

Feasibility of mitigating physical disturbances to eelgrass in northern Casco Bay: Impacts and Options

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Executive Summary

This report has been prepared in response to a requirement set forth in the Maine Department of Environmental Protection's permit issued to the Maine Department of Inland Fisheries and Wildlife for construction of an all-tide boat launch facility on Merepoint Neck, Brunswick, Maine that calls 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.

This report, consequently, focuses on the physical disturbances that have occurred, or continue to occur, to eelgrass in northern Casco Bay. Physical disturbances to eelgrass that occur 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 shows eelgrass distribution in the area to be dynamic over time and eelgrass in the northern Casco Bay region to be currently at or near its maximum areal distribution. Nevertheless, physical disturbances to eelgrass were identified that are caused by fishing and aquaculture activity, boat moorings, propeller scarring, and structures, including private and commercial floats and possibly 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 account for disturbances totaling 2,315 ft² (0.05 acres/0.02 hectare); these disturbances 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 ft² each, account for a total of approximately 51,650 ft² (1.19 ac, 0.48 ha) of disturbance. The total area of scarring attributable to propellers is estimated at 7,025 ft² (0.16 ac, 0.07 ha). Private floats account for approximately 870 ft² (0.02 ac/0.01 ha) of direct coverage and increasing this by 50% to account for shading and disturbance around the float increases the disturbance area to just over 1,300 ft² (0.03 ac/0.01 ha). The float system associated with Paul's Marina in Merepoint Bay directly covers an estimated 1,800 ft² (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 has been doubled thereby increasing the disturbance area to 3,600 ft² (0.08 ac/0.03 ha).

The present extent and density of eelgrass within the northern Casco Bay area makes identification of “off-site” mitigation opportunities very difficult since nearly all areas suitable for eelgrass growth appear to be occupied to some degree of coverage. Nevertheless, opportunities to mitigate existing and on-going physical disturbances do exist.

The harvesting of blue mussels, although currently not a problem, could result in substantial physical disturbances in the future. The Town of Brunswick has a non-legally-binding, “gentlemen’s agreement” with one of the large mussel harvesting companies in Maine, but the agreement does not currently apply to other mussel harvesters, including those in Casco Bay. An opportunity may therefore exist to expand the existing agreement to include additional, perhaps even all, mussel harvesters along the coast following a process model recently developed by the Maine Department of Marine Resources for Taunton Bay, Franklin, Maine that engages stakeholders in discussions leading to a combined marine habitat conservation/protection and marine resource exploitation plan.

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 to 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 thus 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.

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; such have proven effective elsewhere but are relatively uncommon in Casco Bay and some failures have been experienced locally. Concern over reliability and the added cost of installation cause some owners to be reluctant to replace existing, functioning traditional moorings; however, town mooring fee waivers may help defray added costs.

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 ft² 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 and 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.

Introduction

The Maine Department of Inland Fisheries and Wildlife (IF&W) received a permit in 2006 from the Maine Department of Environmental Protection (DEP) to construct a full-tide boat launching ramp at a site on the west side of Merepoint Neck, on Merepoint Bay, Brunswick, Maine. Among the requirements set forth in the permit is the development of a feasibility guide of mitigation options in northern Casco Bay for physical disturbance impacts to eelgrass, *Zostera marina*, occurring there.

Impacts to eelgrass can result from a number of causes: 1) excessive nutrient loading leading to algal growth and consequent competition for light and space, 2) increased turbidity resulting in the loss of light, 3) shading, also resulting in reduced light, and 4) physical disturbances causing reduced growth, damage, or complete uprooting and destruction of the plants.

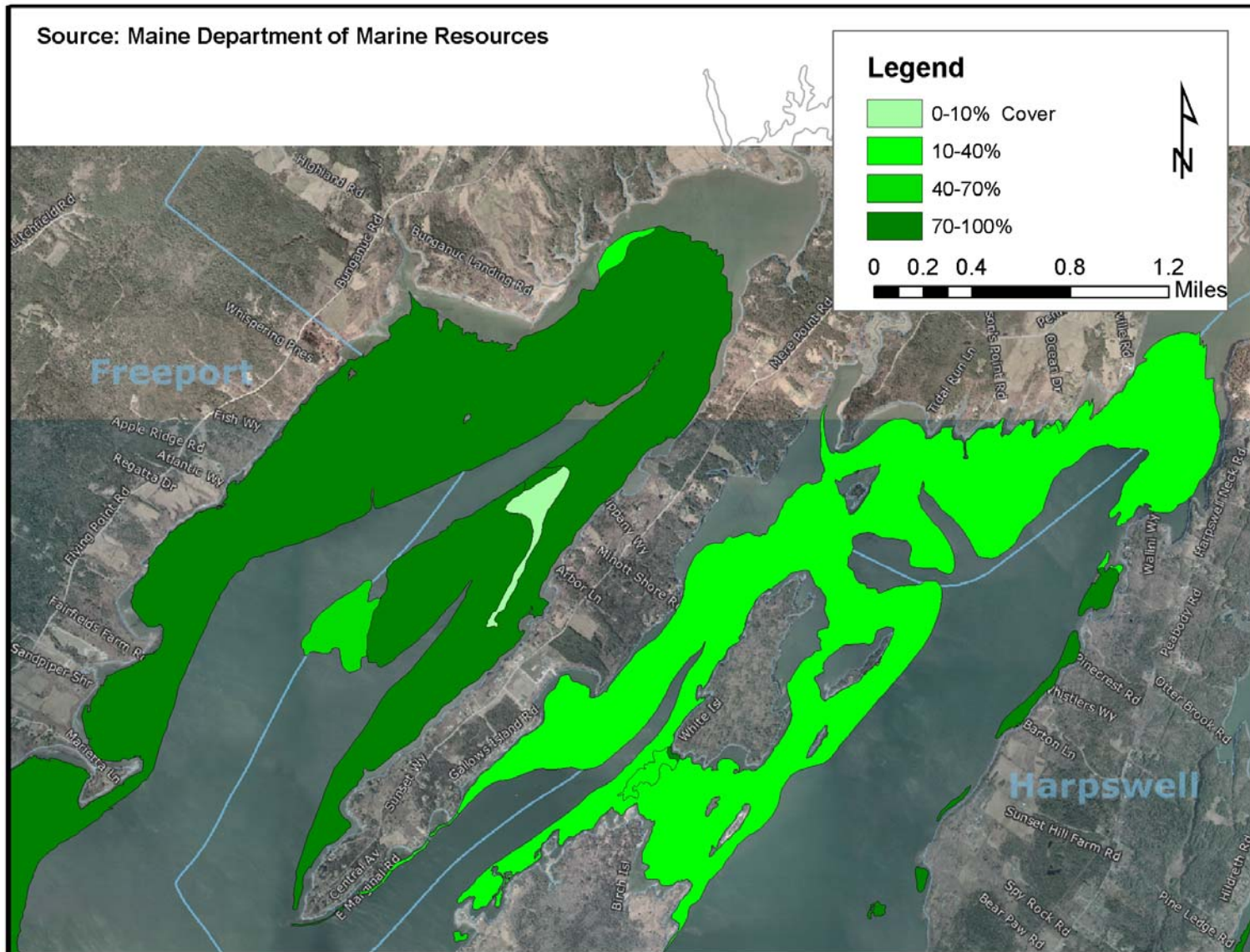
Water quality in northern Casco Bay, which includes the waters of Maquoit Bay, Merepoint Bay, and Middle Bay north of a line drawn from Little Flying Point on the Freeport shore on the west to Wilson Cove on the western shore of Harpswell Neck at the east, is generally very good. There are no major rivers draining into the bays, Bunganuc Brook on the western shore of Maquoit Bay being the largest single source of freshwater entering the bays. Numerous smaller drainages exist along the shores of Maquoit, Merepoint, and Middle Bays, but most run primarily during snow melt and following rain events and turbidity is normally elevated only during these events and coastal storms. Development within the watersheds flowing into the bays is still generally light to moderate with the exception of certain areas of concentrated development, such as along certain sections of Merepoint Neck. Furthermore, 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 (Brunswick Zoning Ordinance Section 209). The towns of Freeport and Harpswell, which share the remainder of the shoreline of northern Casco Bay, do not have similar nitrogen or nutrient limiting ordinances. Nevertheless, given Brunswick's restrictive ordinance and other constraints on development in both Harpswell and Freeport, water quality in northern Casco Bay should continue to remain good.

In view of the generally good water quality and normal turbidity levels, no impacts associated with these are expected in the foreseeable future. This report, therefore, focuses on the physical disturbances that have occurred to eelgrass in northern Casco Bay. Physical disturbances to eelgrass that occur 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. The report outlines the methods used to initially determine and document the current extent of physical disturbances in northern Casco Bay by type and discusses options available to mitigate the impacts related to these disturbances as well as the feasibility of their implementation.

Current distribution of eelgrass in northern Casco Bay

Eelgrass in northern Casco Bay covers much of the lower intertidal and shallow subtidal areas to a depth of approximately 3 m (Neckles et al, 2005); eelgrass distribution in northern Casco Bay has fluctuated over the years. Working in Maquoit Bay, Neckles et al. (2005) calculated annual coverage increases and decreases of 27.5 hectare (ha) and 4.4 ha, respectively, for the period 1993 to 2000 (net annual increase of 23.1 ha), and 37.2 and 2.6, respectively, for the period 2000-2001 (net annual increase of 34.6 ha). They also estimated the area of eelgrass cover in Maquoit Bay as of 2001 at 570.1 ha (1,408.7 ac). No similar estimate has been made of the eelgrass cover in Merepoint and upper Middle Bay, but similar expansion of the eelgrass coverage in these areas has occurred and appears to be at least half the area covered in Maquoit Bay, as shown in Figure 1; if so, eelgrass cover within northern Casco Bay would be approximately 805 ha (1,990 ac). According to Seth Barker of the Maine Department of Marine Resources (DMR) GIS and habitat mapping office, eelgrass in the northern Casco Bay region is at or near its maximum areal distribution.

Figure 1 Distribution of eelgrass in northern Casco Bay based on interpretation of 2001-02 aerial photographs (Seth Barker, Maine DMR).



Identification of physical disturbance causes and estimation of area

Determination of feasibility of mitigation is linked to the extent of impact for which mitigation is being sought, therefore, an estimate of the extent to which eelgrass has been impacted in the area was necessary. To adequately examine the entire area of northern Casco Bay we relied on analysis of aerial photographs of the area.

Aerial photographs of the northern Casco Bay region taken in 1993 and available at the Maine DMR website at <http://www.maine.gov/dmr/aerialphotos/preview/zone2/zone2.html> and subsequent aerial photos taken in 2001-02, provided by Seth Barker of DMR, were reviewed to determine general distribution of eelgrass throughout the region over the period. Although very helpful in clearly showing overall distribution, the altitude of 6,000 ft at which these aerial photos were taken and the resulting large area covered by individual photographs preclude their use in identifying individual physical disturbances, most of which are small and not discernable at the original 9"by 9" photo scale of 1:12,000.

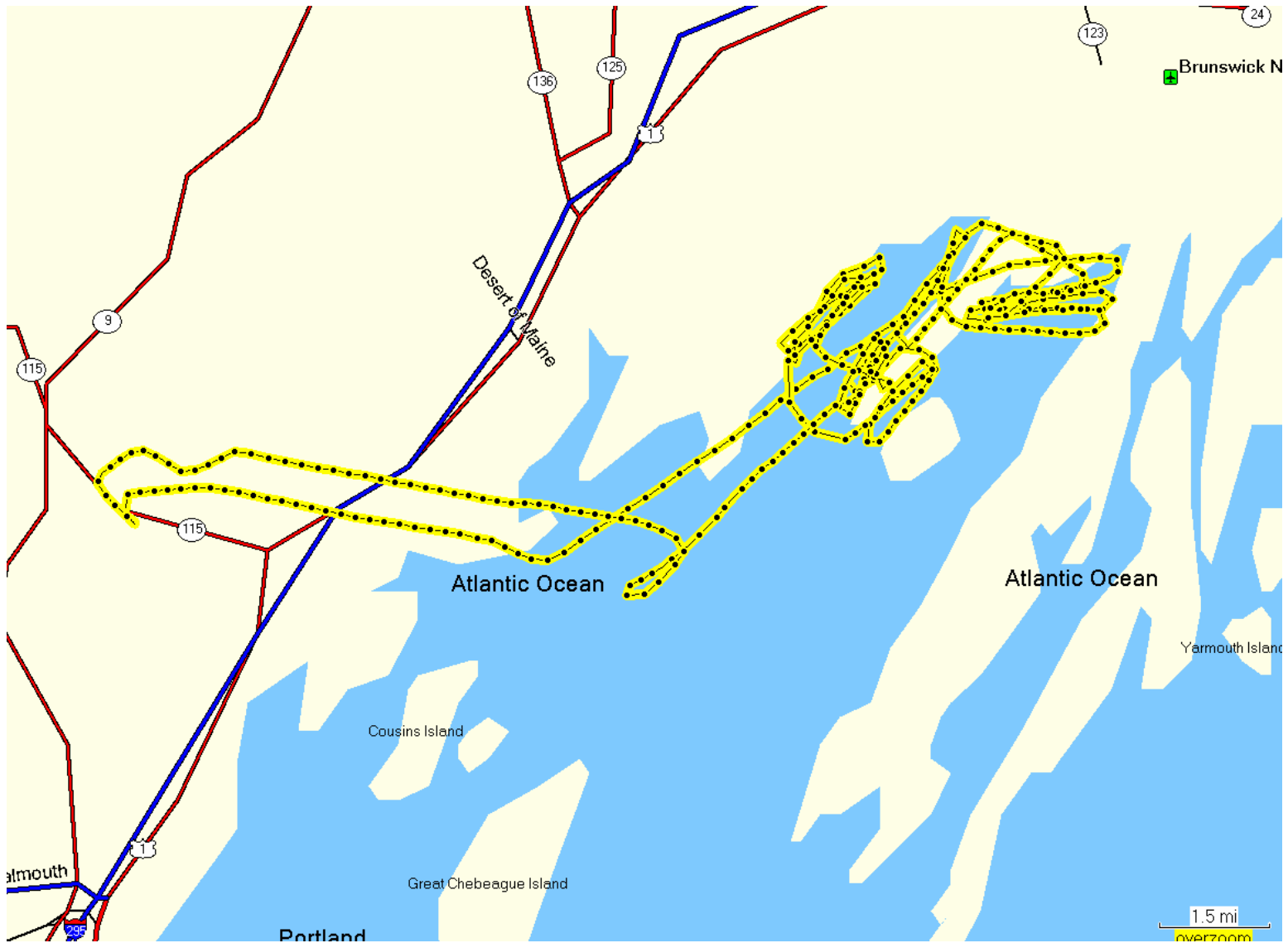
An effort was therefore undertaken to produce a new series of lower altitude aerial photos that would allow a more detailed and up-to-date view of physical damages to eelgrass. To accomplish this, vertical aerial photographs were taken from an Aeronca 7AC aircraft in level flight attitude between 06:20 to 06:50 on August 30, 2007. On that date, a -0.9 ft. low tide at Flying Point, Freeport was predicted to occur at 06:48. A Nikon D70 35mm digital camera equipped with a Nikon 18-55mm f/3.5 - 5.6G lens was strut mounted and controlled through a USB 2.0 cable attached to an IBM T43 ThinkPad using Nikon Camera Control Pro software. Focus was fixed with tape at infinity. Focal length was set at 35 mm resulting in an equivalent focal length of 53 mm for minimal distortion. Aperture speed was 1/200th second with aperture varying depending on light, typically f 5.6. Altitude flown was 2,600 ft. MSL +/- 100 ft. Airspeed was held at 75 mph with groundspeed varying between 65 and 85 mph with a 10 mph tail/headwind. Position and altitude for photography was independently tracked at 10 second intervals using a handheld Garmin GPS 60; flight path is shown in Figure 2. Additional flights to increase aerial photo coverage were planned, but were constrained by the need to coordinate tide height with time of day for proper light (early morning), weather, water clarity, and access to restricted air space around the Brunswick Naval Air Station approach.

A total of 334 photographs were taken during the August 30, 2007 flight; many of the photos were duplicates resulting from several passes over the same area. The aerial photographs are submitted on two CDs accompanying this report and a list is provided in Appendix I. All photographs were submitted to MER Assessment Corporation (MER) unprocessed in JPEG format. All photos were initially reviewed "on-screen" and a selection made of the best contiguous photos representing areas along the shoreline where impacts to eelgrass could be discerned. Sixteen (16) images were selected for detailed review and analysis and printed as 8" by 10" color prints (yielding an approximate scale of 1:2,000); these are attached as Appendix II. Each image is identified by a number corresponding to the original numerical sequence used during flight.

Image clarity over shallower areas is very good and allows clear view of physical disturbances to eelgrass; however, water clarity over deeper areas is obscured by what appears to be a phytoplankton bloom affecting much of the northern Casco Bay area at the time of the flight.

Identification of physical disturbances was done through careful review of images using both printed copies and on-screen imagery allowing the reviewer to zoom in and out on the image. Each of the selected 16 images was imported into Corel Draw[®] to allow delineation and enumeration of each disturbance; delineation of irregularly shaped areas was approximated by using common shape, *i.e.* circles, ovals, and squares. Estimation of area of each disturbance was made by creating a scale based on known measured distances, *e.g.* floats of known width (8 ft), applying the scale to measure diameter or length and width of the common shaped delineations, and calculating the delineated area to within ± 50 ft².

Figure 2 Flight path of August 30, 2007 aerial photography.



Analysis results

Natural change over time

The comparison between the 1993 and 2001 aerial photographs of the northern Casco Bay region shows the dynamic nature of eelgrass distribution in the area over time. The increase in extent and density of eelgrass over this period in Maquoit Bay has been previously reported by Neckles et al. (2005). In upper Maquoit Bay, shown in Figure 3(a) 1993 and 3(b) 2001, eelgrass is seen having extended around the area of Bunganuc Rock (indicated by the arrow and “1” in Figure 3(b)), across much of the area along the western Bunganuc Bluffs shore (indicated by the arrow and “2” in Figure 3(b)), and along the eastern shore north just above the small projection of land (indicated by the arrow and “3” in Figure 3(b)); the mussel dragging scars caused by mussel dragging in June 1999 and studied by Neckles et al. (2005) are indicated by the arrow and “4”.

Similar changes in eelgrass distribution in Merepoint Bay, primarily in the upper section, are shown in Figure 4(a) 1993 and (b) 2001. In 2001 eelgrass had extended into most of Smith Cove (indicated by the arrow and “1” in Figure 4(b)), and had covered much of the area between Merepoint Neck and Whites Island, (indicated by the arrow and “2” in Figure 4(b)), an area having only sparse cover in 1993. Similarly, the area between the north end of Birch Island and south end of Whites Island, nearly devoid of eelgrass in 1993, showed a substantial increase in eelgrass cover in 2001, (indicated by the arrow and “3” in Figure 4(b)). Finally, the area between Whites and Scrag Islands, (indicated by the arrow and “4” in Figure 4(b)), extending north of Crow Island and beyond into Miller Cove, (not shown in Figure 4(a)), areas nearly devoid of eelgrass in 1993, also showed substantial increase in eelgrass cover in 2001. The aerial photos taken in 2007 indicate that eelgrass continues to persist in the areas occupied in 2001, at least within the areas covered by the aerial transects.

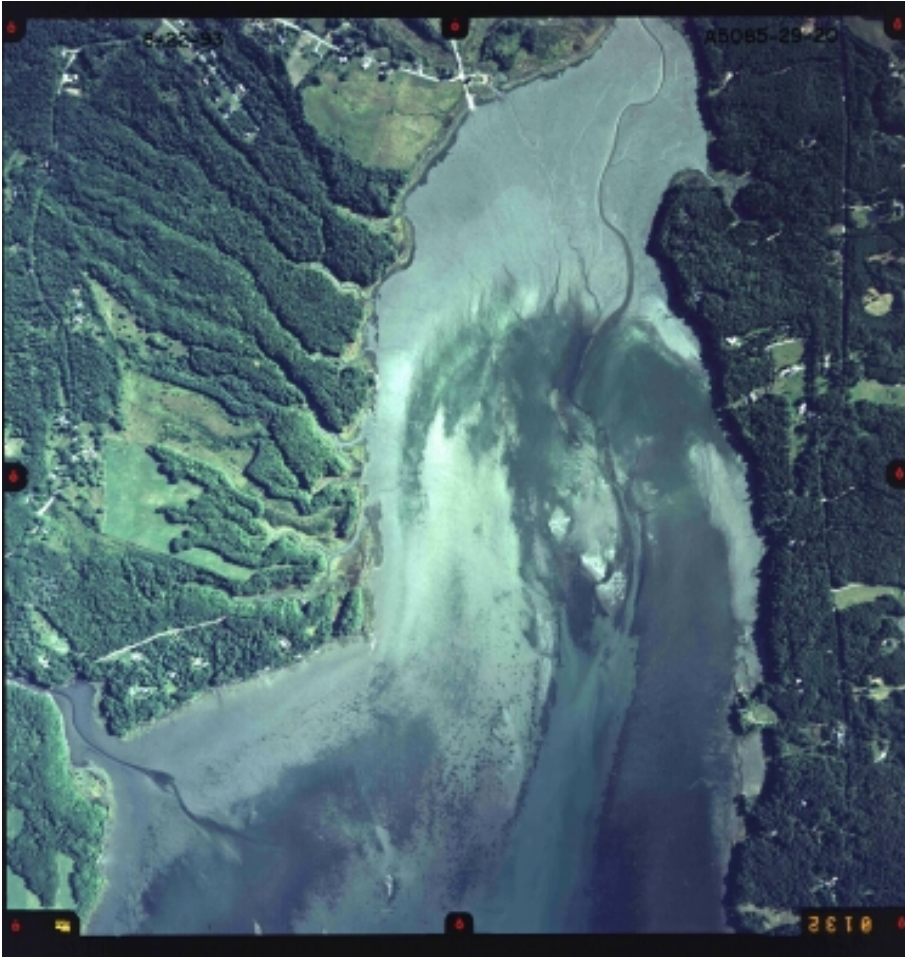
Physical disturbance to eelgrass

Based on the detailed review of the selected aerial photos, the identified physical disturbances or scarring fall into four cause categories: 1) fishing activity, 2) boat mooring, 3) propellers, and 4) structures. Estimated areas of disturbance related to these causes were determined through review and interpretation of the 2007 aerial photos. It should be noted that the delineation of these areas is based on the estimated shape and dimension of disturbance as discernable from the photos. Although every effort has been made to accurately delineate the areas, in many cases the actual boundary of disturbed area is not clear; to more accurately determine the area of disturbance the scar would need to be measured on-site by boat or by diver. Where irregular shapes are encountered the estimated area is based on an estimated average width and length.

Eelgrass coverage within the disturbance area also cannot be estimated solely from the aerial photos, but would need to be determined through direct on-site observation and, as with dimension verification, measured on-site by boat, if sufficiently shallow, or by diver. For the purposes of this report, the estimated areas of disturbance assume 100% loss within the delineated area, thus representing a worst-case estimate. Finally, despite the low draining tide of -0.9 ft on August 30, 2007, the presence of the phytoplankton bloom across the area limited the depth of view and consequently examination of the lower subtidal end of the eelgrass beds; it is therefore possible that additional disturbances exist within the area that remain undetected from the photos. However, most of the disturbances identified through this analysis are located well within the viewable depth range, thus the number of disturbances going undetected would be expected to be small.

Figure 3 Aerial photos of upper portion of Maquoit Bay taken in 1993 (a) and 2001 (b) showing extent of expansion of eelgrass over the period

(a)



(b)

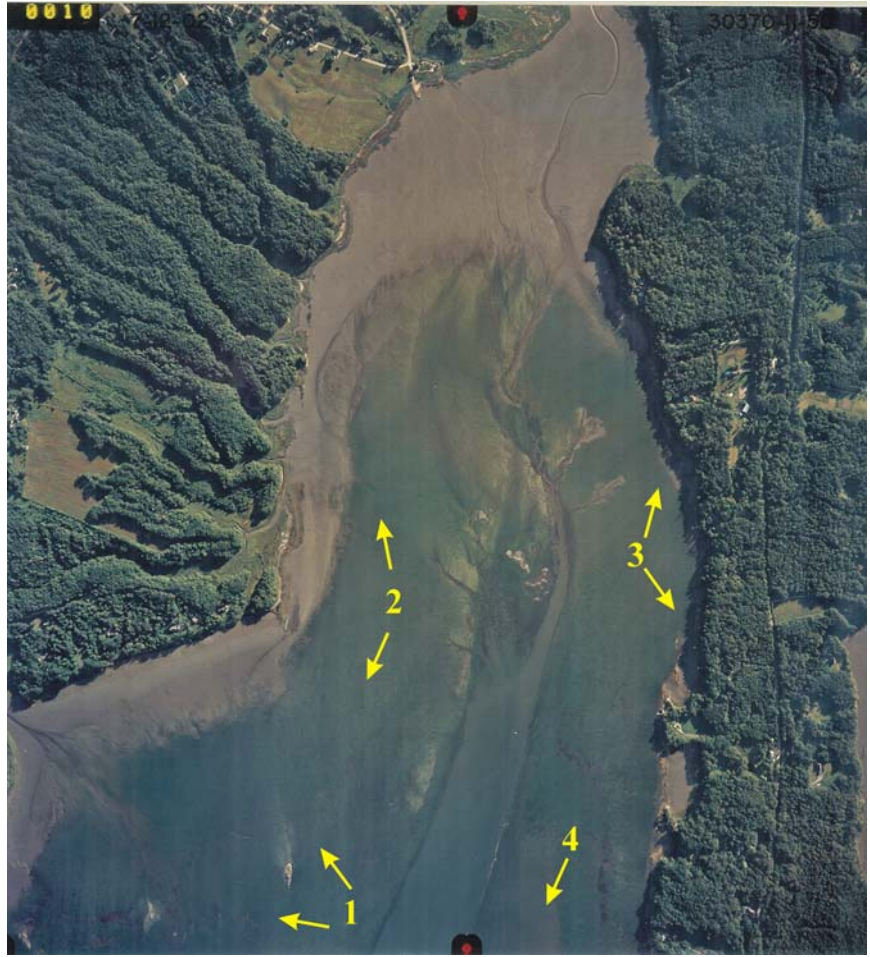
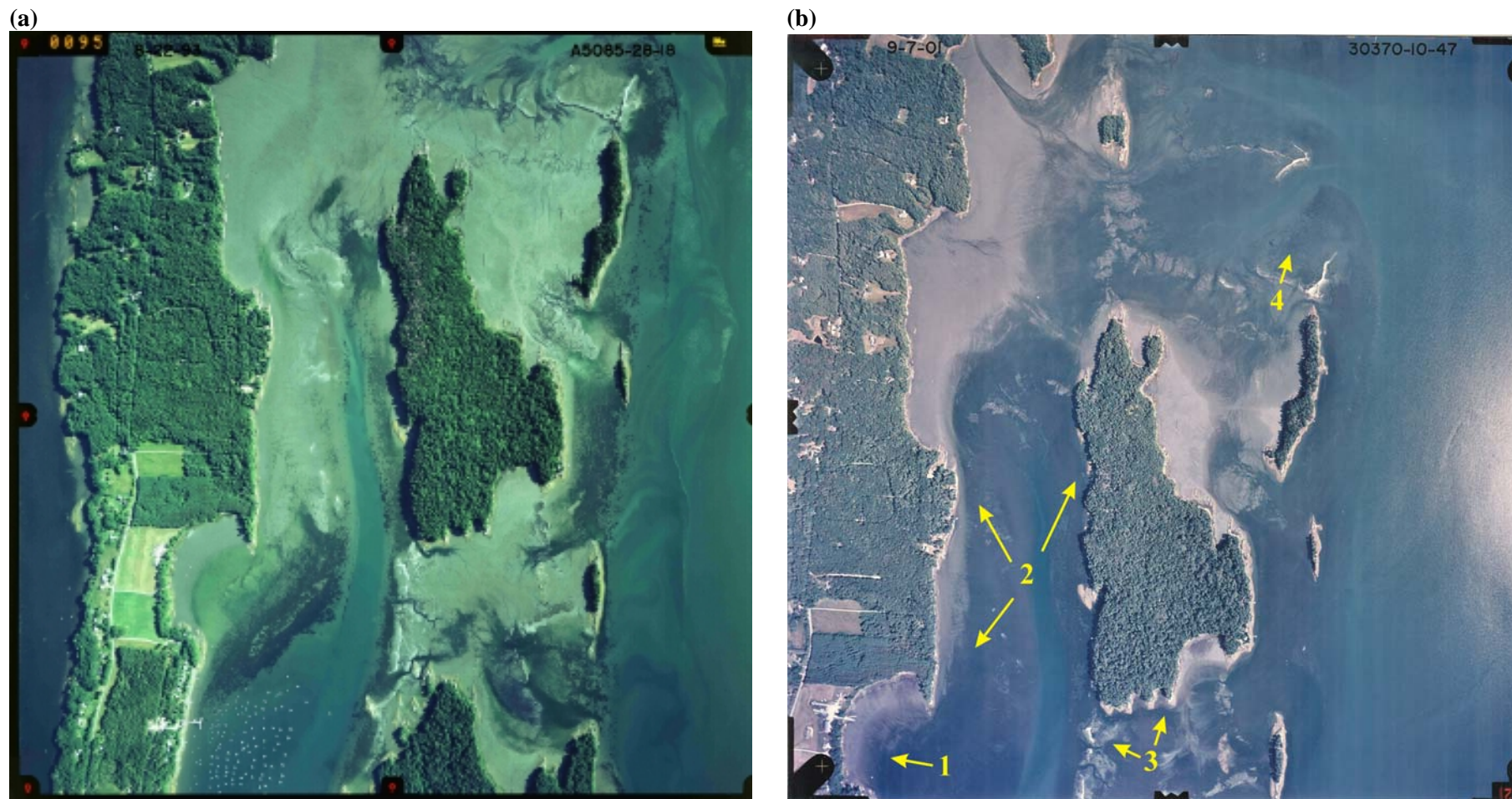


Figure 4 Aerial photos of upper half of Merepoint Bay taken in 1993 (a) and 2001 (b) showing extent of expansion of eelgrass over the period



Fishing activity

Commercial fishing in northern Casco Bay is focused on American lobsters, *Homarus americanus*, rock crab, *Cancer irroratus*, Jonah crab, *C. borealis*, soft-shell clam, *Mya arenaria*, northern quahog, *Mercenaria mercenaria*, blue mussel, *Mytilus edulis*, and worms, the blood worm, *Glycera dibranchiata*, and sand worm, *Nereis virens*.

Lobstering and crabbing are strictly subtidal fisheries, usually carried out in deeper water. However, during the spring when lobsters migrate back into shallower water, the fishery can move into these shallower areas potentially subjecting eelgrass to temporary “flattening” under traps and some, albeit very limited, disturbance and uprooting as traps are dragged across the bottom during hauling. The spring fishery usually lasts from mid-May through July as lobster again move into deeper water and traps are relocated to follow them (D. Millar, pers. comm.). Lobster fishing in the northern section of Casco Bay and the upper reaches of Maquoit, Merepoint, and Middle Bays has been heavy in the past, however in recent years lobster fishing in these areas has declined as more gear is fished in deeper water; a few local area fishermen, however, continue to fish predominantly in these areas (D. Millar, pers. comm.).

Clamming for soft-shell clams is primarily an intertidal fishery that takes place on mudflats. Occasionally soft-shell clams can be found in the lower extreme of the intertidal area, but rarely, if ever, in the subtidal where they are heavily preyed upon by crabs, primarily the green crab, *Carcinus maenas*. Clam harvesting results in a “turning” of the substrate that can potentially damage eelgrass through trampling, cutting, or uprooting. However, harvesting in the lower intertidal is limited and the potential for damage to eelgrass is similarly limited (pers. obs., C. Heinig).

Northern quahogs, or hard-clams, occur within the intertidal area but extend into the shallow subtidal area and are known to exist within eelgrass beds (pers. comm., Dana Wallace; pers. obs. C. Heinig). Harvesting of soft-shell clams is only allowed using hand implements (12 MRSA §6623, 1.), that is, hand-held rakes or “hoes” and hydraulic or mechanical dredging is not allowed unless specifically permitted (12 MRSA §6623, 2.). Dredging or dragging for quahogs is permitted under the law. Historically, the upper sections of Maquoit and Middle Bays supported a lucrative quahog fishery (pers. comm., Dana Wallace), but since the peak of the fishery in the 1950s, little, if any, quahog fishing takes place in these areas even with hand implements and none by dragging or dredging.

Blue mussels occur both intertidally and subtidally and can extend to a depth of several meters. In Maine they can be harvested by both hand implements (12 MRSA §6745) or mechanical drags (12 MRSA §6746). Intertidal mussel beds are usually separate from eelgrass and harvesting of such beds should not result in any physical damage to eelgrass. Mussels are known to settle on eelgrass during the late-larval stage when seeking firm substrate for settlement (Newell et al., 1991; Reusch, 1998; pers. obs. C. Heinig) sometimes resulting in the smothering of the eelgrass and development of extensive mussel beds in the subtidal area. The Maine DMR does not currently impose any restrictions on the harvesting of subtidal mussels within or adjacent to eelgrass beds and these mussels are subject to mechanical harvesting. When harvesting of such beds occurs, the eelgrass within and adjacent to the beds can be destroyed or severely damaged as extensively documented in Maquoit Bay by Neckles et al., (2005).

Blood worm and sand worm harvesting takes place in the intertidal area, but can extend into the extreme lower intertidal zone where eelgrass may be encountered. However, as with soft-shell clams, worm harvesting is only allowed using hand implements (12 MRSA §6771). Worm harvesting does take place in northern Casco Bay, but is extremely limited (pers. comm., Dan Devereaux, Brunswick Marine Warden). Worm harvesting is methodical and creates linearly symmetrical patterns as opposed to the more chaotic and unpredictable patterns of clam harvesting, both shown in Figure 5; propeller scars and clam harvesting patterns are shown in Figure 6.

Figure 5 Clam and worm harvesting patterns in intertidal area of Maquoit Bay, August 30, 2007

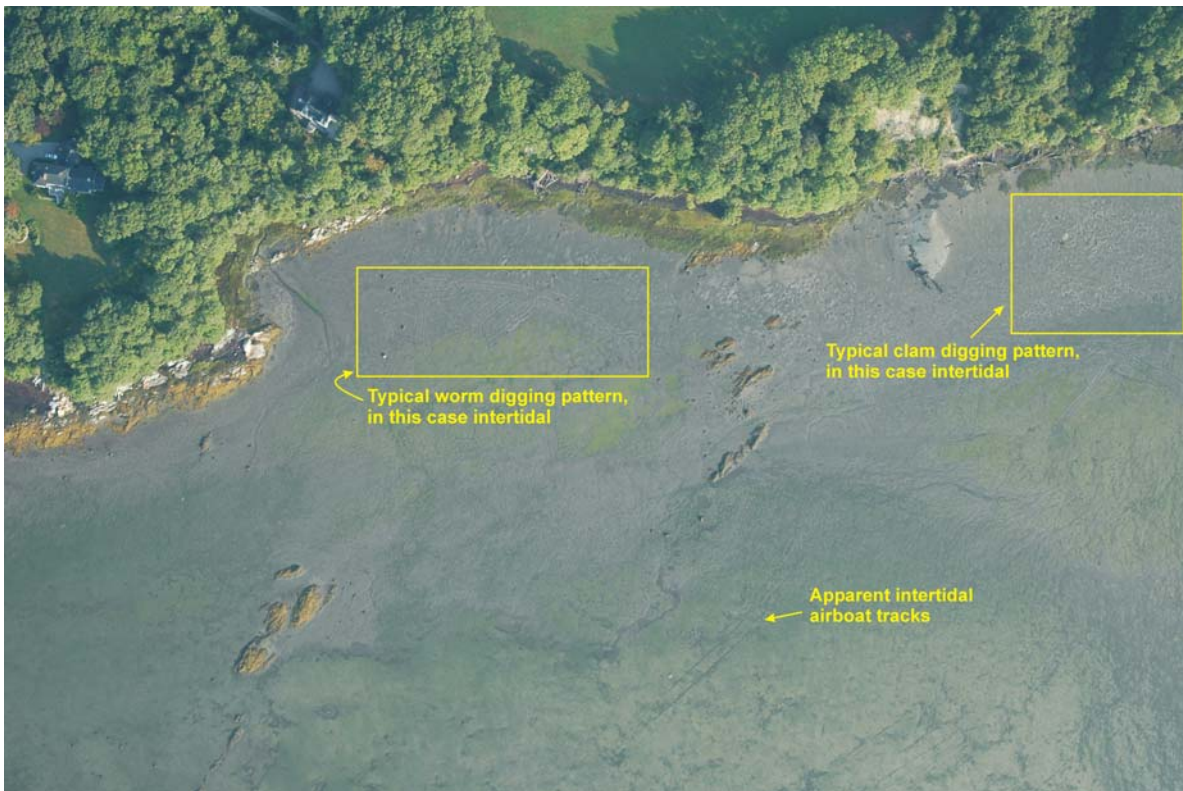


Figure 6 Propeller scars (small yellow arrows) and clam harvesting patterns (larger red arrows) in intertidal area of Merepoint Bay, August 30, 2007



Mooring scars

Traditional mushroom anchor-chain boat mooring assemblies cause damage or complete destruction of eelgrass within a circular pattern over the bottom through which the chain passes with the changing of the tide. The area of physical disturbance depends on the size of the vessel attached to the mooring, the depth of water, and scope of chain-anchor line; generally, the larger the vessel the greater the damage.

Except for certain moorings located at Paul's Marina (an Army Corps of Engineers-permitted commercial marina in Merepoint Bay), based on the review of the 2007 aerial photographs, most of the moorings within the eelgrass band are located relatively closed to shore. This is understandable since boat owners with shorefront property locate moorings to minimize the distance needed to row from shore or their float to reach their moored boat(s); distance from shore increases with size of vessel, but in most cases, boats moored within the eelgrass areas appear to be in the 18 to 24-foot class or smaller.

Based on our review of the 2007 aerial photos there are 95 visible and measurable mooring scars averaging approximately 544 ft² each for a total of approximately 51,650 ft² (1.19 ac, 0.48 ha).

Propeller scarring

Propeller scars are visible within the intertidal and subtidal areas where damage to or removal of eelgrass is evident. Scars within the intertidal area appear to be caused by clam diggers arriving at flats between 2 to 3 hours before low water. In such cases, little impact to eelgrass would be anticipated since these are usually small aluminum boats in the 12-14 foot class powered by 15-25 hp outboards, many of them short-shafted, crossing the eelgrass well before low water; departure from the flats usually mirrors time of arrival, thus height of tide is usually similar.

Propeller scarring is also found in the vicinity of certain floats and where the bottom has a shallow grade and shallow water extends a considerable distance before deeper water is reached (see aerial photo 1227, Appendix II). Very few propeller scars are seen that are not associated with a float, dock, or shellfish harvesting area. These random scars are likely attributable to unintended departures from channels by boaters unfamiliar with the area; often these scars are curved, suggesting an attempt to reverse direction following intrusion into the shallows. The total area of scarring attributable to propellers is estimated at 7,025 ft² (0.16 ac, 0.07 ha).

Structures

Private docks and floats are the most common and numerous structures that extend beyond the shore into the water. Due to the rather steep shoreline around most of the bays' area, in nearly all cases the narrow (4-6 ft wide) fixed structure of the docks extends only over the intertidal area and not into or over the eelgrass (refer to aerial photos 1211-1214, 1261, and 1326-1328 Appendix II). The end of the fixed structure portion is equipped with a narrow ramp extending down to a float, the size of which varies (100-200 ft²). Of the 37 private docks with floats found within the area, 31 were found restricted to the intertidal area and only 6 were found extending into and over eelgrass beds resulting in 868 ft² (0.02 ac/0.01 ha) of direct coverage; increasing this by 50% to account for shading and disturbance around the float increases the disturbance area to just over 1,300 ft² (0.03 ac/0.01 ha). It is important to note that the floats intrude only into the upper boundary of the eelgrass beds and, in most cases, eelgrass remains contiguous beyond the area of shading and disturbance around the floats.

A more extensive float system associated with Paul's Marina in Merepoint Bay directly covers an estimated 1,800 ft² (0.08 ac/0.03 ha). Because of the greater amount of activity associated with these commercial floats the estimated area affected by shading and disturbance has been doubled thereby increasing the disturbance area to 3,600 ft² (0.08 ac/0.03 ha).

The largest man-made structure extending from the shoreline into the eelgrass habitat within northern Casco Bay is the stone pier at Simpson Point. The pier, or “wharf”, was constructed in 1899 and extends perpendicularly from shore approximately 400 feet (Brunswick Telegraph: June 21, 1899, p.3 Brief Notes). The article references the “new wharf” being built “out into the channel” suggesting that the waters off Simpson Point were deeper at the time and that sedimentation over the past 100+ years has caused the general uppermost area of Merepoint Bay to become shallower.

A review of the 2007 aerial photos of the Simpson Point landing area that include the stone pier (aerial photos 1031-1033) show that the shoreward, upper boundary of the eelgrass band stretches from the rocky point of land just to the east, westward over to the end of the stone pier. Further to the east, however, the shoreward boundary of the eelgrass band stretches from one rocky point to the next. A likely reason for this may be that sediment has slowly accumulated on either side of the stone pier over time causing this area to become intertidal or too shallow at low water to support eelgrass; unfortunately, no historical photos exist to support the assumption that eelgrass existed in this area at any time in the past. Nevertheless, had eelgrass existed in the area prior to the construction of the stone pier and had the pattern of distribution been similar to what exists today, the area may have supported an additional 18+ acres of eelgrass, as shown later in Figures 6 and 7.

Table 1, below, summarizes the area of physical disturbance for each of the cause categories; a detailed listing for each category is presented in Appendix III. It should be noted that the Fishing category does not include the dragging scars reported and documented by Neckles et al. (2005) since these were either only partly or not at all visible in the photos; furthermore, substantial recovery of the scarred area makes identification difficult. The possible physical disturbances caused by the Simpson Point pier are separated from the observed disturbances because it is presently unknown whether eelgrass existed in that area prior to construction of the stone pier.

Table 1. Summary of physical disturbance area by cause

Cause	Total ft²	Total acres	Total hectares
Fishing (not including 1993-99 Maquoit “scars”)	1,275	0.03	0.01
Aquaculture	1,040	0.02	0.01
Propeller scars	7,025	0.16	0.07
Mooring	51,650	1.19	0.48
Private docks and floats (@ 150%)	1,300	0.03	0.01
Commercial docks and floats (@ 200%)	3,600	0.08	0.03
Total observed	65,890	1.51	0.61
Simpson Point stone pier	800,000	18.37	7.43
Total observed and Simpson Pt. pier	865,890	19.88	8.04

Based on the previously estimated eelgrass cover in northern Casco Bay of 805 ha (1,990 ac), the total observed physical disturbance is small at approximately 0.61 ha (0.07%); including the potentially affected area around Simpson Point, the 8.04 ha (19.9 ac) represents 1% of the eelgrass covered area of northern Casco Bay.

Mitigation options

The present extent and density of eelgrass within the northern Casco Bay area makes identification of “off-site” mitigation opportunities very difficult since nearly all areas suitable for eelgrass growth appear to be occupied to some degree of coverage. Indeed, mitigation opportunities and options were exhaustively reviewed during the 2004-05 Maine IF&W application process for the Merepoint Boat Launch facility; few existed then and few exist now. Consequently, the mitigation options considered here are focused on opportunities for on-site correction of those causes currently resulting in physical disturbance.

Fishing activity

As stated before, soft-shell clam, quahog, and worm harvesting account for a relatively small amount of physical disturbance to eelgrass in northern Casco Bay since these activities are generally confined to the intertidal mudflat area and arrival and departure from harvesting areas usually occurs well before and after low water thereby reducing the potential for propeller scarring; additionally, the traditional aluminum boats used by harvesters are increasingly being replaced by small airboats that cause very limited and temporary disturbance to eelgrass, if any. The shellfish aquaculture operation along the Freeport shore similarly appears to cause only limited physical disturbance to eelgrass, although boat moorings associated with the operation cause similar disturbances as private boat moorings; these moorings are therefore treated along with private moorings.

By comparison to these fishing activities mussel dragging has the potential to cause substantially greater physical disturbance, as documented by Neckles et al (2005). Maine coastal municipalities which have adopted a shellfish conservation ordinance are granted jurisdiction over the management of certain shellfish resources in the intertidal area within the municipality’s boundaries under Maine law (12 MRSA §6671). Although the definition of “low water” within the definition of “intertidal” remains unclear, most municipalities currently interpret the definition of “intertidal” as the area between the high water mark and the lower low water mark. Additionally, under current law, the definition of “shellfish” is shellstock clams, quahogs other than mahogany quahogs, and oyster shellstock (12 MRSA §6601, sub-§6.). According to this definition, a municipality does not have authority to manage harvesting of mussels within its intertidal jurisdiction.

Pending legislation currently before the Maine State Legislature, however, seeks to allow municipalities the authority to designate certain areas within which mussel dragging will be limited to the degree necessary to support the goals of the shellfish conservation program (LD 2006, item 1, 123rd Maine State Legislature - An Act to Give Municipalities Control of Mussels Located in Intertidal Zones). All three municipalities around northern Casco Bay (Freeport, Brunswick, and Harpswell) have adopted shellfish conservation plans and actively manage their respective soft-shell clam and quahog resources. Therefore, if this legislation passes, it will allow all three municipalities to manage and regulate intertidal mussel harvesting, if they so choose, but only for purposes of shellfish resource conservation, not protection of eelgrass. According to the National Oceanic and Atmospheric Administration (NOAA) Tide Predictions, lower low water in northern Casco Bay reaches -1.8 ft MLLW, or -0.55 m MLLW. According to Neckles et al. (2005) the 1993-99 mussel dragging impact areas in Maquoit Bay ranged in depth from -0.2 to -1.5 m MLW, the majority (49.8 of 53.2 ha) being at a depth \geq -0.6 m. Consequently, although the pending legislation may afford some coincidental protection of a portion of the eelgrass in northern Casco Bay from dragging, a large portion of the area covered by eelgrass and potentially harvestable by mussel draggers would remain beyond the jurisdiction of the municipalities.

However, as a result of the work of Neckles et al. agreement was reached in 2000 with certain mussel draggers on a moratorium on dragging in Maquoit Bay; to-date, no mussel dragging has since occurred in the bay (pers. comm., D. Devereaux). This agreement, however, is not legally-binding, but is instead characterized as a “gentlemen’s agreement” and it does not currently apply to other mussel

harvesters, including those in Casco Bay (refer to Appendix IV). The Maine DMR is currently reviewing options to insure continued harvesting by dragging while managing and minimizing impacts to avoid unreasonable habitat damage (pers. comm., J. Sowles, DMR). An opportunity may therefore exist to expand the existing agreement to include additional, perhaps even all, mussel harvesters along the coast. The Maine DMR has recently developed a process to engage stakeholders in discussions leading to a combined marine habitat conservation/protection and marine resource exploitation plan for Taunton Bay, Franklin, Maine that may serve as a model for similar planning in northern Casco Bay. The Casco Bay Estuary Partnership has been actively engaged in marine issues related to Casco Bay for nearly two decades and perhaps could serve as a facilitator for such discussions.

Moorings

Compared to the magnitude of previous fishing impacts of 53.2 ha, the estimated total area of physical disturbance caused by boat moorings of 0.48 ha is small, but represents a persistent rather than temporary form of disturbance. Two measures are available to mitigate or completely correct these disturbances: 1) mooring removal and relocation, and 2) mooring replacement.

The Brunswick Harbor Ordinance (April 4, 2005) requires registration of all mooring and specifically charges the harbormaster with the responsibility for setting the location of registered moorings. The ordinance also sets forth standards for moorings and authorizes the harbormaster to require removal or relocation of moorings, both new and existing, that do not comply with the standards. The standards specifically state that moorings shall not be located in areas that unreasonably affect natural resources or in areas inconsistent with the terms or conditions offered to, or required by, any federal, state, or local agency as part of a regulatory permitting process. The Harpswell Harbor and Waterfront Ordinance (amended March 11, 2006) makes no reference to location standards other than requiring that moorings be located within Harpswell waters classified as Harbor or Anchorage or adjacent to riparian owner's property, and no further than one half mile from the applicant's point of land access. The Freeport Coastal Waters Ordinance (June 5, 2007) details regulation of moorings located within the Town of Freeport anchorage with particular emphasis on the Harraseeket River Anchorage, but makes no reference to location standards for moorings placed outside of the Harraseeket River (see Appendix V).

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 relatively narrow and the distance to the new location from shore is only slightly greater than to the previous location. Indeed, moorings have recently been successfully relocated in the vicinity of the Merepoint Boat Launch facility where the previous mooring location presented a navigational hazard. However, in other areas 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 previous location. In such cases, relocation poses not only a substantial inconvenience to the mooring owner but also exposes the owner to greater risk given the added distance between shore and the mooring. Under these circumstances, even if so authorized, the harbor master would likely be reluctant to require relocation of the mooring(s) and an alternative mooring replacement option would need to be entertained.

Embedment moorings, sometimes referred to as helix or helical anchors, provide an alternative to the traditional mushroom anchor-chain mooring; embedment anchors reduce physical disturbance to eelgrass by eliminating the sweeping chain of traditional moorings responsible for most of the disturbance. Embedment moorings have proven effective in other places but are relatively uncommon in Casco Bay and some failures have been experienced (Richard Keene and John Blood, Coastal Barge and Mooring). Consequently, some mooring owners are reluctant to consider having them installed. Additionally, the cost of installation for an embedment mooring is substantially higher than that of a traditional mooring, thereby adding to the reluctance to replace existing, functioning traditional moorings.

Many, if not most, of the moorings currently located within eelgrass beds hold boats in the 18-24 foot class or smaller and are generally in shallow water. Embedment anchors may therefore prove to be an effective alternative for traditional moorings now being used for these boats. However, proper installation of embedment moorings requires sufficient sediment depth for complete insertion and torque of the anchor into the bottom; embedment anchors cannot be used where depth to bedrock prevents complete burial of the anchor. Therefore, while the size of the boats moored in shallow water may make their existing moorings good candidates for replacement with embedment anchors, their proximity to the shoreline and the consequent possibility of shallow depth to bedrock may preclude proper installation.

In some cases where embedment mooring installation proves to be a feasible alternative, the cost of replacement may deter the owners from switching. In such cases, the municipality in which the mooring is located might consider a waiver of any annual registration fee for such time as would be necessary to compensate the mooring owner for the difference in cost between a traditional and embedment anchor. The Town of Harpswell currently charges a \$12 per year registration fee for resident moorings, \$60 for non-resident moorings, and \$50 for rental moorings; the Town of Brunswick does not currently charge a mooring registration fee, but is considering such a fee. The Town of Freeport does not charge a mooring registration fee for residential recreational moorings outside of the Harraseeket River anchorage, but does charge an annual registration fee for all other types of moorings within the Town of Freeport anchorage; annual registration fees range from \$95 to \$350.

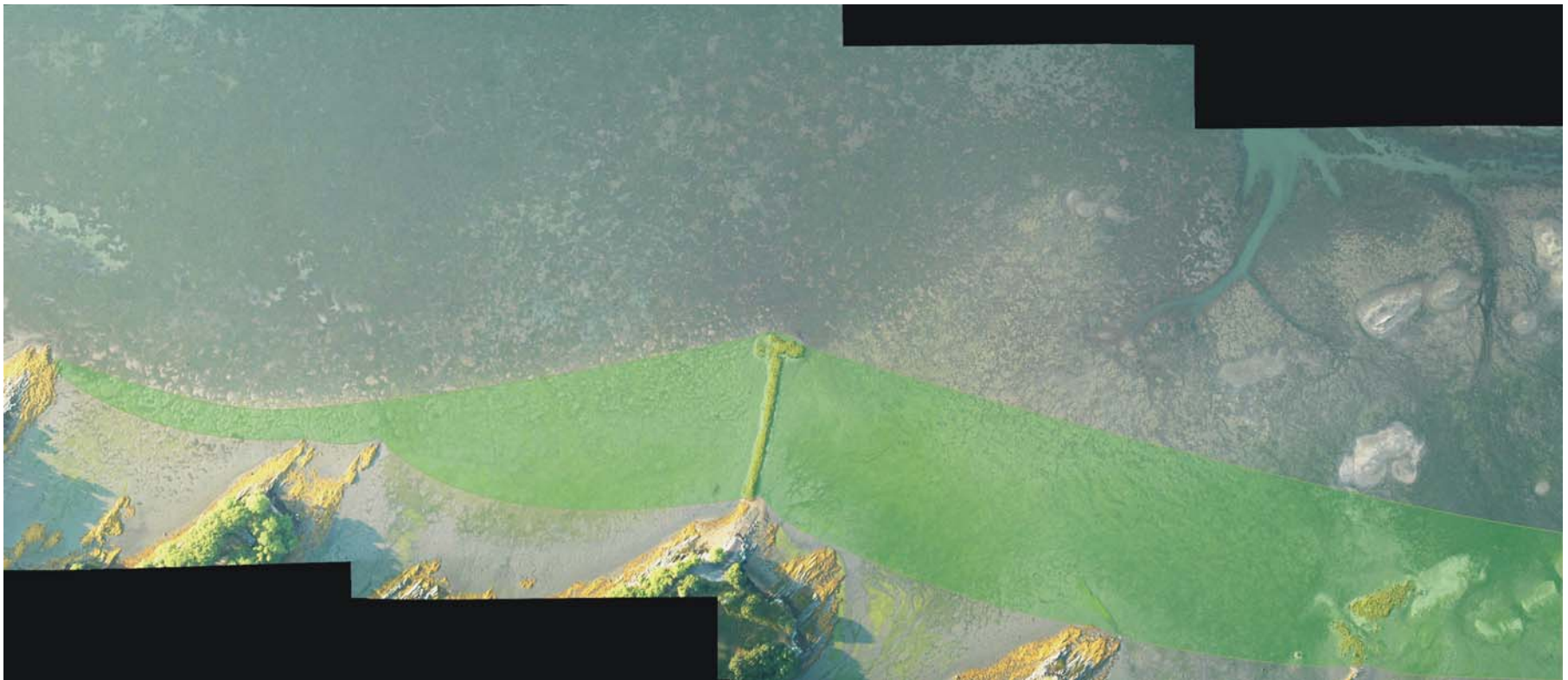
Structures

As stated earlier, most private wharfs, docks, and floats in the northern Casco Bay area do not directly affect eelgrass, and the few that do account for a very small area of disturbance; consequently these do not offer much in the way of mitigation opportunities. The floats at Paul's Marina account for about 3,600 ft² of disturbance, however this facility is fully permitted by the U.S. Army Corps of Engineers as a commercial marina.

Removal of the stone pier at Simpson Pt. represents, perhaps, the largest eelgrass physical disturbance mitigation possibility. However, since the structure has been in place for a little over 100 years it is difficult to determine if the area surrounding the pier was covered with eelgrass at the time of construction and therefore whether it would become suitable habitat for eelgrass following removal of the structure; unfortunately, at the time of construction in 1899 the Brunswick Telegraph did not carry photographs and we are currently unaware of any historical photos of the area.

Based on the eelgrass distribution pattern along the shoreline adjacent to, but beyond the influence of, the stone pier it is estimated that more than 800,000 ft² or 18 acres of eelgrass habitat might be created if the stone structure were removed and the surrounding area were to become revegetated with eelgrass (see Figure 7). Furthermore, it is also difficult to determine if the lack of eelgrass around the structure today is due to sedimentation around the stone pier that, over time, has raised the seafloor to the point that it is no longer suitable as eelgrass habitat. If so, removal of the stone pier by itself may not be sufficient to insure reoccupation of the area by eelgrass; additional removal of sediment may be required if tidal currents alone fail to return the area to its former depth. Clearly, additional work would need to be done to provide high-resolution bathymetry of the area surrounding the pier and the hydrodynamics of the area would need to be studied to develop the necessary models to predict sediment redistribution within the area following removal of the pier.

Figure 7 Stone pier at Simpson Point showing possible eelgrass coverage (green overlay) following removal of the structure.



Although the stone pier is admittedly a man-made structure, 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. Therefore, removal of the structure would ultimately result in the substitution of one habitat (shallow subtidal soft-bottom, eelgrass) for another (intertidal hard-rockweed habitat) and a decision to move forward with such a project would require a habitat-value judgment to be made.

Removal of the pier is undoubtedly 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.

Propeller damage

Propeller damage is found primarily associated with floats where boats routinely arrive and depart over the same bottom. Propeller scars are found outside of these areas that are characteristically curved or hook-shaped indicating an apparent inadvertent intrusion into shallow water followed by an attempt to return to deeper water; such intrusions into shallow water are likely caused by boaters unfamiliar with the area. Although there are few discernable examples of such occurrences, as the number of boaters increases over time the number of such occurrences is also likely to increase. One possible way of avoiding such damage would be to install navigational aids along the sides of the main channels within northern Casco Bay to maintain boaters within channels and direct them away from eelgrass areas. The navigational aids would end at the end of the channel, which in most navigable waters indicates the end of a channel opening into deeper water, thus ending restrictions on direction of navigation. In this case, however, the end of the navigational aids would indicate little or no water ahead at low water and a yellow cautionary buoy might be installed in the middle of the end of the channel indicating "End of Channel".

Conclusion

Water quality in Casco Bay in general and northern Casco Bay in particular is good and measures have been adopted by the municipalities surrounding the region to insure water quality remains good into the future to protect marine resources, including eelgrass.

Physical disturbances to eelgrass in northern Casco Bay have and continue to occur. The most extensive and severe of these disturbances have been associated with mussel dragging and measures have been put in place to minimize, although not entirely eliminate, the possibility of such impacts occurring in the future. Boat moorings, docks and floats, and propeller scarring are the other causes of physical disturbance identified through this effort, but the magnitude of the combined area of disturbance associated with these causes is small, particularly in comparison to the overall current expanse of eelgrass in northern Casco Bay as well as the natural fluctuations in annual areal coverage. Nevertheless, these do represent anthropogenic disturbances that should be corrected if reasonably possible.

Eelgrass in northern Casco Bay is currently at historically high levels and occupies most, if not all of the available habitat, thus making identification of mitigation opportunities rather difficult. Mitigation options do exist to correct some of these causes of physical disturbance at the source, but all are constrained to one extent or another by difficulties. Implementation of these corrective measures must therefore take into account the possible creation of other conflicts, protection of individual and public safety, existing laws and ordinances, and the associated economic and environmental costs.

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 the extension of measures to protect water quality in the upper bay region. As previously stated, the Town of Brunswick has already adopted an ordinance to protect against nutrient loading in Maquoit, Merepoint, and Middle Bays. The towns of Harpswell and Freeport, which share a portion of the shorelines of these bays, have not adopted similar ordinances and an effort might therefore be undertaken to have all three municipalities work together to provide consistent protection against nutrient loading in the region, perhaps at a minimum to restore vegetated buffer zones around agricultural lands and expansive lawn areas, and adopt enhanced stream buffer requirements for new development.

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Town of Freeport – Coastal Waters Ordinance, Chapter 31
<http://www.freeportmaine.com/codes/chap31.doc>

