

TECHNICAL SUMMARY

STUDY TITLE: Continued Archiving of Outer Continental Shelf (OCS) Invertebrates by the Smithsonian Institution National Museum of Natural History

REPORT TITLE: 2020 Implementation Summary and Status Update for Continued Archiving of Outer Continental Shelf (OCS) Invertebrates by the Smithsonian Institution National Museum of Natural History

OCS STUDY NUMBER: BOEM 2020-061

NUMBER OF PAGES: 03

CONTRACT NUMBER: M14PC00003

SPONSORING OCS REGION: National

APPLICABLE PLANNING AREAS: Alaska, Pacific, Gulf of Mexico, Atlantic

FISCAL YEARS OF PROJECT FUNDING: FY 2017-2020

COSTS BY FISCAL YEAR: FY 2017: \$160,000; FY 2018: \$160,000; FY 2019: \$160,000; FY 2020: \$0.

CUMULATIVE PROJECT COST: \$480,000

COMPLETION DATE OF REPORT: September 2020

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KEY WORDS: marine, DNA barcoding, museum specimens, tissues, NMNH Biorepository, Global Genome Initiative, Global Genome Biorepository Network

BRIEF ABSTRACT: In collaboration with BOEM programs and regional marine partners, and in accordance with the standards set forth by the Global Genome Biodiversity Network, the National Museum of Natural History (NMNH) increased taxonomic coverage of genomic resources and reference DNA barcodes for marine invertebrate species from federal waters previously unrepresented in publicly available sequence databases and repositories. Representation of marine invertebrates in cryogenic and tissue collections, as well as voucher-based DNA barcodes for missing families and genera of marine invertebrates from US waters, was increased substantially across most invertebrate phyla over the course of the funding period. Twenty percent (N=361) of the missing families were added to public repositories and

comparative reference databases, improving taxonomic coverage from 12% to 31% for all known marine groups. These new additions included 558 previously unsampled genera. These collections and comparative DNA sequence data significantly improve the ability to identify marine species from environmental samples and enhance ongoing efforts to employ sequence-based approaches to characterize marine diversity of the OCS.

BACKGROUND: For over thirty-five years, the National Museum of Natural History (NMNH), Department of Invertebrate Zoology has worked with the Bureau of Ocean Energy Management – Environmental Studies Program (BOEM-ESP) to archive marine invertebrates from the Outer Continental Shelf. These specimens represent one of the most extensive collections of marine organisms from U.S. waters and provide an invaluable national resource to support baseline assessments as well as taxonomic, evolutionary and ecological research. Recognizing that new genomic approaches greatly enhance our ability to document and monitor biodiversity, the NMNH-BOEM partnership was expanded to augment the vouchering program with genomic-grade tissues and to generate a voucher-based comparative DNA barcode reference library for species not represented in publicly available repositories.

OBJECTIVES: The goal of this project was to continue the documentation of marine invertebrate diversity in US federal waters across BOEM's four OCS regions (Alaska, Pacific, Gulf of Mexico and Atlantic), to expand the vouchering program to include genomic-grade tissues and DNA extractions, and to generate reference DNA barcodes for species unrepresented in public repositories and databases.

METHODS: NMNH conducted a gap analysis of marine invertebrate species found in US federal waters under BOEM's purview based on three criteria as established by the Smithsonian's Global Genome Initiative: (1) the presence of a physical morphological voucher in the museum's collections that can be used for taxonomic comparison, (2) the existence of a DNA barcode GenBank record from that individual for comparative purposes, and, (3) the presence of a high-quality tissue sample in NMNH's Biorepository that is available for future studies. This analysis created a state-of-knowledge document for marine families and genera within all major marine invertebrate phyla. Informed by this gap analysis, a sampling strategy was developed that combined an assessment of existing legacy NMNH-BOEM collections with a proactive outreach plan soliciting specimens and tissues from existing BOEM programs and other national partners with the goal of filling these curation and knowledge gaps.

RESULTS: 23 regional partners/programs contributed 13,127 specimens from over 1819 collecting events from all four BOEM OCS regions. These specimens created 17,985 genomic grade samples, either tissues and/or DNA extractions, and yielded 6278 DNA sequence barcode records. The number of fully curated marine invertebrate families increased from 12% to 31%, covering 20% (N=361) of missing lineages in publicly available repositories (USNM voucher collections, GenBank sequence records, and GGBN tissue records). Highlights include new records for more than half of the missing annelid families (worms), nearly 30% of the missing echinoderm families, and more than 20% of the missing arthropod, molluscan, cnidarian and bryozoan families. The number of fully curated marine invertebrate genera increased from 4% to 13% by adding 558 genera to all 3 curatorial categories, covering 10% of all US marine invertebrate groups. These advances have occurred both by genomically upgrading genera that existed in collections (N=194) as well as by sourcing new lineages (N=364) from ongoing field collection efforts. Highlights include the addition of 14% of all missing annelid genera, 12% of missing cnidarian genera and nearly 10% of missing genera of arthropods, echinoderms, bryozoans and other minor phyla. Overwhelmingly, freshly collected specimens from ongoing

expeditionary work produced higher quality tissues and more DNA barcode sequences than historical collections, emphasizing the importance of engaging field partners early in the specimen collection process. The benefit of enhanced DNA reference libraries was demonstrated in a before and after comparison conducted at the Oregon Institute of Marine Biology. The capacity to identify DNA sequences derived from Autonomous Reef Monitoring Structures improved by 33% after conducting a local BioBlitz to inventory the regional marine invertebrate biota.

CONCLUSIONS: The curatorial workflows as part of the BOEM-NMNH partnership to archive invertebrate diversity of the OCS have been expanded to include not only specimen vouchering for morphological studies, but also the preservation of genomic-grade materials to enhance sequence-based approaches to documenting and monitoring marine ecosystems. In less than two years, this partnership has preserved and characterized 20% of the marine invertebrate lineages found in federal waters previously unrepresented in publicly available databases. Marine invertebrate surveys have been used for decades to monitor ocean health. The improvement of taxonomic coverage in genomic resources for US regional marine waters will enhance marine monitoring through less invasive and less destructive sequence-based surveys, that include eDNA and similar environmental sampling protocols. The capacity to better understand ecosystem function, trophic connections and monitor change will greatly benefit from these improved DNA sequence libraries and genomic resources.

STUDY PRODUCT(S):

1. NMNH, Invertebrate Zoology. 2018. Sample strategy plan; outer continental shelf (OCS) genomic sample strategy to the Bureau of Ocean Energy Management (BOEM) for archiving of OCS invertebrates. Sterling (VA): US Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2019-003. 10 p.
2. BOEM study report: 2020 Status Update for Genomic Sampling, Archiving and Characterization of outer continental shelf (OCS) Marine Invertebrates.
3. GEOME Smithsonian-BOEM Project: <https://geome-db.org/workbench/project-overview?projectId=44>
4. Gillett, D., Weisberg, S., O'Mahoney, M., Meyer, C. 2019. Choose your weapon: comparing the identification of benthic infauna via eDNA, single-specimen barcodes, and morphology. 2019 CERF Biennial Conference.
5. Lundin M., Bipat D., Emler R., Galloway A., Granquist M., Hodder J., Maslakova S., Morgan M., O'Mahoney M., Pecnik S., Uehling A., Watts, M., Yoshioka R., Paulay G. and Meyer, C. 2020. The Importance of a BioBlitz to inform ecological studies. 2020 Ecological Society of America meeting, poster.