2013

Merepoint Boat Launch Facility Eelgrass Mitigation Measures: Final Project Assessment

MER Assessment Corporation

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Prepared for

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18 December 2013

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Executive Summary

The Maine Department of Inland fisheries and Wildlife (IF&W) was issued a permit by the Maine Department of Environmental Protection (DEP) on 13 April 2007 to construct and install a boat launching facility at Merepoint, Brunswick, Maine, construction of which was completed in September 2008. The permit included several conditions for mitigation of possible impacts to eelgrass resulting from construction and operation of the facility. These included: 1) removal and relocation of traditional mushroom anchor-chain moorings within the project area to areas outside eelgrass habitat, 2) replacement of traditional mushroom anchor-chain moorings with "eelgrass-friendly" helical, or embedment, moorings, 3) the closing of the Simpsons Point boat launching ramp to motorized vessels to allow recovery of eelgrass adjacent to the ramp, and 4) the preparation of an Eelgrass Mitigation Opportunities Guide for Northern Casco Bay, reported separately in February 2008.

This report summarizes the work completed and results of the periodic monitoring events as well as special reports completed in compliance with the DEP requirements. Initial work toward the identification of prospective moorings for removal or replacement was conducted in 2007 and was completed in 2008; baseline work at six selected moorings was also completed in 2008 along with baseline work at Simpson Point following the closure of the launching ramp to motorized vessels in September 2008. The Eelgrass Mitigation Opportunities Guide for Northern Casco Bay report was also prepared in 2008. Monitoring was subsequently conducted in 2011 and 2012.

The results of the 2011 and 2012 monitoring efforts clearly showed that the recovery which was expected to occur within the mooring scar areas following either permanent removal of the mooring or replacement of a traditional block and chain or mushroom anchor and chain mooring with 'eelgrass-friendly' helical anchors was not occurring and in some cases the mooring scar area was actually expanding. In certain cases, mooring scar areas exhibited some level of reduction (re-vegetation) between 2008 and 2011. However, in 2012, significant new expansions of scars were observed in aerial and diver surveys. Similarly, the eelgrass in the vicinity of the Simpson Point boat landing appeared to be in decline rather than recovery despite the landing having been closed to motorized boats as part of the mitigation effort. The observations over the period 2008 through 2012 offered evidence of what appeared to be a general decline in eelgrass within the region, particularly within Merepoint Bay and Middle Bay.

Based on the results of the two latter monitoring efforts, IF&W proposed to state and federal regulatory authorities that it would be better to conduct work to advance the science and knowledge surrounding this declining condition instead of just repeating past efforts for the sake of meeting the permit requirement. To this end, IF&W assembled a diverse advisory group of scientists and organizations to assist in formulating plans for the final field season that would compliment ongoing research and advance the level of understanding. This group of scientists represented the US Environmental Protection Agency, Maine DEP Marine Unit, US Geological Service Patuxent Wildlife Research Center, Casco Bay Estuary Partnership (CBEP), Maine

Department of Marine Resources (DMR), MER Assessment Corporation (MER), Woods Hole Oceanographic Institute (WHOI), Mount Desert Island Biological Laboratory, Maine Geologic Survey, and US Army Corps of Engineers (USACOE). This proved to be a very productive partnership, resulting in identification of specific goals for the research, contributions of effort for important components that exceed IF&W's capacity to achieve, and a proactive and positive approach to address an important and ongoing coastal resource issue.

The advisory group recommended several specific goals: Goal 1: Attribute a cause(s) to the observed/perceived decline in eelgrass from 2008-2012. Goal 2: Identify the current status of the eelgrass resource at the 2 geographic locations of interest. Goal 3: Determine why eelgrass is not recovering in the mooring scar areas. Goal 4: Determine if invasive tunicates are significantly causing or contributing to the decline of eelgrass. Other possible causes of the decline included changes in water quality, sediment chemistry and invasive green crabs, *Carcinus maenas*, among others. The 2013 work plan was therefore modified and expanded to include on-site monitoring at identified areas of interest, sampling of sediment chemistry, analysis of above and below ground eelgrass biomass, determination of the presence of eelgrass wasting disease, determination of the presence and coverage of invasive tunicates, collection of light attenuation data (other partners), collection of water quality profile data (other partners), and aerial photography and photo-interpretation of the photographs for eelgrass distribution (other partners).

Many of the partner organizations were also involved in ongoing, related, but separate research efforts and the IF&W study proved to be an exciting opportunity to work collaboratively with experts in the field on this important issue. It is also anticipated that the results of the study will facilitate additional productive work in this area in the future.

The scope of work for the 2013 monitoring was changed to reduce actual monitoring to allow sampling to be conducted at two mooring scars and at the Simpson Point within the eelgrass meadow for eelgrass metrics and sediment chemistry. Unfortunately, eelgrass was only found at the Maquoit Bay mooring scar; no eelgrass was found at the mooring scar in Merepoint Bay or at Simpson Point. The sediment chemistry results did show levels of sulfide above the 600µM level considered to be toxic to eelgrass at all stations; however, it is unclear whether this is cause or effect. Total organic carbon was found to be at normal levels, similar to those found in similarly soft sediments elsewhere in Maine. Water quality results of water column profiles conducted by the Maine DEP in September and November showed nothing unusual, other than elevated oxygen levels possibly associated with wind effects near the surface and benthic diatoms photosynthesis near the bottom.

The most striking results were those of the aerial photography of Maquoit, Merepoint and Middle bays done by Sewall Company with photo-interpretation by Seth Barker, formerly of the Maine DMR conducted as a collaborative effort between the CBEP and the Maine DEP. The comparison of coverage between the dense and expansive meadows seen in 2002 and the limited eelgrass observed in Maquoit Bay and essentially barren condition of Merepoint and Middle Bays seen in 2013 clearly shows the catastrophic loss that has occurred.

The massive loss of eelgrass is not restricted to just Casco Bay but has been reported in several other areas along the coast including Frenchman Bay and Taunton Bay (Jane Disney, email comm.). There are many suggestions as to what may have caused this catastrophic loss of the eelgrass all along the coast in shallower bays over such a short period of time, including destruction by the invasive green crab, the populations of which have exploded over the past two years in northern Casco Bay; elevated seawater temperatures; invasive tunicates; and ocean acidification. Unfortunately, the answer is not clear, but numerous efforts are now underway to investigate and determine the reasons for the loss.

The loss of nearly all of the eelgrass in northern Casco Bay has rendered the eelgrass impacts compensation efforts by Maine IF&W over the past 5 years moot. Despite the good faith efforts by the Department to comply with all requirements over the 5-year period, at the end of the project there is little, and in most cases, no eelgrass left to evaluate. The potential benefits of the IF&W mitigation efforts could not be realized because independent environmental factor(s) have clearly rendered the area unsuitable to eelgrass. Given these circumstances, even if the project was not at its conclusion, any additional mitigation efforts and expenditures would seem ill-advised since these would almost certainly end in failure.

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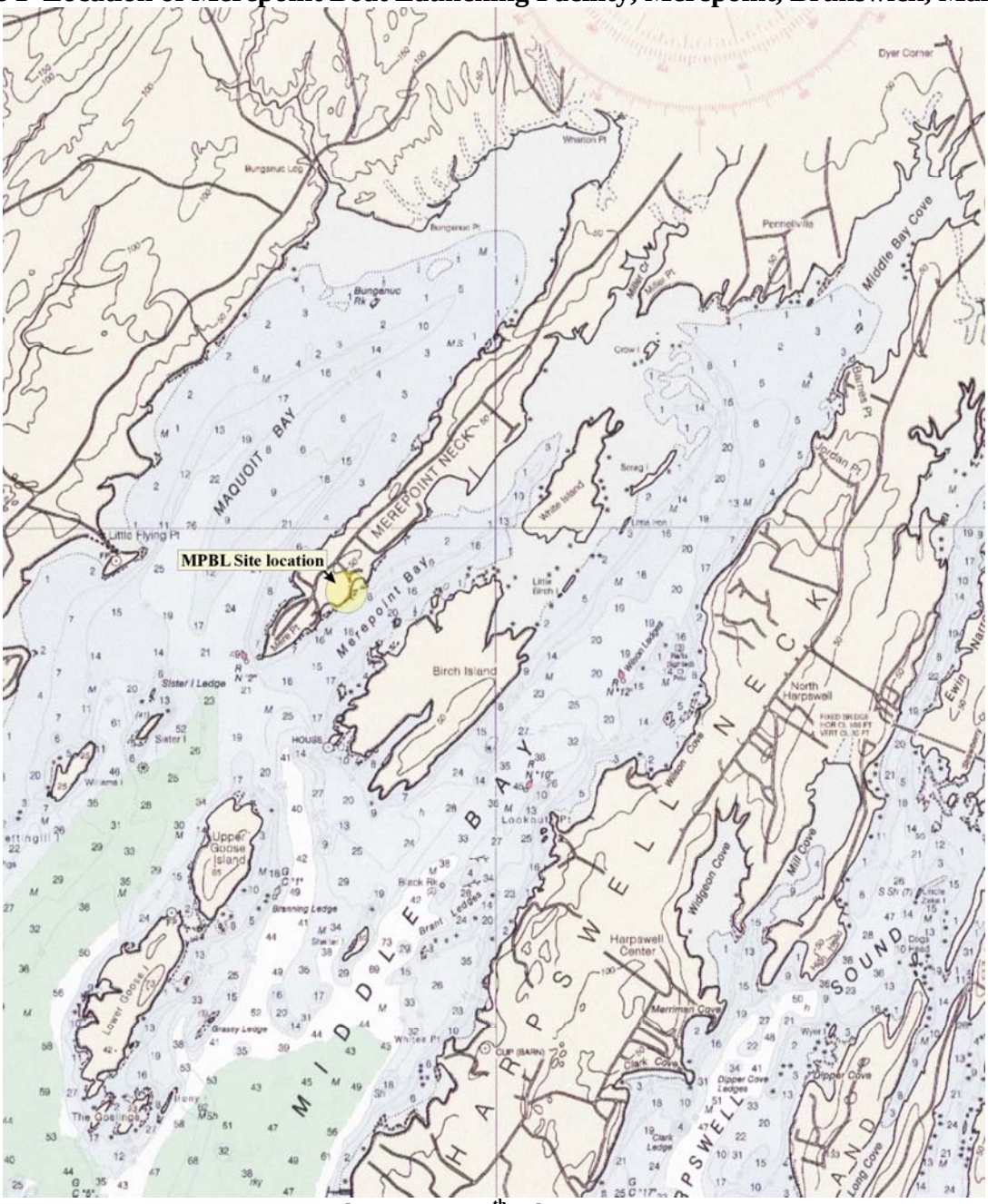
Introduction

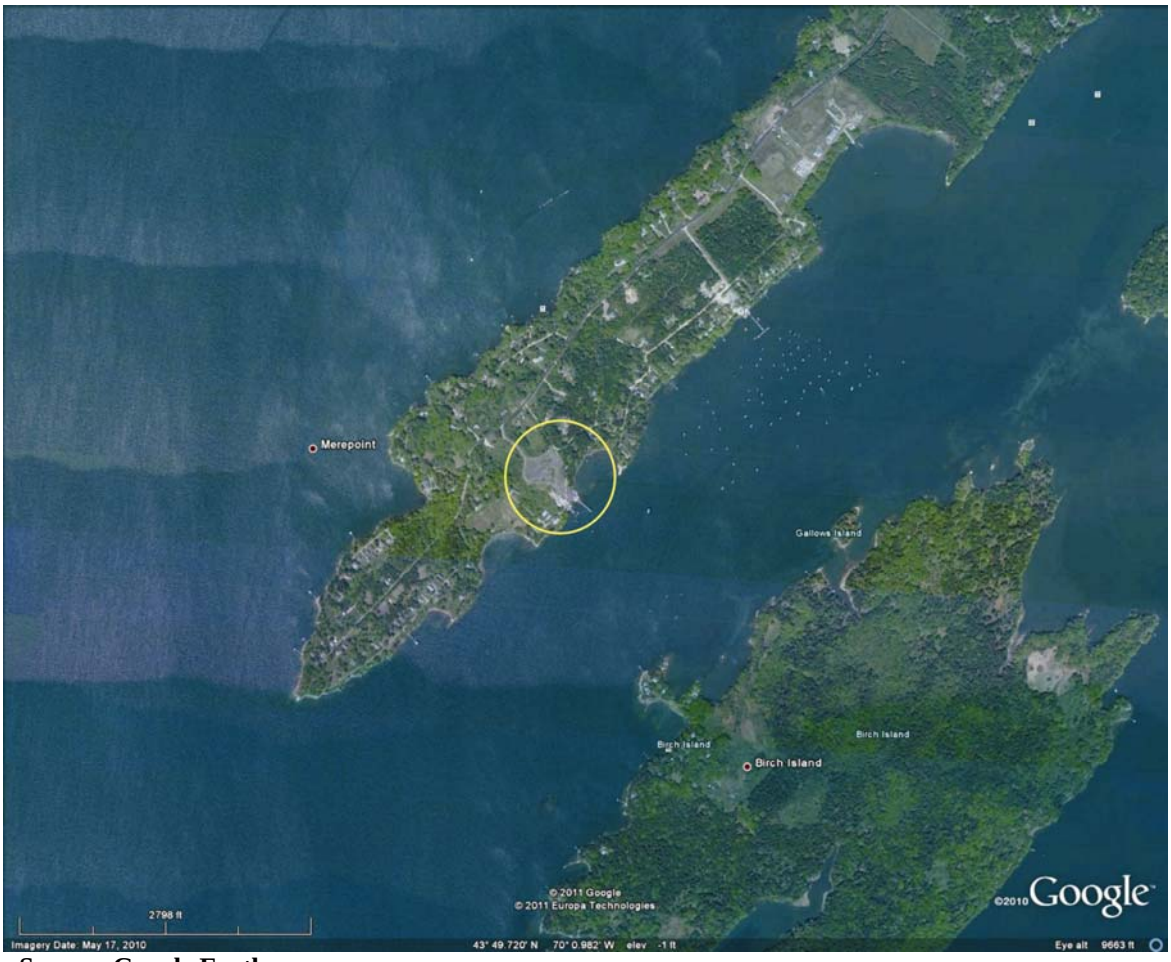
The Maine Department of Inland Fisheries and Wildlife (IF&W) was issued a permit approval for the development and installation of the Merepoint Boat Launching (MPBL) facility at Merepoint, Brunswick, Maine on 13 April 2007. The location of the MPBL is shown in Figures 1 and 2, below.

Figure 1 Location of Merepoint Boat Launching Facility, Merepoint, Brunswick, Maine



Source: NOAA/NOS Casco Bay chart 13290, 37th Ed. Mar./07

Figure 2 Completed Merepoint Boat Launching Facility (center) at Merepoint, Brunswick, Maine (*Google Earth image*)



Source: Google Earth

Several conditions were applied to the permit pertaining to mitigation for impact to eelgrass, *Zostera marina*, resulting from the installation and operation of the boat launching facility including: 1) verification that moorings removed from the floats and access lanes were relocated beyond the eelgrass habitat boundary; 2) replacement of traditional anchor-chain moorings with helical, or embedment, moorings; 3) delineation and assessment of the eelgrass habitat impacted by boat traffic at the existing Simpsons Point boat launch at the head of Merepoint Bay and 4) preparation of an assessment of other eelgrass mitigation options in Northern Casco Bay

This report summarizes the results of work performed from 2007 through 2013 to meet these requirements, specifically: to verify mooring relocation outside of eelgrass habitat; monitor eelgrass recovery in the vicinity of the replacement moorings; monitor recovery of eelgrass in the vicinity of the Simpsons Point boat ramp following closure to motorized vessels; identify other eelgrass impact mitigation opportunities in northern Casco Bay; and finally, to conduct eelgrass parametric measurements and sediment chemistry analyses on samples collected within and outside of selected mooring scars and along two transects at Simpson Point.

Efforts and Results

2007-2008 Project initiation

MER Assessment Corporation (MER) conducted underwater surveys and video documentation between 22 August 2007 and 12 September 2007 of the original and relocated locations for all moorings removed from the project area. All of the relocated moorings were verified to have been placed outside (below) eelgrass habitat.

Selection of moorings for replacement with helical anchors was accomplished using a step-wise approach that included: 1) review of aerial photographs taken in the Middle Bay, Merepoint Bay, and Maquoit Bay area in September 2007 to identify mooring scars for possible mooring replacement, 2) estimates of mooring scar area from the aerial photographs, and 3) preliminary *in situ* scar area measurement. Following development of a list of candidate moorings for replacement, extensive contact was made with candidate mooring owners by Town of Brunswick and Maine IF&W officials. After extensive negotiations, six (6) moorings were approved for replacement or relocation. Traditional moorings were subsequently replaced with helical anchors or relocated to permitted areas by Coastal Barge and Mooring LLC (CB&M) in August and September 2008. Once installation was confirmed, MER conducted detailed *in situ* measurements and documentation of the scars at the original mooring locations that served as baselines for monitoring recovery of the eelgrass over time. The combined mooring scars area was determined to be 6,250 ft^2, 850 ft^2 more of planned restoration area than the DEP required 5,400 ft^2.

2008 Eelgrass impacts mitigation opportunities report

In February 2008, MER prepared a report to respond to a requirement set forth in the Maine DEP's permit issued to IF&W for construction of an all-tide boat launch facility on Merepoint Neck, Brunswick, Maine that called for the development of a feasibility guide of mitigation options in northern Casco Bay for physical disturbance impacts to eelgrass, *Zostera marina*, occurring there.

Water quality in northern Casco Bay, which includes the waters of Maquoit Bay, Merepoint Bay, and Middle Bay north of a line drawn from Little Flying Point on the Freeport shore on the west to Wilson Cove on the western shore of Harpswell Neck at the east, is generally very good. The Town of Brunswick, which accounts for the majority of the shoreline and watershed drainage into the bays, enacted an ordinance in 1992 that restricts development in much of the bays' watersheds and is specifically focused on reducing nitrogen discharges to the bays. Water clarity is also generally good and turbidity is normally only elevated as a result of snow-melt or storm runoff events and during coastal storms.

The report focused on the physical disturbances that had occurred, or continued to occur, to eelgrass in northern Casco Bay. Physical disturbances to eelgrass in the region are associated primarily with fishing activity, mushroom anchor-chain boat moorings, propeller scarring by boats traveling through eelgrass beds at or near low water, and structures extending into the subtidal zone.

Moderate altitude aerial photographs of the northern Casco Bay region taken in 1993 and subsequent aerial photos taken in 2001-02 were reviewed to determine general distribution of eelgrass throughout the region over the period. Additionally, a new series of lower altitude aerial photos was produced to allow a more detailed and up-to-date view of physical damages to eelgrass within the northern Casco Bay area. A total of 334 photographs were taken during an early-morning flight on August 30, 2007 during a low draining tide of -0.9 ft. Of these, sixteen images were selected for detailed review and analysis.

The comparison between the 1993 and 2001 aerial photographs of the northern Casco Bay region showed eelgrass distribution in the area to be dynamic over time and eelgrass in the northern Casco Bay region to be at or near its maximum areal distribution at that time. Nevertheless, physical disturbances to eelgrass were identified that were caused by fishing and aquaculture activity, boat moorings, propeller scarring, and structures, including private and commercial floats and the stone pier at Simpson Point in Merepoint Bay.

Shellfishing for clams, worm harvesting, and aquaculture disturbances are difficult to distinguish from natural patchiness in the shallow subtidal but may have accounted for disturbances totaling 2,315 ft^2 (0.05 acres/0.02 hectare); disturbances of this size are orders of magnitude smaller than those caused by mussel harvesting during the 1990s. A total of 95 visible and measurable mooring scars, averaging approximately 544 ft^2 each, were found to account for a total of approximately 51,650 ft^2 (1.19 ac, 0.48 ha) of disturbance. The total area of scarring that could be attributed to propellers was estimated at 7,025 ft^2 (0.16 ac, 0.07 ha). Private floats accounted for approximately 870 ft^2 (0.02 ac/0.01 ha) of direct coverage; this was increased by 50% to account for shading and disturbance around the floats and increased the disturbance area to just over 1,300 ft^2 (0.03 ac/0.01 ha). The float system associated with Paul's Marina in Merepoint Bay was estimated to directly cover an estimated 1,800 ft^2 (0.08 ac/0.03 ha), but because of the greater amount of activity associated with these commercial floats the estimated area affected by shading and disturbance was doubled thereby increasing the disturbance area to 3,600 ft^2 (0.08 ac/0.03 ha).

The extent and density of eelgrass within the northern Casco Bay area at the time made identification of "off-site" mitigation opportunities very difficult since nearly all areas suitable for eelgrass growth appeared to be occupied to some degree of coverage. Nevertheless, opportunities to mitigate existing and on-going physical disturbances did exist at the time, although circumstances have now changed as discussed below.

The harvesting of blue mussels, although not a problem at the time, could result in substantial physical disturbances. In 2008 the Town of Brunswick had a non-legally-binding, "gentlemen's agreement" with one of the large mussel harvesting companies in Maine, but the agreement did not apply to other mussel harvesters, including those in Casco Bay; the agreement is no longer valid due to the closing of the company. However, an opportunity may still exist to develop a similar agreement to include other mussel harvesters along the coast. The Maine Department of Marine Resources developed a similar model for Taunton Bay, Franklin, Maine that engaged stakeholders in discussions leading to a combined marine habitat conservation/ protection and marine resource exploitation plan and this model may be applicable in Casco Bay.

Two measures are available to mitigate or completely correct mooring-related disturbances: 1) mooring removal and relocation, and 2) mooring replacement. Relocation of an existing mooring located within an eelgrass bed to a deeper location beyond the eelgrass band is relatively easy where the eelgrass band is narrow and the distance to the new location from shore is only slightly greater than that of the previous location; however, where eelgrass coverage is extensive, relocation of moorings beyond the eelgrass coverage area could result in moorings being relocated several hundreds of yards from their original location thereby posing not only a substantial inconvenience to the mooring owner, but also exposing the owner to greater risk given the added distance between shore and the mooring that needs to be traversed.

Replacement of traditional moorings with embedment moorings is feasible in some cases and would reduce physical disturbance to eelgrass by eliminating the sweeping chain of traditional moorings. Embedment moorings have proven effective elsewhere but some structural failures have been experienced locally; these moorings are relatively uncommon in Casco Bay. Consequently, concern over reliability and the added cost of installation have caused some owners to be reluctant to replace existing, functioning traditional moorings; waiver of town mooring fees could help defray costs and encourage mooring owners to choose replacement.

Private and commercial floats are permitted and account for a small amount of disturbance; few options exist to mitigate their associated physical disturbances. Removal of the stone pier at Simpson Point, on the other hand, could result in an estimated 800,000 ft^2 or 18 acres of eelgrass habitat were the surrounding area to become revegetated with eelgrass following removal.

The stone pier, originally constructed in 1899, is admittedly a man-made structure, but since it has been in place for 100+ years, the intertidal hard substrate provided by the structure constitutes habitat for flora and fauna requiring such substrate and removal of the structure would ultimately result in the substitution of one habitat for another; a decision to move forward with such a project would, therefore, require a habitat-value and substitution judgment to be made.

Removal of the pier is technically feasible; however, the total financial cost of removal, including pre-removal studies, project permitting, physical removal, and follow-up monitoring of effectiveness would be substantial. Additionally, although temporary, there would likely be an environmental cost associated with the disturbance created during the removal process, all of which would need to be considered during project planning.

In view of the limited opportunities to mitigate impacts associated with physical disturbances in northern Casco Bay and the difficulties associated with these, additional consideration might be given to extending measures to protect water quality in the northern Casco Bay region, specifically those focused on restoration of vegetated buffer zones around agricultural lands and expansive lawn areas, and adoption of enhanced stream buffer requirements for new development.

2008 Monitoring at Simpson Point

Delineation of the eelgrass meadow at Simpsons Point was conducted in early July 2008 using SCUBA divers to video record transects set within the eelgrass meadow and to locate the upper eelgrass boundary based on GPS coordinates. Although delineation was completed, these efforts were confounded by poor visibility caused by the naturally turbid conditions encountered in the upper bay area; turbidity was further elevated by diver disturbance of the soft silt bottom. Additionally, the patchy nature of eelgrass distribution in the area made clear delineation very difficult. A second approach was therefore taken by having a second set of low altitude aerial photographs taken in September 2008 following the closure of the boat ramp to motorized vessels to supplement the video recordings and allow visual comparison of the extent of the existing eelgrass meadow to that shown in future low altitude aerial photos.

Although diver video and aerial photography offered tools for the delineation of eelgrass habitat, both posed interpretation challenges. The diver video provides a clear image but coverage is limited both with respect to area covered and field of view. Aerial photography offers large-area coverage, but differentiation between vegetation types, specifically between eelgrass and filamentous (*Enteromorpha* sp.) and broadleaf (*Ulva lactuca*) species, is difficult.

Given these difficulties and recent development in side scan sonar (SSS) technology and refinement of eelgrass mapping techniques developed by the Marine Sciences Department of Southern Maine Community College MER recommended consideration SSS as an alternative tool for the mapping and monitoring of recovery of the eelgrass meadow at Simpsons Point. Side scan sonar has the advantage of being unaffected by elevated turbidity since it relies on sound reflection rather than visual imagery. Furthermore, individual patches of eelgrass are clearly visible as discrete plant clusters.

Additionally, based on the results of our work performed in 2007 and 2008, MER recommended the use of an 8-triangle (45° cardinal directions) method of estimating scar area to monitor recovery of eelgrass within previous mooring chain-sweep scars.

2011 Monitoring

MER Assessment Corporation (MER) again conducted detailed *in situ* measurements and video documentation of the 6 mooring scars on 4 and 5 August 2011. Although delineation of some of the scars was straightforward, efforts to accurately delineate certain mooring scars were made difficult due to several factors, including proximity of adjacent boats on moorings, apparent loss of eelgrass between adjacent moorings, and thinning of eelgrass resulting in poor definition of habitat boundaries. This resulted in some scars showing expansion despite the moorings having been removed and no boat being present. Three moorings, MER 11, 17, and 18 appeared to best represent recovery at that point and suggested that recovery ranged between 2% to 29% with an estimated mean of 13%. Accordingly, based on the initial composite scar area of 6,250 ft^2, by 2011 recovery had occurred over approximately only 812 ft^2 (6,250 x .13) toward

the 2008 goal of 5,400 ft^2. These results indicated that recovery was slow and may have been an early indication of the much larger decline to follow.

Video recording and delineation of the eelgrass meadow at Simpsons Point was conducted on 18 August 2011 using the same methods as used in 2008. Specifically SCUBA divers video recorded transects set within the eelgrass meadow and located the upper eelgrass boundary based on GPS coordinates. As in 2008, these efforts were confounded by poor visibility caused by the naturally turbid conditions encountered in the upper bay area and sparseness and increased patchiness of eelgrass within the area that made clear delineation very difficult. Delineation based on video recordings indicated that the upper boundary of the eelgrass habitat in the vicinity of the landing had receded between 12 and 17 meters since 2008.

The reduced shoot density and increase in barren area between eelgrass patches was not restricted to the boundary areas but was observed throughout the survey area. These observations were corroborated by the aerial photography of the area on 31August 2011 which similarly showed thinning of the eelgrass and expansion of barren areas within the meadow compared to 2008. Changes in eelgrass density and distribution are not uncommon and result from both natural and anthropogenic causes. The thinning of the eelgrass was clearly unrelated to boat activity in the area since the Simpsons Point landing had been blocked to the launching of motorized vessels in 2008 and the cause of the decline was unknown.

A side scan sonar (SSS) survey of a section of the Simpson Point eelgrass meadow was conducted on 13 August 2011 by members of the Marine Sciences Department of Southern Maine Community College (SMCC). Mosaic images produced from the collected data, while clearly delineating the outer boundary of the meadow, showed eelgrass density as very high which did not agree with the diver video record or aerial photography. This was attributed to the amount of overlap between passes and the inherent inaccuracy of GPS.

Images created from raw data from individual passes produced images useful in more accurately delineating boundaries but continued to overestimate density. Comparison of side scan sonar images and images taken from the video recordings at selected points along one of the transects were compared in an effort to calibrate the interpretation of the side scan sonar images.

However, the results of the side scan sonar work were not as clear or conclusive as initially hoped. Nevertheless, given the inherent difficulties of conducting eelgrass delineations in turbid conditions and sparse eelgrass coverage, with additional work this technology will likely offer an effective means of accurately mapping eelgrass habitat and improved results would undoubtedly be achieved with improved equipment and GPS accuracy.

Most of the difficulties encountered with the 2011 survey were related to the difficulty in determining the eelgrass boundary in patchy and sparse conditions and the development of a clear and measurable definition of an eelgrass boundary in such conditions is needed.

2012 Monitoring

MER Assessment Corporation (MER) conducted additional detailed *in situ* measurements and video documentation of the selected six mooring scars on August 8 and 9, 2012. The measurements showed expansion of some scars despite the moorings having been removed and no boat being present. Mooring scar MER 16 showed significant expansion due to the apparent loss of eelgrass between adjacent scars; this was clearly an anomaly since the mooring at MER 16 was removed in 2008 and never replaced. These results continued to indicate slow, if any, recovery.

Aerial photography of the Simpson Point area was conducted on August 6, 2012 and video recording and delineation of the eelgrass meadow at Simpson Point was conducted on August 15 and 20, 2012 using the same methods as used in 2008 and 2011. Specifically, a SCUBA diver video recorded transects set within the eelgrass meadow to document eelgrass condition and locate the upper eelgrass boundary based on GPS coordinates. As in previous years, these efforts were once again confounded by poor visibility caused by the naturally turbid conditions encountered in the upper bay area and the sparseness and increased patchiness of eelgrass within the area that made clear delineation very difficult. Delineation based on video recordings continued to indicate that the upper boundary of the eelgrass habitat in the vicinity of the landing had receded between 12 and 17 meters since 2008.

The reduced shoot density and increase in barren area between eelgrass patches was not restricted to the boundary areas but was observed throughout the survey area. These *in situ* observations were corroborated by the aerial photography of the area conducted on August 6, 2012 which continued to show thinning of the eelgrass and expansion of barren areas within the meadow seen in 2011 compared to conditions seen in 2008.

The slow rate of recovery, and in some cases expansion, of the scars seen in 2011 and again in 2012 at the mooring sites selected in 2008 for mooring removal or replacement was clearly unrelated to physical disturbance. Similarly, the general thinning and decline of the eelgrass at Simpsons Point since 2008 is unrelated to boat activity in the area since the Simpson Point landing had been blocked to motorized vessels since 2008. Although several factors, including elevated turbidity and temperature, may have contributed to the lack of recovery and general decline of eelgrass in the area, the increased incidence of the invasive orange-sheathed tunicate, *Botrylloides violaceus,* found attached to, and in some cases encrusting, eelgrass blades may have likely been an important cause.

In Maquoit Bay at MER 11, a helix replacement mooring, some incidence of the orange tunicate was evident, although the eelgrass was in generally healthy condition. However, at mooring scar MER 5, another helix replacement located in Merepoint Bay just north of the Merepoint Boat Launch Facility and just south of Paul's Marina, the infestation by *Botrylloides violaceus* was heavy and the condition of the eelgrass was generally poor in comparison to that observed in Maquoit Bay. All of the other monitored scars were also located in Merepoint Bay around Paul's Marina and showed similar, and in some cases worse, eelgrass condition. Review of the video recordings taken at Simpsons Point showed that the tunicate was also present there throughout the meadow but appeared to become less dense towards the middle of the meadow.

The monitoring results indicated that, given the apparent general decline of eelgrass, the eelgrass habitat recovery rate would take longer than the initially estimated 5 years to achieve 80% recovery. Although several causes may play a role in this, the apparent expansion of infestation by the invasive tunicate *Botrylloides violaceus* was the suspected likely cause. In view of this, the need for additional remedial measures by IF&W did not seem warranted.

Once again, much of the difficulty encountered with the 2012 survey was related to the difficulty in determining the eelgrass boundary in patchy and sparse conditions. The need for development of a clear and measurable definition of an eelgrass boundary in such conditions was again pointed out.

2013 Monitoring

The results of the 2011 and 2012 monitoring efforts clearly showed that the recovery that was expected to occur within the mooring scar areas following either permanent removal of the mooring or replacement of a traditional block and chain or mushroom anchor and chain mooring with "eelgrass-friendly" helical anchors was not occurring and in some cases the mooring scar area was actually expanding. Similarly, the eelgrass in the vicinity of the Simpson Point boat landing appeared to be in decline rather than recovery despite the landing having been closed to motorized boats as part of the mitigation effort. The observations over the period 2008 through 2012 offered evidence of what appeared to be a general decline in eelgrass within the region, particularly within Merepoint Bay and Middle Bay. The decline of the eelgrass between 2008 and 2012 was reported in a brief presentation at the 2013 Eelgrass Conference hosted by Phil Colarusso of EPA in Boston on March 28, 2013.

Following the Boston presentation, IF&W proposed to state and federal regulatory authorities that it would be better to conduct work to advance the science and knowledge surrounding this declining condition instead of just repeating past efforts for the sake of meeting the permit requirement. IF&W then assembled a diverse advisory group of scientists and organizations to assist in formulating plans for the final field season that would compliment ongoing research and advance the level of understanding. This advisory group of scientists represented the US Environmental Protection Agency, Maine DEP Marine Unit, US Geological Service Patuxent Wildlife Research Center, Casco Bay Estuary Partnership, Maine Department of Marine Resources, MER Assessment Corporation, Woods Hole Oceanographic Institute, Mount Desert Island Biological Laboratory, Maine Geologic Survey, and USACOE.

The advisory group established the following goals for the 2013 effort: Goal 1: Attribute a cause(s) to the observed or perceived decline in eelgrass from 2008-2012. Goal 2: Identify the current status of the eelgrass resource at the 2 geographic locations of interest. Goal 3: Determine why eelgrass is not recovering in the mooring scar areas. Goal 4: Determine if invasive tunicates are significantly causing or contributing to the decline of eelgrass; other possible causes of the decline included changes in water quality, sediment chemistry and invasive green crabs, among others. The 2013 work plan was therefore modified and expanded to include on-site monitoring at identified areas of interest, sampling of sediment chemistry, analysis of above and below ground eelgrass biomass, determination of the presence of eelgrass

wasting disease, determination of the presence and coverage of invasive tunicates, collection of light attenuation data (other partners), collection of water quality profile data (other partners), and aerial photography and photo-interpretation of the photographs for eelgrass distribution (other partners). All of MER's fieldwork associated with the 2013 effort was conducted on August 12 and 14, 2013.

The video monitoring at the mooring scars and vicinity of Simpson Point revealed a near catastrophic loss of eelgrass in Maquoit Bay and Merepoint Bay. These observations were confirmed by aerial photography conducted by Sewall Company as part of a collaborative effort by the Maine DEP and DMR and Casco Bay Estuary Partnership (CBEP) with photo-interpretation of eelgrass distribution done by Seth Barker, formerly with the Maine DMR.

Results of the sediment sulfide and total organic carbon (TOC) indicated that sulfide levels within the mooring scar areas were high, well above what is considered toxic level for eelgrass; sulfide levels were also elevated outside the scar areas and at all sampling locations at Simpson Point, all being above the 600µM level considered toxic for eelgrass. Total organic carbon levels, on the other hand, were similar to levels found in soft sediments elsewhere along the Maine coast.

Where eelgrass was found in Maquoit Bay, shoot density and length were both low compared to eelgrass in other areas in Maine and New Hampshire where similar measurements have been conducted. The incidence of tunicates was estimated at 0% to 10% coverage with two tunicate species, *Botrylloides violaceus* and *Diplosoma listerianum* (identification by Mary Carman, WHOI), both invasive species, present. Incidence of wasting disease was estimated to be low at 0% to 10%.

Water quality data collected by the Maine DEP in Maquoit and Middle Bays did not reveal anything particularly out of the normal other than slightly elevated dissolved oxygen saturations, some likely attributable to winds, and elevated chlorophyll levels that increased with depth; this may be attributable to diatoms being stirred up off the bottom from the epilithic diatom mats that covered much, if not most, of the bottom at Simpson Point.

The near total loss of eelgrass in Maquoit Bay and catastrophic loss in Merepoint Bay and at Simpson Point have rendered the mitigation efforts by IF&W over the past five to six years, as well as any further efforts, moot since natural conditions have clearly become unsuitable for eelgrass. This is very unfortunate in view of the time and expense put into these efforts; however, the efforts serve as an inadvertent and unintended documentation of the decline of eelgrass habitat and it is hoped that the sediment chemistry work of the study will provide a baseline set of values against which any future sampling can be compared.

Similar declines in eelgrass have been previously observed as reported anecdotally by many who have "watched" Casco Bay over many years. However, the multiple dramatic changes seen over the past two to three years, but particularly in 2013, indicate that major changes are taking place in Casco Bay, some, perhaps even most, possibly being related to global climate change and therefore well beyond local or even regional control. Nevertheless, efforts to mitigate impacts to marine waters, and specifically eelgrass habitat, obviously should continue.

Project Assessment

The DEP mitigation requirement for impacts to eelgrass related to the construction of the Merepoint Boat Launching Facility in 2007 was 5,400 ft^2. Following extensive efforts on the part of Maine IF&W staff and Town of Brunswick staff, six mooring owners were identified for participation in the mitigation efforts. The six traditional mushroom anchor or granite block and chain moorings were either removed and relocated outside of the eelgrass habitat or were replaced with "eelgrass-friendly" helical anchors in 2008. The combined mooring scars area following removal and/or replacement of the moorings totaled 6,250 ft^2, that is, 850 ft^2 more than the DEP required area. Having completed the mooring removal and replacement, the Maine IF&W had met its obligation to set aside sufficient area for eventual eelgrass recovery to compensate for impacts to eelgrass associated with the construction of the launching ramps and vessel traffic arriving and departing from the floats.

The Maine IF&W was also required to close the Simpson Point boat launching ramp to motorized vessel thereby eliminating scarring and clipping of eelgrass within the eelgrass meadow immediately adjacent to the launching ramp. Access to the Simpson Point launching ramp was blocked to motorized vessels by the installation of Jersey-type barriers in September 2008 thereby complying with the Maine DEP requirement to block motorized vessel access to the launching ramp.

Monitoring of both the mooring scars and eelgrass meadow at Simpson Point between 2008 and 2012 showed that, while some slow recovery was seen at certain mooring scars in 2011, the general health of eelgrass in the northern Casco Bay region, both in Maquoit Bay and Merepoint Bay, was declining resulting in increasing patchiness and barren areas between eelgrass clusters. As a result, by 2012, most of the recovery within the mooring scars that had occurred between 2008 and 2011 had been lost, the exception being mooring scar MER 17 which experienced continued recovery, albeit still slow at only 12% over the 5-year period. Similarly, at Simpson Point where scars within the eelgrass meadow seen in 2007 had recovered by 2008, in 2011 there was clear evidence of recession of the upper meadow boundary and general decline and thinning of the eelgrass within the meadow which continued into 2012.

The unusual and unexpected reversal in recovery at both the mooring scars and Simpson Point was somewhat baffling. Some scars represented cases where the moorings had been removed and relocated elsewhere, therefore no structure remained on the bottom and no boats were moored in the area. In the case of Simpson Point, the barriers on the launching ramp remained in place throughout the period barring all access by motorized vessels.

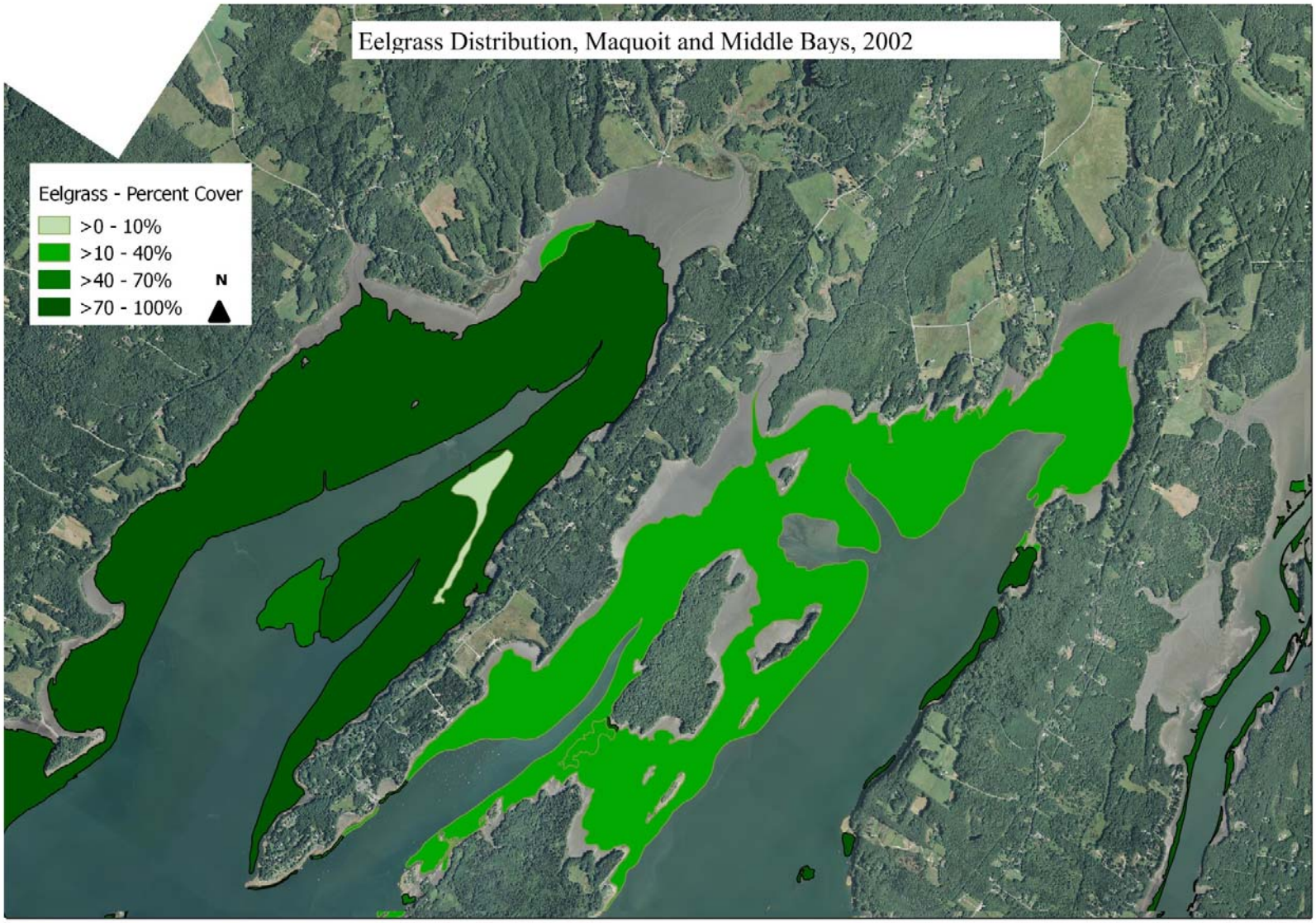
Based on the observation of what appeared to be an increasing amount of tunicates, primarily the orange-sheathed tunicate, *Botrylloides violaceus*, we suggested that the declining health of the eelgrass might be related to this infestation. Indeed, a 2012 cursory sampling of eelgrass floating on the surface revealed 100% of the blades had some level of tunicate present. However, although the incidence of tunicate was high on the eelgrass at the scar locations as well as at Simpson Point, the level of infestation was far less than the incidence found on the detached, floating blades.

The unexplained reversal in recovery and general decline in eelgrass over all the monitored areas observed in 2012 led to the decision in 2013 to change the 2013 effort from a strictly monitoring survey to one that included investigation into the possible cause for observed decline. As already explained, the investigation focused on eelgrass metrics and sediment chemistry. The small amount of eelgrass found during the study limited acquisition of data on eelgrass; however, the sediment chemistry data did reveal sulfide levels in all areas above the 600µM level that is considered toxic to eelgrass, but it remains unclear whether this is cause or effect. The most striking results of the 2013 project are the aerial photography and photo-interpretation of eelgrass distribution in Maquoit, Merepoint and upper Middle Bays. Figure 3 on the following page is the 2013 Sewall Company aerial photo of the area with the photo-interpretation of eelgrass distribution in 2002 done by Seth Barker, formerly with Maine DMR; Figure 4 is the same aerial photograph with Seth Barker's 2013 photo-interpretation of eelgrass distribution in 2013.

The massive loss of eelgrass is not restricted to just Casco Bay but has been reported in several other areas along the coast including Frenchman Bay and Taunton Bay (Jane Disney, pers. comm.). There are many suggestions as to what may have caused this catastrophic loss of the eelgrass all along the coast in shallower bays over such a short period of time, including destruction by the invasive green crab, *Carcinus maenas*, the populations of which have exploded over the past two years in northern Casco Bay; elevated seawater temperatures; invasive tunicates; and ocean acidification. Unfortunately, the answer is not clear, but numerous efforts are now underway to investigate and determine the reasons for the loss.

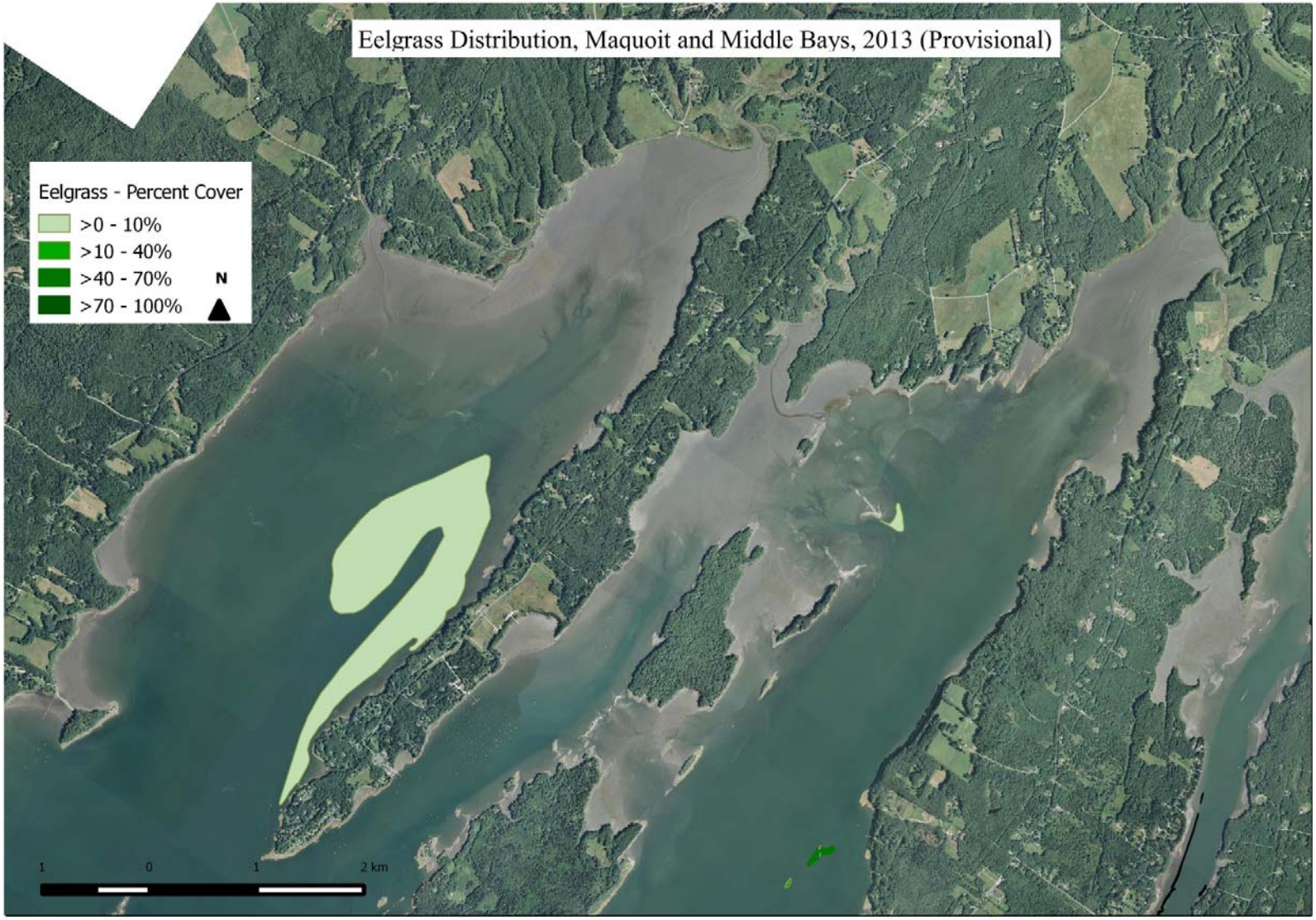
The loss of nearly all of the eelgrass in northern Casco Bay has rendered the eelgrass impacts compensation efforts by Maine IF&W over the past 5 years moot. Despite the good faith efforts by the Department to comply with all requirements over the 5-year period, at the end of the project there is little, and in most cases, no eelgrass left to evaluate. The potential benefits of the IF&W mitigation efforts could not be realized because independent environmental factor(s) have clearly rendered the area unsuitable to eelgrass. Given these circumstances, even if the project was not at its conclusion, any additional mitigation efforts and expenditures would seem ill-advised since these would almost certainly end in failure.

Figure 3. 2013 Sewall aerial photo Maquoit Bay and Middle Bay area in 2013 showing photo-interpreted eelgrass distribution in 2002 per Seth Barker (formerly with Maine DMR).



Source: Seth Barker, November 2013

Figure 4. 2013 Sewall aerial photo Maquoit Bay and Middle Bay area in 2013 showing photo-interpreted eelgrass distribution in 2002 per Seth Barker (formerly with Maine DMR).



Source: Seth Barker, November 2013

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