August 14, 2023

Atlantic Coastal Cooperative Statistics Program

1050 N. Highland St. Ste. 200 A-N Arlington, VA 22201

Dear ACCSP:

We are pleased to submit the proposal titled “Port Sampling for the Maine Atlantic Halibut Fishery” for your consideration. This is a New Project proposal that will collect new data streams to better inform halibut stock assessment.

During the initial pre-proposal review process, we were asked several questions. We will address them here and within the proposal where appropriate.

Question to all proposals: *There is no need for early funding for this proposal.*

1. How has the work from McBride been useful and what is the justification of building on that? Please provide more detail on how this would be used in management and stock assessments. How was the previous work used? – *Given that the McBride work was published just last year, there has not yet been an opportunity to incorporate this work into the halibut stock assessment. Additionally, given that the current assessment does not allow estimation of reference points such as Spawning Stock Biomass, it is currently index based. However, in the future if reference points were available, knowledge of the frequency and duration of skip spawning as calculated from gonad histology would be useful for informing actual estimates of SSB. More details are provided on page 6.*
2. PDF page 260: "is listed" is written twice in last paragraph - *corrected*
3. Budget
    a. Please provide a budget narrative – *added on page 10.*
    b. Explain why new equipment is needed as it appears this builds on previous work. Please provide justification – *New equipment is necessary to allow the DMR otolith lab to process additional otoliths from halibut, as the lab currently only has one otolith setup which is used to maximum capacity by existing projects.*
    c. Requested award amount on page 2 does not match the request in the budget (potential discrepancy) – *the amount listed on page 3 ($89,642.08) is equivalent to the sum of the amounts listed in the budget for ACCSP ($71,225.90) and DMR ($18,416.18) contributions.*
    d. Please calculate the percentage of in-kind. Please justify the relevance/need for conference travel/presentation to the successful completion of the project as it used in the in-kind contribution. – *in kind percentage is 26%, with further details on page 12. Travel will be covered by the department and is necessary to present results of port sampling and other halibut research projects; however, the exact venue/conference and*

staff involved could vary, as there are several flatfish-oriented conferences scheduled for the fall of 2024.

4. CV should not exceed two pages – *CV switched to two page resume*
5. Please include a summary of proposal for ranking – *added, see page 14.*

For a summary of the proposal for ranking purposes, please see page 14. Please contact William DeVoe at the MEDMR with any questions. Thank you for your consideration of this proposal.

Sincerely,
William DeVoe
Marine Resources Scientist III
William.DeVoe@maine.gov
(207) 592-7084

Proposal for Funding made to:
Atlantic Coastal Cooperative Statistics Program
Operations and Advisory Committees
1050 N. Highland Street, Suite 200 A-N
Arlington, VA 22204

Port Sampling for the Maine Atlantic Halibut Fishery

Submitted By:
William DeVoe
Maine Department of Marine Resources
PO Box 8
W. Boothbay Harbor, ME 04575

Applicant Name:	Maine Department of Marine Resources
Project Title:	Port Sampling for the Maine Atlantic Halibut Fishery
Project Type:	New project
Principal Investigator:	William DeVoe (Maine DMR)
Requested Award Amount:	$ 89,642.08
Requested Award Period:	For one year, beginning after the receipt of funds
Date Submitted:	June 13, 2023

Objective:

To improve the data on the stock structure and life history of Atlantic halibut by collecting otolith, maturity, genetic and morphometric data from halibut at dealer locations in Maine.

Need:

Atlantic halibut is an economically important species to many New England fishing communities but relatively little is known about its life history and stock structure. Atlantic halibut is managed by the United States and Canada as distinct stocks defined largely by the jurisdictional boundaries of each country (Shackell et al 2016). However, tagging data from multiple studies has shown that halibut migrate great distances and occupy waters of both countries. Additionally, recent genetic work has shown that Gulf of Maine, Scotian Shelf, and Grand Banks halibut are genetically homogeneous (Kess et al 2021). Halibut are listed as species of "Species of Concern" under the US Endangered Species Act; however, in Canada the fishery is certified as sustainable by the Marine Stewardship Council. A further cross-border disparity occurs in the legal size of halibut in the US vs Canada; in US waters, only halibut over 41 inches in length can be landed, while in Canada the minimum size limit is 32 inches. This dichotomy between management strategies necessitates further research be conducted to understand the nature of the Northwest Atlantic halibut stock.

Recent electronic tagging work conducted by Maine DMR has shown that halibut utilize multiple spawning areas ranging from the Northeast Channel in the Gulf of Maine to The Gully just south of the Laurentian Channel (where the Saint Lawrence River reaches continental margin). Spawning activity has been indicated by abrupt vertical rises of several hundred meters in archival depth time series during the December-February months. The location of the spawning activity has been determined using geolocation modeling and acoustic detections (Liu et al 2019, internal DMR research). Archival data has indicated that some halibut perform spawning rises for multiple subsequent years, yet others engage in skip spawning. This aligns with recent evidence of skip spawning from gonad histology (McBride et al 2022). Results from acoustic tags have indicated that some halibut migrate as far as The Gully and return to the Maine coast in the spring (internal DMR research). The results of this work have drawn further attention to the transboundary nature of Gulf of Maine halibut and the need for further studies on halibut stock structure.

The current assessment model used for Atlantic halibut is a data-poor approach called the First-Second Derivative model which is unable to produce biological reference points or support an analytical determination of stock status. To improve the assessment capabilities for halibut, research efforts are needed to increase the biological understanding of this data-poor species. Tagging produces estimates of movement patterns and spawning activity but provides no estimates of growth rates or stock structure. There is a need for updated age-length keys for halibut as well as maturity indices to inform a better stock assessment. In Maine, recent otolith work occurred as part of Julia Beaty's 2014 Master's thesis (Beaty 2014) and the work done by Richard McBride's team (McBride et al 2022), which also established methods to detect

indicators of spawning activity and maturity from gonad histology. The proportion of the stock that is sexually mature over time is an essential component of a stock assessment.

Atlantic halibut occupy a preferred temperature range that may make them vulnerable to climate change as the Gulf of Maine continues to warm; additionally, their spawning areas occur in regions that may experience shifting current conditions due to climate change, such as the Northeast Channel. This could result in changes in the distribution patterns of larvae. The dynamic nature of the Gulf of Maine in the face of climate changes means that there is a constant need for updated data on all marine species, including halibut, to assess if changes in the distribution, range and population structure of the species are occurring.

Results and Benefits:

There are many benefits to collecting more biological samples from halibut. Collecting otolith samples will allow further age estimates of halibut landed in Maine. This age data is crucial for estimating population structure, growth rates, and recruitment patterns, which are essential components of a stock assessment. Increasing the number of otolith samples would enhance the accuracy and precision of age determination, leading to more reliable stock assessments. Otoliths also provide information about the growth rates of individual halibut by measuring the distance between annuli. By sampling a larger number of otoliths, a more representative sample of the population and clearer picture of the species' life history traits will be obtained, which are vital for accurate stock assessment.

Gonad samples provide essential information about the reproductive potential of Atlantic halibut. Examining the size, maturity stage, and spawning indicators present in the gonads will provide insights into the reproductive health and potential of the population. This information is vital for estimating the reproductive output and the capacity of the Atlantic halibut population to sustain itself. Collecting more gonad samples would provide a larger dataset for assessing the reproductive potential, helping to identify any changes in reproductive patterns and potential impacts on population abundance. Specifically, gonad histology can reveal the proportion of landed halibut that are sexually mature. Previous work (McBride et al 2022) has shown that the proportion of sexually mature halibut is increasing as the stock is expanding and aging; further gonad histology samples would allow this proportion to be recalculated over time, to inform stock assessment biologists if the stock is truly expanding. Halibut is currently managed on a Plan B assessment that does not allow for the estimation of reference points; therefore, currently the assessment is index-based only (NOAA 2022). One of the reference points necessary for a full assessment is Spawning Stock Biomass (SSB). However, even if SSB is known, this number is better informed by knowledge of the frequency of skip spawning within the population.

Analyzing the genetic information contained within halibut samples can reveal valuable insights into the population structure of Atlantic halibut. Genetic markers can help identify distinct subpopulations, migration patterns, and levels of gene flow. Understanding the population structure is crucial for effective stock assessment, as it enables the identification of separate management units and helps estimate population size accurately. Increasing the number of

genetic samples would improve the resolution of genetic analysis, leading to a more comprehensive understanding of the population structure of Atlantic halibut on both sides of the US-Canada border. The analysis of these genetic samples is being funded and led by Fisheries and Oceans Canada, and only requires the collection of genetic samples during port sampling. Previous genetic work by Fisheries and Oceans Canada has revealed large scale trends in the genetics of Northwest Atlantic halibut; specifically, only the Gulf of Saint Lawrence halibut were shown to be a genetically distinct stock as compared with the Gulf of Maine, Scotian Shelf, and Grand Banks regions (Kess et al 2021). Further genetic samples will be used to examine close-kin relationships between sampled halibut, which will be valuable for examining geographic connectivity within the population. This information will eventually be useful in the assessment process for determining stock delineation.

Morphology is an understudied aspect of halibut biology. Seasoned halibut fishermen will often note physical differences between halibut captured ("skinny long black ones", "thick grey ones") and some claim to be able to determine the sex externally by the morphology. However only one study of halibut morphometrics occurs in the literature (Haug and Fevolden 1986). Image capture is a quick and effective method to capture multiple measurements from a single fish for morphometric analysis. Dealer locations are ideal for capturing these images, as the fish are deceased and on a stationary platform (vs an open boat). Analysis of halibut morphology may reveal patterns relating to sex, maturity, and origin that could be used to classify halibut from images instead of tissue samples. Recent work by the International Pacific Halibut Commission (IPHC) has discovered that halibut tail patterns can be used to identify individual fish (IPHC 2018); it is likely that other morphological markers relating to less-individualistic features (like sex and maturity) exist.

Halibut has a strong cultural and economic value in Maine, with participation by both commercial and recreational fishers. The fishery occurs at a time of year when lobstering has yet to pick up, and often provides needed income at a lean time of the year for fishing communities. The fishery in past years has produced $6 million of ex-vessel revenue in Maine. The State's halibut fishery is also one of the few remaining open-access fisheries in the Northeast. Continued sampling to monitor the halibut fishery and inform stock assessments is essential to maintaining this culturally and economically important fishery.

In addition to the better inputs for stock assessments created by the above data streams, there is also the intrinsic value beyond commercial exploitation gained by increasing our understanding of the halibut species. Studying halibut helps us better understand their ecological role and contribution to marine ecosystems. Halibut are a significant predator in their habitats and interact with numerous prey species, and gaining insights into their biology enhances understanding of the broader marine ecosystem.

Data from this program will directly address ACCSP's priorities in the Ranking Guide for *"Biological Sampling"*; additionally, Atlantic halibut is listed on the Biological Review Panel Recommendations Based on Matrix, ranking in the top 5 species among those that are present in Maine.

Data Delivery Plan:

Data collected will be entered into DMR's MARVIN Oracle database, which is the standard data store for many of DMR projects. Port sampling projects for several other fisheries in Maine already utilize this database.

All data collected as part of this project will be submitted to ACCSP for appropriate use by partner agencies.

Approach:

DMR staff will sample halibut from dealer locations during Maine's state halibut season. Maine's state halibut fishery represents a unique opportunity to efficiently collect biological information as Maine's season is short in duration (May-June) but has higher participation per day than the federal fishery leading to more fish being present at dealer locations. The primary dealers for halibut landings will be identified using past dealer data; these dealers will be solicited before the state season begins to discuss ideal times for scheduling sampling trips and will also be consulted throughout the season to optimize the sampling schedule. DMR will hire a halibut port sampling contractor whose primary job duty during the state halibut season will be obtaining halibut samples from dealers. The halibut biologist will also assist in this effort, as well as any other DMR sampling staff who may be available and willing. The port sampling contractor will also be trained on halibut otolith processing, otolith aging, histology, and image analysis.

Port sampling will collect several data elements to support better understanding of halibut biology. Total center line length will be taken for all halibut sampled. Additionally, an image of the fish over a scale grid will be taken for geometric morphometric analysis. Halibut will be examined for intact gonads, which are sometimes removed by harvesters. When available, the gonads will be removed for identification of halibut sex and maturity state; a sample will be taken from the gonads for further histological examination. Gonad samples will be grossed, stored in cassettes preserved in formalin, and sent to a commercial lab for histological sectioning and mounting on slides. Otoliths will be removed for aging post-season. Lastly, genetic samples will be taken for a Fisheries and Oceans Canada project examining Atlantic halibut genetics and close kin relationships. DMR currently collects genetic samples for this project opportunistically during electronic tagging trips and the Maine-NH Inshore Trawl Survey, and this project is expecting to continue soliciting samples until March 2025. Sex will be determined genetically for samples submitted for genetic analysis; this will be of benefit for samples where gonads were removed prior to the fish reaching the dealer, as no other method of sex determination will be available.

After the state season closes, the port sampling contractor and halibut biologist will work to process samples collected. Otolith samples will be sectioned, imaged, and aged in DMR's imagery lab. This proposal includes the purchase of additional equipment to support this effort,

including an otolith saw and imaging system. Additionally, all otolith images will be run through the DeepOtolith tool (Politikos et al 2022) and potentially other otolith processing models to examine the accuracy of automated aging models vs human age readers; this could potentially provide more innovative and economically methods for aging halibut otoliths in future projects.

Gonad samples will be imaged and examined to determine spawning condition following methods described in McBride et al 2022. This proposal includes costs for an external lab performing gonad histology, as well as the cost of a digital microscope for imaging gonad samples. Lastly, images of halibut will be analyzed to obtain morphometric measurements for subsequent analysis.

Results from the initial year of halibut port sampling will be disseminated in a final report to ACCSP. Additionally, the PI and DMR groundfish scientist will present results at the 2024 American Fisheries Society annual meeting. Results will also be shared with the New England Fishery Management Council's Groundfish Plan Development Team, as well as the halibut stock assessment scientist at the Northeast Fishery Science Center.

Geographic Location:

The geographic scope of this project will cover dealers from throughout coastal Maine. These locations represent the majority of Atlantic halibut landings in the United States. Between 2018-2022 the top five Maine ports for halibut landings were Portland, Machiasport, Port Clyde, Stonington, and Cutler.

Milestone Schedule:

Below is a schedule which outlines the work plan for halibut port sampling. Month 3 corresponds to March, which is the start of the ACCSP fiscal year.

	3	4	5	6	7	8	9	10	11	12	1	2
Prepare sampling data sheets/protocols	X											
Identify/interview primary halibut dealers	X											
Hire port sampling contractor		X										
Collect halibut samples from Maine ports			X	X								
Process samples including aging otoliths					X	X	X					
Semi-annual progress report							X					
Present results at AFS annual meeting							X					
Other exploratory analysis; automated otolith aging and morphometrics						X	X	X				
Final analysis of data from port sampling and draft final report								X	X	X		
Final report for first year of port sampling											X	

Project Accomplishments Measurement:

The following table outlines the project goals for the halibut port sampling program.

Project Goal	Measurement of Accomplishment
Collect samples from halibut dealers	Number of halibut sampled
Analyze otoliths to add to halibut age-length keys	Number of halibut otoliths analyzed
Analyze gonads to establish halibut sex and maturity level	Number of halibut gonads analyzed
Analyze images to examine halibut morphology	Number of halibut images analyzed
Communicate results of port sampling to scientific community	Presentation/poster at American Fisheries Society meeting
Communicate results of port sampling to inform management	Submission of final report to ACCSP, NEFSC, and Groundfish PDT

Budget Narrative:

Personnel and Fringe: The PIs time for 1 month of the year is included as an in-kind contribution. This includes both a 1/12 fraction of annual salary as well as fringe benefits. Benefits include retirement benefits, FICA, health insurance, dental insurance, workers compensation and life insurance.

Contracts: Two contracts are included. The first contract is for a 6-month contractor position that will assist in port sampling collection and subsequent processing of otoliths at the DMR lab. The second contract is for histological preparation of up to 300 gonad samples, with the expectation the amount collected may be less.

Travel: All travel costs associated with the proposal will be covered by the MEDMR as in-kind contributions. Travel costs include the cost of lodging and per diems during actual port sampling work, in addition to conference travel costs. Conference costs are estimated for the PI and MEDMR's groundfish biologist to attend the American Fisheries Society 2024 meeting to present results of this project and other relevant department research.

Capital Equipment: Included are the purchase of an additional otolith processing setup (saw and camera) as DMR's current otolith processing saw and camera are in full time use. A microscope for imaging gonad histological samples is also included.

Supplies: Includes a saw blade and fixture for the otolith saw, a camera setup for morphometric imaging, and various gonad/otolith sampling supplies like cassettes, formalin, and envelopes.

Cost Summary:

		ACCSP	DMR
Personnel:			
	Marine Resource Scientist III Salary 1 month	$0.00	$6,149.60
	Subtotal	*$0.00*	*$6,149.60*
Fringe:			
	Marine Resource Scientist III Benefits 1 month	$0.00	$2,106.58
	Subtotal	*$0.00*	*$2,106.58*
Contracts:			
	Temp Agency: Outdoor/Remote (4000 obj)	$22,140.00	$0.00
	Gonad Histology ($30/sample @ 300 samples max)	$9,000.00	$0.00
	Subtotal	*$31,140.00*	*$0.00*
Travel:			
	Conference - Registrations	$0.00	$500.00
	Conference - Airfare	$0.00	$4,000.00
	Conference - Lodging	$0.00	$2,000.00
	Conference - Meals	$0.00	$800.00
	Port Sampling - Ferry	$0.00	$100.00
	Port Sampling - Lodging (10 overnight trips)	$0.00	$1,200.00
	Port Sampling - Per Diem Meals (30 day trips + 10 overnights)	$0.00	$1,560.00
	Subtotal	*$0.00*	*$10,160.00*
Capital Equipment (>$5k):			
Indirect Waived	TechCut 4 Precision Low Speed Otolith Saw	$5,900.00	$0.00
	Otolith Camera Setup	$12,000.00	$0.00
	Leica S9i HD Digital WiFi Microscope on LED Stand	$5,300.00	$0.00
	Subtotal	*$23,200.00*	*$0.00*
Supplies (<$5k):			
	Saw Bone Fixture	$203.00	$0.00
	Saw Blades	$1,600.00	$0.00
	Camera/tripod for morphology images	$2,000.00	$0.00
	gonad/otolith collection and processing supplies	$2,000.00	$0.00
		$0.00	$0.00
		$0.00	$0.00
	Subtotal	*$5,803.00*	*$0.00*

Other:			
	Subtotal	*$0.00*	*$0.00*
	Total Subtotal	**$60,143.00**	**$18,416.18**
	Total Subtotal (Indirect Applied To)	**$36,943.00**	
	30% Indirect	**$11,082.90**	
	Total Costs (including indirect)	**$71,225.90**	**$18,416.18**
		ACCSP	**DMR**

In-kind contributions include:
Below is a list of in-kind contributions to this proposal from Maine DMR.

Item	In-Kind Contribution
William DeVoe (1 month of staff time)	$8,256.18
Port Sampling Travel Costs	$2,860.00
Conference Costs	$7,300.00

The total DMR contribution of $18,416.18 divided by the total ACCSP contribution of $71,225.90 equates to an in kind percentage of 26%.

Principal Investigator:
William DeVoe (Maine DMR)

References:

Armsworthy, Shelley L., and Steven E. Campana. 2010. "Age Determination, Bomb-Radiocarbon Validation and Growth of Atlantic Halibut (Hippoglossus Hippoglossus) from the Northwest Atlantic." *Environmental Biology of Fishes* 89: 279–95. https://doi.org/10.1007/s10641-010-9696-8.

Beaty, Julia M. 2014. "Assessing Growth and Habitat Preferences of Atlantic Halibut Off the Coast of Maine Using Biological Samples and Fishermen's Knowledge." Master's thesis, University of Maine Electronic Theses; Dissertations. 2110. https://digitalcommons.library.umaine.edu/etd/2110.

Haug, T., and S. E. Fevolden. 1986. "Morphology and Biochemical Genetics of Atlantic Halibut, Hippoglossus Hippoglossus (l.), From Various Spawning Grounds." *Journal of Fish Biology* 28 (3): 367–78. https://doi.org/10.1111/j.1095-8649.1986.tb05173.x.

Kess, Tony, Anthony L Einfeldt, Brendan Wringe, Sarah J Lehnert, Kara K S Layton, Meghan C McBride, Dominique Robert, et al. 2021. "A Putative Structural Variant and Environmental

Variation Associated with Genomic Divergence Across the Northwest Atlantic in Atlantic Halibut." Edited by Lorenz Hauser 78 (7): 2371–84. https://doi.org/10.1093/icesjms/fsab061.

Liu, Chang, Crista Bank, Michael Kersula, Geoffrey W Cowles, Douglas R Zemeckis, Steven X Cadrin, and Christopher McGuire. 2019. "Movements of Atlantic Halibut in the Gulf of Maine Based on Geolocation." *ICES Journal of Marine Science* 76 (7): 2020–32.

McBride, Richard, and George Maynard, Scott Elzey, Daniel Hennen, Emilee Tholke, Jocelyn Runnebaum, and Christopher McGuire. 2022. "Evaluating Growth Dimorphism, Maturation, and Skip Spawning of Atlantic Halibut in the Gulf of Maine Using a Collaborative Research Approach." *Journal of Northwest Atlantic Fishery Science* 53 (October): 57–77. https://doi.org/10.2960/j.v53.m736.

Atlantic halibut 2022 Management Track Assessment Report. *National Oceanographic and Atmospheric Association, National Marine Fisheries Service.* https://d23h0vhsm26o6d.cloudfront.net/3D_Atlantic_halibut_Update_2022_12_13_125850_2023-01-17-141555_gflt.pdf

Politikos, Dimitris V., Nikolaos Sykiniotis, Georgios Petasis, Pavlos Dedousis, Alba Ordoñez, Rune Vabø, Aikaterini Anastasopoulou, et al. 2022. "DeepOtolith V1.0: An Open-Source AI Platform for Automating Fish Age Reading from Otolith or Scale Images." *Fishes* 7 (3): 121. https://doi.org/10.3390/fishes7030121.

Shackell, Nancy L., Kenneth T. Frank, Janet A. Nye, and Cornelia E. den Heyer. 2016. "A Transboundary Dilemma: Dichotomous Designations of Atlantic Halibut Status in the Northwest Atlantic." *ICES Journal of Marine Science* 73 (7): 1798–1805. https://doi.org/10.1093/icesjms/fsw042.

Summary of Proposal for ACCSP Ranking

Proposal Type: New

Proposal Primary Program Priority and Percentage of Effort to ACCSP modules:

Biological Sampling (8 points): Halibut port sampling will collect otolith, maturity, genetic and morphometric data from a traditionally data-poor species. These data steams may eventually be used to inform and improve the stock assessment process. Atlantic halibut is a priority species as defined by the Biological Priority Matrix, ranking within the top 10 species in the upper 25% of the matrix.

Data Delivery Plan (2 Points): All port sampling data will be submitted to ACCSP.

Project Quality Factors:

Regional Impact (5 points): Halibut port sampling will cover the entirety of Maine, which is a significant portion of the stock within the Gulf of Maine. Additionally, all data collected will be made available to ACCSP for partner use.

Contains funding transition plan / Defined end-point (4 points): This project aims to collect halibut port sampling data for 2024. This project has multiple off roads depending on outcome, including ending the project or funding from other sources.

In-kind contribution (4 points): the partner contribution of 26% is listed on page 11, equating to 2 points.

Improvement in data quality/quantity/timeliness (4 points): This project will improve the quality and quantity of biological data available on Atlantic halibut by collecting otolith, maturity, genetic and morphometric data.

Innovative (5 points): Halibut port sampling will combine tried and true methods of biological sampling such as otolith collection with newer and more innovative methodologies such as morphometrics and genetic samples.

Impact on stock assessment (3 points): Halibut port sampling will collect information on age-length, length at first maturity, sex ratio, and skip spawning frequency. All of these are informative to a better stock assessment. Additionally, this project will collect genetic samples which may inform insights into the broader stock structure of halibut across the Northwest Atlantic.

Other Factors:

Properly Prepared (5 Points): MEDMR followed ACCSP guidelines and pertinent documents when preparing this proposal.

William L DeVoe
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Boothbay, Harbor, Maine
(207) 592-7084
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Education

Hartwick College, Oneonta, NY.
B.A. Biology

Work Experience

Maine Department of Marine Resources, West Boothbay Harbor, ME.

Marine Resource Scientist III: Spatial Scientist, Technology Coordinator, Atlantic Halibut Biologist, July 2022 – present.

Marine Resource Scientist II: GIS & Oil Spill Response Coordinator, Atlantic Halibut Biologist, June 2017 – June 2022.

Marine Resource Scientist I: Water Quality Scientist, March 2017 – May 2017.

Marine Resource Specialist II (AC): Shoreline Survey Project Leader, October 2017 – March 2017.

Marine Resource Specialist I: Water Quality Specialist, May 2016 – September 2016.

East West Technical Services LLC (EWTS), ports out of New England states. May 2010 – Jan 2013
At-sea monitor

University of Iceland, Hólar, Iceland. August – September 2009.
Lake Ecology Field Technician

Garcia and Associates (GANDA), San Clemente Island, California. June – July 2009
Island Fox Field Technician

National Park Service, Grand Canyon, Arizona. March – June 2009.
Mexican Spotted Owl Observer

US Fish & Wildlife Service, Ray Brook, NY. May – August 2006.
Biological Technician, Sea Lamprey Control

Technical Skills

Data Science and Programming:

- Proficient in the use of ArcGIS and R to produce maps and process geospatial data.
- Focused experience in R using the tidyverse, sf, and raster packages for geospatial analysis, and the Shiny and Leaflet packages for web application development.
- Experience developing R packages for internal agency use.
- Experience interacting with Oracle and MS SQL Server databases using SQL, as well as higher-level languages like Python and R.
- Basic experience with HTML/CSS/JS.
- Experience programming Arduino-compatible microcontrollers using C++, including base Arduino boards, Adafruit variants, and Particle boards.
- Experience designing and building Arduino-based data loggers and sensors for use in the marine environment.
- Experience using version control for project management and collaboration, including Git and GitHub.

Field skills:

- Experience in small boat handling and trailering and marine navigation.
- Experience performing surgery on marine fish (Atlantic halibut) to embed archival and acoustic tags.
- Experience deploying acoustic receiver arrays.
- Skilled in conducting field work in backcountry and offshore environments.
- Proficient with carpentry hand and power tools, maintenance of shop power tools, and restoration/sharpening of hand tools.
- Electrofishing (backpack and deepwater), gill-netting, otter trawls, plankton tows, radio tracking/telemetry, PIT tagging, blood drawing, game calling, spotting scopes, remote cameras, and various other wildlife/fisheries associated technologies.