Appendix I

Eelgrass and Bay Scallop Restoration Blueprint

For Southampton Town Waters in the South Shore Estuary Reserve

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Appendix 1A. Eelgrass Restoration Blueprint

The following "blueprint" is a comprehensive guide for the completion of eelgrass restoration work in the eastern SSER. This information is based on 15 years of experience working with eelgrass on Long Island, as well as information gathered as a result of the Eelgrass and Bay Scallop Restoration Planning Project and current knowledge of eelgrass requirements based on recent literature. These guidelines should be used in conjunction with the model in order to increase the likelihood of success of restoration efforts.

In order to keep all of the information as organized and concise as possible, all of the details necessary for planning, implementing and monitoring the restoration of eelgrass in the eastern SSER are listed in table format.

Tables include:

Table 1. Restoration Site Selection. The following parameters are to be used to select appropriate restoration sites. Available data for several of these factors were incorporated into the Eelgrass Planting Suitability Index Model. In this region, the primary factors affecting eelgrass growth and survival are temperature and light. It is crucial that peak temperatures in late summer don't exceed the tolerance of eelgrass and that enough light is available, especially because transplants are likely more vulnerable to stressors than established eelgrass. The water quality parameters that effect light penetration are highlighted in yellow. Testing one or more of these parameters should be sufficient in determining if enough light is available for eelgrass growth. Once light and temperature have been addressed, several other secondary factors should be considered, such as sediment composition, bioturbation, human conflicts, etc. These parameters should be used as a guideline along with the model for establishing eelgrass in the eastern SSER.

		Description		
		Optimal	**Minimum**	**Maximum**
Physical Parameters				
Peak Water Temperature(s) (Jul/Aug)		<25C	N/A	26C
LIGHT	Secchi Depth*	*See below for details*		
LIGHT	Light (% required at leaf compared to surface)	>22%	15%	N/A
LIGHT	Light (Kd)	<0.46	N/A	0.75
LIGHT	Depth (MLW)	1-2m	≈ 0.5m	3m
LIGHT	Chlorophyll *a*	<5.5 µg/L	N/A	15 µg/L
LIGHT	Total Nitrogen	<0.029mg/L	N/A	0.05 mg/L
LIGHT	Total Phosphorous	<0.071mg/L	N/A	0.08 mg/L
LIGHT	TSS (Total Suspended Solids)	<15 mg/L	N/A	30 mg/L
SEDIMENT	Sediment Grain Size	<15% silt & clay	N/A	15% silt & clay
SEDIMENT	Sediment % Organics	<2%	N/A	8%
SEDIMENT	Sediment sulfide concentration	<400 µM	N/A	1000 µM
Current velocity **		5<X<100 cm/sec *See below for details*		
Biological Parameters				
Existing eelgrass presence		Prefer sites with eelgrass existing within the same embayment, although planting should not be w/in 30m of existing meadow		
Historical eelgrass presence		Prefer sites which historically had eelgrass within the same embayment		
Drift Macroalgae		None	N/A	10%
Drift Macroalgae Species of Concern		Sites with significant presence (>10%) of large drift macroalgae spp. such as *Ulva lactuca* should be avoided.		
Beneficial Grazers		Presence of at least 1 of the following species: *Lacuna vincta, Illyanassa obsoleta, Littorina littorina, Bittium*		

	alternatum, Bittiolum varium, Mitrella lunata, Gammarus mucronatus, Hippolyte zosterae, Polychoerus caudatus, Idotea balthica, Palaemonetes spp.
Species of Concern/ Bioturbators	Significant seasonal and/or persistant presence of any of these spp. may exclude the site from consideration*: Libinia spp., Carcinus maenas, Ovalipes ocellatus, Busycon carica, Busycotypus canaliculatus, Cygnus olor, Branta canadensis, Lunatia heros, Limulus polyphemus, Cancer irroratus*
Human Related Interactions/Conflicts	
Shellfishing activity	None; wherever possible, select sites where shellfishing is not common
Shellfishing closure areas	If other conditions are suitable, sites that are permanently closed to shellfishing are preferred
Boating/Mooring/Marina areas	Any marinas, channels, mooring fields or other active boating areas should be excluded from consideration
Docks, Jetties, Hardened Shorelines	Should not be within 15 meters
Other	Any sites that have a high volume of people (e.g. such as popular bathing beaches) should be avoided.

*A simple and practical tool for measuring the clarity of the water is a Secchi disc. This instrument consists of a black and white disc that is lowered into the water column until it is no longer visible, which would be the "Secchi depth". Because much of the SSER is shallow, if during the growing season the Secchi disc is visible from the surface when resting on the bottom, or where the projected canopy height would be, enough light should be available for eelgrass to grow. The most crucial time to measure Secchi depths would be when algal blooms, turbidity, and other light-affecting factors would be at their peak, usually during the summer months. One method for tracking water clarity during this time would be through the use of volunteers on a scheduled basis.

**The current velocity coupled with other factors (e.g. bottom type) at a restoration site can determine which propagule would be most appropriate. From experience we know that eelgrass can thrive in areas with high current, but in order to establish eelgrass in these areas, adult shoots should be used as the propagule. Once plantings have become sustainable, then some seeding can occur within the planted eelgrass in order to increase genetic variation.

Table 2. Donor Site Selection. In order to assure minimal impact on donor meadows, the following parameters should be abided by when selecting donor sites for eelgrass vegetative and/or reproductive (flowering) shoots. Once the appropriate propagule for restoration has been chosen (seeds or shoots), donor site selection begins.

Parameters	Description
Shoot Collection Site	
Donor Meadow Size	≥ 5 acres total area
Donor Meadow % Coverage	Continuous to nearly continuous; ≥ 75% vegetative cover
Donor Meadow Shoot Density	Minimum of 200 shoots per m^2(w/in vegetative patches)
Seed Collection Site (Same as above plus the following)	
Physical Disturbance	Any site that recently has suffered physical damage should be avoided.
Seedling Recruitment	Any site that shows evidence of significant seedling recruitment (>10% of total shoot density as seedlings) should be eliminated as a potential collection site.
Reproductive Shoot Density	Any site with a reproductive shoot density of less than 10% or greater than 50% should be eliminated as a potential collection site.
Seed/Reproductive Shoot Density	Any site with a seed per reproductive shoot density of less than 10 should be eliminated as a potential collection site.

A. B.

Figure 1. A. An eelgrass (vegetative) shoot. B. An eelgrass flowering (reproductive) shoot.

Table 3. Eelgrass donor shoot metrics and condition. These are the parameters by which individual eelgrass donor shoots should be selected for use in the single shoot method of restoration (see table 4). See www.seagrassli.org "a shoot" for details on plant parts and "wasting disease" for pictures showing typical wasting disease damage.

Parameters	Optimal	Minimum	Maximum
Above-Sediment Parts			
Shoot Length	12-24cm	6 cm	N/A
Shoot Phenology	Only vegetative shoots are to be used for transplantation.		
Wasting Disease (Blades)*	0%	N/A	< 25%
Mechanical Damage	0%	N/A	10%
Epiphyte Load**	0%	N/A	33%
Below-Sediment Parts			
Rhizome/Meristem Condition	Firm; White, Yellow to Brown in color; No black or soft spots		
Rhizome Section Length	2.5-6cm	2.5cm	8cm
Number of Nodes	3-4	2	N/A
Number of Laterals	1-2	N/A	4

* Reference: Burdick et al., 1993. ** If epiphyte load is confined to oldest blades, removal of the blade or section is recommended.

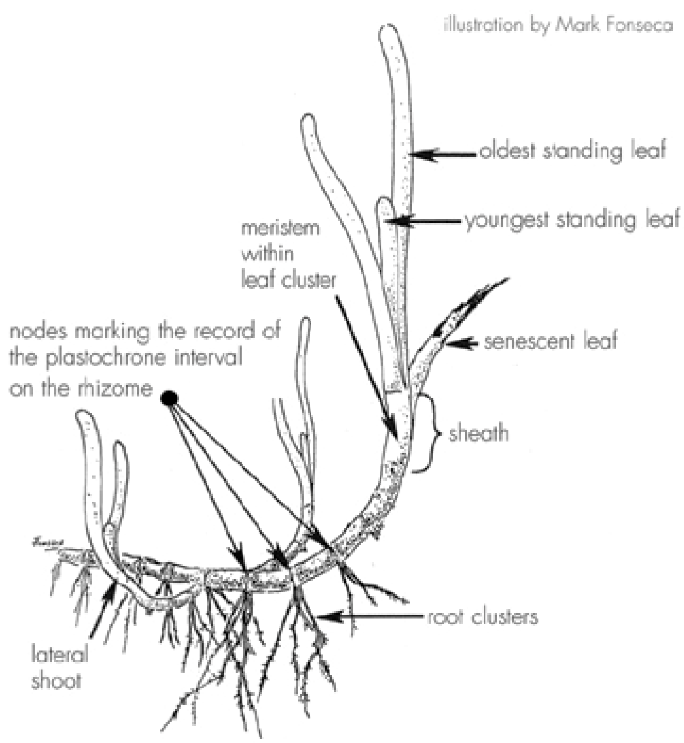


Figure 2. Diagram of an eelgrass shoot with labeled plant parts. Illustration by Mark Fonseca.

Table 4. Vegetative shoot collection, handling and storage. The following methods should be used when collecting and handling donor (vegetative) eelgrass shoots. Keep in mind that it may be necessary to acquire a permit in order to legally remove any vegetation.

Parameters	Description
Shoot Collection (Hand Harvest)	
Single Shoot	Divers collect single shoots at 1 meter intervals within the meadow (1 shoot/m^2). Typical yield should be 4,000 shoots per acre. This represents < 1% of shoots per acre available.
Eroded Edge	Shoots that are no longer anchored due to erosion or bioturbation may be readily collected as they will not re-anchor and will be lost.
Sods/Clumps*	In cases where the above methods aren't feasible, small sods may be collected within a continuous meadow. Using a shovel, small sods no larger than 1 ft^2 in size can be dug, keeping the roots/rhizomes intact. The sediment held by the rhizomes should be shaken into the void left after digging the sod. See below for more details.
Shoot Handling and Storage	
During Collection	All shoots should be placed in plastic mesh bags and suspended so that they float in the water column until all collection activities are completed for the day/site. Shoots must always remain in water and out of direct sunlight to avoid overheating.
Shoot Transport	Collected shoots should be transferred to plastic fish totes, large plastic coolers or similar and filled to the top with cold seawater from the collection site. All efforts should be made to prevent overheating and desiccation during transport. Containers without tops should be covered with a light colored, absorbent material such as a towel.
Shoot Storage	If possible, shoots should be planted the same day they are collected. If this isn't possible, it may be necessary to bring the material back to a holding facility for subsequent planting. In this case, shoots should be held in flowing seawater tanks with cool water and adequate light for a maximum of 7 days. All tanks should be stirred and inspected daily for signs of dead and damaged shoots.
Shoot Sorting (single shoots)	Just prior to planting, shoots should be counted and sorted into manageable bundles (50 or 100) with roots in the same direction. Once sorted, bundles should be placed in small burlap or mesh bags and set in coolers or totes as described in the shoot transport section above. At the restoration site all bags should be immediately removed from the transport

	containers and suspended in the water until divers are ready to plant.
Shoot Sorting (sods/clumps)	Clumps of shoots can be counted and bundled as with the single shoot method above, but it is recommended that these be kept intact.

* Based on the results of the Southampton Eelgrass and Bay Scallop Restoration Planning Project, we determined that $1m^2$ clearance plots within continuous eelgrass beds along the shallow flats east of Shinnecock Inlet will naturally re-vegetate within 2 years. Based on these results, removing sods of approx. $1ft^2$ would be justified. However, this method should only be utilized if other methods of collection are not possible, as it will have the most impact on the donor meadow.

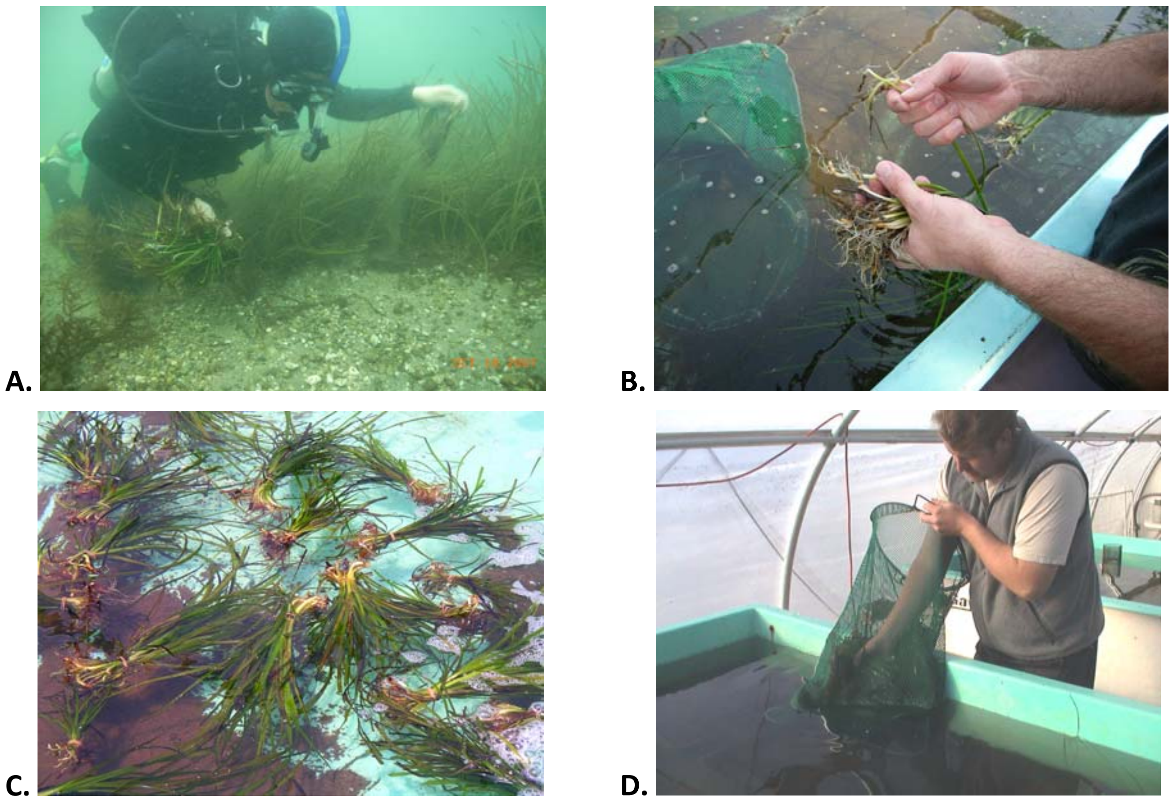


Figure 3. A. Collecting (eroded edge method), B. Counting and sorting, C. Sorted shoots ready for transplant D. Sorted bundles placed in catch bags prior to transport.

Table 5. Seed Collection, Handling, Processing & Storage. Between the months of June and July, seeds will approach maturity in the SSER. The rate of maturation depends primarily on water temperature, so stages of development may vary depending on the proximity of that meadow to an inlet, and may also vary slightly from year to year due to annual fluctuations. Reproductive (flowering) shoots should be collected when the maximum numbers of seeds per shoot are mature. The following measures should be taken to ensure the maximum seed yield is collected, and that the seeds are properly processed and stored until day of planting.

Parameters	Description
Monitoring/Scouting Seed Development	
Color of seeds	Mature viable seeds tend to be olive green to grayish blue or brown and are approximately 3-4 mm in length. Delay collection if the majority of seeds are still bright green and small. One indicator that seeds are close to release is a reddish-colored streak found laterally on one side of the seed, which is sometimes visible before release. It may be necessary to peel back or cut away the sheath in order to get a close look. See Figure 3A-F below.
Past collection times	Although collection windows can vary slightly from year to year at a given location, optimal collection times are typically within 2 weeks of past collection dates at that site. If seed collection has taken place at a given site in the past, monitoring of seed development should take place at least 2 weeks prior the past collection date. Past Collection Dates: Within Shinnecock Bay 6/30-7/4
Beginning to Release	In most cases, the oldest sheath (which encase the seeds) on each rhipidium (branches of the reproductive shoot) will release seeds first which is evident especially when collecting tall (0.5 m +) flowering shoots. These "older" seeds typically release before the majority release, indicating that collection time is near.
Seed Collection and Transport	
Hand Harvest	Divers should collect individual reproductive shoots by hand and place them in plastic mesh bags. Avoid collecting more than 50% of all flowers from a donor site. Flowers should be grabbed from the base to avoid breakage and collected flower bags should remain suspended in water until all collection has ceased.
Seed Transport	Collected reproductive shoots should be transferred to plastic fish totes, large plastic coolers or similar and filled to the top with cold seawater from the collection site. All efforts should be made to prevent overheating and desiccation during transport. Containers without tops should be covered with a light colored, absorbent material such as a towel.

Seed Storage & Processing	
Reproductive Shoot Storage (for use in broadcast seeding)	For use in broadcast seeding, all reproductive shoots should be transported to a holding facility with flowing seawater tanks for a maximum of 4 weeks. Reproductive shoots should be agitated daily to promote seed release and prevent anoxia.
Reproductive Shoot Storage (for BuDS)	Flower shoots should be deployed at restoration site the same day they are collected. See Table 7 for this protocol. See Pickerell et al. 2006 for more details.
Seed Processing (for use in broadcast seeding)	Once all seeds have been released (usually within 2 weeks of collection), seeds must be separated from decaying plant material through the use of sieves. Seeds can be siphoned from the bottom of tanks as they are negatively buoyant, or tanks can be drained into a series of sieves. See Granger et al. (2002) for a detailed seed processing procedure.
Seed Storage (for use in broadcast seeding)	Once seeds have been processed, they can be stored in a flowing seawater tank, preferably with an upweller system, until day of broadcast. Seeds should be stirred daily to prevent anoxia. See Orth and Marion (2007) for different storage methods.

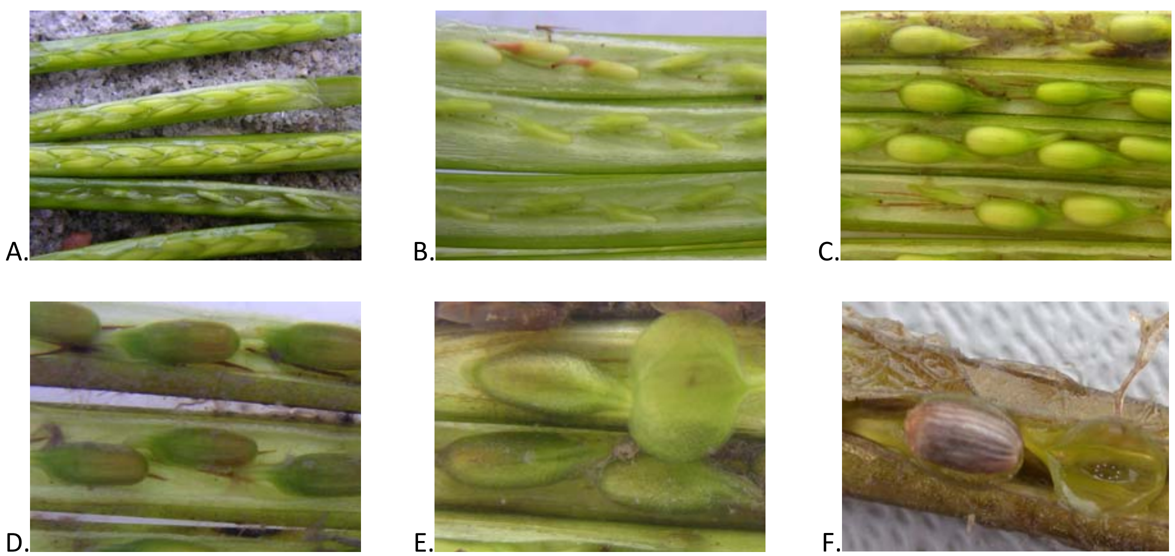


Figure 4. Eelgrass Seed Stages. A-C. Early Seed Stages of Development. D. Ripe seeds just before release. E-F. Ripened seeds beginning to release.

Table 6. Eelgrass Transplant Standards & Methods. The following details should be used to guide the timing and methods used to transplant eelgrass in the SSER.

Parameters	Optimal	Minimum	Maximum
Time of Year	Spring: mid-March to mid-May ; Autumn: September to December		
Temperature	10-20C (50-68F)	4C (40F)	20C (68F)
Depth (MLW)	1-2m	≈ 0.5m	3m
Weather	Planting should be postponed if predicted winds meet or exceed 20mph at the transplant site or if the dive must be called off due to poor visibility or other impeding factors.		
Unanchored Free-Planting	*A 1.0m^2 square or circular plot is considered a planting unit (PU).*		
Planting Depth (relative to sediment surface)	sheath top 2cm above sediment	½ of sheath below sediment	Top of sheath at sediment
	Actual depths should depend on total sheath length which is proportional to overall shoot length.		
Planting Unit Density/Acre	40	20	> 40
PU Shoot Density	100-200 shoots	20 shoots	N/A
PU Arrangement	For the optimal number of planting units (i.e., 40), four 10-unit patches should be established within each acre. Each 10-unit patch should consist of 20,000 shoots.		

A.

B.


Figure 5. A. Planting Depth. B. Planting within a circular 1.0m^2 hoop.

Table 7. Seed Planting Standards & Methods. The following details should be used to guide the timing and methods used to seed eelgrass in the SSER.

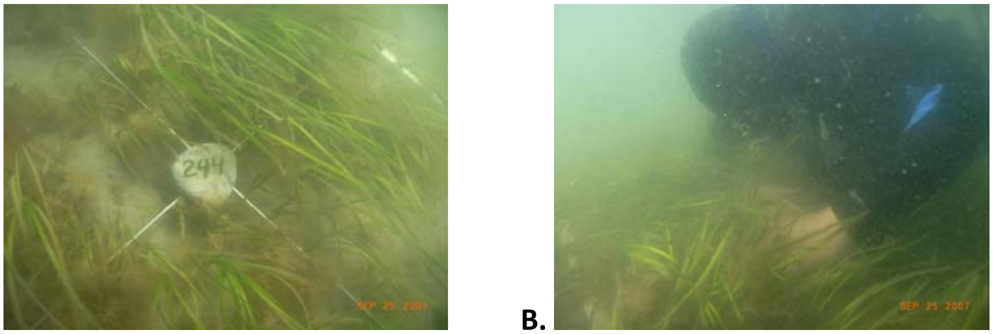
Parameters	Optimal	Minimum	Maximum
Location/Site Selection	Within the chosen restoration location (See Table 1 for details).		
BuDs – *Each BuDs setup is considered a planting unit (PU)*			
Time of Year	Day of seed collection: Late June to early July		
PU Density/Acre	Dependant on size of restoration site and desired density. See Pickerell et al. (2006) for design protocol.		
PU Arrangement	Dependant on size and shape of restoration site.		
Flower Density/Net	Flowers should be measured volumetrically using a container of a standard size (e.g. ½ gallon pot). Count at least 3 pots to get a conservative estimate of total flower yield and count number of seeds in several flower shoots to get an avg. seed yield per flower. See Pickerell et al. (2006) for more details.		
Broadcast Seeding			
Time of Year	Autumn: September to December		
Temperature	<15C (59F)	N/A	15C (59F)
Location	On bare bottom or within/adjacent to transplanted eelgrass with a density of 100 shoots/m^2 or greater. Seeding in naturally occurring eelgrass is not considered a form of restoration. High current sites should be avoided for seed planting.		
Placement	Seeds should be broadcast directly above the planting site and spread to the maximum extent possible in the desired area to achieve even distribution. Where there is an observable current, care should be taken to ensure seeds remain on site: i.e. placed slightly up-current from the planting site.		
Seed Density/acre	500,000	400,000	N/A

A. B. C.

Figure 6. A. BuDS Flower Density. B. BuDS Arrangement. C. Broadcast seeding.

Table 8. Restoration Site Monitoring. These are the performance standards that should be used to determine eelgrass restoration success at an eelgrass transplant site. The same methods should be used in spring to determine the effectiveness of seeding into planted eelgrass.

Parameters	Description
Unanchored Free-Planting	
Monitoring Stations	Ideally, permanent monitoring stations should be established in order to track changes in growth, spread and shoot density. Initial station placement within a patch should be done haphazardly, but permanently marked using DGPS and a permanent marker of some kind (e.g. buoy, stake) for follow-up monitoring. Random counts can also be conducted outside of stations.
Shoot Density Monitoring	At least 10 replicate quadrat counts per station with a 0.10 m^2 quadrat or greater, dependant on the size of the restoration area, labor available, etc. Random quadrat counts can also be conducted outside of the stations.
Monitoring Frequency	Monitoring could be conducted as frequently as needed, however should occur at least three times annually, in mid-Spring, mid-Summer, and mid-Autumn and should focus on the monitoring stations.
Temperature Monitoring	Whenever possible, temperature logger should be deployed at the center of each restoration site to track changes in water temperature (on the bottom) at 2hr intervals.
Seed Planting- Broadcast & BuDS	
Monitoring Stations	Same protocol as free planting, except for BuDS, permanent monitoring stations could focus on several buoy lines.
Shoot Density Monitoring	Same protocol as free planting. See above.
Monitoring Frequency	Same protocol as free planting, except it is crucial to monitor seedlings in early spring, while they are still distinguishable from adult shoots when seeding into transplants or close to natural meadows.
Temperature Monitoring	Same protocol as free planting. See above.



A. B.

Figure 7. Monitoring. A. Marker rock indicates original transplant location for each planting unit. B. Diver counting shoots.

Table 9. Donor Site Impact Assessment. The protocol throughout this blueprint was designed to have minimal impact on donor meadows, however if deemed necessary, the following protocol may be conducted to assess the potential impact of plant collection at donor sites.

Shoot Collection Impact Assessment at Donor Sites	
Monitoring Stations	Density counts should occur within the collection area and outside but adjacent to the collection area at each representative donor meadow. Ideally both stations should be identified by a buoy attached to a helical anchor and/or by a DGPS point for future reference and monitoring.
Shoot Density Monitoring	Both within and outside of collection areas, a diver should count shoot density in at least 10 haphazard tosses of a 0.10m^2 PVC quadrat within each designated area. Counts should be made just prior to and just after shoot collection (see below), and
Monitoring Frequency	Donor site impact assessment could be made several times for up to 1 year following collection.

Table 10. Logistics: Personnel, Skills, Equipment and Facilities needed for each aspect of restoration. If a proposed restoration site meets the required standards in Table 1, this table can help determine which method of restoration will be most feasible depending on funds, labor, facilities and equipment available.

	Adult Shoot Restoration					**Seed Restoration**				
	Shoot Collection and Transport	Processing and Holding	Single Shoot Plantings	Sod/ Clump Plantings	Monitoring	Seed Collection and Transport	Processing and Holding (broadcast)	Broadcast	BuDS	Monitoring
Personnel- Minimum # of People Required										
Min. # of Total People	2-3	1	2	2	2-3	3	1	2	3	2
Min. # of Staff / Trained Personnel	1	1	1	1	2	1	1	1	1	2
Skills Required of Trained Personnel (H) High, (M) Medium, (L) Low; (Y) Yes, (N) No, (T) Typically Necessary (Depending on Location and/or Depth of Site)										
Training Difficulty / Skill level	L-M	M	M	M	H	L-M	H	L	M	H
Potential for volunteer training	Y	Y	Y	Y	N	Y	N	Y	Y	N
SCUBA Cert.	T	N	T	T	T	T	N	N	N	T
Boat Handling (min. 1 person per vessel)	T	N	T	T	T	T	N	T	T	T
Required Vessels / Equipment / Facilities (H) High, (M) Medium, (L) Low; (Y) Yes, (N) No, (T) Typically Necessary (Depending on Location of Site)										
Boats/Vessels	T	N	T	T	T	T	N	T	T	T
Supplies/Materials	L	L	L	L	M	L	M	L	M-H	M
Onshore Facilities/ Holding Tanks	N	T	T	T	T	T	**Y***	T	T	T
Other Considerations										
Season/Time of Year	Spring / Fall				Sp/Su/F	Summer		Fall	Su	Sp/Su/F
Overall Effort (H,M,L)	M	M	M	M	M	M	H	L	M	M
Overall Costs ($, $$, $$$)	$	$-$$	$-$$	$-$$	$-$$	$-$$	$$$	$	$-$$	$-$$

*Holding tanks with flowing seawater will be necessary for seed processing and storage for 3-5 months. See Table 5 for details.

References:

Burdick , D.M., F.T. Short and J. Wolf. 1993. An index to assess and monitor the progression of the wasting disease in eelgrass, Zostera marina. Mar. Ecol. Prog. Ser. 94: 83-90.

Granger, S., M. Traber, S.W. Nixon, and R. Keyes. 2002. A practical guide for the use of seeds in eelgrass (Zostera marina L.) restoration. Part I. Collection, processing, and storage. M. Schwartz (ed.), Rhode Island Sea Grant, Narragansett, R.I. 20 pp.

Larkum, A.W.D., Orth, R.J., Duarte. C.M. (Editors), 2006. Seagrasses: Biology, Ecology and Conservation. Springer.

Marsh, J.A., W.C. Dennison and R.S. Alberte. 1986. Effects of temperature on photosynthesis and respiration in eelgrass (*Zostera marina* L.). *J. Exp. Mar. Biol. Ecol.101*: 257–267.

Orth, R. J., and S. R. Marion. 2007. *Innovative techniques for large-scale collection, processing, and storage of eelgrass (Zostera marina) seeds*. SAV Technical Notes Collection. ERDC/TN SAV-07-2. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Orth, R., S. Marion, S. Granger and M. Traber. 2007. Restoring eelgrass (*Zostera marina)* from seed: A comparison of planting methods for large scale projects. SAV Technical Notes Collection (ERDC/TN SAV-07-4). Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Pickerell, C. H., S. Schott, and S. Wyllie-Echeverria. 2005. Buoy deployed seeding: Demonstration of a new eelgrass (*Zostera marina* L.) planting method. *Ecological Engineering* 25:127-136.

Pickerell, C. H., S. Schott, and S. Wyllie-Echeverria. 2006. *Buoy-deployed seeding: A new low-cost technique for restoration of submerged aquatic vegetation from seed*. SAV Technical Notes Collection. (ERDC/TN SAV-06-2), U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Appendix 1B: Bay Scallop Restoration in the South Shore Estuary Reserve
A Blueprint for Success

Bay Scallop Nomenclature, Taxonomy, Range:

Scientific name: *Argopecten irradians irradians*
Class: Bivalvia
Order: Anisomyaria
Family: Pecinidae
Range: Cape Cod to New Jersey

Background:

Bay Scallops, unlike all other commercially-important bivalve shellfish, are simultaneous hermaphrodites and generally spawn only once during their relatively short (less than two years) lifespan. One year of poor recruitment will directly affect next year's population and can cause many years of low production into the future. While environmental conditions for adults, larvae and juveniles are critical to recruitment success, they are not controllable to those wishing to "jump start" bay scallop populations. However, there are many things that can be done that, if not guarantee success, can improve the odds of significant survival of field-grown scallops as well as the success of their resultant larvae.

The first attempts at large-scale bay scallop restoration in New York occurred in the years after the first brown tide in the Peconic Estuary. That was in 1986-1991 (see Tettelbach and Wenczel 1993), when little was known about how hatchery-reared bay scallops would fare post planting. The major finding from those efforts is that planting small seed (<30-mm) in the fall leads to heavy predation (primarily by crabs) hence very low survival to spawning age the following spring. In later years, survival was increased by planting larger scallops and/or keeping scallops in nets or cages (Tettelbach 2008) until after spawning occurred which is usually in June and July, although fall spawns are not uncommon (Tettelbach et al. 1999). While these were all lessons learned in the Peconic Estuary, many translate well to the South Shore Estuary Reserve. What follows are some of the key points used in the geographical information system-based bay scallop restoration suitability model.

Table 1. Scallop restoration site selection parameters. The following parameters are used to select appropriate restoration sites as well as culture conditions. The majority of these parameters should be at optimal levels in order for a restoration site to be considered. These parameters should be used as a guideline along with the model and local knowledge.

Parameters (General)	**Optimal**	**Minimum**	**Maximum**
Broodstock/Donor Genotype	Local	Regional	N/A
Sediment Grain Size	<20% silt & clay	N/A	50% silt & clay
Depth (MLW)	2-4m (6.5-13ft)	1.5m (5ft)	8m (26ft)
Peak Water Temperature (°C)	<=27	N/A	30
Dissolved Oxygen (ppm)	>5	2	N/A
Salinity (ppt)	28	14*	35
Current Speed (cm/s)	1	0.21	12
Minimum Size (Free-Planting, mm)	>=40	30	N/A
Currently Productive?	Yes	Historical Only	N/A
Wind Exposure/Fetch	Complete protection from winter prevailing winds	Some protection from winter prevailing winds	N/A
Distance from Inlets (depends on circulation patterns)	72.5 km (1.4 NM)	1.8 km (~1 NM)	N/A
Timing of Free-Plants	Spring, pre-spawn	Late Fall	N/A
Density of Free-Plants (scallops/m^2)	10	2	(depends on size)
Density in Containment (scallops/m^2 depends on size)	Less than a monolayer	N/A	monolayer
Attached Macroalgae	Multiple species- *Codium* preferred	1 species	N/A
Drift Macroalgae	None	Minimal	N/A
Hardened Shoreline	None	N/A	Within 15 meters
Shellfishing Activity	None		
Shellfishing Closure Areas	Prefer sites that are temporarily closed to shellfishing		
Boating/Mooring/Marina Areas	Any marinas, mooring fields or other active boating areas should be excluded from consideration		
Existing Eelgrass Presence	Prefer sites with eelgrass		
Species of Concern/ Predators	*Significant presence of any of these spp. may exclude this site from consideration: Libinia spp., Carcinus maenas, Ovalipes ocellatus, Busycon carica, Busycotypus canaliculatus, , Lunatia heros, Cancer irroratus, Urosalpinx cinerea*		

*14 ppt is the minimum for juvenile and adult scallops; larvae need a minimum of 23 ppt to develop from fertilized eggs.

Genotype:

Whenever possible, it is best to use bay scallops local to the area being planted, whether broodstock to produce seed or transplanting juveniles or adults. Seed obtained from other areas, especially other states, may not fare as well and may bring in unwanted diseases or invasives and may change the population genetics. If local populations are low or extinguished, then procuring broodstock or seed from the nearest available area is the next best approach.

Bottom Type/ SAV Presence:

While healthy stands of eelgrass are their preferred habitat, eelgrass is not necessary for scallops to set or live (Marshall 1947), submerged aquatic vegetation can help increase set rate (up to a point) as well as increase post-set survival by providing a predator refuge (Belding 1910; Ekman 1987; Garcia-Esquivel and Bricelj 1993). Macroalgae, especially *Codium* have been shown to be stand-ins for eelgrass (Ingersol 1886, Marshall 1960, Carroll et al. 2008).

Burial by substrate movement, especially in winter can be an issue (Tettelbach et al. 1990). This has more to do with water depth and fetch than substrate composition.

Water Depth:

Scallops are found in waters less than a meter to as deep as 18 meters, but for restoration depths ranging from 2 to 5 meters are optimum, depending somewhat on fetch from the northwest (see below).

Water Quality:

Most waters of the SSER will allow scallops to survive, if not reproduce successfully. High summer water temperatures (> 30C) and low dissolved oxygen (< 2 ppm) are detrimental to juvenile and adult scallops. Salinities greater than 15-20 ppt are required; greater than 25ppt is optimal.

Current Speed:

Kirby-Smith (1972) found juvenile scallops grew faster in slower water currents (but not stagnant water) than in areas with high flow rates. Currents of approximately 0.25 to 4 cm/s were found best for scallop growth (for reference, one knot is equivalent to 51 cm/sec).

Minimum Size for Free-Planting:

Planting bay scallops of at least 40 mm in shell height provides a partial size refuge (Tettelbach 1986) from predators. This can be accomplished by planting large seed in late fall or overwintering seed in containment for planting the following spring.

Predator Assemblages:

There are many known predators of bay scallops. Crabs are by far the most destructive to planted scallops and can move into an area quickly. Other predators include sea stars, whelks and finfish, especially northern puffers (blowfish) (see Garcia-Esquivel and Bricelj 1993). Potting crabs and removing them may help, but can be a full-time job.

Historical Production:

While known areas of historical bay scallop production are usually good candidates for plantings, keep in mind that conditions may have changed, making those areas less than optimal for restoration today.

Fetch from Northwest (winter prevailing wind):

Free planting scallops in shallow areas with a large fetch from the northwest invites stranding or beaching, resulting in mortality of most of these animals. The same wind events that create strandings also usually cause lower-than-average tides which will usually increase the area for beaching.

Distance from Inlets:
Siting broodstock sanctuaries close to inlets invites planktonic larvae to escape to the ocean. Minimum distance to an inlet depends on the size of the embayment and circulation patterns. For the sake of this discussion, a minimum of 1.8 km (~1 NM) is recommended.

Larval Dispersion by Currents and Wind Events:

Larvae are in the plankton from one to two weeks, depending on water temperature and also food. Siting of spawner stocks to "target" larvae to known productive areas is difficult, due to the lack of hydrodynamic studies in many water bodies and the fact that wind events can drive the dispersal process, overriding any tidally-influenced transport of larvae.

Timing of Free-Plants:

Scallops are best free planted just before spawning (late May/early June). This minimizes predation on transplanted pre-spawn broodstock. If scallops are planted in the fall prior to spawning, choose areas with eelgrass and or attached macroalgae and plant the largest animals available.

Density of Free-Plants:

Since bay scallops spawn sequentially, usually starting as males, then switching to releasing eggs, they tend not to self-fertilize. Therefore, the distance between spawning animals is important as sperm may not reach (or be inactive when it does) eggs shed by the next nearest scallop. On the other hand, too many scallops invites higher predation, due to density-dependent predation (Boulding and Hay 1984) where an individual's chance of surviving predation decreases with increases in density. A recommendation of 10 per square meter or one per square foot comes from a variety of research and field experience.

Density in Containment:

Based on work by Tettelbach (2008) and partners for a New York State Department of Environmental Conservation State Wildlife Grant, the best stocking density for contained bay scallops is between 117 and 234 35 mm scallops per square meter (not more than one layer of scallops).

References:

Belding, D.L. 1910. The scallop fishery of Massachusetts. Mass. Dep. Cons., Div. Fish. Game, Mar. Fish. Ser. No. 3. 51 pp.

Boulding, E.G. and T.K. Hay. 1984. Crab response to prey density can result in density-dependent mortality of clams. Can. J. Fish Aquat. Sci. 41(3): 521-525.

Carroll, J., B. J. Peterson, C. F. Smith, D. Bonal, A. Weinstock and S. T. Tettelbach. 2008. A bay scallop's brave new world: can the introduced *Codium fragile* act as an eelgrass surrogate? Abstract. J. Shellfish Res. 27(4):995.

Eckman, J.E. 1987. The role of hydrodynamics in recruitment, growth and survival of *Argopecten irradians* (L.) and *Anomia simplex* (D'Orbigny) within eelgrass meadows. J. Exp. Mar. Biol. Ecol. 106:165-191.

Garcia-Esquivel, Z. and V.M. Bricelj. 1993. Ontogenetic changes in microhabitat distribution of juvenile bay scallops, Argopecten irradians irradians (L.), in eelgrass beds, and their potential significance to early recruitment. Biol. Bull. 185:42-55.

Kirby-Smith, W. W. 1972. Growth of the bay scallop: the influence of experimental currents. J. Exp. Mar. Biol. Ecol. 8: 7-18.

Marshall, N. 1947. Abundance of bay scallops in the absence of eelgrass. Ecology 28: 321-322.

Marshall, N. 1960. Studies of the Niantic River, Connecticut, with special reference to the bay scallop. Limnol. Oceanogr. 5:86-105.

Tettelbach S.T. 1986. Dynamics of crustacean predation on the northern bay scallop, *Argopecten irradians irradians*. Dissertation, University of Connecticut.

Tettelbach S.T. 2008. Bay scallop spawner sanctuary evaluation study. New York State Dept. Env. Cons. Wildlife Grant Program Final Report. 51 pp.

Tettelbach ST, Smith CF, Kaldy JE III, Arroll TW, Denson MR (1990) Burial of transplanted bay scallops Argopecten irradians irradians (Lamarck, 1819) in winter. J Shellfish. Res 9(1):127-134.

Tettelbach, S.T., C.F. Smith, R. Smolowitz, K. Tetrault and S. Dumais. 1999. Evidence for fall spawning of northern bay scallops, *Argopecten irradians irradians* (Lamarck, 1819), in New York. J. Shellfish Res. 18(1):47-58.

Tettelbach, S.T. and Pl Wenczel. 1993. Reseeding efforts and the status of bay scallop Argopecten irradians (Lamarck, 1819) populations in New York following the occurrence of "brown tide" algal blooms. J. Shellfish Res. 12(2):423-431.

Town of Southampton Eelgrass and Bay Scallop Restoration Planning Project

Appendix II. Field Notes/Schedule by Season

Fall 2005

		
21 Nov 2005- The eelgrass at East Pt was small and patchy.	*21 Nov 2005- The eelgrass in Tiana Bay was much larger and more dense.*	*29 Nov 2005- Using snorkel gear, we harvested plants from our Gull Island site.*

TASK 1 - *Monitoring of existing eelgrass meadows*
Eelgrass monitoring efforts began in fall 2005 which included the initial steps for mapping and ground truthing all existing eelgrass meadows in Shinnecock and Moriches bays. This included the creation of digitized aerial photographs for both bays; suspected areas of eelgrass were digitally marked so that the sites could be confirmed through SCUBA observations. Ground truthing was initiated on 21 Nov 2005. At each location, a GPS point was recorded, the presence of eelgrass was noted and digital underwater images of existing eelgrass were taken where present.

Once back at SCMELC, the GPS coordinates were transferred to the aerial photos confirming the presence of eelgrass at that location. Initial steps for site characterization were also taken, including observations and sample collections at several locations within Shinnecock Bay including "East" and "West" Points, Tiana Bay, north of Warner Island, and west of Gull Island. Later in the month (29 Nov 2005), a small amount of eelgrass was harvested from Gull Island for winter grow out and observation in the eelgrass nursery located at SCMELC in Southold.

TASK 2 – Monitoring for existing scallops and planting site selection
During eelgrass monitoring efforts (for Task 1), data on scallop presence/absence and size were collected. Small numbers of animals including bugs and adults were collected at two of stations where present.

TASK 3 – Planting Suitability Index Model
All mapping and ground truthing efforts listed for Task 1. will be used as a parameter in creating the Planting Suitability Index Model.

Spring/Summer 2006

2 Ma y2006- Steve Schott and Kim Petersen taking note of the location of the temperature logger deployed north of Warner Island.

9 May 2006- Michael Patricio, CCE's hatchery manager, and Gregg Rivara, CCE's Aquaculture specialist, distributing scallops into Shinnecock Bay.

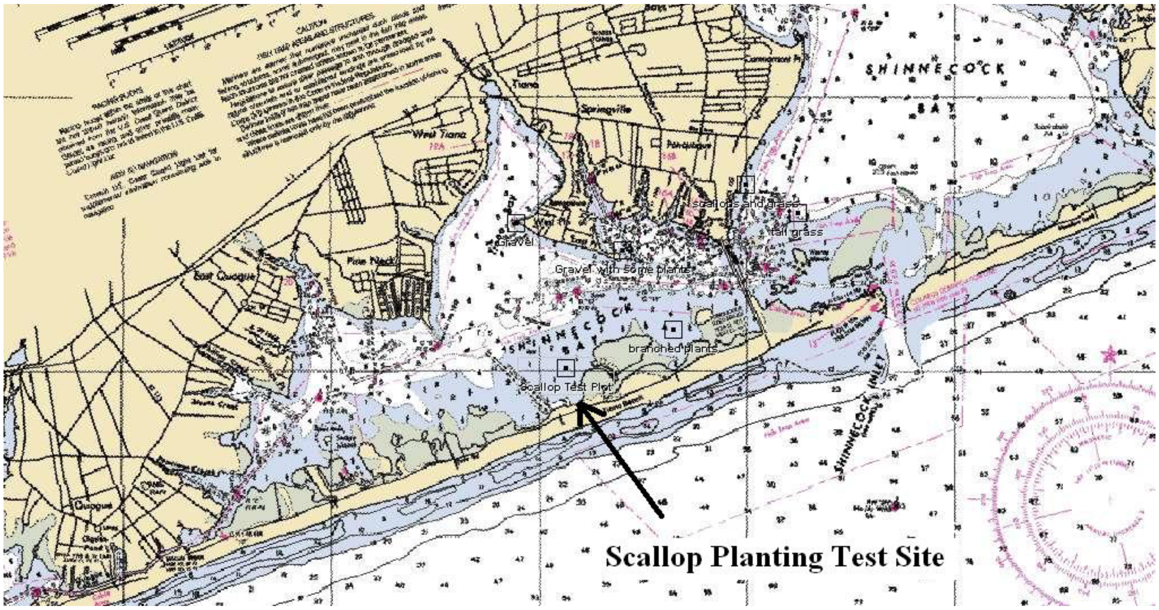
30 June 2006- Diver Steve Schott conducting density counts at a newly established reference site east of Shinnecock Inlet.

TASK 1 - *Monitoring of existing eelgrass meadows*
Beginning in May, eelgrass field work included the placement of temperature loggers (2 May 2006) as well as the initiation of site characterization for the establishment of eight reference sites (see chart below), which began on 30 Jun 2006. More ground-truthing resulted in the identification of additional meadows using aerial photographs for reference. Further eelgrass characterization and monitoring was conducted on 11 July 2006. This included gathering data on shoot density, canopy height, macroalgae presence/absence and sediment composition. Site characteristics including plant phenology, algal cover (macro and epiphytic), and other metrics varied significantly depending on the water depth and proximity to ocean influx of that particular site.

TASK 2 – Monitoring for existing scallops and planting site selection
Prior to planting in May (see Task 5 below), the test site with existing eelgrass was selected. In addition, commercial scallop fishermen were asked to delineate recent past and present scallop populations on a chart of Southampton's South Shore waters.

TASK 3 – *Planting Suitability Index Model*
Sediment and temperature data gathered during this period to be utilized in model.

TASK 5 – Bay scallop plantings
On 9 May 2006, 20,000 bay scallops with an average shell height of 39 mm were planted on a test plot (with existing eelgrass) of approximately 400 square meters in Shinnecock Bay, west of the Ponquogue Bridge (see chart below).



Fall/Winter 2006

		
15 Nov 2006- Shoots collected from the natural meadows were sorted and counted prior to transplanting.	*15 Nov 2006- A test plot being planted at a density of 100 planting units per m².*	*22 Dec 2006- Diver Steve Schott collecting eelgrass from one of the clearance plots.*

TASK 1 - *Monitoring of existing eelgrass meadows*

East of Inlet Clearance Plots: In order to determine the recovery potential of natural eelgrass beds in Shinnecock after a disturbance (such as shellfishing) or transplanting, on 22 Dec 2006 three clearance plots were completed in the meadow near our "East of Inlet" reference site. Three 1m² plots were marked off and cleared of all eelgrass (which we counted, analyzed, and saved for grow-out experiments).

Other monitoring work included offloading temperature loggers and reconnaissance of the "East of Inlet" site (20 Sep 2006).

TASK 3 – *Planting Suitability Index Model*
Temperature data gathered during this period to be utilized in model.

TASK 4 – Seed collection, handling and planting
Eelgrass test plantings occurred on 15 Nov 2006 at two potential restoration sites in Shinnecock Bay. Both test plots occurred in areas with neighboring natural eelgrass meadows, from which the transplants were collected. Our first test plot location was near our "East of Inlet" reference site and the second test plot location was near our "Gull Island" reference site. Each transplant location included 5 plots of a higher density (100 planting units/m^2) and 5 plots of a lower density (12 planting units/m^2-based on Churchill et al. 1978). Each plot was planted at a 1m distance from the next nearest plot with all plots centered around a central point marked by GPS. Each plot had a numbered rock to mark the center and identify the density and person who planted it.

"Planting units" were used instead of individual shoots because of the large number of lateral shoots present and the extremely small size of the plants. In order to have an accurate estimate of the actual number of individual shots per planting unit, samples were counted. Each planting unit was composed of an average of 2 shoots. Numbered rocks were placed in the center of the plots for identification of density and planter. One plot (#225) was planted with 100 units from East of Inlet that were transplanted to the Gull Island site. Observations of epiphyte load, number of lateral shoots, and the presence of scallops were made at each of the natural meadows as well. Sample shoots from each location were taken back to the lab for analysis. Reconnaissance of plantings occurred in December.

TASK 7 - Monitoring of bay scallop seeding
Monitoring of May Plantings: The scallop planting plot seeded in May was assessed for survival and growth on 13 Sept 2006 by divers performing 20 random square meter counts. Each live and dead (single valve) scallop was measured for shell height.

Spring/Summer 2007

7 June 2007- Natural recruitment into a clearance plot since December '06.

7 June 2007- November planting 244 remained and appeared healthy as with other plantings.

2 6June 07- Steve Schott counting a small natural patch of eelgrass in the shallows east of the inlet.

TASK 1 - *Monitoring of existing eelgrass meadows*
Patch Dynamics Study: In late June 2007, observations of patchy meadows in the shallow flats east of the inlet were conducted for a patch dynamics study. Small patches were counted and measured and GPS coordinates were taken for relocation later.

East of Inlet Clearance Plots: The clearance plots East of Inlet were revisited on 7 June 2007. There was some recruitment back into the cleared plots, although not substantial. All shoots that recruited back into the clearance plots were counted and photographs were taken.

TASK 2 – Monitoring for existing scallops and planting site selection
Spat Collection: Bay scallop spat collectors were placed at six sites: three west and three east of the Ponquogue Bridge on 7 June 2007 in order to qualitatively estimate times and magnitude of bay scallop sets in the bay. A total of 12 spat collectors were assembled, each with a concrete block as an anchor, two fine mesh bags (one low, one high) stuffed with rigid plastic netting, a small subsurface float on each bag and a larger marker float on top. Two sets of collectors (a total of four collectors per site) were placed. Every three weeks one set of collectors was removed and a new set placed. The removed collectors were brought back to SCMELC in Southold for analysis. This schedule continued into the fall.

TASK 3 – Planting Suitability Index Model- Temperature data collected for Task 1 was applied to the model.

TASK 4 – Seed collection, handling and planting
Seed Collection: A total of 4.5 bags of flower shoots were collected from patches near "East of Inlet" for potential future seeding efforts in restoration areas and for seed experiments.

TASK 6 - Monitoring of test eelgrass plantings
East of Inlet plantings: East of Inlet plantings conducted in Nov 2006 were revisited on 7 June 2007. Plantings were observed and counted, with the majority still remaining and looking healthy.
Gull Island plantings: Gull Island plantings conducted in Nov 2006 were revisited on 7 June 2007. Plantings were observed and counted, with the majority still remaining and looking healthy.

Fall/Winter 2007

		
25 Sept 2007- Natural recruitment into a clearance plot since December '06. Note the 12 inch ruler for size reference.	*25 Sept 2007-Planting 244 (see above) grew significantly since June.*	*25 Sept 2007- Due to the exceptionally low tide, we were able to photograph from above water significant prop-scarring in natural eelgrass meadows near Warner Island.*

	
3 Oct 2007-One of 5 new plantings near Far Pond.	*3 Oct 2007- Scallop spat found on eelgrass collected for transplant.*

TASK 1 - *Monitoring of existing eelgrass meadows*
East of Inlet clearance plots: The clearance plots East of Inlet were observed on 25 Sept 2007.Recruitment into the clearance plots was measured and counted; in some areas the eelgrass grew over 1 foot into the cleared plot since June.

TASK 2 – Monitoring for existing scallops and planting site selection
Spat collection: Spat collection continued every three weeks throughout the fall until 28 Nov 2007.

TASK 3 – Planting Suitability Index Model- Temperature data gathered during this period to be utilized in model.

TASK 4 – Seed collection, handling and planting
Far Pond plantings: A new transplant was conducted on 3 Oct 2007 in the northeast corner of Shinnecock Bay, near the mouth of Far Pond. Five circle plots (1 m^2 in size each) were planted, each with densities of 100 shoots.

TASK 5 – Bay scallop plantings

Spawner sanctuaries: Three spawner sanctuary plots were set up on 2 Oct 2007, each measuring 20 X 20 m (400 m^2). Two were placed in Shinnecock Bay (one east and one west of the Ponquogue Bridge) while the third was in Tiana Bay. These three sites were selected with Southampton Town Trustee advice and were all somewhat different in terms of depth, bottom type and presence or absence of eelgrass.

The bay scallops were planted into these plots on 16 Oct 2007, each with 10,000 bay scallops that were spawned at the SCMELC hatchery in Southold. The average shell height of these scallops was 35 mm. Water temperature in the area ranged from 15-17C. The scallops were dispersed as evenly as possible, with a theoretical density of 25 scallops per m^2.

TASK 6 - Monitoring of test eelgrass plantings

East of Inlet plantings: The East of Inlet planting plots conducted in Nov 2006 were observed on 25 Sept 2007. Plantings were located, photographed, and observed with the majority of plantings looking healthy and many had put on significant growth and had expanded. Photos were taken.

Gull Island plantings: The Gull Island planting plots conducted in Nov 2006 were observed on 3 Oct 2007.These plantings didn't take as well to the transplant as did those near East of Inlet, but those that were still present were healthy. Those that were lost may have been due to bioturbation; crabs and whelks were numerous and active in the area of the plantings the day of observation. The temperature logger from the “Gull Island” site was also retrieved. Photos were taken.

TASK 7 - Monitoring of bay scallop seeding

On 22 Oct 2007, all three spawner sanctuaries planted on 16 Oct 2007 were observed by SCUBA divers, and 10- 1m^2 counts of surviving scallops were made at each site.

Other observations: Two bay scallop spat were found on the eelgrass that was collected for transplant near “East of Inlet” to the new planting site near Far Pond. Water clarity was poor throughout most of the bay. Also, due to an exceptionally low tide in September, we were able to photograph from above water significant prop-scarring in natural eelgrass meadows near Warner Island.

<u>Spring/Summer 2008</u>

		
17 June 2008- Natural recruitment into a clearance plot from December '06.	*17 June 2008- November plantings expanded considerably. This is plot #244 also seen in June and Sept '07 photos.*	*17 June 2008- One of the floating clumps of eelgrass found in the bay with rhizomes still intact.*

TASK 1 - *Monitoring of existing eelgrass meadows*

<u>East of Inlet Clearance plots</u>: Reconnaissance of clearance plots occurred on 17 June 2008. Two of the clearance plots had filled in nearly 100%, and one was about 75% filled in, but a large colony of tube-dwelling worms likely prevented further recruitment into the unvegetated areas of that plot. Without the rebar marker stakes, the plots are indistinguishable from the surrounding eelgrass.

TASK 2 – Monitoring for existing scallops and planting site selection
Along with the eelgrass team, potential scallop planting sites for future plantings were surveyed in the summer of 2008.

TASK 3 – *Planting Suitability Index Model-* Temperature data gathered during this period to be utilized in model.

TASK 4 – Seed collection, handling and planting
Seed development at the "Bay Ave" reference site was evaluated to determine optimal timing of seed collection. Seed collection occurred on June 30 and July 1 for use in winter grow-out experiments.

TASK 6 - Monitoring of test eelgrass plantings

East of Inlet plantings: Reconnaissance of the East of Inlet plantings occurred on 17 June 2008. The experimental plots with various shoot densities have outgrown expectations. Most of the surviving plots were too large now to count shoots, as they have begun to coalesce. In fact, we had a hard time telling the difference between the nearby natural grass patches and our transplants until our transplant markers were located. The center photo above shows planting #244 (seen in Summer and Fall '07 photos earlier) has expanded considerably.

Far Pond plantings: Reconnaissance of Far Pond plantings occurred on 17 June 2008. No plots remained. Evidence of “easing” was observed throughout the planting area. “Easing” trenches were ~1ft deep and some were several feet wide. “Easing” had also occurred within a few feet of natural eelgrass at the site.

TASK 7 - Monitoring of bay scallop seeding

On 1 May 2008 areas that were planted with scallops in October of 2007 were sampled, excepting the Tiana Bay site, which had no survival due to heavy predation within the first month of planting.

<u>Other work/ observations:</u>

In June 2008, a fair amount of floating eelgrass was found, especially in the Northeast portion of the bay, probably uprooted due to "easing" or "churning" activity because the rhizomes were still perfectly intact.

Appendix III- GPS Coordinates for Work Locations

Reference Sites
1) East Side N40.88261 W72.47928
2) East of Inlet N40.85463 W72.45844
3) Warner Island N40.85243 W72.49162
4) Shinnecock Ave N40.85600 W72.50007
5) Gull Island N40.83876 W72.51550
6) East Point N40.84784 W72.51951
7) West Point N40.85103 W72.53606
8) Tiana Bay N40.84737 W72.54916

Temperature Loggers
1) Warner Island N40.85243 W72.49162
2) Gull Island West N40.83876 W72.51550

Transplant Sites
A) Far Pond N40.87605 W72.45074
B) East Of Inlet N40.85328 W72.45905
C) Gull Island N40.83778 W72.51450

Clearance plots
1) Plot 11 N40.85304 W72.45872
2) Plot 12 N40.85306 W72.45886
3) Plot 13 N40.85318 W72.45888

Appendix IV. Average daily temperature for 2006 and 2007 at our Warner Island and Gull Island reference sites.
Figure 5 within this report plots these data points for comparison.

Date	WI 2007	WI 2006	GI 2006	GI 2007
1/1	8.3725			7.88
1/2	7.99			7.80
1/3	7.68			6.28
1/4	8.0625			7.29
1/5	8.64			8.42
1/6	9.175			9.66
1/7	8.64			8.73
1/8	8.9075			8.96
1/9	7.405			5.62
1/10	6.045			3.49
1/11	5.9275			2.46
1/12	4.995			4.01
1/13	7.0175			5.97
1/14	7.29			7.45
1/15	7.715			7.65
1/16	7.445			7.21
1/17	5.03			3.06
1/18	5.3825			3.09
1/19	6.2			4.44
1/20	4.175			0.70
1/21	3.0275			-0.20
1/22	4.015			2.50
1/23	4.1325			2.90
1/24	4.4025			2.35
1/25	3.9425			2.46
1/26	0.8875			-0.55
1/27	2.4475			-0.18
1/28	4.3675			1.67
1/29	2.915			2.02
1/30	2.6425			0.59
1/31	2.9175			1.67
2/1	3.5875			1.55
2/2	3.82			3.02
2/3	3.235			1.83
2/4	1.5775			-1.64
2/5	-0.1525			-2.60
2/6	-0.8775			-2.39
2/7	-0.3125			-1.52
2/8	-0.835			-1.48
2/9	-1.08			-1.61
2/10	-0.0275			-1.24
2/11	0.575			-0.87
2/12	0.13			-0.71

2/13	0.1725	-0.54
2/14	0.655	0.75
2/15	-0.35	-1.52
2/16	-0.835	-2.43
2/17	-0.0725	-0.89
2/18	0.975	0.02
2/19	-0.1125	-1.32
2/20	1.2525	0.26
2/21	1.9675	2.26
2/22	2.365	2.35
2/23	2.0475	1.99
2/24	0.895	0.14
2/25	1.37	0.91
2/26	1.6125	1.83
2/27	2.13	2.07
2/28	2.8	3.45
3/1	2.96	4.00
3/2	3.705	4.52
3/3	3.9775	5.26
3/4	3.665	4.67
3/5	2.765	2.43
3/6	0.7325	-2.39
3/7	0.6075	-1.11
3/8	0.94	-0.95
3/9	1.1275	-0.26
3/10	2.5625	1.94
3/11	3.39	4.63
3/12	3.82	5.07
3/13	4.25	5.69
3/14	4.8375	6.82
3/15	5.265	7.25
3/16	3.43	3.33
3/17	2.9575	3.02
3/18	3.0375	2.82
3/19	3.35	2.22
3/20	4.2525	5.14
3/21	3.895	3.29
3/22	4.6825	5.81
3/23	5.19	7.02
3/24	5.345	6.75
3/25	5.89	6.55
3/26	6.2	7.76
3/27	7.17	9.86
3/28	7.9475	10.91
3/29	7.2875	8.11
3/30	6.705	7.72
3/31	6.8225	8.81

4/1	6.6675		7.72
4/2	6.82		7.30
4/3	6.98		7.96
4/4	6.4325		6.12
4/5	6.24		6.24
4/6	5.5375		4.91
4/7	5.8875		5.26
4/8	5.5		4.91
4/9	5.9675		6.47
4/10	6.3575		6.63
4/11	6.86		7.56
4/12	6.24		5.97
4/13	6.3575		6.83
4/14	6.6275		8.26
4/15	6.4725		6.83
4/16	6.6675		7.06
4/17	6.785		6.94
4/18	6.55		6.51
4/19	6.9775		7.10
4/20	7.4025		8.65
4/21	7.8675		10.28
4/22	8.4875		11.49
4/23	9.22		12.65
4/24	11.1925		14.14
4/25	10.11		12.15
4/26	10.265		12.69
4/27	9.5625		11.06
4/28	9.4425		11.92
4/29	9.72		12.15
4/30	9.9525		12.74
5/1	10.1475		12.74
5/2	9.64		11.92
5/3	10.6125	10.54	13.09
5/4	10.7675	11.04	13.09
5/5	10.2625	11.35	13.48
5/6	9.915	11.86	10.87
5/7	10.885	11.86	11.72
5/8	11.2325	11.51	13.87
5/9	11.58	11.31	15.56
5/10	11.8925	11.23	15.92
5/11	11.505	11.51	14.62
5/12	12.625	11.50	14.57
5/13	13.2875	12.51	14.53
5/14	13.0175	12.66	15.01
5/15	11.815	12.16	14.67
5/16	9.9175	12.24	14.56
5/17	11.2275	11.77	13.77

5/18	11.1575	11.85	10.24
5/19	11.0375	11.97	10.67
5/20	11.35	11.66	12.89
5/21	12.3125	11.70	14.57
5/22	12.2775	11.70	15.80
5/23	13.4425	11.27	16.56
5/24	14.4525	11.35	17.39
5/25	13.29	11.66	17.64
5/26	13.0575	13.17	17.84
5/27	14.38	13.67	17.83
5/28	14.53	15.32	18.80
5/29	15.1175	15.71	18.97
5/30	14.7225	16.11	19.02
5/31	15.71	17.02	18.87
6/1	16.2225	16.02	19.19
6/2	15.085	14.80	19.61
6/3	14.57	15.39	18.37
6/4	16.1425	15.55	15.63
6/5	16.265	15.31	18.32
6/6	16.465	15.87	18.35
6/7	15.59	15.94	16.91
6/8		15.20	
6/9		14.53	
6/10		15.15	
6/11		15.08	
6/12		14.92	
6/13		15.83	
6/14		15.67	
6/15		16.59	
6/16		16.70	
6/17		16.90	
6/18		17.02	
6/19		16.62	
6/20		16.62	
6/21		16.92	
6/22		17.38	
6/23		17.74	
6/24		17.18	
6/25		17.22	
6/26		18.42	
6/27		20.09	
6/28		20.29	
6/29		19.48	
6/30		18.54	
7/1		18.22	
7/2		19.19	
7/3		18.79	

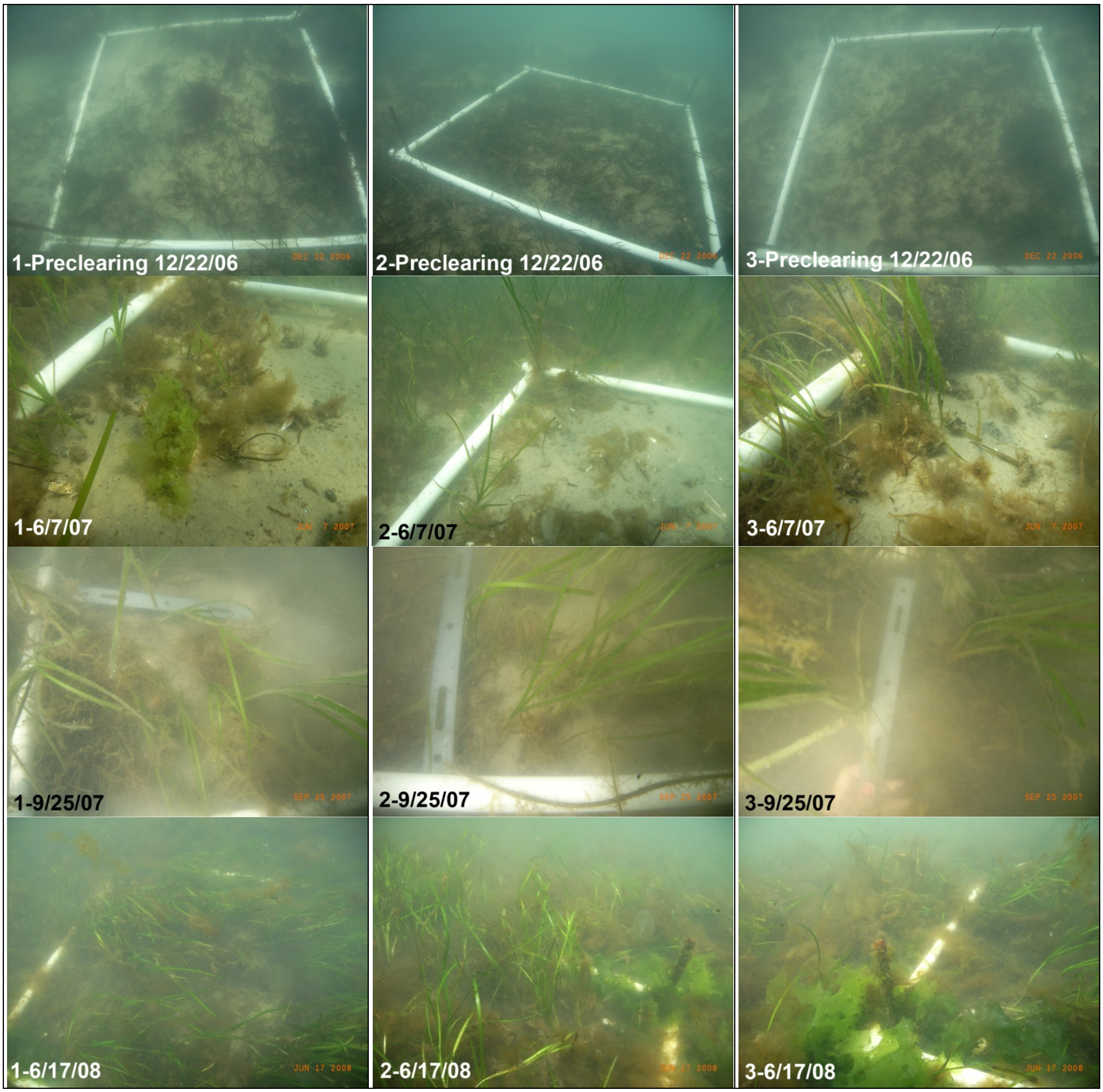
7/4	17.38	
7/5	18.14	
7/6	19.07	
7/7	19.43	
7/8	20.09	
7/9	20.86	
7/10	20.53	
7/11	19.96	
7/12	19.84	22.51
7/13	19.47	22.13
7/14	19.60	22.16
7/15	19.88	22.48
7/16	19.35	22.82
7/17	20.00	24.05
7/18	19.88	24.68
7/19	20.86	24.05
7/20	22.01	22.38
7/21	21.93	23.06
7/22	21.35	23.92
7/23	21.40	23.06
7/24	19.35	22.97
7/25	20.53	23.65
7/26	21.35	23.87
7/27	21.68	24.47
7/28	21.65	24.65
7/29	21.15	24.78
7/30	20.25	24.50
7/31	20.33	24.32
8/1	22.06	25.74
8/2	21.81	26.80
8/3	21.60	26.52
8/4	21.07	25.82
8/5	23.11	26.09
8/6	23.87	25.87
8/7	24.00	25.73
8/8	23.66	25.52
8/9	23.79	24.51
8/10	22.64	24.29
8/11	22.06	22.63
8/12	22.10	22.04
8/13	21.06	21.51
8/14	20.73	22.01
8/15	20.53	22.17
8/16	19.72	22.05
8/17	20.90	23.10
8/18	21.85	23.52
8/19	21.85	24.09

8/20	22.22	24.52
8/21	21.15	23.46
8/22	20.25	23.31
8/23	20.94	23.56
8/24	21.77	23.22
8/25	21.89	22.58
8/26	21.06	21.13
8/27	20.24	19.69
8/28	20.12	20.51
8/29	20.40	20.46
8/30	19.88	20.06
8/31	19.96	19.98
9/1	19.72	19.33
9/2	18.50	18.47
9/3	18.91	19.45
9/4	19.44	20.47
9/5	19.40	20.06
9/6	19.44	20.02
9/7	19.80	20.97
9/8	19.84	21.13
9/9	20.00	21.42
9/10	20.08	20.72
9/11	19.15	18.80
9/12	18.71	18.19
9/13	19.03	18.27
9/14	18.99	18.55
9/15	19.07	18.96
9/16	19.36	19.77
9/17	19.80	20.93
9/18	20.04	21.63
9/19	20.20	21.76
9/20	20.00	21.30
9/21	18.99	19.12
9/22	18.91	19.17
9/23	18.74	18.96
9/24	19.28	19.98
9/25	19.40	19.81
9/26	18.99	19.08
9/27	18.87	19.33
9/28	18.95	19.17
9/29	18.95	18.80
9/30	18.67	17.47
10/1	18.34	17.90
10/2	18.46	17.95
10/3	18.55	18.47
10/4	18.95	19.69
10/5	18.95	19.00

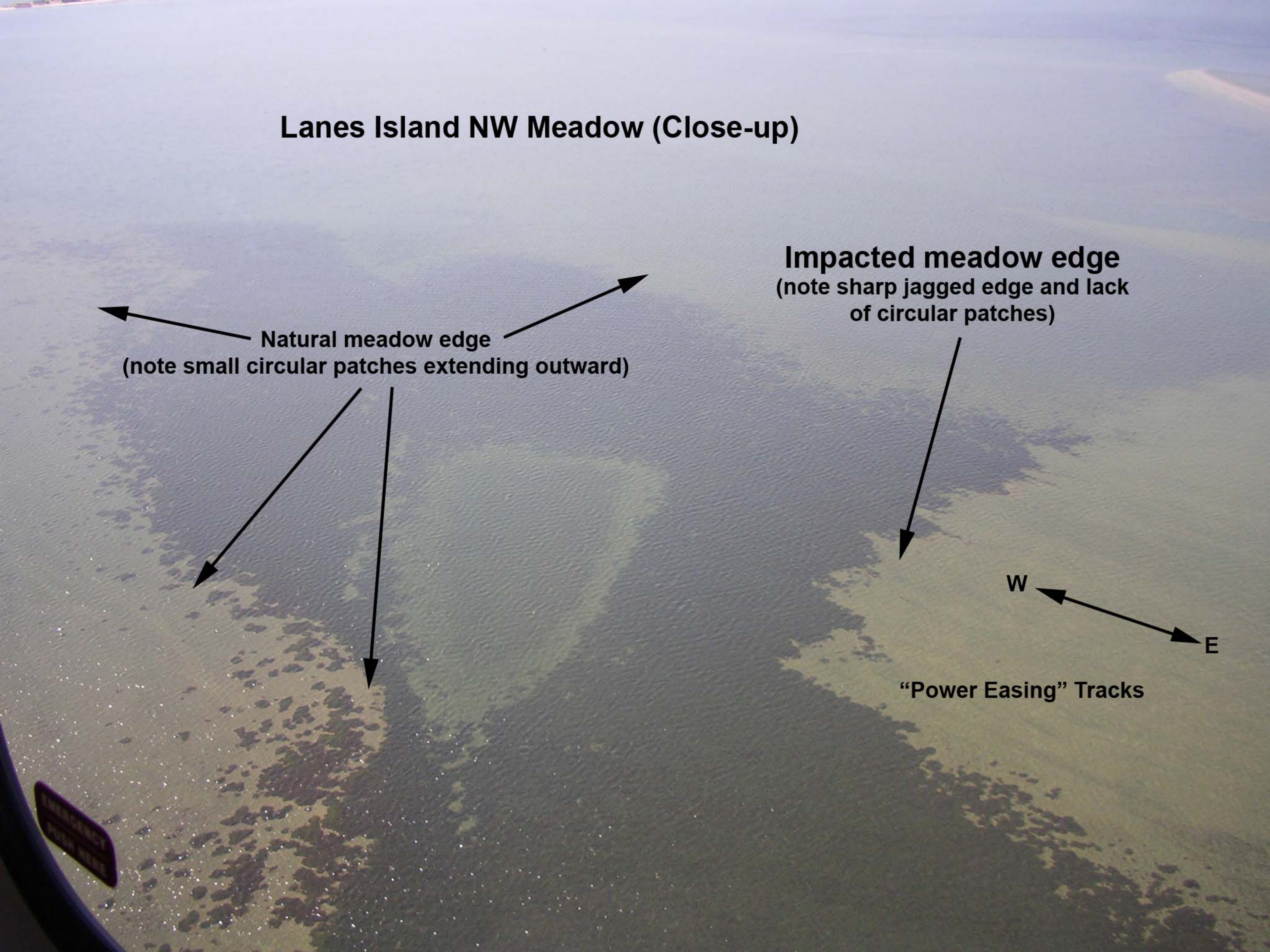
10/6	17.53	17.18
10/7	16.62	16.62
10/8	16.74	16.54
10/9	17.34	17.06
10/10	17.70	17.71
10/11	17.42	17.18
10/12	17.54	17.83
10/13	17.14	15.67
10/14	16.42	14.10
10/15	15.51	12.50
10/16	16.14	13.94
10/17	15.87	14.21
10/18	15.91	15.83
10/19	16.58	16.82
10/20	16.62	16.62
10/21	15.51	13.39
10/22	15.16	13.82
10/23	15.71	14.29
10/24	15.08	12.46
10/25	13.82	11.10
10/26	12.78	10.21
10/27	13.75	10.67
10/28	14.37	13.16
10/29	10.89	8.14
10/30	10.03	8.30
10/31	12.44	11.37
11/1	13.55	13.27
11/2	13.25	13.08
11/3	12.51	11.68
11/4	12.47	11.17
11/5	12.32	11.02
11/6	12.75	11.02
11/7	12.79	11.60
11/8	12.90	13.12
11/9	13.48	13.98
11/10	13.48	13.32
11/11	13.59	13.05
11/12	13.71	13.78
11/13	13.90	14.05
11/14	13.94	14.21
11/15	13.90	14.25
11/16	14.10	14.84
11/17	14.76	15.55
11/18	13.63	13.59
11/19	13.13	12.65
11/20	12.36	10.94
11/21	11.00	9.55

11/22	10.73	10.59
11/23	10.50	10.68
11/24	10.31	9.97
11/25	10.46	9.70
11/26	11.23	9.31
11/27	11.58	9.74
11/28	11.70	10.94
11/29	11.50	11.49
11/30	12.20	12.23
12/1	12.70	13.24
12/2	12.20	11.10
12/3	11.00	9.12
12/4	10.69	8.85
12/5	9.68	6.43
12/6	9.49	6.27
12/7	9.84	8.11
12/8	6.94	2.02
12/9	6.01	0.99
12/10	4.41	2.38
12/11	6.55	5.03
12/12	7.21	6.16
12/13	8.26	7.76
12/14	8.49	8.07
12/15	8.99	8.61
12/16	8.83	8.11
12/17	9.06	8.23
12/18	9.72	8.92
12/19	9.07	8.03
12/20	8.91	7.06
12/21	8.10	6.43
12/22	7.13	7.09
12/23	9.53	9.46
12/24	9.22	8.15
12/25	8.57	6.98
12/26	9.29	9.27
12/27	8.41	7.44
12/28	8.02	6.12
12/29	7.68	7.02
12/30	7.75	6.63
12/31	7.56	6.36

Appendix V. Clearance Plot Photo Comparison. Shown below are a series of photos monitoring the natural re-vegetation of cleared 1 m^2 plots within natural eelgrass. Each column below depicts one of the clearance plots over time. After approximately 6 months, only a small number of shoots had encroached into the plot. After about 9 months, the eelgrass had encroached approximately 30 cm into the plot from most sides. After 18 months, the plots were indistinguishable from the neighboring natural eelgrass. According to these observations, the eelgrass in the flats east of Shinnecock Inlet will naturally re-vegetate after a disturbance within 18 months assuming the disturbance is of similar size. Because of low tides and also low visibility due once stirred up, it was often difficult to photograph the entire clearance plot. In order for us to quantify the area revegetated in these cases, we drew sketches on dive slates in the field and compared these to photographs of portions of the plots. See Table 4. within this report for results.

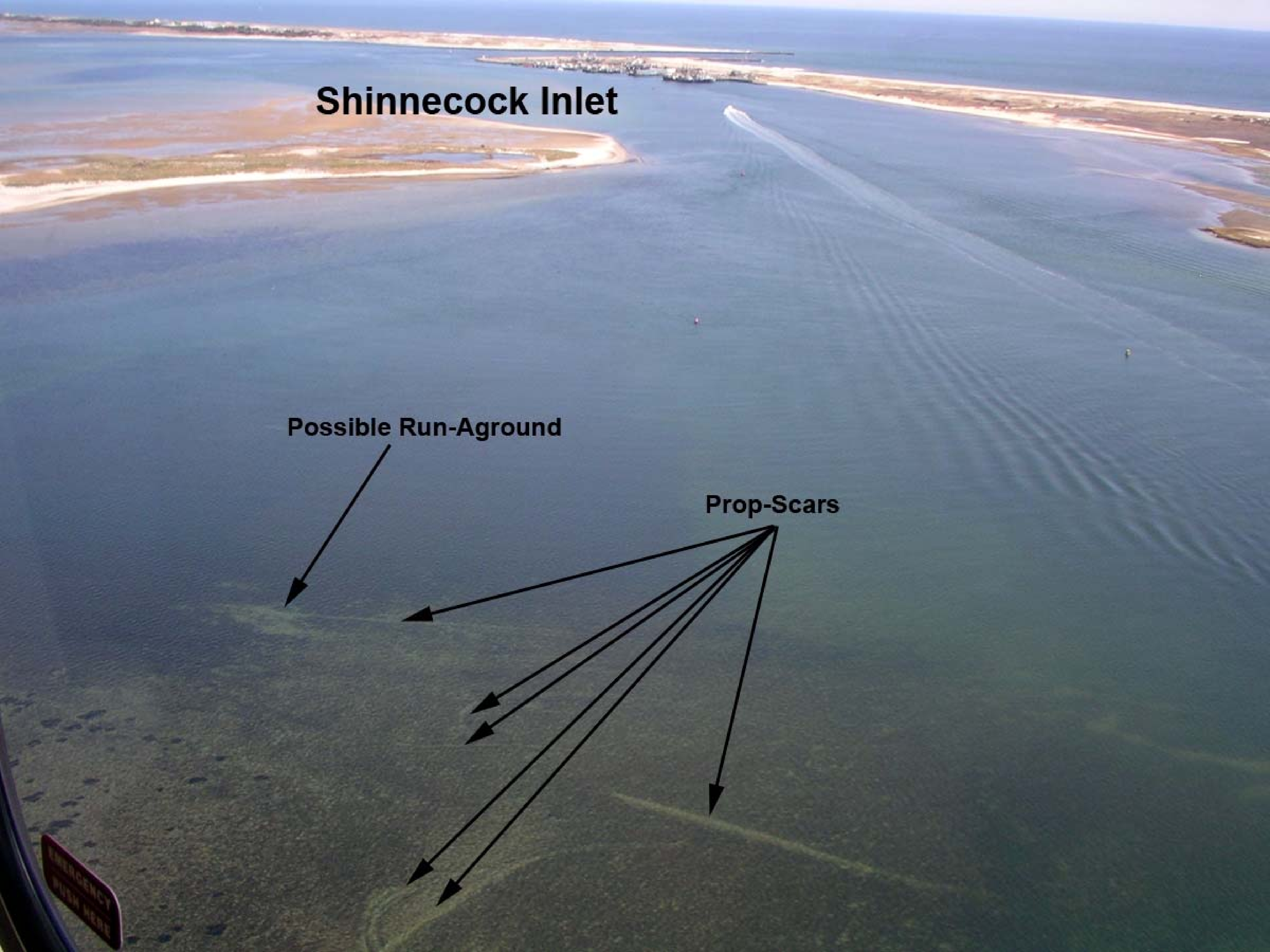


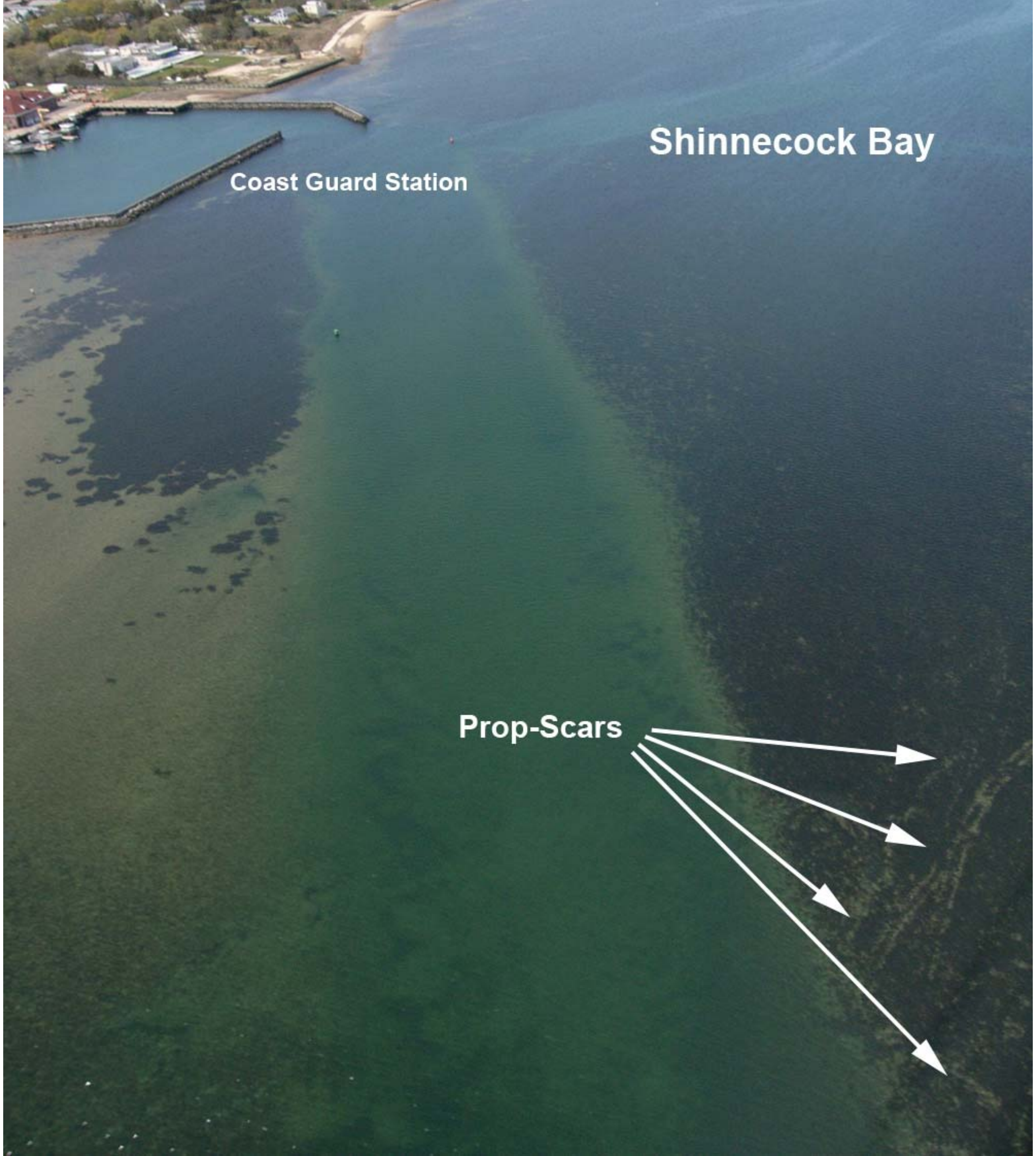
Appendix VI. Photos of Eelgrass Impacts: Shellfishing and Boating Activity

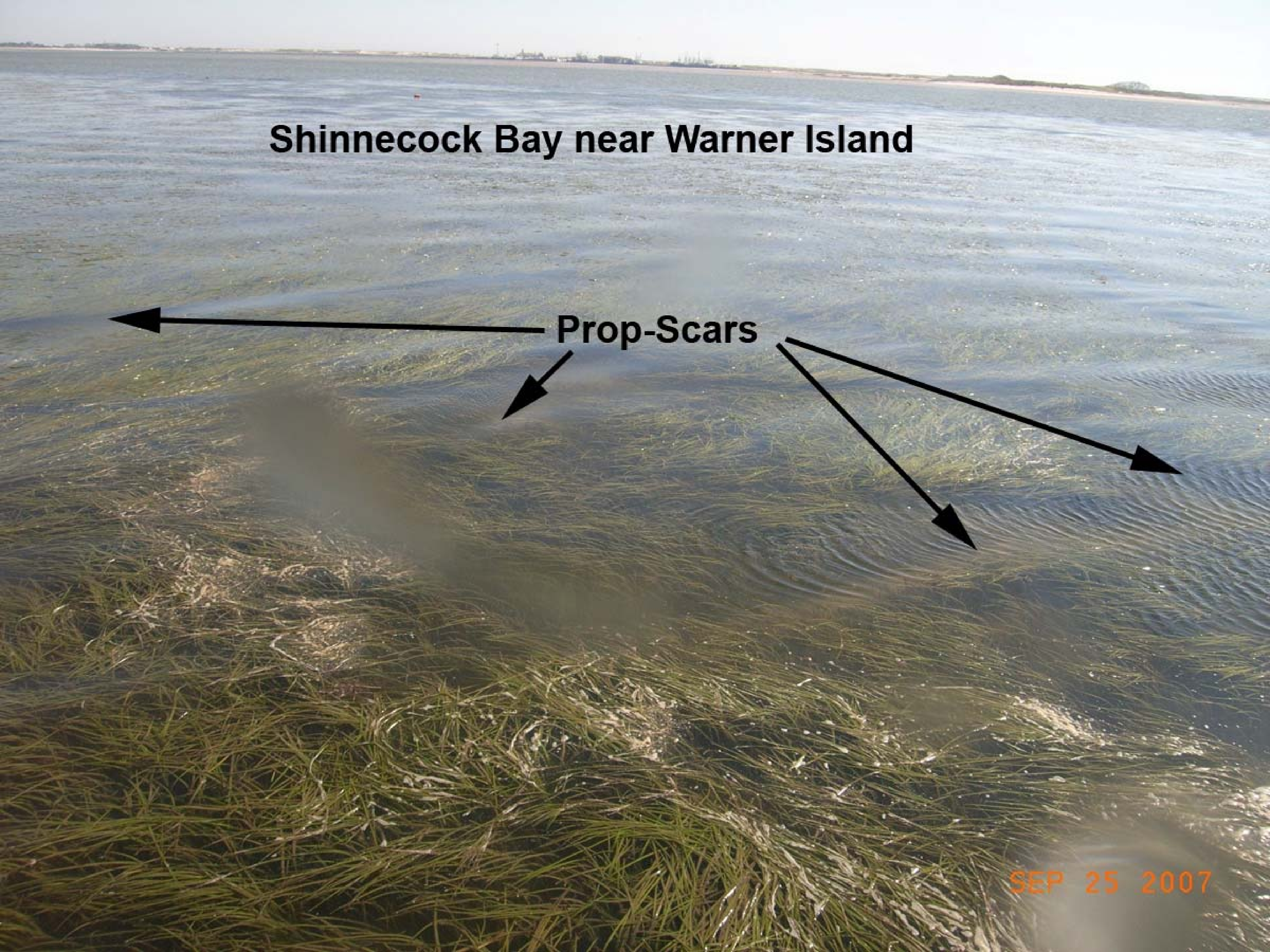

Lanes Island NW Meadow (Close-up)
Natural meadow edge
(note small circular patches extending outward)
Impacted meadow edge
(note sharp jagged edge and lack
of circular patches)
W
E
“Power Easing” Tracks

"Power easing" tracks-Shinnecock Bay eastern flats
through patchy eelgrass
JUN 21 2008


"Easing" tracks Moriches Bay
impacting meadow edge


Shinnecock Inlet
Possible Run-Aground
Prop-Scars


Shinnecock Bay
Coast Guard Station
Prop-Scars


Shinnecock Bay near Warner Island
Prop-Scars
SEP 25 2007


Moriches Bay
Clammer Digging in Eelgrass

Floating eelgrass with rhizomes intact found downwind of baymen working on north side of Warner Island (Shinnecock Bay) 6/17/08.

Another large clump of floating eelgrass found with rhizomes intact, most likely uprooted by "power easing".