

REVIEW, CONCEPT, AND SYNTHESIS



Toward a global reference database of COI barcodes for marine zooplankton

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Status of DNA Barcoding – North Pacific

	# of species	COI	12S	16S	18S	28S
All invertebrates	14,604	2,240 (41%)	791 (14%)	1,405 (26%)	880 (16%)	687 (12%)

Marine fauna of the North Pacific

[\[back to MZGdb Intro Page \]](#)

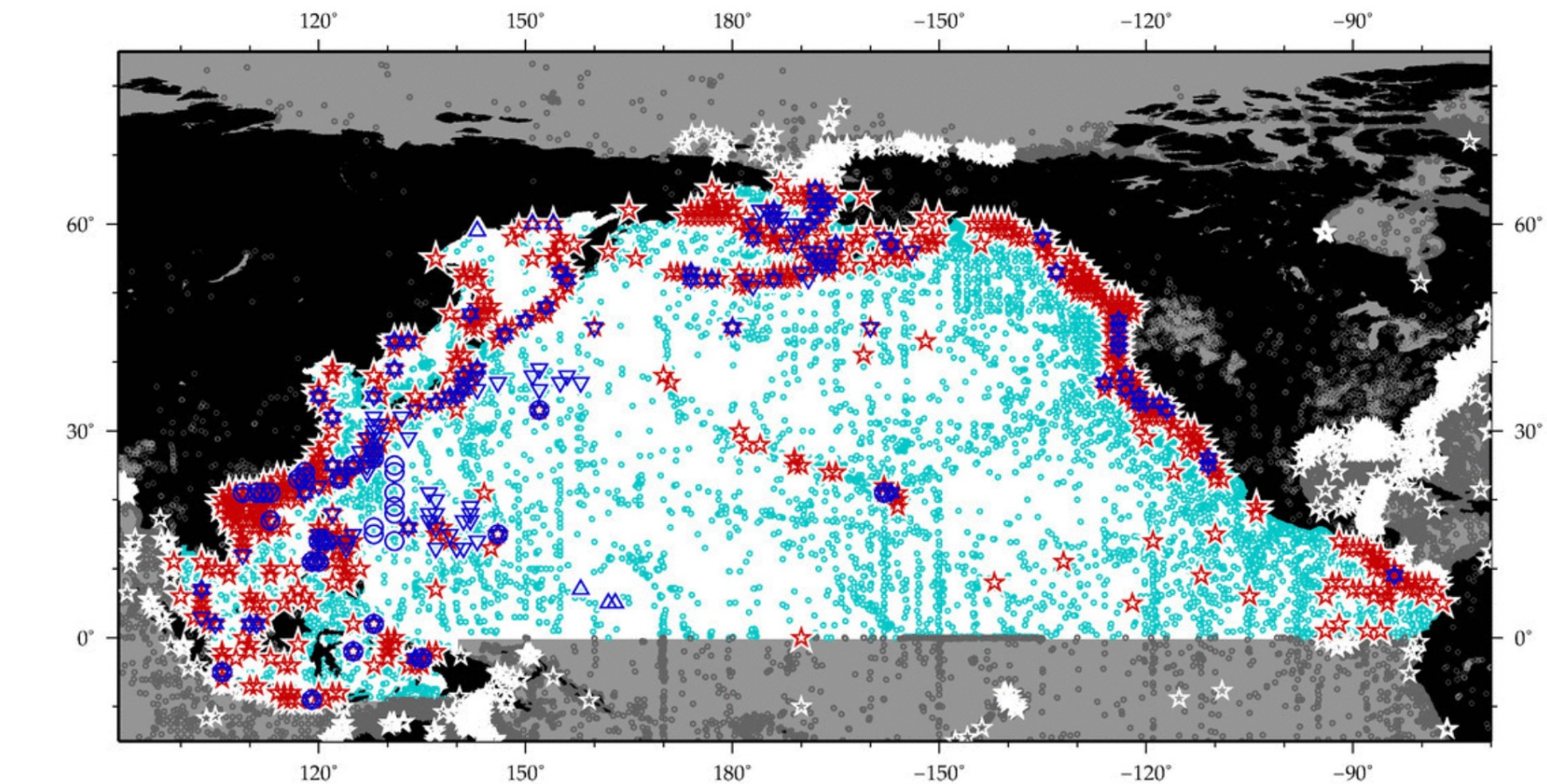
Oceans/Seas/Region:

- World (all oceans)
- Arctic
- North Atlantic
 - Baltic Sea
 - Mediterranean Sea
 - ICES-NATL
- South Atlantic
- North Pacific
- South Pacific
 - Australia subregion
- Indian Ocean
- Southern Ocean / Antarctic

[MZGdb Data Access](#)

[--> Click Here <--](#)

All Invertebrates [14604 | 6403 | 43% | 2757 | 18%]
All Vertebrates [5818 | 4187 | 71% | 2936 | 50%]



Marine Vertebrates barcodes and observations in the North Pacific

2023-Jan-14

Crustacean Invertebrates

# of Crustacean Species	COI	12S	16S	18S	28S
5371	2240 41%	791 14%	1405 26%	880 16%	687 12%

Non-Crustacean Invertebrates

# of Non-Crustacean Species	COI	12S	16S	18S	28S
9233	4163 45%	1306 14%	2762 29%	1788 19%	1781 19%

Marine Vertebrates

# of Fish/Mammal Species	COI	12S	16S	18S	28S
5818	4187 71%	3502 60%	3118 53%	265 4%	340 5%

Group	# of species	COI	12S	16S	18S	28S
Amphipoda	808	29%	1%	6%	13%	10%
Copepoda	908	40%	7%	14%	29%	25%
Decapoda	2,395	53%	26%	44%	14%	12%
Euphausiacea	50	84%	0%	62%	44%	18%
Isopoda	403	25%	2%	11%	6%	1%
Mysida	89	19%	2%	6%	15%	6%
Annelida	1,596	40%	3%	20%	24%	14%
Bryozoa	263	29%	3%	10%	10%	4%
Chaetognatha	39	56%	3%	8%	49%	59%
Tunicata	291	38%	2%	2%	28%	2%
Cnidaria	2,679	24%	7%	20%	16%	14%
Ctenophora	20	70%	10%	10%	65%	10%
Echinodermata	1,740	34%	9%	19%	11%	10%
Mollusca	3627	53%	24%	40%	16%	24%
Nematoda	52	0%	0%	0%	0%	0%
Nemertea	88	77%	6%	63%	34%	56%
And more...						



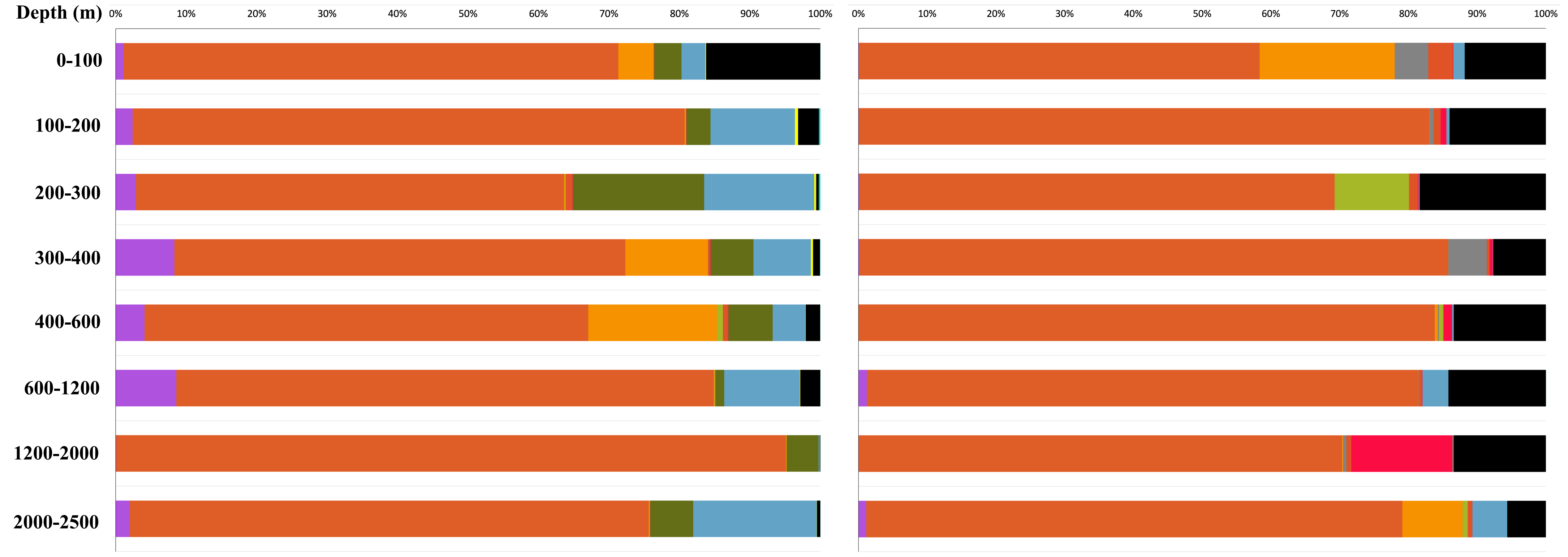
M
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Community composition by depth

GAK13.5 MOCNESS & MultiNet – Sequence Nos.

18S

COI



Annelida
Tunicata

Copepoda
Cnidaria

Decapoda
Ctenophora

Amphipoda
Echinodermata

Mysida
Gastropoda

Ostracoda
Nemertea

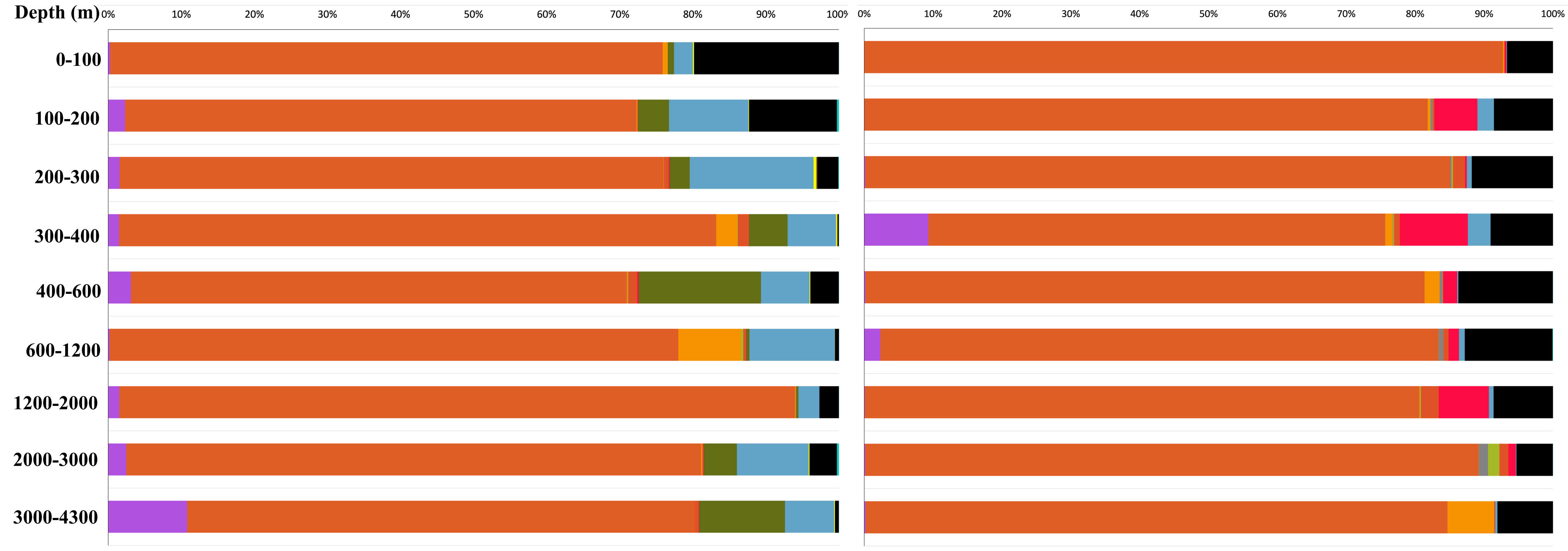
Chaetognatha

Community composition by depth

GAK19 MOCNESS & MultiNet – Sequence Nos.

18S

COI



Next Steps

- Funding from NOAA OER for 2024 expedition and remaining 2019 sample analysis
- Perform integrated analysis with morphological and metabarcode data
- Ostracod identification with Martin Angel and colleagues
- Species-level analyses with COI for cryptic speciation, morphotypes, and newly described species
- Genome Skimming for barcode genes
- Keep on barcoding...
 - UN 2021 Ocean Decade Action No. 102.2
 - MetaZooGene: Metabarcoding Zooplankton Diversity



2021
2030

United Nations Decade
of Ocean Science
for Sustainable Development



Thank you for your attention

Funding:



**Ocean Exploration
and Research**

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- Smithsonian NMNH L.A.B
- UAF Genetics CORE lab

