Annual Report of the Massachusetts Marine Fisheries Institute

Period of Report: 1 July 2018 to 30 June 2019

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This report was prepared with materials contributed by the MFI Executive Committee with contributions from SMAST and DMF faculty, staff, and students. We are grateful for the efforts of the many students, staff, and faculty who have contributed to the numerous accomplishments of the MFI.

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Preface

The Massachusetts Marine Fisheries Institute (MFI) was established in 2002 through a Memorandum of Agreement (MOA) between the Massachusetts Department of Fisheries Wildlife and Environmental Law Enforcement's (later renamed the Department of Fish and Game) Division of Marine Fisheries and the University of Massachusetts Intercampus Graduate School of Marine Science and Technology (later renamed the Intercampus Marine Science Graduate Program). In March 2013, the partnership between the University of Massachusetts and the Commonwealth in fisheries research and education was reaffirmed in a revised MOA that designated the Massachusetts Division of Marine Fisheries (DMF) as the lead organization for the Commonwealth and the School for Marine Science and Technology (SMAST) at the University of Massachusetts Dartmouth as the lead organization among "University of Massachusetts campuses, divisions, and departments that may contribute to the Institute's mission."

The administrative structure, as well as policies and procedures of MFI, are consistent with University and Division policies and strategic plans. The MFI benefits from consultation with an Advisory Council "consisting of individuals with expertise appropriate to the MFI mission and appointed from faculty and academic leadership in the University of Massachusetts system and from stakeholder groups with interest in the mission of the MFI." A list of current Advisory Council members, Co-Chairs, and Executive Committee members is appended to this report (Appendix I).

This annual report for the 2018-2019 fiscal year is submitted as required by University policies for Centers and Institutes and as described in the most recent MFI MOA. The remainder of the report restates the goals and mission of the MFI and provides information as to how the MFI has accomplished its goals and mission, including descriptions of major programs and completed and continuing projects. Fiscal year financial reports are provided that identify the amount of total revenue received using the Integrated Postsecondary Education Data System (IPEDS) sources of revenue categories and total expenditures using the letter level categories of the University's Financial Reporting System (FRS). In addition, names are provided of all employees and consultants affiliated with each project associated with the MFI during the fiscal year as well as a list of all physical space occupied and used by the MFI.

Mission and Goals

The primary mission of the MFI is to "promote sustainable fisheries through scientific study to advance understanding and through the provision of timely information and guidance to protect, conserve, and manage Massachusetts and New England fisheries and their habitats in a manner that balances the economic, environmental, and cultural interests of the citizens of the Commonwealth." Goals include the following:

1. develop innovative and practical fisheries management applications contributing to scientific understanding, management, and economic growth and sustainability of our oceans and communities of Massachusetts that border on the ocean;
2. administer and conduct research projects involving faculty, professional researchers, technical staff, and graduate and undergraduate students from the five UMass campuses, multiple disciplines, and several coastal facilities;
3. promote sustainable fisheries by providing timely information, recommendations, and proposals for the conservation and management of Massachusetts marine and coastal resources.

Background

The MFI has an extensive record of independent scientific research applied to regional, national, and international marine fisheries with an emphasis on cooperative research between scientists and fishermen. The MFI also partners with the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service as well as other public and private research organizations and state and federal agencies. MFI research draws on the complementary resources from each partner, integrating the application of new scientific technologies, effective field research, and fishermen's expertise and experience.

The MFI conducts fisheries research that can be applied to decision support for fisheries management. This research is necessarily interdisciplinary and includes biology, physics, chemistry, oceanography, statistics, economics, social science, management science, and operations research. To be both scientifically sound and have application to management, this system involves the study of two fundamental and complex challenges – estimating fish abundance and characterizing the ocean environment. This comprehensive approach to resource assessment provides managers with a spatially and temporally adaptive framework for decision making.

MFI researchers have been highly productive in a variety of areas, including bycatch reduction, conservation engineering, population dynamics, stock assessment, survey methodology, and management research. In addition to MFI contributions to research, MFI has also been a vehicle for advancing graduate education in fisheries-related fields. This includes direct involvement by and support for students in MFI research and workshop activities, participation by DMF scientists in graduate and post-doctoral advising and development of courses, enrollment of DMF personnel in graduate programs, as well as other educational efforts.

In this report we describe the activities of major programs and associated projects that support MFI's mission, including publications, grants, student research topics, and presentations. Two types of research funding are represented, including grants directly to the MFI and grants that support collaborative DMF-SMAST research projects that support the MFI mission. Information about the personnel associated with each MFI project and the associated space is provided. Additionally, information about outreach and educational activities of the MFI and goals for the upcoming year are presented.



Program Descriptions

Bycatch Reduction and Conservation Engineering

The conservation impacts associated with bycatch and discards of non-target species in commercial fisheries range from the depletion of overfished and endangered species to the loss of ecological diversity. Fisheries scientists, managers, and industry members are challenged to determine strategies to mitigate the impacts of bycatch while maintaining sustainable commercial harvest levels. To meet our goals of promoting sustainable fisheries and developing innovative management applications, MFI researchers and managers have investigated a range of bycatch mitigation measures, including voluntary avoidance programs and gear modifications. Bycatch reduction research is collaborative by nature with an emphasis on working directly with members of the fishing industry to modify fishing practices and decisions. MFI has focused on the importance of bycatch mitigation through graduate courses, student theses and dissertations, cooperative research projects, peer-reviewed publications, and management recommendations.

River Herring Bycatch Avoidance Program

Since 2010, DMF and SMAST have partnered with mid-water trawl fishermen and Rhode Island bottom trawl fishermen to reduce river herring and shad bycatch independent of management action, aiding in the effort to rebuild river herring and providing fishermen with a tool to avoid area closures. The incidental catch of river herring (alewife and blueback herring) by vessels targeting Atlantic herring and mackerel has become a concern for their conservation. Though the direct effect of this bycatch on river herring populations is unknown, managers have created river herring catch limits. If river herring catch limits are reached, large areas of the Atlantic herring fishery, or the entire mackerel fishery, are closed. The MFI collaboration involves increased portside sampling, a near real-time information system on the location of bycatch events, and testing oceanographic features that can be used to indicate areas with a high probability of bycatch. The near real-time information system has positively influenced fishing habits and played a role in the ~60% decrease in total bycatch and 20% decrease in the bycatch ratio observed since the program began.

In addition to helping fishermen avoid exceeding bycatch limits, the project has greatly increased the data available to monitor river herring bycatch. Program coordinators are in constant contact with technical staff associated with the New England and Mid-Atlantic Fishery Management Councils (NEFMC, MAFMC), the Atlantic States Marine Fisheries Commission (ASMFC), the Greater Atlantic Regional Fisheries Office (GARFO), and the River Herring Technical Expert Working Group. The program was started with funding from the National Fish and Wildlife Foundation and continued with funding from The Nature Conservancy. Since 2015, portside sampling and bycatch avoidance work has been funded by the Atlantic Herring Research Set-Aside Program. A new grant from the Atlantic Herring Research Set Aside Program will continue the bycatch avoidance program through 2021 and potentially expand bycatch avoidance strategies to haddock. This grant will also help transition the state portside monitoring program to the federal government, potentially stabilizing funding and enhancing the long-term viability of the program. Additional funding from NOAA's Bycatch Reduction Engineering Program (BREP) has supported testing of oceanographic models to forecast high river herring bycatch areas for the Atlantic herring and mackerel fisheries.

Research Projects:

- "Maintaining and expanding bycatch avoidance strategies in the mid-water trawl Atlantic herring fishery" PIs: N.D. Bethoney (SMAST) and B.P. Schondelmeier (DMF); NOAA Atlantic Herring Research Set-Aside Program: $134,979; Award Period: 2/2019 – 12/2021.
    - The objective of this project is to continue and expand the bycatch avoidance program utilized by the mid-water trawl fishery to maximize utilization of target species while reducing bycatch of river herring.
- "Developing and testing a pelagic species distribution model to forecast river herring bycatch hotspots" PIs: N.D. Bethoney (SMAST), B.P. Schondelmeier (DMF), S. Turner (DMF), C. O'Keefe (DMF) and W. Hoffman (DMF); NOAA Bycatch Reduction Engineering Program: $116,789; Award period: 11/2017 – 1/2021.
    - The objective of this project is to test the utility of a forecasting model of river herring distribution to assist in reducing bycatch by the mid-water trawl fishery.

Conferences and Seminars:

- Schondelmeier, B.P. and N.D. Bethoney. River Herring Bycatch Avoidance Program in the Atlantic herring and mackerel fisheries. Atlantic Coastal Cooperative Statistics Program Bycatch Prioritization Committee Annual Meeting. Savannah, GA. February 2019.
- Bethoney, N.D. and B.P. Schondelmeier. River Herring Bycatch Avoidance Program in the Atlantic herring and mackerel fisheries. National Fish and Wildlife Foundation Fisheries Innovation Fund Fisheries Innovation Fund- Bycatch Reduction Webinar. December 2018.
- Bethoney, N.D., B. Schondelmeier, S. Turner, T. Lowery, A. Lisi, C. O'Keefe and W. Hoffman. Update on river herring bycatch projects. Massachusetts Marine Fisheries Institute Advisory Council Meeting. New Bedford, MA. November 2018.
- Bethoney, N.D. and B.P. Schondelmeier. Collective action as an aid to fisheries management: An example addressing bycatch in the northwest Atlantic mid-water trawl fishery. ICES Annual Science Conference. Hamburg, Germany. September 2018.

Brad Schondelmeier (DMF; right) reviewing electronic reporting protocols for the herring bycatch avoidance program aboard the F/V Western Venture.

Conservation Engineering

The partnership and collaboration between SMAST Professor Pingguo He's Fish Behavior and Conservation Engineering (FBACE) group and DMF's Conservation Engineering Project (CE) led by Dr. Mike Pol has a long history. These two teams share resources, knowledge, and experience to understand principles and mechanisms of fish behavior and fish capture processes for long-term sustainable exploitation of Massachusetts's fisheries resources. Together, they have co-authored more than ten peer-reviewed papers. Working both independently of each other and together, they apply fish behavioral knowledge to design fishing gears, methods, and devices to reduce bycatch, discards, and other unintended mortalities and collateral impact during fishing operations. Recent joint conservation engineering projects, funded through external competitive funding sources, include a deep look into the healthy Acadian redfish stock and how the fishery could be increased and maintained. This project was the basis of Dr. Pol's PhD dissertation with Dr. He serving as advisor. They also co-led a comprehensive support network for groundfish sectors, soliciting and advising crucial research needs as defined by fishermen. The groups have successfully developed cod-avoiding trawls based on knowledge of cod behavior while being herded into the net.

Drs. Pol and He have been long standing members of the ICES-FAO Working Group on Fishing Technology and Fish Behavior. Both are former chairs and current chairs of the working group or related groups. They collaborated to chair and host the most recent meeting in Shanghai in April 2019. This was the first time the meeting of global gear and fish behavior experts was held in China, and the MFI collaborators moderated sessions and made presentations on reducing abandoned, lost or otherwise discarded fishing gear. Over 100 attendees shared current knowledge on cutting edge topics. Drs. Pol and He will jointly edit the symposium volume which will be published in the scientific journal Aquaculture and Fisheries. Drs. He and Pol also continue to serve as scientific and gear advisors to the Joint MAFMC/NEFMC Northeast Trawl Advisory Panel, whose mission is to identify concerns about regional research survey performance and data, to identify methods to address or mitigate these concerns, and to promote mutual understanding and acceptance of the results of this work among their peers and in the broader community.

The FBACE-CE partnership supports graduate education opportunities with Dr. He collaborating with DMF staff to develop and teach courses on data collection techniques and field sampling methods, as well as Dr. Pol being appointed as an adjunct faculty member at SMAST and serving on graduate student theses committees. The partnership also includes mutual technical assistance in the form of equipment sharing and backups for expensive items including net mensuration sensors, electronic net measurement gauges, motion-compensated platform scales, and lowlight cameras. They also collaborate on technological development of electronic sampling equipment, and storage of large items.

Continued financial and administrative support from MFI for conservation engineering research has greatly enhanced the collaboration between CE and FBACE, profiting from the synergy that exists between the two groups and contributing to sustainable utilization of the Commonwealth's and national fisheries resources. The two groups submitted multiple research proposals to NOAA Fisheries, including developing an innovative trawl cod-end for capturing live fish to improve quality of trawl-caught fish and to reduce mortality of those fish discarded from trawls. The groups also submitted proposals to improve the quality of groundfish trawls by improvement of gear and handling to reduce discards and to assess survivability of escapees and discards. The groups continue to submit project ideas to create fishing opportunities for MA fishermen, and to enhance sustainability of coastal resources in the state.


Left: Dr. Mike Pol and Dr. Pingguo He tested a sorting grid inside of a fishing net to reduce bycatch of flounder. Right: Testing gear to increase utilization of Acadian redfish while reducing bycatch of non-targeted species.

Research Projects:

- "Off-bottom trawl: Complementary testing of off-bottom trawls to target Georges Bank haddock" PIs: M. Pol (DMF), P. He (SMAST), Gulf of Maine Research Institute, Capt. M. Phillips (F/V Illusion); NOAA Saltonstall-Kennedy Grant Program: $299,083; Award Period: 01/2017 – 12/2019.
    - The objective of this study is to demonstrate the effectiveness of off-bottom mid-water trawls to target Georges Bank haddock and redfish, including a comparison of an off-bottom trawl to a Ruhle trawl, and industry testing of an off-bottom trawl.

Graduate Students:

- Davis, Farrell, MS, "Selectivity of the scallop dredge"
- Politis, Philip, PhD "Understanding fish behavior and controlling trawl geometry to minimize variability in bottom trawl survey abundance estimates"
- Rillahan, Christopher, PhD "Applications of novel optical and acoustic technologies to improve understanding of fish behavior and ecology"
- Wilsterman, Margot, MS "Swimming ability of windowpane and yellowtail flounders"

Technical Reports:

- He, P., D. Davy, J. Sciortino, M.C. Beveridge, R. Arnason and A. Gudmundsson. (2019) Countering climate change: measures and tools to reduce energy use and greenhouse gas emission in fisheries and aquaculture. Impacts of Climate Change on Fisheries and Aquaculture, FAO Fisheries and Aquaculture Technical Report 627. p. 585.
- Eayrs, S., M. Pol, C. Glass, M.J. Knight, P. He, C.J. Ford, D. Murphy and P. Winger. (2018) Developing an ultra-low-opening groundfish trawl to avoid cod and ensure a prosperous inshore fishing fleet. Final Report to the Saltonstall Kennedy Grant Program, Award # NOAA-NMFS-FHQ-2015-200424.

Conferences and Seminars

- Pol, M. and P. He. One Fish, Redfish, Two Fish, Dead Fish: Unaccounted mortality can lead to stock misperception. American Fisheries Society Meeting. Atlantic City, NJ. August 2018.

Additional Bycatch Reduction Initiatives

DMF biologist Dr. Greg Skomal, in collaboration with SMAST Professor Steve Cadrin and graduate student Janne Haugen, are working on bycatch and discard estimates for porbeagle sharks in Northeast U.S. trawl and gillnet fisheries. Objectives for this study are to estimate discard to kept ratios and at-vessel mortality, identify bycatch hotspots, and estimate vertical vulnerability of porbeagle bycatch. The project will be included in Janne Haugen's PhD dissertation to be completed in 2020.

- Janne Haugen, PhD, "Management, conservation, and bycatch of North Atlantic porbeagle (*Lamna nasus*)"

SMAST graduate student Brooke Wright, under advisor Dr. Steve Cadrin, is collaborating with DMF Marine Science and Policy Analyst Dr. Cate O'Keefe to complete a review of the Scallop Bycatch Avoidance Program as a chapter of her PhD dissertation. The goal of the review is to examine the effectiveness of a voluntary avoidance program under changing management actions and determine how fishermen use fishery-dependent data in business decision-making.

- Brooke Wright, PhD, "Fishery dependent data for stock assessments, fishery management, and maximizing yield"

DMF biologists Micah Dean, Bill Hoffman, Matt Ayer and Greg DeCelles are collaborating with Dr. John Mandelman and Emily Jones from the New England Aquarium, Rutgers Professor Doug Zemeckis, and Emily Keiley from GARFO to develop a bycatch avoidance tool for Gulf of Maine cod in the recreational fishery. Observations from DMF's Gulf of Maine Cod Industry Based Survey are being combined with environmental data to create spatially resolved maps of cod and haddock distribution in the Gulf of Maine. The primary objective is to develop simple, monthly fishery guidance maps that provide recreational fishermen with spatially specific information to avoid high bycatch areas.

Drs. Cate O'Keefe (DMF) and Dave Bethoney (SMAST) serve on NEFMC's Scallop Plan Development Team and work collaboratively with Dr. Greg DeCelles (DMF) who serves on the Groundfish Plan Development Team. Together they have proposed measures to reduce flatfish bycatch in the scallop fishery with modified gear configurations, time/area closures, and stock assessment review.

Surveys

Estimating fish abundance and characterizing the ocean environment are critical components for managing sustainable fisheries and contributing to scientific understanding, management, and economic growth and sustainability of our oceans and communities of Massachusetts. MFI conducts a variety of resource surveys aimed at managing both state and federal fisheries, including the annual DMF coast wide bottom trawl survey, resource-wide scallop video survey, Gulf of Maine cod Industry-Based Survey, ventless trap and suction lobster surveys, and open cod-end video survey for groundfish. MFI researchers have collaborated with members of the fishing industry and other organizations to develop innovative sampling tools that minimize impacts on ocean resources and utilize fishing vessels as research platforms. Information collected from the range of MFI surveys is used regionally by NOAA and NEFMC to inform stock assessments, fisheries allocations, and focused research questions. Most recently, MFI has expanded the application of surveys to collect baseline information from wind farm lease areas and monitor impacts of offshore energy development.

Alternative Groundfish Surveys Using Advanced Video Imaging Technology

The MFI developed a groundfish survey implementing technology that combines traditional fishermen's knowledge with advanced video imaging techniques. The objective is to explore and develop a non-intrusive, efficient survey to investigate the abundance, spatial distribution, and size structure of the groundfish stocks. The survey started in 2013 and 16 surveys have been completed to date; nine on Georges Bank and seven in the Gulf of Maine. This year, research focused on Gulf of Maine Atlantic cod, conducting research cruises on Stellwagen Bank and exploratory tows on Jeffreys Ledge in January and April 2019 (Figure 1), which was funded by the Commonwealth of Massachusetts. We also repeated our survey of yellowtail flounder in the southern portion of Georges Bank in October 2018 and April 2019 (Figure 2) with additional fishing industry funding.

Area swept abundance and biomass estimates were derived from each survey for the species of interest, Georges Bank yellowtail flounder and Gulf of Maine Atlantic cod. The efficiency of the survey net has not been investigated to date. Therefore, our calculations are highly conservative because they assume that the survey net can catch 100% of the fish that are within the path of the trawl doors (i.e., the net has 100% herding and capture efficiency). Area swept abundance and biomass estimates for the species of interest were calculated using closed tow collections for the Georges Bank surveys and a combination of open and closed tow collections for the Gulf of Maine surveys.

From the surveys conducted we have seen a substantial drop in abundance and biomass for Gulf of Maine Atlantic cod (Table 1) and Georges Bank yellowtail flounder (Table 2). For Gulf of Maine Atlantic cod the winter 2017 survey had the highest abundance and biomass estimates while the latest survey during spring 2019 had the lowest. For Georges Bank yellowtail flounder the fall 2014 survey had the highest abundance and biomass estimates while the latest survey during spring 2019 had the lowest. As fishing pressure has been reduced for both species, other factors may result in the shown decline.

The "video survey" involves local fishermen using industry vessels and a local fishing gear manufacturer. The survey fully utilizes SMAST's strength in field video equipment operations, imaging analysis, spatial statistics, and stock assessment. Two MS students graduated in 2018, both utilizing the data obtained from the video trawl survey. Travis Lowery focused on Georges Bank yellowtail flounder, and Nick Calabrese focused on Gulf of Maine cod. Continued support for this non-capture, ecosystem-based sampling effort is essential to provide alternative assessment for critical groundfish species.

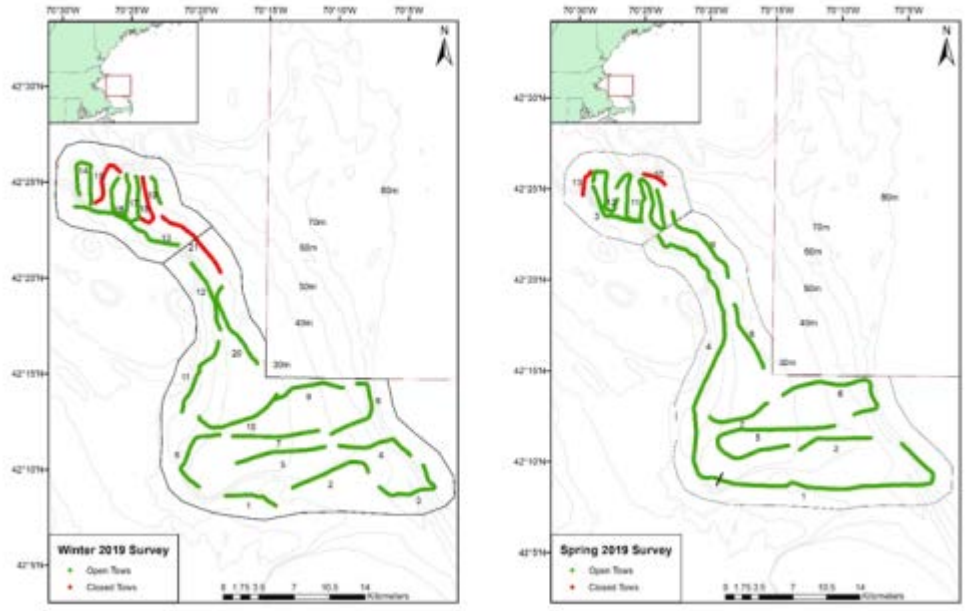


Figure 1. Location of open and closed cod-end trawl tows that were completed during the winter 2019 (left) and spring 2019 (right) Gulf of Maine surveys. Closed cod-end tows are indicated in red and open codend tows are indicated in green. The size of the study area footprint was 536 km^2 and 548 km^2 for the winter and spring surveys, respectively, depicted by the the black boundary line.

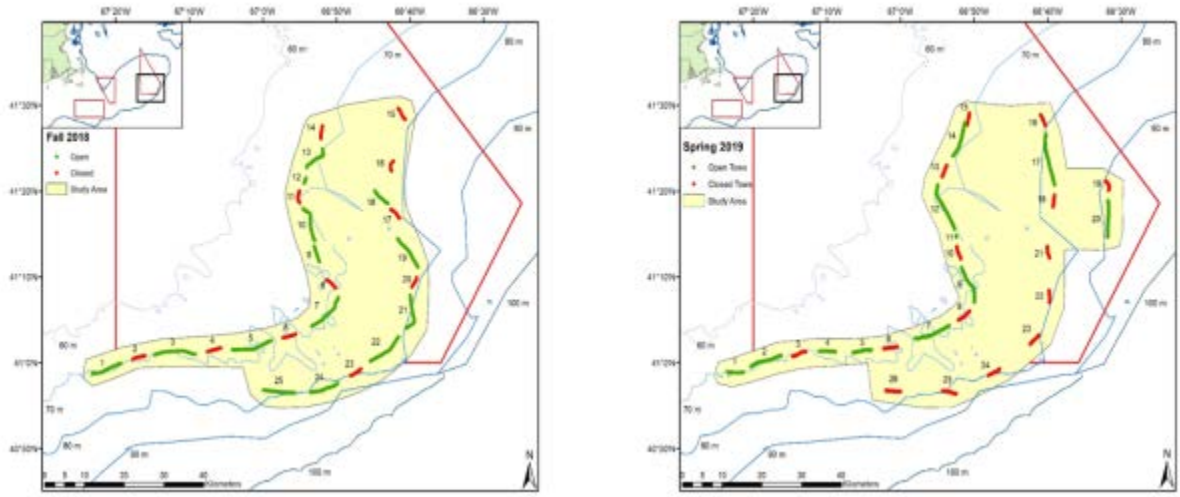


Figure 2. Location of open and closed cod-end trawl tows that were completed during the fall 2018 (left) and spring 2019 (right) Georges Bank surveys. Closed cod-end tows are indicated in red and open codend tows are indicated in green. The size of the study area footprint was 2,320 km^2 and 2,603 km^2 for the fall and spring surveys, respectively, depicted by yellow boundary area.

MFI researchers are currently exploring methods to integrate the data from the open cod-end video trawl survey to an automated algorithm developed by CVision AI. The cod counting algorithm currently consists of four parts: object detection, tracking, counting, and classification. The object detector finds any fish in each video frame and defines a bounding box around them. The tracking algorithm is loosely based on an algorithm that uses constrained Kernighan-Lin with joins (CKLJ) to solve a graph with weights assigned using a bidirectional gated recurrent unit (GRU). This algorithm works by iteratively

joining "tracklets" of increasing length and with greater temporal gaps between them. The counting algorithm determines whether a track is entering the frame and should be counted, or if it has already entered the frame and should be ignored. This algorithm accepts the track's motion features as input and uses a sequence classification algorithm on both the beginning and end of the motion sequence to decide whether the track should be counted. The classification algorithm determines the species of each track. It uses appearance features and inputs them into a sequence classification algorithm for only the first part of the track when the fish is closest to the camera.

Once classification of the tracks is complete, a threshold is applied that yields a precision of ~85% and recall of ~95%. Tracks that are not cod or flatfish are discarded, and false positives in the remaining dataset may be corrected by an analyst. The algorithm is deployed on a GPU cluster with a web interface for hosting videos, executing the algorithm, and analyzing/correcting algorithm outputs. Future work may include fine tuning the algorithm on data generated from correcting false positives, optimizing the code base to increase execution speed, and breaking the algorithm into multiple containers so that it will only execute on GPU nodes when needed. To meet the fast turnaround needs of the survey, the computer infrastructure may be improved by expanding the GPU cluster with additional nodes/GPUs, and/or by hosting models using a server so that multiple smaller networks may be executed concurrently on the same GPU. The web application for analysis may also be improved to do more complex data analysis, such as population distribution maps.

Table 1. Atlantic cod catch from open and closed cod-end tows during the seven completed surveys in the Gulf of Maine. Open tows were incorporated in the estimate with a length-weight equation using fish lengths from the closed tows. The area swept abundance and biomass estimates for cod were completed using doorspread.

Year	Season	Dates	Tows	Study Area (km^2)	Mean Cod Catch (number/tow)	Cod Abundance	Cod Biomass (mt)
2016	Winter	1/6-1/10	18	270	237	264,453	345
2017	Winter	1/9-1/14	27	491	171	279,704	405
2017	Spring	4/3-4/9	20	351	234	218,579	360
2018	Winter	1/9-1/16	26	596	13	14,842	33
2018	Spring	4/3-4/10	27	596	44	43,611	71
2019	Winter	1/4-1/11	22	536	6	8,366	9
2019	Spring	4/1-4/8	15	548	4	3,340	3
Average			22	484	101	118,985	175

Table 2. Yellowtail flounder catch from closed cod-end tows during the nine completed surveys on Georges Bank. The area swept abundance and biomass estimates for yellowtail were completed using doorspread.

Year	Season	Dates	Closed Tows	Study Area (km^2)	Mean YT Catch (number/tow)	YT Abundance	YT Biomass (mt)
2013	Fall	11/8-11/13	8	1,483	249	2,132,402	870
2014	Spring	4/4-4/11	15	1,908	91	935,450	517
2014	Fall	10/19-10/23- & 10/30-10/31	17	2,709	195	3,557,232	1,252
2015	Spring	5/14-5/20	38	2,900	31	579,368	207
2015	Fall	10/13-10/20	8	2,396	129	1,954,306	701
2016	Spring	4/10-4/15	8	2,365	82	1,207,437	477
2016	Fall	10/14-10/20	12	2,778	67	1,220,960	489
2018	Fall	10/18-10/24	11	2,320	39	591,767	282
2019	Spring	4/24-4/30	15	2,603	19	294,593	150
Average			15	2,385	100	1,385,946	549

Research Projects:

- "Alternative groundfish surveys using advanced video imaging technology" PI: K.D.E. Stokesbury (SMAST); Commonwealth of Massachusetts Marine Fisheries Institute – Division of Marine Fisheries: $400,000; Award Period: 7/2018 – 6/2019.
- "A new groundfish survey technique with an emphasis on the Gulf of Maine Atlantic cod" PI: K.D.E. Stokesbury; Commonwealth of Massachusetts Marine Fisheries Institute - Division of Marine Fisheries: $400,000; pending.
    - The objective of these projects is to continue the development and utilization of the open cod-end video trawl survey to assess fishery resources, specifically Atlantic cod in the Gulf of Maine and yellowtail flounder on Georges Bank.

Graduate Students:

- Calabrese, Nicholas, PhD, "Combining mark-recapture techniques with new technology to improve population estimates"

Primary Publications:

- Stokesbury, K.D.E., N.M. Calabrese and T.M. Lowery (in review) Windowpane Flounder seasonal distribution and survey availability on the southern portion of Georges Bank, USA.

Technical Reports:

- Stokesbury K.D.E., T. M. Lowery and N.M. Calabrese (2019) 2018-2019 Groundfish video trawl survey. Report to Massachusetts Marine Fisheries Institute.

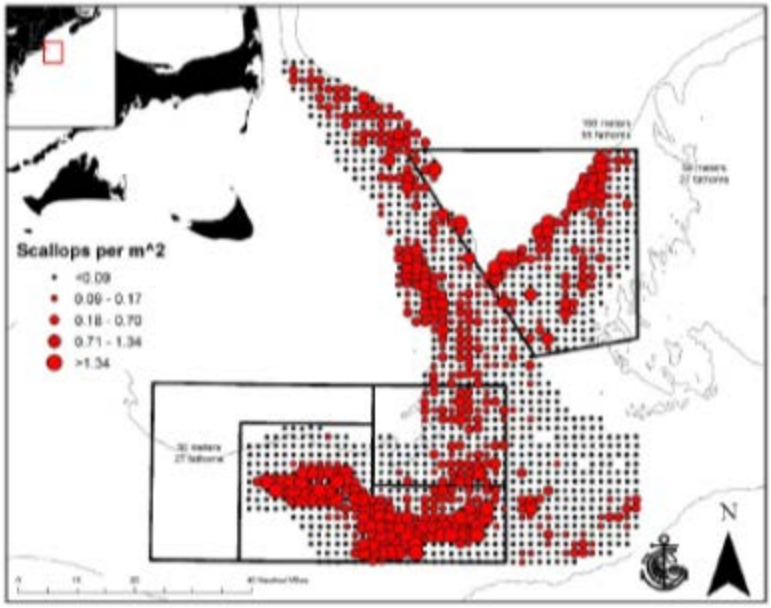
Conferences and Seminars:

- Stokesbury, K.D.E. and D. Eilertsen. "Gonna change my way of thinking . . ." Collaborative research in the New England scallop and ground fisheries. Invited Speaker. Lowell Wakefield Fisheries Symposium. Anchorage, AK. May 2019.
- Stokesbury, K.D.E. and D. Eilertsen. "Gonna change my way of thinking . . ." Collaborative research in the New England scallop and ground fisheries. UMASSD Alumni Annual Luncheon. New Bedford, MA. May 2019.
- Stokesbury, K.D.E., T. Lowery and N. Calabrese. A new sampling system for New England groundfish using video technology. SMAST Department of Fisheries Oceanography Seminar. New Bedford, MA. April 2019.
- Stokesbury, K.D.E., T. Lowery and N. Calabrese. A new sampling system for New England groundfish using video technology. University of Maine School for Marine Sciences Seminar. Orono, ME. January 2019.
- Calabrese, N.M., K.D. E. Stokesbury and T. Lowery. A Video Trawl Survey for Atlantic Cod *(Gadus morhua)* in New England. ICES Annual Science Meeting, Hamburg, Germany. September 2018.

Broadscale Video Survey of the U.S. East Coast Sea Scallop Resource

The scallop broadscale drop camera video survey began as one of the principal MFI projects in 1999. It is now supported by the fishing industry and the Scallop Research Set-Aside Program. Since 1999, Dr. Kevin Stokesbury's laboratory with members of the commercial sea scallop industry have completed over 200 video cruises surveying Georges Bank and the Mid-Atlantic (>1,000 days at sea) covering the entire scallop resource (70,000 km^2) from 2003 to 2018. These data provide assessments of scallop and

other macroinvertebrate densities and sediment and habitat distributions in closed and open scallop fishing areas in U.S. and Canadian waters. The survey protocol has been accepted by the National Marine Fisheries Service as a complete independent stock assessment, one of only six in the nation. It has been published in over 30 peer-reviewed scientific papers and is used annually by NEFMC's Scallop Plan Development Team. Over 200 students, scientists and fishermen have worked together on the project to contribute to New Bedford, MA as the number one fishing port in the United States for value landed for 18 years because of the sea scallop harvest.



Left: Scallop video survey sampling pyramid; Right: Scallop distribution in the Great South Channel 2018.

Research Projects:

- "SMAST drop camera survey of Browns Bank and the Canadian portion of Georges Bank, 2018" PIs: K.D.E. Stokesbury and N.D. Bethoney; Clearwater Seafoods: $156,363; Award Period: 9/2018 – 6/2019.
- "SMAST Drop Camera Survey of Patagonian Scallop Management Unit B, 2018" PIs: K.D.E. Stokesbury and N. D. Bethoney; Clearwater Seafoods: $96,997; Award Period: 4/2018 – 6/2019.
- "High-resolution drop camera surveys to track scallop aggregations in Closed Area I access area, Nantucket Lightship, and Great South Channel" PIs: K.D.E. Stokesbury, N.D. Bethoney and B. Woodward; Scallop Research Set Aside Program: $212,138; Award Period: 4/2019 – 3/2020.
- "Drop camera surveys examining the scallop population of the Mid-Atlantic and assessment of automated scallop count and measurement algorithm" PIs: N.D. Bethoney, K.D.E. Stokesbury and B. Woodward; Scallop Research Set Aside Program: $234,566; Award Period: 4/2019 – 3/2020.
    - The objective of these projects is to provide estimates of sea scallop density, abundance, biomass and distribution within several scallop resource regions.

Graduate Students:

- Lego, Craig, MS, "Examining sea star dynamics in dense sea scallop beds in the Nantucket Lightship Closed Area"
- Goulet, Melissa, MS, "Resiliency of marine benthic communities in sea scallop rotational management areas on Georges Bank"

Primary Publications:

- Stokesbury, K.D.E., N.D. Bethoney, D. Georgianna, S. Inglis and E.F. Keiley. (2019) Convergence of a disease and litigation leading to increased scallop discard mortality and economic loss in the Georges Bank, USA fishery. North American Journal of Fisheries Management 39: 1-8.
- Rosellon-Druker J. and K.D.E. Stokesbury. (2019) Characterization and quantification of echinoderms (Echinodermata) on Georges Bank and the potential role of marine protected areas on these populations. Invertebrate Biology 00: 1-17.
- Bethoney, N.D. and K.D.E. Stokesbury. (2019) Implications of extremely high recruitment: crowding and reduced growth within spatial closures. Marine Ecological Progress Series 611: 157-165.

Technical Reports:

- Stokesbury, K.D.E. and N.D. Bethoney. (2018) 2017 broadscale drop camera survey of the US east coast sea scallop resource. Final Report NOAA Award.
- Stokesbury, K.D.E. and N.D. Bethoney. (2018) High-resolution drop camera survey examining the scallop population and habitat in the Closed Area I access area and sliver. Final Report NOAA Award.
- Bethoney, N.D., A.D. Lisi, K.S. Cassidy and K.D.E. Stokesbury. (2018) SMAST drop camera survey of Patagonian scallop Management Unit B, 2018. Final Report to Clearwater Seafoods.
- Bethoney, N.D., K.D.E. Stokesbury and L.D. Jacobson. (2018) Updated selectivity of large camera data from the SMAST drop camera survey using digital still images. Appendix A5. In: 65th Northeast Regional Stock Assessment Workshop Assessment.

Conferences and Seminars:

- Stokesbury, K.D.E. and N.D. Bethoney. How many scallops are there and why does it matter? 22nd International Pectinid Workshop. Santiago de Compostela, Spain. April 2019.
- Stokesbury, K.D.E., E. Heupel and S. Inglis. Estimating seasonal growth in sea scallops using isotopic data in a changing environment. 22nd International Pectinid Workshop. Santiago de Compostela, Spain. April 2019.
- Cassidy, K., N.D. Bethoney, A. Lisi and K.D.E. Stokesbury. Advancement of the drop camera survey: The Journey to Argentina. 22nd International Pectinid Workshop. Santiago de Compostela, Spain. April 2019.
- Lisi, A., N.D. Bethoney, K. Cassidy, B. Woodward and K. Stokesbury. Continued improvements and quality controls of an Atlantic sea scallop, *Placopecten magellanicus*, drop camera survey. 22nd International Pectinid Workshop. Santiago de Compostela, Spain. April 2019.
- Stokesbury, K.D.E. The U.S. Scallop Fishery 1997-2018. UK Scallop Management Conference 2019. London, England. February 2019.
- Stokesbury, K.D.E., N.D. Bethoney, A. Lisi and K. Cassidy. SMAST drop camera survey of Patagonian scallop Management Unit B, 2018. Programa Pesquerias de Moluscos Bentónicos Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP) Paseo Victoria Ocampo s/n - Escollera Norte Mar del Plata, Argentina. December 2018.
- Stokesbury, K.D.E. and N.D. Bethoney. The sea scallop drop camera survey 2018. Programa Pesquerias de Moluscos Bentónicos Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP) Paseo Victoria Ocampo s/n - Escollera Norte Mar del Plata, Argentina. December 2018.
- Stokesbury, K.D.E. Video of research techniques counting fish and scallops. Fishing Partnership Support Services: Seafood Day. Boston, MA. October 2018.

Additional Survey Initiatives

Researchers at DMF continued investigations of survey net efficiency focused on the herding effect of the trawl doors, bridles, and ground cables. The Gulf of Maine Cod Industry-Based Survey has provided important information on species abundance and distribution, as well as new understanding about the efficiency of survey gear. The objective of the efficiency studies is to reduce uncertainty in estimates of abundance and biomass that stem from lack of information on survey gear performance. The studies provide a comprehensive view of trawl net efficiency, allowing for an accurate, independent estimate of the biomass of several groundfish species in the Western Gulf of Maine.

Sample from the Gulf of Maine Cod industry-Based Survey aboard the F/V Miss Emily.

Dr. Christian Petitpas (DMF) continues to collaborate with Dr. Jefferson Turner (SMAST) on surveys studying estuarine and ocean environments. The partnership includes monitoring water quality in Buzzards Bay, which has produced a long-term time series of data, including plankton community composition and abundance and water quality parameters, as well as numerous publications and student theses. One of the most significant impacts of this partnership is that the Buzzards Bay monitoring enhances the spatial and temporal phytoplankton monitoring performed by DMF and provides timely notification to DMF when observations of harmful algal blooms occur, particularly blooms that could threaten shellfish food safety and public health.

Population Dynamics

MFI researchers are active in fishery stock assessment, which applies population dynamics models to: 1) estimate fish stock abundance and harvest rates relative to sustainable reference points; and 2) forecast outcomes of alternative management scenarios. Stock assessment also draws on many aspects of fisheries science by synthesizing information on fish biology and ecology, fishery monitoring, and fishery resource surveys, as well as advising on fishery management decisions and policy.

MFI provides many substantial contributions to regional and international stock assessments. MFI scientists actively participate in the Northeast Regional Stock Assessment Workshops, Plan Development Teams and technical committees of NEMFC, MAFMC and ASMFC, as well as expert groups of the International Council for the Exploration of the Sea (ICES), the International Commission for the Conservation of Atlantic Tunas (ICCAT), and the UN Food and Agriculture Organization (FAO). MFI scientists also collaborate on extensive stock assessment research and applications. Research on spatial structure of Atlantic cod is a prime example of MFI collaborations related to stock assessment.

Stock Structure of Atlantic Cod

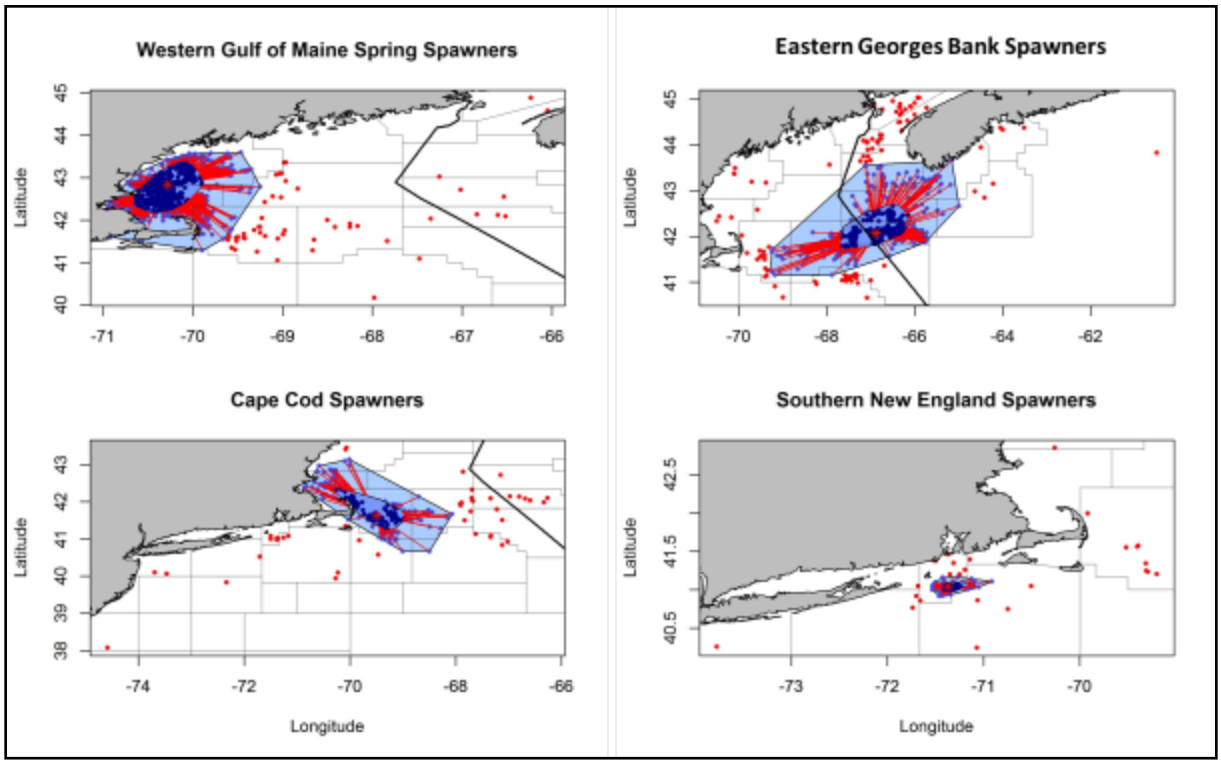
Conventional stock assessments assume that a stock has negligible mixing with adjacent stocks and no spatial structure within the stock, but MFI research provides compelling evidence that current U.S. management units for cod (Gulf of Maine and Georges Bank) do not reflect spatial population structure. In the last year, MFI continued to play a lead role in investigating cod stock structure in the region.

SMAST and DMF have been collaboratively tagging cod since 2000, and cod tagging continued with the MFI federal earmark funding to evaluate movement patterns among fishing grounds. These early MFI tagging efforts led to the more comprehensive Northeast Regional Cod Tagging Program (2002-2003; Tallack et al. 2005, Cadrin et al. 2008). The next stage of MFI cod tagging (2004-2014) applied an interdisciplinary sampling design including conventional and archival tags, sampling of tissues for genetic analysis, otoliths for life history studies, and gonad staging to investigate movement patterns within and among spawning groups.

More recently, MFI scientists collaborated on finer-scale tagging studies that involved acoustic, archival and conventional tagging of persistent spawning aggregations of spring spawning cod in Massachusetts Bay (Zemeckis et al. 2014b) and winter-spawning cod in Massachusetts Bay (Zemeckis et al. 2019) to estimate residence time and fidelity to spawning grounds, and similar research is being planned for later this year on Cox Ledge. Data from acoustic tags provided information on spawning behavior (Dean et al. 2014) with implications for spatial fishery management (Armstrong et al. 2013, Hernandez et al. 2013, Zemeckis et al. 2014a). Data from archival tags were used to geolocate tagged cod to evaluate post-spawning dispersal (Liu et al. 2017, Zemeckis et al. 2017).

In addition to cod tagging studies, MFI collaborations contributed to several investigations of cod stock identification, including genetic population structure (e.g., Clucas et al. 2019), identification of spawning grounds on Georges Bank (DeCelles et al. 2017), egg and larval dispersal (e.g., Churchill et al. 2010), otolith microstructure (e.g., Dean et al. 2019), body shape (Kerr et al. 2017), otolith chemistry (Kerr et al. 2017), and spatial population modeling (Runge et al. 2010, Kerr et al. 2014) of seasonal spawning populations. Interdisciplinary synthesis of this information has led to a new paradigm of population structure that is not consistent with current fishery management units (Zemeckis et al. 2014a).

In 2018, an Atlantic Cod Stock Structure Working Group (ACSSWG) was formed to determine the most appropriate representation of stock structure for use in regional stock assessments based on currently available information, and MFI scientists are playing a large role in the Working Group. Micah Dean (DMF) is leading a review of early life history – spawning to settlement, Greg DeCelles (DMF) is leading an investigation of Fishermen's Ecological Knowledge, Steve Cadrin (SMAST) and Doug Zemeckis (Rutgers, previously an MFI funded PhD student and post-doc at SMAST) are leading an analysis of tagging information, Lisa Kerr (GMRI, previously an MFI funded post-doc at SMAST) is leading a review of natural markers, and all are contributing the Working Group's conclusions. Recommendations from the Working Group will be considered during the 2023 research track stock assessments for cod. MFI's extensive research agenda on cod stock structure offers an example of productive collaborations and scientific contributions that are relevant to advancing stock assessments in the region.



Dispersal patterns of cod spawning populations from combined tagging studies, including several MFI efforts.

Primary Publications and Technical Reports:

- Armstrong, M.P., M.J. Dean, W.S. Hoffman, D. Zemeckis, T. Nies, D.E. Pierce, P.J. Diodati and D.J. McKiernan. (2013) The application of small scale fishery closures to protect Atlantic cod spawning aggregations in the inshore Gulf of Maine. Fisheries Research 141:62–69.
- Cadrin, S., K. La Valley, R. Gallant Feeney, G. Shepherd and S. Tallack. (2009) Tagging 2008: A report on the northeast regional tagging symposium. N.H. Sea Grant College Program UNHMP-R-SG-09-02.
- Churchill, J.H., J. Runge and C. Chen. (2010) Processes controlling retention of spring-spawned Atlantic cod (*Gadus morhua*) in the western Gulf of Maine and their relationship to an index of recruitment success. Fisheries Oceanography 20:32-46.
- Clucas, G.V., L.A. Kerr, S.X. Cadrin, D.R. Zemeckis, G.D. Sherwood, D. Goethel, Z. Whitener and A.I. Kovach. (2019) Adaptive genetic variation underlies biocomplexity of Atlantic Cod in the Gulf of Maine and Georges Bank. PLoS ONE 14(5): e0216992 doi.org/10.1371/journal.pone.0216992.

- Dean, M.J., S.P. Elzey, W.S. Hoffman, N.C. Buchan and J.H. Grabowski. (2019) The relative importance of sub-populations to the Gulf of Maine stock of Atlantic cod. ICES Journal of Marine Science doi:10.1093/icesjms/fsz083.
- Dean, M.J., W.S. Hoffman, D. Zemeckis and M.P. Armstrong. (2014) Fine-scale diel and gender-based patterns in behaviour of Atlantic cod (*Gadus morhua*) on a spawning ground in the western Gulf of Maine. ICES Journal of Marine Science 71:1474–1489.
- DeCelles, G., D. Martins, D.R. Zemeckis and S.X. Cadrin. (2017) Using fishermen's ecological knowledge to map Atlantic cod spawning grounds on Georges Bank. ICES Journal of Marine Science 74:1587–1601.
- Hernandez, K.M., D. Risch, D.M. Cholewiak, M.J. Dean, L.T. Hatch, W.S. Hoffman, A.N. Rice, D. Zemeckis and S.M. Van Parijs. (2013) Acoustic monitoring of Atlantic cod (*Gadus morhua*) in Massachusetts Bay: implications for management and conservation. ICES Journal of Marine Science 70:628–635.
- Kerr, L.A., S.X. Cadrin and A.I. Kovach. (2014) Consequences of a mismatch between biological and management units on our perception of Atlantic cod off New England. ICES Journal of Marine Science 71:1366-1381.
- Kerr, L.A., G. Sherwood, A. Kovach, S.X. Cadrin, D. Goethel, D. Zemeckis and Z. Whitener. (2017) Ecological diversity of Atlantic cod in the Gulf of Maine and its role in resiliency of a fishery. Report to NOAA NA14NMF4270014.
- Liu, C., G. Cowles, D.R. Zemeckis, S.X. Cadrin and M.J. Dean. (2017) Validation of a hidden Markov model for the geolocation of Atlantic cod. Canadian Journal of Fisheries and Aquatic Science 74:1862–1877.
- Runge, J.A., A. Kovach, J. Churchill, L. Kerr, J.R. Morrison, R. Beardsley, D. Berlinsky, C. Chen, S. Cadrin, C. Davis, K. Ford, J.H. Grabowski, W.H. Howell, R. Ji, R. Jones, A. Pershing, N. Record, A. Thomas, G. Sherwood, S. Tallack and D. Townsend. (2010) Understanding climate impacts on recruitment and spatial dynamics of Atlantic cod in the Gulf of Maine: integration of observations and modeling. Progress in Oceanography 87:251–263.
- Tallack, S., P. Rago, S. Cadrin and J. Hoey. (2005) Proceedings of a workshop to review and evaluate the design and utility of fish mark recapture projects in the northeastern United States. NEFSC Reference Document 05-02.
- Zemeckis, D.R., M.J. Dean, A.I. DeAngelis, S.M. Van Parijs, W.S. Hoffman, M. Baumgartner, L. Hatch, S.X. Cadrin and C.H. McGuire. (2019) Identifying the distribution of Atlantic cod spawning using multiple fixed and glider-mounted acoustic technologies. ICES Journal of Marine Science doi.org/10.1093/icesjms/fsz064.
- Zemeckis, D.R., D. Martins, L.A. Kerr and S.X. Cadrin. (2014) Stock identification of Atlantic cod (*Gadus morhua*) in US waters: an interdisciplinary approach. ICES Journal of Marine Science 71:1490-1506.
- Zemeckis, D.R., M.J. Dean and S.X. Cadrin. (2014a) Spawning dynamics and associated management implications for Atlantic cod (*Gadus morhua*). North American Journal of Fishery Management 34:424–442.
- Zemeckis, D.R., W.S. Hoffman, M. Dean, M.P. Armstrong and S.X. Cadrin. (2014b) Spawning site fidelity by Atlantic cod (*Gadus morhua*) in the Gulf of Maine: implications for population structure and rebuilding. ICES Journal of Marine Science 71:1356-1365.
- Zemeckis, D.R., C. Liu, G.W. Cowles, M.J. Dean, W.S. Hoffman, D. Martins and S.X. Cadrin. (2017) Seasonal movements and connectivity of an Atlantic cod (*Gadus morhua*) spawning component in the western Gulf of Maine. ICES Journal of Marine Science 74:1780–1796.

Additional Population Dynamics Initiatives

MFI researchers have been investigating white shark population dynamics through a tagging and population modeling study for the past five years. With funding support from NOAA Sea Grant's Population Dynamics Fellowship Program and the Atlantic White Shark Conservancy, Drs. Greg Skomal (DMF) and Gavin Fay (SMAST), along with graduate student Megan Winton (SMAST) have modeled relationships between species occurrence and environmental covariates from acoustic telemetry data to account for differences in the spatial distribution of tagged individuals, as well as the detection process. The project titled, "Estimating individual- and population-level variation in space use of white sharks off Cape Cod, MA, from passive acoustic telemetry" will be included as part of Ms. Winton's PhD.

Drs. Cate O'Keefe (DMF) and Steve Cadrin (SMAST) worked with graduate student Brooke Wright (SMAST) to complete a study examining factors that influence scallop catch rates and landings. The project, "Factors Influencing Scallop Landings per Unit Effort (LPUE)" was funded by the Scallop Research Set-Aside Program and reviewed by the 65th Stock Assessment Working Group. The MFI scientists collaborated with members of the U.S. Limited Access scallop fleet to develop a tool for improved landings per unit effort estimates. More accurate LPUE projections are expected to reduce uncertainty in setting days at sea allocations.

Left: Scallopers pick through a large catch on deck; Right: Dr. Tracy Pugh researching lobsters in the SMAST lab.

Dr. Steve Cadrin chaired the NEFMC's "Fishery Data for Stock Assessment Working Group" in 2018-2019. The working group was formed to discuss the topic of how fishery-dependent data can be used to inform stock abundance to address four main deliverables: 1) explain how fishery-dependent and independent data are used in stock assessment; 2) summarize the utility and limitations of using catch rates (catch per unit effort, CPUE) as an index of abundance for groundfish stocks; 3) identify the factors and fishery-dependent data needed to create a CPUE that would be a reliable index of abundance; and 4) compare the desired factors identified with existing conditions and data for the fishery. Several MFI researchers and students participated in working group activities and contributed to recommendations (Cate O'Keefe (DMF), Greg DeCelles (DMF), Brooke Wright (SMAST), Alex Hansell (SMAST)).

DMF's Invertebrate Fisheries Project is utilizing the SMAST wet lab space in support of two large ongoing research projects funded by NOAA's Saltonstall-Kennedy Grant Program. The first project, under PIs Derek Perry (DMF) and Robert Glenn (DMF), is a large-scale movement and growth study for Jonah crabs

in the Gulf of Maine, Georges Bank, and southern New England regions. The second project, under PI Tracy Pugh (DMF), is a study on the sub-lethal effects of shell disease in American lobster. Results from both studies will be used to inform lobster and crab assessments and management.

Graduate Students:

- Alex Hansell, PhD, "Standardized catch rates for assessment of data-limited fisheries"
- Janne Haugen, PhD, "Assessment and conservation of porbeagle shark in the north Atlantic"
- Owen Nichols, PhD, "Environmental effects on intra-annual variability in squid distribution in Nantucket Sound"
- Megan Winton, PhD, "Integrating telemetry data to improve abundance estimates and management advice for highly migratory marine species"
- Brooke Wright, PhD, "Application of fishery-dependent data in fishery assessment and management"

Primary Publications:

- Winton, M.V., J. Kneebone, D.R. Zemeckis and G. Fay. (2018) A spatial point process model to estimate individual centers of activity from passive acoustic telemetry data. Methods in Ecology and Evolution 9:2262-2272.
- Kneebone J., M.V. Winton, A. Danylchuk, J. Chisholm and G.B. Skomal. (2018) An assessment of juvenile sand tiger (*Carcharias taurus*) activity patterns in a seasonal nursery using accelerometer transmitters. Environmental Biology of Fishes 101:1739-1756.

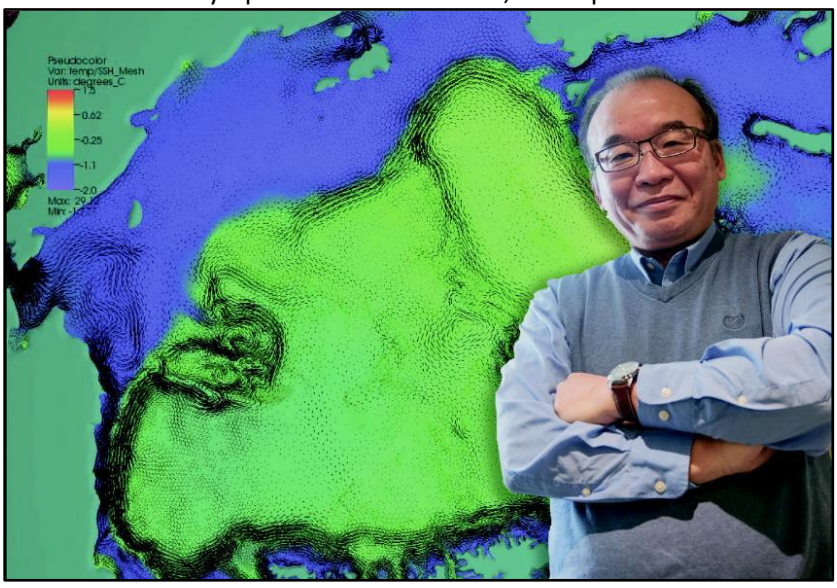
MFI researchers prepare to tag a white shark off Cape Cod, Massachusetts.

Technical Reports:

- Cadrin, S.X. and C.E. O'Keefe. (2019) Factors Influencing Scallop Landings per Unit Effort (LPUE). Final Report NOAA Award NA17NMF4540033.
- Hansell, A.C., G. DeCelles and S. Cadrin. (2018) Incorporating fisher knowledge into an index of abundance for Atlantic halibut (*Hippoglossus hippoglossus*) in the Gulf of Maine. ICES C.M. 2018/R:281.
- Hansell, A.C., G. DeCelles and S. Cadrin. (2018) Using Fishermen's Knowledge to Improve Abundance Estimates for Atlantic Halibut (*Hippoglossus hippoglossus*) in the Gulf of Maine. NEFSC Reference Document 18-14: 28.
- Wright, B., A. Hansell, S. Cadrin, M. Sanderson, M. Hager and C. McGuire. (2018) Applications of voluntary electronic monitoring system data in the Northeast US groundfish fishery. ICES C.M. 2018/P:220.

Conferences and Seminars:

- Cadrin, S., R. Frede, E. Keiley, B. Linton, J-J. Maguire, P. Rago, R. Bell, V. Giacalone, C. Demarest, C. Brown, M. Gibson, C. O'Keefe, G. DeCelles, B. Wright, A. Hansell, C. McGuire and D. Hennen. Fishery Data for Stock Assessment Working Group Report. Maine Fishermen's Forum. Rockport, ME. March 2019.
- Hansell A.C., G. DeCelles and S. Cadrin. A standardized index of abundance for halibut using ME DMR logbook data. Maine Fishermen's Forum, Rockport, ME. March 2019.
- Hansell A.C., G. DeCelles and S. Cadrin. Standardized Catch Rates for Maine's Atlantic Halibut (*Hippoglossus hippoglossus*) Fishery. New England Fishery Management Council, Fishery Data for Stock Assessment Working Group. New Bedford, MA. June 2018.
- Winton, M., J. Chisholm and G. Skomal. White shark research off Cape Cod: past, present, and future. Mid-Atlantic Telemetry Workshop. Newark, DE. April 2019.
- Winton, M.V., A. Cicia, J. Sulikowski and G. Skomal. Vertical habitat use of white sharks off Cape Cod, Massachusetts. Cape Cod Natural History Conference. Hyannis, MA. March 2019.
- Winton, M.V., G. Fay, J. Chisholm and G.B. Skomal. Estimating individual- and population-level variation in space use of white sharks off Cape Cod, Massachusetts, from passive acoustic telemetry data. International Statistical Ecology Conference. St. Andrews, Scotland. July 2018.
- Winton, M.V., G. Fay, J. Chisholm and G.B. Skomal. Estimating individual- and population-level variation in space use of white sharks off Cape Cod, Massachusetts, from passive acoustic telemetry data. National Marine Fisheries Service – Sea Grant Graduate Fellows Symposium. Honolulu, HI. March 2019.
- Winton, M.V., J. Kneebone, D.R. Zemeckis and G. Fay. A spatial point process model to estimate individual centers of activity from passive acoustic telemetry data. American Fisheries Society Annual Meeting. Atlantic City, NJ. August 2018.
- Wright B.L., C.E. O'Keefe, B. Galuardi, J. Peros and S.X. Cadrin. Projecting scallop LPUE in the northeast US with fishermen's help. Lowell Wakefield Fisheries Symposium. Anchorage, AK. May 2019.
- Wright B.L., C.E. O'Keefe, B. Galuardi, J. Peros and S.X. Cadrin. Using fishermen's insights in projections of scallop landings per unit effort (LPUE) in the northeast US. UMass Intercampus Marine Science Research Symposium. New Bedford, MA. April 2019.



Dr. Changsheng Chen demonstrates results from his FVCOM model (Photo credit: Yu Zhang).

Offshore Renewable Energy Development

The development of the wind farm industry off the east coast of the United States has great potential for additional supply of sustainable energy, but it will take up a large amount of space in an already crowded marine environment. The proposed wind farms include plans for construction of ~1,800 turbines providing over 18,000 megawatts of power over the next ten years. Developing the wind farms will change the marine ecosystems throughout the area by altering seafloor habitat, currents, and associated abundance, distribution and behavior of marine organisms on multiple scales. The ability of fisheries to operate within or next to a wind farm depends on the type of fishery. The scope of spatial management and examination required to determine the impact of the wind farms on fisheries is large and requires a scientific framework.

Offshore wind energy developers have begun monitoring lease areas to collect baseline information on the marine environment and the associated organisms. Monitoring plans, involving video surveys of habitat, trawl surveys for finfish, and trap surveys for shellfish, have been developed for the Vineyard Wind lease areas by SMAST researchers in collaboration with members of the fishing industry and scientific input from DMF. The surveys will examine a Before-After-Control-Impact (BACI) design to assess impacts from construction, implementation, and operation of the wind turbine arrays.

MFI supports the Massachusetts Fisheries Working Group, which is an offshore wind development advisory committee. The working group provides communication with the fishing industry about offshore wind activities, solicits feedback regarding the development of the Massachusetts Wind Energy Area, and opens lines of communication regarding how to minimize conflict between offshore wind and commercial and recreational fisheries. The working group has been an influential voice in developing research priorities for the BOEM and in Environmental Impact Statements for offshore wind development.

Research Projects:

- "Development of a Monitoring Plan" PIs: S.X. Cadrin and K.D.E. Stokesbury; Vineyard Wind.
- "Vineyard Wind Groundfish Bottom Trawl Survey"PI: K.D.E. Stokesbury; Vineyard Wind.
- "Vineyard Wind Ventless Trap Monitoring Survey" PI: K.D.E. Stokesbury; Vineyard Wind.
- "Vineyard Wind Habitat Drop Camera Monitoring Survey" PI: K.D.E. Stokesbury; Vineyard Wind.
- "Vineyard Wind Groundfish Bottom Trawl Monitoring Survey" PI: P. He; Vineyard Wind.

Graduate Students:

- Zygmunt, Alex, MS, "Ventless trap lobster BACI Vineyard Wind study"
- Riley, Caitlyn, MS, "Invertebrate macro-community BACI Vineyard Wind study"
- Meli, Amanda, MS, thesis title to be determined

Technical Reports:

- DMF, BOEM, NOAA, RIDEM. (2018) Recommended regional scale studies related to fisheries in the MA and RI-MA offshore Wind Energy Areas. Report to MA Fisheries Working Group.
- Cadrin, S.X., K.D.E. Stokesbury and A. Zygmunt. (2019) Recommendations and planning pre- and post-construction assessment of fisheries in the Vineyard Wind offshore wind lease area. Final Report to Vineyard Wind.
- Stokesbury, K.D.E. and T. Lowery. (2019) Vineyard Wind Groundfish Bottom Trawl Survey – Spring 2019. Final Report to Vineyard Wind.

Education and Outreach

The Marine Fisheries Institute was created as a means for SMAST and DMF to partner so that the strengths of each entity could be fully utilized to direct and reach research and management goals. Utilizing graduate students with an interest in marine biology, ecology, habitat, and fisheries management is a great benefit to both DMF and SMAST. DMF is able to fund and employ students with an interest in the work of the agency, and students are given the opportunity to put their education to practical at the agency. DMF employees have the opportunity of continuing education for graduate degrees. DMF scientists also serve as adjunct faculty, teaching courses, mentoring students as committee members, and collaborating with SMAST faculty and students on student research topics.

Our researchers, faculty, and students continue to be involved in regional and international fishery management as well as local outreach. MFI scientists make substantial contributions to the NEFMC, the Northeast Regional Stock Assessment Workshops, and ICES Councils and Committees. Local outreach includes the fisheries safety course that takes place at SMAST and participation in regional seafood and fisheries festivals. MFI scientists continue to meet with our Scallop Fishing Industry Steering Committee, which includes fishermen, owners, and processors to discuss management issues, the needs and concerns of industry, our present research, and future goals. MFI also organizes and hosts topical symposia and workshops on fisheries science and management.

Public Outreach Events:

- Boston Seafood Festival and Boston Seafood Show
- Center for Ocean Sciences Education Excellence
- New Bedford Dock-u-mentaries Series
- New Bedford Working Waterfront Festival
- Massachusetts State Science and Engineering Fair

Management, Science, and Technical Team Involvement:

- Atlantic Cod Stock Structure Working Group
- Atlantic Large Whale Take Reduction Team
- Atlantic States Marine Fisheries Commission
- Fishery Dependent Data for Stock Assessment Working Group
- ICES/FAO Fishing Technology and Fish Behavior Working Group
- ICES Working Groups: Stock Assessment Methods, Multispecies Assessment, Northwest Atlantic Regional Sea
- Massachusetts Fisheries Working Group for Offshore Wind Development
- Mid-Atlantic Fishery Management Council
- New Bedford Port Authority
- New England Fishery Management Council
- New England Plan Development Teams: Ecosystem Based Fisheries Management, Groundfish, Habitat, Herring, Monkfish, Scallop
- Northeast Trawl Survey Advisory Panel
- River Herring Technical Expert Group
- Stellwagen Bank Sanctuary Advisory Council

MFI Symposia

- "Making Waves: The Role of Politics in Fisheries Science and Management"; Organizers: C. O'Keefe (DMF), S. Cadrin (SMAST), S. Lucey (SMAST/NEFSC); Presentations included D. Pierce (DMF) Communicating the science of fisheries management to diverse audiences. American Fisheries Society, Atlantic City, NJ. August 2018.

Adjunct Faculty

- Michael Armstrong, DMF Assistant Director
- Gregory DeCelles, DMF Stock Assessment Specialist
- Catherine O'Keefe, DMF Marine Science and Policy Analyst
- David Pierce, DMF Director
- Michael Pol, DMF Conservation Engineering Project Lead
- Tracy Pugh, DMF Invertebrate Fisheries Project Leader

Students (2018-2019 graduated and announced PhD dissertation defenses)

- Nicholas Calabrese, MS, "A video trawl survey for Atlantic cod (*Gadus morhua*) in New England" Advisor: Kevin Stokesbury
- Alexa Kretsch, MS, "Surfclam survey strategies" Advisor: Kevin Stokesbury
- Chang Liu, PhD, "Quantifying connectivity in Buzzards Bay with application to the study of recruitment variability in the bay scallop" Advisor: Geoffrey Cowles
- Molly Morse, MS, "Misspecifying the maguro: Evaluating stock assessment performance on mixed stocks of Atlantic bluefin tuna" Advisor: Steven Cadrin
- Pooja Potti, MS, "Comparison of historic Eastern oyster populations (*Crassostrea virginica*) to present day restoration activities in East Coast, U.S.A. estuaries" Advisor: Cynthia Pilskaln
- Katyanne Shoemaker, PhD, "Composition and activity of bacterial communities associated with copepods in the oligotrophic North Atlantic Ocean" Advisor: Pia Moisander
- Melissa Staggs, PSM, "The decline of the monarch butterfly in North America" Advisor: Steven Lohrenz
- Amber Unruh, MS, "Attenuation of nitrogen in freshwater ponds within estuarine watersheds" Advisor: Brian Howes
- Ashley Weston, MS, "Implication of environmental effects on recruitment in stock assessments and management of Alaskan groundfish fisheries" Advisor: Gavin Fay

MFI Advisory Council Activities

The MFI Advisory Council consists of individuals with expertise appropriate to the MFI mission and appointed from faculty and academic leadership in the University of Massachusetts system and from stakeholder groups with interest in the mission of the MFI. A list of current Advisory Council members is provided in Appendix I. The Advisory Council met on November 29, 2018 to: 1) receive updates on MFI projects; 2) review aquaculture and wind energy activities; and 3) consider recommendations for future research projects. Additionally, the Advisory Council reviewed MFI objectives, mission and vision statements and discussed potential workshop ideas related to groundfish assessment methods. The meeting notes are appended to this report (Appendix II).

Goals for MFI 2019-2020

The following are MFI goals for the upcoming fiscal year drawn from the recommendations of the MFI Advisory Council as well as input from the MFI Executive Committee:

1. Continue to investigate the health and ecology of the scallop population and seek opportunities to provide scientific information to support scallop management (Scallop RSA, Plan Development Team, NEFMC, etc.).
2. Continue to contribute to Atlantic cod stock structure research and management efforts as part of the Atlantic Cod Stock Structure Working Group and the research assessments of cod.
3. Continue to provide scientific support for other fisheries stock assessment and management approaches, including advancing the open cod-end video survey approach, fisheries-dependent monitoring (including industry-based surveys), and fisheries independent surveys. This also includes other related issues such as continuing and expanding bycatch avoidance efforts, identifying realistic rebuilding targets (environmental vs. fishing mortality), and improvements in data sharing.
4. Serve as a resource for fisheries-related knowledge and expertise for the state administration and state leadership.
5. Continue to improve external communication about MFI (website, newsletter, social media, etc.).
6. Continue education and training of students in quantitative fisheries science and outreach to the public on fisheries-related issues (public presentations, fisherman's survival training, etc.) and investigate approaches for expanding undergraduate educational activities.
7. Continue service and participation related to fisheries management advisory groups (science and statistical committees, plan development teams, technical working groups, etc.).
8. Investigate approaches for further developing social science capabilities.
9. Develop an MFI Strategic Plan with input from the Advisory Council and DMF/SMAST faculty, staff, and students.
10. Develop a data sharing agreement between MFI and NOAA to facilitate access to fishery-dependent and independent data sources for use by faculty, staff, and students.

MFI Budget

There are currently no University funds designated for operational support for the MFI. The tables below include more information about the MFI budget.

Table 1. FY 2019 Financial Statement (as of June 30, 2019)
Grants Directly Supported by the MFI

Project	*MFI Graduate Education Program Director FY19*	*DMF Environmental Review Worker FY17-19*	*FY19 Groundfish Video Trawl Survey*	*Complementary Testing of Off-Bottom Trawls*	*Developing and Testing a Pelagic Species Distribution Model to Forecast River Herring*	*Factors Influencing Scallop Landings per Unit Effort (LPUE)*	*Sustaining, Improving and Evaluating Portside Sampling and River Herring Incident*
Principal Investigator	Cadrin	Pilskaln/ Marino	Stokesbury	He	Bethoney	Cadrin	Bethoney
Funding Agency	MA DMF	MA DMF	MA DMF	MA DMF	MA DMF	NOAA	NOAA
Award Start Date	8/20/2018	7/1/2016	8/20/2018	5/15/2017	10/19/2017	3/1/2017	1/1/2016
Award End Date	6/30/2019	6/30/2019	6/30/2019	12/31/2018	12/31/2019	2/28/2019	12/31/2019
Total Award Amount	50,000.00	90,000.00	400,000.00	9,639.00	56,156.00	77,199.00	408,004.00
Beginning Fund Balance							
Fund Balance	-	32,434.36	-	3,972.25	43,142.43	40,039.51	346,569.55
REVENUES							
Operating Revenues							
Federal Operating G&C	-	-	-	-	-	-	-
State Operating G&C	50,000.00	30,000.00	400,000.00	-	-	-	-
Total Operating Revenue	50,000.00	30,000.00	400,000.00	-	-	-	-
EXPENSES							
Operating Expenses							
Payroll & Fringes							
700483 Regular Salary	29,953.49		83,014.77	2,305.37	17,062.10	17,420.18	9,274.98
700484 Special Salary	-	20,851.86	24,632.56	-	1,836.93	1,661.60	-
700829 Fringe	6,961.44	108.56	27,583.09	847.21	6,516.83	6,666.27	3,552.91
TOTAL PAYROLL & FRINGE	***36,914.93***	***20,960.42***	***135,230.42***	***3,152.58***	***25,415.86***	***25,748.05***	***12,827.89***

Table 1 (Continued). FY 2019 Financial Statement (as of June 30, 2019)
Grants Directly Supported by the MFI

Project	*MFI Graduate Education Program Director FY19*	*DMF Environmental Review Worker FY17-19*	*FY19 Groundfish Video Trawl Survey*	*Complementary Testing of Off-Bottom Trawls*	*Developing and Testing a Pelagic Species Distribution Model to Forecast River Herring*	*Factors Influencing Scallop Landings per Unit Effort (LPUE)*	*Sustaining, Improving and Evaluating Portside Sampling and River Herring Incident*
Non-Payroll							
700485 National Travel	60.00	-	13.93	-	-	(515.35)	275.58
700486 Foreign Travel	-	-	-	-	-	-	-
Employee Related Expenses	***60.00***	***-***	***13.93***	***-***	***-***	***(515.35)***	***275.58***
700877 Supplies and Materials	2,707.61	-	3,379.61	-	-	-	-
Administrative Expenses	***2,707.61***	***-***	***3,379.61***	***-***	***-***	***-***	***-***
Facility Operational Expenses	***-***	***-***	***-***	***-***	***-***	***-***	***-***
700488 Consultants		-	96,749.98	-	-	-	-
Consultant Services	***-***	***-***	***96,749.98***	***-***	***-***	***-***	***-***
700494 Equip Lease & Rental	-	-	72,369.70	-	-	-	-
Equipment Lease & Maintenance	***-***	***-***	***72,369.70***	***-***	***-***	***-***	***-***
700849 Subrecipient <$25k	-	-	-	-	-	-	17,034.69
Subrecipient <$25k	***-***	***-***	***-***	***-***	***-***	***-***	***17,034.69***
700459 Equipment	-	-		-	-	-	-
Equipment Purchase	***-***	***-***	***-***	***-***	***-***	***-***	***-***
700825 Other Non-Personnel	-	3,802.34	9,716.68	-	-	928.78	-
Other Non Payroll	***-***	***3,802.34***	***9,716.68***	***-***	***-***	***928.78***	***-***
TOTAL NON PAYROLL	***2,767.61***	***3,802.34***	***182,229.90***	***-***	***-***	***413.43***	***17,310.27***
Indirect							
700828 Indirect	10,317.46	2,476.23	82,539.68	819.67	6,608.22	13,878.03	16,576.07
TOTAL INDIRECT COSTS	***10,317.46***	***2,476.23***	***82,539.68***	***819.67***	***6,608.22***	***13,878.03***	***16,576.07***
Total Expenses & Deductions	**50,000.00**	**27,238.99**	**400,000.00**	**3,972.25**	**32,024.08**	**40,039.51**	**46,714.23**
Net Revenue Less Expense	**-**	**2,761.01**	**-**	**(3,972.25)**	**(32,024.08)**	**(40,039.51)**	**(46,714.23)**
Ending Fund Balance	**-**	**35,195.37**	**-**	**-**	**11,118.35**	**-**	**299,855.32**

Table 2. List of Space Occupied by Personnel Associated with MFI

Employee Name	Office/suite	NSF
Bethoney, N.David	SMASTE-123	134
Cadrin, Steven	SMASTE-121	134
Calabrese, Nicholas	SMASTE-119	47
Cassidy, Kyle	SMASTE-128	71
Chen, Changsheng	SMASTE-226	134
Cowles, Geoffrey	SMASTE-227	134
Davis, Farrell	SMASTE-137	47
Fay, Gavin	SMASTE-228	134
Fox, Christine	SMASTE-202	71
Georgianna, Daniel	SMASTE-124	134
Goulet, Melissa	SMASTE-119	47
Hansell, Alex	SMASTE-120	47
Haugen, Janne	SMASTE-120	47
He, Pingguo	SMASTE-127	134
Heupel, Eric	SMASTE-128	71
Lego, Craig	SMASTE-119	47
Lisi, Amber	SMASTE-128	71
Lowery, Travis	SMASTE-128	71
Lohrenz, Steven	SMASTE-203	272
Meli, Amanda	SMASTE-135	47
Nuttall, Ryan	SMASTE-3rd floor	*included below
Pierce, David	SMASTE-126	134
Pilskaln, Cynthia	SMASTW-218	134
Politis, Philip	SMASTE-137	47
Potti, Pooja	SMASTW-218	47
Riley, Caitlyn	SMASTE-128	71
Rillahan, Christopher	SMASTE-129	71
Rothschild, Brian	SMASTE-125	134
Stokesbury, Kevin	SMASTE-122	134
Turner, Jefferson	SMASTW-214	127
Whitman, Sarah	SMASTE-120	47
Wilsterman, Margot	SMASTE-120	47
Winton, Megan	SMASTE-222	47
Wright, Brooke Lowman	SMASTE-129	71

Employee Name	Office/suite	NSF	
He Dry Lab	SMASTE-137	420	
He Digitizing Lab	SMASTE-138	204	
Chen Computation Lab	SMASTE-237	420	
Chen Computation Lab	SMASTE-238	420	
Cowles Computation Lab	SMASTE-239	420	
Fay Computation Lab	SMASTE-245	420	
DFO Operations	SMASTE-146	204	
DFO Shared Dry lab (Dirty)	SMASTE-144	204	
DFO Shared Dry lab (Clean)	SMASTE-143	204	
DFO Shared Wet Lab	SMASTE-141	420	
Dive Gear/Washdown	SMASTE-115-116	425	
Storage	SMASTE-149	1509	*3/4 of space
Seawater Tank Facility	SMASTE-148	2301	*3/4 of space
Seawater Tank Facility	SMASTW-117	1583	*3/4 of space
Storage (Offsite)	Hathaway Mills	725	*1/3 of space
Armstrong, Michael	DMF-Gloucester		
Ayer, Matthew	DMF-Gloucester		
Chosid, David	DMF-Gloucester		
Dean, Micah	DMF-Gloucester		
DeCelles, Gregory	DMF-Gloucester		
Ford, Kathryn	DMF-New Bedford		
Glenn, Robert	DMF-New Bedford		
Hoffman, William	DMF-Gloucester		
Martins, David	DMF-New Bedford		
McKiernan, Daniel	DMF-Boston		
O'Keefe, Catherine	DMF-New Bedford		
Perry, Derek	DMF-New Bedford		
Petitpas, Christian	DMF-Gloucester		
Pol, Michael	DMF-Gloucester		
Pugh, Tracy	DMF-New Bedford		
Schondelmeier, Brad	DMF-Gloucester		
Skomal, Gregory	DMF-Gloucester		
Turner, Sara	DMF-New Bedford		
DMF BacT Lab	SMASTW-216	611	

Appendices

APPENDIX I

MASSACHUSETTS MARINE FISHERIES INSTITUTE

Massachusetts Marine Fisheries Institute Advisory Council Members

Ramprasad Balasubramanian, Academic Affairs, University of Massachusetts Dartmouth

Roy Enoksen, Eastern Fisheries

Vito Giacalone, Gloucester Fishing Community Preservation Fund; Northeast Seafood Coalition

Robyn Hannigan, School for the Environment, University of Massachusetts Boston

Eric Hansen, Hansen Scalloping Inc., F/V *Endeavor*

Jonathan Hare, Northeast Fisheries Science Center, NOAA Fisheries

Adrian Jordaan, Department of Environmental Conservation, University of Massachusetts Amherst

James Kendall, New Bedford Seafood Consulting; Massachusetts Fishermen's Partnership

Lisa Kerr, Gulf of Maine Research Institute

Christopher McGuire, The Nature Conservancy

Jason McNamee, Rhode Island Department of Environmental Management

Frank Mirarchi, Massachusetts Fisherman

Kenneth Oliveira, Biology Department, University of Massachusetts Dartmouth

Michael Pentony, Greater Atlantic Regional Fisheries Office, NOAA Fisheries

John Quinn, New England Fishery Management Council; University of Massachusetts School of Law

Laura Foley Ramsden, M.F. Foley Fish Company

Brian Rothschild, School for Marine Science and Technology, University of Massachusetts Dartmouth

Massachusetts Marine Fisheries Institute Co-Chairs

Steven Lohrenz, School for Marine Science and Technology, University of Massachusetts Dartmouth

David Pierce, Massachusetts Division of Marine Fisheries

Massachusetts Marine Fisheries Institute Executive Committee

Steven Cadrin, School for Marine Science and Technology, University of Massachusetts Dartmouth

Catherine O'Keefe, Massachusetts Division of Marine Fisheries

Kevin Stokesbury, School for Marine Science and Technology, University of Massachusetts Dartmouth

APPENDIX II

MASSACHUSETTS MARINE FISHERIES INSTITUTE ADVISORY COUNCIL MEETING

November 29, 2018

Meeting Location: SMAST-West, 706 South Rodney French Boulevard, New Bedford, MA

Executive Committee: Steve Lohrenz (UMass SMAST), David Pierce (MA DMF); Steve Cadrin (UMass SMAST); Cate O'Keefe (MA DMF); Kevin Stokesbury (UMass SMAST)

Advisory Council: Brian Rothschild (Council Chair; UMass SMAST); Roy Enoksen (Eastern Fisheries); Eric Hansen (Hansen Scalloping Inc.); Jon Hare (Northeast Fisheries Science Center); Jim Kendall (New Bedford Seafood Consulting); Lisa Kerr (Gulf of Maine Research Institute); Chris McGuire (The Nature Conservancy); Jason McNamee (Rhode Island Dept. of Environmental Management); Frank Mirarchi (fisherman); Michael Pentony (NOAA Fisheries); John Quinn (UMass School of Law);

Invited Speakers and Guests: Dave Bethoney (UMass SMAST); Geoff Cowles (UMass SMAST); Tiffany Cunningham (MA DMF); Micah Dean (MA DMF); Tracy Pugh (MA DMF); Chris Schillaci (MA DMF); Greg Skomal (MA DMF); Arlene Wilkinson (UMass SMAST)

Unable to participate: Ramprasad Balasubrananian (UMass Dartmouth); Laura Foley (Foley Fish); Vito Giacalone (Gloucester Fishing Preservation Fund, Northeast Seafood Coalition); Robyn Hannigan (UMass Boston); Adrian Jordaan (UMass Amherst); Ken Oliviera (UMass Dartmouth); Mike Sissenwine (NEFMC)

Meeting Objectives:

- MFI Project Updates
- Update on Aquaculture/Wind Energy Activities
- Recommendations for Future Research Priorities

Welcome and Introductions:
Steve Lohrenz and David Pierce welcomed everyone, and participants introduced themselves. New Advisory Council members in attendance were recognized and introduced to the group. The Co-Chairs provided a brief overview of the meeting and reflected upon the importance of the Advisory Council to continue to promote the unique partnership of the MFI.

Research Updates:

Industry-Based Survey for Gulf of Maine Cod (Micah Dean, MA DMF)
Micah Dean presented results from a study on the importance of cod subpopulations in the Gulf of Maine. The project is based on data collected from the Industry-Based Survey for Gulf of Maine cod that was conducted from 2003-2007 and again from 2016 to the present. The objective of the study was to examine cod population structure and determine relative contributions from spring and winter spawning subpopulations to the Gulf of Maine cod stock.

Two sub-populations of cod (spring spawners and winter spawners) were distinguished by examining differences in early life history traits. Results showed differences in spawning time and location, with spring spawners concentrated in Ipswich Bay and Jeffreys Ledge during spawning season, moving to the Western Gulf of Maine Closed Area after spawning. Winter spawners were concentrated in Massachusetts Bay/Ipswich Bay during spawning and moved to Stellwagen Bank and Platts Bank after spawning. Retrospective analysis of otoliths suggests past recruitment was dominated by spring spawners, but recent recruitment is dominated by winter spawners.

The presentation concluded that Gulf of Maine cod sub-populations are not homogeneously distributed and the closed areas in the Gulf of Maine provide more protection for spring spawners, while the fishery is predominantly catching winter spawners. In addition, there are significant differences in vital rates between the two sub-populations. Winter spawners grow and mature faster and experience higher fishing mortality, whereas spring spawners grow larger but contribute less to recruitment.

The Advisory Council discussed the study results in relation to the location and timing of cod spawning closures. There was interest in having the results shared broadly to determine if there may be reason to re-examine spatial management in the Gulf of Maine. There may be tradeoffs between protecting both spawning groups and maintaining protections for the higher productivity portion of the population.

Video Trawl Survey (Kevin Stokesbury, UMass SMAST)
Kevin Stokesbury presented an update on recent survey work using the open cod-end video trawl survey system. The system has been utilized since 2013 to survey Georges Bank yellowtail flounder in the southern portion of Closed Area II and Gulf of Maine cod concentrated on Stellwagen Bank. The survey work has been supported through a state earmark, championed by Representative Tony Cabral with continued interest from Governor Baker. The survey observed an increasing average weight per animal for Georges Bank yellowtail between 2013 and 2018, but a decrease in density of fish in the survey area. Additionally, the survey observed a reduction in abundance of cod between 2017 and 2018 on Stellwagen Bank.

The research team has discussed sharing survey results with the Northeast Fisheries Science Center (NEFSC) to inform the assessments of yellowtail and cod. The team is continuing to work with C-Vision to develop the deep learning counting algorithm for identification of fish species and expects to be able to automatically discern cod and haddock within the next year.

The Advisory Council considered possible next steps and future research for the video trawl system. There is interest in expanding the survey to cover the entire broad stock areas for yellowtail, cod and possibly other species. The research team will incorporate a stereoscopic camera in upcoming surveys so that fish measurements can be made. The group also considered using the video trawl survey as a shadow survey with the NEFSC.

White Shark Research (Greg Skomal, MA DMF)

Greg Skomal presented results from the five-year white shark tagging project conducted in Massachusetts state waters off the backside of Cape Cod. Greg partnered with SMAST professor Gavin Fay and SMAST student Megan Winton to study movement ecology and population dynamics of white sharks through a combination of tagging, survey, and modeling efforts.

To date, there have been over 2,000 white shark sightings with over 320 individual sharks identified. Over 150 sharks have been tagged with acoustic, pop-up or transmitting devices. The project has coordinated with towns and communities around Cape Cod to deploy and maintain acoustic receivers to track the movements of the sharks in the vicinity. The data and analysis are providing new insights about shark behavior and movement patterns, and there is a high level of community interest in the results in order to manage public safety.

The Advisory Council discussed the overlap of sharks and seals and considered public safety issues. The group supported additional research on white sharks in general, and the potential to consider seal distribution to inform predictive patterns of shark movement. The group also discussed the potential for new technology, such as drone surveys, to reduce the costs associated with tracking sharks.

Surf Clam Fishery Access (David Pierce, MA DMF/John Quinn, NEFMC)

The New England Fishery Management Council (NEFMC) was considering allowing access in the Great South Channel Habitat Management Area (GSC HMA) for the surfclam dredge fishery. The Omnibus Habitat Amendment II, implemented in mid-2018, granted the surfclam fishery a one-year exemption to continue fishing in the GSC HMA. The NEFMC will determine if that exemption can be continued or will expire in April 2019.

The surfclam fishery is poised to support research and survey efforts in the GSC HMA if fishing access continues to be allowed. Previous survey work conducted by Kevin Stokesbury, combined with recent surveys supported by the surfclam industry, show there may be areas that do not have sensitive habitat and support surfclams.

UPDATE: After the Advisory Council meeting, the NEFMC met in December and approved measures that would allow surfclam fishing in certain portions of the GSC HMA while closing

other areas. Additionally, the NEFMC recommended development of a research plan to examine distribution of sensitive habitat in the region with the objective to possibly allow future access to the surfclam fishery.

Black Sea Bass (Tiffany Cunningham, MA DMF/Steve Cadrin, UMass SMAST)

Tiffany Cunningham presented plans for research focused on the spawning timing and location of black sea bass in Massachusetts waters. Black sea bass have increased in importance as a recreationally targeted species in Massachusetts as their range has shifted more northerly in recent years. Recreational fishing vessels are known to concentrate in areas where spawning aggregations occur and may be a proxy to determine spawning time and location. MA DMF is conducting aerial surveys to locate concentrations of recreational vessels, and then conducting spawning sampling with rod and reel at the locations identified by the aerial surveys.

The Advisory Council discussed the approach to use aerial surveys as a proxy for spawning aggregations and supported additional validation studies to ensure black sea bass are the target species. Several research questions related to sea bass spawning are being investigated, including which habitat types are important for spawning, does spawning behavior change with habitat type, and how is spawning success linked to habitat type.

Steve Cadrin presented an overview of the recent stock assessment for black sea bass, including new modeling efforts that examine large scale movements and regional structure. The sea bass assessment assumes spatial structure of the species northern and south of Hudson Canyon. New model approaches conducted by Gavin Fay at SMAST examined seasonal structure in combination with spatial structure. The new model was considered an improvement to the understanding of black sea bass population dynamics. The Advisory Council noted that results from the research will be applied to a research track assessment of black sea bass in 2022.

River Herring Bycatch Avoidance (Dave Bethoney, UMass SMAST)

Dave Bethoney presented an update on the River Herring Bycatch Avoidance System. The system, which has been in place since 2010, uses portside sampling data to inform the sea herring fishing fleet of locations where river herring bycatch occurs. In 2017, MFI received a grant from NOAA's Bycatch Reduction Engineering Program (BREP) to develop habitat forecasts of high bycatch locations. The objective of the forecasts is to provide proactive information to facilitate avoidance of possible bycatch locations. The project has completed a historical evaluation with hindcasted probabilities of river herring bycatch locations. Next steps include prediction maps of high bycatch locations and distribution of the information to the fishing fleet.

The Advisory Council discussed the potential to incorporate additional habitat variables, such as chlorophyll, as predictors for river herring location. The model currently incorporates temperature, salinity, depth and sun angle. Additional environmental variables may enhance model performance and refine the areas where river herring probability is predicted to be high.

Scallop Assessment (Kevin Stokesbury, UMass SMAST)

A benchmark assessment of scallops was completed in 2018 with results suggesting stock biomass is currently at record high levels and fishing mortality is the lowest in the time series of

data. Kevin Stokesbury presented information related to the assessment results and future of the scallop stock. The fishing mortality reference point has increased in every assessment for the last ten years and was estimated at F_{MSY}=0.64 in the most recent assessment. While stock biomass is currently high, recruitment has been average/below average for the last five years, leading to concern about the fishing mortality reference point.

The Advisory Council discussed the conservative approach taken by the NEFMC to manage scallops at a fishing mortality rate lower than the reference point. They also acknowledged the importance of recruitment to the stock and noted that there will be an update assessment for scallops every year moving forward.

Lobster Research (Geoff Cowles, UMass SMAST)

Geoff Cowles presented research related to the impacts of climate change on the Southern New England lobster population. There has been a significant reduction in the size of the Southern New England lobster stock over the last decade possibly due to thermal stress. The objective of this study was to conduct field surveys and modeling to assess the impacts of temperature on egg bearing females and determine if there has been a change in the ability to deliver larvae to Buzzards Bay. The combined surveys and modeling efforts found that there has been a change in the amount of time larvae spend over suitable habitat, resulting in less larvae settlement and a reduction in the population.

The Advisory Council supported continuation of this and other related projects to examine the impacts of thermal constraints resulting from climate change on lobsters and other species. They noted that research efforts have largely focused on adults; but it may be critical to understand impacts on juvenile animals.

New Initiatives:

Aquaculture (Chris Schillachi, MA MDF/Steve Lohrenz, UMass SMAST)

Chris Schillaci presented an overview of the MA DMF aquaculture program and recent initiatives for aquaculture in state waters. Aquaculture is a large industry in Massachusetts, generating over $27 million per year, primarily from oysters, but also including quahogs and soft-shell clams. There are approximately 1,300 acres of nearshore aquaculture in the state with 100 acres developed in just the last two years. *Vibrio* continues to be a challenge for aquaculture operations, however there has been a decrease in occurrence in recent years resulting from increased educational outreach and development of consistent regulations.

New initiatives in aquaculture include nitrogen mitigation for eutrophication and kelp growing. There are currently multiple pilot projects underway to evaluate nitrogen uptake rates by shellfish. Municipalities are managing some of these pilot efforts, but questions have arisen about municipal vs. private aquaculture and the fate of the grown shellfish if not harvested. There are limited projects examining the commercial potential for kelp. Currently, there is no market for kelp, and it is a very difficult species to grow in Massachusetts state waters.

Massachusetts is currently improving the aquaculture permitting guide and continues to work with the Interstate Shellfish Sanitation Chapter (ISSC) to manage impacts from bird and

mammal waste. The new permitting plan will include performance metrics to minimize environmental impacts and user group conflict.

Steve Lohrenz presented an overview of the recent Consortium for Ocean Leadership's Industry Forum on U.S. Offshore Aquaculture. Major take-home points from the Forum included considering the difficulties of permitting, mammal entanglement, and finfish escapement.
The Advisory Council considered the potential opportunities associated with aquaculture, including employment for displaced fishermen, and creation of artificial reefs to attract recreational fishing. Federal funding opportunities have emphasized expansion of aquaculture in recent years, and New Bedford Port Authority is exploring possible aquaculture opportunities for Clarks Cove.

Offshore Wind (David Pierce, DMF/Kevin Stokesbury, SMAST/Steve Cadrin, SMAST)
David Pierce provided a brief overview of MA DMF's efforts to develop potential regional scale research and monitoring priorities related to development of offshore wind farms. MA DMF has submitted comment letters to the Bureau of Offshore Energy Management (BOEM) throughout the development process of the three current wind farm areas in southern New England. John Quinn briefly updated the Advisory Council on NEFMC's engagement in wind energy issues and explained that offshore wind development is currently included in the responsibilities of the NEFMC's Habitat Plan Chair and Habitat Committee. It was noted that David Pierce and Kathryn Ford from DMF and Kevin Stokesbury from SMAST are involved in the Fisheries Working Group on Offshore Wind convened by the Massachusetts Office of Energy and Environmental Affairs and the Mass Clean Energy Center. MFI Advisory Council members Eric Hansen and Jim Kendall also serve on this group.

Steve Cadrin and Kevin Stokesbury presented information about recent workshops that SMAST has facilitated between members of the fishing industry and Vineyard Wind. Additionally, SMAST conducted a survey using the open cod-end video trawl in the area where Vineyard Wind is planning turbine construction. Input from members of the fishing industry suggest that there is equal concern about the turbines and cable routes, as well as concerns about both local and regional impacts.

The Advisory Council had a lengthy discussion about offshore wind energy development. The group suggested that MFI should have a broad focus on the regional scale cumulative impacts, rather than focus on any individual wind energy area. The group is interested in developing a regional framework to monitor and consider impacts on the overall marine ecosystem. The Advisory Council suggested an adaptive management approach to offshore wind energy development so that adjustments can be made as we understand how these areas are impacted. There was some interest from the Advisory Council in developing an MFI white paper on the potential impacts of wind farms and suggestions for monitoring; but there was also concern that construction is imminent and research needs to begin immediately. The group discussed the potential for coexistence of wind farms and fisheries and suggested research that would support continued fishing in wind energy areas. The group discussed the Before-After-Control-Impact (BACI) studies that were conducted at the Block Island Wind Farm site and suggested that similar studies get underway with funds from the states of MA ($400,000) and RI. The group

noted that the International Council for the Exploration of the Sea (ICES) has convened a working group on wind energy development and suggested additional U.S. participation.

Update MFI Objectives, Mission, Vision (Steve Lohrenz SMAST, David Pierce DMF)

The MFI Co-Chairs announced a new initiative to develop a strategic plan for the MFI in 2019. MA DMF is currently updating their strategic plan to span 2019-2023, and SMAST recently completed their Implementation Plan of the Strategic Plan, which will take effect in 2019. The MFI Executive Committee will be drafting a plan with a high level overview of where we currently are and where MFI hopes to go in the next five years. A draft of the plan will be presented to the Advisory Council in late 2019.

MFI Workshops:

Plan B Assessment Approach (Steve Cadrin, UMass SMAST/Cate O'Keefe, MA DMF)

MFI has conducted several workshops on fisheries "hot topics," including an end-end review of groundfish science and management and Accountability Measures. The Executive Committee proposed a workshop topic for 2019/2020 on the 'Plan B' Assessment Approach (i.e., a scientific procedure to derive acceptable catch when an analytical stock assessment method is rejected). Previous MFI workshops followed a multi-day format that was inclusive of stakeholders in the region to produce recommendations for improved science and management. The Plan B Assessment Approach is a priority topic for New England and has been indentified for review by the NEFMC, NEFSC and Northeast Region Coordinating Council (NRCC). The workshop would include a review of assessment approaches from other regions, nationally and internationally, and consider best practices for data limited assessments.

The Advisory Council considered this topic to be appropriate for MFI to address, timely for integration with other regional efforts, and relevant to the new stock assessment process. There will be a research track assessment by the NEFSC starting in 2020 to address this topic, so a 2019 workshop could produce starting point recommendations and a holistic overview of the issue.

Adjourn: The meeting adjourned at 1:45pm.