CENTER FOR BIOLOGICAL RESEARCH COLLECTIONS
ANNUAL REPORT

April 1, 2021 – April 15, 2022

Center for Biological Research Collections – CBRC - includes two natural history collections:

- The IU Paleontology Collections (IUPC), housed within the Department of Earth and Atmospheric Sciences, holds > 1.5 million fossil specimens, including more than 1,000 unique type specimens, representing more than 400 million years of Earth's history. The IUPC holdings are global in their geographic scope but most are representative of the Paleozoic of North America, with many specimens from the State of Indiana.
- The William R. Adams Zooarchaeology Laboratory (WRAZL) is housed in the Department of Anthropology and includes over 10,000 modern comparative faunal remains inclusive of mammals, reptiles, amphibians and fish, and archaeological research projects from the North American Plains.

The IU Paleontology Collection and William R. Adams Zooarchaeology Lab are formal research repositories for natural history specimens. These specimens form the basis for research in paleontology, zooarchaeology, functional morphology, ecology and paleoecology, evolutionary biology, and related disciplines. The specimens are the primary sources of data on the structure and composition of organisms of the present and past, and they serve as tangible evidence that those organisms lived in particular places and times. Like archival research libraries, the materials in these collections are used by researchers at IU and around the world. CBRC and the faculty and staff associated with the two collections thus carry out independent research on the collections, but also maintain the integrity and accessibility of the collections for the research community. This arrangement works in kind; faculty and staff at other universities and museums provide IU researchers with equivalent access to collections around the world.
CBRC is a pooled resource to support these collections and the faculty who are responsible for them. CBRC serves as a vehicle for collaborative grants to enhance the collections and to support research; it maintains digital infrastructure such as collection management databases and digitization facilities; it provides training to faculty, graduate students, and undergraduates in collection-based research methods and in collection care; and it facilitates access and use by researchers by providing support in locating specimens, processing loans, and linking specimens with associated data.

Director,
Claudia C. Johnson, Department of Earth and Atmospheric Sciences

Executive Committee Members
P. David Polly, Department of Earth and Atmospheric Sciences

Collections Manager, Paleontology and Zooarchaeology
Jess Miller-Camp, Department of Earth and Atmospheric Sciences

Affiliate Members
Gary Motz, Information Technology Manager, University Collections

Governance
The Center is run by a Director and an Executive Committee consisting of faculty and research scientists who oversee IU's paleo- and biological and collections.

Operating Budget

The CBRC is funded by the College of Arts and Sciences, the Department of Anthropology, and the Department of Geological Sciences.

The operating budget of 2021-2022 was allocated for staff, graduate and undergraduate student salaries, equipment repair, contractual services for equipment maintenance, consortium dues, institutional membership dues, and warranties for technical equipment for digitization of specimens.

CBRC's Mission

The Center for Biological Research Collections (CBRC) is a consortium of research-based scientific collections at Indiana University.

The mission of the CBRC is to enhance collection-based research and education in biodiversity, zooarchaeology, paleontology, and related disciplines by providing shared infrastructural and data management support of IU's natural history collections.

The Center focuses on collections of biological specimens, including fossils and archaeological remains, that have shared taxonomic, geographic, and temporal metadata requirements. The Center coordinates policy, develops digital infrastructure, provides shared resources, facilitates educational outreach, and serves as a collaborative research platform for IU's biological and paleontological specimen collections.

CBRC develops external funding streams for upkeep and development of collection infrastructure, and it helps support data management and digitization for research grants that use IU's collections. CBRC's research collections are the focus of National Science Foundation and the Institute of Museum and Library Services awards.

The Center interfaces with partners to develop the specific digital infrastructure needed for biological collections. The Center collaborates with other collections to develop shared infrastructure and best practices. CBRC's partners include Heather Calloway and the University Collections office of Vice President for Research, the IU Digital Library Project, the IU University Information Technology Services (UITS), the Indiana Geological & Water Survey, now the IUMAA but formerly the Glenn Black Laboratory of Archaeology and the Mathers Museum of World Cultures, the IU Advanced Visualization Laboratory, the Data to Insight Center of the IU Pervasive Technology Institute, and the IU School of Education.

CBRC is not a degree-granting program or department

Accomplishments in Student Research Training

CBRC enhances the teaching and research mission of Indiana University by training undergraduate students in laboratory work for the digitization of zooarchaeology and fossil specimens and their associated metadata, and graduate students in enhanced specimen research and in advising undergraduates on specimen-related, technological research, managerial and curatorial procedures. ***We continue to train students in underrepresented groups in STEM, thereby contributing to diversity, equity and inclusion goals of Indiana University.***

CBRC OUTPUTS (2021–2022 and grants, presentations, etc. not included in previous years' reports)

External Grants

Completed:

- *National Science Foundation Research Grant* 2019-2021. Title: Marine Sky Brightening: Prospects and Consequences. Kravitz, B, Johnson, C. C., Kieu, C., $299,994
- *Sigma Xi Grants in Aid of Research*, 2020, Burtt, A., $975
- *Indiana Academy of Science Senior Research Grant*, 2020, Burtt, A., $1,250
- *Geological Society of America Graduate Student Research Grant*, 2020-2021, Enigmatic evolution of lumbar vertebrae and diversification of locomotion in mammals, Kort, A. E.
- *Society for Sedimentary Geology Student Research Grant*, 2022, Anderson, S.B.
- *Nancy Wilke Fellowship for Archaeological Field School Experience*, Carleton College, 2020, Anderson, S.B.

In Progress:

- Dovetail Genomics "Tree of Life" award. 2020-2022. Sequencing the genome of *Poecilozonites bermudensis*, the Bermudian land snail. A.C. Stone (PI), P.D. Polly (co-PI), S. Winingear, M. Outerbridge, $35,000.
- *NSFGEO-NERC*: Vertebrate functional traits as indicators of ecosystem function through deep and shallow time. Pineda-Munoz, Senior Personnel.
- *Tilly Edinger Travel Grant*, Travel Scavengers, 2021, Nelson, A.E.

In Review:

- *National Oceanic and Atmospheric Administration, Ocean Acidification Program*. Title: Ocean Protector: A game-based curriculum to teach the impacts of ocean acidification and positive actions to help. Zimmerman, A.N., and Johnson, C.C., $40,000; 9/1/2022 – 8/31/2023
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Not funded:

- *NSF EAR Sedimentary Geology & Paleobiology program*. Declined. "Collaborative Research: Swimming against the stream: evaluating hydrodynamic trade-offs in the post-Tr-J diversification of ammonites". Polly, P. D. (IU PI), K. Ritterbush (Utah PI) ($722,156 to IU, $175,185 to Utah).

Internal Grants

In Progress:

- *McCormick Science Grant*, 2022, Kort, A. E., College of Arts and Sciences, IUB
- *Glenn A. Black Laboratory Academic Year Fellowship*, 2020-2021, Burtt, A., $7,500
- *Grant-in-Aid. Department of Earth and Atmospheric Sciences*, IUB, 2020 and 2022, Kort, A. E., Enigmatic evolution of lumbar vertebrae and diversification of locomotion in mammals.
- *Museum of Archaeology and Anthropology Dissertation Research Fellowship*, IUB, 2021, Burtt, A., $3,500
- Indiana University Department of Anthropology Skomp Feasibility Fellowship, IUB, 2022, Hawley, Kirsten M.

In Review:

- Indiana University Center for Latin American and Caribbean Studies Tinker Field Research Grant, Summer 2022, Hawley, Kirsten M.

Not funded:

- Please see Appendix I.

Publications

Published:

Bethke, Brandi and Amanda A. Burtt (eds.) (2020) *Dogs: Archaeology Beyond Domestication*. University Press of Florida, Gainesville.

Burtt, Amanda A. and Larisa R.G. DeSantis (2022) Exploring durophagy among modern gray wolves from the Greater Yellowstone Ecosystem with dental microwear texture analysis. *Journal of Zoology*, 1-12, https://doi.org/10.1111/jzo.12957

Burtt, Amanda A. and Larisa R.G. DeSantis (2020) Using dental microwear texture analysis to understand the dietary behavior of domestic dogs in pre-contact North America. In Bethke, Brandi and Amanda A Burtt (eds.) *Dogs: Archaeology Beyond Domestication*. University Press of Florida, Gainesville.

Cardini, A., S. Elton, K.F. Kovarovic, U.S. Viðarsdóttir, and P.D. Polly. 2021. Impact of sampling error on the assessment of morphospecies using geometric morphometrics in primates and other mammals. Evolutionary Biology, 48: 190-220 (10.1007/s11692-021-09531-3).

Chandroth, A., & Chattopadhyay, D. (2022). Micromorphy Offers Effective Defense Against Predation: Insights from Cost-Benefit Analyses of the Miocene Microgastropod Predation Record from Kerala, India. *Museum of Paleontology, The University of Michigan*, *34*, 63–81.

Christison B.E., F. Gaidies, S. Pineda-Munoz, A. R. Evans & D. Fraser (2022). Creodonts and carnivorans of the late Eocene (Chadronian) Cypress Hills Formation occupied different dietary niches. *Journal of Mammalogy, 103(1)*.

Franco-Moreno, R. A., P. D. Polly, V. Toro-Ibacache, G. Hernández-Carmona, R. Aguilar-Medrano, E. Marín-Enríquez, and V. H. Cruz-Escalano. 2021. Bite force in four pinniped species from the west coast of Baja California, Mexico, in relation to diet, feeding strategy, and niche differentiation. Journal of Mammalian Evolution, 28: 307-321 (10.1007/s10914-020-09524-7).

Fraser, D., A. Villaseñor, Tóth, A., M. Balk, J.T. Eronen, W. A. Barr, A.K. Behrensmeyer, M. Davis, A. Du, J.T. Faith, N.J. Gotelli, G.R. Graves, A.M. Jukar, C.V. Looy, B.J. McGill, J.H. Miller, **S. Pineda-Munoz**, R. Potts, A.B. Shupinski, L.C. Soul, and S.K. Lyons. Profound Holocene biotic homogenization of North American mammalian faunas. *Nature Communications. Accepted, NCOMMS-21-20323*.

Fraser, D., Soul, L. C., Tóth, A. B., Balk, M. A., Eronen, J. T., Pineda-Munoz, S., Shupinski, A. B., Villaseñor, A., Barr, W. A., Behrensmeyer, A. K., Du, A., Faith, J. T., Gotelli, N. J., Graves, G. R., Jukar, A. M., Looy, C. V., Miller, J. H., Potts, R., & Lyons, S. K. (2021). Investigating Biotic Interactions in Deep Time. Trends in Ecology & Evolution, 36(1), 61-75.

Gallagher, R. V., D. S. Falster, B. S. Maitner, R.Salguero-Gómez, V. Vandvik, W. D. Pearse, F. D. Schneider, J. Kattge, J. Alroy, M. J. Ankenbrand, S. C. Andrew, M. Balk, L. M. Bland, B. L. Boyle, C. H. Bravo-Avila, I. Brennan, A. J. R. Carthey, R. Catullo, B. R. Cavazos, S. Chown, B. Fadrique, X. Feng, H. Gibb, A. H. Halbritter, J. Hammock, J. A. Hogan, H. Holewa, M. Hope, C. M. Iversen, M. Jochum, M. Kearney, A. Keller, P. Mabee, J. S. Madin, P. Manning, L. McCormack, S. T. Michaletz, D. S. Park, C. Penone, T. M. Perez, S. Pineda-Munoz, , J. Poelen, C. A. Ray, M. Rossetto, H. Sauquet, B. Sparrow, M. J. Spasojevic, R. J. Telford, J. A. Tobias, , C. Violle, R. Walls, K. C., B. Weiss, M. Westoby, I. J. Wright & B. J. Enquist (2020). Open Science principles for accelerating trait-based science across the Tree of Life. *Nature Ecology and Evolution*, 4(3), 294-303.

Hoffman, D., J. Miller-Camp, and A. Heckert, 2021, Tooth enamel microstructure in Phytosauria (Diapsida:Archosauriformes): implications for biogeography and ecology of a Late Triassic clade of crocodylian-like predators, Paleontologica Electronica 24(3):a32 doi:10.26879/1162.

Kort, A. E., H. Ahrens, P. D. Polly, and M. Morlo. 2022. Postcrania and paleobiology of *Patriofelis ulta* (Mammalia, Oxyaenodonta) of the Bridgerian (Early-Middle Eocene) of North America. *Journal of Vertebrate Paleontology*. (in press) https://doi.org/10.1080/02724634.2021.2045491

Kort, A. E., and N. Famoso. 2020. Novel analysis of locality data can inform better inventory and monitoring practices for paleontological resources at John Day Fossil Beds National Monument, Oregon, USA. *Palaeontologia Electronica*. 23(1): a17. https://doi.org/10.26879/1053

Monfils, Anna K., Erica R Krimmel, John M Bates, Jennifer E Bauer, Michael W Belitz, Blake C Cahill, Alyssa M Caywood, Neil S Cobb, Julia B Colby, Shari A Ellis, Dianna M Krejsa, Todd D Levine, Travis D Marsico, Teresa J Mayfield-Meyer, **Jess A Miller-Camp**, Roy M (Gil) Nelson, Molly A Phillips, Marcia A Revelez, Dawn R Roberts, Randal A Singer, Jennifer M Zaspel, 2020, Regional Collections Are an Essential Component of Biodiversity Research Infrastructure, *BioScience*, 70:12 p. 1045–1047, https://doi.org/10.1093/biosci/biaa102

Novack-Gottshal, P.M., Sultan, A., Smith, N.S., Purcell, J., Hanson, K.E., Lively, R., Ranjha, I., Collins, C., Parker R., Sumrall, C.D. and Deline, B., 2022. Morphological volatility precedes ecological innovation in early echinoderms. Nature Ecology & Evolution. *https://doi.org/10.1038/s41559-021-01656-0*

n.b. This is a publication that resulted from an IUB Institute for Advanced Study Summer Repository Fellowship to the first author for use of our IU Paleontology Collections specimens analyzed in this research.

Pearson, A., P. D. Polly, and E. Bruner. 2021. Temporal lobe evolution in Javanese Homo erectus and African Homo ergaster: inferences from the cranial base. Quaternary International, 603: 5-21 (10.1016/j.quaint.2020.07.048).

Pineda-Munoz, S., Wang, Y., Lyons, S. K., Tóth, A. B., & McGuire, J. L. (2021). Mammal species occupy different climates following the expansion of human impacts. Proceedings of the National Academy of Sciences, 118(2).

Pineda-Munoz, S., Jukar, A. M., Tóth, A. B., Fraser, D., Du, A., Barr, W. A., Amatangelo, K. L., Balk, M. A., Behrensmeyer, A. K., Blois, J., Davis, M., Eronen, J. T., Gotelli, N. J., Looy, C., Miller, J. H., Shupinski, A. B., Soul, L. C., Villaseñor, A., Wing, S., & Lyons, S. K. (2021). Body mass-related changes in mammal community assembly patterns during the late Quaternary of North America. Ecography, 44(1), 56-66.

Rhoda, D., P. D. Polly, and M. Segall. 2021. Morphological integration and modularity in the hyperkinetic feeding system of aquatic-foraging snakes. Evolution, 75: 56-72 (10.1111/evo.14130).

Singh, D., S. Reed, A. Kimmitt, K. Alford, C. Stricker, P.D. Polly, and E. Ketterson, 2021. Breeding at higher latitude is associated with higher photoperiod threshold and delayed reproductive development in a songbird. Hormones and Behavior, 128: 104907 (10.1016/j.yhbeh.2020.104907).

Zimmerman, A. N., Johnson, C. C., Bussberg, N. W., and Dalkilic, M. M. (2020). Stability and decline in deep-sea coral biodiversity, Gulf of Mexico and US West Atlantic. *Coral Reefs*, 39:2, p. 345-359.

Accepted:

Kort, A., H. Ahrens, P. D. Polly, and M. Morlo. Accepted. Postcrania and paleobiology of Patriofelis ulta (Mammalia, Oxyaenodonta) of the Bridgerian (Early-Middle Eocene) of North America. Journal of Vertebrate Paleontology.

Mo, J., and P. D. Polly. Accepted. The role of dispersal, selection intensity, and extirpation risk in resilience to climate change: a trait-based modeling approach. Global Ecology and Biogeography.

O'Keefe, R., J. Meachen, and P. D. Polly. Accepted. On information rank deficiency in phenotypic covariance matrices. Systematic Biology.

In Review, In Revision, or Submitted:

Ascari, S. H. and P. D. Polly. In review. Geometric morphometric analysis of the enlarged second claws of deinonychosaurs (Dinosauria, Deinonychosauridae) suggests they were used for pinning prey, not climbing. PLoS One.

Camargo, I., S. T. Àlvarez-Castañeda, P. D. Polly, J. D. Stuhler, J. E. Maldonado. In revision. Molecular phylogenetic and taxonomic status of the large-eared desert shrew Notiosorex evotis (Eulipothyphla: Soricidae), with the designation of a neotype. Journal of Mammalogy (10.1093/jmammal/gyaa178).

Polly, P. D. In review. The politics of public land management: the creation, reduction and restoration of Grand Staircase-Escalante and Bears Ears National Monuments. Geological Curator.

Short, R. A., J. L. McGuire, P. D. Polly, and A. M. Lawing. Submitted. Anthropogenic impact disrupts the functional relationship between traits and environment in large mammals. Proceedings of the National Academy of Sciences, USA.

Zimmerman, A. N., Johnson, C. C., Phillips, G. E., and Ehret, D. J. Submitted. Taxonomy and paleobiogeography of rudist bivalves from upper Cretaceous strata, Gulf Coastal Plain and Puerto Rico, USA. (2022). Submitted to *Journal of Paleontology*.

Book Reviews

Miller-Camp, J, 2020, Recognizing the work of women, Science 370:6517, pp. 668, ed. Valerie Thompson, review of Rebels, Scholars, Explorers: Women in Vertebrate Paleontology by Annalisa Berta and Susan Turner.

Creative Works

Miller-Camp, J.A. and M. Bramnik, 2022 (*accepted, May publication)*, "Dinosaurs and Other Prehistoric Beasts of Kortos and Erran" *in* Wayfinder *#22,* Paizo Publishing, LLC, Seattle, WA, pp. TBD.

A.E. Nelson, Palaeontologia Electronica Poster Contest Runner Up**,** Palaeontologia Electronica, January 2022

Awards

Hawley, Kirsten M.
Cecilia M. Connelly Graduate Scholarship in Underwater Archaeology, 2022, awarded through the Women Diver's Hall of Fame.

Kort, Anne E.
McCormick Science Grant, 2022, College of Arts and Sciences, IUB

Pineda-Munoz, S.
Science Achievement Award, Smithsonian Institution, for article Tóth, et al., 2020. Reorganization of surviving mammal communities after the end-Pleistocene megafaunal extinction. *Science,* 326(5956), 1100-1103.

Dissertations and Theses

Zimmerman, Alex: PhD Defense: The Importance of Biodiversity in Advancing Evolutionary Paleoecology, December 16, 2020

Burtt, Amanda: Ph.D. Defense: The dietary behavior of Indigenous canids: A multimethod approach, April 14, 2022.

Qualifying Exam Presentations

Charles Salcido: Qualifying Exam Presentation: Evolutionary lag and the evolution of carnivory in Cenozoic Mammals, December 14, 2021

Anne Kort: Qualifying Exam Presentation: Evolution of Mammalian Lumbar Vertebrae and Locomotion in the Paleogene, December 2020

Conference Presentations

Burtt, Amanda A. Stable isotope analysis of canid teeth from the Angel site (12Vg1). Presented at the *87th Annual Meeting of the Society of American Archaeology, Chicago, Illinois, April 2022.*

Burtt, Amanda A. Taboo to Chew: Cultural Influences on Dog-feeding. *Invited Participant in, "Zooarchaeology Interest Group Sponsored Symposium: Animal Bones to Human Behavior." Presented at the 86th Annual Meeting of the Society for American Archaeology, Virtual Locations, April 2021.*

Chandroth, A., and Chattopadhyay, D. (2020). Micromorphy offers effective defense against drilling and durophagous predation. Geological Society of America Annual Conference (2020). *Oral presentation.

Edie, R. A., Kort, A. E., and Polly, P. D. 2020. Shape gradient across the lumbar vertebrae reflects locomotor style in mammals. Society of Vertebrate Paleontology Annual Meeting, 2020.

Grossnickle, D., Brightly, W., Law, C., Pevsner, S., Roston, R., Stanchak, K., Weaver, L., Polly, P. D., "Increased potential for convergence in morphological specialists", Virtual Evolution 2021, Society for the Study of Evolution / Society of Systematic Biologists / American Society of Naturalists, online, Academic, International. (June 21, 2021).

Hawley, Kirsten M., Dominic Bush, Therese Westman, and Jack Pink (organizers). Careers in Underwater Archaeology. Panel discussion planned for the 2022 Society for Historical Archaeology Conference (Philadelphia, PA). POSTPONED, will be given online April 2022.

Hawley, Kirsten M. and Aleck Tan (organizers). Digital Media and Public Outreach in Underwater Archaeology. Panel discussion at the 2021 Society for Historical Archaeology Conference (virtual).

Hawley, Kirsten M. (participant), Tan, Aleck and Morgan Smith (organizers). Women and People of Color in Underwater Archaeology. Panel discussion at the 2020 Society for Historical Archaeology Conference (Ft. Worth, MO).

Kort, A. E., Polly, P. D. "XRCT scans reveal unusual characteristics of lumbar vertebrae in extinct mammals", Conference, GSA Connects 2021, Geological Society of America, Portland, OR, United States, Academic, International. (October 10, 2021).

Kort, A. E., Edie, R. A., and Polly, P. D. 2021 XRCT scans reveal unusual characteristics of lumbar vertebrae in extinct mammals. Geological Society of America Annual Meeting, 2021.

Kort, A. E., Hicks, E. K., and Smiley, T. M. 2020. The beginner's guide to 3D data processing: A pipeline for computed tomography (CT) data. Digital Data Conference, 2020

Pearson, A., Polly, P. David, Brunner, E., "Making sense of modern human sulcal pattern variation, brain size and temporal lobe boundaries: implications for fossil Homo", Conference, American Association of Physical Anthropologists Annual Meeting, Baltimore, MD, United States, Academic, International. (April 7, 2021).

Pineda Munoz, S., Chandroth, A., Graduate Fulghum, H., Hawley, K., LaBarge, T., Lopezalles, S., Nelson, A., Salcido, C. J., Polly, P.D., "The Conservation Archives: Bridging conservation research and practice", International Biogeography Society Biennial Conference, Vancouver, Canada, Academic, International. (June 2, 2022).

Pineda Munoz, S., P. D. Polly "Dietary generalism and its implications to paleoecology, dental morphology and wear", 81st Annual Meeting Society of Vertebrate Paleontology Conference, (November 1, 2021).

Pineda-Munoz, S*, A.B. Tóth, S.K. Lyons, Y. Wang, J. McGuire. Humans landscape impacts have shaped North American mammal niches. 2nd Crossing the Palaeontological-Ecological Gap (2021), Berlin, Germany (Virtual oral presentation).

Pineda-Munoz, S*, A.B. Tóth, S.K. Lyons, Y. Wang, J. McGuire. Humans have shaped the climatic distributions of modern North American mammals. 80th Annual Meeting Society of Vertebrate Paleontology (2020), Cincinnati, Ohio (Virtual oral presentation).

Polly, P. D., Royal Tyrrell Museum, "Paleontology and US National Monuments: Implications for Science and Public Lands," 24 Feb 2022 (online talk).

Polly, P. D., Université Claude Bernard Lyon 1, "Macroevolution in Paleontology", Biology and Paleontology MSc program, 24 September 2021 (online talk).

Polly, P. D., Pennsylvania State University, Department of Geosciences seminar series, "Punctuated equilibrium, Earth systems, and the Common Cause hypothesis extended: A new look at Gould's Pleistocene snails from Bermuda", 21 September 2021.

Polly, P. D., Indiana University Institute for Advanced Study, "Resilience, climate, and species: perspectives from deep time", Resilience & Memory in Archives, Libraries, and Museums, a Research in Repositories webinar, 16 September 2021 (online talk).

Polly, P. D., American Society of Mammalogists Annual Meeting, Anchorage, Alaska (virtual), "Ecometric frameworks for studying functional trait change in mammalian communities through space and time", 18 June 2021.

Polly, P. D., Virtual symposium: Macroevolution of form and function in the mammalian locomotor system, Humboldt Universität, Berlin, "The landscape of adaptive landscapes: trade-offs between performance surfaces in space and time", 27 March 2021 (online talk).

Polly, P. D., Turkana University College, Lodwar, Kenya, "The vertebrate body plan: an overview of vertebrate anatomy", Vertebrate Paleontology Module. 24 Feb 2021 (online talk).

Polly, P. D. "Shrews and marmots", STEM education video series, Colorado State University video series on scientific research on small mammals by Tanya Dewey, Zoom, Fort Collins, CO, United States. (September 1, 2021).

Polly, P.D., "Historic and ecogeographic processes in speciation: glacial cycles, dynamic reproductive barriers, and diversification of mid-latitude mammals from a paleontological perspective", Conference, Virtual Evolution 2021, Society for the Study of Evolution / Society of Systematic Biologists / American Naturalist Society. (June 21, 2021).

Salcido, C.J., Polly, P.D. (2020). Influence of biomechanics on the mandible shape amongst carnivorous therian Mammals. 2020 Soceity of Vertebrate Paleontology Annual Conference. *Poster presentation

Zimmerman, A. N., Johnson, C. C., and Dalkilic, M. M. (2021). Quantifying effects of thermal changes on predicted suitable habitat of the deep-sea coral *Lophelia pertusa*. 2021 Geological Society of America Annual Conference. *Oral presentation.

Zimmerman, A. N., Johnson, C. C., Phillips, G. E., and Ehret, D. J. (2020). Taxonomy and Paleoecology of Rudist Bivalves from Upper Cretaceous Strata, Gulf Coastal Plain, USA. 2020 Geological Society of America Annual Conference. *Oral presentation.

Department Presentations

Couch, S. April 5, 2021. Dr. Akshay Sarathi's *Introduction to Zooarchaeology* course. Indiana University. "Process and Practices of Fish Identification in Archaeological Contexts."

Hawley, Kirsten and Tori Galloway. September 21, 2021. Dr. Anne Pyburn's *Ancient Technology* course. Indiana University. "Nautical Technology."

Hawley, Kirsten. October 6, 2021. Dr. Sarah Osterhoudt's *People and Protected Areas* course. Indiana University. "Underwater Resources: Protection, Preserves, and Activism."

Kort, A. E. XRCT scans reveal unusual lumbar vertebrae in extinct mammals, September 2021

Nelson, Allison, An exploration of the *Canis lupus* and *Canis rufus* species boundary via morphometrics, Crossroads Conference, 2022

Pineda-Munoz, S. Seminar talk for Department of Integrative Biology at University of South Florida. Of fossil, teeth and maps: Merging paleontology, dental morphology evolution, and biogeography to advance conservation biology. Virtual.

Pineda-Munoz, S. Seminar talk for Fall Weeks Lecture at University of Wisconsin-Madison. Fossils, maps, and teeth: Merging paleontology and ecology to advance conservation practices. Virtual.

Pineda-Munoz, S. Open discussion about the publication "Mammal species occupy different climates following the expansion of human impacts" for the "Conservation Paleobiology" course at Virginia Polytechnoic Institute and State University. Virtual.

Pineda-Munoz, S. Seminar Talk for Universidad Districtal, Colombia: Fossils, maps and

Salcido, Charles. Paleontological inventory of Theodore Roosevelt National Park, IDEAS Talks, 2021.

Educational Outreach

Burtt, Amanda (2021) Dog research – At home edition (blog). The Florida Bookshelf, News from the University Press of Florida.

Couch, S. May 15, 2020. Specimen lent to WonderLab Museum for use in their virtual educational program, "Dive Deeper: Oil Spills."

Couch, S. January 22, 2021. Specimen lent to WonderLab Museum for use in their virtual educational program, "Dive Deeper: Ice Age Animals."

Couch, S. March 5, 2021. Specimen lent to WonderLab Museum for use in their virtual educational program, "Animal Hour: Brains in the Animal Kingdom."

Couch, S., Miller-Camp, J. July 10, 2020. Represented WRAZL in WonderLab Museum's virtual educational program, "Dive Deeper: Ancient Fishes."

Couch, S. April 23, 2021. Represented WRAZL in WonderLab Museum's virtual educational program in WRAZL. "Animal Hour: Lab Life" which was hosted in the lab.

Couch, S. January 28, 2022. Represented WRAZL in WonderLab Museum's virtual educational program in WRAZL. "Animal Hour: Lab Life" which was hosted in the lab.

Kort, A. E. 2020-2022 (ongoing). Youtube Video Series. The Virtual Paleontologist. https://www.youtube.com/channel/UCJaiHFrVy0wdObYoV-rwXPw/videos

Miller-Camp, J. June 5, 2020. Represented WRAZL in WonderLab Museum's virtual educational program, "Science Story Time."

Nelson, A. E. 2022 (ongoing). Writer for ScIU: Conversations in Science at Indiana University: "What is a Species and Why Should We Care? "; The New Beast in our Backyards "; "The Grocery Store Sells Many Kinds of Salt, But Are They Actually Different? "; "Red Wolves are Endangered, But How Can We Protect a Species We Can't Define? "

Nelson, A. E. 2021. Travel Scavengers: "Allison's Experience at the Society of Vertebrate Paleontology Conference "; "Meet the Scientist: Allison Nelson, Vertebrate Paleontology Master's Student "

Salcido, C. J. 2020-2022. Writer for YouTube channel PBS Eons episodes: "How South America Made the Marsupials ;" "When Dinosaurs Chilled in the Arctic ;" "The Rise and Fall of the Tallest Mammal to Walk the Earth ;" "The Traits That Spawned the Age of Mammals "

Various authors, IU Paleo Collection Facebook page

Various authors, IU Paleo Collection Instagram page

Various authors, WRAZL Instagram page

Exhibits

Couch, S., Miller-Camp, J. Three displays are maintained by WRAZL staff that reside outside the door of the lab. One contains pieces from the Stotter Mollusk Collection, the second highlights student projects from 2019, before COVID and the third is a tribute to William R. Adams and his work through time.

Miller-Camp, J., G. Motz, and C. Johnson, Feb–Dec 2022, The Stotter Collection, a full room exhibit of IUPC and WRAZL specimens in the McCalla Building of IU Collections.

Root-Sturgeon, P. and G. Motz, 2022, MegaJeff, initially a travelling and currently a full room exhibit including some IUPC specimens in the McCalla Building of IU Collections.

Internal loan of Paleozoic invertebrates made to the Grunwald Gallery for use in a display about Indiana railroads.

Workshops

Kort, A. E. and Hannah Hughes Practical Guidelines for STEM Lab Associate Instructors, Center for Innovative Teaching and Learning, Bloomington, IN. August 2021.

Kort, A. E. Basics of Digital Preparation with Open-Source Software, Association for Materials and Methods in Paleontology Annual Meeting, online. April 2021.

Government Reports

Salcido, C.J., P. Wilson, J.S. Tweet, B.E. McCann, C.A. Boyd, and V.L. Santucci. 2022. Theodore Roosevelt National Park: Paleontological resource inventory (sensitive version). Natural Resource Report NPS/THRO/NRR—2022/2347. National Park Service, Fort Collins, Colorado.

Total Educational Offerings from CBRC Collections

Specimen loans for classroom use, research projects, tours to public visitors, and outreach and collaboration with educational and research entities were severely cut back due to the pandemic and personnel turnover. We are beginning to return to normal levels of specimen usage now that most of the materials have re-settled back in the Geology Building post-renovations. During the pandemic we continued to field multiple fossil identification requests from citizens of Indiana and surrounding states.

External loans from and visits to CBRC Collections

Two external researchers visited the IUPC during the waning pandemic months of the 2021-2022 academic year to study specimens for their research. Numerous visitors viewed specimens or inquired informally or formally about research specimens in our Collections, in the anticipation of furthering their research analyses in the post-pandemic months. An artist-in-residence with the Ashkenazi Museum visited the IUPC and WRAZL twice to study and photograph specimens and the specimen processing process. A fellowship awarded in 2016 by IUB's Institute for Advanced Study Summer Repository Fellowship program resulted in a 2021 publication in the prestigious journal *Nature Ecology & Evolution*.

Novack-Gottshal, P.M., Sultan, A., Smith, N.S., Purcell, J., Hanson, K.E., Lively, R., Ranjha, I., Collins, C., Parker R., Sumrall, C.D. and Deline, B., 2022. Morphological volatility precedes ecological innovation in early echinoderms. *Nature Ecology & Evolution.* https://doi.org/10.1038/s41559-021-01656-0

***Major activities in* 2021–2022**

Stitching and stacking of image files from the GIGAMacro system resumed following a session with the software creators to repair a major technical glitch. Migration of these files from GEODE will be required. IU Collections is actively seeking a technical storage option for multiple collections as none of the options currently offered by the university fit our needs.

CBRC operates the Specify database system, which is a specialized system for recording associated specimen data (taxonomy, sex, date and location collected, geologic age, storage location, etc.), accession information (documents that show the specimen was collected legally and belongs to Indiana University), loan processing, history of use, etc. IU Collections has been looking into an alternate free, open-source database program called Collective Access following successful implementation by the Indiana Geological and Water Survey. Given our continuing issues with Specify and their success with Collective Access, a switch may be forthcoming.

WRAZL had a particularly unusual set of issues in that the lab director's position at IUB was terminated. The Collections Manager and the Anthropology department Chair have spent the time after (Fall 2020 through the present) trying to keep things in order. The Collections Manager has spent time acquainting the department head with the lab and dealing with department-related questions and issues as they arise. Without a permanent lab director, operations continue to be slow, though they have picked up in Spring 2022.

A search for a new director was undertaken by the Anthropology Department, with four candidates doing "on-campus" interviews (plans had to be moved to Zoom), including virtual lab tours by the Collections Manager and Assistant Collections Manager. The Collections Manager's recommendations on the candidates were taken very seriously due to their familiarity with the lab's needs and their history in museum studies. Their first choice has been offered the job and, with the department head's support and the Collections Manager and Assistant Collections Manager's recommendations, the candidate was able to negotiate additional resources for WRAZL.

WRAZL's annual IU IBC protocol and permit paperwork have been filed. The WRAZL freezer was re-inventoried following the final departure of the former director and removal of her personal specimens over this past year. Progress has been made on specimen maceration and inventory of these newly-processed specimens. Multiple specimens were acquired through donation.

Two RAs were funded through CBRC to work in the IU Paleontology Collections in Spring 2021. They used the Collection Manager's inventory workflow to finish inventorying the entire fifth-floor collection space. They then worked on organizing the digital files into a more logical arrangement than that which had existed previously. In Spring 2022, CBRC supported another IUPC RA to unpack and organize the inventoried boxes, train undergraduates, and begin work on research projects. This summer, CBRC will support an RA to build laser scanning and photogrammetry workflows for both WRAZL and IUPC using key specimens we have selected, and to do two test runs of training workshops in anticipation of full runs starting in Fall 2022. The RA will also be training the first few undergraduates for these functions during the summer.

As of Spring 2022, we have resumed training of undergraduate workers in both WRAZL and IUPC, as well as one non-student volunteer who initially reached out to us before the pandemic. Many students expressed interest in the paid positions and we were able to accept all who confirmed their interest in collections research. In IUPC, some worked with the current RA to unpack and organize boxes and return materials to the collections room, and did so at an impressive rate. Post-Spring Break 2022, students have begun familiarizing themselves with a research project on Indiana fossils donated several years ago on which five other undergraduates had previously worked. In WRAZL, undergraduate students have been working with the Assistant Collections Manager on specimen processing techniques, and with the Collections Manager on the anatomical knowledge required for inventory of those specimens. In addition, undergraduates have been working with the Collections Manager to resort mammal specimen

boxes on the shelves, as some were misplaced over the years, and the arrangement had not been updated to reflect modern phylogenetic hypotheses.

With the opening of McCalla as the new Collections Teaching, Research & Exhibition Center (CTREC), we have begun an exhibit-building relationship with University Collections. The *Megajeff* exhibit includes a case of IUPC fossils whose boxes and labels are still covered in soot from the building fire that signaled the beginning of the original *Megalonyx jeffersoni*'s fall into neglect, with the tale of the necessity of collections preservation purposefully made glaringly visible.

University Collections came to us in mid-November 2021 asking us to create an exhibit on the Stotter Shell Collection shared between IUPC and WRAZL. The exhibit progressed from initial discussions in mid-November to full installation in late February 2022, which is an *incredibly* short timespan for a full room of displays. This scale of undertaking would normally take half a year minimum, with a full year being more likely. The exhibit includes eight display cases, one large specimen on a pedestal, an array of photo collages along the walls, and three screens displaying related digital features. The IU Collections Digital Manager, the CBRC Director, and the Collections Manager worked together to come up with themes for each display and initial thoughts about specimen choice. The physical displays are: shape, size, color, pattern, ornamentation, how shells are made, how humans have used shells, and a re-creation of a reef ecosystem, plus the three foot-wide giant clam in the center of the room. The digital displays are an episode of *Blue Planet*, a livestream from a coral reef in Florida, and the 3D model of the IUPC room produced by the previous CBRC Project Manager/current University Collections Information Technology Manager. The Collections Manager selected individual specimens, then inventoried and packed the loan with the WRAZL Assistant Collections Manager, the IUPC RA, and one of the IUPC undergraduate workers. The Collections Manager wrote exhibit copy to educate patrons about the specimens. The Department of Earth & Atmospheric Science's graphic designer created and printed the collages for the walls.

This Stotter Shell Collection exhibit and its reception are the realization of a longtime hope of ours, and of University Chancellor McRobbie's, by his own words. Potential donors to IU Collections toured it during a two-day event and expressed great admiration and appreciation for the accessible scientific content and visual beauty of the display. The Chancellor and University Fellow Laurie Burns McRobbie were given private access and stayed for hours, and subsequently came to the Geology Building for a (second) private tour of the IU Paleontology Collections.

The Collections Manager gave a private tour of the Stotter Shell Collection to a local shell expert, and she and her daughter (who is also in the museum field) intend to volunteer with us to identify all of our specimens to species level. As people have been trickling into the McCalla CTREC exhibit space, many have remarked to IU Collections Staff on how much they love the collection and exhibit. Most recently, more of that same high praise for the Stotter Shell Collection exhibit came during the opening of a neighboring exhibit by the Kinsey Institute.

On the back of this overwhelming success, we are currently working with University Collections to provide specimens and information from IUPC, WRAZL, and related research by affiliates of those two collections for a multi-collection permanent installment on dentition planned to open in early Spring 2023. WRAZL in particular will be featured by way of an entire wall displaying skulls from various animals in our collection.

Highlights of CBRC accomplishments of major activities

- Completion of a *Turtle Osteology Guide* to accompany the new turtle element inventory sheet created prior to the pandemic. The purpose of these documents is to instruct students on how to conduct accurate element inventories, then to build those accurate inventories themselves. The Collections Manager spread the word of its completion on a social media blast with an offer to provide copies as a community resource. Within two days, workers from fourteen collections at other institutions requested copies to use, with several later remarking positively on the value of the guide.

- Unpacking in IUPC – unpacking heavy rocks is a laborious effort; unpacking delicate specimens is a paleontologist's delight
- WRAZL director search
- Stotter Exhibit completion for University Collections and CTREC
- Dentition exhibit plans for University Collections and CTREC
- Undergraduate student resumption of internship positions for research and management training in IUPC and WRAZL
- Seven undergraduate researchers engaged in reef and archaeology-related research projects
- Graduate RAs in IUPC and plans for an upcoming IUPC/WRAZL RA
- Update of WRAZL website, with ongoing efforts to work out technical issues
- Hosting of two visiting researchers to IUPC and one visiting artist-in-residence to both IUPC and WRAZL
- Private tour of IUPC for Chancellor McRobbie and University Fellow Laurie Burns McRobbie
- Transfer of human remains (old teaching specimens and former Bloomington Police Department case evidence) to NAGPRA

Future Plans

In keeping with CBRC's goal of advancing digital initiatives in all of our natural history collections, we aim to:

- Enhance graduate student utilization of research collections across the natural sciences
- Continue to instruct undergraduate students in specimen-based research
- Train students from diverse fields in museum management processes and techniques
- Advertise the value of specimens to enhance classroom student learning experiences across natural sciences, arts and humanities, and social and historical studies
- Continue fundraising efforts to support the Center's activities and personnel
- Develop research proposals for externally funded grants
- Connect with technical units to leverage digital support for collections
- Convene regular meetings with CBRC Executive Committee members
- Clarify organizational structure and governance
- The Collections Manager plans to create osteology guides for other major taxonomic groups in WRAZL, and to present on this format of combination guide & workflow at future conferences.
- The Collections Manager plans to create a related presentation on the use of ADHD coping mechanisms to increase worker engagement and productivity with tedious museum tasks
- Incorporate element inventories into the collections database such that specimens can be searched by presence of certain elements in addition to the already-supported taxonomic and location searches
- Dentition exhibit completion for University Collections in February 2023
- Continued updates of WRAZL and IUPC websites
- Continue building the relational databases for WRAZL and IUPC, continue filling out and updating our digital catalogue, and serving that data to our websites and online aggregators
- Introduction of new WRAZL director, resumption of archaeological research, and creation of a 5-year-plan for grants, projects, and curatorial activities
- Completion of project on Indiana fossil donation, including presentation and publication

Outreach and Education

WRAZL has maintained a close working relationship with WonderLab Museum of Science, Health & Technology since 2018 that involves frequent loans of specimens, lab tours and access to staff for camps, educational programming and events both at WonderLab and in WRAZL. Between 2020 and 2022 WRAZL has been involved in seven of WonderLab's virtual programs, three in 2020, three in 2021 and one as of April 2022, with potential for more this year. Two of these programs involved hosting the lab, and specimens were loaned for six of them. Topics included the danger of oil spills that utilized a specimen acquired from the Valdez Oil Spill, ancient animals, and the importance of fossil records as well as what it is like to work in a lab.

Special issues and challenges

We are now back on track and functioning fully in collections-based research and education. Importantly, we acknowledge with great appreciation the funding provided by the College and OVPR that allowed us to regain our focus from pandemic times and from building renovation disruptions through collections space reorganization.

However, it is important to note the challenges we faced to arrive at this place, and then to leave them behind.

I. COVID-19 brought work to a halt in spring & summer 2021 for the IUPC and WRAZL laboratories. Many curatorial and digitization tasks could not occur because of restricted access and dispersal of undergraduate hourlies away from campus.

II. Renovation of the Geology Building required removal then replacement and re-organization of rocks and specimens. During this time, research access to collections was restricted to faculty and graduate students. Specimens were not provided to faculty and students in courses, but rather, photographic images were provided to instructors where possible. IMPORTANT: some material is still temporarily at the Otis Warehouse awaiting return by IU Space Utilization Office

III. A comprehensive external review of the CBRC, the IU Paleontology Collection, and the William R. Adams Zooarchaeology Collection was to be scheduled for Spring 2021, to assess scholarly impact, progress in enhancing effectiveness, including digital initiatives, and levels of success in garnering external support. Geology Building renovation and restoring collections in the IUPC, and recovery of operations from the COVID-19 pandemic necessitated the review to be moved to a later date. Spring 2023 is the suggested time for the review.

IV. We dealt with multiple environmental issues that were potentially damaging to our IUPC specimens housed in our offsite storage within IGWS storage space.

V. The continued empty position of WRAZL's director, and long-term health and family issues of the Collections Manager and Assistant Collections Manager severely hampered WRAZL's ability to function for a while. At this moment, we are awaiting final confirmation from the candidate offered the directorial position. If they say yes, we are looking forward to a very good and productive relationship. The latter issues began to be addressed in 2021, and as of Spring 2022 the pace has begun to pick back up.

New Challenges

I. CBRC has more than 17 TB of digital data that require a storage platform. Migration of data from Box

to Google Drive and to OneDrive was accomplished successfully after a semester of dedicated 2-person RA work, and now the migration must move from Google Drive to another, yet unknown platform that can accommodate large files. A discussion with University Collections is required so that CBRC can move forward with a solution for working with its digital data for research objectives.

II. The MOU among CBRC, the College and OVPR established expectations and financial contributions from July 1, 2019 – June 30, 2022. OVPR provided an additional year of funding through June 30, 2022. Our CBRC external review was in anticipation of the termination of the MOU, but persistence of the pandemic, building renovation, and loss of the WRAZL director stalled CBRC progress, necessitating the review to occur in Spring 2023. CBRC would be grateful for the opportunity to negotiate for an extra year of funding to address digital migration and renewal of collection-based research opportunities to take us through the 2022-23 academic year and the external review. Now that the Collections Manager position is stabilized in both the Anthropology and Earth and Atmospheric Sciences departments, the next step might be to normalize a small budget line for hourly support and technology in the departments.

Appendix I

Grants Applied for and Not Received

Anderson, S.B., Geological Society of America Graduate Research Grant 2022
Anderson, S.B., Indiana Space Grant Consortium Master's Fellowship 2022
Anderson, S.B., Indianaview Consortium Scholarship 2022
Burtt, Amanda, National Science Foundation – Archaeology DDRI - Doctoral Dissertation Research: Establishing a Framework of Dog Feeding Practices Using Dental Microwear Texture Analysis
Chandroth, A. (Well's Grant PRI 2022)
Harris, K., T. Marsico, J.A. Miller-Camp, A. Flemming, (NHODE) The Natural History Organizations for (bio)Diversity and Education (NHODE) Network: Enhancing Undergraduate Biodiversity Education through Specimen Collections (NSF RCN-UBE), 2020.
Kort, A. E., Graduate Women in Science Fellowship. 2020
Kort, A. E., Evolving Earth Foundation Student Grant. 2020
Kort, A. E., American Society of Mammologists Patton Award. 2020
Kort, A. E., Society of Vertebrate Paleontology Wood Award. 2020.
Kort, A. E., Society for the Study of Evolution Rosemary Grant Advanced Award. 2021.
Kort, A. E., Geological Society of America Graduate Student Grant 2022.
Kort, A. E., Paleontological Society Student Research Grants. 2022.
Miller-Camp, J.A. and L. Scheiber. (IMLS), Pilot Towards an Indiana Digital Atlas of Osteology (IMLS Spark!), 2020.
Nelson, A.E., American Geosciences Institute Harriet Evelyn Wallace Scholarship 2021
Nelson, A.E., Indiana University Graduate and Professional Student Government Research Award 2022
Pineda-Munoz, S. and P.D. Polly. NSF-DEB: Human landscape modification as a driver of the geographic distributions of modern North American mammals
Salcido, C. J., Society of Vertebrate Paleontology Wood Award. 2021
Salcido, C. J., Geological Society of America Graduate Student Grant 2022
Salcido, C. J., Paleontological Society Student Research Grants, 2022