STATE OF MAINE
DEPARTMENT OF MARINE RESOURCES

In Re: Nor'Easter Oyster Co,
Experimental Lease Application

EXHIBIT LIST OF
INTERVENORS BETH AND JOHNNY WALKER CONSOLIDATED WITH INTERVENOR RACHEL WALKER (NO RELATION)

1. **Walker Ex 1** - Expert Report of Chris Kincaid, "Results from the ROMS Hydrodynamic-Transport Model for Circulation and Transport Processes in upper Johns Bay (ME)"

2. **Walker Ex 2** - Video – Example of Near Surface Water Column Ocean Modeling Results (Sig13_d243_253)

3. **Walker Ex 3** - Video – Example of Near Bottom Water Column Ocean Modeling Results (Sig2_d233_243)

4. **Walker Ex 4** - Video – Example of Near Surface Water Column Ocean Modeling Results (Sig13_d233_243)

5. **Walker Ex 5** - Expert Report of Jason Krumholtz, "A Review of the Ecological Suitability of the Upper Johns Bay/Johns River to Support Eelgrass (Zostera marina),"

6. **Walker Ex 6** – Photograph of Anchored Large Boats, Group of 3

7. **Walker Ex 7** – Annotated Aerial Photograph of Johns River Showing Launch, Mooring

8. **Walker Ex 8** – Photograph Looking South from Launch Area (Unmarked Ledge)

9. **Walker Ex 9** – Annotated Aerial Photograph Showing Routes to Skirt Lease

10. **Walker Ex 10** – Annotated Aerial Photograph Showing Seal Haul-Outs

Walker Exhibit 1

Report: Results from the ROMS Hydrodynamic-Transport Model for Circulation and Transport Processes in upper Johns Bay (ME)

Chris Kincaid, Kincaid Consulting, LLC.   August 5, 2025

Executive Summary: In order to simulate the flushing (or retention) patterns from inputs to the local waters from the proposed Nor'Easter shellfish lease, a new four-dimensional coastal ocean hydrodynamic-transport model was developed for the Johns Bay / Johns River using the widely used and tested, public domain Regional Ocean Modeling System (or ROMS). The model controverts a common misconception that flushing in an estuary is due to tidal rise and fall of the water and related flood and ebb currents. Here, it is the subtidal or net-non-tidal flow that controls longer term transport currents and the flushing vs. retentive fates of biogeochemical constituents within the water. These 4-D hydrodynamic simulations reaffirm the importance and complexity of subtidal circulation trends for longer term flushing of materials that would be discharged to the water by Nor'Easter activities. Simulated flows respond to realistic forcing conditions (winds, tides, water density gradients) and reveal subtidal flow pathways that are highly unfavorable to flushing processes. High resolution simulations use a dense distribution of model grid nodes (or cells) to show subtidal circulation of both shallower, less dense waters and deeper, denser water around the proposed lease site tend toward retentive, gyre-like flow paths around local islands and within nearby coves/embayments. Results counter the common oversimplification that shallower waters and ebb tide releases flush pollutants seaward and call for careful consideration of local conditions that are highly unfavorable to flushing processes when considering the impact of Nor'Easter's proposed activities.

Project Summary/Methods: In order to simulate how proposed inputs to the local waters of the proposed Nor'Easter oyster aquaculture lease area circulate in the area lying between Peabow and Foster Islands in the north of Johns Bay (JB), a well-established, widely used ocean circulation computer model has been used in developing a hydrodynamic-transport model. This model simulates the three-dimensional, time varying water circulation patterns within and between these water bodies. The new model is referred to as the JB-ROMS hydrodynamic model, which developed through two stages of computational grids described in Figures 1 and 2. Here ROMS refers to the Regional Ocean Modeling System, an continuously evolving, public domain platform for solving the coupled equations for coastal circulation and both thermal and salt transport. Estuarine flow is driven by winds and tides, along with density differences related to water temperature and salinity derived from inputs from the watershed, atmospheric parameters (e.g. rain fall, air temperature, long/shortwave radiation, etc.) and intrusions of cool, salty offshore waters. Local JB watershed/river inputs are estimated using the ratio of local drainage areas to those of gauged ME rivers. JB exchanges with the inner shelf waters are estimated from larger domain ROMS models done for a NOAA project on the Northeast US Shelf (NEUS) circulation. Outputs from this NEUS -ROMS model provide needed "boundary forcing" information at the ocean interface of the JB-ROMS domain, included 3-D flow vectors, water level changes and temperature (T) and salinity (S) conditions for shelf water entering the estuary.

Computational models of estuarine dynamics solve the coupled set of conservation equations for mass, momentum and various transport processes (heat, salt, chemical fields). The technique for solving these equations involves discretizing the 3-D water body into tiny cells defined by a densely packed collection of grid nodes and using solvable algebraic expressions for math that describes gradients and processes of flow and exchange between neighboring grid cells. A first grid was tried (Figure 1), but the domain was too large to run efficiently on the supercomputer. A second, more focused grid domain of the model (Figure 2) eliminated these problems while still encompassing waters between South and West Bristol and Pemaquid Harbor to the east. The model includes fresh water input from local sources like the Johns and the Pemaquid Rivers, and natural exchange with inner shelf waters south of JB. The newer grid utilizes 288 grid nodes in the shelf coastline parallel direction and 1088 grid nodes in the coastline normal or mouth to head direction of the estuary. The 3rd dimension, or vertical processes are represented using a 15 grid cells spaced between the ocean floor and the water surface. Changing water depth due to bottom topography is accounted for using a vertical stretched coordinate (or sigma coordinate). The water surface level varies with tidal changes, primarily the semi-diurnal or M2 tidal oscillation. Wind stresses applied to the water surface move the surface water, and can produce local water level gradients that also drive internal, water column circulation.

The model simulates how proposed inputs to the local waters of the proposed Nor'Easter oyster aquaculture lease area circulate in the area lying between Peabow and Foster Islands in the north of JB (referred to as PFI region) (Figure 3). JB-ROMS models are designed and applied to simulate and quantify processes controlling either the retention or flushing of local alterations or inputs to the water due to these activities. This involves using JB-ROMS to solve for estuarine circulation and transport processes. The simulations solve for time-varying 3-D flow vectors at each of the 4,700,160 grid cells within the JB-ROMS (288 x 1088 cells (in mapview) x 15 sigma levels in the vertical dimension).

Flushing and transport of inputs to the local waters of interest are simulated using modeled passive drifters (a.k.a. floats or Lagrangian drifters) released from 22 latitude-longitude sites (with four release depths per site) within the PFI area (Figure 3). The motion, or advection of floats is calculated using the 3-D velocity of the local grid cell, interpolated to the exact location/depth of the float. New float cohorts are introduced at all 88 location/depth combinations every 10 minutes and tracked throughout the simulations from that point. The float paths reveal both the oscillatory water flow (flood vs. ebb) due to tides and, more importantly, the "subtidal" flows that contribute to the flushing (or retention) of water. The combined tidal and subtidal motions of these passively moving floats are used to quantitatively characterize flushing (or retention) patterns for waters of different depths that continually occupy the PFI area for the range of environmental conditions experienced during the simulations (e.g. spring-neap tides, different winds, runoff conditions, etc.).

Simulations utilize starting temperature (T) and salinity (S) information for all JB-ROMS grid nodes and ocean exchange information from existing 2020 simulations done using the coarser grid NEUS-ROMS that includes the Gulf of Maine. For this reason, simulations begin on day 190 (July, 9th, 2020) and "spin up" to the local JB conditions from day 190 to day 213 (8/1/20) using the model input files for key parameters, including river discharge, applied surface wind stress and ocean exchange (e.g. tidal variations) of hydrodynamic and hydrographic parameters through the mouth of the JB-ROMS model. From this point, simulations are run for 10 day increments covering the time window from day 213 to day 253 (9/10/20). The full complement of continuously released floats are tracked over each of the 10 day increments. Matlab graphical analysis scripts are used to produce movie sequences of float paths evolving over time. Statistics are also calculate at each model time step for total numbers of floats released at each time compared with total numbers that are either flushed from the area or retained within the area.

Results: These results reveal retention/flushing patterns for floats released to two sub-regions (Figure 3). One is for releases closer to the northern shore of the PFI area (red symbols), with a second population (yellow symbols) for floats introduced to water that is further south in the PFI area. Distinct, repeatable modes of float transport are seen for flood versus ebb stages of the semi-diurnal (M2) tide cycle (Figures 4-7). During flood periods, pathways for floats released to the PFI area bifurcate, with arms moving northwestward and northward. Many floats released to the PFI area move west and then northwest into the Johns River "Northern Branch", where they hug the eastern shore of this area (path F_1 in Figure 4) due to the "Coriolis" effect, where Earth's rotation acts to turn or deflect moving water (and air) to the right of its intended path (in the Northern Hemisphere). Another common flood tide path for PFI waters is northward toward and into the North Cove (north-northeast of Peabow Island) (path F_2 in Figure 4) where it can be retained in a sluggish clockwise gyre (Figure 7b). Flood tide currents also carry water eastward towards Foster Island. These float paths show a tendency for water to become trapped in a clockwise, around island gyre (path F_3) or to continue eastward, feeding into a sluggish gyre within the embayment northwest of Foster Island (path F_4). The retentive circulation effect of small islands (e.g., Figure 4 path F_3; Figure 5 paths E_1 , E_3) is common in these high resolution simulations. These retentive island gyres that hinder flushing result from combined impacts of friction from the island bathymetry and the Coriolis force that deflects water flow to the right of its path.

Local bathymetry also has an impact on float paths during the Ebb stage of the tide cycle. Retentive paths ($E_{1,3,4}$ in Figure 5) show floats being entrained into around Peabow Island flow or the islands/embayments east of the release sites. The primary flushing pathway (E_2) is also highlighted in Figure 5. Simulations show floats that can avoid the Peabow Island retention current, may ride ebb currents far enough south from the release area, reaching a point where the next northward flood current transit leaves them south of the release site and they are able to exit this area entirely on subsequent ebb currents (via a flushing jet shown in Figure 5). Examples of these flood and ebb stage float distribution patterns are shown in Figures 6a and b, respectively. In Figure 6a, both red and yellow floats released into the near-bottom waters are shown to move west and north into the Northern Branch area. The tendency for floats to move towards the North Cove/northern shore, and extrude eastward to the high retention area northwest of Foster Island are also shown. In Figure 6b, the deflection of yellow floats into a clockwise pattern around Peabow Island are apparent during the ebb tide. These general dispersion patterns, outlined schematically in Figures 4 and 5, are seen to occur throughout the simulation period, as shown by near-bottom float distributions from days 214, 218 and 221 (frames a-c in Figure 7). The ultimate flushing process/pathway from this section of the estuary is revealed by floats that slowly escape southward from the retentive PFI area. But the simulations show how smaller scale, retentive flows in and around the PFI area during flood and ebb stages significantly hinder and slow the movement of PFI releases ability to reach the starting area for flushing current highlighted in Figures 5 and 7c.

The longer term trends for flushing versus retention of floats released to the PFI area are summarized for different release time windows and depth levels (Figures 8-13). Each plot shows the total number of floats released through time, and the relative numbers of those floats that are either flushed from the area (blue) or retained in the area (red). For near-bottom releases during the period day213-223, most of the floats are retained. Towards the end of the simulation window the percentages evolve to equal flushing versus retention of floats (Figure 8).

A similar plot, but for later in the summer, as density stratification of the water is increased, the trend is toward even higher ratios of retained to flushed floats in the bottom water (Figure 9). This is consistent with increased isolation of bottom water as zone of mid-water stratification, or the pycnocline, gets progressively stronger.

The next set of plots shows results for the fate of floats released into the near-surface waters. The most efficient flushing seen in these simulations occurs during the early time window for near-surface floats (Figure 10). This is one of the few periods where the flushing efficiency exceeds the tendency for floats to be retained. However, the patterns for near-surface waters follow a similar trend as near-bottom water further into the summer season. This is shown in plots for the time period of day 223-233 (Figure 11) where slightly more floats are being retained versus being flushed. Figure 12 shows the retention of near-surface PFI region waters also becomes stronger during the later stage time window, from day 233 to 243. A final plot (Figure 13), summarizes near-bottom float behaviors for the latest stage simulation window, from day 243 to 249. Here again, the results show relatively limited flushing efficiency for PFI waters.

Conclusions: These Johns Bay / Johns River coastal hydrodynamic-transport simulations show a number of key features for circulation and its impact on flushing efficiency in the northern parts of the estuary, near Peabow and Foster Islands. Results show that simply considering "tidal" flows or to assume that ebb tide releases alone will result in flushing are misleading concepts. These 4-D hydrodynamic simulations reaffirm the importance and complexity of subtidal circulation trends for longer term flushing of material discharged to an estuarine water body. In these simulations subtidal flow of deeper, denser (cooler, saltier) water moves inward or northward, becoming entrained within smaller scale recirculatory flows in coves, embayments or around islands of the PFI region, that are highly unfavorable to flushing processes. It is a common oversimplification that shallower, less dense water tends to move/flush seaward from the estuary as flushing favorable currents. Simulations show subtidal flow of shallower PFI region water is highly complex, feeling influences of the local coastline and bathymetry and landward blowing winds that combine for subtidal pathways that are also highly retentive. Float paths show plumes of PFI water commonly get caught in current loops, moving into the North Branch area during the flood only to return to the PFI region during ebb tide. Simulations clearly show the tendency for PFI floats residing in the upper water column to also become trapped by around-island retentive flows (paths F_3, E_1, E_3, Figures 4,5) and within gyres of North Cove (Figure 5, path E_5) and the embayment by Foster Island (Figure 5, path E_4) over the tide cycle.

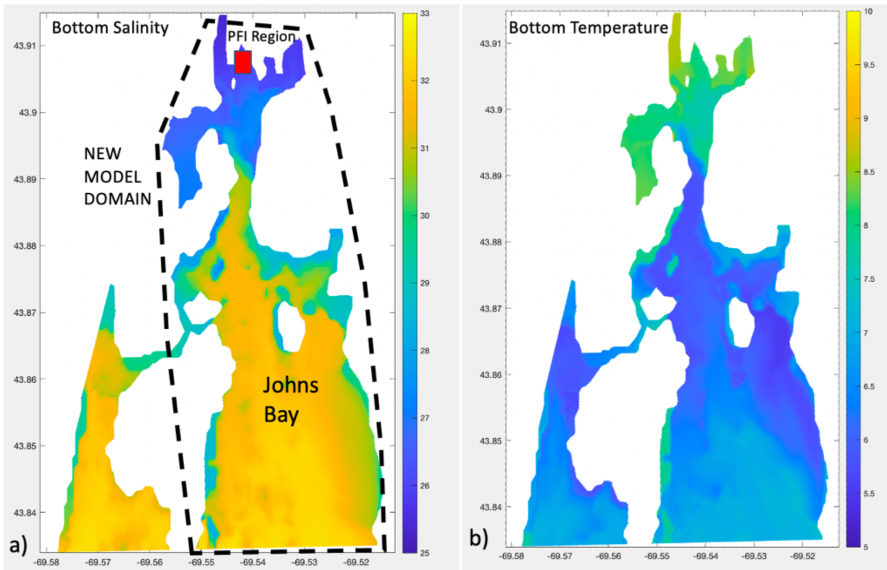


Figure 1. A first pass Johns Bay/Johns River ROMS Model (or JB-ROMS) was constructed that included the area of interest to the north (red square) where the open ocean boundary was far removed to avoid unwanted interactions with the ocean boundary conditions applied at this interface with the open ocean. This model domain is shown as color maps for a) near-bottom water salinity (ppt) and b) near-bottom temperature (°C). This first model also extended to the west of Johns Bay. This first grid included 500 grid cells in the along-coast direction and 1200 grid cells in the coast-normal direction (e.g., into/out of the estuary). When combined with 15 vertical (sigma) cells, this resulted in 9 million total cells causing the computational times to be excessively long. It also produced numerical instabilities within the interior narrow channel connecting western and eastern sub-regions, further limiting computational efficiency. To improve grid resolution a new, refined model domain was developed.

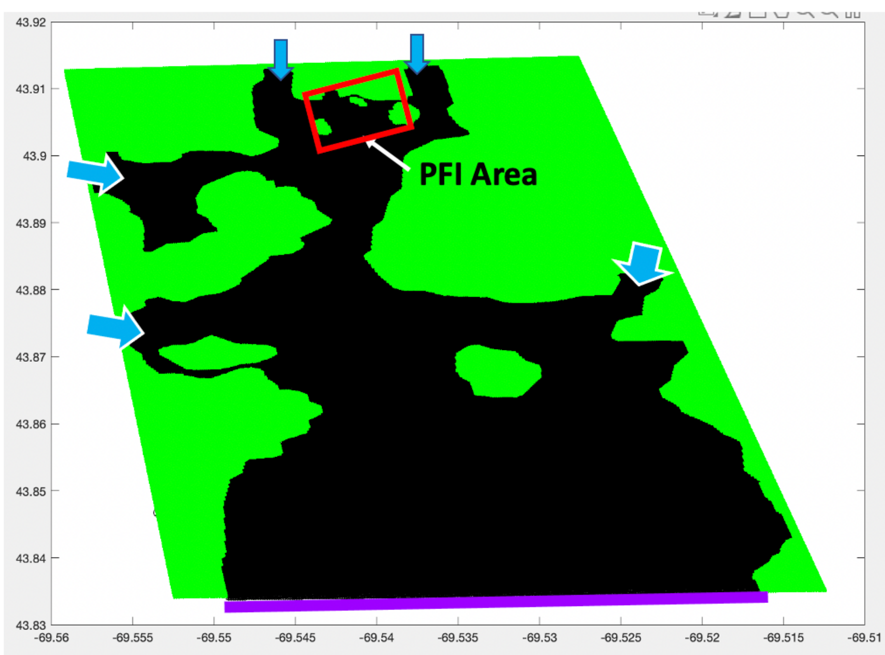


Figure 2. The final version of the JB-ROMS model is shown here (black=water cells or nodes; green=land nodes). The new JB-ROMS uses 288 cells in the east-west (along-coast) direction and 1088 cells in the coastline normal or into/out of estuary direction. This model uses fewer total cells, for faster simulation run times, but maintains denser or finer grid spacing in the northern area of the model, where the red rectangle shows the Nor'Easter lease site, between Peabow and Foster Islands (PFI area), where passive floats are released at 22 sites (4 depths per site). Blue arrows show locations of 5 fresh water discharge rivers applied to the model simulations. The magenta line marks the "open ocean" model boundary, where a boundary forcing file applies tide/water level changes, intrusion/extrusion exchange flows and T,S conditions between the estuary mouth and the inner shelf waters.

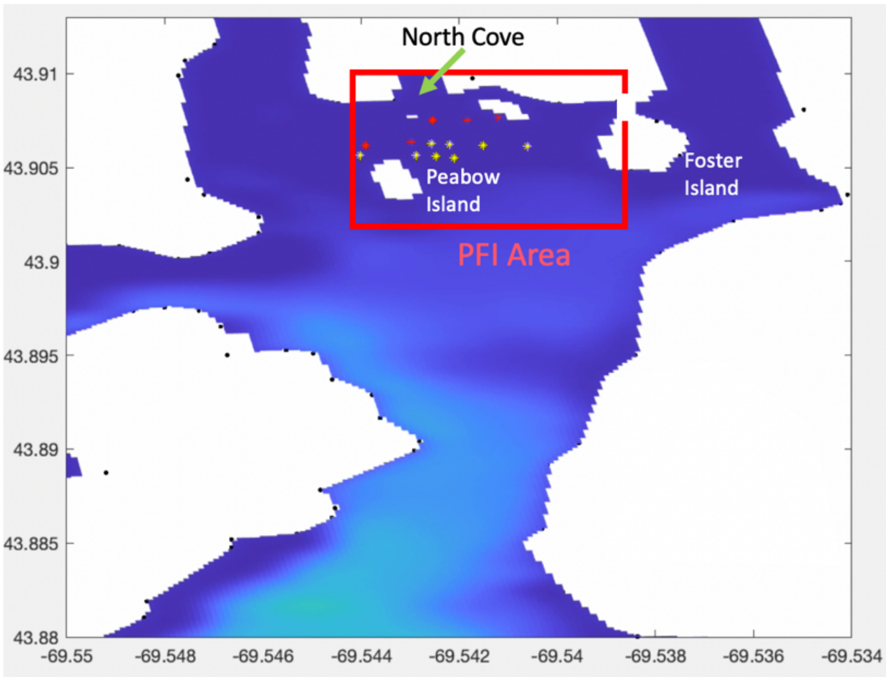


Figure 3. A map view of the water nodes of the JB-ROMS model grid focused in the northern area of interest, between Peabow and Foster Islands. The locations of two areas of passive float release sites are shown. Red marks show a set of inner, or closer to coast release sites. Yellow marks show a set of more southern release sites. Release depths are sigma levels 2, 4, 6 and 13. Sigma 2 is closer to the bottom (e.g. sigma 1), sigma 13 is closer to the surface (sigma 15). The Peabow to Foster Island (or PFI) is highlighted, as is the region referred to as the North Cove, northeast-northeast from Peabow Island.

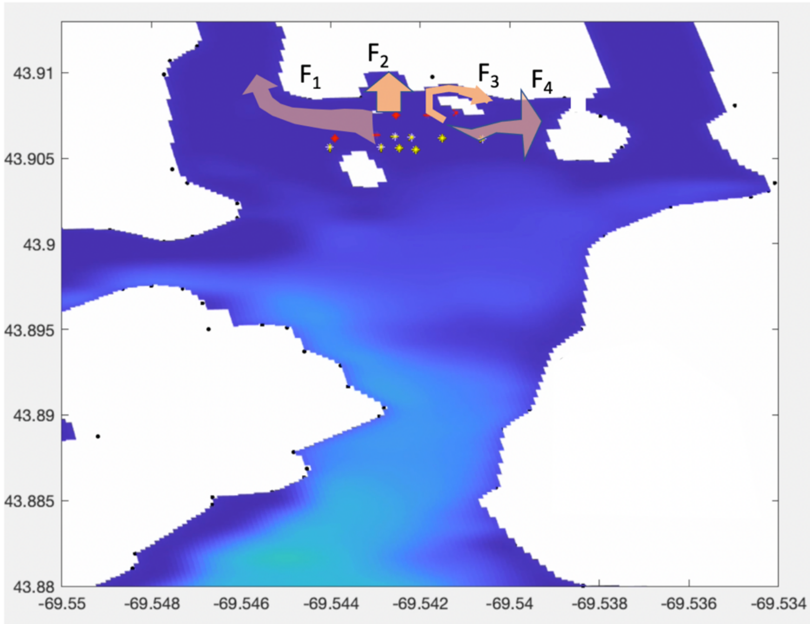


Figure 4. Schematic arrows are used to show common float paths during flood tide. A common transport mode is to the west-northwest (F_1), which is shown to reverse during ebb, bringing these floats back to the release area. A second path is northward transport to North Cove (F_2). A third, retentive flood transport mode (F_3) is clockwise, around-island circulation gyres (F_3). A fourth mode of flood stage transport (F_4) is shown by floats moving eastward from the Nor'Easter site, becoming trapped in weak, gyre-like flow in the cove northwest of Foster Island.

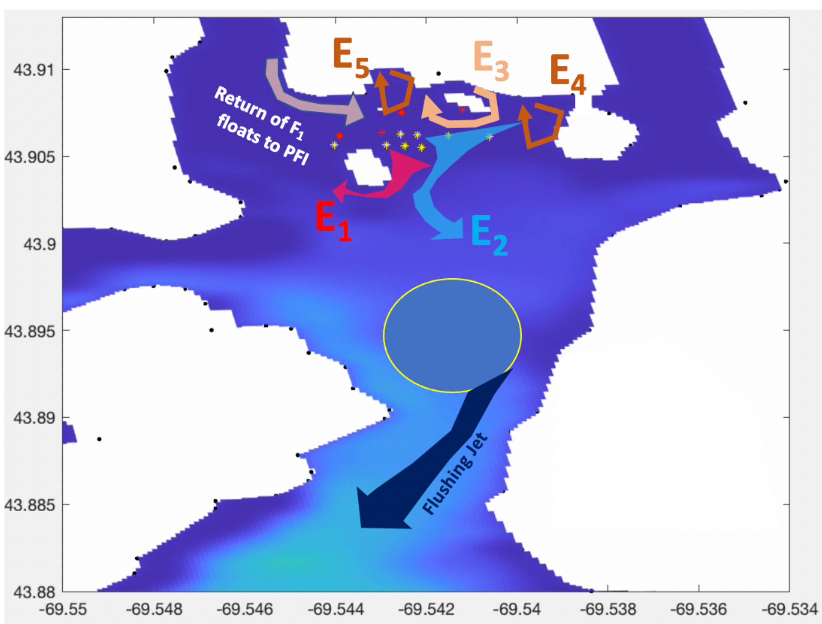


Figure 5. Schematic arrows are used to show common float paths during ebb tide. One mode of ebb current flow involves becoming entrained within an around island current (E_1), resulting in floats being retained in the area for another tide cycle. A second mode of ebb flow for released floats is reaching an area south of the two islands (yellow circle). Once here, the floats tend to experience a weaker-northward/ stronger-southward tidal flow cycle that puts them into an a flushing jet that moves them through the east-west constriction where they can more fully flush. Locally retaining pathways for ebb currents are also shown for around-island and within embayment gyres as E_3 and $E_{4,5}$. Floats tend to get retained, rather than flush, due to circular style flows relating to the Coriolis force(flow to the right of its path in the northern hemisphere) and the frictional influence of islands in areas east of the release sites (E_3 E_4). The path for floats that went to the North Branch (path F1) and return during ebb is also shown.

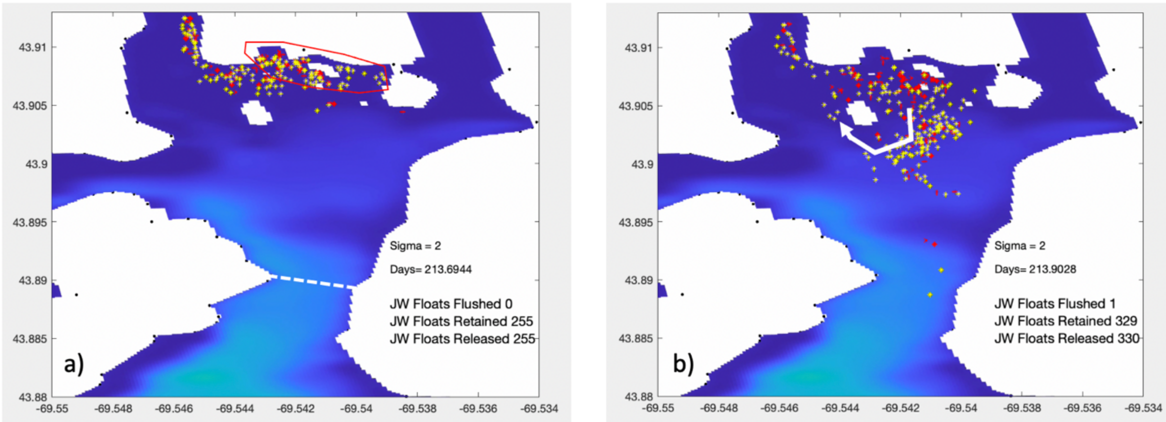
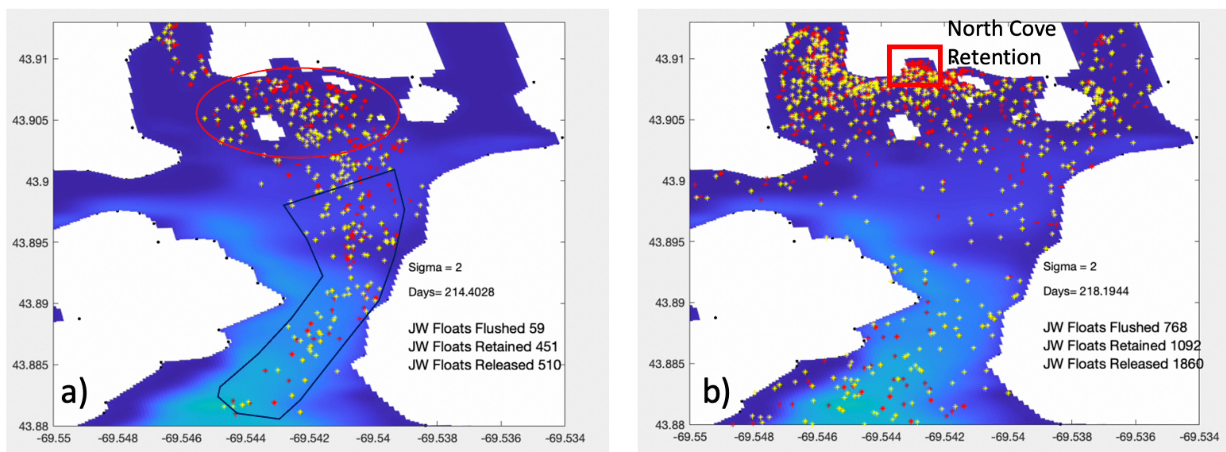


Figure 6. Red and yellow float positions are shown that have been released to near-bottom (sigma 2) waters starting on day 213.0 and running for approximately a day, through two flood/ebb cycles. The inset numbers show the total number of floats released at sigma 2 up to this point, along with the number that have been retained versus flushed from this area (white dash line). a) Float transport paths typical of flood tide periods are shown, including west-northwest motions (F_1 in Figure 4) and floats retained along the coastline north and east of the proposed aquaculture lease site (red outlined region, paths F_2 & F_3 in Figure 4). b) Similar to (frame a) but for the second ebb current of the day. After a day of 2 floods and 2 ebbs the majority of released floats remain in the general area of the release sites for near-bottom waters.



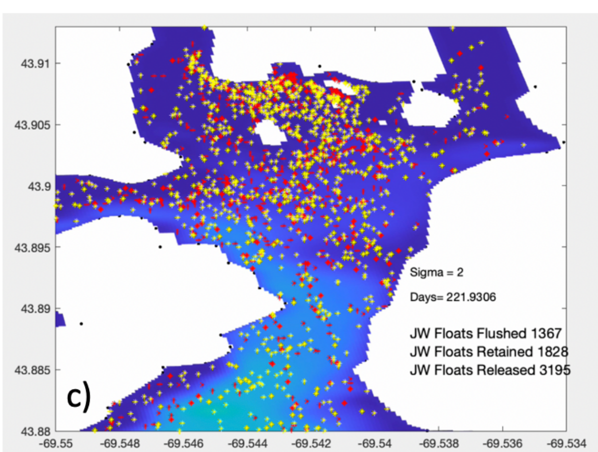


Figure 7. Similar to figure 6, for red and yellow float positions released to near-bottom (sigma 2) waters starting on day 213.0 but showing flushing/retention patterns after a) 1.5 days, b) 5 days and c) 8 days. a) After 1.5 days of simulation time, this frame shows near bottom floats that are retained in the release site by around island retention paths (red circle; Path E_1 in Figure 5) versus paths that have reached the pre-flushing zone, and eventually moved south from the region via the jet like outflow current (highlighted schematically in Figure 5). **As the 10 day simulation proceeds the numbers for floats released (vs. retained) are a) 510 (451), b) 1860 (1092) and c) 3195 (451). Frame b highlights common periods of strong retention of Nor'Easter releases in the North Cove.**

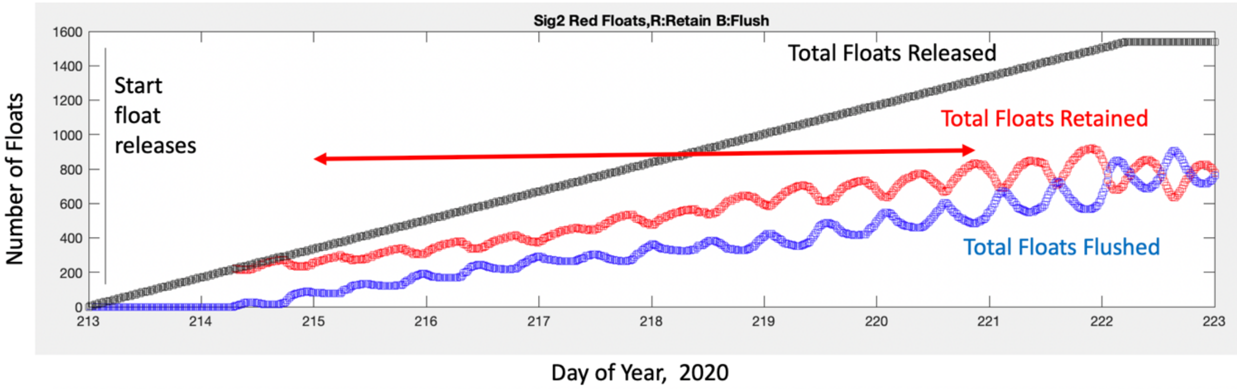


Figure 8. Plot showing total RED float releases versus time (black line) for the near-bottom floats during the simulation from day 213 to 223. The numbers for flushed (blue line) versus retained (red line) are also shown through time for near-bottom (sigma 2) released red floats. Late in the simulation the number of floats flushed reaches the number retained (~50% flushing).

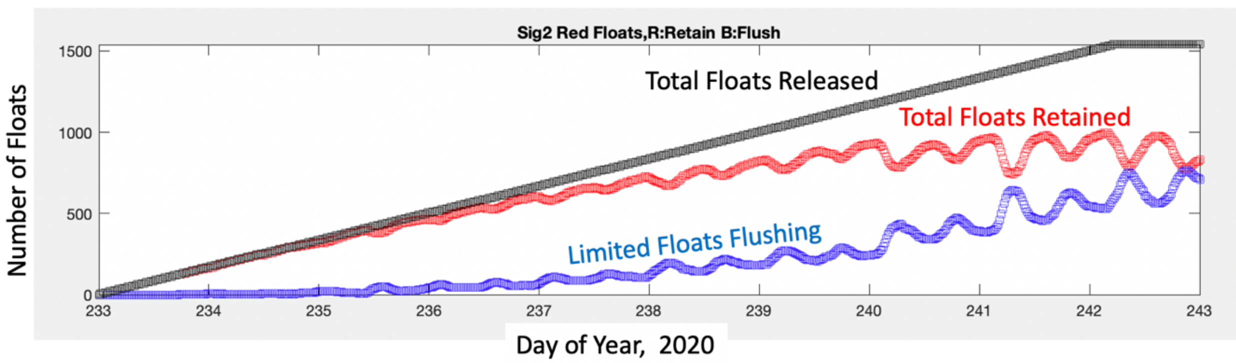


Figure 9. Similar to plot figure 8, but for simulation window from day 233 to 243. Results show that later in the summer, when waters are more stratified, there is a tendency for stronger retention (weaker flushing) of near-bottom waters.

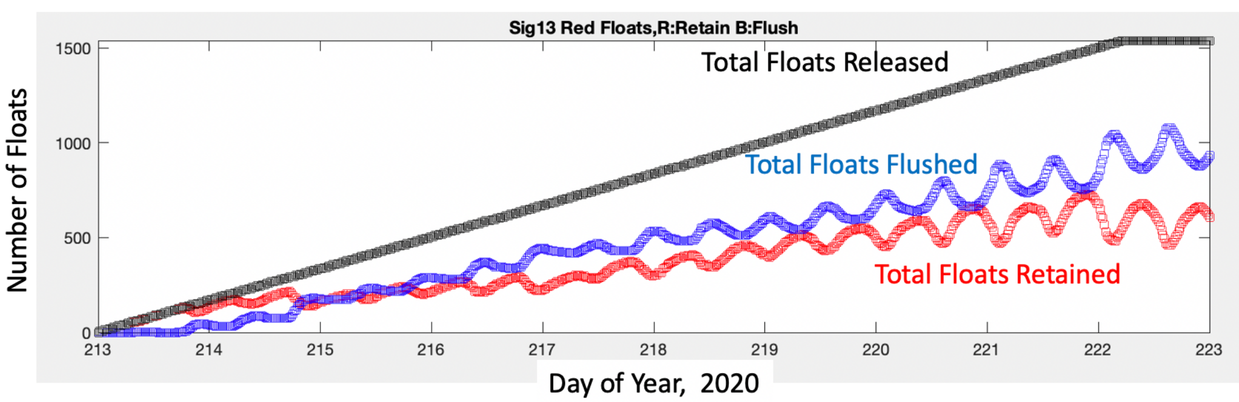


Figure 10. Similar to plot figure 8, with same day 213-223 simulation window, but for near-surface float releases (sigma 13). FOr shallower water levels, the simulations show a greater tendency for floats to reach the pre-flushing zone (yellow circle in Figure 5), where they can more easily flush to the south from this region of the estuary.

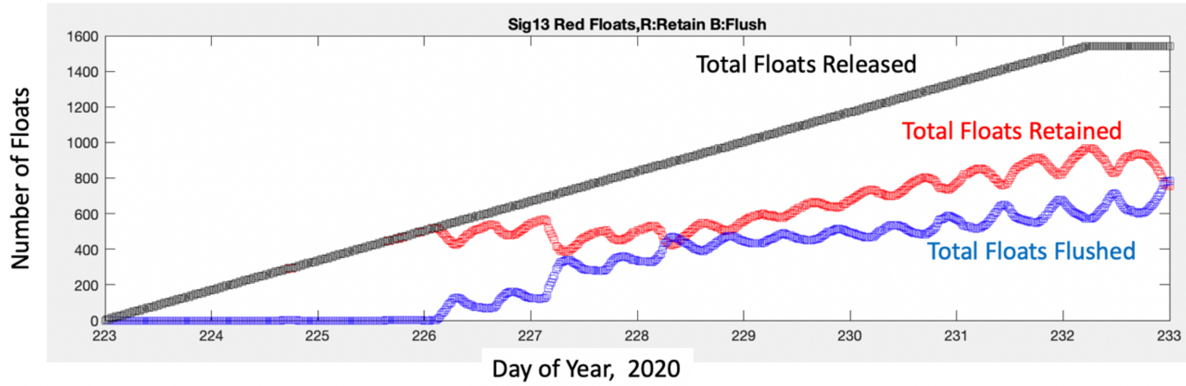


Figure 11. Similar to plot near surface float flushing patterns as in Figure 10, but for the day 223-233 simulation window. Here the surface floats have similar patterns to deeper waters, where more floats are retained than flushed from the area between Peabow and Foster Islands. Results show these surface flushing patterns are more strongly related to prevailing wind conditions.

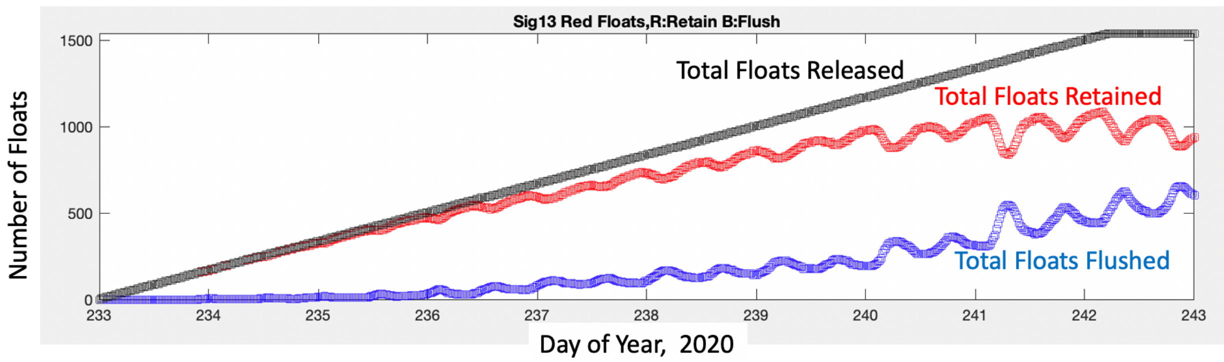


Figure 12. Similar to plot near surface float flushing patterns as in Figure 10, but for the day 233-243 simulation window, as shown for bottom water in Figure 9. Here again, the effect of later summer conditions results in more surface floats that are retained than flushed from the area between Peabow and Foster Islands.

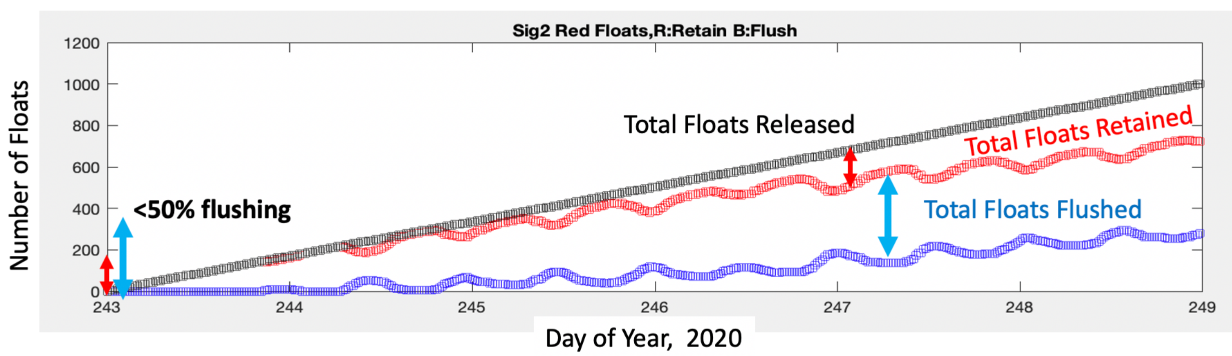


Figure 13. Flushing patterns for deeper floats during more stratified summer periods shows the tendency for strong retention (limited flushing) of deeper waters in the area of Penbow-Foster Island area.

Walker Exhibit
5

A Review of the Ecological Suitability of the Upper Johns Bay/Johns River to Support Eelgrass (*Zostera marina*)

Prepared by:

Remote Ecologist

Dr. Jason Krumholz, Dr. Jamie Vaudrey, and Mr. Kieran Garrity

7/26/2025

Executive Summary

The proposed Nor'Easter shellfish lease was surveyed for suitability as eelgrass habitat. The survey considered 1) known historic eelgrass beds nearby 2) diver surveys of the lease area 3) assessment of water and sediment quality and comparison to the Eelgrass Habitat Suitability Index (EHSI), developed for New England waters. Five stations in and around the proposed lease were surveyed. Water quality parameters (clarity, nutrients, pH) were consistently pristine at all five sites. Sediment parameters were more variable, and ranged from excellent to marginally suitable, with sediment organic content levels higher than generally expected for pristine coastal waters. Taken in total, all 5 sites scored as "suitable" (>50) for eelgrass on the EHSI, with two stations, one in the lease area, and one in the vicinity of nearby historic eelgrass beds, scoring at or near the threshold for "exceptional" (>88) eelgrass habitat. Diver surveys recorded sparse patchy eelgrass beds at the border of the proposed lease area. The potential for negative impacts; shading, turbidity, and increased sediment organics, combined with the tenuous nature of the existing eelgrass beds in the area, suggests that the proposed lease should be denied. This is particularly true given the wide range of stressors contributing to net eelgrass loss for the State. In addition, the allowance for onsite powerwashing and/or air drying poses additional risk of turbidity, increased sediment organics, and invasive species spread, which can damage eelgrass and other sensitive coastal ecosystems.

Introduction

Remote Ecologist was hired to conduct an assessment of whether the area suggested for the proposed Nor'Easter Aquaculture site between Pebow and Foster Island, in upper Johns Bay, ME (Figure 1) constitutes suitable habitat fo eelgrass (*Zostera marina*), and whether the proposed aquaculture lease might compromise the ability of this region to be supportive of eelgrass.

The State of Maine is highly conservative of eelgrass and eelgrass habitat, with the Department of Environmental Protection (DEP) leading efforts at eelgrass mapping. The Marine Vegetation Mapping Program (MVMP), established under Title 38 M.R.S. § 1805, mandates systematic mapping of eelgrass (*Zostera marina*) and salt marsh vegetation along the entire Maine coast. Mapping occurs on a five-year regional rotation, field monitoring is conducted via both aerial imagery and SCUBA-based diver transect surveys managed by DEP's Marine Unit. Divers assess shoot density, percent cover, canopy height, and other indicators twice annually at fixed locations, linking eelgrass health to surrounding water quality, particularly nitrogen levels. This survey methodology, while thorough and comprehensive, is prone to missing small and/or patchy eelgrass beds that are difficult to detect from aerial imagery. It therefore is not considered to be a comprehensive list of all eelgrass in the state.

Eelgrass is recognized by Maine DEP as a sensitive indicator of excess nitrogen in coastal waters. DEP developed specialized water quality criteria identifying concentrations above which eelgrass beds fail to thrive. In particular, if the ambient nitrogen concentration near a discharge exceeds approximately 0.32 mg/L, DEP evaluates adjacent eelgrass beds for evidence of stress (e.g., thinning or slimy appearance). If degradation is evident, DEP may limit nitrogen discharge through permitting to protect eelgrass habitat.

Figure 1 Satellite image showing the proposed location for the Nor'Easter Aquaculture lease in upper Johns Bay, ME

In order to assess the suitability of the proposed site as eelgrass habitat, Remote Ecologist employed the following criteria:

1) Identify any eelgrass present in or adjacent to the proposed site.
2) Review the historical extent of eelgrass in the region.
3) Identify suitable physical, chemical, and biological characteristics supportive of eelgrass within the area of interest.

The third part of this analysis was based on an eelgrass habitat suitability index (EHSI)[1], a model which assesses eelgrass suitability at a site based on scoring commonly available oceanographic parameters (see methods section for more detail). This model utilizes cutpoints for parameters applicable to New England waters.

These first three criteria are objective criteria governed by established scientific principles and published literature on eelgrass in New England. We will conclude the report with a subjective evaluation of the potential for this proposed aquaculture lease to negatively impact the ability of the region to support eelgrass. While any such assessment is, by its

[1] Vaudrey, Jamie M.P.; Eddings, Justin; Pickerell, Christopher; Brousseau, Lorne; and Yarish, Charles. 2013 "Development and Application of a GIS-based Long Island Sound Eelgrass Habitat Suitability Index Model". *Department of Marine Sciences*. https://digitalcommons.lib.uconn.edu/marine_sci/3

nature, judgment-based, the authors have previously worked on eelgrass and aquaculture interactions (oyster depuration cages)[2] and are currently examining the potential beneficial interactions between eelgrass and shellfish aquaculture related to carbonate chemistry in the water column, funded by Connecticut Sea Grant. Thus, we feel well qualified to share our opinion on this topic and hope you will find it useful.

Methods

The site was sampled on 5/20/2025. We collected water and sediment from five stations, three located within the proposed Nor'Easter lease, and two in the historic eelgrass bed northwest of the proposed site (Figure 2). At each station, water was collected for physical parameters and nutrients, and sediment was collected by a diver to analyze for sediment organics and grain size.

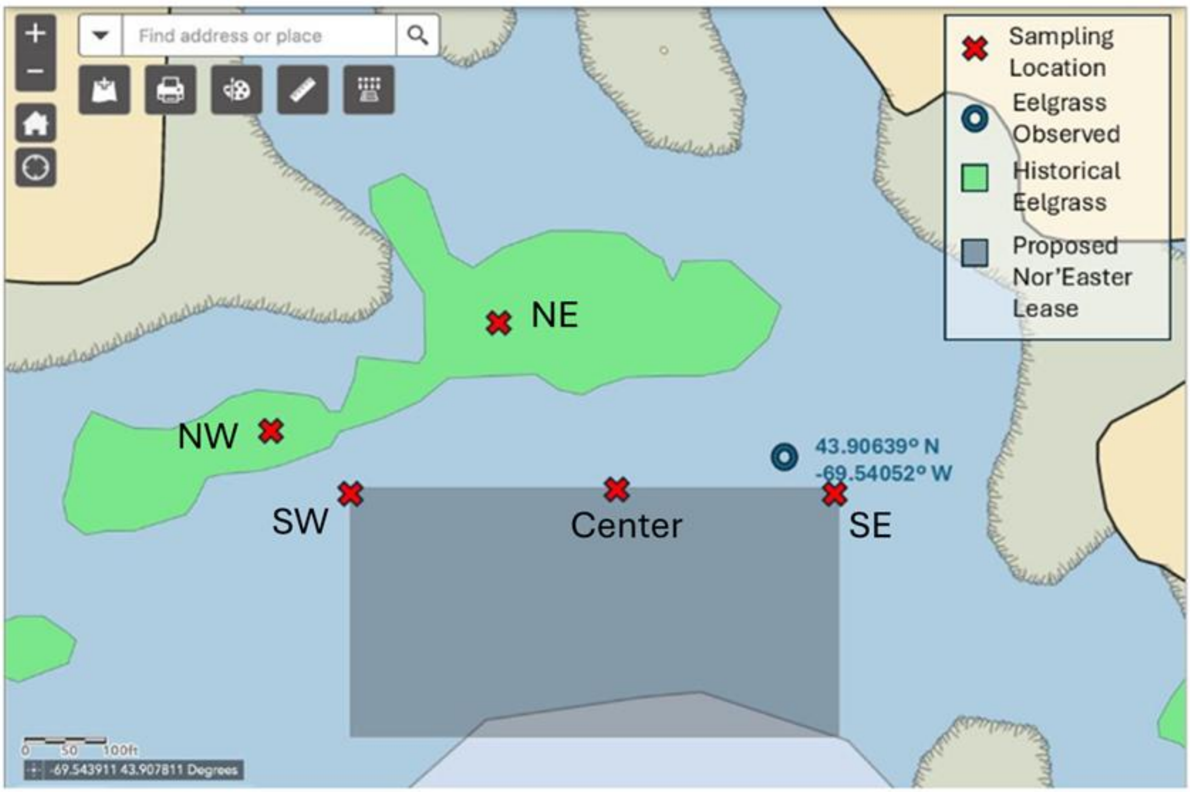


Figure 2 Map showing stations sampled for water quality as they relate to the proposed Nor'Easter lease, and to the areas denoted as historic (2010) eelgrass beds. The blue circle denotes the location where the diver noted extant patchy eelgrass bed.

Water was analyzed for pH, nitrate, nitrite, and ammonia using Hach field test strip kits (https://www.hach.com). While these kits are not as precise as laboratory segmented flow colorimetric analysis, they are an efficient and cost effective method for assessing the approximate nutrient levels in a body of water, and are generally precise enough to determine whether waters

[2] Vaudrey, J.M.P., T. Getchis, K. Shaw, J. Markow, R. Britton, and J.N Kremer (2009) Effects of oyster depuration gear on eelgrass (Zostera marina L.) growth rate and eelgrass sediment bed characteristics in a low density aquaculture site in Long Island Sound. Journal of Shellfish Research. 28(2): 243-250.

are above or below the state's 0.32mg/L threshold for eelgrass, or whether they are in the vicinity and more precise methods are necessary.

Sediment was collected by divers, and stored in whirlpak™ bags for transport to the University of Connecticut for analysis according to the loss on ignition procedure in Heiri et al. 2001[3]. Samples were stored frozen at -20°C to inhibit biological activity and degradation of organic matter. Samples were thawed and placed into a dessicator at 50°C until dry. Each sample was homogenized with mortar and pestle. In duplicate, approximately 2 grams of sediment was added to cleaned and weighed crucibles. Crucibles with sediment were weighed to five decimal places before and after being muffled at 550°C for 4.5 hours.

These parameters were combined and compared with established literature values from the EHSI to determine any variability in sediment and water quality between the proposed lease area and the nearby historic eelgrass area (as determined by literature search), as well as whether these areas remain suitable for eelgrass. EHSI also considers parameters such as oxygen, light availability, and salinity, but these parameters are known to be well within the range suitable for eelgrass, due to the shallow well mixed nature of the area in question, and because the bottom is clearly visible in satellite imagery throughout the proposed area, indicating that sufficient light is reaching the bottom to support eelgrass.

Results

Historic eelgrass maps for the area in question are available from Maine Department of Marine Resources (DMR) open data portal[4]. Available surveys for the area in question in 1997 and 2010 show patchy and variable eelgrass beds in the vicinity of the area in question (Figure 3). The Johns Bay/Johns river complex has only approximately 30 acres of eelgrass according to the 2010 survey, and this amount has held steady during this time period, despite a statewide decline. The diver collecting samples observed patchy eelgrass, including shoots and rhizomes, immediately adjacent to the proposed lease area (see photos in Figure 4), affirming eelgrass is still present in the area as observed in 2010 (Figure 2). This eelgrass is clearly not in optimal condition, it is very sparse and patchy, and would easily have been missed by an aerial survey, but eelgrass is definitely present within the area in question.

Water quality results showed a fairly consistent pH of 7.5 within the area, with all nutrient samples at all stations below detection (0.25 mg/L). Although the Hach strips are not the most precise technique, values consistently below detection suggest the water quality in the area in question is fairly pristine, and likely below the 0.32 mg/L eelgrass threshold at the time of sampling. Although this represents only a snapshot, and nutrients are known to be both spatially and temporally variable, all five stations did come back below detection, and there are no observable sources of pollution in the area, suggesting that water column nutrients are likely within a range that is supportive of eelgrass.

For sediment organic matter (SOM), levels above 10% are generally considered unsupportive of or stressful to eelgrass, though eelgrass can be found in higher organic sediments. For the five stations tested, the SOM was less than 10% in all cases (Table 1). For three of the sites, the SOM was below 5%, indicating even better conditions for eelgrass.

The EHSI, while not developed for this particular location, can be used as a reference point to estimate the suitability of this area for eelgrass. In the EHSI, SOM accounts for 20% of the model score, similar to a single test counting for 20% of the semester grade in a class. In the EHSI, light accounts for 30% of the score, temperature for 20% of the score, and dissolved

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[3] Heiri, O., A. F. Lotter, and G. Lemcke. 2001. Loss on ignition as a method for estimating organic and carbonate content in sediments: Reproducibility and comparability of results. *Journal of Paleolimnology* **25** :101-110.

[4] https://dmr-maine.opendata.arcgis.com/apps/mainedmr-historical-eelgrass-coverage-viewer/explore

oxygen for 10% of the score. The remaining 20% of the score is based on sediment grain size, which often tracks the SOM. If we assume that grain size is similar to the SOM score, and that all other parameters have a score of 90%, we are able to estimate the suitability of these sites for eelgrass (Table 1, last column).

Figure 3 Historic eelgrass distribution within proximity to the proposed Nor'Easter lease. Data from Maine DMR's Open data portal shows patchy and somewhat ephemeral beds in the vicinity of the proposed aquaculture lease (https://dmr-maine.opendata.arcgis.com/apps/mainedmr-historical-eelgrass-coverage-viewer/explore).

Figure 4 Photographs of eelgrass present at the site. The location of these photographs is 43°54'23"N 69°32'26"W, which is a few feet north of the northern edge of the proposed Nor'Easter lease.

Table 1: Sediment Organic Matter (SOM) at each station. The SOM score varies between 100% for SOM levels less than or equal to 0.5% to a score of 0% for SOM levels greater than or equal to 10%. Grain size typically carries a score similar to SOM, so the two are set equal for this estimate. In the EHSI, used as a reference point, all other criteria were set equal to a score of 90% (light, temperature, oxygen). Each sediment parameter (SOM, grain size) accounts for 20% of the model score.

Station ID	Sediment Organic Matter, SOM (%); average of 2 replicates ± standard deviation	Sediment Organic Matter Score (%)	Estimated EHSI Score, assuming grain size score equals SOM and all other parameters are at 90% (%)
NE (traditional eelgrass location)	4.7 ± 0.3	55	76
NW (traditional eelgrass location)	2.5 ± 0	79	86
SE (proposed lease area)	1.8 ± 0.1	86	89
Center (proposed lease area)	9.6 ± 0.2	4	56
SW (proposed lease area)	8.0 ± 0.1	21	62

Based on analysis of the EHSI results in Long Island Sound versus eelgrass presence, eelgrass occurred in areas where model scores were greater than or equal to 50%, which is true at all five stations sampled. When conducting eelgrass restoration, practitioners often look for areas with the most favorable conditions, to maximize the chance of the restoration efforts being successful in establishing new beds of eelgrass. Restoration success of eelgrass improved greatly when model scores were above 88%, considered exceptional suitability, which is true (89%) at one station, and nearly true (86%) at a second station. Using the EHSI as a rough approximation (as it was not developed for this site specifically and the dataset is incomplete), **all sites would be considered suitable for eelgrass** (Table 1).

Discussion

The totality of the information in hand suggests the environmental conditions in upper Johns Bay, including the proposed Nor'Easter lease area are generally supportive of eelgrass and that this area has supported eelgrass in the past. We also observed very sparse eelgrass immediately adjacent to the proposed lease. This suggests the historical eelgrass beds in the area may be hanging on, or beginning to regrow in this area, but they certainly are not robust enough to withstand substantial perturbation. The US Army Corps of Engineers (USACE) recommends that aquaculture permits not be issued within 100 meters of extant eelgrass, which would preclude a lease at the proposed location.

Shellfish aquaculture is not traditionally associated with the large fluxes of excess nutrients associated with finfish aquaculture. In many cases, shellfish aquaculture can offer beneficial ecosystem services such as water column filtration, providing habitat for some species of finfish, and reducing pressure on natural shellfish beds; for this reason, shellfish aquaculture is generally viewed favorably in a regulatory capacity, though there are the possibility of environmental impacts. Shellfish aquaculture moves nutrients and organic matter from the water column to the benthos, which in phytoplankton dominated systems can *improve* water clarity, but in this shallow coastal system which appears to be dominated by rockweeds, is more likely to increase sediment organic content and locally aggregate nutrients in the area, which, as pointed out by Dr. Kincaid's modeling efforts, may result in localized retention of organic matter. This is particularly problematic in this case, as two of the five stations sampled had sediment organic matter concentrations (9.6 and 8.0, see Table 1) very close to the 10% threshold above which the habitat would be considered no longer suitable for eelgrass.

In addition, the permitted use of on site powerwashing and/or air drying would result in increased turbidity and flux of organic matter to the benthos. Increased turbidity combined with potential shading from aquaculture cages could reduce light available to eelgrass. Furthermore, on site powerwashing is likely to cause the resuspension and dispersion of potentially problematic and/or invasive organisms such as bryozoans and tunicates, which can grow epiphytically on eelgrass, harming the health of existing nearby eelgrass beds and other habitats. Native fauna throughout New England coastal ecosystems are struggling to adapt to a number of particularly problematic invasive species (e.g*., Botryloides spp., Didemnum vexillum, Botrylus schlosseri*) which could be spread in this way, and which have been shown to harm natural shellfish beds by overgrowing and outcompeting native species for space. For this reason, on site powerwashing is often not considered a sound management practice when it comes to shellfish aquaculture. While in deeper or better flushed systems, this can be mitigated by powerwashing on an outgoing tide, the extremely shallow nature of the proposed lease area, combined with the localized physics, suggest that most of that material is going to be retained, even on an outgoing tide, and thus, onsite powerwashing is not advisable.

Eelgrass is clearly present in the area of interest, but under stress. In the face of declining eelgrass abundance throughout the state, it seems pertinent to apply the precautionary principle and limit any development which has the potential to negatively impact the quality or quantity of suitable eelgrass habitat. In this case, these stressors include permitting additional shellfish aquaculture in the immediate vicinity of these beds.

As an aside, but pertinent to the potential permitting of this aquaculture site, it seems likely that, should the proposed lease go through, the adjacent residents and others would be unable to skirt the proposed lease without potentially violating the Marine Mammal Protection Act by approaching too close to the established haulouts on the small rock islands adjacent to the sites during times when seals are present.

Conclusion

Based on the available data, it is our opinion that there is ample evidence the proposed Nor'Easter aquaculture lease overlies suitable eelgrass habitat, based on historical presence of eelgrass, measurements of water and sediment quality in the area, and observation of sparse, stressed eelgrass beds immediately adjacent to the proposed site. Due to the stressed nature of the adjacent eelgrass, it seems likely that the cumulative impacts of even a relatively minor additional stress such as an aquaculture lease may be sufficient to result in the complete loss of eelgrass from the area under discussion, which would obviously be undesirable. Therefore, despite some emerging evidence that eelgrass and shellfish aquaculture may be able to coexist in some circumstances, we recommend the State deny the permit (as written) for this proposed aquaculture lease.

Walker Exhibit
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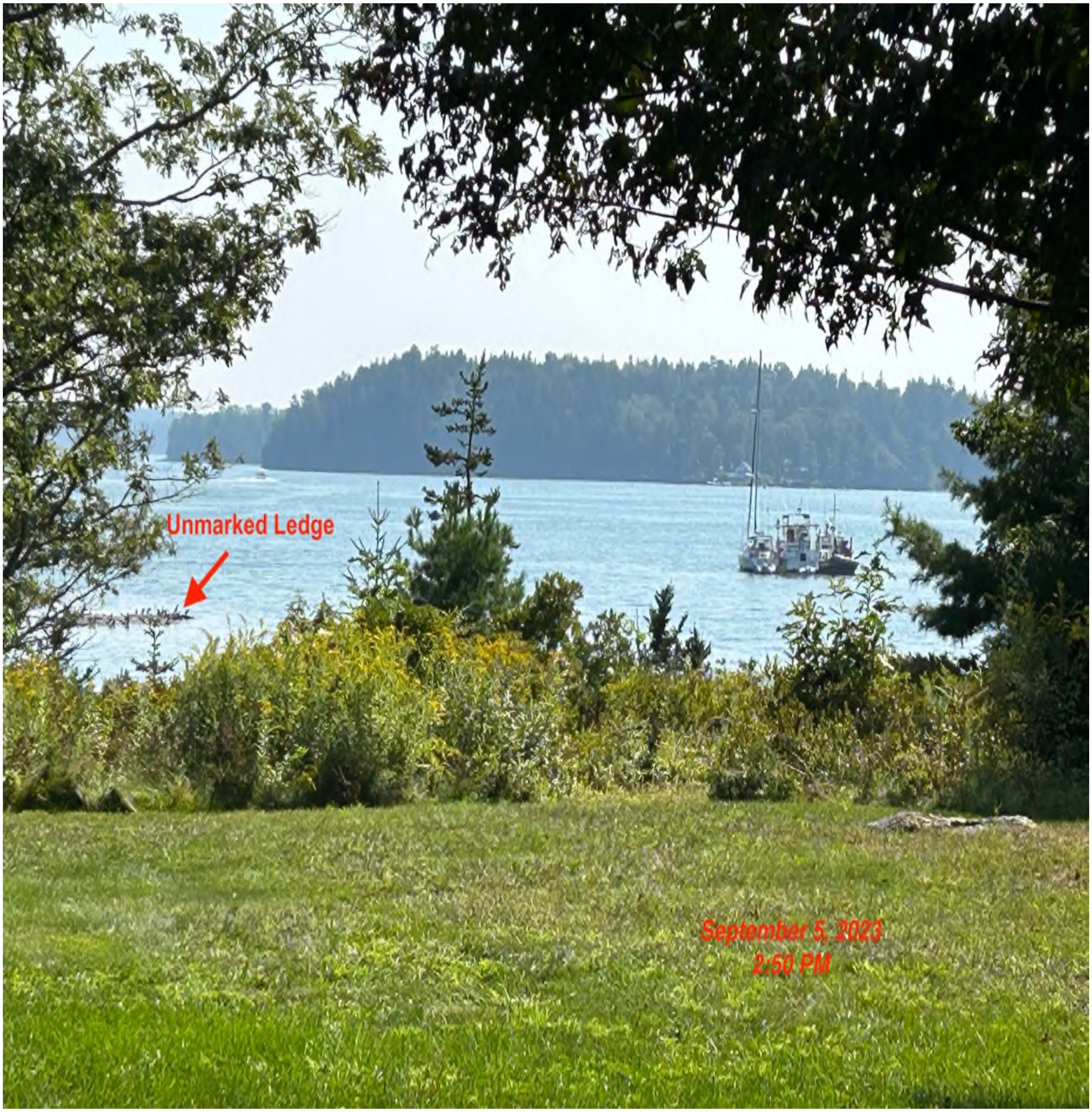

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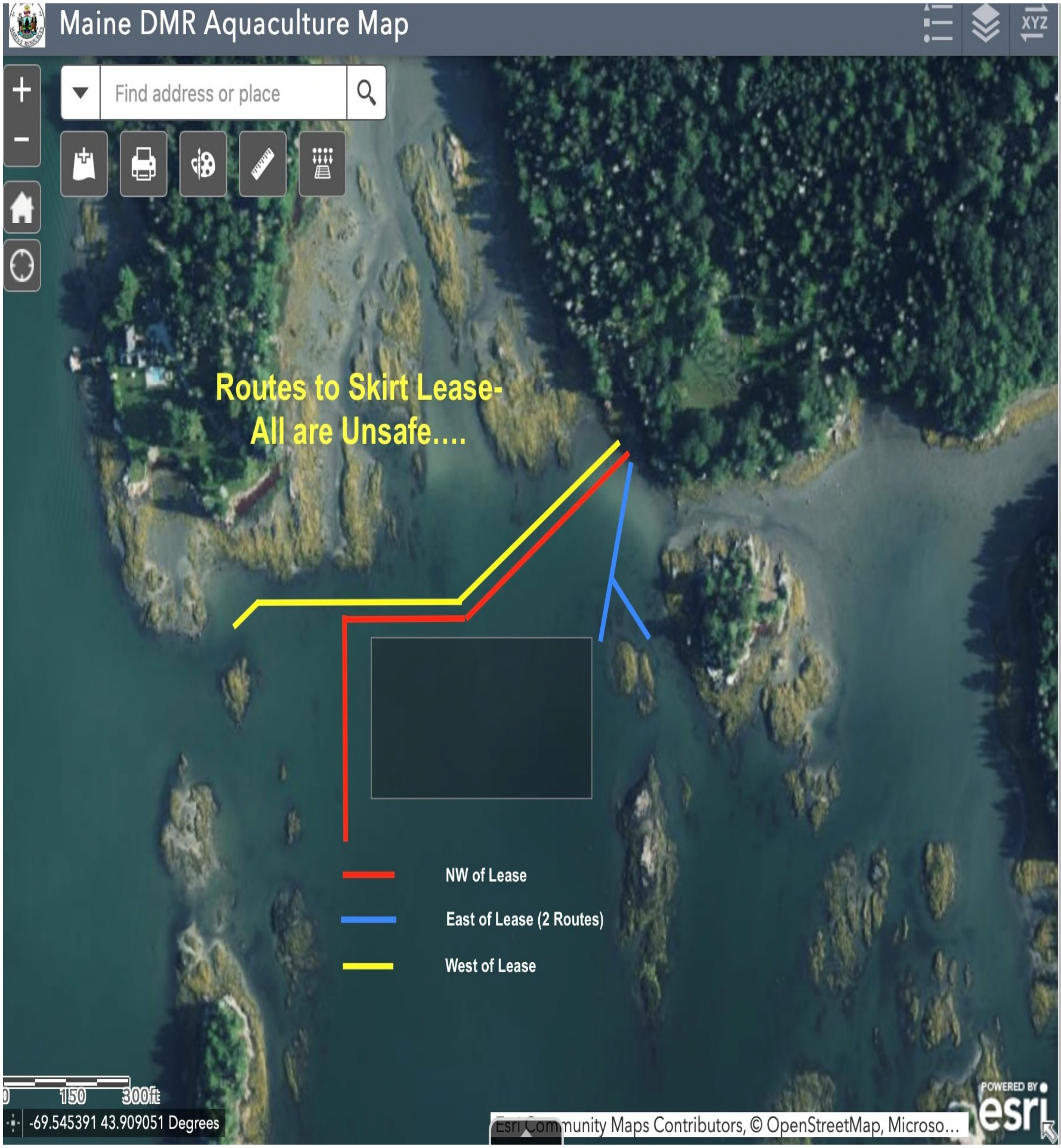
Walker Exhibit 9



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