OCEAN GENOME LEGACY
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A red striped crab collected in Cape Coast, Ghana by researchers from the Sena Institute of Technology (Penyi, Ghana). *Photo credit: Kwasi Agbleke.*

OCEAN GENOME LEGACY

2022 Annual Report

FROM THE DIRECTOR

This year I am happy to report that, although the pandemic may not be entirely a thing of the past, many labs around the world have returned to full operation and this has allowed OGL's accessions and distributions for FY22 to resume their robust pre-pandemic growth trends. Much of this growth reflects strategic decisions made during the pandemic to emphasize the acquisition of legacy collections from researchers nearing retirement. This strategy not only prevents the irreversible loss of thousands of valuable samples and associated data painstakingly collected by leading researchers but has also given OGL access to new research communities and funders.

The uncertainty of the past several years has also brought into sharp focus the need to prepare OGL for an unpredictable future. OGL began a concerted push towards this aim in FY20-21 with the acquisition of four new, climate-friendly, and energy-efficient ultracold freezers. These freezers substantially expand OGL's capacity to house new samples and promise longer service life and more consistent operation. In FY21-22 we also began bringing our data and database into compliance with the newly developed, globally accepted Darwin Core biological data standard, paving the way for greater integration with global data aggregators. This made it possible for OGL to make its entire collection and all its data discoverable via global data aggregators in FY22, including the Global Genome Biodiversity Network (GGBN), the Global Biodiversity Information Facility (GBIF), and the Ocean Biodiversity Information System (OBIS).

Doing so allowed OGL, for the first time, to make meaningful comparisons of its collections to others. For example, GGBN's website now lists OGL as the eighth largest genome resource collection among its 106 member institutions, which includes such major genome resource collections as those of the Smithsonian National Museum of Natural History in Washington, DC and the Natural History Museum of London. Within OGL's marine niche, the numbers are even more impressive. In GGBN, OGL accounts for >39% and >43% of marine invertebrate DNA and tissue samples, respectively. Additionally, OGL's fish and marine mammal DNA samples account for >23% of all vertebrate DNA samples in GGBN collections.

As both OGL and the global biorepository community continue to grow, it is becoming ever more important to integrate and utilize the resources, tools, and data developed by the members of this community. Although OGL has made great strides towards adopting emerging community standards and serving data to global aggregators, there are limits to what we can do on our own. Fortunately, several collection networks and consortia have emerged that aim to bring together collection managers and database developers from many collections to create tools and platforms to address shared challenges. As you will learn in this report, OGL aims to join with one of these consortia in FY23 to leverage the common knowledge, strengths, and resources of the growing museum and biorepository community.

In each of these ways, and others described herein, OGL has continued to increase its visibility, credibility, and impact on marine genomic research and conservation, while at the same time adopting strategies that will continue to increase its relevance in the future. We cannot thank our advisors, funders, and collaborators enough for the support that has made this progress possible.

Daniel L. Distel

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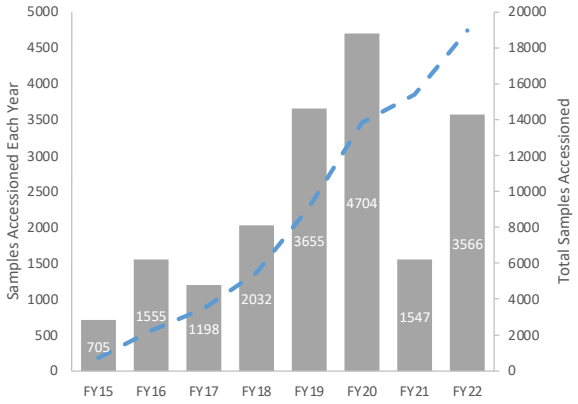
FY22 HIGHLIGHTED IMPACTS & ACCOMPLISHMENTS

Biorepository Acquisitions & Services

Contributions to the Collection

- OGL acquired 3,566 samples (Figure 1A) from 8 countries—Belize, El Salvador, Fiji, Mexico, Philippines, Seychelles, Tonga, and the United States of America—and 4 ocean basins—Atlantic, Indian, Pacific, and Southern (Figure 2).
- New additions include at least 131 taxa of which 30 are new to OGL (Figure 1B).

(A) Samples



(B) Taxa

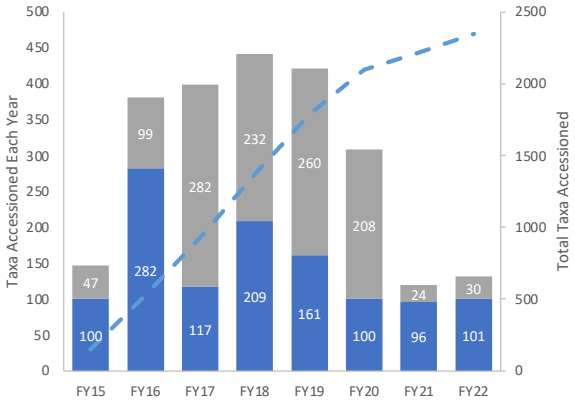


Figure 1. OGL collection metrics. (A) Samples and (B) taxa acquired by the OGL Collection over the past 8 fiscal years at NU (left axes). (A) Gray bars indicate the samples acquired by OGL. (B) Gray bars represent taxa new to the collection and blue bars indicate new representatives of taxa already in OGL. The light blue lines track the cumulative growth of (A) samples and (B) taxa in OGL (right axes).

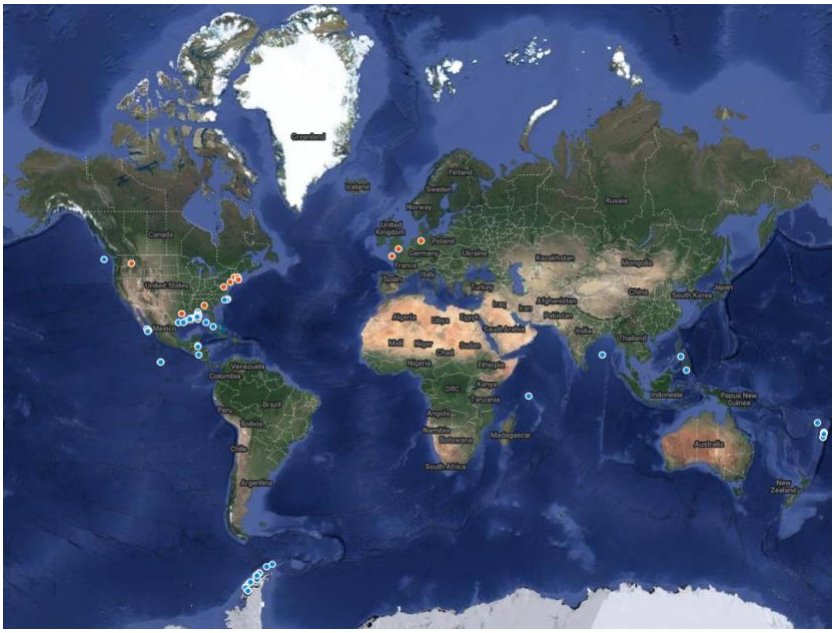


Figure 2. Geographic distribution of OGL contributions (blue) and distributions (red) in FY22.

- Highlights: New accessions include research legacy collections from Penn State University's Dr. Charles Fisher (invertebrate specimens from deep-sea hydrothermal vents and cold seeps) and Northeastern University's Dr. H. William Detrich (icefish and invertebrates from his 2008, 2010, 2012, 2014, and 2016 field seasons in Antarctica). Other accessions include whale samples from Canada; invertebrates and bacterial isolates from the Alabama Undersea Forest; and sea stars (*Asterias forbesi*) infected with sea star wasting disease.

Distributions from the Collection

- Distributions from the OGL Collection increased substantially in FY22.
- OGL made 1,318 distributions (Figure 3) to researchers from 11 institutions in France, Germany, United Kingdom, and United States of America (Figure 2).
- Highlighted Applications: OGL materials were used in phylogeographic analyses of deep-sea cold-seep mussels; phylogenetic analyses of crinoids (sea lilies); whole genome sequencing of the North Pacific zoarcid fish *Bathymaster signatus*; genetic analyses of black cod (*Notothenia coriiceps*); sequencing of mitochondrial genomes of deep-sea and shallow-water wood-boring bivalves; phylogenetic analyses, mitochondrial genome sequencing, and the formal description of the new shallow-water bathymodiolin mussel genus and species *Vadumodiolus teredinicola*; and establishment of a new icefish research program by new University of Houston Assistant Professor Jake Daane.

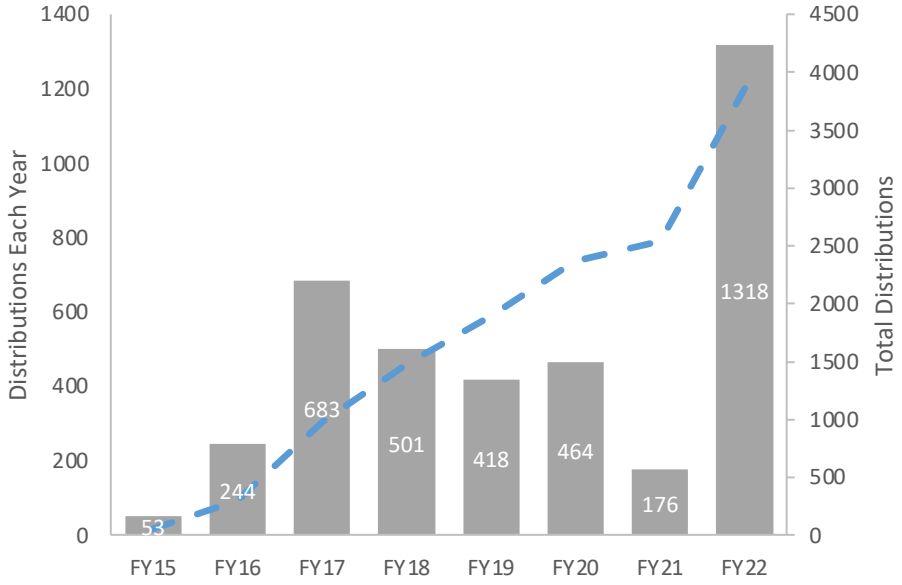


Figure 3. OGL distributions. Gray bars represent distributions from the OGL collection over the past 8 fiscal years at NU (left axis). Blue line tracks cumulative distributions from OGL (right axis).

Global Impact

OGL continues to maintain a global impact (Figure 2).

Fee-for-Service (DNA Barcoding)

- OGL has been contracted:
    - By the Gemological Institute of America (GIA) to develop protocols for pearl identification by DNA barcoding to be completed in FY23 (Figure 4A).

- By a crowdsourced DIY science project for the Barnstable Clean Water Coalition to study *Aurelia* (moon jellies) in Mashpee Bay to be completed in FY23 (Figure 4B).

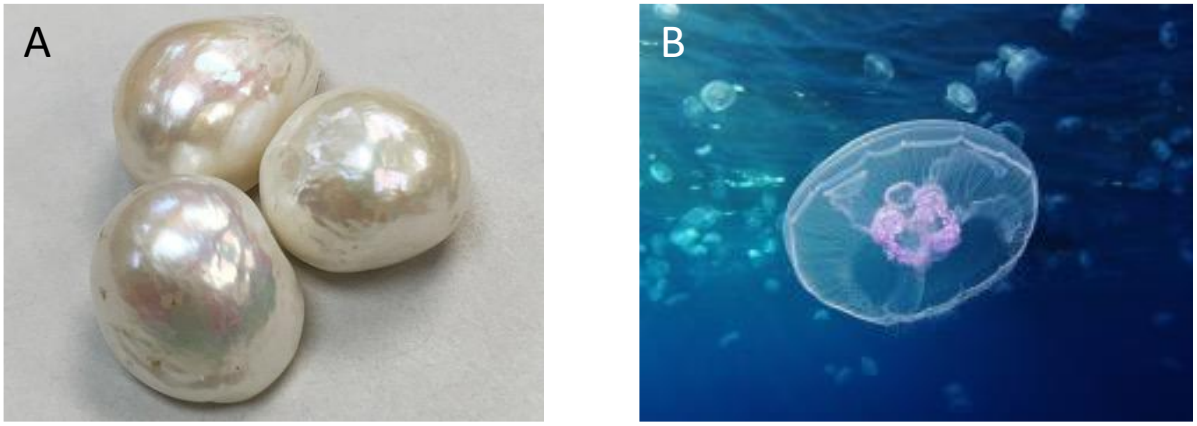


Figure 4. Fee-for-service work in FY23. In FY23 OGL has been contracted to develop protocols for DNA barcoding to identify the source species of (A) cultured and natural pearls and (B) invasive jellyfish. *Photo credits: Tyler Houck (pearls) and Alexander Vasenin (moon jelly).*

Impacts of OGL Collections & Research

- OGL continues to see year-over-year increases in publications referencing OGL, OGL samples, OGL data, or OGL authors, driven in part by collection data made available on GBIF (Figure 5). In FY22, 74 scientific publications (67 in print and 7 published pre-prints) and 1 dissertation/thesis referenced OGL, OGL samples, OGL data, or OGL authors (Appendix A).
- OGL staff and students presented at 7 meetings: 3 presentations described OGL, 3 described OGL applied research, and 1 described OGL basic research (Appendix B).

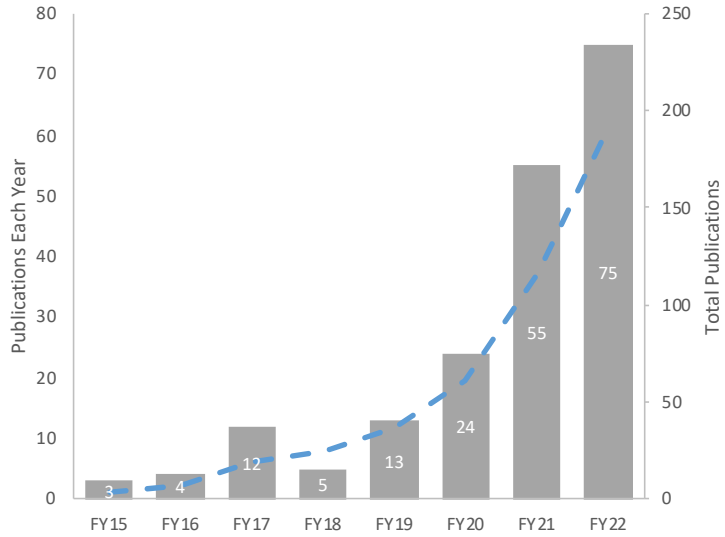


Figure 5. OGL citations. Gray bars represent publications and reports referencing OGL, OGL samples, OGL data, or OGL authors over the past 8 fiscal years at NU (left axis). Blue line tracks cumulative publications referencing OGL (right axis).

Projects & Collaborations

Collections

Research Collection Rescue—Saving the Legacy Collections of Retiring Researchers

Since January 2021, OGL has been working with Dr. H. William Detrich (Marine and Environmental Sciences, Northeastern University) to accession thousands of samples from his 17+ years of research expeditions to Antarctica to create the Polar Genomic Resource Collection (PGRC; Figure 6A). To date, this project has trained three OGL student co-op interns and has supported one part time and one full time temporary student employee. These students have been funded by awards from the Francis Goelet Charitable Lead Trust, Dr. H. William Detrich's NSF grant, and a Research Experience for Undergraduates (REU) supplement to that NSF grant. As of October 25, 2022, these students have accessioned 3,677 samples into OGL's PGRC. OGL students also completed the accession of 2,264 tissue samples, 18 DNA samples, and 45 fluid preserved specimens from the research legacy collection of Dr. Charles Fisher in FY22 (Figure 6B).

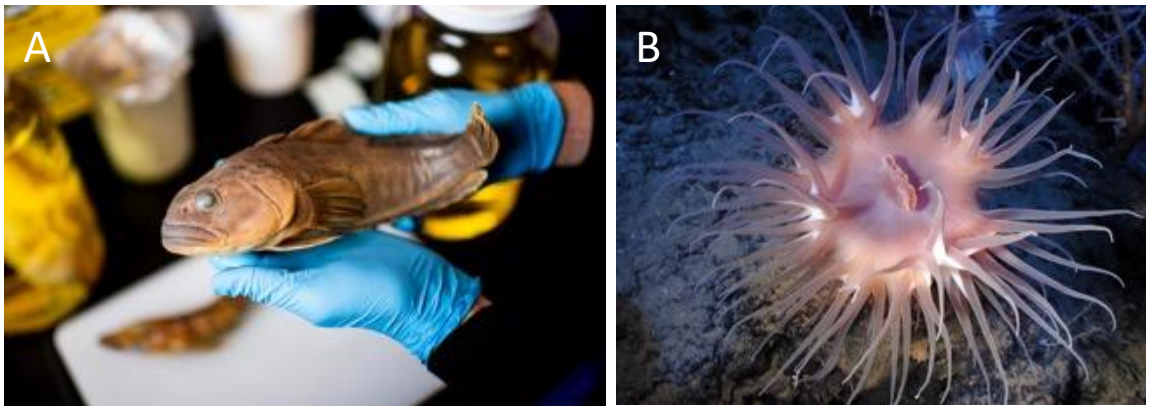


Figure 6. Research legacy collections. (A) Notothenioid ice fish from the legacy collection of Dr. H. William Detrich and (B) anemone from the collection of Dr. Charles Fisher. *Photo credits: Matthew Modoono, Northeastern University (Nototheniod ice fish) and Dr. Charles Fisher, Penn State University (anemone).*

Expanding the OGL Polar Genomic Resource Collection (PGRC)

The unique and diverse marine biodiversity of Antarctica faces imminent threats from climate change. In addition to contributing his research legacy collection to OGL, Dr. H. William Detrich introduced OGL to the Antarctic research community. This led to an invitation for OGL to participate in an NSF-funded workshop to explore the establishment of a Biorepository Network for the National Science Foundation's U.S. Antarctic Program. As a deliverable of this workshop, OGL co-authored a manuscript entitled "The Time is Right for an Antarctic Biorepository Network," which has been accepted for publication in *The Proceedings of the National Academy of Sciences* in FY23. With the acquisition of Dr. H. William Detrich's legacy collection and two newly initiated legacy collection rescues for retiring Professors Charles Amsler (University of Alabama) and Lisa Crockett (Ohio University), OGL has positioned itself to become a key biorepository in this proposed network. Additionally, OGL has been invited to join Professor Kristin O'Brien (University of Alaska) in producing a grant proposal in FY23 to create this NSF-supported Antarctic Biorepository. The credibility established through these collaborations has placed OGL in a leadership position with respect to archiving materials and developing protocols and best practices for sample collection and management in the Antarctic research community.

OGL Grows as a Data Provider

In September 2020, OGL received a grant from the Global Genome Biodiversity Network (GGBN) and Global Genome Initiative (GGI) to continue its efforts to bring the OGL collection in line with developing international data standards (Darwin Core) and to improve interoperability with the international data aggregators GGBN, the Ocean Biodiversity Information System (OBIS), and the Global Biodiversity Information Facility (GBIF). In FY22, OGL served 14,255 new records to OBIS and GBIF, bringing OGL's total to 31,073 specimen occurrence records (Figure 7). As of October 25, 2022, these data have been included in >24,955 downloads via the GBIF data portal and used in 135 publications, which include studies of biodiversity, invasive species, and climate change. Additionally, this dataset has appeared in 49,282 downloads on the OBIS portal in 2022, with a total of 32,272,801 records downloaded. In May 2022, OGL served 43,757 sample records and 30,684 extract records to the GGBN data portal, thereby completing the work funded by the GGBN—GGI grant. This brings these databases up to date for all current OGL records.

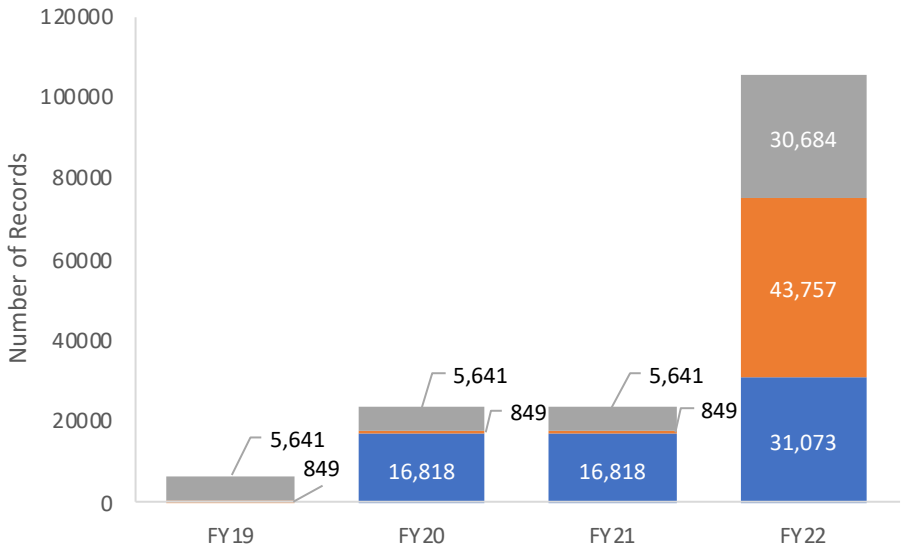


Figure 7. OGL data served to data aggregators. Records served to data aggregators over the past 4 fiscal years. Gray bars represent DNA extract data served to GGBN, orange bars represent sample data served to GGBN, and blue bars represent specimen data served to GBIF and OBIS.

How Does OGL Compare to Other Genomic Resource Collections?

OGL is one of the founding members of the Global Genome Biodiversity Network (GGBN), which is comprised of 106 participating institutions and is the largest network of genome resource collections in the world. Together, these collections house over 3.74 million DNA and tissue samples. OGL's collection ranks eighth among these repositories in total number of sample records. For comparison, OGL's genome resource collection is twice as large as that of the Natural History Museum of London and one third as large as that of the Smithsonian National Museum of Natural History. However, OGL's collections really stand out when it comes to marine samples. In GGBN, OGL accounts for >39% and >43% of marine invertebrate DNA and tissue samples, respectively. OGL's collections also account for >23% of all vertebrate DNA samples and 75% of all Antarctic samples in GGBN.

Futureproofing Data & Sample Management for the OGL Collection

Since the OGL data and sample management system was established, several new collection management platforms and user communities have emerged that aim to unify the efforts of numerous collections around the world. We have assessed four such initiatives and have identified one that best

matches OGL's growing data management needs. The Arctos Collection Management Consortium is a nonprofit community of museums and biorepositories dedicated to developing a common collection data management platform that includes well-designed and simple interfaces for collection staff and users, tools for entering, cleaning, and exporting bulk data, tracking of sample biogeography, provenance, storage, and fate, flexible generation of queries and reports, automated reporting to global data aggregators, and the ability to link to other collections. Our aims in this project are to:

(i) Expand OGL's management capacity from tens of thousands to millions of samples.
(ii) Adopt a data management platform based on Darwin Core, the world's most widely used biological data standard, and PostgresSQL, a well-established open-source database query language.
(iii) Facilitate workforce growth and simplify staff transitions by migrating to a platform with preexisting training materials and a pool of experienced users and developers from which we can draw assistance and make hires.
(iv) Increase the impact and accessibility of OGL's collections to better support critical research in biodiversity, medicine, biotechnology, and global change.

This transition will streamline repetitive, labor-intensive tasks, allowing OGL to redirect resources and staff time to more productive activities. Most importantly, this provides the opportunity for OGL to actively participate in a robust community of collection managers and database developers that is working together to build more effective solutions for biodiversity collection management. OGL has submitted a proposal to the Francis Goelet Charitable Lead Trust to help cover the costs of this major project.

Research

Caribbean Coral Disease Working Group

With increasing influence of climate change, coral disease is on the rise throughout the Caribbean. Fortunately, the Vollmer lab did not observe stony coral tissue loss disease in Panama during the FY22 field season. Due to this unexpected (but encouraging) result, some planned activities were postponed and some funds from the FY21 Horvitz Family donation remain unspent. The Vollmer lab is now developing a new pathogen profiling technique using Nanopore sequencing, which will allow better identification of the key pathogens, and is combining these with novel bacterial growth assays to determine which pathogens are most infectious. This method is being developed using nursery-raised corals from Florida. The Vollmer lab plans to test these newly developed methods in the field in Panama in early 2023 and hopes to be able to apply them in Mexico and Puerto Rico at a future date.

Alabama Undersea Forest

OGL is leading the first biodiversity exploration of an ancient, submerged forest which, due to sea level rise, now sits 60 feet beneath the sea and eight miles off the coast of Alabama. Here are some highlights of this project's most important accomplishments in FY22.

New species described: Phylogenetic analyses performed in FY22 have confirmed the discovery at the Alabama Undersea Forest of a previously undescribed mussel species and genus that is entirely new to science (Figure 8). What makes this discovery particularly exciting is that this species belongs to a group of mussels that has been thought to exclusively inhabit the deep sea until now! Publication pending.

Figure 8. A new species of mussel that was discovered at the Alabama Undersea Forest belongs to a deep-sea group that has never been observed in shallow water before. This tiny specimen is just 5 mm in length. *Photo credit: Marvin A. Altamia, OGL.*

Mitochondrial genome evolution in the deep sea: OGL scientists and colleagues sequenced 42 complete mitochondrial genomes from 22 bivalve species in two closely related bivalve families, one that inhabits shallow water and a second that inhabits the deep sea (Figure 9). Although the two families share the same lifestyle and unique feeding habits, they have followed opposite trajectories with respect to mitochondrial genome evolution. In the deep-water family, gene sequence is highly conserved, but gene order is wildly variable. In contrast, gene order is conserved but gene sequence is evolving more quickly in the shallow-water family. This work was published in *Genome Biology and Evolution* in a manuscript entitled "Contrasting modes of mitochondrial genome evolution in sister taxa of wood-eating marine bivalves (Teredinidae and Xylophagaidae)" (Appendix A).

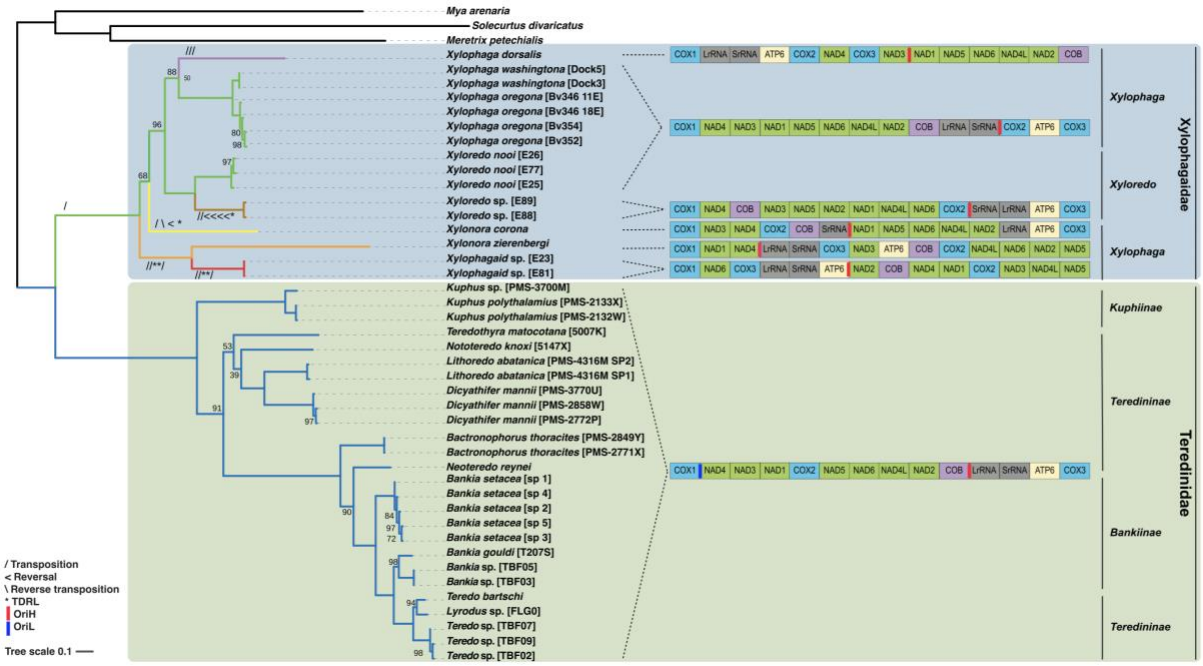


Figure 9: Mitochondrial genome evolution. OGL scientists and colleagues discovered sharply contrasting modes of mitochondrial genome evolution in two closely related bivalve families that share lifestyles but differ in depth distribution. Note that members of the deep-water family, Xylophagaidae, display six different patterns of gene order but are separated by short branches in the phylogenetic tree. This indicates rapid evolution of genome organization, but slow rates of gene sequence evolution. The opposite pattern is observed in the shallow-water family Teredinidea.

Student Research in DNA Preservation

OGL, through its student research program, continues to pioneer the use of metal-chelating reagents to preserve high molecular weight DNA in tissue samples, while at the same time providing intensive research training for undergraduate students. This new preservative approach, which has many advantages over traditional methods, was first published by OGL staff and students in August 2020. In FY22, a second student co-authored manuscript describing significant methodological improvements was submitted for publication and is now in review. This research formed the basis of a non-provisional patent application covering the use of metal chelators for preserving DNA in biological specimens (US20210267189A1, February 2021). OGL has applied for a Northeastern University SPARK Fund award in FY23 to facilitate commercialization of products based on this discovery. OGL's successful Student Research program was funded by a generous gift from Robert and Eileen Matz and is a priority for future OGL fundraising efforts.

Seafood Genome Reference Collection (SGRC)

In FY22, OGL continued to develop tools for analysis of seafood ID data. In collaboration with Dr. Amy Mueller (Marine and Environmental Sciences, Civil and Environmental Engineering, Northeastern University), OGL developed analytical tools for quantitative comparison of data sets. Seafood mislabeling defrauds consumers and hinders the management of fisheries, particularly those threatened by overfishing and climate change. DNA-based seafood testing can fight mislabeling. However, the lack of available reference DNA samples has slowed development and implementation of fast and cost-effective testing methods. To address these issues, OGL has continued the SGRC project to test a promising new seafood ID method.

Other New & Continuing Projects

In FY22, OGL continued to participate in numerous projects and partnerships including the California Science Center, the Adventure Aquarium, the Tennessee Aquarium, the Massachusetts Department of Marine Fisheries, the Proteus Ocean Group, the Center for Molecular Medicine (Austrian Academy of Sciences), and the Sena Institute of Technology (Penyi, Ghana). Coming in FY23, OGL has initiated a project to archive research samples from the Gloucester Marine Genomics Institute as part of a larger planned collaboration with the Northeastern University Marine Science Center.

Education & Outreach

Student Training

- Undergraduate Students:
    - Student Research in DNA Preservation (Don Comb Research Co-op): 2 students.
    - OGL–Detrich Collections Assistant Co-op: 2 students.
    - Collections Assistant: 1 student.
    - Laboratory Assistant: 1 student.
- Master's Students:
    - Seafood Genome Research Collection, in collaboration with Dr. Amy Mueller: 1 student.

Other

- Talks, demonstrations, and activities presented at 8 outreach events, modules featured in 1 educator newsletter, 2 undergraduate research symposia hosted, 4 videos published to YouTube, and 2 public tours given (Figure 10; Appendices C and D).

A

B

Figure 10. Undergraduate research. OGL hosted two undergraduate research symposia for students remotely via Zoom in (A) December 2021 and (B) June 2022.

Key Performance Indicators

- Funds raised in FY22.
- Changes in sample contributions, requests, and uses:
    - Annual FY22 sample contributions increased by 131% over FY21.
    - Annual FY22 sample distributions increased by 649% over FY21.
    - Annual FY22 citations increased by 36% over FY21.
- Media mentions at NU and beyond:
    - 11 media mentions in FY22.
- No turnover of permanent staff in FY22.

APPENDIX A

Publications Citing OGL, OGL Samples, OGL Data, or OGL Authors

Peer Reviewed Papers & Book Chapters

1. Zoonomia Consortium. A comparative genomics multitool for scientific discovery and conservation. Nature. 2020;587(7833):240-5. **[Samples provided by OGL]**
2. Perkin JS, Troia MJ, Acre MR. Conservation status of native fishes in the Chihuahuan Desert region of the United States: A spatial perspective. Proceedings of the Desert Fishes Council Special Publication. 2021:77-103. **[OGL data]**
3. Miller BW, Lim AL, Lin Z, Bailey J, Aoyagi KL, Fisher MA, et al. Shipworm symbiosis ecology-guided discovery of an antibiotic that kills colistin-resistant *Acinetobacter*. Cell Chemical Biology. 2021. **[Samples provided by OGL]**
4. McManamay RA, Vernon CR, Jager HI. Global biodiversity implications of alternative electrification strategies under the shared socioeconomic pathways. Biological Conservation. 2021;260. **[OGL data]**
5. Jachowski D, Kays R, Butler A, Hoylman AM, Gompper ME. Tracking the decline of weasels in North America. PLoS One. 2021;16(7):e0254387. **[OGL data]**
6. Oliver RY, Meyer C, Ranipeta A, Winner K, Jetz W. Global and national trends, gaps, and opportunities in documenting and monitoring species distributions. PLoS Biology. 2021;19(8):e3001336. **[OGL data]**
7. Buffalo V. Quantifying the relationship between genetic diversity and population size suggests natural selection cannot explain Lewontin's Paradox. Elife. 2021;10. **[OGL data]**
8. Bonnamour A, Gippet JMW, Bertelsmeier C. Insect and plant invasions follow two waves of globalisation. Ecology Letters. 2021. **[OGL data]**
9. Sharifuzzaman SM, Rubby IA, Habib KA, Kimura S, Rasid MH, Islam MJ, et al. Annotated checklist of ponyfishes (Perciformes: Leiognathidae) from Bangladesh, the northern Bay of Bengal. Journal of Fish Biology. 2021. **[OGL data]**
10. Raxworthy CJ, Smith BT. Mining museums for historical DNA: Advances and challenges in museomics. Trends in Ecology & Evolution. 2021. **[OGL data]**
11. Toussaint A, Brosse S, Bueno CG, Partel M, Tamme R, Carmona CP. Extinction of threatened vertebrates will lead to idiosyncratic changes in functional diversity across the world. Nature Communications. 2021;12(1):5162. **[OGL data]**
12. Arfianti T, Costello MJ. The distribution of benthic amphipod crustaceans in Indonesian seas. PeerJ. 2021;9. **[OGL data]**
13. Qu J, Xu Y, Cui Y, Wu S, Wang L, Liu X, et al. MODB: A comprehensive mitochondrial genome database for Mollusca. Database (Oxford). 2021;2021. **[OGL data]**
14. Giannini TC, Acosta AL, Costa WF, Miranda L, Pinto CE, Watanabe MTC, et al. Flora of ferruginous outcrops under climate change: A study in the Cangas of Carajás (Eastern Amazon). Frontiers in Plant Science. 2021;12:699034. **[OGL data]**
15. Carmona CP, Bueno CG, Toussaint A, Trager S, Diaz S, Moora M, et al. Fine-root traits in the global spectrum of plant form and function. Nature. 2021;597(7878):683-7. **[OGL data]**
16. Lavender E, Fox CJ, Burrows MT. Modelling the impacts of climate change on thermal habitat suitability for shallow-water marine fish at a global scale. PLoS One. 2021;16(10):e0258184. **[OGL data]**

17. Goldsmit J, Schlegel RW, Filbee-Dexter K, MacGregor KA, Johnson LE, Mundy CJ, et al. Kelp in the Eastern Canadian Arctic: Current and future predictions of habitat suitability and cover. Frontiers in Marine Science. 2021;18. **[OGL data]**
18. Heberling JM. Herbaria as big data sources of plant traits. International Journal of Plant Sciences. 2021. **[OGL data]**
19. Xue T, Gadagkar SR, Albright TP, Yang X, Li J, Xia C, et al. Prioritizing conservation of biodiversity in an alpine region: Distribution pattern and conservation status of seed plants in the Qinghai-Tibetan Plateau. Global Ecology and Conservation. 2021;32. **[OGL data]**
20. Shirazi S, Meyer RS, Shapiro B. Revisiting the effect of PCR replication and sequencing depth on biodiversity metrics in environmental DNA metabarcoding. Ecology and Evolution. 2021. **[OGL data]**
21. Satterthwaite EV, Bax NJ, Miloslavich P, Ratnarajah L, Canonico G, Dunn D, et al. Establishing the foundation for the global observing system for marine life. Frontiers in Marine Science. 2021;8. **[OGL data]**
22. Reddy MM, Jennings L, Thomas OP. Marine biodiscovery in a changing world. In: Kinghorn AD, Falk H, Gibbons S, Asakawa Y, Liu J-K, Dirsch VM, editors. Progress in the Chemistry of Organic Natural Products. 116: Springer, Cham; 2021. p. 1-36. **[OGL mentioned]**
23. Sharifian S, Kamrani E, Saeedi H. Insights toward the future potential distribution of mangrove crabs in the Persian Gulf and the Sea of Oman. Journal of Zoological Systematics and Evolutionary Research. 2021;59(7):1620-31. **[OGL data]**
24. Ross RE, Gonzalez-Mirelis G, Lozano P, Buhl-Mortensen P. Discerning the management-relevant ecology and distribution of sea pens (Cnidaria: Pennatulacea) in Norway and beyond. Frontiers in Marine Science. 2021;8. **[OGL data]**
25. Chevalier M, Chase BM, Quick LJ, Scott L. An atlas of southern African pollen types and their climatic affinities. Quaternary Vegetation Dynamics – The African Pollen Database. London: CRC Press; 2021. p. 239-58. **[OGL data]**
26. Laeseke P, Martínez B, Mansilla A, Bischof K. Invaders in waiting? Non-equilibrium in Southern Hemisphere seaweed distributions may lead to underestimation of Antarctic invasion potential. Frontiers of Biogeography. 2021;13(4). **[OGL data]**
27. Daru BH, Davies TJ, Willis CG, Meineke EK, Ronk A, Zobel M, et al. Widespread homogenization of plant communities in the Anthropocene. Nature Communications. 2021;12(1):6983. **[OGL data]**
28. Strona G, Beck PSA, Cabeza M, Fattorini S, Guilhaumon F, Micheli F, et al. Ecological dependencies make remote reef fish communities most vulnerable to coral loss. Nature Communications. 2021;12(1):7282. **[OGL data]**
29. Davidson SC, Ruhs EC. Understanding the dynamics of Arctic animal migrations in a changing world. Animal Migration. 2021;8(1):56-64. **[OGL data]**
30. Staude IR, Pereira HM, Daskalova GN, Bernhardt-Romermann M, Diekmann M, Pauli H, et al. Directional turnover towards larger-ranged plants over time and across habitats. Ecology Letters. 2022;25(2):466-82. **[OGL data]**
31. Christianson LM, Johnson SB, Schultz DT, Haddock SHD. Hidden diversity of Ctenophora revealed by new mitochondrial COI primers and sequences. Molecular Ecology Resources. 2022;22(1):283-94. **[OGL mentioned]**
32. Sudo K, Maehara S, Nakaoka M, Fujii M. Predicting future shifts in the distribution of tropicalization indicator fish that affect coastal ecosystem services of Japan. Frontiers in Built Environment. 2022;7. **[OGL data]**
33. Bledsoe-Becerra YM, Whittaker IS, Horowitz J, Naranjo KM, Johnson-Rosemond J, Mullins KH, et al. Mitogenomics reveals low variation within a trigeneric complex of black corals from the

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APPENDIX B

Presentations

Presentations About OGL

1. Kutenplon N. Creating the Polar Genetic Resource Collection (PGRC) at OGL. Undergraduate Research Symposium Fall 2021; Zoom 2021-12-10.
2. Distel DL, Amsler C. Financial management plan for a biorepository. Antarctica Biorepository Workshop; Zoom 2022-02-04.
3. Fenuccio L. What's in the freezer? Undergraduate Research Symposium Spring 2022; Zoom 2022-06-22.

Presentations About OGL Applied Research

1. Wang P. DNA preservation: Can we combine the benefits of EDTA and ethanol? Undergraduate Research Symposium Fall 2021; Zoom 2021-12-10.
2. Shah P. Leveraging machine learning and statistics to enable fast on-site fish species identification. Research, Innovation, Scholarship, Entrepreneurship 2022; Zoom 2022-04-14.
3. Becker Y. Preserving DNA from marine animals: Experiments with EDTA and ethanol. Undergraduate Research Symposium Spring 2022; Zoom 2022-06-22.

Presentations About OGL Basic Research

1. Altamia MA, Lin Z, Schmidt EW, Haygood MG, Distel DL. Probing the global diversity of shipworm symbionts using genomic, metagenomic and cultivation-based methods. Boston Bacterial Meeting; Boston 2022-06-13.

APPENDIX C

Education & Outreach

- Coastal Ocean Science Academy (August 2021)
    - Impacts: Taught "Fish Forensics" workshop, presented OGL specimen show-and-tell, and provided content and materials for "DNA Bracelet" activity for 14 middle school students; taught "Snow Pea Extraction" and "Fish Forensics" workshops and presented on shipworms and the Alabama Undersea Forest to 12 high school students.
- Assisted with Field Trips (Fall 2021)
    - Impacts: Provided field identification assistance during field trips for 85 high school students; discussed the importance of biorepositories with 21 high school students.
- Ham radio event (September 2021)
    - Impacts: Hundreds of ham radio operators from around the world learned about the Alabama Undersea Forest research during the activation of the special FCC callsign W4U.
- Meet the Researcher Series (November 2021)
    - Impacts: OGL staff member Rosie Poulin and the Collections Assistant co-op discussed their work with OGL with 61 high school students for this series at Lynn Public Schools.
- Featured Educator Resource (November 2021)
    - Impacts: OGL was featured in the MSC Outreach educator resource "The Cornucopia of Genetics," distributed to 1,616 area marine educators.
- School to Sea (December 2021)
    - Impacts: Presented OGL's mission and research twice for the NU Marine Science Center's "School to Sea" program that reached more than 51 high school students in Lynn Public High Schools.
- Undergraduate Research Symposia (December 2021 and June 2022)
    - Impacts: Provided a forum for 9 undergraduate students from the MSC community to present their work to the MES/MSC community.

APPENDIX D

Media Mention Highlights

1. Dybas CL. Of Penguins and Polar Bears, Sponges, Shipworms, and Snails. BioScience. 2021;71(7):676-82.
2. Distel D. Ocean Genome Chat: What IS that? Crossman M, Weiss J, editors. Experience Magazine. Facebook. 2021-07-07.
3. Kutenplon N, Poulin R, Appiah-Madson HJ, Patterson M, Distel DL. Federal Communications Commission special event station (W4U) celebrating the Alabama Undersea Forest. NOAA Ocean Exploration and Research. 2021-09-02.
4. Piselli G. Ocean waves meet radio waves: HAM radio at the MSC. Between Northeastern Tides. 2021-09-15.
5. Crossman M. The ocean has more species than we can track, but these biologists are trying. Experience. 2021-11-10.
6. Imbler S. Finding a retirement home for 466 frozen flatworm fragments. The New York Times. 2022-03-08.

7. Botkin-Kowacki E. What happens to decades of deep-sea specimens when a scientist retires? They might not end up in the trash—anymore. News@Northeastern. 2022-03-21.
8. Ford ML. Her career was ending. What to do with her worm samples? Newser. 2022-03-27.
9. Thomsen I. The legacy of H. William Detrich is rising with the Antarctic tide. News@Northeastern. 2022-04-07.
10. Castañón L. What lurks in a drowned forest in Alabama? Nautilus. 2022-04-25.
11. Poulin R, Appiah-Madson HJ, Distel DL. A critical biodiversity resource may be in your own freezer: a call to action for genomic biodiversity conservation. GOBI Newsletter Summer 2022. 2022-06-24.

OGL News Briefs

1. Messner E, Appiah-Madson HJ, Distel DL. Meet OGL's new faces—and their new projects! OGL News Briefs. 2021-07-19.
2. Kutenplon N, Poulin R, Appiah-Madson HJ, Patterson M, Distel DL. Federal Communications Commission special event station (W4U) celebrating the Alabama Undersea Forest. OGL News Briefs. 2021-09-01.
3. Wang P, Appiah-Madson HJ, Distel DL. Nightmare fuel from the sea. OGL News Briefs. 2021-10-29.
4. Kutenplon N, Appiah-Madson HJ, Distel DL. Freezing Antarctic icefish in time. OGL News Briefs. 2021-11-16.
5. Kutenplon N, Appiah-Madson HJ, Poulin R, Distel DL. Public aquariums: More than just a fun day out? OGL News Briefs. 2021-12-22.
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7. Fenuccio L, Poulin R, Distel DL. OGL publishes a new paper—about itself! OGL News Briefs. 2022-02-24.
8. Fenuccio L, Appiah-Madson HJ, Distel DL. OGL's Genome Resource Rescue program in the NY Times. OGL News Briefs. 2022-03-09.
9. Fenuccio L, Distel DL. The wacky underwater world. OGL News Brief. 2022-05-19.

OGL YouTube Videos

1. Kutenplon N. Meet OGL's Collections Assistant. Ocean Genome Legacy's YouTube Channel. 2021-11-09.
2. Wang P. Meet OGL's Research Assistant Prince. Ocean Genome Legacy's YouTube Channel. 2022-05-13.
3. Fenuccio L. Meet OGL's Collections Assistant Lee. Ocean Genome Legacy's YouTube Channel. 2022-06-24.
4. Becker Y. Meet OGL's Laboratory Assistant Kira. Ocean Genome Legacy's YouTube Channel. 2022-06-30.