Photo credit: Carly McCall

Photo credit: Emily Pierce

Photo credit: Remy Gatins

Jonah crab (*Cancer borealis*), black sea bass (*Centropristis striata*), and Boston facelina (*Facelina bostoniensis*)—all native New England species—are having their genomes sequenced! All three species were deposited into the Ocean Genome Legacy Collection in FY23 as part of new collaborations with the Gloucester Marine Genomics Institute's Dr. Kate Castellano, incoming Northeastern University assistant professor Dr. Remy Gatins, and the Maine Center for Genetics in the Environment's Dr. Erin Grey.

OCEAN GENOME LEGACY

2023 Annual Report

If the world needs anything right now, it is good news. Today I am happy to share a few pieces of good news from OGL.

The first is OGL's progress in migrating our database to the **Arctos Collaborative Collection Management Solution**. Our database is the beating heart of OGL, so changing database platforms is something akin to a heart transplant. It is an extremely difficult, complicated, and delicate procedure, but when completed, the outcome will be a stronger, healthier OGL.

With this move, OGL joins a global community of museums, collections, and organizations that provides a collaborative environment for sharing data and data standards; curating and improving the quality of shared data; and forming strong links between catalog records, stored materials, users, depositors, and research outcomes. **The new platform will increase OGL's impact** by making all its data visible to the public in real time, reducing OGL's sample management workload, simplifying material requests, automating data uploads to global data aggregators, and making OGL's data more interoperable and searchable.

A second advancement is OGL's role in the formation of **Ocean Census**. Ocean Census is a new large-scale international collaborative science mission coordinated by the Nippon Foundation and Nekton, and dedicated to the discovery, taxonomic identification, and protection of marine species. The aim of Ocean Census is to develop and implement strategies and advanced technologies to **accelerate ocean species discovery, halt the ocean biodiversity crisis, and meet societal needs for sustainable development.** The project aims to name and describe 100,000 marine species in the next decade, and is expected to be the highest funded ocean biodiversity project ever to be undertaken. We anticipate that Ocean Census will be a valuable source of collaborators, ideas, biomaterials, exposure, and new funding for OGL.

Additionally, with an initial nomination and generous donation from Cell Signaling Technology, **OGL became a 1% for the Planet Environmental Partner** this year. This makes OGL eligible for donations from over 5,000 businesses that have pledged one percent of sales to support important environmental causes. With the help of our board members and friends, our aim now is to recruit more 1% for the Planet corporate donors to help support OGL's critical mission.

Finally, I want to congratulate OGL-affiliated Northeastern University professor Dr. Steve Vollmer for his group's groundbreaking research recently published in the journal *Science*. This new work **provides a powerful new genetic tool in the fight against white band disease,** which has decimated reef-forming corals across the Caribbean. Thanks to Dr. Vollmer's fantastic work—and to the generous support of OGL board members and donors who helped make this and other OGL-affiliated research possible—we can now begin to see new hope for the ocean's future.
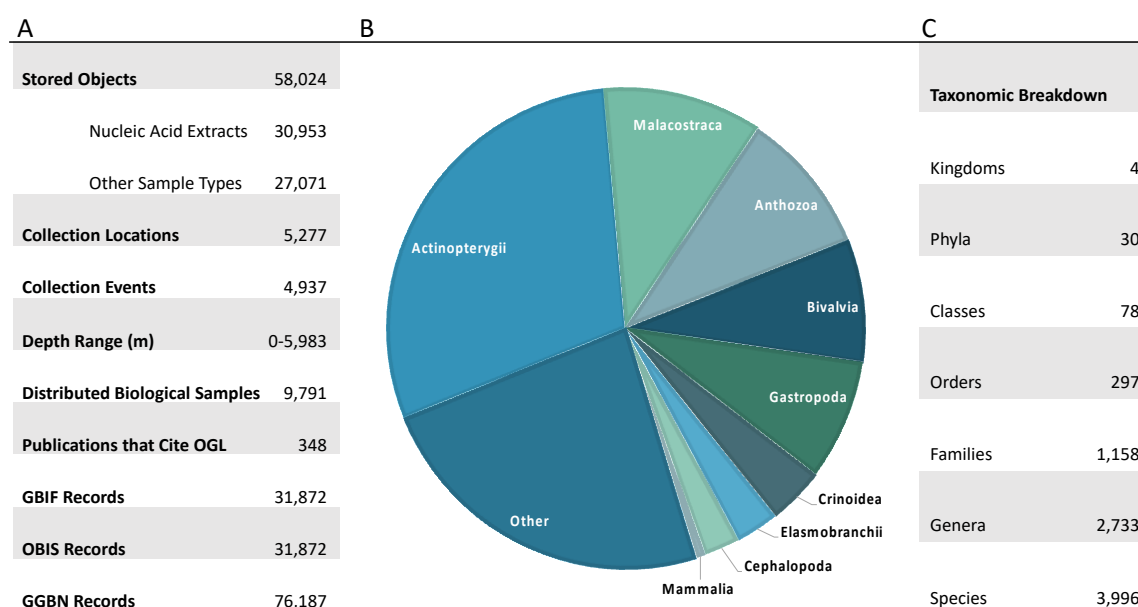
Sincerely,

Daniel L. Distel

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Please see FY2023 Annual Report Appendices to see Publications Citing OGL, OGL Samples, OGL Data, or OGL Authors (Appendix A), Presentations (Appendix B), Education & Outreach (Appendix C), and OGL in the Media (Appendix D).

OGL is the first non-profit, open-access, public DNA bank dedicated to preserving and sharing the DNA of all marine species. Our mission is to make the DNA of the sea widely available to support ground-breaking research in conservation, medicine, food production, biotechnology, and more.

OGL works with scientists and research institutions around the world to preserve and facilitate voluntary sharing of marine DNA and tissue samples, enabling discoveries that would not otherwise be possible, saving research dollars, and reducing the need for repeated sampling in environmentally sensitive locations.

As of October 2023, OGL holds >58,000 DNA and tissue samples from >5,200 locations, representing 4 kingdoms, 30 phyla, 1,158 families, and 3,996 species, including >1,600 samples from endangered and threatened species (Figure 1). OGL has provided >9,700 samples to researchers and >139,000 records for big data analysis, resulting in >356 publications to date.

A			B	C	
Stored Objects	58,024				
Nucleic Acid Extracts	30,953			**Taxonomic Breakdown**	
Other Sample Types	27,071			Kingdoms	4
Collection Locations	5,277			Phyla	30
Collection Events	4,937			Classes	78
Depth Range (m)	0-5,983			Orders	297
Distributed Biological Samples	9,791				
Publications that Cite OGL	348			Families	1,158
GBIF Records	31,872			Genera	2,733
OBIS Records	31,872				
GGBN Records	76,187			Species	3,996

Figure 1. The OGL Genomic Resource Collection. (A) Description of OGL holdings and products, including distributed biological materials and data. (B) Taxonomic ranks represented by stored objects held in the OGL Collection. (C) Proportion of stored objects in the OGL Collection by class. All data reflect the Collection as of October 12, 2023. GBIF, Global Biodiversity Information Facility; OBIS, Ocean Biodiversity Information System; GGBN, Global Genome Biodiversity Network.

HOW DOES OGL COMPARE TO OTHER GENOMIC RESOURCE COLLECTIONS?

OGL is one of 35 biorepositories contributing samples and data to the Global Genome Biodiversity Network, the largest network of genome resource collections in the world. Together, these collections house over 3.74 million DNA and tissue samples. As of October 3, 2023, OGL's collection ranks ninth among these repositories in total number of sample records. For comparison, OGL's genomic resource collection is twice as large as that of the Natural History Museum of London and one third the size of the Smithsonian National Museum of Natural History's genomic resource collection.

FY23 BIOREPOSITORY ACQUISITIONS, DISTRIBUTIONS, & USES

ACQUISITIONS

- **OGL acquired 4,566 samples (Figure 2A) from 23 countries**—Antarctica; Australia; Bermuda; Bonaire, Sint Eustatius and Saba; Brazil; Canada; Dominican Republic; Ecuador; France; Ghana; Guadeloupe; Guam; Indonesia; Japan; New Zealand; Philippines; South Africa; Spain; Sweden; Tonga; Trinidad and Tobago; United Kingdom; United States of America—and 4 ocean basins—Atlantic; Indian; Pacific; Southern (Figure 3).
- **OGL added 339 taxa, of which 133 are new to OGL** (Figure 2B).
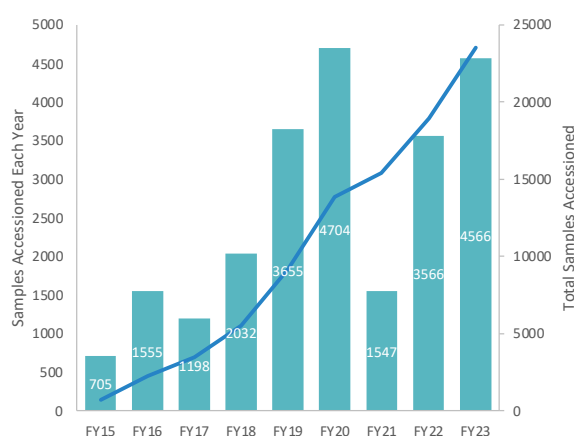
(A) Samples   (B) Taxa
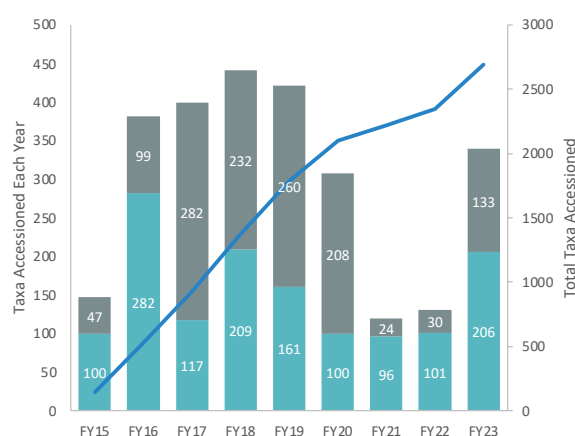
Figure 2. OGL collection metrics. (A) Samples and (B) taxa acquired by the OGL Collection over the past 9 fiscal years at Northeastern University (left axes). (A) Teal bars indicate the samples acquired by OGL. (B) Gray bars represent taxa new to the collection and teal bars indicate new representatives of taxa already in the collection. The blue lines track the cumulative growth of (A) samples and (B) taxa in the OGL Collection (right axes).

- ACCESSION HIGHLIGHTS: New accessions include legacy research collections from Ohio University's Dr. Lisa Crockett (Antarctic icefish samples), Northeastern University's Dr. Bill Detrich (Antarctic icefish embryos and DNA samples), University of Alabama at Birmingham's Dr. Chuck Amsler (Antarctic invertebrate specimens), and Northeastern University's Dr. Dan Distel (marine bivalves); tissues accessioned for genome sequencing projects from Northeastern University's Dr. Remy Gatins (black sea bass), Gloucester Marine Genomics Institute's Dr. Kate Castellano (Jonah crab), and Maine Center for Genetics in the Environment's Dr. Erin Grey (nudibranchs); Ghanaian fish and invertebrate samples from Sena Institute of Technology's Dr. Kwasi Agbleke; invertebrate and plant tissue samples from University of Arizona's Biosphere 2; invertebrate tissues and bacteria strains from the Alabama Undersea Forest.

Figure 3. Geographic distribution of OGL contributions (blue) and distributions (red) in FY23.

DISTRIBUTIONS

- **OGL made 68 distributions (Figure 4) to researchers from 6 institutions** in the United States of America and South Africa (Figure 3).
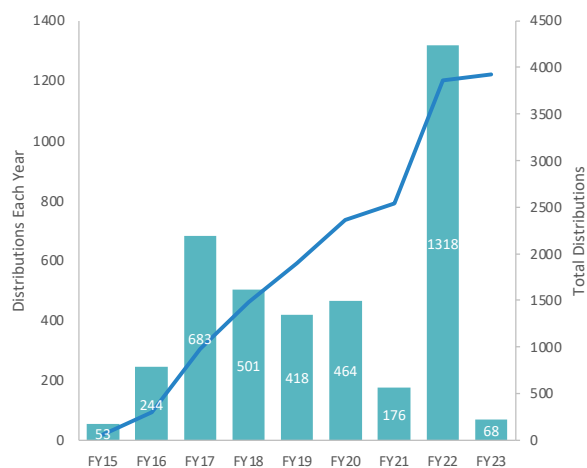
Figure 4. OGL distributions. Teal bars represent distributions from the OGL Collection over the past 9 fiscal years at Northeastern University (left axis). The blue line tracks cumulative distributions from OGL (right axis).

- DISTRIBUTION HIGHLIGHTS: OGL materials were used to build a reference library for environmental DNA (eDNA) studies; explore the hidden biodiversity of ctenophores (comb jellies); and to search for new antibiotics with activity against antibiotic resistant infections.

- OGL continues to see year-over-year increases in publications referencing OGL, driven in part by collection data made available on the Global Biodiversity Information Facility (Figure 5).
- **In FY23, 91 scientific publications** referenced OGL, OGL samples, OGL data, or OGL authors, including 76 peer-reviewed publications, 9 pre-print publications, 5 dissertations/theses, and 1 published dataset (Appendix A).
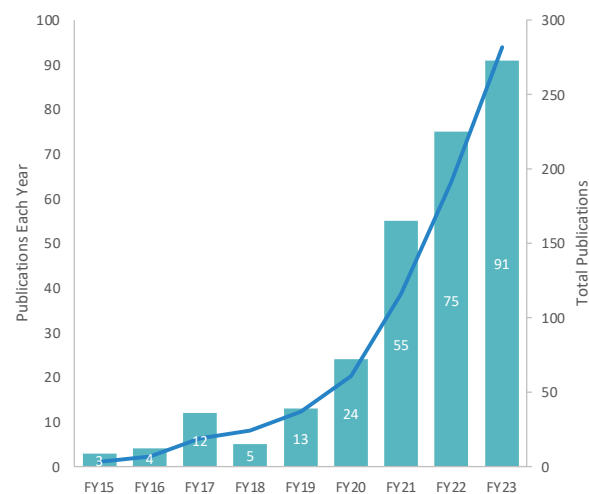

Figure 5. OGL citations in literature. Teal bars represent publications and reports referencing OGL, OGL samples, OGL data, or OGL authors over the past 9 fiscal years at Northeastern University (left axis). The blue line tracks cumulative publications referencing OGL (right axis).

DATA SERVED TO GLOBAL DATA AGGREGATORS

- OGL's data is widely used in research. **OGL currently serves 139,931 records** to the global data aggregators Global Biodiversity Information Facility (GBIF), Ocean Biodiversity Information System (OBIS), and Global Genome Biodiversity Network (GGBN; Figure 6).
- As of October 4, 2023, OGL's data have been included in >37,526 downloads via the GBIF data portal and used in 215 publications—including studies of biodiversity, invasive species, and climate change.
- Between January 1 and October 4, 2023, OGL's data have appeared in >33,343 downloads on the OBIS portal, with a total of >47,651,931 records downloaded.
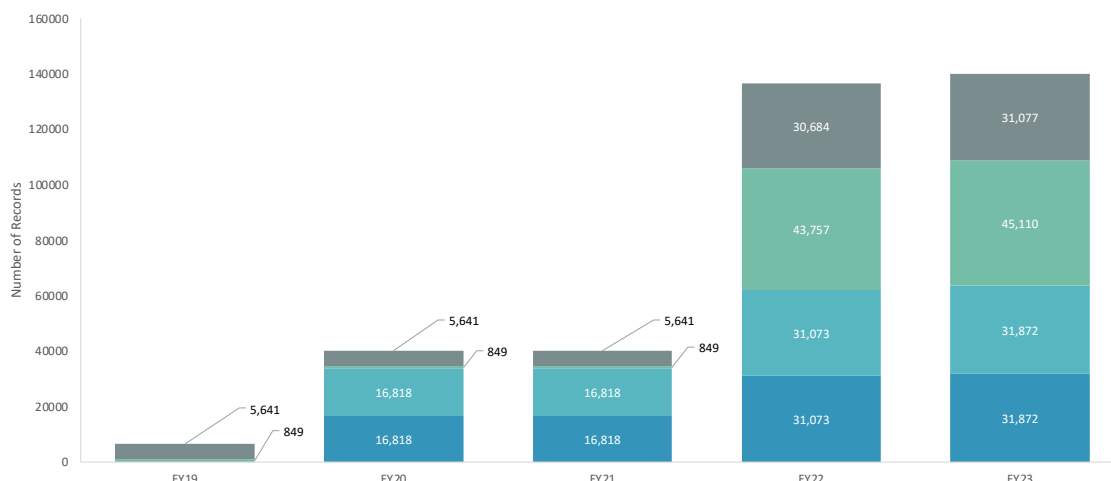
Figure 6. OGL data served to global data aggregators. Records served to data aggregators over the past 5 fiscal years. Blue bars represent specimen data served to the Global Biodiversity Information Facility, teal bars represent specimen data served to the Ocean Biodiversity Information System, and green bars represent sample data and gray bars represent DNA extract data served to the Global Genome Biodiversity Network.

FEE-FOR-SERVICE (DNA BARCODING)

- In FY22, OGL was contracted by the Gemological Institute of America to develop protocols for pearl identification by DNA barcoding. In FY23, OGL successfully extracted and barcoded samples from the powder of untreated cultured and natural pearls.
- In FY22, OGL was contracted by the Barnstable Clean Water Coalition for a crowdsourced DIY science project to study *Aurelia* (moon jellies) in Mashpee Bay. In FY23, OGL's work demonstrated that a moon jelly species related to *Aurelia aurita* is responsible for recent blooms of stinging jellyfish observed in the waters of Cape Cod. OGL published the barcode sequence for this as yet unidentified species to the Barcode of Life Datasystem.
- In FY23, OGL provided 185 DNA barcode sequences to collaborators.

OGL PUBLICATIONS, CONFERENCES, & PRESENTATIONS

PUBLICATIONS

- OGL authors contributed to **4 peer-reviewed publications and 1 editorial** in FY23.
- PUBLICATION HIGHLIGHTS: OGL's Student Research in DNA Preservation program published a study demonstrating the pH dependence of EDTA as a tissue preservative and describing a simple modification for improved DNA preservation in tissue (Appendix A, publication #40); OGL researchers solved a 175-year-old mystery in bivalve morphology and explained how shipworms transport bacterial enzymes from their gills to their guts to help digest wood (Appendix A, publication #22); OGL researchers and collaborators used 600 diverse OGL samples to explore the evolution of epigenetic gene regulation across the animal kingdom (Appendix A, publication #37); OGL samples contributed to an exploration of the microbial and metabolite diversity of the Earth's microbiomes (Appendix A, publication #28); OGL authors and colleagues presented a case

for a distributed Antarctic Biorepository Network in an editorial in *the Proceedings of the National Academy of Sciences* (Appendix A, publication #33).

CONFERENCES & PRESENATIONS

- **OGL staff and students presented at 7 meetings**—2 presentations described OGL, 8 described OGL applied research, and 2 described OGL basic research (Appendix B).
- **OGL staff attended 1 international and 2 national biorepository meetings and working groups** (Appendix B).
- PRESENTATION HIGHLIGHTS: 8 OGL student co-authors presented their research at the Northeastern University Research, Innovation, Scholarship, and Entrepreneurship Expo; OGL staff members Hannah Appiah-Madson and Rosie Poulin presented methodological advances in DNA preservation to the Society for the Preservation of Natural History Collections; Dan Distel presented OGL's work from the Alabama Undersea Forest as an invited speaker at Salem State University's Darwin Festival and at the University of Vienna.

PROJECTS & COLLABORATIONS

COLLECTION, DATA, & SAMPLE MANAGEMENT PROJECTS

ARCTOS COLLABORATIVE COLLECTION MANAGEMENT SOLUTION

Among OGL's most important concerns are securing the future of our genomic resource collection and increasing its global impact. To accomplish these aims, OGL employs the highest standards of collection, data, and sample management. Recently, after a thorough assessment of all available biodiversity data and sample management platforms, OGL elected to migrate its data management to the Arctos Collaborative Collection Management Solution (Figure 7). Arctos 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 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. On May 10, 2023, Northeastern University executed the Memorandum of Understanding for OGL's migration to Arctos.

Photo credit: Arctos Collaborative Collection Management Solution

Figure 7. The Arctos Collaborative Collection Management Solution facilitates improved data standards, automated data sharing with global data aggregators, and the formation of strong links between catalog records, stored materials, biogeographic location information, researchers, and research outcomes.

As the first genomic resource biorepository in the Arctos consortium, **OGL is now working closely with consortium members to develop standardized vocabulary and code tables to accommodate DNA data for all users of the Arctos Collaborative Collection Management Solution**. We expect to have all OGL records and data migrated to the Arctos system in 2024.

Our aims in joining Arctos are to:

- Increase the impact and accessibility of OGL's Collection to better support critical research in biodiversity, medicine, biotechnology, and global change.
- Streamline repetitive, labor-intensive tasks, allowing OGL to redirect resources and staff time to more productive activities.
- Improve and automate tracking of the physical locations of specimens, samples, and DNA extracts.
- Expand OGL's sample management capacity from tens of thousands to millions of samples.
- 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 future hires.
- Adopt a data management platform that is highly interoperable with other biodiversity and data initiatives.

OCEAN CENSUS

Surprisingly, 75–90% of the estimated 1–2 million species living in the world's ocean remain undiscovered and undescribed. To understand how the ocean works and what we can do to protect it, we first need to understand these missing species. To tackle this massive problem, OGL joined as a founding member in the formation of Ocean Census, an international scientific consortium dedicated to the discovery, taxonomic identification, and protection of novel marine species. Coordinated by the Nippon Foundation and Nekton, the aim of Ocean Census is to develop and implement strategies and advanced technologies to accelerate ocean species discovery, halt the ocean biodiversity crisis, and meet societal needs for sustainable development (Figure 8). Ocean Census aims to name and identify 100,000 marine species in the next 10 years. **We anticipate that Ocean Census will be a valuable source of collaborators, ideas, biological samples, exposure, and new funding for OGL.**
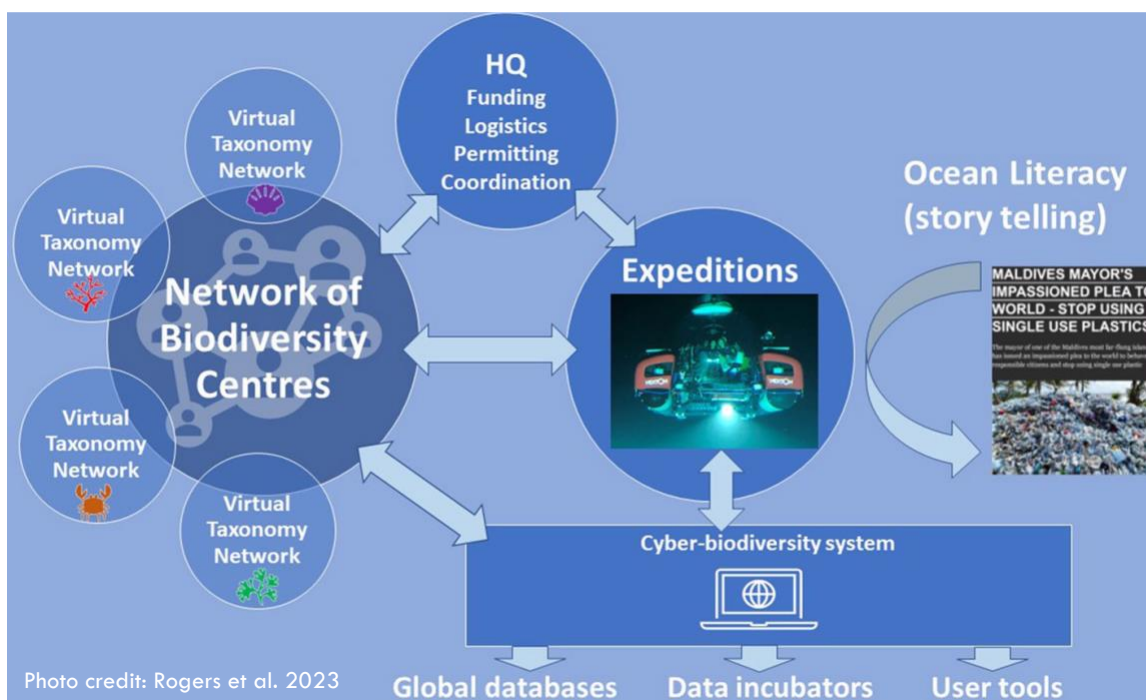

Figure 8. Ocean Census structure. The Ocean Census program envisions a network of biodiversity centers and virtual taxonomy networks enabling biodiversity researchers, taxonomists, and conservation advocates to cooperate and coordinate their activities globally.

SENA INSTITUTE OF TECHNOLOGY

Most of the ocean's biodiversity may be found in the waters of developing nations. Unfortunately, these are the very locations where the fewest resources may be available for species discovery and conservation. This is especially true of the African continent. To address this issue, OGL has established a collaboration with the Sena Institute of Technology (SIT) in Ghana.

SIT is a research organization dedicated to the intersection of biodiversity, culture, and science education in Africa. OGL's collaboration with this nascent organization was featured prominently in Northeastern University's Global Leadership Summit in Accra, Ghana in March 2023.

As part of its mission, SIT is building natural and cultural history collections to support African research and education. OGL is working with Dr. Kwasi Agbleke, co-founder of SIT, to establish the Sub-Saharan African Genome Repository (Figure 9). This collection, which is mirrored at OGL and SIT, currently contains 143 specimens, each with DNA extracts and tissues. Additionally, OGL has generated 127 DNA barcodes identifying 80 marine taxa among these specimens. These barcodes have been provided to Dr. Agbleke for documentation of Ghanaian biodiversity and for use in training students in DNA sequence analysis.
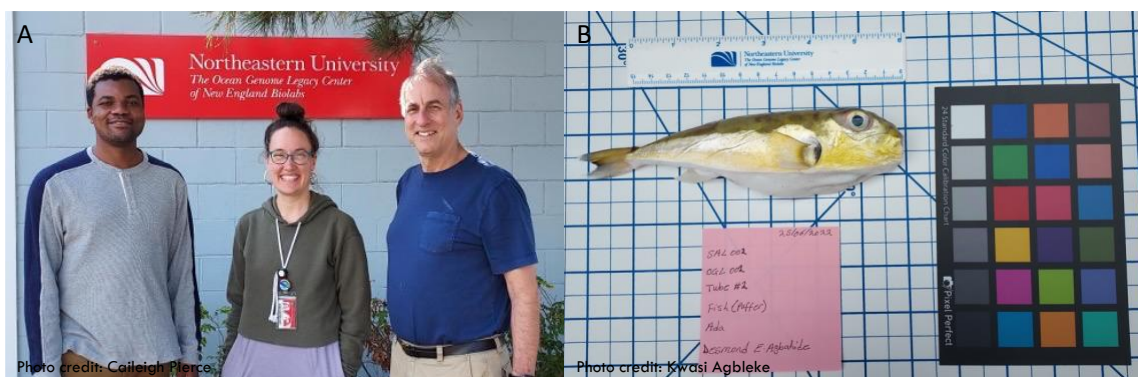
Figure 9. New Sena Institute of Technology and OGL Collaboration. (A) Dr. Kwasi Agbleke, Hannah Appiah-Madson, and Dan Distel at the Marine Science Center in Nahant, MA and (B) puffer fish collected by Dr. Kwasi Agbleke's team in Ada, Ghana and identified as *Lagocephalus* sp. by OGL.

Additionally, thanks to an award from the Francis Goelet Charitable Lead Trust—which covered replacement of OGL's ultracold freezers in FY22—OGL was able to donate one used ultracold freezer to SIT.

THE GENOME RESOURCE RESCUE PROGRAM

Among OGL's most successful initiatives is the Genome Resource Rescue (GRR) program, which aims to prevent the loss of valuable personal collections when researchers retire. OGL continues to expand the GRR collection, which now includes 7,888 tissue samples, 852 DNA extracts, and 153 DNA sequences contributed by 6 researchers prior to their retirements (Table 1). To date, these materials represent 3 kingdoms, 14 phyla, 25 classes, 65 orders, 145 families, 254 genera, and 288 species. OGL has also distributed a total of 1,457 tissue and DNA samples from these materials to other researchers.

GRR	PGRC	Legacy Collection	Taxa	Specimens	Samples	Extracts	Sequences	Distributions
		Bill Detrich	101	706	4,012	322	0	1,456
		Chuck Amsler	10	31	31	0	0	0
		Lisa Crockett	TBD	TBD	TBD	TBD	TBD	TBD
		Marian Litvaitis	104	466	466	465	153	0
		Chuck Fisher	156	2,140	2,273	18	0	0
		Dan Distel	130	314	1,106	47	0	1
Totals			**501**	**3,657**	**7,888**	**852**	**153**	**1,457**

Table 1. Genome Resource Rescue (GRR) program and Polar Genomic Resource Collection (PGRC) Accessions.

Receiving rescue collections is just the start. Once acquired, samples must be vetted in close cooperation with depositing PIs, associated with contextual data describing them, repackaged, relabeled, and finally accessioned into the collection. This work is ongoing with approximately 1,500 samples from two PIs slated to be processed in FY24.

Funding for the GRR program has been provided by an NSF Research Experience for Undergraduates (REU) award to Dr. Bill Detrich (subcontracted to OGL) and generous gifts from the Francis Goelet Charitable Lead Trust and Dr. Solomon Katz.

THE POLAR GENOMIC RESOURCE COLLECTION

Approximately half of the materials in the Genome Resource Rescue program have been contributed by Antarctic researchers. These samples comprise the Polar Genomic Resource Collection (PGRC), one of OGL's fastest growing special collections (Table 1). This collection was created in response to a logistical crisis in Antarctic research brought on by COVID-19, which shut down research in Antarctica for the past three years. NSF Polar Programs now recognizes that biorepository collections can provide materials to support Antarctic research when fieldwork is not possible. For this reason, Polar Programs began requiring new grant proposals to budget for depositing samples in publicly accessible collections within two years of project completion. To this end, OGL has created boilerplate language that researchers can use to designate OGL as their biorepository of choice when submitting grants to NSF Polar Programs. In his recently submitted NSF proposal, Dr. Chuck Amsler was the first to include this language requesting funding to support archival storage of reference samples to OGL. OGL anticipates that this strategy will help build the PGRC in coming years.
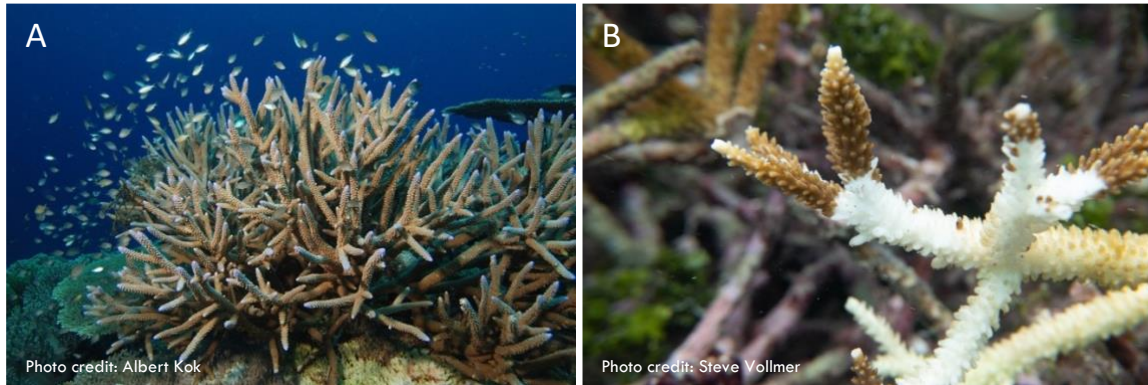
RESEARCH

CARIBBEAN CORAL DISEASE WORKING GROUP

In the past several years, white band disease has exploded across the Caribbean, killing a broad range of coral species and leaving a swath of destruction in its wake (Figure 10). **Now, groundbreaking research by OGL-affiliated Northeastern University Professor Dr. Steve Vollmer and his team provides a powerful new tool in the fight against white band disease.** In a landmark paper published recently in the journal *Science*, Dr. Vollmer reports that his research group sequenced the genomes of 76 staghorn coral genotypes and discovered that sequence data from just 10 genes can accurately predict disease resistance in both wild and nursery stocks of staghorn corals. This discovery has great potential to accelerate coral reef restoration efforts by showing conservation managers which stocks are most resistant to white band disease and which are most susceptible. Dr. Vollmer's research provides hope that similar methods can be used to help restore not only this critically important coral species, but other vulnerable corals as well.

Figure 10. (A) Staghorn corals were a dominant reef-building species in the Caribbean until they were (B) decimated by white band disease. New research gives scientists tools for coral restoration by predicting disease resistance among remaining corals.

ALABAMA UNDERSEA FOREST (AUF)

OGL recently completed the first biodiversity exploration of an ancient bald cypress forest that grew near the Gulf of Mexico during the Paleocene ice age approximately 60,000 years before present. As the ice age ended, sea level rose hundreds of feet, inundating and burying this ancient forest beneath the sea floor. Remnants of this forest, which now sits eight miles off the coast of Alabama and 60 feet beneath the sea surface, were recently uncovered by storm activity, creating an extraordinary undersea environment unlike any previously examined. Here are some highlights of this project's most important accomplishments.

AUF COLLECTIONS: 10 collections were conducted over the course of the AUF project, during which OGL collected 3,587 samples from 1,162 specimens including 896 animal and plant specimens and 260 unique bacterial strains. Collected individuals represent 11 phyla, 12 orders, 14 families, and a yet to be determined number of species. Among these, 25 bacterial species and 1 animal species have thus far been identified as new to science.

NEW ANIMAL SPECIES DESCRIBED: OGL researchers discovered and became the first to describe a new, never-before-seen species of marine mussel at the AUF site. Despite its tiny size—typically less than a centimeter in length—this new species is an ancient cousin of the giant thioautotrophic (sulfur-eating) mussels found at deep-sea hydrothermal vents.

What makes this discovery particularly exciting is that these mussels were found living at shallow depths (20 meters), yet they belong to a taxonomic group called Bathymodiolinae that was previously thought to be found only in the deep sea! All previously published records of this group are deeper than 100 meters, with 98% occurring between 200 and 4,000 meters.

This new species was found living on submerged wood (Figure 11), adding critical support to the "Wooden Steps" hypothesis, which proposes that bathymodiolin mussels evolved in shallow water on sunken or floating wood and that sinking wood acted as the "steppingstones" that introduced them to deep-sea hydrothermal vents. However, **until now, no shallow-water wood-associated bathymodiolin mussel had ever been discovered.** A new manuscript formally naming and describing this new genus and species, which we are calling *Vadumodiolus teredinicola*, is now in review for publication in the journal *Deep Sea Research*.

5 mm

Photo credit: Marvin Altamia

Figure 11. *Vadumodiolus teredinicola.* A new species of mussel discovered in wood from the Alabama Undersea Forest belongs to a deep-sea group (Bathymodiolinae) that has not been observed previously in shallow water. This tiny specimen (arrow) is just 5 mm in length.

CREATING AN AUF NATIONAL MARINE SANCTUARY: OGL's research is contributing to ongoing efforts to establish a national marine sanctuary at the AUF site. OGL is working with representatives of the Alabama Coastal Foundation and others to support the passage of the Alabama Underwater Forest National Marine Sanctuary and Protection Act.

STUDENT RESEARCH IN DNA PRESERVATION

OGL's student research program aims to perform cutting edge research in DNA preservation while providing intensive research training for undergraduate students. In FY23, this program continued to pioneer the use of the metal-chelating reagent EDTA to preserve high molecular weight DNA in tissue samples. This new preservative approach, which has many advantages over traditional methods, was first published by OGL staff and students in August 2020. In FY23, a second student co-authored manuscript was published showing that this preservative can be made even more effective by simply raising its pH from 8 to 10.

A third manuscript is now in preparation demonstrating a new use for EDTA as a transitioning agent for frozen tissue. Although freezing at ultracold temperatures (-80°C) is considered the gold standard for DNA preservation, our new research shows that DNA is often damaged during extraction from frozen tissue. Our results show that thawing frozen tissues into an EDTA solution can prevent this DNA damage. **This discovery can improve DNA recovery from millions of tissue samples stored in research freezers around the world.**

OGL's EDTA 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 applied for Northeastern University SPARK Fund awards and met with representatives of Northeastern University's Center for Research Innovation in FY23 to explore commercialization of products based on this discovery.

OGL's successful student research program has been funded by generous support from the Richard Lounsbery Foundation, Robert and Eileen Matz, and Cell Signaling Technology through its 1% for the Planet commitment. **This program remains a top priority for future OGL fundraising efforts.**

SEAFOOD IDENTIFICATION

Seafood mislabeling is a major problem for global food security as it defrauds consumers and hinders the management of fisheries—particularly those threatened by overfishing and climate change. A newly developed DNA-based seafood testing method called FASTFISH-ID has shown promise for inexpensive real-time, on-site identification of fish species. However, software that can provide accurate, quantitative, and statistically supportable analysis of FASTFISH-ID data are lacking. In collaboration with Northeastern University's Dr. Amy Mueller, OGL has developed and tested 6 analytical models for accuracy in identifying fish samples based on FASTFISH-ID data. These include both mathematical and machine learning approaches (Figure 12). OGL's best model achieved 92% accuracy over 185 replicates of 16 species. A manuscript describing this work is in preparation.
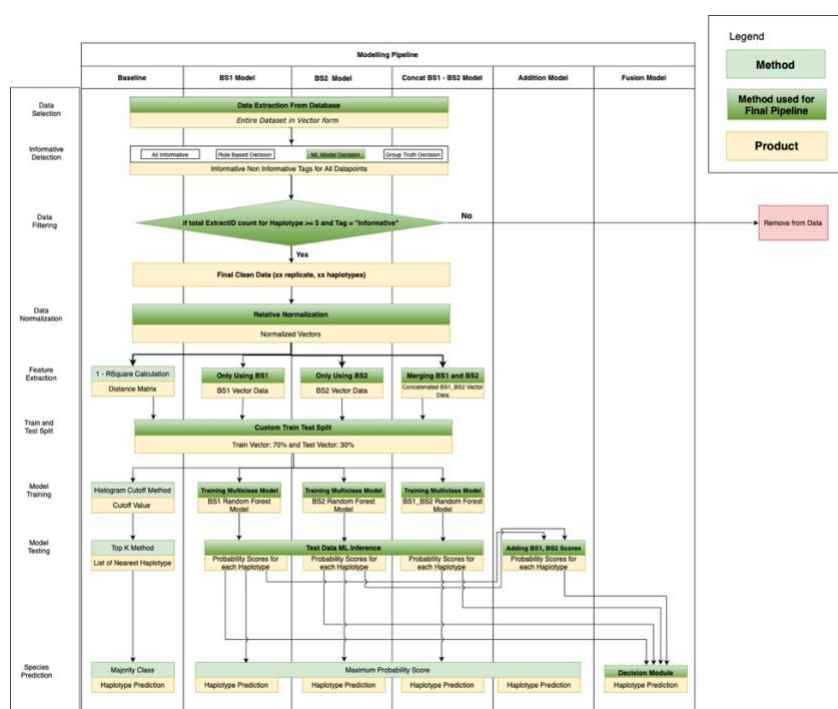
Figure 12. New analysis method for seafood identification. Flow diagram describing 6 analytical models for fish species identification based on FASTFISH-ID data.

OTHER NEW & CONTINUING PROJECTS

In FY23, OGL continued to participate in numerous projects and partnerships including with Proteus Ocean Group, Mission Blue, Gloucester Marine Genomics Institute, University of Utah, Johns Hopkins University Applied Physics Lab, the Golden Nugget Las Vegas, Maine Center for Genetics in the Environment, University of Oregon, University of Arizona (Biosphere 2), and Origin Bioscience, Inc.

EDUCATION & OUTREACH

STUDENT EDUCATION & TRAINING

- Undergraduate Students:
    - Don Comb Research Co-op in DNA Preservation: 2 students.
    - OGL Collections Assistant Co-op: 1 student.
    - Collections Assistant: 2 students.
    - Laboratory Assistant: 1 student.
- Master's Students:
    - Seafood Identification, in collaboration with Dr. Amy Mueller: 1 student.
    - NPM 6140: Grant & Report Writing in Northeastern University's College of Professional Studies Nonprofit Management Program: 1 student.

PUBLIC EDUCATIONAL OUTREACH

- Talks, demonstrations, and activities were presented at 29 outreach events including 2 undergraduate research symposia hosted by OGL and 5 tours for students and the public (Figure 13; Appendix C).
- OGL published 1 educational module to the OGL website (Appendix C) and posted 2 videos to the OGL YouTube Channel (Appendix D).
- Through OGL's collections assistant co-op position, which is now integrated with the MSC Outreach Program, 1,017 students, educators, and members of the general public were introduced to the OGL mission.
- IMPACT: Through all strategies combined, 1,511 students, educators, and members of the general public were introduced to OGL, learned about collections, and received hands-on training in scientific methods.
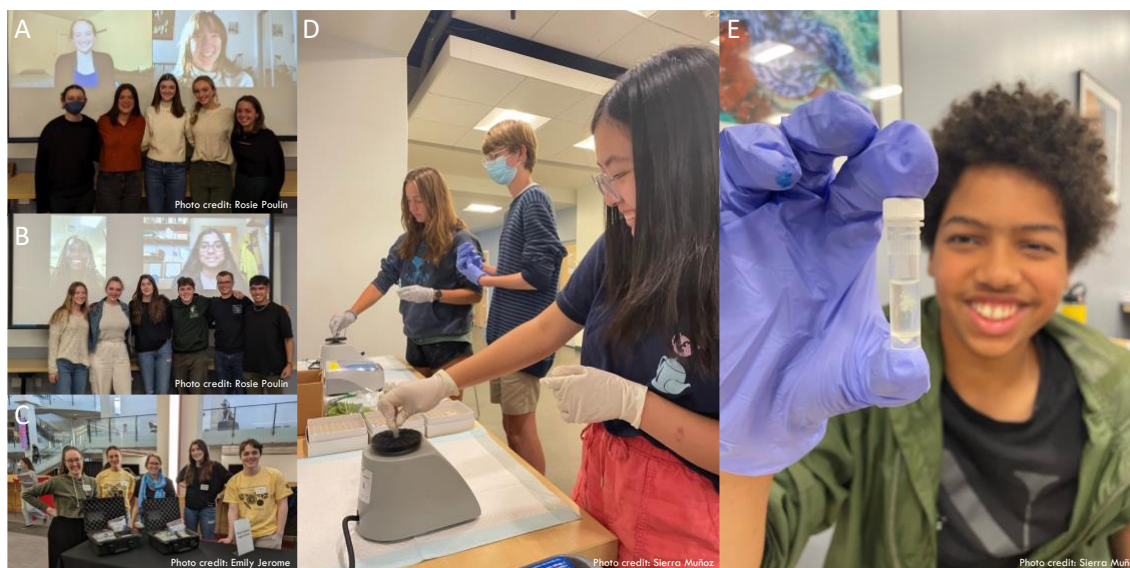
Figure 13. OGL outreach. OGL co-hosted 2 undergraduate research symposia for 15 undergraduate students in (A) December 2022 (B) and June 2023; (C) introduced >120 high school students to collections at the High School Marine Science Symposium; and (D and E) taught high school students how to extract DNA at Northeastern University's Coastal Ocean Science Academy.

FY23 PROGRESS TOWARDS GOALS

KEY PERFORMANCE INDICATORS

- Percent changes in sample contributions, requests, and citations:
  - Annual FY23 sample contributions increased by 28% from FY22.
  - Annual FY23 sample distributions decreased by 95% from FY22.
  - Annual FY23 citations increased by 21% from FY22.
- Media mentions at Northeastern University and beyond:
  - 5 mentions in media in FY23.