A Concise Environmental Assessement (EA) for Emergency Restoration of Seagrass Impacts from the Deepwater Horizon Oil Spill Response

1. Introduction

The National Oceanic and Atmospheric Administration's (NOAA) Restoration Center proposes to conduct emergency restoration in the Gulf of Mexico to restore seagrasses that were injured during the response to the DWH Oil Spill. In April 2010, an accident at the Mississippi Canyon 252 Deepwater Horizon drilling site caused a huge spill of oil in the Gulf of Mexico (Gulf). The oil release occurred in very deep Federal waters but spread to coastal areas and had impacts to marine and coastal resources in ecosystems along the coastal waters of Florida, Alabama, Mississippi, Louisiana and Texas.

Under the Oil Pollution Act of 1990 (OPA), several federal and state agencies have been designated as natural resource trustees (Trustees) and include the Department of Commerce, represented by NOAA; the Department of the Interior; the Department of Defense, represented by the Navy; and all five states mentioned above. Under OPA, the Trustees must assess injuries to natural resources and prepare a restoration plan to compensate the public for impacts to those resources. As a part of this process, OPA provides for the implementation of emergency restoration, where doing so will reduce or prevent additional spill-related injury to resources. The Trustees have considered this provision and have agreed that emergency seagrass restoration is appropriate to address spill-related injuries to seagrasses in the Gulf. NOAA's Restoration Center (RC) has been designated as the lead on behalf of the Trustees to conduct the proposed emergency seagrass restoration.

2. Purpose and Need for Action

2.1. *Purpose*

Injuries to natural resources can happen as a direct result of oiling, as a result of response activities, or a combination of the two. The purpose of the proposed seagrass restoration is to address injuries to seagrass beds that resulted from response activities by motorized boats, including propeller scars, blowholes from response vessels, or scouring from boom curtains and anchor tethers. Seagrass scar injuries are formed by the dredging effect of the turning propeller, or occasionally the vessel's hull, as the boat travels over a shallow bank. The severity (width and depth) of propeller scars varies depending on many factors, including the size of the vessel and the extent to which the propeller is forced into the seagrass bed. Blowholes are depressions formed from the concentrated force of propeller wash as a vessel attempts to power off a shallow seagrass bed. The depth and area of the blowholes also vary depending on the size of the vessel, extent of power used to remove the vessel, and type of bottom substrate in which the seagrass is growing. Scouring of seagrass beds from boom curtains occurs when a boom is placed in shallow water over a seagrass bed and is pulled across it. Injury from placement of large anchors that hold the booms in place has also been observed, and can create holes and scars when the anchor is relocated or removed. Once an injury occurs, rising and falling tides, wind, waves, vessel wakes or currents can exacerbate it.

2.2. *Need for Action*

The proposed restoration actions are necessary to restore the damaged seagrass beds and decrease the risk of secondary injury to nearby seagrass communities from the unstable conditions created by wide propeller/scouring scars and blowholes at affected sites. Progressive deterioration of seagrass injuries from storm and hurricane force wave energy has been documented to expand seagrass injuries in such cases. Delays in restoring the injured seagrass areas could result in more damage to the seagrass beds, hence longer times for restoration efforts and increased labor costs.

2.3. *Authorities and Legal Requirements*

Each agency is a designated natural resource trustee under OPA (33 U.S.C. §2706(b)), and the National Contingency Plan (40 C.F.R. §§300.600 et seq.), for natural resources and services injured by the Deepwater Horizon oil spill. Each agency, as a designated trustee, is authorized to act on behalf of the public under federal and state law to assess natural resource damages and to plan and implement actions to restore natural resources and services injured or lost as the result of a discharge or substantial threat of a discharge of oil.

2.3.1 Overview of OPA – Emergency Restoration Requirements

NRDA is described under Section 1006(c) of OPA (33 U.S.C. § 2706(c)). Under the OPA NRDA regulations at 15 C.F.R. Part 990, the NRDA process consists of three phases: 1) Preassessment; 2) Restoration Planning; and 3) Restoration Implementation. Before completing the NRDA process, the Trustees may take emergency action provided that:

(1) The action is needed to avoid irreversible loss of natural resources, or to prevent or reduce any continuing danger to natural resources or similar need for emergency action;
(2) The action will not be undertaken by the lead response agency;
(3) The action is feasible and likely to succeed;
(4) Delay of the action to complete the restoration planning process established in this part likely would result in increased natural resource damages; and
(5) The costs of the action are not unreasonable.

2.4. *Coordination with the Responsible Party*

The OPA natural resource damage assessment regulations (15 CFR Part 990) require the Trustees to provide notice to identified responsible parties (RP) of any emergency restoration actions and, to the extent time permits, invite their participation in the conduct of those actions as provided in section 990.14(c) of OPA.

NOAA, as the federal lead on behalf of the Trustees, has coordinated all aspects of restoration planning for emergency restoration with the RP. In turn, the RP's representatives have been a part of field reconnaissance work. The data gathered during these activities will be used to develop a restoration plan, complete with costs, that will be presented to the RP for funding and implementation.

2.5. *Coordination with the Public*

Section 990.26(d) of OPA requires the Trustees to provide notice to the public, to the extent practicable, of any planned emergency restoration actions. Trustees must also provide public notice of the justification for, nature and extent of, and results of emergency restoration actions within a reasonable time frame.

The Trustees are currently considering the best method to address this requirement, which could include posting pertinent documents (Final Environmental Assessment, Final Restoration Plan, annual monitoring reports, etc.) to NOAA's Deepwater Horizon website.

3. Alternatives Considered

3.1. *No Action Alternative*

Under the no action alternative, the Trustees would not conduct emergency restoration activities to restore seagrasses and natural resource services they provide. Existing conditions would have the potential to recover naturally over time, however, the condition of many of the injured areas could get worse due to wind, waves, storms, and subsequent navigation activities.

3.2. *Preferred Alternative*

3.2.1 <u>Description of Proposed Action</u>

The proposed action would be phased, and include evaluating areas with injury to seagrasses, identifying an appropriate type of restoration for that area, and implementing the restoration. It is important to note that NOAA will ensure that any boats being used in restoration activities to implement the preferred alternative will avoid causing the same kind of damage to seagrassess that response boats caused. There will be careful oversight by Trustees in the implementation of the restoration actions.

3.2.2 <u>Site Identification and Characterization</u>

The first steps taken have been to document and map potential and known impacts to seagrass beds from response vessels. A desktop exercise was used to overlay GIS map layer files and analyze where known areas of seagrass beds intersect with known areas of boom use and other types of injurious response activities. Depth contours of less than one meter depth (3.3 ft) were targeted to identify potential sites with a high likelihood of injury to seagrass beds. This information was cross-referenced with reports of actual vessel and boom impacts to seagrass beds and a thorough review of high resolution aerial imagery (Aerometric October 2010 imagery).

NOAA's field staff has performed on-site verification of about 65 areas that were identified in the first phase of the integrated desk-top GIS analysis. In situ verification involved actual site injury confirmation, using coordinates within GIS generated polygons of prioritized areas of known and potential response injuries. NOAA staff evaluated and characterized seagrass injuries, and environmental conditions surrounding the potential restoration site. Information collected during the site visits included the areal extent of injury (length times width) and its configuration, sediment characteristics, depth of scar/scour, adjacent seagrass species, proximity to other injuries, and surrounding site attributes, etc. Characteristics of the injuries that were identified allowed for more precise and informed decision making regarding prioritization of sites and potential alternatives for restoration.

3.2.3 Identification of suitable restoration methods, and prioritization

The following criteria were used to help focus site selection and preferred restoration alternatives identified in this plan. These criteria helped determine the likelihood of an action to satisfy the restoration objective while taking into account technical, environmental, economic, and social factors.

Criteria for Evaluating Restoration Options

- *Technical Feasibility* – this criterion includes the likelihood that a given restoration action will work at the site and that technology and management skills exist to implement the restoration action. Factors considered include depth, current regimes, ability for restoration teams to work in the area and travel distance.

- *Reducing Recovery Time* – use of measures that will accelerate or sustain the long-term natural processes important to recovery of the affected resources and/or services injured or lost in the incident. Species composition (seagrass) will be a factor here, with *Thalassia testudinum* dominated habitats generally requiring more intensive restoration than *Halodule wrightii*, but exceptions to this general rule exist (Kenworthy et al. 2000).

- *Reducing Potential for Additional Injury* – the likelihood that the requirements, materials, or implementation of a restoration action will minimize the potential for additional injury. Factors may include fetch/exposure to wind and wave energy, proximity to highly traveled navigation channels and current regime.

- *Aesthetic Acceptability* - use of restoration alternatives that will create substrates and topography that most closely resemble the surrounding habitat and minimize visual degradation.

- *Site Specific Context* – selection of restoration alternatives depending on the site specific context of existing environmental conditions. Factors may include, but are not limited to, the following: location, extent and severity of the injury, hydrological characteristics of the site, seagrass species composition, and other social and resource management concerns.

Information gathered by the field teams is necessary for developing, prioritizing and selecting injured sites (e.g. maps of specific injured areas), as well as for determining the appropriate successful methods for restoration activities.

Project Implementation and Construction Timeline

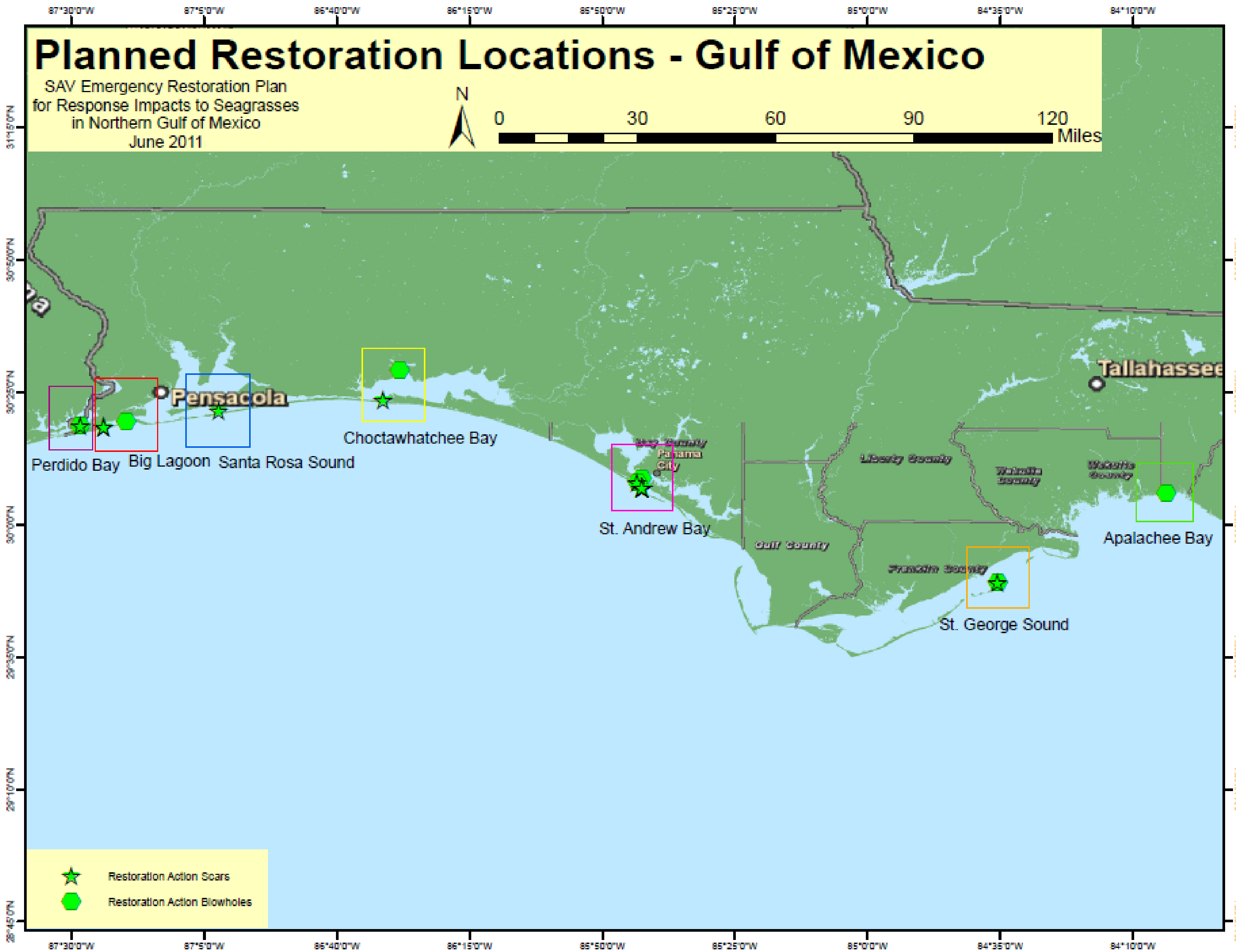
Schedule	**Actitivity**
Feb/March 2011	Damage Assessment: GIS review/Site Identification (done)
May 2011	Field Reconnaissance (done)
May 2011	Develop Regionally-based Restoration Plan
June 2011	Permitting , consultations, and EA
June/July 2011	Develop 6-year Monitoring Plan (done)
June 2011	Write statement of work, determine contracting method
July 2011	review bids and award contract
July - Aug 2011	Implement restoration activities
Aug. 2011 – Aug. 2017	Monitoring (per 6-yr plan)

4. Affected Environment

4.1 *Proposed Action Area*

The proposed action area is within coastal areas of the Gulf of Mexico in state waters of Florida (Fig.1). The area of seagrass habitat proposed for restoration includes about 526 square meters of seagrass scars and about 115 square meters of blowholes. These seagrass habitats are located within areas of Perdido Lagoon, Pensacola Bay (Santa Rosa Sound), Choctowhatchee Bay, St. Andrews Bay, and St. George Sound (Apalachee Bay).

Figure 1. Map of East Florida showing location of potential restoration sites.



4.2 *Seagrass functions*

Healthy seagrass communities serve critical ecological and economic functions in the Gulf of Mexico. The predominant species of seagrasses are *Thalassia testudinum*, *Syringodium filiforme*, and *Halodule wrightii*. From an ecological perspective, seagrass beds serve as nursery habitat and as a source of food for numerous species of fish, which from an economic perspective help support recreational and commercial fishing. Over 70% of recreationally and commercially important fish and invertebrates in the Gulf of Mexico spend some portion of their lives in seagrass systems (Florida Fish and Wildlife Commission, [FWC], 2003). Highly productive seagrass meadows also export their productivity to continental shelf communities either directly as detritus or in trophically converted biomass in the form of migrating fish and invertebrates.

Furthermore, seagrass beds create a frictional buffer to storm surge and also serve as natural filters to reduce the level of suspended sediment and nutrients in the water. Seagrass meadows are also extremely important in storing carbon and buffering against carbon dioxide mediated climate change. Although covering only 0.1% of the seafloor globally, 15% of the total surplus carbon fixed in the oceans is stored in seagrass (Duarte and Chiscano, 1999) and seagrass meadows sequester 50 times the carbon in their hydrosoils per hectare when compared with tropical rainforests (Laffoley and Grimsditch, 2009). Restoration of seagrass injuries is an important step in reducing the cumulative impact to seagrasses throughout the nearshore waters, and in preserving this important ecosystem.

For further descriptions of the potentially affected seagrasses, please see Appendix 1.

5. Environmental Effects

5.1. *No Action Alternative*

Under the no action alternative, there are two potential outcomes: 1) natural recovery (this may occur, but would take longer compared to pro-active restoration alternatives); and 2) further deterioration of seagrass beds.

Implementing a no-action alternative would rely on natural processes for sediment to fill blowholes and propeller/scouring scars, and natural re-colonization of seagrass species to occur. Selecting the no-action alternative could also increase the risk of secondary injury to nearby seagrass communities from the unstable conditions created by wide propeller/scouring scars and blowholes at the grounding site. Progressive deterioration of seagrass injuries from storm and hurricane force wave energy has been documented to expand seagrass injuries in such cases (Whitfield, 2002). Areas with high current regimes, such as those waters near inlets or along shorelines with offshore fetch are also prone to longer term recovery or further deterioration. The no-action alternative is most often used when restoration specialists determine an injury site is more likely to recover in a short period of time with a low likelihood of injury expansion (Uhrin, et al, 2010), or where other social, environmental, or logistical considerations dictate that no-action is the best course. If selected, this alternative could delay recovery of injured seagrass resources and reestablishment of ecosystem services.

5.2. *Preferred Alternative*

5.2.1. Seagrass Transplants

Planting of seagrass in injured areas is known to be an effective way of stabilizing the sediments and decreasing the injury recovery time (Fonseca et al. 1998). In combination with fertilization, planting faster growing opportunistic species like *Halodule wrightii* or *Syringodium filiforme* serve as a temporary substitute for the climax species, *Thalassia testudinum*. This temporary substitution is referred to as "modified compressed succession" (Durako and Moffler 1984; Lewis 1987). Depending on the environmental conditions at the restoration site, the selection of seagrass transplants as a preferred restoration alternative will vary. For example, transplants may be selected most frequently at more quiescent sites where the probability of transplant loss due to high water velocity is lowest. Due to the high risk of hurricanes between August 15 and October 15, no seagrass transplanting will be done during this period.

Seagrass transplants will be selectively removed from healthy seagrass beds located near the injury site, or from local seagrass beds designated previously by the Trustees as "donor" beds. Donor material will be collected in accordance with all necessary permits and in a manner to ensure that the donor seagrass beds are not degraded (Fonseca et al. 1998). No adverse impacts to the ecological health of neighboring seagrass communities are anticipated from collection of seagrass transplant materials.

The number of seagrass transplants and stakes required for propeller/scouring scars is determined according to general guidelines explained below. These guidelines are subject to change pending site-specific injury characteristics and the professional judgment of NOAA and the State restoration experts. In general, the first row of bird stakes and seagrass transplants are inserted 0.5 meters from the edge of the scar. If the propeller/scouring scar is wider than 0.5 meters then subsequent rows of stakes and seagrass transplants are inserted with 2.0 meters distance between each row. If the width of the scar is less than 0.5 meters, then a single row is placed in the middle of the scar. In each row, stakes are placed every 2.0 meters and seagrass transplants located every 0.5 meters between the stakes. For scars that have a wide and/or uneven scar geometry, for example, blowholes, the staking and seagrass transplant sequence is similar to that used for wide propeller/scouring scars; however in addition the perimeter of the blowhole is staked at 2.0-meter intervals. Over time, stakes may be re-positioned and additional seagrass transplants inserted as necessary, depending upon transplant survival and restoration success criteria thresholds achieved.

It is unlikely that use of transplants will have any adverse effect to federally protected or managed species or cultural resources, since any initial disturbance will only be very brief, and would not interfere with migration, nesting or refuge areas.

Protected species in the areas for restoration include sea turtles, manatees, and Gulf sturgeon. Placement of the transplants and/or bird stakes and signage will entail personnel entering the water for brief periods. Signs and stakes will be placed by hand. All protected species likely present in these areas are highly mobile and will be able to avoid the restoration activity. Sea turtles and manatees are likely to feed in these areas, signage and bird stakes will be placed at great distances apart (minimum 2 meters) so there will be no impacts on the passage of these species. Sturgeon are not likely to be using the seagrass habitat for feeding because they typically feed in bare sandy substrate. If they do choose to feed in the seagrass bed, their activities would not be affected. There will be no impacts to the function of critical habitat as the area taken up by the posts for bird stakes and signage is insignificant, relative to the total area, and all bird stakes will be removed following completion of the project.

The result of the restoration will be a net benefit to the existing seagrass communities, to the habitat services they provide , and to biological resources that depend on them.

5.2.2. Use of Bird Stakes

For most areas of the Gulf of Mexico, seagrasses are not nutrient limited. However, vessel injuries that disturb the sediment nutrient reservoir and physically alter the properties of the substrate may alter this condition. Where phosphorous is a limiting nutrient factor, a method of fertilization that uses bird roosting stakes ("bird stakes" or "stakes") has proved to be successful in the Florida Keys and South Florida region (Fourqurean et al. 1992a; Fourqurean et al. 1992b; Fourqurean et al. 1995; Kenworthy et al. 2000). The nutrient composition of bird feces deposited from birds using the stakes was documented to be an effective treatment to encourage re-growth of seagrasses in disturbed sediments, and/or caused faster growth of seagrass transplants.

Placement of bird stakes will follow published guidelines (Fonseca et al. 1998; Kenworthy et al. 2000). These consist of PVC pipes with wooden perches approximately 0.5 meter above high water and will be placed every two meters within a scar. To be effective, bird staking requires that bird feces reach the seafloor at effective concentrations. Water depths of 1.5 meters or less at high tide are generally considered ideal for bird staking. At water depths greater than one-meter Mean High Water (MHW) bird stakes will not be used. Depending on how water depth changes over the injury area, the length of each stake may vary slightly in order to maintain approximately 0.5m elevation above the high water level.

In most cases, bird stakes will accompany seagrass transplants. However, at injury locations with a high density of fast-growing species such as Halodule wrightii in the undisturbed seagrass populations adjacent to injury sites, the insertion of bird stakes alone may be sufficient to facilitate re-colonization. This decision is based on factors including the exposure of the site to wave action, density of fast-growing species in the undisturbed side populations, scar substrate composition, and type of nutrient limitation in sediments and surrounding waters.

The possibility for bird stakes interfering with vessel navigation is low, as bird stakes will be positioned in shallow water areas that should be avoided by motorized or wind powered vessels. In areas of high vessel traffic, additional steps may be taken to minimize the possibility of confusing stakes for navigational aids. This may involve the placement of additional bird stakes at either end of the prop scar or displacement of shallow water caution signs around the restoration site.

It is also unlikely there would be any adverse affect to federally protected or managed species or cultural resources, since placement of the stakes can occur quickly and disturbance if any, is only very brief. Movement of fish or wildlife will not be impeded by the stakes, and the stakes will only be temporarily in place. Stakes may need to be in place at the injury site for the full duration of the monitoring period when appropriate, but will be removed as soon as recovery is documented as being well underway. Observations have shown that placement of stakes actually deters boats from these areas during their deployment time allowing seagrass to recover with minimal further human disturbance.

5.2.3. Sediment Fill

The filling of blowholes or wide propeller and scouring scars is a rapid way of returning the seafloor to its original elevation and grade. In general, any excavation with an escarpment (i.e., drop-off) greater than 15 cm depth at the perimeter is considered a potential candidate for filling. The focus of this alternative is to stabilize the substrate as soon as possible after an incident. This will prevent further deterioration of the seagrass bed as a result of erosion, prepare the area for re-colonization by neighboring or transplanted seagrasses, and reduce likelihood of rhizome meristem photoinhibition.

Wherever this alternative is determined to be most appropriate, native fill (i.e., local sediment) of the same granulometry and composition as that of the injury site will be transported to the site, and directly placed in the designated injury areas. Sediment materials will be transported to the site by a means deemed feasible by the contractor selected to do the restoration. Feasibility must include no damage to seagrass in areas adjacent to injuries. No visual impairment will occur and many of the repairs will be indistinguishable from surrounding substrate within a short period of time. All operations will conform to engineering specifications and comply with federal and state permits. No negative impacts to vessel navigation or the ecological health of neighboring seagrass or other aquatic communities are anticipated from the placement of sediment fill.

Fill will be placed in a blowhole or propeller/scouring scar up to 10 cm above level grade. After fill is placed, it must be allowed to settle for at least 60 days before any other restoration action (e.g. staking, planting) is taken. If it is determined that the fill has settled below grade, it may be necessary to add more fill and wait another 60 days to establish whether or not it has settled.

It is anticipated this activity will have only very brief and minor effects to any federally protected or managed species or cultural resources. The duration and extent of disturbance will not significantly interfere with migration, nesting or refuge areas, since adjacent areas of similar habitat will be available and undisturbed, and most organisms could easily move away from disturbance activity to undisturbed areas when it occurs. The result will be a net benefit to the present benthic and seagrass communities, and to the habitat services they provide to biological resources dependent on them.

5.2.4. Sediment Tubes/Bags

An additional seagrass restoration technique involves the placement of biodegradable sediment-filled fabric mesh tubes or bags (referred hereinafter as “sediment tubes”) inside a propeller/scour trench, or on top of sediment fill when placed in blowholes (Hall et. al 2006). The sediment tubes are about 1.5 m (~1.6 ft) in length and 15 – 20 cm (6 – 8 inches) in diameter and weight about 30 – 40 pounds when filled with sand (Hall et. al 2006). They are effective in reducing erosion rates in injuries and fostering conditions suitable for natural re-colonization of the injured area by neighboring seagrasses and growth of seagrass transplants. Sediment tubes as a restoration technique may be appropriate in a variety of injury locations including , but not limited to, propeller scar injury excavations and small blowholes or when blowhole fill requires a protective barrier to reduce erosional forces. As such, the design of tubes will be slightly tailored to the specific geometry of each injury.

Most of the tube deployments would involve hand-placement of a single tube within the prop scar, to cap the sediment in the excavation and fill the void created by the vessel impact. Use of tubes does not include a 10 cm above-grade topping of sediment fill, which is required when tubes are not used. If seagrass transplants are also required, they will be planted in the tubes by insertion through perforations in sediment tube materials. Depending on the specific context of the injury, sediment tubes may be used in combination with any other restoration technique to expedite stabilization and recovery of the injured area. A primary advantage of using sediment tubes is their ability to mitigate erosional forces that may otherwise act to remove or displace the sediment fill as seagrass plants begin to recolonize the injury site. Depending on the specific conditions of an injury site, it is foreseeable that restoration actions may include a combination of techniques in order to most effectively stabilize the site and encourage seagrass recolonization.

The placement and use of these biodegradable tubes would have no adverse effects to any federally protected or managed species or cultural resources. The duration and extent of this disturbance will not significantly interfere with migration, nesting or refuge areas, since adjacent areas of similar habitat will be available and undisturbed, and most organisms could move away from disturbed areas when it occurs. The result will be a net benefit to the benthic and seagrass communities present, to the habitat services they provide, and to biological resources that depend on them.

6. Cumulative Effects

Cumulative effects include the effects of current and future similar actions that are reasonably certain to occur in the action area considered in this EA. There are no known current similar actions proposed or being conducted within the area of potential effect. Any future similar actions that may be contemplated would need to be considered by the Trustees, and at this time it is unknown if any such actions are likely to be proposed. Future federal actions that are unrelated to the proposed action were not considered, since no categories of effects beyond those already described above are expected in the action area.

7. Agencies Consulted/Permits Required

NOAA will coordinate with each Gulf state to secure required federal and local permits.

7.1. *Federal permits and required approvals:*

- National Marine Fisheries Service, Southeast Region (St. Petersburg, FL) - for ESA section 7 informal consultation, and MSA/EFH consultation.
- Department of the Interior - U.S. Fish and Wildlife Service for ESA section 7 informal consultation.
- U.S. Army Corps of Engineers for obtaining a Nationwide # 32 exemption, covering these types of restoration activities.

7.2. *State approvals:*

It is anticipated that the following permits will be required:

- FL – A '*de minimis* exemption' will be requested from the Florida Department of Environmental Protection for compliance with Environmental Resource Permit Requirements. If seagrass transplants are used, an Aquatic Plant Permit is also required under Florida Statutes Chapter 369 (from Dept. of Agriculture and Consumer Services Chapter 5B-64, F.A.C.); sign posting permits required from Florida Fish and Wildlife Commission (FWC).

8. Attachment - Finding of No Significant Impact (FONSI)

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LIST OF APPENDICES

APPENDIX 1. General characteristics of seagrasses to be restored

APPENDIX 2. List of common species found in seagrasses (from various sources)

APPENDIX 3. List of restoration sites and proposed restoration techniques

APPENDIX 1. General characteristics of seagrasses to be restored

Species Name	Common Name	Temperature Range (° C)[1]	Salinity Range (ppt)[2]		Range
Halodule wrightii	Shoalgrass	9 - 37	3.5 - 44	• Grows in the lower intertidal and upper subtidal zones on sandy and muddy substrates in sheltered and exposed locations • Grows on coral reefs and in creeks in mangrove swamps • Found in waters up to 8- 12 m deep[3] • This grass is relatively hardy, and is known as a pioneer species in bare sediment habitats. In Santa Rosa Sound the landward distribution of this species is limited by mean low water, but it does tolerate limited air exposure and low temperature associated with shallow water.[4]	Caribbean, Gulf of Mexico
Thalassia testudinum	turtlegrass	20 - 35	3.5 - 60	• Commonly occurs in subtidal waters from low tide to 10 m deep • In clear water the species is found in water up to 30 m	Distributed in the tropical western

[1] Fonseca M.S., Kenworthy W.J., Thayer G.W.1998. "Guidelines for the Conservation and Restoration of Seagrasses in the United States and Adjacent Waters". NOAA Coastal Ocean Program Decision Analysis Series No. 12. NOAA Coastal Ocean Office, Silver Spring, MD. 222pp. p. 98.

[2] Fonseca M.S., Ibid.

[3] (Phillips, R. Florida Fish and Wildlife Conservation Commission website http://myfwc.com/research/habitat/seagrasses/information/gallery/halodule-wrightii-shoalgrass-(1)/)

[4] (Flora and Fauna of Northwest Florida, University of West Florida web site at: http://uwf.edu/rsnyder/ffnwf/seagras/seagras.html)

				deep • Prefers mud and/or mud substrates in relatively sheltered locations [5] • Thick piles of shed *Thalassia* blades are common on area beaches in the winter. *Thalassia* will not tolerate any air exposure in Santa Rosa Sound, FL and so it does not occur as close into shore as *Halodule*. Its shoreward distribution is mostly controlled by the lowest low tides that occur in winter. As a result, there is a band of pure *Halodule* close to shore, and mixed *Halodule* and *Thalassia* out further to a depth of 6-8 feet. Beyond that depth, light penetration to the bottom is reduced beyond the needs of both plants.[6]	Atlantic from Venezuela to eastern Florida and Bermuda

[5] (Phillips, R. Florida Fish and Wildlife Conservation Commission website: http://myfwc.com/research/habitat/seagrasses/information/gallery/thalassia-testudinum-turtle-grass-(1)/)

[6] (Flora and Fauna of Northwest Florida, University of West Florida web site at: http://uwf.edu/rsnyder/ffnwf/seagras/seagras.html)

Syringodium filiforme	Manatee grass	20 - 35	20 - 35	• Restricted to the subtidal zones and thrives at 0.7- 0. 5 m deep • Often occurs in mixed meadows with *Thalassia testudinum* • May form monospecific meadows down to 18 m deep[7] • Manatee Grass typically grows at depths ranging from around one to three meters[8] • It is found in the sublittoral zone (the region between the low tide mark and the edge of the continental shelf) of marine waters with sandy or muddy bottoms[9]	Manatee Grass is found in Florida, Louisiana, Mississippi, and Texas; eastern Mexico; the West Indies; Bermuda; Central America (Belize, Nicaragua, Costa Rica, Panama); and northern South America (Colombia, Venezuela) [10]

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7 (Florida fish and Wildlife Commission webstire at : http://myfwc.com/research/habitat/seagrasses/information/gallery/syringodium-filiforme-manatee-grass/)

8 Duarte, C. M., Marba N., Krause-Jensen D., & Sanchez-Camacho M. (2007). Testing the Predictive Power of Seagrass Depth Limit Models. Estuaries and Coasts. 30, 652-656.

9 Haynes, R. R. (2000). Cymodoceaceae: Manatee-grass Family. (of Committee F., Ed.).22, 86-89. New York: Oxford University Press.

10 Haynes, R. R. Ibid.

APPENDIX 2. Species found in seagrass (from various sources).

1. List of common species associated with seagrasses in Santa Rosa Sound, FL (Flora and Fauna of Northwest Florida, University of West Florida web site at: http://uwf.edu/rsnyder/ffnwf/seagras/seagras.html)

Crustaceans	
Amphipods	*Gammarus* sp.
Green Striped Hermit Crab	*Clibanarius vittatus*
Blue Crab	*Calinectes sapidus*
Spider Crab	*Lubinia emarginata*
Mud Crab	*spp*
Grass Shrimp	*Palaemonetes sp.*
Broken Back Shrimp	*Hippolyte* sp.
White Shrimp	*Penaeus setifers*
Pink Shrimp	*Penaeus duorarum*
Brown Shrimp	*Penaeus aztecus*
Snapping Shrimp	*Alepheus heterochaeli*s
Coelenterates	
Hydroids	
Molluscs	
Crown Conch	*Melongena corona*
Oyster	*Crassostrea virginica*
Bay Scallop	*Argopecten irradians*
Lightning Whelk	*Busycon contrarium*
Mud Snail	*Ilyanassa obseleta*
Oyster Drill	*Urosalpinx cinerea*
Fishes	
Goby	spp.
Pinfish	*Lagodon rhomboides*
Pipefish	*Syngnathus scovelli*
Toadfish	*Opsanus beta*
Bay Anchovy	*Anchoa mitchelli*
Silverside	*Menidia berylina.*
Killifish	spp
Spotted Seatrout	*Cynoscion nebulosus*
Red Fish (drum)	*Sciaenops ocellatus*

Croaker	*Micropogonias undulatus*
Spot	*Leiostomous xanthurus*
Needlefish	*Strongylura marina*
Ladyfish	*Elops saurus*
Striped burrfish	*Chilomycterus schoepfi*

2. List of common macrobenthic animals associated with seagrasses in Santa Rosa Sound, FL from Table 2 in Stoner et al. 1983. (Allan W. Stoner, Holly S. Greening, Joseph D. Ryan, Robert J. Livingston. 1983. Comparison of Macrobenthos Collected with Cores and Suction Sampler in Vegetated and Unvegetated Marine Habitats. Estuaries, Vol. 6, No. 1 (Mar., 1983), pp. 76-82

Amphipoda

Ampelisca verrilli
Cymadusa compta
Gammarus mucronatus
Gitanopsis tortugae
Grandidierella bonnieroides
Haustorius sp.
Monoculodes edwardsi
Paracaprella pusilla
Pontogenia sp.

Polychaeta

Amphicteis gunneri
Amphinome rostrata
Aricidea sp.
Axiothella mucosa
Chone sp.
Eteone heteropoda
Glycinde solitaria
Haploscoloplos fragilis
Heteromastus filiformis
Loandalia americana
Mediomastus californiensis
Nereis sp.
Platynereis dumerili
Polydora socialis
Potamilla reniformis
Scolelepis squamata
Sigambra bassi
Streblospio benedicti
Syllis sp.

Mollusca

Acteocina canaliculata
Amygdalum papyria
Crepidula maculosa
Ensis minor
Mactra fragilis
Mitrella lunata
Mulinia lateralis
Polinices duplicata
Unident. pelecypod (juv.)

Isopoda

Edotea sp.
Erichsonella filiformis
Hargeria rapax (tanaid)
Paracerceis candata
Mysidacea
Bowmaniella dissimilis
Mysidopsis bahia
Mysidopsis bigelowi
Taphromysis bowmani

Decapoda

Callinectes similis
Clibanarius vittatus
Hippolyte zostericola
Pagurus bonairensis
Penaeus aztecus
Periclimenes longicandatus
Portunus gibbesii
Unid. shrimp postlarvae
Unid. Megalops

Cumacea

Nemertea

Oligochaeta

Turbellaria

3. List of common fish species associated with seagrasses in Laguna Madre TX from Table 2 in Tolan et al. 1997 (Tolan, J. M., Scott A. Holt and Christopher P. Onuf. 1997. Distribution and community structure of ichthyoplankton in Laguna Madre Seagrass meadows: Potential impact of seagrass species change. Estuaries and Coasts. Volume 20, Number 2, 450-464.)

TABLE 2. List of species captured from Redfish Bay, Texas, in the seasonal seagrass study, 1993.[a] Total number of organisms and percent total are given in descending order of abundance. Species common names follow Robins et al. (1991).

Species Common Name	Scientific Name	Total Number	Percent Total
Larval anchovy	*Anchoa* spp.	82,201	76.51
Gulf menhaden	*Brevoortia patronus*	10,333	9.62
Tidewater silverside	*Menidia peninsulae*	2,731	2.54
Bay anchovy	*Anchoa mitchilli*	2,612	2.43
Code goby	*Gobiosoma robustum*	1,856	1.73
Pinfish	*Lagodon rhomboides*	1,670	1.55
Gulf pipefish	*Syngnathus scovelli*	989	0.92
Naked goby	*Gobiosoma bosc*	609	0.57
Spotfin mojarra	*Eucinostomus argenteus*	573	0.53
Red drum	*Sciaenops ocellatus*	526	0.49
Dusky pipefish	*Syngnathus floridae*	410	0.38
Spotted seatrout	*Cynoscion nebulosus*	385	0.36
Chain pipefish	*Syngnathus louisianae*	375	0.35
Blenniidae sp.	Blenniidae spp.	364	0.34
Lined sole	*Achirus lineatus*	341	0.32
Green goby	*Microgobius thalassinus*	280	0.26
Sciaenid sp.	Sciaenidae spp.	267	0.25
Spot	*Leiostomus xanthurus*	235	0.22
Striped anchovy	*Anchoa hepsetus*	82	0.08
Silverside sp.	Atherinidae spp.	72	0.07
Goby sp.	Gobiidae spp.	70	0.07
Darter goby	*Gobionellus boleosoma*	52	0.05
Sole sp.	Soleidae spp.	41	0.04
Least puffer	*Sphoeroides parvus*	33	0.03
Scaled sardine	*Harengula jaguana*	33	0.03
Violet goby	*Gobioides broussoneti*	29	0.03
Dwarf seahorse	*Hippocampus zosterae*	27	0.03
Atlantic leatherjacket	*Oligoplites saurus*	27	0.03
Silver perch	*Bairdiella chrysoura*	24	0.02
Atlantic thread herring	*Opisthonema oglinum*	18	0.02

[a] Twenty-five additional species, each accounting for <0.01% of the total catch, were captured.

APPENDIX 3. List of restoration sites and proposed restoration techniques

Bay	Scar Length (m)	Scar Avg. Width (cm)	Blowhole area (m2)	Scar Avg. Depth (cm)	Area of damage (length x width) - m2	Volume of damage (area x depth) - m3	Sediment type (S- Sand; MS - Muddy Sand; SM - Sandy Mud)	Restoration Alternative
Big Lagoon	47	31	-	8.6	14.57	1.25302	S	Fill
Big Lagoon	30.4	28	-	7.2	8.512	0.612864	S	Fill
Big Lagoon	N/A		62.1	45	62.1	27.945	S	Fill and Plant
Big Lagoon	38.9	33		9.6	12.837	1.23	S	Fill and Plant
Santa Rosa Sound	593.7	52.8	n/a	6.1	313.47	19.12	S	Plant
Choctawhatchee Bay	-	n/a	1.4	19.3	-	0.2702	S	Fill
Choctawhatchee Bay	11.3	93.3	-	12.6	10.5429	1.3284054	S	Fill, Plant and Stake
St. Andrews Bay	-	n/a	2.2	41.7	-	0.9174	S	Fill
St. Andrews Bay	72.8	35.4	-	12.5	25.7712	3.2214	S	Fill
St. Andrews Bay	N/A	N/A	4	12	4	0.48	S	Fill and Plant
St. Andrews Bay	-	n/a	7.5	11	-	0.825	S	Fill and Plant
St. Andrews Bay	n/a	n/a	500	5.4	500	27.05	S	Stake only
Apalachee	-	n/a	24.2	110	-	26.62	MS	Fill
St. George Sound	16.8	75	-	13.8	12.6	1.7388	S	Fill
St. George Sound	-	-	5.4	15	-	0.81	S	Fill
Perdido	10	83	-	12.6	8.3	1.0458	S	Fill and Stake
Perdido	-	n/a	11.8	26.7	-	3.1506	S	Fill and Stake