APPENDIX F

ESSENTIAL FISH HABITAT ASSESSMENT

NARROW RIVER ESTUARY RESILIENCY RESTORATION PROGRAM

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ESSENTIAL FISH HABITAT ASSESSMENT

This Appendix to the EA evaluates potential effects of implementation of the proposed action on Essential Fish Habitat (EFH) and managed species, in compliance with the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1908, PL 94-265 as amended). The format of this Appendix is based on the Code of Federal Regulations guidance for EFH Assessments (50 C.F.R. 600.920).

F.1 Description of Action—Restore Estuarine Habitat to Promote Resiliency in the Narrow River Estuary

The proposed Narrow River Estuary Resiliency Restoration is an integrated set of actions designed to restore, enhance and preserve estuarine habitat functions, values, and resiliency, including actions to enhance eelgrass *(Zostera marina)* beds, salt marshes, tide flat habitat, water quality, EFH and other shallow-water habitats. The project is intended to improve the health and productivity of the range of fish and wildlife species that utilize the estuary, including managed species and other marine and estuarine fish and shellfish. The EA and its appendices provide a detailed description of the proposed action and its consequences. This Appendix focuses on the evaluation of effects on marine fish and essential fish habitat.

F.1.1 Purpose and Need for Action - Narrow River Estuary Resiliency Restoration

The purpose of this resiliency restoration program is to abate degradation of fish and wildlife habitat and to increase the ecological health of the Narrow River Estuary. Enhancing the health of system components now will allow the estuary to become more resilient to changes brought about by sea level rise, climate change, and future storm events. Enhancement of estuarine conditions will also help achieve the mission of the National Wildlife Refuge System, and the purposes for which the John H. Chafee National Wildlife Refuge was established.

Estuaries and estuarine habitats are among the productive ecosystems known, serving as critical transitional areas between land and sea, and provide a wealth of values to society, including fish and wildlife production, pollution attenuation, and socio-economic values such as flood control and recreation (NHDES 2004; RAE 2007; Tiner 1989). Estuarine habitats are important to numerous life stages of many fish species (Stevenson et al., 2014); indeed 75% of commercial fish species depend on estuaries for their feeding habitat, spawning grounds, and nurseries (www.edc.uri.edu/restoration/html, 2009).

Salt marshes are recognized as some of the most ecologically important wetland habitats in Narragansett Bay (Schwartz 2009). These wetlands support the coastal estuarine ecosystem because of their role in providing food, space, and refugia for a wide variety of terrestrial and aquatic species (Teal and others 1999). Salt marshes buffer and protect estuarine waters and habitats from land-based pollutants (USEPA 1993). The location of salt marshes between river and upland sites provides a buffer during storm events, and aide in reducing nitrogen inputs from uplands into estuaries (Weigand and others 2004). Salt marshes provide habitat to wildlife species of highly restricted range, such as the salt marsh sparrow (*Ammodramus caudacutus*), a salt marsh obligate species of high conservation concern (USFWS 2008). Salt marshes are also valued as open space and provide scenic vistas.

The Narrow River drains a watershed approximately 14 square miles in size, and provides estuarine habitat in roughly half of the river's length. The estuary supports a variety of diverse habitats, including eelgrass

beds, estuarine channels and basins, shallow water habitats, intertidal shoals (tide flats), and extensive salt marshes.

Despite the important biological, economic, and social values this area provides, these estuarine habitats are threatened from a variety of natural and anthropogenic influences; and several characteristics of this estuary suggest key components are in decline. There is a need to act.

The estuary is susceptible to increased rates of sea level rise. The RI Coastal Resource Management Council (CRMC) predicts a one foot sea level rise over 1990 levels by 2050 (URI 2013). Saltmarsh habitats occur at elevations less than two feet above mean sea level, therefore only modest increases in sea level rise can have a marked change in the amount, type, distribution, and quality of saltmarsh habitats.

Locations where saltmarsh vegetation can migrate inland in response to sea level rise is limited and will accommodate less than half of the current marsh acreage, with remaining marsh having a much patchier fragmented distribution (USFWS 2014). Relatively flat elevations on some marsh surfaces suggest that with only slight increases in sea level, large expanses of saltmarsh will be lost at one time.

Changes in climate will also influence the estuary. If current predictions hold true, increased precipitation can increase freshwater input onto saltmarsh surfaces, further degrading marsh conditions. Shifts in wind directions can make now stable shorelines more susceptible to wind driven waves. Increased frequency of storm events could limit recovery times and make some habitats less resilient to future storm events.

Despite ongoing efforts of the State, local municipalities, and the Narrow River Preservation Association (NRPA) to improve water quality, the estuary suffers from low water quality in the form of excess nitrogen influx and the presence of coliform bacteria, particularly after rainfall events (NRPA 2012). Excessive nitrogen loading can limit production of roots and rhizomes which help bind and stabilize saltmarsh banks (Johnson et al, 2012), and make above ground vegetation more susceptible to grazing (Ramnarine and others 2008). Poor water quality can reduce the diversity of aquatic insects, and protracted flushing rates such as in Pettaquamscutt Cove limit the system's ability to abate water quality issues (RICRMC 1999).

Saltmarsh habitats have declined over time in both abundance and health. We estimate that over 12 acres have been lost to development of bare pans and mud flats on the saltmarsh surface from waterlogging and entrapment of water on the saltmarsh surface. Shoreline erosion continues at a rapid pace in some portions of the estuary. In combination with the natural undercutting of banks and accelerated erosion from boat wakes in some areas, large lengths of shoreline are failing, with little, if any recruitment of saltmarsh areas apparent in the watershed (USFWS 2009; 2012). In 2014, most of Sedge Island's Eastern shore has failed with two feet or more of the marsh bank lost due to channel erosion.

Over 39% of current saltmarsh habitat is dominated by a mixture of stressed vegetation and bare pans, typical of degraded marsh conditions. Vegetated high marsh surfaces and permanent marsh pools provide important habitat for marine fish during higher tidal periods (MacKenzie & Dionne, 2008), yet access to these marshes has declined over time. Clogging of channels in the estuary limits access to 17 acres of otherwise suitable habitat except during lunar or higher tides than average.

Historic changes in channels draining the estuary are likely due both to natural and anthropogenic factors, with once clear secondary river channels transformed into growing flood and ebb tidal deltas. Increasing sediment deposition has resulted in a loss of deeper habitat areas that provide feeding areas and thermal

refuge for estuarine fish. Channel braiding as a result of sediment loads in excess of the river's ability to carry them has caused channels to migrate against saltmarsh shorelines, causing deteriorating salt marsh and shallow-water habitats.

Important marine habitats such as eelgrass beds appear to have recently expanded in the estuary South of Middlebridge, although this increase has been located in shallow areas, making the bed susceptible to elevated summer temperatures and prop scarring from motorized vessels. High summertime water temperatures, reduced biomass on marsh surfaces, limited access to the saltmarsh surface by fish species, and the limited availability of cold water refugia all likely limit fish production.

In short, estuarine habitats in the Narrow River are threatened and declining due to a number of anthropogenic and natural factors. These include climate-change-driven factors such as sea level rise, as well as use-driven factors such as shoreline erosion as aggravated by motorboat wakes, and lingering effects of historic alterations (ditching, berm construction, etc.). As a result, the estuary is losing the mosaic of healthy habitats that supports its diverse ecosystem. Salt marsh vegetation is dying, transforming formerly healthy marsh areas into hypersaline pans of low habitat value. Salt marsh edges are eroding, causing net loss of marsh habitat. Marsh erosion transports sediments into sub-tidal areas of the estuary, aggravating shoaling. This anthropogenic shoaling combines with natural shoaling trends caused by the expansion of flood-tide deltas in the estuary, increasing the area of tidal flats, and eliminating deeper areas that formerly provided important essential fish habitat and shallow-water habitats.

The cumulative impact of these changes is a loss of habitat diversity in the estuary and a "leveling" trend towards more uniform habitats. Where the estuary once supported high marsh, some low marsh, tidal flats, and deeper estuarine areas including eelgrass beds, it is losing habitats at both the higher and lower ends of the elevational range. As deeper areas of the estuary are lost, areas of passage, feeding and thermal refuge are lost for a variety of marine fish species. Benthic and estuarine habitat diversity is declining in the estuary.

This trend is expected to negatively impact estuarine fish and wildlife resources. Larger fish species such as striped bass *(Morone saxatilis)* and bluefish *(Pomatomus saltatrix)* that require deeper areas to feed, and species such as winter flounder *(Pseudopleuronectes americanus)* that utilize deeper areas for spawning and thermal refuge will likely see further declines in habitat quality. Wildlife species such as salt marsh sparrows, which require high marsh habitat for nesting are expected to decline. Lacking restorative actions, the salt marsh sparrow is likely to require protection under the Endangered Species Act within a few years, and faces the possibility of extinction by 2050 (S. Paton, pers. comm. 2014).

Reversing these trends and restoring key estuarine components, preventing the loss of habitat diversity, and increasing the resiliency of fish and wildlife habitats will allow us to achieve the goals and objectives of the John H. Chafee National Wildlife Refuge, and the National Wildlife Refuge System.

F.1.2 Description of the Proposed Action

In developing this proposed restoration plan, the Service surveyed and evaluated potential EFH and shallow-water habitat resources, including salt marshes; eelgrass beds; tidal flats; mud, sand, and gravel bottoms; and benthic fauna, including shellfish beds. Using the results of these inventories and in consultation with fisheries biologists, initial restoration plans were modified to insure that implementation of the plan would benefit all of the key components of the estuary, while avoiding any significant adverse

impacts to existing EFH and shallow-water habitats. The modifications included removal of areas where nekton production for fish was high; elimination of a boat channel originally intended to bring motorized vessels away from saltmarsh banks (due to the presence of eelgrass), inclusion of measures to enhance eelgrass habitat, provision of cool water refugia for fish, enhance access to upper saltmarsh surfaces and production of prey species in those areas, and to protect and expand the amount of low marsh habitats in the estuary. By restoring salt marshes, shallow-water habitats, and estuarine areas, the proposed action will restore ecological resilience to the Narrow River Estuary as intended by Congress and the President under the Sandy Recovery and Improvement Act of 2013 (PL 113-2), and will benefit EFH and managed species.

The Environmental Assessment and Appendix G provide a more detailed description of the proposed action than what is presented here. The Service proposes to implement, over the next 3 years, an integrated set of actions to help restore key estuarine resources in the Narrow River Estuary:

Action A. Watershed and Water Quality Restoration

The objective of this action is to improve knowledge of non-point source pollution, improve water quality, and improve flushing in Pettaquamscutt Cove.

(1) In collaboration with NRPA, intensify ongoing, long term water quality monitoring to enhance knowledge of non-point source pollution in an attempt to locate priority sites for water quality abatement actions. Further investigate the source of pollution in the Mumford Brook using such techniques as trained canines.
(2) In collaboration with the R.I. Dept. of Environmental Management (RIDEM), survey, design, and install (funding dependent) best management practice sites in the Mettatuxet drainage in Narragansett and at Kimberly Drive in South Kingstown. The BMP's will remove excess nutrients and pathogens from storm water runoff in order to reduce anthropogenic sources of fecal coliform as well as nutrients and sediments which impair habitat quality of the waters of the estuary. All BMP work will be conducted in upland areas. Final design of BMPS will be subject to approval by the RIDEM.
(3) Improve flushing and water circulation in Upper Pettaquamscutt Cove by removing remnants of a narrow gauge line which crossed the Cove in the 1800's. The current arrangement of materials suggest that these remnants are inhibiting natural flow and flushing. Material will be excavated to the depth of typical bottom elevations Northeast and Southwest of the crossing. Material (typically coarse gravel, small rock to 12" diameter) will be placed to the side of the channel to create a rock and gravel substrate to preserve rock/sand bottom types for EFH.

Appendix G provides maps, management controls, and background materials of the action as summarized here.

Action B. Eelgrass Management, Estuarine Channel and Basin Restoration.

This action takes advantage of the opportunity to enhance marine fisheries habitat by creating habitat conducive to eelgrass establishment and creation of thermal refugia. Basins and channels will be deepened by removing existing sediments to a depth of approximately -5 feet NAVD88. Areas where excavation will occur are channels which have been previous present historically (Appendix A). All treatment areas are

where deposition of flood and ebb tidal deltas has formed over time, shifting channel flow to less favorable locations for preservation of other EFH values.

This action will establish 7 acres of deeper estuarine areas, suitable for eelgrass habitat and serving as thermal refugia and passage for important estuarine fish species. The depth is anticipated to provide ideal habitat for existing eelgrass beds to expand, will insure they are at a depth not susceptible to prop scarring, and will provide for cooler temperatures for growth and production.

To insure no significant loss of *upper* tidal flat habitat for important shore and wading birds and shellfish, over three acres of tidal flat will be created or enhanced in areas less prone to disturbance compared to current locations. Sand bottom habitat will be maintained on side slopes, remaining tidal flats, and at the bottom of excavated areas.

As shown in Appendix G 35,629 cubic yards of material will be excavated. As existing eelgrass beds provide a ready seed source, no planting or seeding of eelgrass is proposed. Sediments removed from restoration areas will be repurposed for beneficial re-use in restoring degraded and lost salt marshes (Actions D and E, below). Sediments in proposed restoration areas are generally sandy, with fines ranging from 2-60%, but less than 25% in 78% of the units analyzed. All strata were tested for potential chemical contaminants, including TPH, PCBs, SVOCs and metals. All parameters are within EPA and state criteria for beneficial use of dredged material.

Maps of sediment types, bottom habitats and bathymetry are included in Section F.2.2..Appendix G provides maps, management controls, and background materials of the action as summarized here.

Action C: Restore Saltmarsh Shorelines

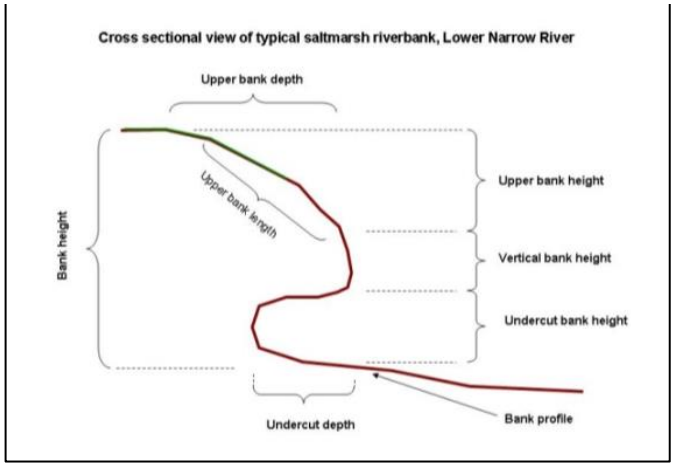
This action builds upon the existing installation of living shoreline techniques in the river and the associated monitoring which is taking place to expand a variety of applications of living shoreline treatments to shorelines with serious bank stability issues, where such application is expected to be effective and possible.

Collapse of undercut banks appears to be the primary causal factor of saltmarsh shoreline loss, and frequently occurs as a mass, or catastrophic loss along several feet of shoreline. In 2013/2014, this pattern of bank loss has occurred along the eastern shore of Sedge Island and near Starr Drive. Surveys completed in 2012 of saltmarsh shorelines found that 96% of the banks along the main river channel are undercut (fig. 2).

Living shoreline applications are generally not suited in areas of deeper water or in very high energy locations. This action is intended to reduce marsh erosion using a variety of designs using a combination of biodegradable erosion control materials (bank stabilizer) and shell reefs (wave attenuator) that have been proven successful in protecting eroding shorelines and enhancing important estuarine processes and services elsewhere (John O'Brien, personal communication 2014).

Fiber (coir) logs and bagged oyster shell will be placed in a variety of formations along eroding marsh edges. In 2014, CRMC and The Nature Conservancy completed a pilot-scale test of this approach that is demonstrating its effectiveness to enhance marsh edge habitat through re-vegetation and colonization. Shell bags were stacked to a set height to attenuate waves and wakes. A sill which approximates a rectangle (20 x 5 x 2.5-ft) with a set gap (approximately 10-ft) was placed between units.

Figure 1. Typical Saltmarsh Shoreline Bank



Other, simpler arrangements will be used to retard undercut erosion and failure by placing coir logs within the undercut area of the banks. Providing further protection of undercuts is anticipated to (a) retard bank failure; and (b) maximize lateral growth from the saltmarsh, rather than having this horizontal extension of saltmarsh lost due to bank failure from undercuts.

Appendix G summarizes treatments by saltmarsh management units, and conceptual maps showing general locations (subject to field verification, actual locations may vary) where living shoreline protection strategies will be applied. Approximately 7% of all marsh shoreline in the estuary will be treated using living shoreline techniques.

ACTION D: Restore Saltmarsh Surface Hydrology through Drainage Restoration/Runnels.

This action is intended to help restore growing conditions for marsh vegetation while improving habitat and productivity of small estuarine fish such as mummichog, striped killifish *(Fundulus majalas)*, and other fish and invertebrates that utilize high marsh surfaces and permanent marsh pools.

The combination of freshwater flow and seepage onto saltmarsh shorelines, and entrapment of tidal flows due to a lack of adequate drainage has resulted in degraded saltmarsh conditions on 39% of saltmarshes in the estuary. As shown in Appendix B, pools and pans have expanded significantly on saltmarsh surfaces over the past 75 years. Most historical pools have high value for fish production, wildlife habitat, and biological diversity and will not receive treatment, however newer pools and pans are shallow, devoid of vegetation, dry up in the summertime, and have little biological value.

In areas where excess water is entrapped on the saltmarsh surfaces, vegetation shows evidence of stress. Degraded marsh is typified by the presence of bare areas, and where glasswort (S*alicornia spp*.) and short forms of smooth cordgrass (*Spartina alternaflora*) are dominant with fringes of saltgrass (*Distichlis spicata*). In many cases, smooth cordgrass is less than 4" high and frequently shorter with a low density (fig. 3).

Comparatively areas which are well drained (in general, within 50 feet of a drainage or shoreline) are dominated by robust stands of saltmarsh hay (*Spartina patens*) or mixed vegetation including tall forms of smooth cordgrass, saltgrass, and much lower densities of glasswort. Vegetation is robust, important in maintaining the saltmarshes ability to keep pace with sea level rise (Fig. 4).

Degraded salt marshes will be restored by improving surface drainage using the “runnel” method -- excavating shallow (generally 8” to 12” or less in depth and two feet wide) channels on the surface of the marsh to provide surface drainage. The minimum number and lengths of runnels will be created, with the density based on site specific analysis. In some cases, existing pannes and pools will be connected to tidal waters, but only newly developed pannes will be drained.

In addition, some clogged existing ditches which have filled with sediments will be cleared, but only to the extent surface drainage can be achieved (6” to a foot in depth or less). In all cases, both the minimum number and minimum depths and width will be used to enhance drainage. The purpose is to allow drainage while minimizing any increased volume or flow onto the surface. This approach has been used successfully to restore salt marshes on Narragansett Bay and in the South Shore salt ponds of Rhode Island by Save The Bay (Ferguson, personal communication 2014).

Figure 3. Degraded Saltmarsh Conditions.

Figure 4. Healthy Saltmarsh Conditions

This action will be implemented on 46.9 acres, and will be undertaken through an adaptive approach -- beginning small scale in the first year, then evaluating the need and opportunity for continued hydrologic restoration. In most areas, creation of runnels will be completed by hand, although in some areas of excavation will be accomplished using low-ground-pressure excavation equipment.

Appendix G provides maps, management controls, and background materials of the action as summarized here.

ACTION E: Restore Lost Low Marsh, Restore Degraded Marsh, and Enhance Resiliency to Sea Level Rise through Restoration of Intertidal Elevations.

The objectives for this action are to increase the availability of low marsh habitat, to restore degraded saltmarsh, and to increase saltmarsh elevations to enhance resiliency in the face of sea level rise. This will be accomplished by repurposing sediments dredged under Action B (Eelgrass Restoration), for beneficial use through thin layer deposition (TLD) of dredged sediments.

The material excavated for eelgrass and channel enhancements (Action B) will be completed with the use of the barges, excavator, and use of the staging area Sprague Bridge, will be brought to saltmarsh creation

or thin layer deposition areas by barge. Material within the containers will be re-slurried and sprayed onto saltmarsh surfaces, or the excavator will place material directly into areas designated for low marsh creation. Material placed on the marsh surface will be retained using a series of small coir logs or similar retaining methods until it settles. Once target elevations are met, material will be sprayed in the next compartment. A series of straw bale fences will be installed within the drainage channels in order to keep sediments on site. Following placement of material, elevations will be retaken to determine whether additional placement of material will be needed.

These activities will be confined to the dredging window of November 15 through January 31, thereby avoiding impacts to fish and the busy summer boating season. During the winter, navigation through the river will be difficult with all of the equipment and barges, but it is likely boat traffic will be able to pass through the area. Appendix G provides a more detailed description of the action, including management controls and mitigation.

Low Marsh Restoration. The availability of low marsh in the estuary is inherently limited by the relatively high elevations of the saltmarsh surface. Survey of the mean high tide line in 2009 found that the high tide line lies within 1 foot of the saltmarsh bank with the river (Appendix D). Subsequent surveys of saltmarshes between Middlebridge and Sprague Bridge has also shown that most areas of the saltmarsh lie above MHW (NAVD 88; Appendix G).

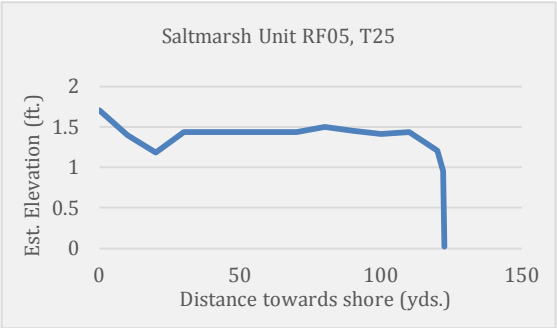
Low marsh is important for marine fish because they are frequently inundated in most if not all tide cycles, and provide habitat for a variety of species prey. Currently, low marsh (areas dominated by tall form smooth cordgrass) or as a mixture of vegetation including smooth cordgrass with salt hay, saltgrass, and glasswort occurs only in stringers along drainages and tidal creeks. Given the changes in saltmarshes in the estuary over time, particularly in areas to the Southeast of Sedge Island (App A), it seems reasonable that low marsh was more abundant than what occurs currently.

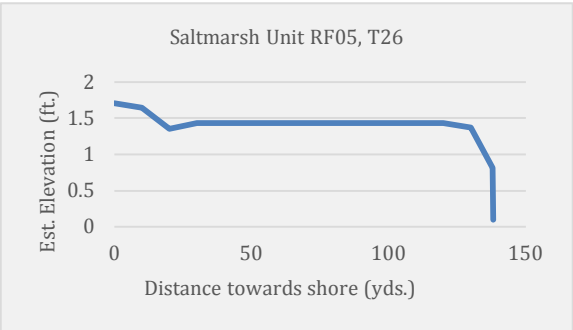
A total of 1.2 acres in areas of historical marsh occurrence will be designated for low marsh creation. Target elevations will be 0.850 feet NAVD88, with gentle (20:1 or greater) slopes to provide drainage. Coir logs, 12 inches in diameter or less, will be installed along the periphery of the salt marsh units to contain the material. Material will be transported to the site on the barges (as described under action B) and offloaded using the excavator to design required elevations.

All sites will be planted with saltmarsh plugs (*S. alternaflora* and *D. spicata*) on a 30” x 30” spacing or less once the material has settled and growing conditions are suitable. This approach to marsh restoration has been used successfully in Jamaica Bay, NY, Chesapeake Bay, MD, and elsewhere (ACOE 2014; Frame 2006; Frame 2007; Wilson 2014).

Elevation Capital and Restoration of Degraded Marsh. The intent of this action is to restore degraded marsh where tidal water entrapment on the saltmarsh surface has resulted in reduced productivity and expanding bare pans on the marsh surface (see description under action item B, above); and to provide elevation capital so that treated areas are more resilient to sea level rise.

As shown in the surface profiles below taken on the eastern bank of the river (Unit 8 from Appendix G), elevations across the marsh surface are relatively uniform:





In the case of T25 (left) lower elevations in the back of the marsh and the presence of higher areas in the middle show that water flowing onto the marsh has a high likelihood of entrapment, resulting in degraded saltmarsh conditions. Application of materials can aide in development of better drainage.

Examination of the profile at T26 shows that the surface profile is essentially flat. As sea level rise progresses to the point it reaches the upper bank, the entire length of the marsh surface will be inundated at once, potentially causing an expansive loss of saltmarsh habitat in a short period of time. Applying material to the saltmarsh surface on an incremental basis (higher to the back of the marsh, lower closest to the riverbank) will allow a more gradual loss of saltmarsh over a longer period of time. Based on RICRMC's estimated sea level rise average rate of 0.2 inches per year, this catastrophic loss of saltmarsh at Unit 8 would be expected to occur within decades without treatment.

This action applies a thin layer of locally sourced sediment to the surface of the marsh (TLD), raising intertidal elevations in order to mimic and augment natural accretion processes. This method has been successfully used on Delaware Bay, DE, Chesapeake Bay, MD, and Jamaica Bay, NY, to restore marshes adversely affected by accelerated sea level rise (ACOE 2014; Frame 2006; Frame 2007; Wilson 2014).

TLD will be used to restore approximately 14 acres of degraded marsh by applying sediments to recently degraded marsh areas. Marsh elevational restoration will target degraded and ponded areas, particularly areas of new or increasing pans and stressed/low density vegetation, and will seek to restore high marsh habitat and vegetation such as saltmarsh hay and saltmarsh rush *(Juncus gerardii).* Areas adjacent to the existing banks containing tall form cordgrass, or stands of salt hay will not receive treatment.

Appendix G provides maps of application areas, purposes, management controls, estimated materials, and vegetation and elevation information for this action. It also summarizes how elevation targets were derived for TLD.

ACTION F: Test Treatments to Enhance Conditions for Marsh Migration

Within a two acre site currently comprised of an oak forest overstory near saltmarsh transition zones, trees will be girdled to stimulate shrub production in the understory. Adjacent control sites in untreated oak forest neat the saltmarsh transition zone will be evaluated and compared to determine whether this treatment has

the potential to enhance conditions for saltmarsh migration. This action will occur in upland sites and will have no impact on EFH or managed species.

F.1.3. Monitoring

Monitoring is a key component of adaptive management strategies. Information collected as part of monitoring can be used to adjust treatment as necessary to insure objectives are met.

Fisheries:
R.I. Dept. of Environmental Management (RIDEM), Div. of Fish & Wildlife, monitors finfish at three sites in the Narrow River Estuary on an ongoing basis. Fish samples are collected using a seine 130 ft. long (39.62m), 5.5 ft deep (1.67m) with ¼" mesh (6.4mm). The seine has a bag at its midpoint, a weighted footrope and floats on the head rope. The area swept by the seine net is estimated to be between 2000 and 2400 square feet. The beach seine is set in a semi-circle, away from the shoreline and back again using an outboard-powered 16' Lund aluminum boat. The net is then hauled toward the beach by hand and the bag is emptied into a large water-filled tote. All fish collected are identified by species, measured, enumerated, and sub-samples are taken when appropriate. Water quality parameters temperature, salinity and dissolved oxygen, are measured at each station. Seining at each station is conducted once a month for 6 months of the year between May and October.

The coordinates of the RIDEM fishery monitoring stations in Narrow River are:

NR1:	41 29' 09.6"	71 26' 53.3"	41.486	- 71.448139
NR2:	41 27' 28.6"	71 27' 06.9"	41.457944	- 71.451917
NR3:	41 27' 17.1"	71 27' 10.0"	41.45475	- 71.452778

Results of this monitoring are described in Section F.2, below.

Nekton:
*As part of the Regional Saltmarsh Integrity Monitoring Program (SMI), t*he Service monitors salt marsh nekton at 20 randomly chosen stations within the estuary. Additional sample locations will be established within TLD treatment units. Nekton are sampled from pools, pannes, ditches and creeks in the salt marsh using either a ditch net or throw trap depending on the type of water body. Salinity data are also collected at each sampling location. The results of this survey were used to monitor nekton use over time.

Both the Fisheries and Nekton monitoring programs will be used to track ongoing status and trends of fish and invertebrate communities in the estuary, including any changes resulting from the proposed action.

Water quality:
The Narrow River Preservation Association will monitor nutrients and bacteria using methodologies approved by RIDEM and EPA for water quality monitoring in compliance with Clean Water Act reporting requirements throughout Rhode Island.

Tidal flow and volumes:
Water level data loggers, and water volume loggers, have been installed at five sites within the estuary from just North of Middlebridge, just South of Sprague Bridge, two at Sedge Island, and one at Gooseberry Island. These data loggers have been operating continuously since July of 2014, and will be run over the

next two years. This data will be used to determine how treatments applied in the estuary have influenced flows. Additional loggers will be installed at the crossing in Upper Pet Cove should the crossing remnant be removed in upper Pettaquamscutt Cove.

Living shorelines:
Saltmarsh shoreline condition surveys (USFWS 2012) will be re-run in 2015 and in 2016 to determine trends in saltmarsh shoreline conditions within and outside of treatment areas.

The Nature Conservancy has developed monitoring protocol to evaluate response to installation of shoreline treatments in those installments completed in 2014. This same protocol will be continued over the next two years.

Shoreline condition surveys (USFWS 2012) will be completed before and immediately after installation of additional shoreline treatments. Inspections will be completed in all shoreline treatment areas three times per year and after any significant storm event to monitor structure integrity.

Boat wakes:
Shorelines including those with and without living shoreline treatments, will be monitored for erosion. Protocol for evaluating boat wakes and accelerated erosion will be redone and compared to data collected in 2009 (USFWS 2009).

Saltmarsh elevations:
A total of 16 Surface Elevation Tables (SETS) have been installed within the estuary on saltmarsh surfaces to monitor saltmarsh elevations and compare them to rates of sea level rise. Sets have been installed both within and outside of treatment units.

Within TLD units, elevations before and after applications will be completed at levels sufficient to determine saltmarsh elevations both within and adjacent to treated sites. Surveys will be re-run at 6 month intervals for a period of two years. Monitoring protocol developed for the Pepper Creek TLD project in Delaware will be modified for application here.

Save the Bay has developed protocol for intensive monitoring of two sites where runnels treatments will be applied (STB 2014). In other areas, elevation profiles will be completed along with establishment of photo plots at each site. Monitoring will occur at 6 month intervals following treatment. General inspections of all runnel treatment areas will be made three times per year to determine whether the treatments are trending towards achievement of goals, and to identify any modifications necessary to abate any unintended results (unanticipated levels of erosion, etc..).

Low marsh creation
Elevation surveys will be undertaken before and immediately after creation. Standard planting success surveys will be implemented to determine whether saltmarsh plug planting is successful. Sites will be inspected three times per year over two years to determine whether objectives are being met, whether erosion or drainage issues appear so as to rectify them.

Degraded saltmarsh restoration with elevation capital (TLD treatments):
Elevation surveys will be completed prior to application, and immediately afterward. Target elevations will be staked throughout the units to guide application. Pre and post vegetation surveys will be undertaken and

repeated at yearly intervals for three years. The combination of standard vegetation monitoring (USFWS 2013), in combination with unit wide vegetation surveys will help determine vegetation response. Both within and outside units, bulk density and estimates of above and below ground biomass will be completed. Monitoring protocol developed for the Pepper Creek TLD project in Delaware will be modified for application here.

Marsh migration treatments:
Surveys for vegetation composition will be completed on a yearly basis for three years.

F.2 Potential Effects on EFH and Managed Species

In order to evaluate potential impacts on EFH and managed species, this section provides information on fish and shellfish in Narragansett Bay and the Narrow River Estuary (Sec. F.2.1); describes existing EFH and fish habitat, including an analysis of the value of shallow-water habitats (Sec. F.2.2); and evaluates potential adverse effects of the actions on EFH and managed species (Sec. F.2.3).

In addition, literature was reviewed regarding utilization of salt marsh surfaces by estuarine fish in order to fully understand the value of salt marsh to estuarine species, and better assess potential impacts of the project on EFH and managed species (Sec. F.5.2). Based on this information and these assessments, conclusions regarding potential effects of the project on EFH and managed species are summarized in Section F.3.

F.2.1 Fish and Shellfish in Narragansett Bay and the Narrow River Estuary

In order to develop a list of potential EFH and managed species in the Narrow River, the combined results of NOAA's 10 Minute Square EFH Tables (see http://www.greateratlantic.fisheries.noaa.gov/hcd/webintro.html) and results of a query to the NOAA Essential Fish Habitat Mapper V. 3.0 (as advised by NMFS staff on Sept. 18, 2014) was used. The combined list is provided in Table 1. Species which have been documented in the Narrow River by RIDEM are indicated by the shaded rows. The query to the EFH mapper and discussions with NMFS staff indicate there are no Habitat Areas of Particular Concern (HAPC) within the project area.

The RIDEM finfish survey has documented more than 70 species of fish and shellfish in the Narrow River Estuary, as listed in the table below. Shaded rows indicate those for which NMFS has designated Narragansett Bay as potential EFH (Table 2). The Service's nekton monitoring has documented more than 20 species of fish and invertebrates utilizing salt marsh pools, pannes and ditches. These species are listed in table 3.

Table 1. Potential EFH Species in the Narrow River Area (NMFS 2014)*.					
Species (from NOAA 10 x 10 tables)	Eggs	Larvae	Juveniles	Adults	Spawning Adults
haddock (Melanogrammus aeglefinus)		X			
red hake (Urophycis chuss)		X	X	X	X
redfish (Sebastes fasciatus)	n/a				
winter flounder (Pleuronectes americanus)	X	X	X	X	X
windowpane flounder (Scopthalmus aquosus)	X	X	X	X	X
American plaice (Hippoglossoides platessoides)		X	X	X	
Atlantic sea herring (Clupea harengus)		X	X	X	
bluefish (Pomatomus saltatrix)			X	X	
long finned squid (Loligo pealei)	n/a	n/a			
short finned squid (Illex illecebrosus)	n/a	n/a			
Atlantic mackerel (Scomber scombrus)	X	X	X	X	
summer flounder (Paralicthys dentatus)		X	X	X	
scup (Stenotomus chrysops)	X	X	X	X	
black sea bass (Centropristus striata)			X	X	
surf clam (Spisula solidissima)	n/a	n/a			
ocean quahog (Artica islandica)	n/a	n/a			
spiny dogfish (Squalus acanthias)	n/a	n/a			
king mackerel (Scomberomorus cavalla)	X	X	X	X	
Spanish mackerel (Scomberomorus maculatus)	X	X	X	X	
cobia (Rachycentron canadum)	X	X	X	X	
Additional Species from EFH Mapper	Life Stages from EFH Mapper				
ocean pout (Zoarces americanus)	Juvenile, Adult, Eggs, Larvae, All				
sand tiger shark (Carcharias taurus),	Neonate, All				
winter skate (Leucoraja ocellata)	Adult, Juvenile, All				
little skate (Leucoraja erinacea)	Adult, Juvenile, All				
Atlantic cod (Gadus morhua)	Adult				
silver hake (Merluccius bilinearis)	Larvae, Eggs, Juvenile, All				
bluefin tuna (Thunnus thynnus)	Juvenile, Adult				
monkfish (Lophius americanus)	Eggs, Larvae, All				
white shark (Carcharodon carcharias)	All				
smooth dogfish (Mustelus canis)	All				
common thresher shark (Alopias vulpinus)	All				
sandbar shark (Carcharhinus plumbeus)	Adult, All				
Atlantic butterfish (Peprilus triacanthus)	Adult, All, Juvenile				
* The notation "n/a" in the tables indicates some of the species either have no data available on the designated life stages, or those life stages are not present in the species' reproductive cycle.					

Table 2. RIDEM Narrow River Fisheries Survey Results*			
COMMON NAME	SCIENTIFIC NAME	COMMON NAME	SCIENTIFIC NAME
ALEWIFE	ALOSA PSEUDOHARENGUS	GOBY NAKED	GOBIOSOMA BOSC
ANCHOVY BAY	ANCHOA MITCHILLI	GOBY SEABOARD	GOBIOSOMA GINSBURGI
ANCHOVY STRIPED	ANCHOA HEPSETUS	GRUBBY	MYOXOCEPHALUS AENAEUS
BARBFISH	SCORPAENA BRASILIENSIS	GUNNEL ROCK	PHOLIS GUNNELLUS
BASS LARGEMOUTH	MICROPTERUS SALMOIDES	HADDOCK	MELANOGRAMMUS AEGLEFINUS
BASS STRIPED	MORONE SAXATILIS	HAKE RED	UROPHYCIS CHUSS
BIGEYE	PRIACANTHUS ARENATUS	HAKE SPOTTED	UROPHYCIS REGIA
BLUE CRAB	CALINECTES SAPIDIUS	HAKE WHITE	UROPHYCIS TENUIS
BLUEFISH	POMATOMUS SALTATRIX	HERRING ATLANTIC	CLUPEA HARENGUS
BUTTERFISH	PEPRILUS TRIACANTHUS	HERRING BLUEBACK	ALOSA AESTIVALIS
COD ATLANTIC	GADUS MORHUA	HOGCHOKER	TRINECTES MACULATUS
CONGER EEL	CONGER OCEANICUS	HORSESHOE CRAB	LIMULUS POLYPHEMUS
CUNNER	TAUTOGOLABRUS ADSPERSUS	JACK CREVALLE	CARANX HIPPOS
EEL AMERICAN	ANGUILLA ROSTRATA	JENNY SILVER	EUCINOSTOMUS GULA
FLOUNDER GULFSTREAM	CITHARICHTHYS ARCTIFRONS	KILLIFISH STRIPED	FUNDULUS MAJALIS
FLOUNDER SMALLMOUTH	ETROPUS MICROSTOMUS	KINGFISH NORTHERN	MENTICIRRHUS SAXATILIS
FLOUNDER SUMMER	PARALICHTHYS DENTATUS	LIZARDFISH INSHORE	SYNODUS FOETENS
FLOUNDER WINTER	PSEUDOPLEURONECTES AMERICANUS	GOBY NAKED	GOBIOSOMA BOSC
FLYING GURNARD	DACTYLOPTERUS VOLITANS	SEA BASS BLACK	CENTROPRISTIS STRIATA
MENHADEN ATLANTIC	BREVOORTIA TYRANNUS	SEA BASS BLACK	CENTROPRISTIS STRIATA
MINNOW SHEEPSHEAD	CYPRINODON VARIEGATUS	SEAHORSE LINED	HIPPOCAMPUS ERECTUS
MOJARRA SPOTFIN	EUCINOSTOMUS ARGENTEUS	SEAROBIN NORTHERN	PRIONOTUS CAROLINUS
MULLET STRIPED	MUGIL CEPHALUS	SEAROBIN STRIPED	PRIONOTUS EVOLANS
MULLET WHITE	MUGIL CUREMA	SENNET NORTHERN	SPHYRAENA BOREALIS
MUMMICHOG	FUNDULUS HETEROCLITUS	SILVERSIDE ATLANTIC	MENIDIA MENIDIA
NEEDLEFISH ATLANTIC	STRONGYLURA MARINA	SILVERSIDES	ATHERINIDAE
PERCH SILVER	BAIRDIELLA CHRYSOURA	SMELT RAINBOW	OSMERUS MORDAX
PERCH WHITE	MORONE AMERICANA	SNAPPER GRAY	LUTJANUS GRISEUS
PERMIT	TRACHINOTUS FALCATUS	SPOT	LEIOSTOMUS XANTHURUS
PIPEFISH NORTHERN	SYNGNATHUS FUSCUS	STICKLEBACK FOURSPINE	APELTES QUADRACUS
POLLOCK	POLLACHIUS VIRENS	STICKLEBACK NINESPINE	PUNGITIUS PUNGITIUS
POMPANO AFRICAN	ALECTIS CILIARIS	STICKLEBACK THREESPINE	GASTEROSTEUS ACULEATUS
PUFFER BANDTAIL	SPHOEROIDES SPENGLERI	TAUTOG	TAUTOGA ONITIS
PUFFER NORTHERN	SPHOEROIDES MACULATUS	TOADFISH OYSTER	OPSANUS TAU
RAINWATER KILLIFISH	LUCANIA PARVA	TOMCOD ATLANTIC	MICROGADUS TOMCOD
SAND LANCE AMERICAN	AMMODYTES AMERICANUS	WINDOWPANE	SCOPHTHALMUS AQUOSUS
SCAD BIGEYE	SELAR CRUMENOPHTHALMUS		
SCUP	STENOTOMUS CHRYSOPS		

Table 3. Nekton species sampled at the John H. Chafee and Sachuest NWR from 2012-2014	
Common Name	Scientific Name
mummichog	Fundulus heteroclitus
striped killifish	Fundulus majalis
banded killifish	Fundulus diaphanous
sheepshead minnow	Cyprinodon variegatus
Atlantic silverside	Menidia menidia
ninespine stickleback	Pungitius pungitius
fourspine stickleback	Apeltes quadracas
rainwater killifish	Lucania parva
bluefish	Pomatomus saltatrix
white perch	Morone Americana
alewife	Alosa pseudoharengus
northern pipefish	Syngnathus fuscus
American eel	Anguilla rostrata
winter flounder	Psuedopleuronectes americanus
blue crab	Callinectes sapidus
sand fiddler crab	Uca pugilator
European green crab	Carcinus maenas
Asian shore crab	Hemigrapsus sanguineus
common spider crab	Libinia emarginata
daggerblade grass shrimp	Palaemonetes pugio
American prawn	Palaemonetes vulgaris
sand shrimp	Crangon septemspinosa

RIDEM survey results indicate the most abundant species in the estuary are Atlantic silverside, mummichog, winter flounder, sheepshead minnow, striped killifish, four-spine stickleback, Northern pipefish and Atlantic menhaden. Of these, potential EFH is designated in the area only for winter flounder; however all of these species are of great ecological importance, providing forage for larger fish species as well as predatory birds and marine mammals. Fish species of greatest commercial and recreational importance found by RIDEM are bluefish, tautog, black sea bass and striped bass (RIDEM 2014). NOAA has designated the estuary as potential EFH for all of these species except striped bass.

Diadromous species present in estuary include alewife, blueback herring and American eel. The Gilbert Stuart Brook system in North Kingstown supports one of Narragansett Bay's most important river herring runs; all of these fish pass through the Narrow River Estuary while migrating between salt and fresh water habitats (RICRMC 2001).

Winter flounder were an abundant recreational and commercial fishery species on Narragansett Bay as late as the 1970's. The species declined significantly over the past several decades due to ecological and anthropogenic factors (Gibson 2013), leading to increased recreational and commercial fishery restrictions. Juvenile winter flounder are abundant in the Narrow River Estuary, indicating the high value of the estuary as spawning habitat for this species and its ecological importance in maintaining Narragansett Bay's fish populations.

According to RIDEM, alewife, blueback herring, winter flounder and American eel are regionally declining or vulnerable to decline. Fishing bans are in effect on alewives and blueback herring due to regional population declines; however local populations of these fish are stable, due in part to the abundant Narrow River runs (Lake 2014).

During the 1950's the estuary supported a commercial fishery for striped bass (RICRMC 2001); it also formerly supported a beach seine fishery for white perch (O'Brien personal communication 2014). Today the estuary remains an important feeding area for striped bass, and the Narrow River Inlet, as well as open-water areas within the estuary, are popular recreational fishing spots for this species. Striped bass is among the most important fishery species on the U.S. Atlantic Coast. The species experienced a period of rebuilding following fishery restrictions during the 1980's, but has declined somewhat in abundance over the past decade (ASMFC 2014).

Shellfish presence is varied but for many species they occur in relatively low densities (table 4). Shoreline surveys conducted in 2009 found the density of ribbed mussel (*Geukensia demissa*) increases with increased distance from the mouth of the river, assumedly due to a salinity gradient (USFWS 2009). Oyster (*Ostrea virginica)* occur throughout the estuary, but are generally limited because of unfavorable substrates. Razor clam (*Siliqua patula*), quahog (*Mercenaria mercenaria*), and soft shell clams (*Mya arenaria)* all occur, but the density of quahog and soft shell clams, at least in the tidal flats near Sedge Island, occur in very low density (less than one per square meter; CRMC data 2014).

Table 4. Historical Presence of Shellfish in the Estuary (adapted from Berounsky and Nixon 2007)

Author	Study Dates	Shellfish Description	Locations
Wright et al.	1948	little commercial shellfishing	
		"fairly large crop of quahaugs" for rec. shellfishing	throughout river
Campbell in Wright 1958	Summer 1957		maps of shellfish beds are included in the report
		Quahaugs (hard clams) = now *Mercenaria mercenaria*:	found between Sprague Bridge and Middle Bridge, mostly on low marsh islands
		soft shell clams = *Mya arenaria:*	found only in one bed, in channel north of Bridgetown Bridge
		oysters = *Ostrea virginica,* now *Crassotrea virginica:*	continually line both shores from Upper Pond to Bridgetown Bridge
		oysters = *Crassotrea virginica:*	patches south of Bridgetown Bridge until Middle Bridge.
		mussels = *Mytilus edulis:*	found only between Middle Bridge and Sprague Bridge
		blue crabs = *Callinectes sapidus*	found along entire river, numbers fluctuate, 1957 season very productive
Nixon & Oviatt	July 1970	*Mercenaria mercenaria*, Biomass = 292.2 g/m2	Middle Bridge area,
		Mya arenaria, Biomass = 0.2 g/m2	Middle Bridge area,
Baczenski & Ganz	1980	Density = 2/m2 oysters, (*Crassotrea virginica*)	Upper Pond
		Density = 6/m2 oysters	Lower Pond
		Density = 0.5/m2 razor clams	Middle Bridge
		Density = 0.5/m2 razor clams	Pettaquamscutt Cove
		Density= 4/m2 softshell clams	Pettaquamscutt Cove
		Density = 2/m2 quahogs	Pettaquamscutt Cove
		Density = 0.5/m2 mussels (*Mytilus edulis*)	breachway
		Density=0.5/m2 softshell clams	breachway
		Density = 0.5/m2 quahogs	breachway
Kelz	10/1990-8/1991		*turnover occurred in Oct.1990
		nothing noted	Upper Pond
		abundant oysters (Crassotrea virginica)	Lower Pond (off beach at Pettaquamscutt Lake Shores)
		patches of oysters (Crassotrea virginica)	Pettequamscutt Terrace Beach
		small mussel beds (Mytilus edulis)	100 m south of Middle Bridge
		mussel bed covers most of channel (M. edulis)	200m west of Sprague Bridge
	1996	oysters	population "wide-spread" on gravel edges of both Ponds
		oysters	no oysters found in mud areas of Ponds

F.2.2 SHALLOW WATER HABITAT ANALYSIS

Shallow water habitats important as essential fish habitat include mud, sand, and gravel/cobble substrates, eelgrass beds, and saltmarsh (Tidal creeks and channels) habitat. No Habitat Areas of Particular Concern (HAPC) are listed by NOAA within the project area.

To fully assess fish habitat values in the Narrow River Estuary, an analysis of the value of shallow-water habitats was completed using information from, and employing the analytical approach used by, Stevenson et al. (2014) in the report Shallow Water Benthic Habitats in the Gulf of Maine. This analysis was applied to species in the Stevenson report that are present in estuary, based on RIDEM surveys, or for which EFH habitat is expected to be present, based on NOAA EFH tables and mapper results.

Results of the shallow-water habitat analysis are presented in Table 5 for each shallow-water habitat type present in the estuary (mud, sand, eelgrass, salt marsh, and gravel/cobble) below, followed by an analysis of relative values for all species (Fig. 5).

Tables 5a – 5e. Shallow water habitat analysis for the Narrow River Estuary.

Mud									
Species	Scientific Name	RIDEM Survey	NOAA EFH	Life History Stage					
				Eggs	Larvae	YOY	Older	Adults	Spawning Adults
						Juveniles			
American eel	*Anguilla rostrata*	Yes	No	NA	NA	1	1	1	-
Atlantic cod	*Gadus morhua*	Yes	Yes	NA	NA	1	1	-	-
Atlantic tomcod	*Microgadus tomcod*	Yes	No	0	NA	1	NA	1	0
Cunner	*Tautogolabrus adspersus*	Yes	No	NA	NA	0	0	0	0
Little skate	*Leucoraja erinacea*	No	Yes	0	NA	1	1	1	0
Pollock	*Pollachius virens*	Yes	No	NA	NA	1	-	-	-
Red hake	*Urophycis chuss*	Yes	Yes	-	-	1	-	-	-
Tautog	*Tautoga onitis*	Yes	No	NA	NA	0	0	0	0
White hake	*Urophycis tenuis*	Yes	No	NA	NA	1	-	-	-
Windowpane Flounder	*Scophthalmus aquosus*	Yes	Yes	NA	NA	1	1	1	-
Winter flounder	*Pseudopleuronectes americanus*	Yes	Yes	1	NA	2	2	1	1

Sand

Species	Scientific Name	RIDEM Survey	NOAA EFH	Life History Stage					
				Eggs	Larvae	YOY Juveniles	Older Juveniles	Adults	Spawning Adults
American eel	Anguilla rostrata	Yes	No	NA	NA	1	1	1	-
Atlantic cod	Gadus morhua	Yes	Yes	NA	NA	1	1	-	-
Atlantic tomcod	Microgadus tomcod	Yes	No	1	NA	1	NA	1	1
Cunner	Tautogolabrus adspersus	Yes	No	NA	NA	0	0	0	0
Little skate	Leucoraja erinacea	No	Yes	2	2	2	2	2	2
Pollock	Pollachius virens	Yes	No	NA	NA	1	-	-	-
Red hake	Urophycis chuss	Yes	Yes	-	-	1	-	-	-
Tautog	Tautoga onitis	Yes	No	NA	NA	1	0	0	0
White hake	Urophycis tenuis	Yes	No	NA	NA	1	-	-	-
Windowpane	Scophthalmus aquosus	Yes	Yes	NA	NA	2	2	2	-
Winter flounder	Pseudopleuronectes americanus	Yes	Yes	2	NA	2	2	1	2

Salt Marsh

Species	Scientific Name	RIDEM Survey	NOAA EFH	Life History Stage					
				Eggs	Larvae	YOY Juveniles	Older Juveniles	Adults	Spawning Adults
American eel	Anguilla rostrata	Yes	No	NA	NA	-	1	1	-
Atlantic cod	Gadus morhua	Yes	Yes	NA	NA	1	1	-	-
Atlantic tomcod	Microgadus tomcod	Yes	No	1	NA	1	NA	1	1
Cunner	Tautogolabrus adspersus	Yes	No	NA	NA	0	1	1	1
Little skate	Leucoraja erinacea	No	Yes	0	0	0	0	0	0
Pollock	Pollachius virens	Yes	No	NA	NA	1	-	-	-
Red hake	Urophycis chuss	Yes	Yes	-	-	1	-	-	-
Tautog	Tautoga onitis	Yes	No	NA	NA	0	0	0	0
White hake	Urophycis tenuis	Yes	No	NA	NA	2	-	-	-
Windowpane	Scophthalmus aquosus	Yes	Yes	NA	NA	1	1	1	-
Winter flounder	Pseudopleuronectes americanus	Yes	Yes	0	NA	1	2	1	0

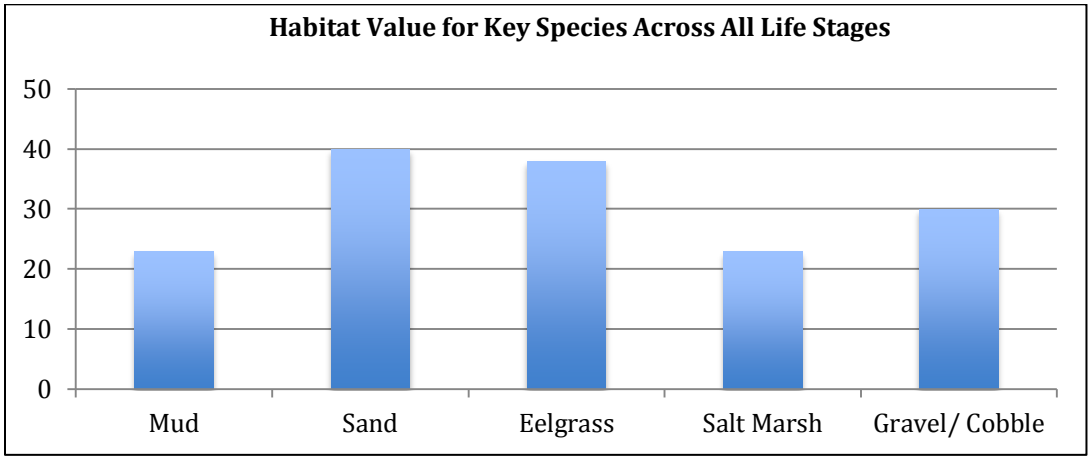
Eelgrass

Species	Scientific Name	RIDEM Survey	NOAA EFH	Life History Stage					
				Eggs	Larvae	YOY Juveniles	Older Juveniles	Adults	Spawning Adults
American eel	Anguilla rostrata	Yes	No	NA	NA	1	0	0	-
Atlantic cod	Gadus morhua	Yes	Yes	NA	NA	2	0	-	-
Atlantic tomcod	Microgadus tomcod	Yes	No	1	NA	2	NA	1	1
Cunner	Tautogolabrus adspersus	Yes	No	NA	NA	1	1	1	1
Little skate	Leucoraja erinacea	No	Yes	0	0	0	0	0	0
Pollock	Pollachius virens	Yes	No	NA	NA	2	-	-	-
Red hake	Urophycis chuss	Yes	Yes	-	-	2	-	-	-
Tautog	Tautoga onitis	Yes	No	NA	NA	2	2	2	2
White hake	Urophycis tenuis	Yes	No	NA	NA	2	-	-	-
Windowpane	Scophthalmus aquosus	Yes	Yes	NA	NA	1	1	1	-
Winter flounder	Pseudopleuronectes americanus	Yes	Yes	2	NA	2	2	1	2

Gravel/Cobble

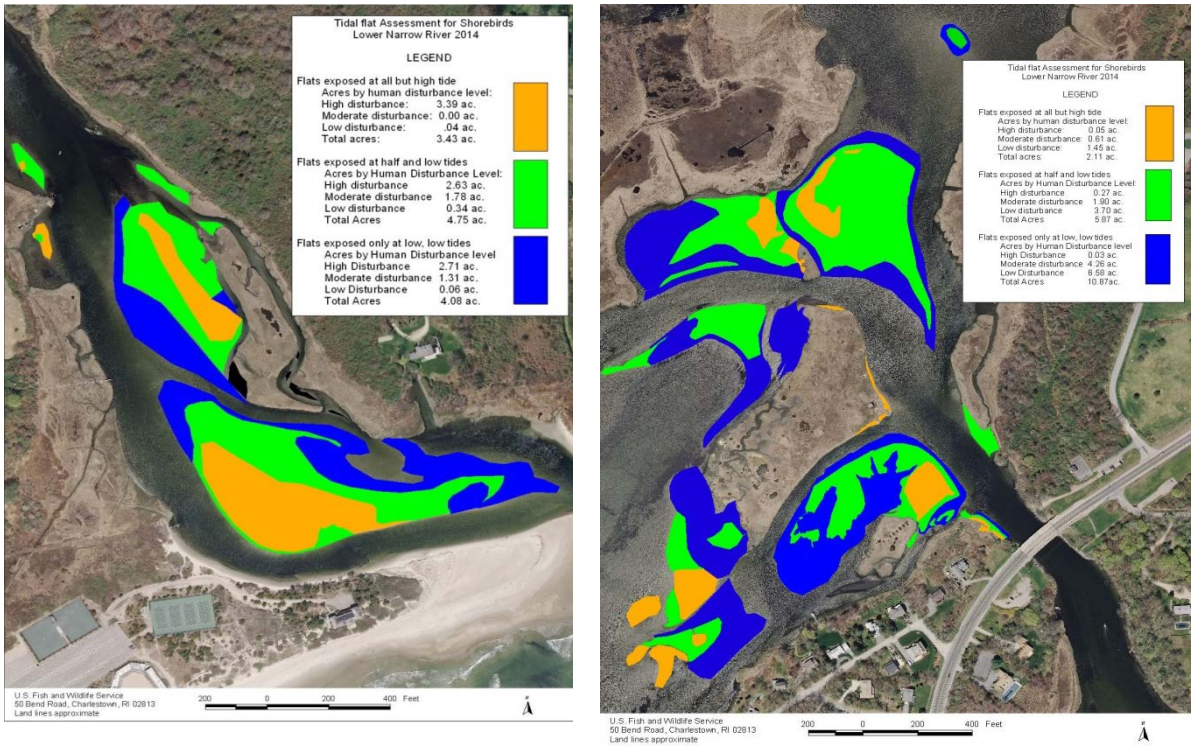
Species	Scientific Name	RIDEM Survey	NOAA EFH	Life History Stage					
				Eggs	Larvae	YOY Juveniles	Older Juveniles	Adults	Spawning Adults
American eel	Anguilla rostrata	Yes	No	NA	NA	-	1	1	-
Atlantic cod	Gadus morhua	Yes	Yes	NA	NA	2	1	-	-
Atlantic tomcod	Microgadus tomcod	Yes	No	1	NA	1	NA	1	1
Cunner	Tautogolabrus adspersus	Yes	No	NA	NA	1	1	1	1
Little skate	Leucoraja erinacea	No	Yes	0	NA	2	2	2	0
Pollock	Pollachius virens	Yes	No	NA	NA	1	-	-	-
Red hake	Urophycis chuss	Yes	Yes	-	-	1	-	-	-
Tautog	Tautoga onitis	Yes	No	NA	NA	1	1	1	1
White hake	Urophycis tenuis	Yes	No	NA	NA	2	-	-	-
Windowpane	Scophthalmus aquosus	Yes	Yes	NA	NA	0	0	0	-
Winter flounder	Pseudopleuronectes americanus	Yes	Yes	1	NA	-	0	1	1

Figure 5. Relative Value of All Narrow River Shallow Water Habitats for Estuarine Fish



The analysis demonstrates that all shallow-water habitats present are valuable to estuarine fish. Sand-bottom and eelgrass appear to be the most valuable, although this result is qualified by the fact that much of the fine sand habitat is intertidal or very shallow (less than 2 feet MLW), and therefore cannot provide sufficient depth or temperature to support estuarine species during lower tides or warmer weather. As shown in Figure 6, most fine sand habitat is concentrated within tidal flats. Course sands and cobbles occur in deeper portions of the channel and provide better habitat conditions than the shallow fine sand deposits.

Figure 6. Occurrence of Tidal Flats in the Lower estuary (Based on aerial photo interpretation).



Examination of fish survey data collected by RIDEM (Lake 2014), demonstrates that the waters of the estuary have little fish habitat value once water temperature reaches 26-28 degrees C, which commonly occurs in the shallowest areas during the summer:

Water column and temperature conditions in the Narrow River (Lake, 2014)

Water Conditions:
Near Lacy (Bridgetown) Bridge

- Average Temperature: 21.2 +/- 4.6 ^{o}C
- Average Salinity: 17.2 +/- 5.3 ppt
- Average Dissolved Oxygen: 7.7 +/- 1.7 mg/l

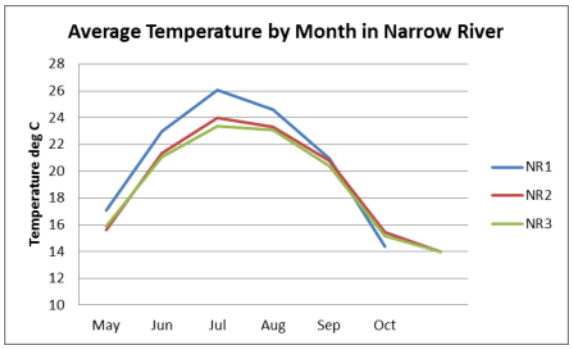
At Middlebridge

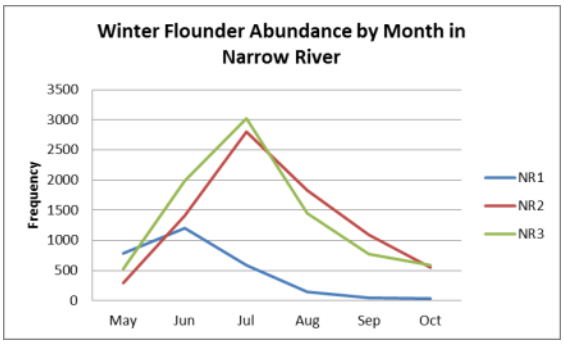
- Average Temperature: 20.3 +/- 4.2 ^{o}C
- Average Salinity: 26.9 +/- 5.3 ppt
- Average Dissolved Oxygen: 7.6 +/- 1.3 mg/l

At Refuge Reach

- Average Temperature: 19.9 +/- 4.0 ^{o}C
- Average Salinity: 27.4 +/- 4.7 ppt
- Average Dissolved Oxygen: 7.6 +/- 1.3 mg/l

Comparison between Average Temperature and Abundance of Winter Flounder in the estuary.





It is therefore likely that eelgrass is in fact the most valuable fish habitat in the Narrow River Estuary. Although salt marsh creeks and channels did not score as highly as sand and eelgrass, they provide value to at least nine species of fish across multiple life stages. Most important, the analysis demonstrates that the Narrow River's historic mosaic of shallow-water and estuarine habitats provides EFH value across multiple species and life stages.

While an inventory of habitats has not been completed Estuary wide, they have been completed for the area between Middlebridge and Sprague Bridge, where most proposed intensive actions will take place. Figures 7 – 8 display elevations (bathymetry), and benthic habitat types respectively.

. Figure 7. Bathymetry of the Middle Portion of the Narrow River Estuary (Boothroyd and Oakley 1987).

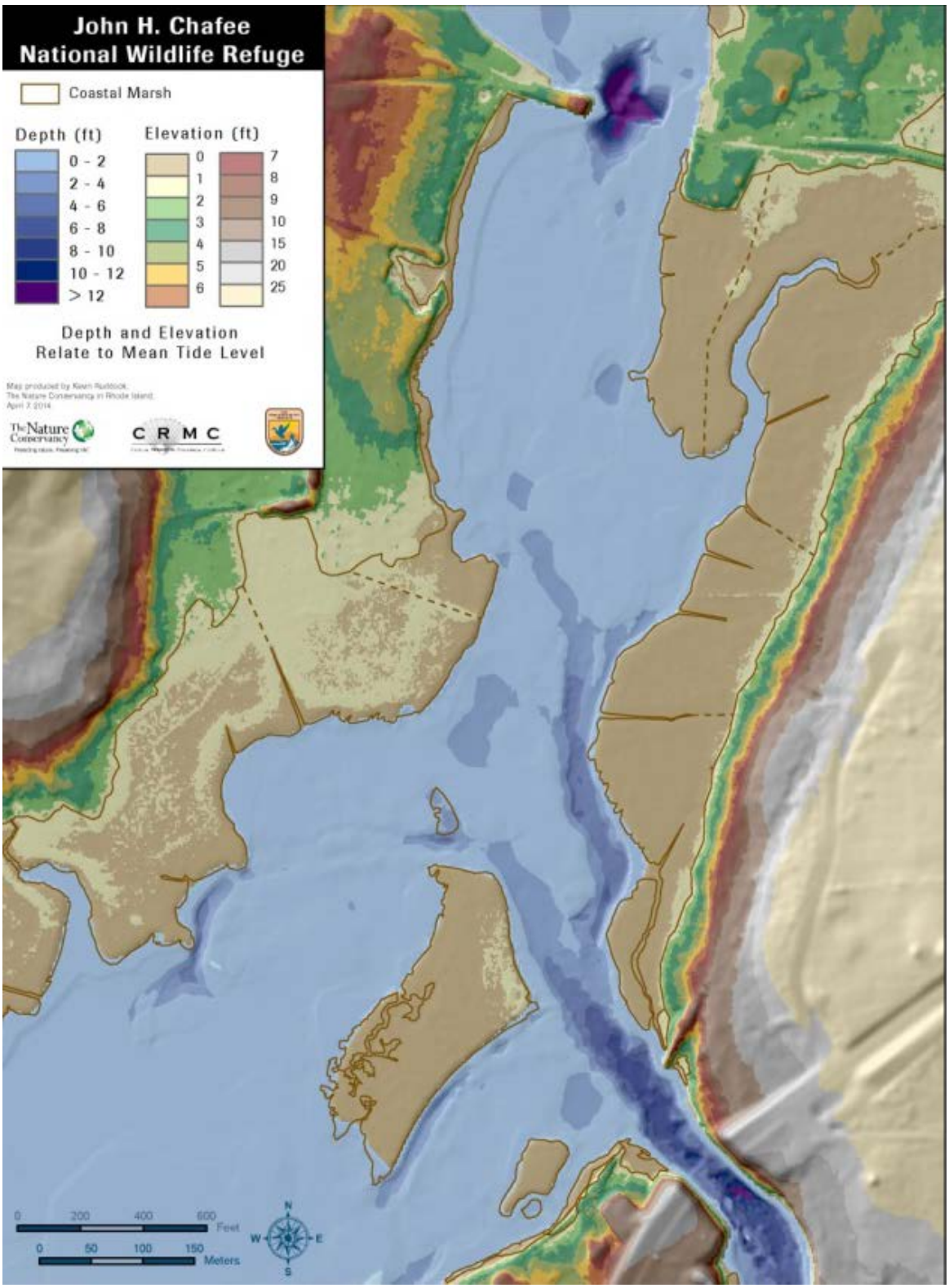
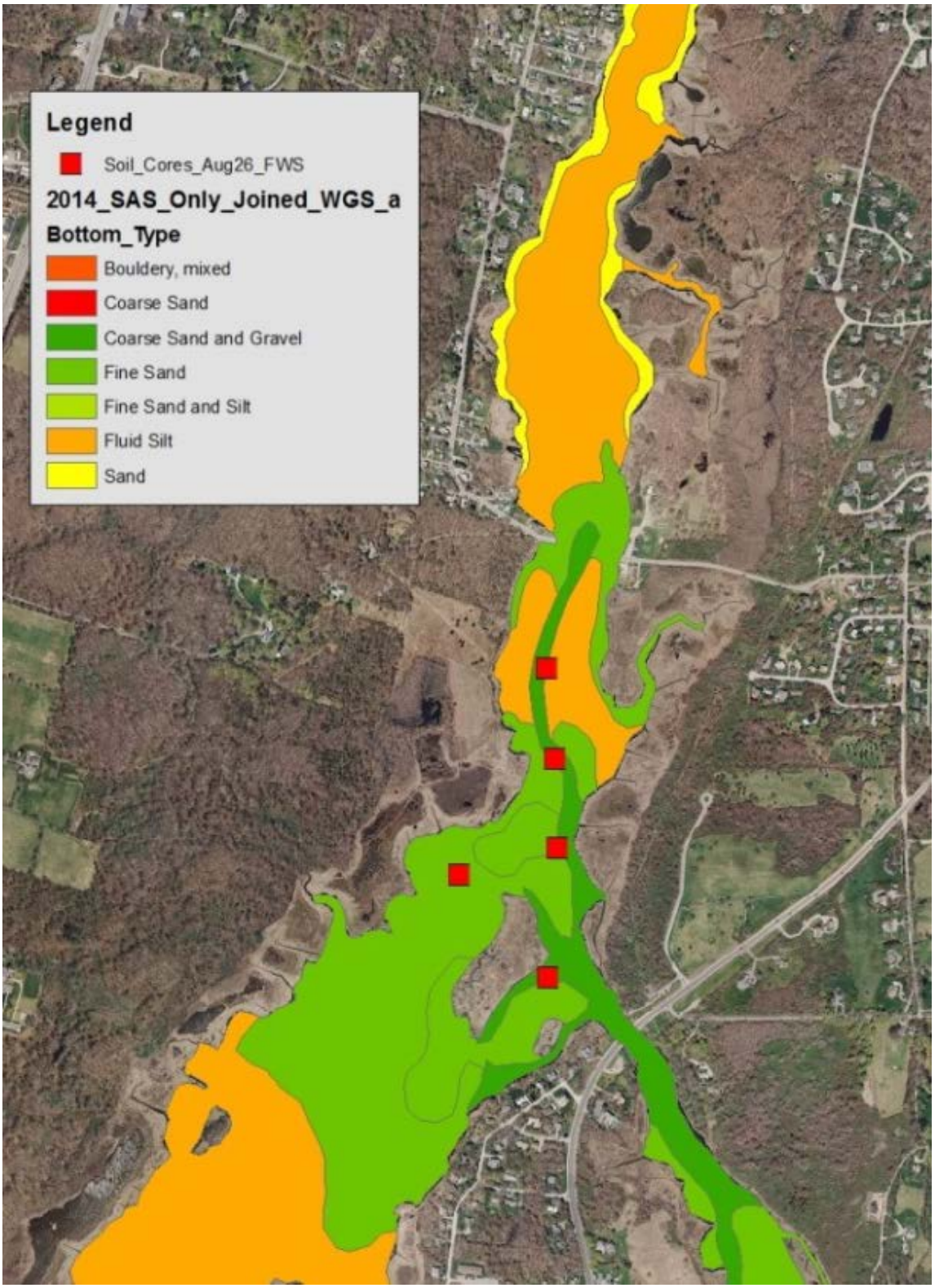


Figure 8. Benthic Habitats in the Narrow River Estuary (NRCS 2007).



Eelgrass distribution in the Estuary has varied markedly over time. Since at least 1948, the main bed for eelgrass has been near Middle Bridge; and eelgrass apparently occurred to the breachway in the 1940's (Berounsky and Nixon 2007; see table 6). Bradley (2012) surveyed South of Middlebridge and only found three small locations where eelgrass was present. In contrast, surveys in 2014 (USFWS 2014) found eelgrass in many areas, albeit at low densities. The 2014 surveys did not detect any eelgrass downstream of Sprague Bridge (Fig.9).

Table 6. Presence of Eelgrass in the Estuary (adapted from Berounsky and Nixon 2007

Author	Study Dates	Locations	Eelgrass description
Wright et al.	1948	south of Middle Bridge to breachway	"excellent"
		north of Middle Bridge	extends a few hundred yards
		Pettaquamscutt Cove to Rock Island	"good" stand
		south of Rock Island	absent
		east by old railroad piling	some
		Unidentified areas	"great expanses" with no eelgrass
Nixon & Oviatt	July 1970	Middle Bridge area, south	eelgrass present, used for experiment
Nagle	1971	Gilbert Stuart Stream	no vegetation
		mouth of Gilbert Stuart Stream	no vegetation
		Upper Pond beach, west shore	no vegetation
		Walmsley Lane end, west shore	no vegetation
		Bridgetown Bridge, upstream, east shore	no vegetation
		Middle Bridge, near bridge, west shore	none near shore, but extensive beds in River
		Middle Bridge, downstream, west shore	extensive eelgrass beds
		Sprague Bridge, upstream, south shore`	no vegetation
		Sprague Bridge, downstream, north shore	extensive eelgrass beds
Sieburth & Thomas	October 1971	mid-Narrow River	mature, 1st year plants
	March-April 1972	mid-Narrow River	young plants collected by SCUBA divers
Kesler	March-April 1973	Bridgetown Bridge, downstream, west shore	eelgrass present
		Middle Bridge, downstream, west shore	eelgrass abundant
		Sprague Bridge, downstream, west shore	no eelgrass mentioned
Short	1974-75	Middle Bridge, south	abundant large eelgrass beds
	1989	Middle Bridge, south	no eelgrass, much macroalage
Kelz	*Oct.1990-August 1991	Upper Pond	no eelgrass noted
*turnover in Oct.1990		Lower Pond (off beach at Pettaquamscutt Lake Shores)	no eelgrass noted
		Pettequamscutt Terrace Beach	no eelgrass noted
		100 m south of Middle Bridge	small eelgrass stand
		200m west of Sprague Bridge	no eelgrass noted
Tuxbury	2006	Whole river via aerial photos	no eelgrass identified
Bradley	2012	South of Middlebdrige	Three small patches found
USFWS	2014	Middlebridge to Mouth excluding Pettaquamscutt Cove.	Light density from Middlebridge downstream to North of Sedge Island in deeper channels.

Figure 9. Current Distribution of Eelgrass below Middlebridge (USFWS 2014). Areas above Middlebridge contain a high density of eelgrass.

The Environmental Assessment provides a more detailed discussion of saltmarsh habitat availability, conditions, and trends. Appendix B provides detailed information regarding current saltmarsh habitats in the estuary, as summarized in Table 7.

Table 7. Availability of Saltmarsh Habitats in the Narrow River Estuary.

RIVER REACH	TOTAL ACRES	CURRENT HABITAT AVAILABILITY (AC.)								FUTURE HABITAT	
		SALT MARSH	POOLS AND PANS				Non-TIDAL (BRACKISH) MARSH	ESTUARINE SHRUB WETLAND	TOTAL ALL HABITATS	MARSH MIGRATION AREA	% OF EXIST. MARSH
			NEW POOL & PANS	OLD POOL & PANS	ALL POOL & PANS	% POOLS & PANS					
Lacy Bridge	31.7	15.2	4.4	0.9	5.2	34.3	5.3	0.2	25.9	5.8	38.1
Mettatuxet	2.0	1.6	0.0	0.0	0.0		0.1	0.0	1.8	0.2	14.7
Middle-bridge	83.3	31.6	3.3	4.9	8.2	26.0	9.2	2.1	51.1	32.2	102.2
Refuge	36.9	24.8	1.0	0.5	1.5	5.9	1.6	1.3	29.1	7.8	31.3
Pett. Cove	169.0	86.8	5.7	14.2	20.0	23.0	12.6	0.6	119.9	49.1	56.5
Lower Narrow River	21.4	14.0	0.0	0.5	0.5	3.7	0.0	0.0	14.5	6.8	48.8
All River Reaches	344.2	174.0	14.3	21.0	35.4	20.3	28.8	4.2	242.3	101.9	58.6

Low marsh, typified by the presence of tall form variant of s. alternaflora, is inherently limited in availability because of the relatively high elevations of saltmarsh in the estuary. Most saltmarsh lies above the mean high water line, calculated to be 0.85 feet NAGVD88 in 2009. A survey of the marsh in 2009 found the high tide line typically occurs within two feet of the saltmarsh bank interior from the river.

The Tall form variant of s. alternaflora primarily occurs at elevations of .90 feet NAVD88 or lower primarily along drainage ways and shorelines within 10 to 20 feet of the bank, and is typically associated with *glasswort (salicornia spp.) and saltgrass (distichlis spicata).* There is an estimated 24 acres of healthy, low marsh in the estuary. Saltmarsh at higher elevations and in well drained areas is dominated by salt hay (*S. patens),* and rushes *(juncus spp.).*

In waterlogged, poorly drained sites, a mix of sparse short form variant of S. alternaflora and glasswort occur interspersed with open bare flats, many of which contain residual root masses of salt marsh hay. These areas are considered as degraded saltmarsh. Many of these sites are believed to have been dominated by a mixture of s.patens, juncus, and tall form s. alternaflora. But because of trapped water on the saltmarsh surface, only sparse short form alternaflora, large areas dominated by salicornia, and open pans dominate these sites. Ongoing vegetation monitoring indicates these sites are expanding (figures 10a-c).

At the upper edge of saltmarsh habitats, high tide bush *(Iva fructecsens)* occurs as well as non-tidal, brackish marsh plant communities dominated in varying degrees with cattail *(typha spp.)* phragmites *(Phragmites austrailus),* and bullrush *(sciurpus spp)* (USFWS data 2009-2014), where saltmarsh is typically dominated by s. patens high marsh communities, and are typically located on higher elevations above mean high water not regularly flooded by tides (Montague and Wiegert 1990).

Saltmarsh habitat has likely declined over time in the Narrow River. Comparison of coastal survey maps completed in the 1800's and early aerial photography reveals that over 12 acres of saltmarsh has been lost over time, and saltmarsh shoreline surveys conducted by the Service (USFWS 2009, 2012) show a continuing loss of saltmarsh along the shoreline (Appendix D). This survey revealed that over 96% of saltmarsh shorelines along the river are undercut on average by two feet or more, and that this causes catastrophic loss of saltmarsh banks as the undercut areas fail.

Saltmarsh habitat has also declined from the expansion of newer pools and pans on the saltmarsh surface by an estimated 14.3 acres. Increased tide heights, drainage of freshwater sources directly onto the saltmarsh surface, pooling of tidal water on the marsh due to poor drainage of the surface all seem to be adversely affecting the amount of saltmarsh vegetation, species composition within saltmarsh habitats the health or robustness of vegetation, and biomass production needed to aide saltmarshes keep up with sea level rise. The presence and possible overabundance of green crabs (carcinus spp.) may also play a role in reduced bank vegetation from herbivory.

Field surveys indicate that the pools which were present on the marsh in 1939 (based on aerial photo interpretation) and are still present today provide high quality habitat for fish, in particular mummichog , killifish and stickleback. These "historic" pools (table 7) are deeper and have established banks than newer pans which have developed since 1939. Fish production in these pools attracts a wide variety of wading birds and waterfowl, and also aide in mosquito abatement. Newer pools and pans are much shallower, dry up in the summertime, and have little biological value.

Tidal channels and ditches provide ready access onto the surface of the marsh and into some pools for managed species (Table 8; note each side of a slough was counted separately). There are approximately 17 acres of tidal marsh where clogging of channels and ditches with sediment has limited access to these areas (see Appendix B for locations). The length of channels providing access is expected to decline over time as they fill with sediment and vegetation.

Table 8. Slough and Channels Providing Access to Saltmarsh Habitats.

River Reach	Functional drainage (ft)*	Non-functional Drainage (ft)	Accessible Marsh (ac.)**	Limited Accessible Marsh (ac.)***
Lacy Bridge	6,003	2,281	11.4	4
Middlebridge	12,366	1,887	17.5	3.4
Pettaquamscutt Cove	18,427	3,984	54.6	7.9
Refuge	7,035	1,810	12.1	1.8
Lower	7,972	58	11.7	0.1
Total	51,803	10,020	107.3	17.2

* Length of slough and channel shorelines. **Areas within 50 ft of a functional drainage. *** Areas farther than 50' from functional drainage.

F.2.3 POTENTIAL EFFECTS ON ESSENTIAL FISH HABITAT AND MANAGED SPECIES

The Narrow River Estuary supports and depends on a mosaic of diverse estuarine habitats, ranging from eelgrass beds in deeper waters to high marsh habitat. However, habitat degradation and loss are occurring in the estuary due to accelerating sea level rise, motorboat wakes and other anthropogenic factors. The proposed restoration is intended to address these ongoing impacts, to preserve and restore existing habitats while preventing and reducing habitat loss. The proposed project will restore the mosaic of healthy estuarine habitats, including EFH, by deepening estuarine areas, providing conditions suitable for eelgrass expansion, restoring salt marsh surfaces and vegetation, restoring salt marsh shorelines, and reducing the rate of salt marsh loss.

ACTION A: Watershed and Water Quality Restoration:

Increased knowledge of non-point source pollution form intensified monitoring will allow informed decisions on how best to effectively abate pollution sources in the estuary. Further investigation of pollution sources within the Mumford Brook drainage, which has the poorest water quality of all tributaries to the estuary, will further efforts for the detection of specific pollution source locations.

Design and construction of Best Management Practices in two of the highest priority sites will directly reduce pollution into the estuary by treating stormwater runoff. If funds are unavailable for construction, designs created and approved by RIDEM will provide “shovel ready” projects should other funding sources become available. All BMP work will be conducted in upland areas and therefore their construction will not impact EFH.

Reductions in nitrogen entering the aquatic system can beneficially influence both saltmarsh shoreline stability and biomass production on the marsh. In estuaries with excessive nitrogen inputs, above ground biomass increased, however Johnson and others (2012) found that taller saltmarsh grasses also produced fewer roots and rhizomes, which normally help stabilize the edge of the marsh creek. Over time, wide cracks began forming in the grassy banks of the tidal creeks, which eventually slumped down and collapsed into the muddy creek taller grass also produced fewer roots and rhizomes, which normally help stabilize the edge of the marsh creek. Excessive nitrogen loading can adversely impact below ground biomass production in saltmarshes, in addition to making above ground production more susceptible to grazing from species such as the Asian green crab (carcinus spp.) (Ramnarine and others 2008). Maximizing above and below ground biomass production on saltmarsh surfaces will help rates of elevation gain on the saltmarsh as a whole.

Possible removal of portions of the trestle crossing will enhance flushing in Upper Pettaquamscutt Cove, alleviating, to a degree, water impairments in this portion of the Cove. While trestle remnant removal may cause short term disruption of benthic habitats, gravel and boulder materials will be retained on site and habitat values will be maintained over time. Benthic conditions in the area of proposed deposition appear to favor maintenance of this habitat type as opposed to siltation.

Reductions in nitrogen loading and placement of the crossing material adjacent to saltmarsh shorelines is anticipated to enhance saltmarsh bank stability on 3,000 feet of shoreline.

ACTION B: Eelgrass, Estuarine Channel and Basin Restoration:

Estuarine basins and channels will be deepened by removing existing sediments to a depth of approximately -5 feet NAVD88.

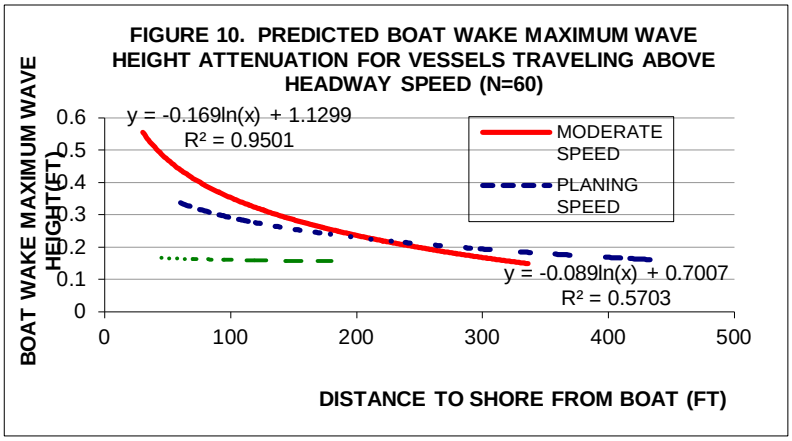
The action is likely to have the following results:

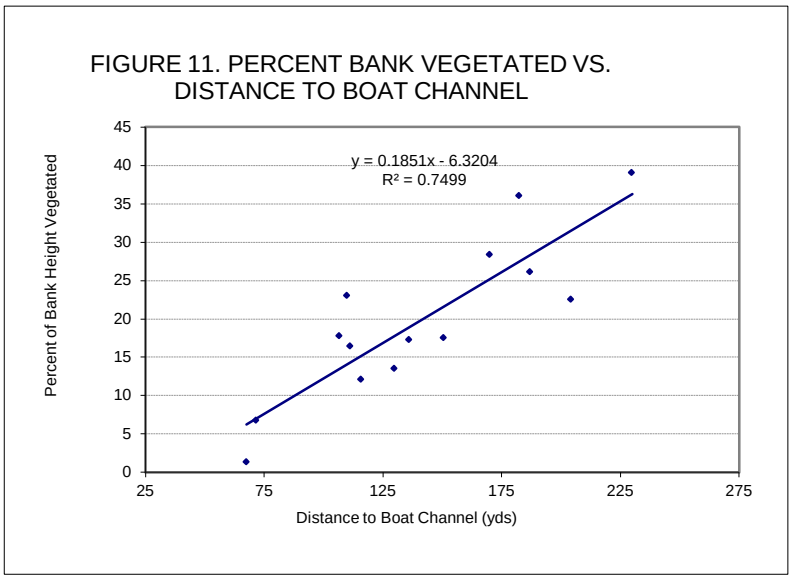
- Establish depths suitable for eelgrass colonization and the expansion of existing eelgrass beds on 7 acres;
- Improve estuarine fish habitat and by increasing estuarine and benthic habitat diversity: restoring deeper areas of passage, feeding and thermal refuge for species such as winter flounder and striped bass on 7 acres;
- Improve flushing of nutrients and pathogens from Pettaquamscutt Cove, thereby enhancing water quality to improve fish and wildlife habitat, ecosystem functions and human health;
- Protect and restore salt marsh shorelines by reducing current speeds along marsh shorelines and moving boat traffic and wakes further from eroding marsh banks, mechanical weakening of the banks from wave action, and reduction in potentials for further prop scarring of the saltmarsh shoreline;
- Provide material for beneficial re-use, including living shoreline restoration and marsh restoration (Actions C and E, below).
- Testing of different excavation techniques will allow for evaluation of whether local materials and equipment can be successfully employed to apply similar treatments in other restoration areas along coastal Rhode Island and New England.

As noted above, eelgrass occurs at depths greater than 2 feet NAVGD88. By increasing areas at or below this depth, the proposed action is expected to result in an expansion of up to 7 acres of eelgrass habitat and deeper estuarine areas, with substantial benefits to managed species and EFH within the estuary. Re-alignment of the channel Easterly of Sedge Island will improve eelgrass habitat availability by creating a channel shallower than current depths of 8 feet, which may be less than ideal for eelgrass because of the excessive depth. In Ninigret Pond, Charlestown, RI, a similar project to deepen flood-tide shoals within a coastal pond resulted in significant colonization by eelgrass (ACOE 2011). As shown by the shallow-water habitat analysis above, eelgrass is one of the most valuable -- likely the most valuable -- types of estuarine habitat present.

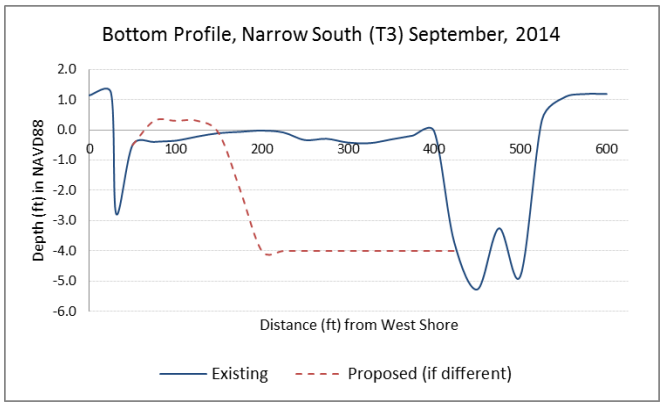
Providing deeper water away from saltmarsh shorelines will allow motorized vessels to pass further from saltmarsh shorelines. Currently, motorized vessels have no choice, due to shallow water, than to pass within 65 feet of saltmarsh shorelines in the vicinity of Sedge Island. Boat wake wave attenuation modelling (USFWS 2009) indicates that the closer vessels travel to a shoreline, the greater the wave energy (synonymous with maximum wave height) and hence erosive potential these boat wakes will have (Figure 10). Applying this model, this action could result in reducing boat wake wave energy on saltmarsh shorelines by 65%.

Allowing motorized vessels to pass farther from saltmarsh shorelines may also enhance vegetative growth on some banks. As shown in Figure 11, there appears to be a relationship between percent bank vegetative cover and distance from boat channel (USFWS 2012). Applying this relationship suggests that vegetative growth on affected saltmarsh shorelines may increase by 25%.





In areas of eelgrass restoration 7 acres of existing shallow-water course sand and tide flat habitat will be affected, however the amount of surface area, or wetted area of this habitat available to fish will not be significantly reduced. As shown in the sample excavation profile below, the primary change in surface area available to fish is in the distribution of habitat by depth. Currently within areas proposed for deepening, 90% of the wetted surface area lies above -2NAVD88. Implementing the proposed action would essentially



reverse this distribution, providing more course sand at greater depth, where cooler and deeper water favors fish habitat use. The new sand bottom will remain in sand habitat until eelgrass colonizes the area, a habitat of heightened value. Areas targeted for creation of sand bottom habitats for excavation are in areas of low biological value, based on the results of eelgrass and shellfish/infauna surveys (RICRMC data, 2014; USFWS 2014). The larger tidal flats in the lower river will remain available, and likely expand over time. Under the proposed action, minor loss of tide flat habitat will be more than compensated by the restoration of valuable, declining habitats such as low marsh, high marsh, fringing marsh, and deeper estuarine areas suitable for the expansion of eelgrass beds and thermal refugia. The wetted surface of course sand benthic habitats will change little over existing conditions. This change in tidal flat habitat will be offset by 3.3 acres of tide flat enhancement.

Tide flats can provide important habitat for benthic infauna; feeding habitat for estuarine fish and invertebrates during higher portions of the tidal cycle; and valuable feeding and resting habitat for several shorebird species of conservation concern (as described in detail in the EA). Tide flats are an important component of the estuary's mosaic of estuarine habitats.

The RIDEM finfish surveys have demonstrated that in summer, the deeper, cooler waters support greater fish abundance and diversity than shallower, warmer areas. Winter flounder are absent from areas of the estuary once water temperature reaches 26-28 degrees C (Lake, 2014). This action will improve habitat for managed species by increasing areas of thermal refuge for species such as winter flounder and improving feeding access for larger fish such as bluefish and striped bass.

As shown in Appendix A, filling of river channels in this area with shoals and flats has taken a number of years. Therefore, while tidal flats can be expected to return in these areas, the effectiveness of this beneficial treatment can be expected to persist for a long period of time.

Creation of eelgrass beds is not anticipated to significantly change tidal flow in the River. The presence of a large flood tidal delta at the mouth of the river, and channel restriction caused by the abutments of Sprague Bridge combine to inherently limit the volume of water passing into and out of the upper reaches (USACOE 2007). Because of these restrictions, tidal flows are delayed approximately one hour after the tides measured at Narragansett Pier.

By restoring estuarine habitat complexity and diversity; by promoting the expansion of eelgrass beds; by restoring valuable shallow-water habitat; and by providing areas of thermal refuge for species such as winter flounder, restoration of estuarine depths is expected to have a positive effect on EFH and managed species in the Narrow River Estuary.

In summary, anticipated effects include:

- Improve estuarine fish habitat and EFH by increasing estuarine and benthic habitat diversity: restoring deeper areas of passage, feeding and thermal refuge for species such as winter flounder and striped bass;
- Improve flushing of nutrients and pathogens from Pettaquamscutt Cove, thereby enhancing water quality to improve fish and wildlife habitat, ecosystem functions and human health;
- Better protect salt marsh shorelines by reducing current speeds along marsh shorelines. This will benefit resources in the vicinity of Sedge Island, where river flows originally were disaggregated into two channels, and are now concentrated into one, deep channel flowing against the Eastern

shore of Sedge Island. This will also aide the conservation of saltmarsh on the Eastern shore of the river Northeast of Sedge Island.

- Better protect saltmarsh shorelines from boat wake accelerated erosion along saltmarsh shorelines. In some portions of the estuary, motorized vessels must past by saltmarsh shorelines within 65 feet due to shallow waters and restricted channels. Boat wakes generated by boats this close to the saltmarsh shoreline is likely causing accelerated erosion rates on the bank, and prop scarring on the edge of the marsh has caused direct loss of habitat. Based on boat wake wave modelling and wave energy assessments (USFWS 2009), boat wake wave energy reaching saltmarsh shorelines may decline by as much as 65% in some areas.
- Provide material for beneficial re-use, including living shoreline restoration and marsh restoration (Actions C and E, below).

ACTION C: Restore Saltmarsh Shorelines:

The stability and health of saltmarsh shorelines will benefit from implementation of actions A (Water Quality Management) and B (Eelgrass Management). Reducing pollutants, in particular excess Nitrogen loading may help in promoting both aboveground and below ground biomass (Johnson and others 2012). Enhancing eelgrass and providing cool water refugia for fish and insuring no net loss in shorebird and wading bird habitats may, to an unknown degree, increase predation on green crab (*carcinus spp*.) and thereby reducing herbivory on saltmarsh banks. In itself however, these actions will not adequately address bank erosion of saltmarsh shorelines.

This action will reduce ongoing erosion and loss of salt marshes caused in part by motorboat wakes, mechanical weakening of the bank, and direct loss through prop scarring. Living shoreline treatments such as coir logs and bagged oyster shell along approximately 7% of all marsh shorelines, targeting the most vulnerable banks, based on shoreline stability assessments by USFWS (2012).

At present, eroding marsh banks are deeply undercut. Pilot-scale living shoreline treatments placed by CRMC and the Nature Conservancy in 2014 were rapidly colonized by *Spartina alterniflora*, stabilizing the marsh edge and establishing fringing low marsh habitat.

Salt marsh edge erosion is a major source of salt marsh loss in the Narrow River Estuary, and motorboat wakes are a significant factor in accelerating marsh edge erosion. At mid and low tides, boat wakes enter undercut areas of banks, and in addition to enhancing erosive conditions, boat wake generated waves have been observed to move the cut bank up and down mechanically. Excessive nitrogen loading with may reduce below ground biomass, and natural events such as ambient, wind driven waves, ice carving, and natural erosion all combine to influence saltmarsh shoreline stability.

Collapse of undercut banks appears to be the primary causal factor of saltmarsh shoreline loss, and frequently occurs as a mass, or catastrophic loss along several feet of shoreline. In 2013/2014, this pattern of bank loss has occurred along the eastern shore of Sedge Island and near Starr Drive

It is believed the natural rate of collapse and erosion of undercut shorelines may be exacerbated by boat wakes in those portions of the estuary from Mettatuxett downstream to the mouth (USFWS 2010). Approximately 70% of the wave energy reaching some saltmarsh shorelines during the summer months was estimated to originate from boat wakes. Ambient wave action, channels which have shifted over time

onto saltmarsh shorelines, and accelerated erosion caused by boat wakes and loss from prop scarring all are contributing to active erosion of saltmarsh shorelines.

This action will improve marsh shoreline complexity, stability and habitat value by interspersing the undercut areas with fringing marsh. The fringing marsh created by the living shoreline treatment will provide similar habitat value as the low marsh created under Action E, including colonization and feeding areas for invertebrates, feeding and refuge for small fish and nekton, and food web support to larger estuarine and marine fish.

Saltmarsh grows both vertically and horizontally. Gains in horizontal saltmarsh growth are typically lost due to collapse of undercut shoreline banks. Reducing the rate of undercutting could reasonably be expected to allow the marsh to expand, rather than being continually lost from undercut bank failure.

More stable marsh shorelines will support higher trophic level epifauna than the current eroding banks, improving biodiversity throughout the estuary. Like other marsh restoration actions proposed, marsh shoreline restoration will help protect estuarine water quality by reducing or reversing the rate of marsh loss. By reducing erosion, marsh shoreline restoration will reduce sediment re-suspension and transport into deeper areas, thereby improving water clarity and helping to protect eelgrass and other benthic and shallow-water habitats.

By improving estuarine habitat complexity and stability, reducing marsh erosion, improving biodiversity, and reducing sedimentation, marsh shoreline restoration will have positive affects on EFH and managed species in the Narrow River Estuary.

ACTION D: Restore Saltmarsh Surface Hydrology and Drainage (Runnels):

Degraded salt marshes will be improved by enhancing surface drainage using the “runnel” method -- excavating shallow tidal channels on the surface of the marsh. This approach has been used successfully elsewhere on Narragansett Bay to restore degraded marsh surfaces, spur re-vegetation by *S. alterniflora* and other marsh plants, and improve habitat connectivity (Ferguson, personal communication 2014). This action will affect 47 acres, and will be undertaken through an adaptive approach -- beginning small scale in the first year, then evaluating the need and opportunity for continued hydrologic restoration. A robust and detailed monitoring plan is being implemented for the first treatments under this action, using BACI study design at two sites, while long-term vegetative monitoring will be used at other sites.

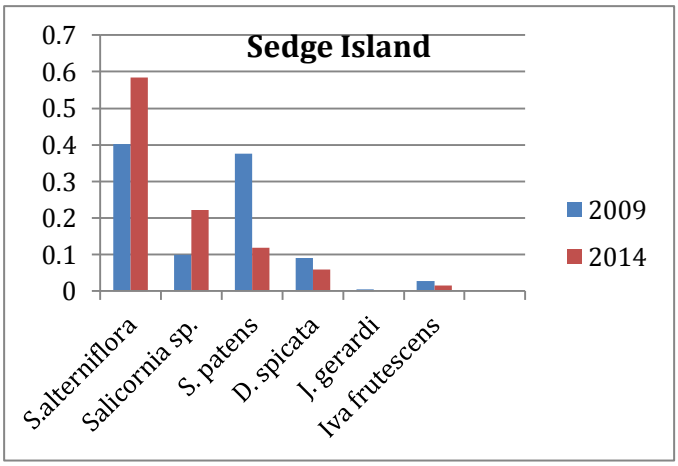
The proposed action D will have marked improvement in saltmarsh conditions (see previous section on saltmarsh impacts). Action D will restore marsh creeks and channels and create access through runnels which, as shown by the shallow-water habitat analysis (Appendix F), provide significant value to estuarine fish, including winter flounder. Habitat connectivity will be increased, allowing fish and invertebrates access and egress to and from pans and pools on the marsh surface. This is expected to improve production of small fish and other nekton adapted to the harsh conditions of these shallow water features, such as mummichog, striped killifish, ninespine stickleback, fourspine stickleback, and daggerblade grass shrimp. By enhancing conditions for these important prey species, this action will improve EFH for larger, managed species such as winter flounder that feed on these and other marsh surface users. Enhanced access from clearing clogged channels and creation of small runnels to the marsh surface is expected to occur over 47 acres.

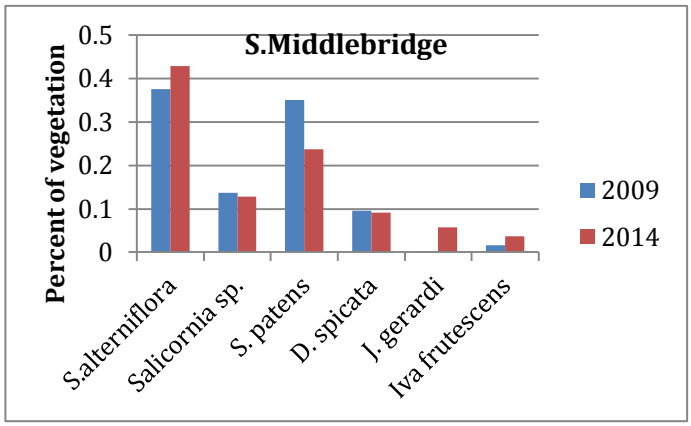
This action will improve fish habitat on the surface of the marsh by improving habitat structure and condition. High marsh surfaces, marsh creeks, and permanent marsh pools provide highly productive habitat for many small estuarine fish and other nekton (USFWS Nekton Survey data; MacKenzie & Dionne 2008). By restoring vegetative complexity to the surface of the marsh, this action will improve habitat for many small fish and invertebrates, particularly during spring high tides when the surface of the marsh is flooded. Historical pools and pans, which provide important habitat for marine fish, will be protected.

As discussed previously, areas where excess water is entrapped on the saltmarsh surfaces, vegetation shows evidence of stress, and bare pannes eventually become prevalent. Degraded marsh is typified by the presence of bare areas, areas where glasswort (*salicornia spp.*) dominate in association with short forms of Spartina alternaflora. Biomass production is reduced in these areas, inhibiting their capability of keeping pace with sea level rise.

Without restorative actions, the amount of degraded saltmarsh can be expected to increase in the estuary. As shown in the graphs below, the amount of short form S. Alternaflora and salicornia has increased in the estuary, while the amount of S. patens has declined (Figures 12a-12b; USFWS data 2014).

Figures 12a and 12b. Changes in Vegetation Composition of saltmarsh vegetation from 2009-2014.





Restoring 14.3 acres of saltmarsh habitat lost to development of newer, shallow pools and pans which dry up in the summertime will improve saltmarsh conditions. Of these acres, we estimate 4 acres of newly created, low marsh dominated by the tall form variant of s. alternaflora will occur. This would be an important contribution to managed species, given the low amount of low marsh currently available in the estuary. Protection of historical pools and pans within treated areas will retain habitat diversity and the important values to fish.

Hydrologic restoration of marsh surfaces can benefit open water estuarine habitats such as eelgrass beds by maintaining salt marshes that, in turn, help maintain water quality in the Narrow River Estuary. Salt marshes buffer and protect estuarine waters and habitats from land-based pollutants from largely developed watershed (USEPA 1993).

By restoring estuarine habitat complexity, diversity and connectivity on marsh surfaces; by providing vegetated habitat for marsh epifauna; by restoring valuable shallow-water habitat; and by helping to maintain and improve estuarine water quality, hydrologic restoration of marshes will have a positive effect on EFH and managed species in the Narrow River Estuary.

ACTION E: Restore low marsh, degrade marsh, and intertidal elevations

Thin layer deposition (TLD) of dredged sediments will be applied to narrowly targeted areas of degraded marshes, in order to prevent and reduce estuarine habitat loss, improve habitat resiliency and aide in preventing catastrophic loss of saltmarsh with incremental sea level rise. TLD applications are expected to establish conditions to restore and maintain vegetated marsh in areas of vegetation die-back, waterlogging, and rapidly expanding pools and pannes.

The TLD approach will use a thin layer of sediment produced during the eelgrass restoration work, applying it to the surface of the marsh and raising intertidal elevations in order to mimic and augment natural accretion processes. This measure is intended to help salt marshes keep pace with accelerating sea level rise, and to restore low marsh habitat to lost areas of historic marsh. USFWS will also use this method to restore limited tide flat areas.

This action is closely integrated with Action B, Eelgrass Management and Restoration; Estuarine Channel and Basin Restoration, which will provide source material for this action. A map of proposed restoration areas, and a table of proposed areas and volumes, for this measure are included in Appendix G.

Thin layer deposition (TLD) of dredged sediments (Action E) will be applied to narrowly targeted areas of degraded marshes, in order to prevent and reduce estuarine habitat loss, improve habitat resiliency and aide in preventing catastrophic loss of saltmarsh with incremental sea level rise. TLD applications are expected to establish conditions to restore and maintain vegetated marsh in areas of vegetation die-back, waterlogging, and rapidly expanding new pools and pans. This action will restore approximately 15.3 acres of degraded high marsh, 4 acres of low marsh; approximately 1.2 acres of lost low marsh areas; and approximately 3.3 acres of tide flat habitat. Providing increased resiliency to sea level rise, these habitats will continue to be present for a longer period of time than without treatment, and will help prevent the large scale loss of saltmarsh by enhancing relief. TLD would not be applied next to the saltmarsh creeks, thereby retaining existing low marsh values, and areas where tall form variant of s. alternaflora occurs in a mix with other species.

Like Action D, this measure will improve fish habitat on the surface of marshes by improving habitat structure and condition, particularly during spring high tides when the surface of the marsh is flooded. Also like Action D, it will restore vegetative complexity to the surface of the marsh, improving habitat for many small fish and invertebrates. MacKenzie & Dionne demonstrate that even high marsh surfaces are important estuarine fish habitat. The literature review in Appendix F provides further studies of the importance of high marsh habitat to estuarine fish.

Restoration of lost low marsh habitat (Actions C,D, and E) will greatly increase habitat complexity and value for estuarine fish, invertebrates and epifauna. Low marshes provide valuable colonization and feeding areas for invertebrates such as ribbed mussel, fiddler crab, and snails such as *Littorina littorea* and *Melampus bidentatus*. During mid-high tides when covered with water, *S. alterniflora* low marshes provide valuable feeding and refuge for fish and nekton such as mummichogs, killifish, sticklebacks and shrimp which, in turn, provide food web support to fish species of commercial and recreational values, including winter flounder, bluefish and striped bass.

This restoration action will help restore the historic balance of estuarine habitats, restoring valuable marsh habitat for estuarine fish and nekton, including areas of feeding and refuge. By restoring and improving estuarine habitat complexity, diversity and value for fish and invertebrates, restoration of marsh and tide flat habitat is expected to provide significant benefit to EFH and managed species. Further, this action will help improve and protect estuarine water quality, with benefits to EFH, shallow-water habitats, and managed species in the Narrow River Estuary.

Management controls, including limiting dredging operations during seasons where minimal impact to manage species will occur (November 15-January 31), application of best management practices to control erosion, protecting key habitats such as pools and pans, and minimizing channel clearing and runnels development to only the minimum levels needed will help insure short term impacts are minimized (Appendix G).

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ACTION F. Test Treatments to enhance conditions for marsh migration.

This action will occur in upland sites and will not effect managed species or EFH.

Potential Short-Term Construction Impacts and Avoidance Measures:

Potential short-term impacts from construction include:

- Displacement of estuarine habitats: Estuarine deepening actions, if poorly sited, could displace valuable existing habitats. To avoid this impact, detailed surveys and analysis of benthic, shallow-water and intertidal habitats were undertaken, including mud and sand habitats, eelgrass beds, gravel/cobble bottoms, shellfish and other benthic infauna. The results of these surveys and

analyses were used to site dredging activities in areas of low biological value, removed from eelgrass beds or other valuable estuarine habitats or resources.

- In-water sedimentation impacts: The Service has considered the potential impact of re-suspension of sediments and sediment deposition on estuarine habitats (e.g. eelgrass beds), causing loss of habitat or disruption to fish spawning, feeding or passage. Areas to be dredged are primarily fine sandy areas, where sediment re-suspension is short-lived and sediment transport distances are short. Mechanical, rather than hydraulic dredging equipment are being tested in order to better control dredging areas and impacts. Much of the excavation will be performed at lower tides, "in the dry," in areas which are exposed at low tide; in these cases there will be little opportunity for re-suspension of sediments. In addition, seasonal restrictions for in-water dredging activities, and will limit dredging activities to the period of least biological activity (November 1 - January 31). This window was developed in consultation with RIDEM fishery biologists to protect the fall outmigration of juvenile river herring as well as winter flounder spawning.
- Marsh surface sedimentation impacts: The Service has considered the potential that marsh restoration actions could disrupt marsh surface biota through uncontrolled sediment deposition. Sediment controls such coir logs to compartmentalize treatment areas will help ensure that sediment application is limited to targeted restoration areas. The coir logs will also be positioned and removed to mimic natural shallow marsh creeks on the surface of the marsh, in order to maintain habitat connectivity and provide valuable shallow-water habitat in restoration areas.
- Hay bale fences will be installed in channels which drain the areas to further contain sediments on site. Hay bales will not completely restrict flows, and will be installed in series to enhance effectiveness.
- Construction equipment impacts: Construction equipment has the potential to impact the salt marshes through compaction of marsh peat, leading to a loss of marsh elevation, or damage to marsh turf, causing accelerated erosion. Much of the drainage restoration will be performed by hand digging, which has been shown elsewhere to have negligible impacts on marsh surfaces. Where construction equipment operation on marsh surfaces is unavoidable, specialized low-ground-pressure equipment designed for wetland restoration, ground protection mats, and/or other best practices for construction on marsh surfaces will be used, and will target cold-weather periods for sensitive construction activities in order to take advantage of partially frozen marsh surfaces. For in-water work, equipment will be floated on barges rather than driven over the marsh in order to avoid damage to marsh surfaces. As noted above, lower-impact mechanical equipment will be used rather than hydraulic dredging equipment. Contractual requirements and inspections will insure adherence to all applicable RIDEM stormwater management requirements at the staging area.
- Fishing access impacts: The Sprague Bridge access site on the Northeast side of the bridge (off Route 1A by Sprague Bridge in Narragansett) will be used for construction staging. This will disrupt fishing access and parking at this location during the winter construction period. The Service will work to minimize impacts on recreational use during the summer season; however some disruption of fishing access will be unavoidable. Temporary closure of this area will result in the temporary loss of 12 parking spaces; however, most people fishing park on the South Side of Sprague Bridge and on the east side of Boston Neck Road. Moreover, an alternate boat launch location is available at Pollock Avenue, South Kingstown, approximately one mile north. Excavation and movement of the channel near Sedge Island may make access to the front of Sedge Island difficult. However, enhanced habitat for fish (deeper waters with course sand bottom habitat and eelgrass) will be created closer to parking areas, and walk in fishing access to the Eastern shore of the River will be maintained.

Summary:

Applying the series of interconnected restoration/resiliency actions is anticipated to result in the following:

- Action A, Watershed Management / Water Quality Restoration: Improve estuarine water quality and flushing; reduce pollutant concentrations, particularly in Pettaquamscutt Cove. Potential long-term improvement in ecosystem function, fishery closures and human health. Slight increase in available rock/cobble/sand habitat from removal of the remnant crossing materials in Pettaquamscutt Cove. Increased bank stability on 3,300 ft of saltmarsh shoreline.
- Action B, Eelgrass Management and Restoration, Estuarine Basins and Channels: Provide conditions for establishment of up to 7 acres of new eelgrass beds. Improve flushing, provide areas of thermal refuge, feeding and passage for important estuarine fish such as striped bass and winter flounder. Reduce boat wake impacts on saltmarsh shorelines; limit shoreline loss along the eastern side of Sedge Island.
- Action C, Restore Salt Marsh Shorelines: Restore 7% of saltmarsh shorelines which are eroding; preserve salt marsh habitat; enhance low marsh habitat and stable marsh banks; reduce sedimentation and infilling of estuarine habitats. Increase shoreline habitat diversity and productivity for prey; create fringe habitat with low marsh characteristics.
- Action D, Restore Salt Marsh Surface Hydrology: Restore hydrology to 47 acres while simultaneousy clearing clogged channels and creation of linkage to habitats with runnels; restore 14.3 acres which are currently occupied by new, shallow pools and pans which dry up in the summertime. Of these acres, roughly 4 acres are expected to be occupied by productive low marsh, dominanted by tall for smooth cordgrass; spur revegetation of recently degraded/denuded marsh areas; restore habitat structure and function, particularly during higher tides.
- Action E, Marsh and Tide Flat Restoration: Restore 15.3 acres of degraded existing marsh; up to 1.2 acres of lost low marsh; and up to 3 acres of tide flat habitat. Protect existing, productive low marsh and mixed low marsh habitats within treatment areas; Restore estuarine habitat complexity, diversity and value to a total of 19.5 acres.
- Action F, Test enhancement of marsh migration: Girdle trees to release shrub understory; will determine whether this techniques can be successfully applied elsewhere to promote marsh migration.

Potential Cumulative Impacts:

Water Quality in the Narrow River will remain in a degraded condition or slightly improve. While the project will help improve conditions in some portions of the watershed, storm runoff and persistent non-point sources will continue to inhibit water quality in the watershed as a whole. The action is not expected to have a significant effect outside of the watershed.

While the project is expected to improve saltmarsh habitat conditions in the estuary, areas remaining untreated will continue to decline. While treatments to enhance elevation capital will help prevent catastrophic loss of saltmarsh in the near term, sea level rise will continue to add stress on saltmarsh and estuarine habitats not only in the Narrow River, but in Narragansett Bay and along the entire Eastern Seaboard. While projects located on the South Coast of Rhode Island in Ninigret, Quononchataug, and Winnapaug Ponds will aide in “buying time” against the full consequences of sea level rise and climate

change, current trends and projections suggest that the health and availability of saltmarsh habitats will decline markedly in the region, whether or not this project is implemented. Only in areas where saltmarsh has the opportunity to migrate inland, or where treatments are applied for elevation capital will saltmarsh communities be maintained in the short term.

The health of managed species will likely improve in the estuary. Based on previous distribution of eelgrass demonstrating it's likely occupation of suitable habitat, and providing cold water refugia will have a marked benefit on habitat conditions for managed species. However long term trends in habitat as influenced by sea level rise, climate change, stock health and harvest, and other factors will ultimately determine the stability of managed species.

F.3 CONCLUSIONS REGARDING EFH IMPACTS

The Service concludes that the proposed Narrow River Estuary Resiliency/ Restoration project will provide significant overall and long-term benefits to EFH, managed species, and shallow-water habitats by:

- Restoring and preserving the historic mosaic of estuarine habitats within the Narrow River Estuary;
- Improving estuarine water quality and clarity; improving flushing, and reducing concentrations of nutrients and pathogens;
- Increasing areas of sufficient depth to support eelgrass habitats, with expected expansion of eelgrass beds;
- Improving and increasing habitat complexity, including shoreline complexity and stability;
- Increasing the area and lineal extent of low marsh and fringing low marsh, providing new areas of settlement for estuarine infauna and epifauna; areas for feeding and refuge for small estuarine fish and nekton; and food web support and production for larger fish species;
- Reducing rates of marsh erosion and loss, thereby reducing sedimentation and helping to maintain estuarine water quality;
- Increasing vegetated marsh area, with benefits for estuarine fish and other wildlife;
- Increasing areas of thermal refuge for species such as winter flounder;
- Providing increased feeding and passage areas for larger fish species such as striped bass and bluefish.

The proposed action will have minor short-term negative consequences such as the disruption of fishing access due to construction staging, and all practicable measures to avoid and reduce short-term impacts on EFH and managed species will be implemented. This impact is not anticipated to be significant.

The proposed action will impact current tide flat and very shallow water areas by 7 acres in areas, but the wetted surface available to fish will not be altered significantly. The course sand habitat, instead of concentrated in less than two feet of water, will be concentrated in deeper water, which will provide better foraging for striped bass and bluefish, and provide cool water refugia for winter flounder. Approximately 3.3 acres of tidal flat will be enhanced. Tide flat habitat is currently expanding due to natural and anthropogenic processes.

The proposed action will have substantial positive impacts for EFH, shallow-water habitats and managed species, and no significant adverse effects on EFH, shallow-water habitats or managed species.

USFWS expects the cumulative impact of this project to be beneficial to EFH locally, shallow-water habitats and managed species by providing greater habitat diversity and complexity, including improved estuarine productivity, improved water quality, areas for fish feeding, refuge from predators, settlement areas for a greater diversity of infauna and epifauna, areas of thermal refuge for species such as winter flounder, and a restoration of the Narrow River Estuary's historic mosaic of estuarine habitats. No adverse cumulative impacts are anticipated.

F.4 PROPOSED MITIGATION

All appropriate permits from the U.S. Army Corp of Engineers, RI Coastal Resource Management Council, National Oceanic & Atmospheric Administration, R.I. Dept. of Environmental Management, and other regulatory agencies will be obtained prior to undertaking any restoration actions. Cultural resource clearance under the Historic Preservation Act will be obtained prior to conducting ground-disturbing activities. In areas proposed for restoration on non-federal lands, written permission from the landowner will be secured prior to taking any action. All mitigation measures and conditions identified in the permits will be adhered to.

Actions B and E of the restoration will be coordinated in order to minimize construction impacts: minimize sediment storage, maximize equipment utilization, and minimize adverse impacts from restoration operations. Excavators on floats or operating on sand will be used to restore estuarine habitat depths; these sediments will then be applied in very limited areas to achieve target elevations, in order to implement Action E. Coir logs and other controls, as specified above, will limit sediment application to target areas, and to maintain habitat connectivity following the restoration.

USFWS will perform in-water work from November 15 to January 31 in order to protect outmigrating alewives and spawning winter flounder. For work on the surface of the marsh, summer seasonal restrictions in appropriate areas will be implemented to protect nesting birds such as salt marsh sparrows.

Implementation of monitoring will provide a feedback loop which will be used to assess, evaluate, and as necessary change management activities to insure they are effective, are not resulting in deleterious effects, and are appropriate to site conditions.

To minimize impacts to recreational uses of the river, including recreational fishing, actions which could significantly hamper recreational use of the river will be timed to occur outside of the heavily used summer season.

Appendix G details the specific control measures by action to avoid or reduce potential impacts from implementation of the proposed action.

F.5 ADDITIONAL INFORMATION

F.5.1 Site-specific Information

The EA as well as the Appendices provide site-specific information regarding the estuary, alternatives considered, and anticipated effects of the action.

F.5.2 Literature Review

In order to ensure that the proposed restoration of low and high marsh habitats is beneficial to managed species and EFH, and to ensure the avoidance of impacts to valuable fish habitat, the Service has been conducting nekton monitoring on the surface of the estuary salt marshes. In addition, we conducted a literature review of estuarine fish use of salt marsh habitats.

Most of the available research pertains to *Fundulus heteroclitus*, the common mummichog, and is summarized here. This species is an important indicator of EFH functions and values of the estuary salt marshes, since *Fundulus* spp. are among the most abundant fish utilizing salt marsh habitats in the estuary, and because of their value to the estuarine food web and larger managed species. *F. heteroclitus* is an important energy link between the marsh surface and subtidal food webs (Weisberg and Lotrich, 1982).

In addition to the mummichog, the Service's nekton monitoring, described above, indicates that at least 20 other species of fish and invertebrates are using these habitats as well. Certainly many of the marsh habitat values and uses indicated for *Fundulus* would apply to other species documented on the surface of the marsh.

Research by DiMichele and Taylor (1980) and Petersen et al. (2010) indicates that most *Fundulus* spawning occurs during spring high tides. *Fundulus* lay eggs on mud under *S. patens*, at juncture of leaves and stems of *S. alterniflora*, and unvegetated gravel. Eggs incubate in the open air, not in water, over 7-9 days or longer. Hatching occurs when the eggs are stimulated by immersion in tidal waters. This research demonstrates that vegetated high marsh is needed for mummichog spawning, and suggests that vegetated marsh restoration, as proposed for the estuary marshes, would benefit estuarine food web productivity and EFH.

Research by Kneib and Stiven (1978), Taylor et al. (1979), and Able et al. (2006) has shown that young of year *Fundulus heteroclitus* and *F. luciae* are found almost exclusively in the intertidal marsh surface microhabitats of shallow depressions and pools. The proposed restoration will preserve this habitat type by preventing marsh loss (conversion of intertidal marsh surfaces to subtidal habitats, which offer no predator protection and therefore reduced production for small fish such as *Fundulus*). Moreover the proposed restoration will preserve historic marsh pools, pannes and creeks shown by this and other studies to be valuable habitat for *Fundulus* and other estuarine nekton at various life stages (e.g., Allen et al. 1994, Able et al. 2012).

Research indicates the value of intertidal and high marsh habitat to feeding, growth and production of *Fundulus*. Studies by Weisberg and Lotrich (1982) and Weisberg (1986) show that "growth rates were significantly higher for mummichogs allowed access to the marsh surface." MacKenzie and Dionne (2008) showed that high marsh habitat, in particular, stimulates mummichog growth and productivity. Studies by Butner and Brattstrom (1960), Meyer and Posey (2009), and Banikas and Thompson (2012) indicate that this is likely a function both of food availability and predator protection provided by high marsh, and that interior marsh surfaces are preferred when accessible, with tidal creeks serving as access pathways when high marsh surfaces are not flooded. The proposed restoration will restore tide creeks and runnels, in order to maintain habitat connectivity, in addition to restoring marsh surfaces through TLD and elevational enhancement, and restoration of habitat structure by improving conditions for vegetation growth and by planting restored marsh surfaces.

All of these studies support the Service's determination that the proposed action will benefit EFH functions and values by restoring both low marsh and high marsh habitat structure to the estuary, enhancing the productivity of *Fundulus spp.* and other estuarine nekton, and thereby restoring and enhancing the estuarine food web and trophic network of the Narrow River Estuary.

F.5.3. Alternatives Analysis

The EA provides a full alternatives analysis of the proposed action. This section evaluates alternatives as they may potentially affect EFH and managed species only. Two alternatives were evaluated: the no-action alternative, and the proposed restoration action described above.

The no-action alternative would have no immediate impacts on EFH; however, the habitats of the Narrow River Estuary, including EFH such as deeper estuarine areas and low salt marsh, will continue to decline, as demonstrated by current trends in the estuary. The no-action alternative is expected to lead to a reduction in eelgrass beds; a reduction in vegetated marsh areas; and a reduction in salt marsh habitat health and abundance. As marshes continue to erode and decline, the no-action alternative is expected to lead to increased sedimentation and reduced water quality. The no-action alternative would therefore have a long-term adverse effect on EFH and managed fish species in the Narrow River Estuary.

Flood and ebb tidal deltas are likely to continue their expansion, resulting in some loss of deeper areas which provide cool water refugia for winter flounder and foraging habitat for larger species such as striped bass. Similarly, habitat available for eelgrass will decline commensurate with loss of deeper channels.

Saltmarsh habitat will continue to decline in extent by an estimated 6.2 acres per decade, and eventually succumbing to sea level rise, and turning into mudflats with eventual loss. Continued entrapment of water on the saltmarsh surface will further degrade vegetation, which will become less dense with open bare pans becoming prevalent. This will hamper the marshes ability to keep pace with sea level rise, hastening the time period before loss. Marsh channels and creeks will continue to fill with sediments, limiting fish access to the upper marsh surfaces for foraging.

Under the no-action alternative, as deeper estuarine habitats and eelgrass beds are reduced in the estuary, these species will become more vulnerable to predators, with potential local and regional impacts. These species are important components of the diet of striped bass, the most important and valuable recreational fishing species on Narragansett Bay, which also tend to utilize deeper areas of the estuary. The no-action alternative is expected to allow further declines in diadromous fish and striped bass in the estuary and Narragansett Bay; this, in turn, will affect the fishing and recreational values of the estuary and Rhode Island.

The overall loss of estuarine habitat diversity caused by the no-action alternative will lead to reduced fish diversity in the estuary, with consequences for many other kinds of fish and wildlife, both within and beyond the Narrow River Estuary.

The proposed restoration action will provide significant improvement of EFH and shallow-water habitats -- specifically, a restoration of historic estuarine habitat mosaic; restoration and improvement of estuarine habitat diversity; restoration and improvement of estuarine habitat complexity; improvement of areas for fish passage, feeding, predator protection and thermal refuge. By restoring deeper areas suitable for eelgrass bed establishment, the proposed action is likely to result in an increase in habitat considered most

important to managed species in the estuary. By reducing the process of marsh erosion and loss, the proposed action will reduce sedimentation and restore and maintain estuarine water quality. The proposed restoration action will therefore provide significant short- and long-term benefits to EFH and managed fish species.

The proposed action has the potential for minor negative impacts on EFH, including minor short-term construction impacts, and minor loss of low-value tide flat habitat. In implementing the Narrow River Estuary Resiliency Restoration Project, All practicable measures to avoid and minimize such potential impacts to EFH, including the observance of seasonal restrictions, sediment controls where warranted, minimization of operations on marsh surfaces, and use of best construction practices such as stormwater management at staging areas.

The alternatives analysis demonstrates that the proposed action is preferred in order to preserve and restore EFH and managed species.