Abstracts
For
The MIT Sea Grant Research Symposium
March 20, 2024, 12-4pm

PIs:
Pingguo He, University of Massachusetts Dartmouth

Additional Individuals:
Christopher Rillahan and Ming Shao, University of Massachusetts Dartmouth; Josh Wiersma and Jeff Douglas, Integrated Monitoring Inc.; Rick Usher and Peter Melanson, AIS Inc.

Title:
Incorporating Machine Learning into the NE Multispecies Groundfish Electronic Monitoring Programs to Quantify Species and Sizes of Discards

Abstract:
This presentation reports the design and construction of an intelligent discard chute that incorporates optical imaging and machine learning/Artificial intelligence to automatically detect species and measure sizes of fish that are being discarded through the chute. Images from the camera inside the chute are integrated to video images from other deck cameras, and are streamed via Starlink network to the office for processing and auditing. Algorithms for video image analysis using artificial intelligence and machine learning are being developed to document species and measure size (length) of fish being discarded. This project is a collaborative effort among an electronic monitoring enterprise, an at-sea observer company, and fisheries researchers and an AI/ML expert, with an aim to incorporate new technologies in the field of fisheries electronic monitoring to meet the increased fisheries monitoring requirements in New England and elsewhere in the world.

PIs:

Krish Sharman, University of Massachusetts Amherst

Title:

Implementation of Low-Cost Conductive Yarn Sensors into Aquaculture Enclosures for Strand and Rope Integrity Monitoring

Abstract:

In this project we examine the feasibility of integrating a conductive yarn, originally developed for military applications, into a mooring rope for sensing environmental and operational loads. A functional braided composite yarn with integrated electromagnetic properties was developed by project affiliate (Nautilus Defense) and integrated into a 5 mm rope at their manufacturing facility. Project partner MITRE labs developed electronics and data processing algorithms for the sensors. Laboratory tests were conducted at the Ocean Resources and Renewable Energy (ORRE) laboratory at UMass Amherst, where rope samples were subject to varying levels of static and dynamic forcing in dry and underwater. In this talk we will present some of the results showing correlation between sensor capacitance, tension and extension. We will discuss the potential for the sensor to support condition monitoring efforts of mooring lines for aquaculture and marine renewable energy.

PI:
Michael R. Benjamin, Massachusetts Institute of Technology (MIT)

Additional Individuals:
Michael Sacarny, MIT Sea Grant College Program; Ching-Tang Hung and Chi-Fang Chen, National Taiwan University, Taiwan; Katrina Zarrella-Smith, University of Massachusetts Amherst

Title:
Tracking Acoustically Tagged Fish by Autonomous Sailboat While Underway

Abstract:
Using an autonomous sailboat to track acoustically tagged fish has potential advantages over using stationary receivers or underwater gliders, including improved spatial coverage and flexibility over survey areas. Yet, surface vehicle detection capabilities can be limited by noise interference from the surface and the vehicle itself. This work examined design considerations related to sensor placement and the resulting acoustic detection efficiency using an autonomous sailboat. The sailboat was outfitted with a common acoustic receiver, high-performance hydrophone, and new autonomous control algorithms to survey an area of Boston Harbor, USA for winter flounder. To achieve improved acoustic detection capabilities, a high-transmissivity, flooded cowling that protected the sensors and reduced drag was designed. From the design results, the impact of wave-induced bubble plumes on mobile receiver efficiency was confirmed in field trials and was quantified over a range of wind speeds. An algorithm for detecting the signal of tags and estimating the likelihood of fish within the surveyed habitat based on the passive sonar equation, underwater acoustic transmission loss equation, and Bayesian theorem was also developed to evaluate the performance of the mobile receiver. Overall, 21 tagged winter flounder were detected, or 10.6% of known fish at liberty, whereas stationary receivers in the same test area detected 11.6%, demonstrating the utility of the autonomous sailboat for movement ecologists. Overall, these results provide design and data analysis guidance for tracking acoustically tagged fish by an autonomous sailboat while underway, an underutilized method in fish tracking.

PIs:
Steven E. Lohrenz, University of Massachusetts Dartmouth

Additional Individuals:
Haley E. Synan and Brian L. Howes, University of Massachusetts Dartmouth

Title:
A Satellite-Based Approach Using Landsat 8 for Water Quality Monitoring of Coastal Waters in Pleasant Bay, Massachusetts

Abstract:
Water quality monitoring is essential to assess and manage anthropogenic eutrophication, especially for coastal estuaries in heavily populated areas. Current monitoring techniques rely on in-situ sampling, which can be expensive and limited in spatial and temporal coverage. Satellite remote sensing, using the Landsat 8 (Operational Land Imager, OLI) platform, has the potential to provide more extensive coverage than traditional methods. Coastal waters are optically more complex and often shallower and more enclosed than the open ocean, presenting conditions that pose challenges to remote sensing approaches. Here we compared in-situ data from 16 stations around Pleasant Bay, Massachusetts from the years 2013-2021 to contemporaneous observations with Landsat 8 OLI. Initial evaluations identified a subset of stations that were not suitable for satellite remote sensing, due to depth and proximity to land. Satellite-derived estimates of chlorophyll-a and Secchi depth were acquired using the "Case-2 Regional/Coast Color" (C2RCC) and "Case-2 Extreme" (C2X) processing algorithms and compared to in situ observations using a random forest machine learning algorithm. Based on our results, predictions of water quality indices from both C2RCC and random forest techniques can be a useful addition to existing water quality monitoring efforts, potentially expanding both spatial and temporal coverage of monitoring efforts.

PIs:
David Ralston, Woods Hole Oceanographic Institution

Additional Individuals:
Matt Long, Hauke Kite-Powell, Woods Hole Oceanographic Institution

Title:
Ocean Acidification in an Intensely Farmed Coastal Bay System

Abstract:
Ocean acidification (OA) is increasingly of concern in the coastal waters of Massachusetts**.** Acidification in the Gulf of Maine has been mitigated by increasing water temperatures that reduce CO_2 solubility, but continued increases in atmospheric CO_2 are expected to lower pH below ecologically important thresholds. Estuaries are even more sensitive to anthropogenic pressures and show increasing temperature, decreasing dissolved oxygen, and decreasing pH, both regionally and globally. In addition to increasing atmospheric CO_2 and water temperature, acidification in estuaries depends on local factors like freshwater inputs and eutrophication that alter primary productivity, respiration, and dissolved oxygen (DO), thereby affecting the pH. We conducted a scoping study to better understand the spatial gradients and temporal variability in OA in Duxbury Bay on the South Shore. Duxbury Bay is the northern part of the Plymouth-Kingston-Duxbury Bays (PKDB) system and is one of the largest producers of farmed oysters in the state. OA is of particular concern due to the sensitivity of juvenile shellfish development to low pH, and oyster farmers in Duxbury Bay have already begun to modify hatchery operations for decreasing pH. We conducted shipboard surveys from April to October 2023 to map the distributions of physical (temperature, salinity) and chemical (pH, pCO_2, DO) properties in the bay. The shipboard survey data were complemented by time series observations with a suite of water quality sensors including salinity, temperature, pH, and DO. Results show distinct spatial gradients in pH and pCO_2 between offshore and estuarine waters. Around high tide, the upper parts of the bay consistently had pH values that were lower by 0.2-0.3 than the water near the mouth. Diurnal variability of pH and DO showed influences of respiration and primary productivity, but this was modulated by the phasing of the tides with the daily insolation. Along with the observational data, a numerical model was developed for the circulation, salinity, and temperature in Duxbury and the adjacent bays over the study period. Data analysis is on-going, and results are being shared with local stakeholders.

PIs:
Ted Maney, Salem State University

Title:
Developing Ropeless, Autonomous Depth Controlled Habitats for Shellfish and Other Aquaculture Farmers to Enable US Farmers to Improve Productivity and Expand Further Offshore

Abstract:
Summary:
Restorative submersed underwater platform-based ocean seafood farm with little or no surface lines and with hurricane proof anchors connected by horizontal ropes with surrounding screens to protect from endangered species like right whales. The platform depth is controlled by AiCT proprietary electronics sensors and machine learning algorithms that control platform depth to seek out and maintain depth, in near perfect conditions, that are often impacted by global warming and seasonal changes.

Long-term Goals:
Our long-term goal is to assist US aquaculture farmers both small and large in replacing certain labour-intensive, repetitive processes with artificial intelligence (AI) and automation to maximize growth while minimizing to-market costs.

Once designed, built, tested, and validated, we will have a system and technology that will allow large aquaculture farmers and rural traditional farming communities to prosper by adopting up to date low-cost technologies to improve operator health and safety, dramatically reduce operating expenses (OPEX), in-water boat costs, competitiveness against importers and allow operations scaling by moving further offshore.

Overall, AiCT technology will facilitate quick responses to upcoming storms (automated submergence), prevent sinking to the bottom from rafts that need more buoyancy as crop grows, eliminate risk significantly and provide a reliable control system for this environmentally sustainable method of growing food.

PI:
Petros Koumoutsakos, Harvard University

Additional Individuals:
Donna Dimarchopoulou, Woods Hole Oceanographic Institution

Title:
Data Driven, Causal Discovery of the Effects of Climate Change, Ocean Acidification and Management in Fish and Invertebrate Stocks

Abstract:
Climate change and ocean acidification are viewed as primary causes of variations in fish and shellfish stocks yet at the same time there is concern that inappropriate management may be contributing to this situation. A rational understanding of the relative importance of these causal relationships will be a hallmark of scientific understanding and powerful enabler to forecasting and prediction for fisheries managers and policy makers. In this scoping study, we focused on the Gulf of Maine and its iconic stocks of lobster and cod. We aimed at bringing together local science experts and stakeholders in a workshop to discuss personal experiences, observations, and knowledge on past and current stock status, climate-related shifting distributions, and data sources. This capacity building is expected to help us sharpen our questions in an effort to build models that provide verified causal relationships between environmental factors (e.g., nutrients, temperature, currents, acidity), fisheries management, and spatiotemporal distributions of fish and invertebrate stocks in the Gulf of Maine. Our ultimate goal is to leverage these local relationships to increase our understanding of shifting species distribution in an everchanging ocean that is affected by climate change and exploitation, and its relationship to environmental factors. In the future, we plan to use state-of-the-art methods of causal inference, such as the Learning Effective Dynamics (LED) and the Deep Latent Variable (DLV) models and deploy them for the first time in fisheries related problems.

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PI:
Dick Yue, Massachusetts Institute of Technology

Additional Individuals:
Grgur Tokic, Massachusetts Institute of Technology

Title:
Coupled Multi-Scale, Multi-Disciplinary Modeling of Fish Aquaculture Farms: From Fish Biomechanics to Cage Hydrodynamics

Abstract:
We are developing a coupled multi-physics model of offshore cage-based aquaculture in order to understand and optimize the design and feed management of floating fish farms, as well as their impact on the environment. Due to the significant mutual influences, a coupled model of fish-cage-flow interaction is crucial for advancing the understanding and implementation of offshore aquaculture. We leverage simple, but complete theoretical and computational models of individual fish biomechanics and hydrodynamics, and fast computational methods for hydrodynamic interactions among hundreds of fish to obtain realistic models of fish schools. In this Symposium, we will discuss our recent developments in extending the existing social interaction models of fish schooling to include confinement-induced effects. We show that the introduction of aggressive behavior, which is ubiquitous among captive fish in tightly packed cages, significantly changes the schooling dynamics. We find that the stable schooling structures that emerge in open ocean become unstable when aggression is introduced. Depending on the fish density and the probability of aggression, new schooling structures emerge. The aggression-altered schooling behavior is accompanied with an increase of exhaustion among fish and the associated lactic acid levels. These findings are relevant for understanding the trade-offs associated with increasing the fish density in aquaculture cages. They pave the way for designing and operating optimized offshore aquaculture farms, which would lead to competitive advantages for the local aquaculture industry.

PI:
Dipanjan Saha, Northeastern University

Title:
TRRAFICC: Toolbox for Robust, Real-time, Automated Fish Classification and Counting

Abstract:
Accurate assessment of fish population and spawning abundance is crucial for aquaculture and long-term ecosystem studies. This assessment provides fishery management staff and marine scientists with valuable data necessary for sustainability, ecosystem monitoring, understanding patterns of fish abundance and behavior in underwater habitats including near aquaculture farm habitats. A motivating example is River Herring (RH) in the northeastern United States. While the adult Herrings grow in seawater, they migrate to freshwater for spawning every spring. In turn, the juvenile Herrings migrate to seawater every summer and fall. This yearly migration pattern makes RH an essential component of both freshwater and marine ecosystems, as well as coastal fisheries. The need for continuous monitoring was established more than ten years ago, when a decline in population to less than 3% of the historical peaks led to the closure of many RH fisheries. The state-of-the-art fish counting methods based on visual, electronic, and video monitoring are labor-intensive, and they often require a significant amount of post-processing. Real-time, automated species classification and counting of underwater fish is a complex problem. An underwater environment has multiple sources of uncertainty such as water turbidity, lighting conditions (e.g., day vs. night), fish overlap during periods of high passage rates, potential for double counting (i.e., tracking multiple occurrences of the same fish entering the view frame), varying size and orientation of fish, and fish partially hidden from view. Deep learning (DL) has great potential to account for uncertainties; however, very few annotated fish datasets are publicly available. This work is developing a DL-based fish classification and counting framework, which localizes fish in video frames and further investigates each localized fish across the frames. The localization leverages Ensemble Learning to combine three methods: background subtraction, semantic segmentation, and optical flow. Each method has some unique benefits as well as challenges. Results show that weighted voting is a good way to combine the methods with minimal manual labeling. The next steps will compare two approaches for species classification and counting, as well as field-test the algorithms with real RH.