

Drakes Estero Restoration Project

Removal of Oyster Racks and Aquacultural Debris from Subtidal Lands of Drakes Estero

PROJECT DESCRIPTION April 2015

The Drakes Estero Restoration Project is intended to remove all oyster racks and aquacultural debris and to restore conditions supporting natural ecological and hydrologic process within Drakes Estero within Point Reyes National Seashore (Figure 1). The restoration actions include removal of wooden racks, aquacultural debris (including tubes, bags and strings), oyster mats, anchors and lines, as well as development and implementation of long-term monitoring programs to document the ecological response and transition of Drakes Estero to the cessation of aquaculture activities and restoration. The project involves the following activities:

- A. Restoration Operations and Activities
 - a. Temporary Offload and Transfer Site Development
 - b. Anchoring
 - c. Debris Hauling
 - d. Interim Buoys for Removed Racks
 - e. Channel Markers for Project Operations
- B. Oyster Rack Removal
 - a. Rack Removal Method
 - b. Collapsed Rack Removal
 - c. Hydraulic Cutting Tools
 - d. Environmental Considerations for Hydraulic Operations
 - e. Inadvertent Breakage
 - f. Rack Removal Summary
- C. Marine Debris/Non-Native Shellfish Removal
 - a. Aquaculture Debris Removal (Oyster Strings, Tubes, and Bags)
 - b. In-Situ Treatment of Accumulated Shell (Experimental)
 - c. Removal of Oyster Mats
 - d. Removal of Established Anchors and Lines
 - e. Removal of Uncontained Manila Clam
- D. Drakes Estero Stewardship Program
- E. Drakes Estero Monitoring Program

In addition to the Project Description, the Project submittals also include the following:

- Appendix A – Eelgrass and Debris Assessment and Assumptions
- Appendix B REVISED APRIL 2015 – Oyster Shell Debris Treatment and Response
- Appendix C – Drakes Estero Long-term Monitoring Program
- Appendix D – Operational Guidelines
- Supplemental Appendix 1 – Impacts Analysis and Avoidance Measures
- Title I Preliminary Engineering Report, Holladay Engineering Company, March 2015 (submitted under separate cover)

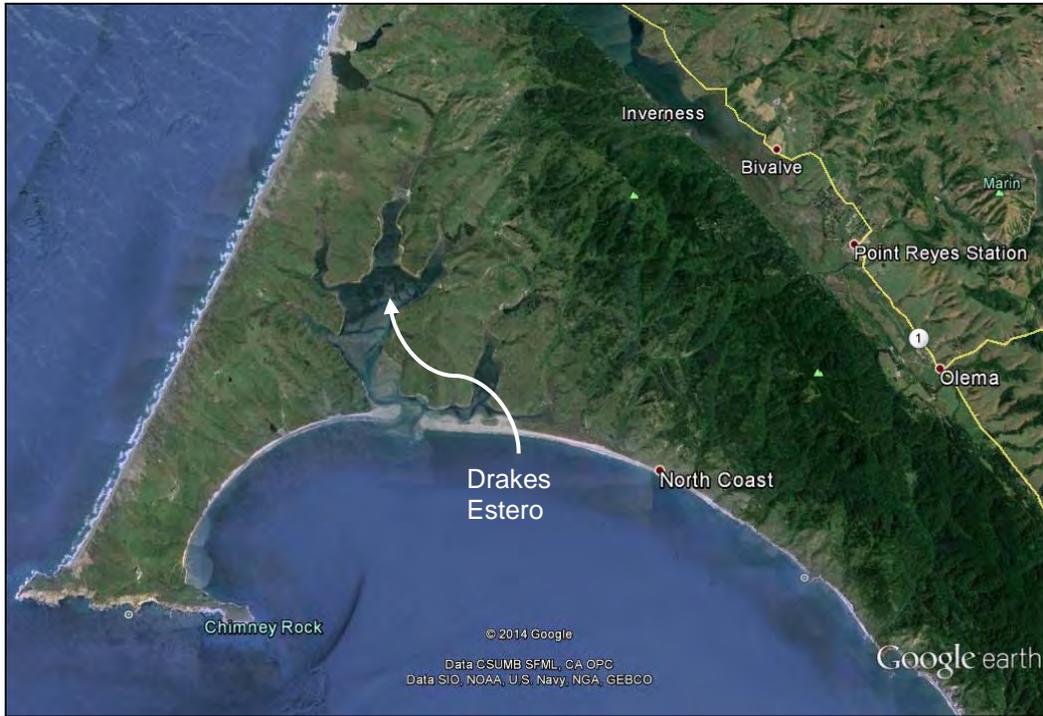


Figure 1: Project Vicinity Map (Map Source: Google Earth)

Drakes Estero Restoration Project Goals, Environmental Considerations and Constraints

The primary planning approach for this project is to maximize removal of aquacultural infrastructure and debris while minimizing impacts to existing eelgrass beds. The NPS intends to remove or treat as much unnatural hard structure as feasible to improve potential for eelgrass to expand, and to minimize potential habitat for the non-native invasive tunicate *Didemnum vexillum* (Dvex).

The NPS has observed that while eelgrass is present around the active racks, in many cases there is little to no eelgrass present beneath the racks. The factors influencing this include shading from the rack and the former hanging culture, as well as debris accumulation forming an oyster shell cap over the bed surface.

The nature of the work (removal of infrastructure), the proximity of eelgrass to many of the structures (within and immediately adjacent), and the hydrodynamics of the estuary (high tidal flushing) make the design and evaluation of the project and its potential impacts unique. The removal of infrastructure that is unnatural to the system is beneficial both in the short and long-term. Eelgrass is immediately adjacent to many of the racks and removal of the racks necessitates access to and likely impacts to eelgrass adjacent to the racks. Removal of materials and debris associated with these linear structures will necessitate that the contractor moves along the line quickly. As a result, the duration of work at any one location will be minimal. This coupled with the energetic tidal dynamics and hydrologic turnover, the indirect impacts associated with rack removal and aquacultural debris removal will be minimal. The project will

include long-term monitoring to evaluate multiple response, restoration, and research questions regarding removal of aquaculture infrastructure and debris from Drakes Estero.

Project Planning Assumptions

The Project Area is represented by the offshore and onshore areas of the former commercial oyster operation within Drakes Estero. There are a number of specific areas within the restoration project area where the NPS plans to implement removal and restoration activities (Figure 2). Barge and boat traffic associated with the demolition and restoration activities will primarily follow established vessel transit corridors.

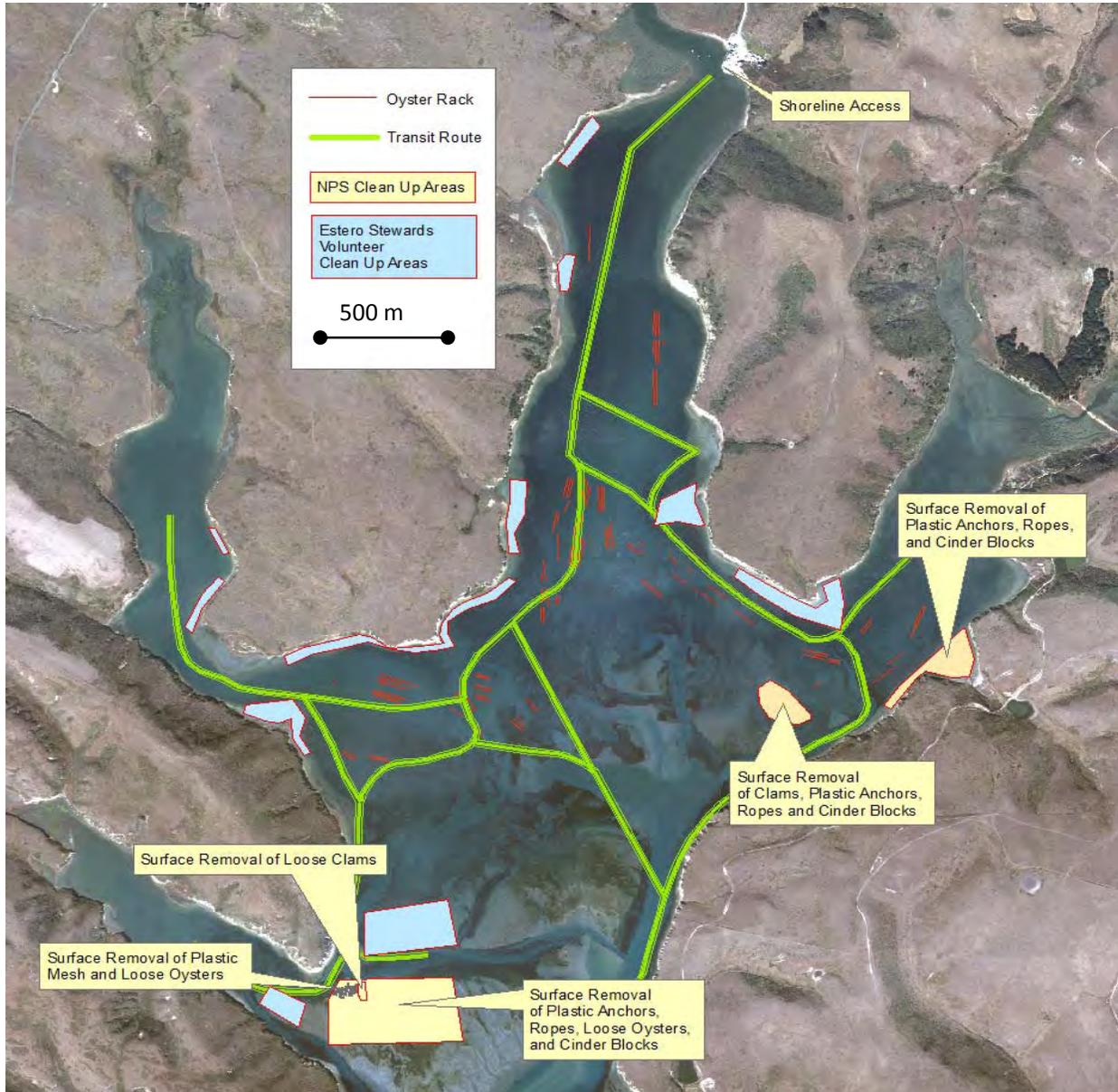


Figure 2: Project Treatment Areas, and primary vessel transit routes within Drakes Estero

The 95 oyster racks comprise approximately 7.07 acres of area (308,000 square feet), and if lined up end to end are more than 5 miles long. The Project will result in removal of between 200,000 and 250,000 total board feet (approximately 477 tons) of lumber from Drakes Estero. In the long-term, the project will enhance and restore conditions within the entire 7.07 acre footprint through the removal of infrastructure and restoration of more natural conditions. The NPS estimates that approximately 2,234 vertical structures (bents) are installed in the bed of the estero holding the racks in place. It is estimated that approximately 40% of the posts and 41% of the length of bottom cross-member (deadman) are adjacent to and could affect existing eelgrass habitat. Table 1, below identifies the overall project area footprint and impact area within areas where eelgrass is documented.

Table 1. Summary of Cumulative and eelgrass impact areas.

Impact area for posts and deadmen are estimated based on general observations of impact area from the method pull test conducted in February 2015 (see oyster rack removal section for more details). The estimate for stringers is based on their dimensional footprint (approx. 4" wide by length of stringer). Deadmen are not included for Racks 4A, 8A, 8B and 8C. Aquaculture debris is included within the Moderate/Heavy debris area calculation, so it is not double counted in the total. The debris experiment area is subtracted from the Shell debris area. All values are estimated from underwater video footage from 71 of the 95 racks. Level of error for eelgrass cover, stringers on the estero floor, shell debris, and plastic/wire is unknown, but is likely less than 25%.

Component	Cumulative Impact Area		Eelgrass Impact Area	
	Sq Ft	Acres	Sq Ft	Acres
<u>Within Rack Footprint</u>				
Posts (assume 1.3 SF/post)	8,713	0.20	3,572	0.08
Bottom Cross-member (assume 1 SF/LF)	30,072	0.69	12,726	0.29
Stringers on Estero Floor (total area of boards covering bed of Estero)	11,928	0.27	6,232	0.14
Moderate/Heavy Aquaculture and Shell Debris	103,830	2.38	0	0.00
Aquaculture Debris – Bag, Tube and String Cleanup*	41,818	0.96	0	0.00
In-Situ Shell Debris Treatment*	21,800	0.50	0	0.00
Total Impact Area within Rack Footprint	154,542	3.55	22,530	0.52
Total Project Area within Rack Footprint	308,016	7.07	126,287	2.90
<u>Outside Rack Footprint</u>				
Dock and Anchors [#]	3,200	0.07	3,200	0.07
Oyster Mat Removal	16,988	0.39	0	0.00
Manila Clam Treatment (Bed 17)	21,344	0.49	0	0.00
TOTAL IMPACT AREA	196,075	4.50	25,730	0.59
TOTAL PROJECT AREA	349,549	8.02	129,487	2.94

*areas within Total Moderate/Heavy Shell Debris Area

[#]see text for calculation of eelgrass impact

The other primary component of the project is the removal of aquacultural debris. It is estimated that approximately 2.4 acres of the 7.07 acre rack footprint is covered in moderate/heavy shell debris. These moderate/heavy accumulations of shell and aquaculture debris may impede or prevent potential for eelgrass recovery. Within that 2.4 acre area, the NPS has documented approximately one (1) acre where the debris includes accumulations of aquaculture debris such as tubes, strings and bags.

The NPS has considered multiple approaches to treatment of accumulated moderate/heavy aquaculture debris and shell beneath the racks. The primary approach will be to remove all accumulated aquaculture debris (approximately 1 acre) using either mechanical means (excavator with an appropriate bucket to scoop or grab the debris) or using divers for more precise hand removal. The targeted treatment of aquaculture debris from the bottom will ensure all the plastic and materials associated with the former commercial operations are removed. Any shell contained within or on the aquaculture debris will also be removed.

In the remaining moderate/heavy debris areas beneath the racks, the NPS has evaluated a number of treatment or management scenarios, however there are no other examples of this type of condition or treatment being addressed in the literature. The primary concern is whether leaving shell caps in place or treating them with a mix-in activity would promote eelgrass growth and minimize habitat for Dvex. There is not information either way that the NPS can cite that would identify whether such in-situ treatment would address the identified concerns, or if it could inadvertently aggravate those same concerns (e.g. create more Dvex habitat by mobilizing more shell to the surface).

Therefore, any in-situ treatments would now be limited in areal extent only to the heaviest shell accumulation areas which are devoid of eelgrass as documented by our side boat videos. The NPS anticipates that this treatment would be limited to approximately 0.5 acres (not the entire 2.4 acre area of heavy/moderate debris). The specific treatment areas would be selected based on density of shell accumulation, as well as proximity to the other work areas. The NPS is working with design engineers to identify a tool that could be used that would effectively mix shell down into the soil leaving the treated area with less shell exposed on the surface, and more area for fine sediment and eelgrass growing habitat. These efforts are not intended to spread or change the footprint of the accumulated shell. Further discussion of this approach is included in the Marine Debris/Non-Native Shellfish Removal section.

The NPS has identified additional actions for areas outside of the current rack footprints. Activities proposed for 0.88 acres of sand bar debris areas include removal of oyster mats, anchors and lines, and uncontained manila clam from the area. These actions are described further in the Marine Debris/Non-Native Shellfish Removal section.

Duration of Work

This project requires a high level of coordinated effort. Since the project is in the marine environment, tidal and weather elements will have a significant impact on the ability of a contractor to conduct the demolition. In addition to potential tidal impacts to the project schedule

(low tides in middle of the day), the summer months typically experience higher winds. A 16% estimated likelihood of winds between 10-20 mph has been used. Winds at this level will curtail or prevent demolition activities on the Estero. The demolition activities are projected to start on July 1st. Design engineers have estimated that the work associated with all demolition activities will take approximately 109 work days. Because of wind and tide factors, it is anticipated that the work would be completed over approximately 146 work days (Table 2).

Table 2 – Work Day Evaluation				
Month	Work Days	Tidal Delay Days	Wind Delay Days	Contract Work Days
July	23	6	4	33
August	21	2	3	26
September	22		4	26
October	22	6	4	32
November	21	5	3	29
Recommended Contract Work Days				146

For contracting purposes it is assumed that the project will allow approximately 204 calendar days for the work. The contract window for the project is anticipated from July 1, 2015 to January 20, 2016.

Restoration Operations and Activities

There are a number of temporary operational actions and activities necessary to support restoration of Drakes Estero. In addition to temporary onshore improvements for unloading and transfer of debris recovered from the Estero, there are a number of offshore operational activities that will be necessary during the active project period.

Temporary Onshore Transfer Facility

The project staging area can be as much as 8 feet above the water level at low tide. Even at high tide, the slope of the shore does not allow for direct access to floating vessels from the shore. The extensive volume of debris that has to be transported out of the estero through the staging area requires development of a temporary onshore transfer facility. Temporary site improvements are necessary to allow for the efficient transfer of debris containers from the demolition vessels onto the shore. The extent of onshore development required for the project is dependent on the type and volume of materials that will be removed from Drakes Estero. All constructed improvements will be removed at the completion of the project.

The NPS is still evaluating removal methods and debris transport solutions that may allow for the use of a smaller dock (thereby reducing temporary impacts described as part of the floating dock) or eliminate the need for a dock (in which case a smaller footprint may need to be affected to unload materials at the shoreline site). For the purpose of this analysis, the NPS has analyzed the 20'x150' dock, with the understanding that smaller structure, or alternative access may ultimately meet the site needs and result in far more limited impact footprint than currently identified.

A temporary floating dock may be constructed with a bulkhead on the shore in order to secure multiple barges in series to the shore. This floating dock would facilitate docking, unloading and loading of the debris boxes from offshore barges within deeper water areas allowing operations at a broader range of tides. The concept drawing for a 20 ft wide by 150 ft long temporary floating dock is attached (Figure 14 in the Title I report (Holladay Engineering 2015)). The temporary floating dock of that length would likely require temporary anchors at approximately 20 foot intervals to ensure the dock remains in a stable alignment. Surveys of the bottom bathymetry and eelgrass presence within the general area of the dock will be conducted to determine final location of the dock, and to minimize impacts associated with this temporary facility. A wheeled forklift would likely transport debris boxes along the floating dock to the onshore processing area. For heavier debris, an excavator may be required for transport of boxes for the length of the dock.

The temporary dock would result in temporary impacts through shading and limited settling at low tide over a 3,000 square foot area. Placement of temporary dock anchors to secure the dock will result in temporary impacts to an additional 200 square feet (assumes 10 square feet/anchor). The NPS has documented intermittent eelgrass beds in some areas within the footprint of the floating dock. As part of the site survey, the actual area of eelgrass can be determined but based on site visits is currently estimated at 50% of the total dock impact area, but for the purposes of this analysis, the entire 3,200 SF area is anticipated to impact eelgrass habitat.

Once rack and aquacultural debris is transported to the onshore area, all other work will be conducted outside of the Mean High Water level. Debris will be sorted and transferred from the smaller containers used over water to larger containers for transport and delivery to approved disposal facilities.

The temporary onshore staging site development plan is attached (Figure 12 of the Title I report). Based on discussions with the design engineer, the onshore area will not require a shell washing station and other onshore separation and preparation areas. This conceptual plan is not to scale but represents the general location and distribution for the work site facilities that will be in operation for the duration of the work period.

We do not anticipate that installation of the job trailer and job restroom and work office facilities will require any additional grading. There is power to the site and the contractor could work with PG&E to connect. The contractor would be required to provide all water. The restroom facility would be self contained (e.g – no connection to a site disposal system) and the contractor or a contracted company would be responsible for maintenance and disposal of all septic water away from the site.

The contractor would likely need to conduct some grading in upland areas (eg areas above MHW) in association with installation of the temporary dock approach and bulkhead but the overall need for additional grading at the site would be minimal.

Once offshore demolition activities are complete, the contractor will remove the temporary onshore transfer facility infrastructure and regrade the site to generally match current conditions.

Vessel Operations

It is assumed that there will be multiple crews working on the Estero, and multiple debris transport barges. A preliminary estimate is between 8-12 vessels, though the actual number of vessels would be determined by the contractor's approach. Most of the vessels would likely be barges for support of removal operations (e.g. barge with excavator on it) and debris transport (e.g. barge and possibly push/tow vehicle), with 1-2 small vessels for daily crew access to the barges.

Anchoring

Vessels containing debris containers and/or excavators are anticipated to be larger than the floating dock used in the rack removal method test conducted February 17-18. A more robust anchoring system will be necessary for these vessels than a vertical pole used for positioning and anchoring in the method test.

The rack and aquacultural debris removal activities will require the operation and use of equipment from multiple barges (see below for barge descriptions). Operational barges supporting operations of the excavators and other removal equipment will require a flexible and stable anchoring system. They will need to move along the line of the racks during demolition and will also be best anchored in the water overnight. Debris transport barges will be generally mobile and may be tied off to operational barges. It is anticipated that the larger barges and equipment will be more susceptible to wind, wave and tide effects.

General anchoring of the demolition vessels will be conducted in a manner so as not to impact eelgrass by anchoring within the boundaries of oyster racks and in areas without eelgrass. Anchoring of barges overnight will be done in areas without eelgrass. In areas of established eelgrass, anchoring will be conducted in a manner to minimize disturbance of established eelgrass (i.e. limiting mooring lines, vertical anchoring, and no anchor chains allowed to "sweep" the bottom.) Anchoring is proposed that will allow the demolition vessel to use the anchors to pull the vessel forward and position it in front of oyster rack bents.

Additional discussion of anchoring and potential impact avoidance is included in the Supplemental Appendix 1.

Debris Hauling

Material removed for disposal will be lifted directly into a debris container on a debris transport barge. The material will be placed directly into containers (not dug or scraped across barge decks or container edges) in order to prevent the loss of *Dvex* from the debris material back into the estero. Debris containers, when full, will be taken by self-propelled barges or towed by support boats back to the staging area along identified vessel transit routes. Debris transports will tie off along the onshore floating dock. The configuration of the dock could allow for multiple transports to be tied off at one time. Debris boxes would be lifted from the barges transferred to shore using a wheeled lift and transferred onshore. Empty containers would be loaded back onto the barges for transit back to the work areas.

Offsite debris disposal

The type of vehicles used to transport debris offsite has not been specified or determined, however, it is likely that the debris from the offshore work would be consolidated into larger debris boxes for transport to an approved disposal facility. For planning purposes, it is anticipated that the contractor will minimize truck trips by using larger transport containers – e.g. 10 CY dump trucks or 20 CY debris box transports, and by making sure the debris boxes are fully loaded prior to leaving the site.

The preliminary estimates for weight of lumber, sandbar debris, and other aquaculture debris exceeds 500 tons. Given the overall mass of materials, and anticipated duration of work on the water, the number of trips per day of operation would not likely exceed 20 but is more likely on the order of 10 trips per day.

During the week of January 12, 2015, the onshore demolition contractor removed all of the commercial structures and associated infrastructure and debris at the site. This totaled 660 cubic yards of material (buildings, docks, and debris) and 6,256 square feet of asphalt and concrete. For that week there were approximately 10-15 trips per day required to remove the 660 CY of debris from the site. During that same period, a separate contractor removed approximately 37,000 pounds of shellfish and affiliated material (plastic tubes, mesh bags, etc) from the Estero using smaller vehicles.

Interim Buoys or Markers for Removed Racks

The oyster rack perimeter will be marked with buoys or other markers (anchored inside the oyster rack footprint) during the demolition process. This will allow for easy identification of rack perimeter where moderate and heavy shell debris removal or treatment is planned, and will allow for easy location of the treatment area for final inspection. All buoys will be removed at the completion of the project.

Channel Markers for Project Operations

Channel markers for the main channel running north to south in Schooner Bay remain in place, and will remain for the duration of operations to accommodate safe and efficient transport of materials. As noted above, contractors will also install temporary buoys or PVC pipe to mark the footprint of racks until inspections for completion are complete. NPS will evaluate transit routes and install or remove markers as necessary during the project. Following completion of the project, NPS will remove markers from Drakes Estero consistent with Wilderness status.

Oyster Rack Removal

It is estimated that the 95 oyster racks contain between 200,000 and 250,000 linear feet of dimensional lumber. Materials used to construct the racks typically consisted of 2 in. x 4 in. and/or 2 in. x 6 in. milled lumber (see Figure 3 and Figure 4 for typical condition). Some oyster racks were constructed using pressure treated lumber. Drakes Bay Oyster Company (DBOC) was not permitted to construct or add new lumber to the oyster racks for the last ten years. Therefore, it is assumed that all lumber in the Estero has been in-place for at least 10 years, with much of it present in the estero for 3-4 decades.

The racks are comprised of vertical bent structures sunk into the mud, and horizontal stringers that were used to hang oyster strings. Vertical bent structures consist of three (3) vertical 2x6 inch posts affixed and stabilized by a 14-foot long 2x6 inch horizontal cross-member. Our observations indicate that in some cases, the cross-member is buried below the mud line, but in other cases it is at or above the mud line. The three vertical spars stick down into the mud approximately 5 feet. We have identified four racks representing approximately 80 bents where the posts are 4-inch round poles, which do not appear to have the bottom cross-member.

The top of the bent structure is held together by a 2-inch by 4-inch and 2-inch by 6-inch cap board. Stringers are installed over the tops of the bents, spanning the bents horizontally to hang the strings of oysters. Six stringer boards spaced equally across the bents, make up the top of the rack for the entire length of the rack. The approximate width of the racks is 12 feet. The stringers are generally 2-inch by 4-inch boards. Individual stringer boards are installed with overlap and secured generally by a high volume of nails. It is estimated that there is a 20-25 percent overlap for the stringer boards. Field tests indicate that the stringer boards are difficult to pry apart and will be most efficiently removed using hydraulic shears, scissors or hand-held, portable hydraulic submersible reciprocating saws.

The oyster racks are in various conditions ranging from in-tact to extremely dilapidated. Based on submittals DBOC up to 54 racks were actively used through September and October 2014. A total of 41 racks were classified as unused by DBOC at that time and likely reflect more degraded conditions. The conditions of these abandoned racks include an assortment of broken and missing stringers, and broken and partially intact bents / posts.

Table 3 presents an inventory of the oyster racks based on reporting from DBOC that has been corroborated by NPS using visual inspections and aerial photographs.



Figure 3: Typical Oyster Rack in Drakes Estero (Photo Source: www.sfweekly.com)

Table 3 – Oyster Rack Inventory	
Racks	95 UNITS
In-tact Bents	2106 EA
Collapsed Bents	128 EA
Posts	6702 EA
Stringers	154,008 LF
Top Cross-members	21,450 LF
Bottom Cross-member (mud-line)	31,276 LF



Figure 4: Typical Oyster Rack in Drakes Estero (Photo Source: www.sfweekly.com)

Rack Removal Method

In mid-February 2015 contractors tested methods to determine the preferred method for rack removal. The contractor tested a winch and pulley system for removal of posts and stringers. The rack removal investigation demonstrated that the force applied by a 2,000 lb winch was not consistent in its effectiveness in removing the oyster rack posts and consumed more time than was expected. In addition, there are safety concerns for operating personnel associated with the necessarily high cable tension observed in the rack removal investigation. The February pull-test also showed that removal of the rack stringers using crowbars was extremely difficult and time consuming and a more efficient method of cutting to separate the lumber is essential.

Underwater monitoring and video did show that when a single post was pulled, disturbance to the estero floor was limited to a very small area and the hole from the pulled post immediately filled in with sediment level to the surrounding sea floor. Increases in turbidity as a result of the pull returned back to pre-pull conditions in one to three minutes.

The rack removal investigation applied a removal force to the oyster rack posts of 2,000 lbs or less. It is assumed that increasing the pull-out tension will decrease the duration of time for each post removal. However, there is a limit to the amount of force that should be applied to the posts. The oyster rack posts are assumed to be No. 2 douglas fir-larch 2"x6" sawn lumber. According to the American Wood Council, the tension capacity of a new No. 2 douglas fir-larch 2"x6" is 6,160 lbs. in tension. The oyster rack posts have been in the water for a minimum of 10 years. The removed 2"x6" posts have shown degradation in the section that was exposed to the tidal fluctuations. Therefore, the tensional strength of the oyster racks is assumed to be degraded. Assuming a degradation of 30%, the oyster rack posts should not be removed with a tension force greater than 4,312 lbs. The oyster rack posts may break at an unacceptable rate if tensions greater than 4,300 lbs are applied to the posts.

Based on the results of these tests and constraints to complete the project within the time schedule as stipulated in the Basis of Design, the use of hydraulic equipment is planned for rack removal. A hydraulic excavator secured to a barge may be highly effective at removing posts, and would provide good flexibility for removal of stringers and bent cross-members. The NPS is continuing to evaluate rack removal approaches, with the interest in increasing operational flexibility and removal efficiency. While a mini-excavator is shown in Figure 5, other types of equipment may prove more efficient at achieving the removal objectives and would be considered by the NPS as part of this project. Larger



Figure 5: Typical Mini-Excavator
Photo: www.cat.com

excavators, which have been described for use in debris removal and in-situ treatment, could also be highly effective for rack removal activities because they could allow operators to have a longer reach and therefore require less anchoring. Additionally, the NPS is evaluating how the

use of smaller hand-held hydraulic cutting tools (reciprocating saw blade) may increase efficiency with the removal efforts. The primary issue is that with 2,234 bents (6,702 posts), any increase to operational efficiency (reduced anchoring, fewer times barges need to be moved for set up) would result in substantial time savings and overall impact reduction.

The Estero is a shallow water body and rack removal requires a variety of activities and likely requires flexibility. A combination of hydraulic excavator and lighter boat or diver operations may prove most efficient to support rack removal. Lighter equipment has the advantage of increasing the duration of operation within the Estero through tidal fluctuations. Crews using hand-held cutting tools, working from lighter boats (eg pontoon boats) or in the water (divers) may be more efficient at accessing, cutting, and removing much of the horizontal stringers from the racks. Excavators feature independent boom swing with interchangeable appurtenances depending upon the application of the machine. The use of the excavator for post removal allows for a more consistent force to be applied on each post and is expected to reduce potential for post breakage. An excavator may operate with a grapple-claw for the grabbing of debris material and depositing it into a debris container on the same barge or a hydraulic cutters.

Collapsed Rack Removal

In addition to the 128 collapsed bents, the NPS has identified that approximately 30% of the intact bents within Drakes Estero have stringers lying on the bed of the estero, generally within the footprint of the rack. Our calculations estimate that there is a total of 11,925 SF of stingers. Most of these highly dilapidated racks have been abandoned for a long period, and eelgrass is present within the footprint of the rack.

The removal of collapsed racks present a slightly more complex situation and may take more time to remove these racks. In many cases the stringer units are still intact but lying on the bottom, and would need to be cut prior to removal to minimize bottom impacts. Divers using hydraulic cutting tools (see below) could efficiently cut and with surface support operations focused on picking up the cut pieces. Diver cutting operations in combination with excavator support to remove materials could provide effective and efficient means of removing the debris from the bottom of the estero while minimizing impact to surrounding eelgrass.

Use of hydraulic cutting tools (other than hydraulic shears)

The park is evaluating the use of underwater operable, hand-held reciprocating saws to cut members rather than only the use of hydraulic shears on the head of the excavator arm. The reciprocating saw blade is narrower with much smaller teeth than a chainsaw (less than 1/8 inch wide). The utility of smaller, handheld reciprocating saws could provide far greater flexibility for a contractor to remove the wood members from the structure without requiring the larger barge supporting the excavator to constantly be moved and re-anchored. The saws could be operated by crews on lighter boats as well as divers. The increased flexibility is anticipated to increase speed and reduce bottom impacts during the rack deconstruction of both in-tact and collapsed racks.

The cutting of all stringers and cap lumber will remove all lumber connections to, and therefore facilitate simple removal of the posts. It is also anticipated that the divers could cut the bottom cross-beam located at or just below the bottom surface. Cutting of the bottom cross-member

would allow the board to rotate as it is pulled out with the vertical post, and could reduce the breakage impacts to the adjacent bottom habitat if the in-tact cross member is lifted and breaks a part of post removal.

The discharge of saturated fine wood particles from the reciprocating saw blade would be minimal for any single cut, and because it would be generated from already saturated lumber, the fine wood particles would likely drop directly to the bottom without any further dispersion. There is little likelihood that any of the fine wood particles would disperse on the surface because of the wood saturation. Other concerns related to this activity are those related to potential for mobilization of chemicals used in pressure treatment of the lumber in the water. As part of the early planning process, the NPS ran the leaching model developed by the NMFS for pressure treated lumber in salt water. The model showed that any chemicals would have leached from the wood in less than 1 year. Because all of the lumber that is to be removed has been in Drakes Estero for 1-4 decades, any potential for leaching has likely passed.

Assuming all wood members would need to be cut, the NPS anticipates that the potential volume of wood debris that is lost during the cutting would be approximately 35 cubic feet. There are many members and bents that will not require as many cuts, so the volume is likely less than 35 CF. While most easily referred to as saw dust, the actual discharge would be saturated fine wood particles in essentially a mush-like form. The limited volume of material would not accumulate in any one area and would not result in additional impacts. No additional BMPs are identified at this time.

Environmental Considerations for Hydraulic Operations

The use of hydraulic equipment increases the presence of petroleum products on the estero during demolition activities. However, the most significant environment spill potential is associated with a broken hydraulic line. Therefore, it is recommended that food grade vegetable oil be used as the hydraulic fluid in all hydraulic equipment used on the estero. In addition, spill response plans and containment protocols in the event of a fuel or oil spill are typical requirements of federal contracts.

Inadvertent Breakage of Posts

In cases where posts break on multiple attempts to remove them, the contractor will be directed to cut broken posts at the mudline. NPS will monitor post breakage during the demolition activities. The contractor will be required to modify the means and method of demolition if the breakage of posts during removal is too frequent. The project is assuming a breakage of 5%. This may leave up to 335 (6702 posts x .05) buried post segments in the estero floor; approximately 20 square feet.

Rack Removal Summary

The rack removal is the most extensive restoration project task. The project summary table (Table 1) identifies the general impact footprint to the subtidal land and to eelgrass within the footprint of the racks.

Eelgrass is limited to absent within the footprint of at least the 54 racks that were actively used through the fall of 2014. For racks that have long been collapsed (e.g. classified as in poor

condition by DBOC in 2010), it is typical that there is eelgrass growing within the footprint of the rack. In many cases, just outside the rack footprint, eelgrass coverage is moderate to dense. Similarly, with respect to debris accumulation, we have found that in areas of moderate to heavy shell accumulation, eelgrass is not present, but in areas of low shell accumulation, we have observed some eelgrass growing between debris and/or shell.

Our calculations for eelgrass are based on the following information. For 71 racks, NPS staff reviewed and identified the number of bents where eelgrass was present around the base of the posts, over buried cross-members, or outside the footprint but within the 1-foot overlap area of the buried cross-member. Based on our assessment, we estimate that approximately 41 percent (2,719 of 6,702) vertical posts are located in areas where eelgrass is present. As presented in Table 1, removal of these posts will affect approximately 8,713 SF (0.20 acres) of subtidal land, and has the potential to affect approximately 3,572 SF (0.08 acres) of eelgrass.

It is estimated that there are 839 cross-members that are present in areas where eelgrass is present, and would likely result in impacts to eelgrass when the cross-member is pulled out with the bent. In the case where the cross-member is exposed, we have not assumed impacts to eelgrass from the removal of the cross-member. As presented in Table 1, removal of these bottom-cross-members will affect approximately 30,072 SF (0.69 acres) of subtidal land, and has the potential to affect approximately 12,726 SF (0.29 acres) of eelgrass. A single cut of the bottom cross-member between each vertical post using the hand-held reciprocating saw could also reduce the direct impact of cross-beam removal associated with eelgrass. Any reductions to the 1 SF/linear foot estimate could result in substantial reduction of the estimated 0.29 acres of eelgrass impact associated with the bottom cross-member removal.

Approximately 30% of the in-tact racks have some collapsed stringer sections associated with them. The total estimated area of the lumber associated with these collapsed stringers is 11,928 SF (0.27 acres) with approximately 6,232 SF (0.14 acres) of collapsed stringers planned for removal within established eelgrass habitat.

Overall, removal 7.07 acres of oyster racks from Drakes Estero will affect approximately 51,000 SF (1.17 acres) of the subtidal land and 22,530 SF (0.52 acres) of eelgrass present within the footprint of the racks. Additional information related to removal/treatment of shell accumulation areas is described below.

Marine Debris/Non-Native Shellfish Removal

The NPS has documented extensive accumulation of shells, strings and tubes from aquaculture operations at various locations below oyster racks within Drakes Estero as well as identified the presence of oyster mats, anchors and lines in other parts of the estero. The density of the debris accumulation below the racks likely affects, and in high densities, appears to preclude eelgrass growth. The proposed approach for treatment of debris accumulation is to remove all aquaculture debris, initiate in-situ treatment on a limited area (0.5 acres) of the heaviest shell accumulation, and to initiate a long-term monitoring effort to determine effectiveness of in-situ treatment. Approximately 0.88 acres of sand bar habitat will be accessed to remove escaped Manila clam as well as shellfish growing debris, including oyster mats, anchors, lines and tubes.

A total of 2.4 acres of area beneath the oyster racks have moderate to heavy accumulation of oyster shell and aquaculture debris. Within that 2.4 acre area, there are a number of locations totaling 1 acre where aquaculture debris, including French tubes, oyster strings and mesh bags full of oysters is present. This accumulation of this aquaculture debris is inconsistent with the long-term wilderness and restoration values of the Estero, and may provide unnatural substrate impeding growth of eelgrass or providing a hard-structure foothold to the growth of other non-native fouling organisms such as *Dvex*.

Table 4 presents the estimate of total debris accumulation areas (aquaculture debris and oyster shell) from those investigations.

Table 4 – Debris accumulation areas within footprint of oyster racks (includes areas of aquaculture debris and oyster shell debris)	
	Area (Square Feet)
Oyster Racks with heavy debris	73,819
Oyster Racks with moderate debris	30,011

The NPS evaluated the feasibility of full scale vacuum or hydraulic suction and removal of aquaculture debris and heavy/moderate density shell accumulated under approximately 2.4 acres of racks (Sections 5.2.1 and 5.2.2 of Title I Report). The equipment necessary for such an operation would include a specialized self-propelled barge is fitted with an adjustable suction line and typically a 24 inch horizontal auger head. The auger combines the debris on the estero flow with water to form a slurry that will be hydraulically pumped back to a dewatering tank on a separate barge. All materials removed from the estero, mud, shell and water, would be captured in frac tanks and transported to shore. Handling of the more than 24,000 cubic yards of material and water from the estero would require extensive dewatering ponds and separation containment areas to dry mud and shell for future disposal. The NPS determined that at this time, the scale of the operation, including equipment, space for materials handling and management, and disposal of materials is not feasible given site access limitations, site space constraints and the shallow nature and tidal dynamics of the Estero.

Further, based on consultation with local eelgrass research experts, it is recommended that the bed elevation generally be maintained near that of adjacent eelgrass beds and that in-situ treatment that breaks the shell cap may potential habitat for eelgrass to move in to the heavy and moderate shell accumulation areas.

The NPS has identified the following approaches to address concerns related to the aquaculture debris and to implement limited in-situ treatment the accumulated shell. The project will proceed with the following activities:

- Remove all accumulated aquaculture debris, including tubes, strings and plastic or mesh bags used in aquaculture operations from approximately 1 acre of heavy/moderate shell accumulation areas using mechanical removal or hand removal by diver.

- Initiate in-situ treatment shell accumulation areas covering 0.5 acres (21,800 SF) of heavy debris accumulation. See method description below
- Following removal work, establish 60 plots to test eelgrass infill within full removal, in-situ treatment and no treatment plots (see Appendix B REVISED APRIL 2015). Results of monitoring would indicate and inform the need for any additional treatment.

Aquaculture Debris Removal(Oyster Strings, Tubes and Bags)

The NPS documented approximately 1 acre of aquaculture debris (tubes, strings, bags and lines) within the footprint of the racks. An excavator using a clamshell or equivalent dredge bucket type was originally identified as the equipment that would access and remove accumulated aquaculture debris (bags, strings, and tubes) from the bottom surface (See Figure 6).



Figure 6: Dredge Bucket (Photo:<http://www.gradall.com>)

The NPS has further evaluated methods and objectives described in the aquaculture debris removal section to identify what method can most effectively, efficiently, and safely remove the aquaculture debris while minimizing disturbance of Dvex, sediment and indirect impacts to eelgrass as part of the removal. The NPS is examining whether other bucket types deployed from an excavator arm may be more effective. The NPS is also evaluating whether this scale of work could be achieved by divers removing the debris by hand. Hand removal would be supported with some mechanical equipment to assist with pulling heavier debris, etc. This approach, however, would generally have reduced indirect sediment impacts than mechanical removal, so if hand-removal is used for implementation the NPS would expect an overall reduction in potential indirect impacts associated with this activity. While hand-removal methods are being explored, the analysis of the impacts should still assume mechanical removal.

In-situ Treatment of Shell Debris

The NPS is continuing to consult on the in-situ shell treatment approaches. There are no other examples of this type of condition or treatment being addressed in the literature. The primary question is whether leaving shell caps in place or treating them with a mix-in activity would promote eelgrass growth and minimize habitat for Dvex. Because there is not information either way that the NPS can cite to that would identify whether such in-situ treatment would address the identified concerns, or if it could inadvertently aggravate those same concerns (e.g. create more Dvex habitat by mobilizing more shell to the surface) the following approach is to a revision to the March 17 Project Description.

Any in-situ treatments would now be limited in areal extent only to the heaviest shell accumulation areas as documented by our side boat videos. The NPS anticipates that this treatment would be limited to approximately 0.5 acres. The specific treatment areas would be selected based on density of shell accumulation, as well as proximity to the other work areas. The NPS is working with design engineers to identify a tool that could be used that would

effectively mix shell down into the soil leaving the treated area with less shell exposed on the surface, and more area for fine sediment and eelgrass growing habitat.

No treatment is anticipated for areas with minor shell accumulation.

There will be short-term localized effects to turbidity as a result of materials removal from the Estero bottomlands. This impact is short-term in duration, and will result in improved condition through removal of aquaculture debris. Supplemental Appendix 1 includes more specific information related to impacts and impact avoidance measures. While the potential hardstructure for *Dvex* to attach to remains, monitoring will be conducted to determine if a more aggressive treatment approach to shell accumulation is necessary in the longer term.

Removal of Oyster Mats

It appears that sometime between 2009 and 2014 DBOC rolled out plastic mesh mats that were used to grow oysters outside of bags or containment (Figure 7).

The NPS has documented, through review of recent aerial photos and field inspection, the presence of approximately 15 sections of this 12 foot wide mat, ranging in length from 50 to 100 feet on the western portions of the sandbar near bed 17 (see Figure 8). The total area covered by these mats is approximately 16,900 SF (0.39 acres). These mats are covered by 2-6 inches of sand and a large number of uncontained live large pacific oysters (see left portion of Figure 7).



Figure 7: Plastic Mesh Fabric Oyster Mat

Based on field tests, it is likely that with limited water depth (approximately 6-12”), these mats could be rolled by hand with the oysters mostly contained. The rolled mats would have to be hoisted out of the water and onto a barge. The width of the mesh would allow most sand to sluice through the porous fabric. Any additional areas where mats are identified will be treated in the same manner.

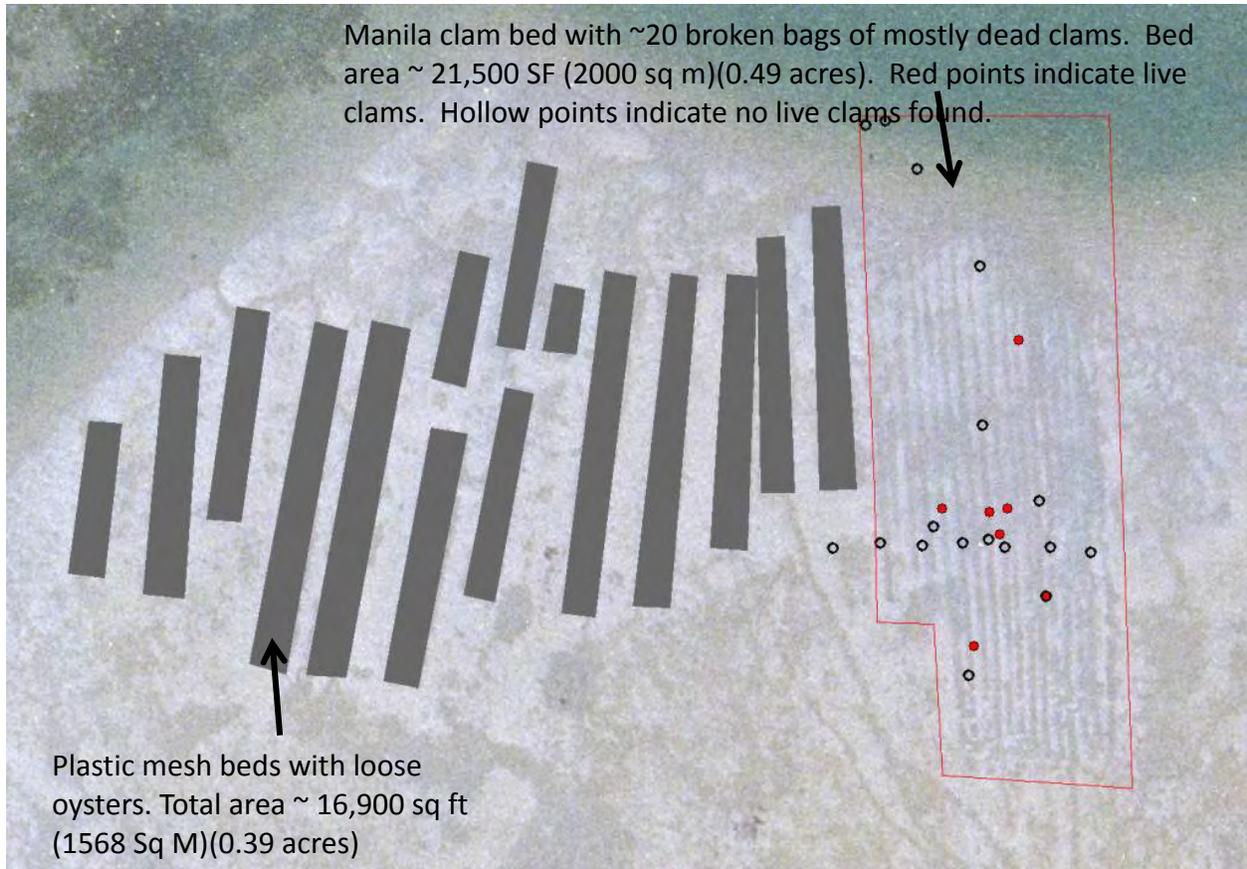


Figure 8: Locations of mesh mats (n = 15) and former Manila clam bed with broken bags and live clams in the sediment near bed 17. See Figure 2 (Project Map) for location with project area.

These fabricated mesh mats are made of plastic fabric that is long-lasting in the natural environment. Removal actions will benefit and restore approximately 0.39 acres of sandbar habitat. Additionally removal of remaining free pacific oyster from areas on the mats will jump-start the long-term volunteer stewardship removal efforts of those oysters outside of the established mats (See Drakes Estero Stewards Program description below).

Removal of Established Anchors and Lines

DBOC provided GPS locations of more than 30 plastic anchors that would be left at the close of their operations in areas of Bed 17 (Figure 10), Bed 7 (Figure 9), and Bed 39 (Figure 11). The NPS has observed that these anchors still include a network of connected lines. Additional infrastructure, including cinder block anchors

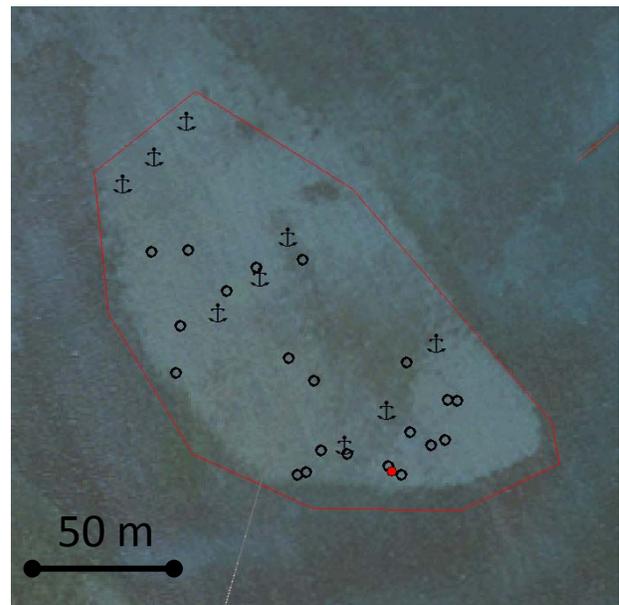


Figure 9: Former manila clam bed (Bed 7) with ~10 broken bags of dead clams. Bed area = approx. 20,000 sq m. (4.94 acres). Red points indicate live clams. Hollow points indicate no live clams found. Anchor symbols are plastic anchors.

and many other lines will be removed as they are encountered (See Figure 12).

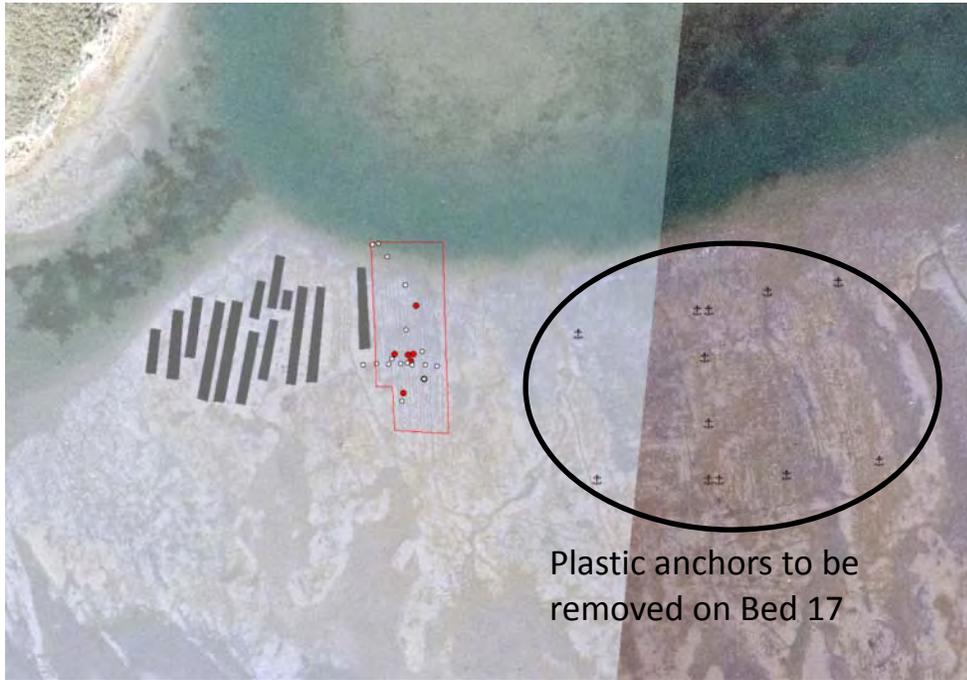


Figure 10: Plastic anchors to be removed on Bed 17.



Figure 11: Plastic anchors to be removed on Bed 39.



Figure 12: Examples of screw anchors and lines on Bed 17.

Anchors and lines provide unnatural habitat for attachment of marine fouling organisms on sandbar areas. Removal of anchors and lines and other debris is important to long-term protection and restoration of the sand bar areas.

Removal of Uncontained Manila Clam

As part of reconnaissance surveys in early January 2015, the NPS identified specific areas where bags of manila clam had broken, with most clams distributed on the sandbar (Figure 13). An attempt to remove these was made by contractors in January, but at that time it was documented that the clams were far more broadly spread than the 10 bags that were initially observed.

NPS conducted Manila clam surveys on February 17 and 25, 2015 to assess if and how far clams have spread beyond the growing beds. A series of test cores using a small shovel were dug to approx 8" deep with a diameter of 6" and sieved through a 5mm screen. Number and size of manila clams were recorded. 22 test holes were sampled near bed 15-17 and 22 were sampled on bed 7. Both sites were active manila clam growing areas and had manila clam bags (both in tact and spilled) present on January 1, 2015. Sample locations and positive detections of clams are shown in Figures 8 and 9. In the bed 15-17 area, clams were generally only found directly beneath or near broken surface bags, however



Figure 13: Remains of dead and live manila clams from spilled clam bags near bed 17. January 2015. See Figures 8 and 10 for location.

Grosholz (2010) also found a few Manila clams in the same area. In Bed 7, we found a single live 10mm Manila clam.

Based on current results, the NPS plans to employ limited methods to remove the clam from a 0.49 acre area near bed 17, but will continue to consult with experts to assess whether this action is likely to successfully remove Manila clams from Drakes Estero. If determined to have a low probability of success, the NPS would likely not implement this activity. Additional surveys are also required at Bed 7 before NPS proposes to attempt any clam removal.

It is anticipated that this work would be done at low or shallow water conditions over the sand bars, and the potential impacts would be limited to redistribution of existing sand within the sandbar treatment footprint. Water and sand would be immediately discharged to the same area and there would be no lasting effect on sandbar condition or turbidity. There is no eelgrass in these areas, so the work would not result in either direct or indirect impacts to eelgrass.

Drakes Estero Stewardship Program

The NPS anticipates that as part of ongoing monitoring and operations, that additional debris, strings, bags, lines and tubes will be found. The NPS has initiated a long-term volunteer effort – Drakes Estero Stewards Program – that will assist with mapping, monitoring and debris collection that will engage the public in the restoration effort. Through this program, we anticipate continuing removal of non-native shellfish and culture materials. NPS will provide transport and disposal of debris collected by volunteers. The planned sites of volunteer clean-up are shown on Figure 2. As of March 11, 2015, the NPS has signed up 12 formal volunteers for the program, has a ~25 person kayak clean up and mapping program planned for after the harbor seal pupping season (with the Petaluma Paddlers). Also, *Leave No Trace* and the Point Reyes National Seashore Association have scheduled a shoreline cleanup for April 11, 2015. The NPS anticipates that marine debris removal will continue on for multiple years through ongoing volunteer efforts such as these.

Drakes Estero Monitoring Program

Two individual but complementary bottom condition monitoring programs will be conducted to (1) determine the effectiveness of the experimental treatments to inform future shell pile treatments within Drakes Estero and in other marine systems (see Appendix B REVISED APRIL 2015), and (2) assess the overall level of changes in cover of eelgrass, marine debris, and fouling organisms for the entire rack removal and shell mixing program. (see Appendix C). These programs consist of baseline and follow up underwater assessment of cover of eelgrass, marine debris and fouling organisms and are described in detail in the appendix.

Additionally, since 1997 the NPS has conducted a long-term harbor seal monitoring program in Drakes Estero (and the entire Point Reyes Peninsula). Maintenance of this monitoring program will be important to document and track any changes in the breeding season harbor seal population pre and post-restoration (see Appendix C).

Project Approach and Impact Avoidance Measures

The National Park Service (NPS) has documented that the footprint of the removal activities is approximately 8.02 acres, including 7.07 acres in the footprint of the racks, 0.88 acres of debris areas on sand bars (outside of oyster rack footprint), and 0.07 acres for placement of a temporary dock facility to facilitate removal of debris from Drakes Estero. The NPS has documented areas of heavy/moderate debris accumulation over nearly 2.4 acres of bottomlands beneath the racks, including ~1 acre comprised of fallen tubes, bags and strings. While all agencies were aware of the presence of aquaculture debris below the racks, the areal extent (approximately 1 acre) was not fully understood until extensive reconnaissance surveys in late January 2015. Activities proposed for the 0.88 acres identified as sand bar debris areas includes removal of oyster mats, anchors and lines, and uncontained manila clam from the area documented in the Project Description.

Overall, the NPS has calculated that within the 7.07 acre area of the racks, there are 2.9 acres that currently include some level of eelgrass growth, whether underneath collapsed racks or right at the edges of in-tact structures. It is anticipated that removal of the oyster racks will create approximately 1.8 acres of eelgrass habitat and removal of aquacultural debris will enhance an additional 1 acre of habitat. As described in the project description, the NPS is evaluating the potential impact/benefit of the proposed in-situ treatments. As a result, the NPS proposes to implement in-situ treatment of accumulated shell on approximately 0.5 acres and to conduct experimental monitoring to determine effectiveness of this type of treatment.

Estimates from field reconnaissance surveys indicate that the rack removal and temporary dock installation will result in temporary impacts to approximately 0.59 acres of eelgrass. The restoration project, including complete removal of oyster racks and accumulated aquaculture debris (tubes, strings, and bags), will provide 4.5:1 eelgrass benefit. The sandbar treatment areas identified as part of the project are not within, and therefore are not anticipated to impact eelgrass habitat or the impact calculation ratios presented above. Overall, for the purposes of planning, the removal activities would far exceed the eelgrass mitigation threshold of >1.2:1 and therefore no eelgrass mitigation is proposed.

Supplemental Appendix 1 – Impact Analysis and Avoidance Measures provides a more detailed assessment and discussion of impacts and considerations relevant to recommended treatment approaches associated with this project.

General Constraints and Construction Monitoring

As part of the Drakes Estero Restoration Project, the NPS has identified a number of general conditions and constraints to ensure protection of sensitive resources during the project. Appendix D includes a number of operational practices and constraints intended to reduce or avoid impacts to resources as part of the on-water operations. The NPS will have an onsite inspector to oversee operations with the ability to identify and cease work as necessary to minimize impacts. Additionally, the project will have post-treatment inspection surveys to document completed condition to ensure that removal requirements and restoration objectives are achieved.

Pinniped Avoidance Program

The NPS has a long-term pinniped monitoring program that will assess harbor seal populations in Drakes Estero both pre-and post-restoration (Appendix C).

The operations in the Estero, with transport of debris barges and operations barges will be low speed in nature and will not result in any anticipated impacts. The crew vessels – to get out to the work barges will likely operate at higher speeds, but still generally less than 10 knots. The NPS will brief contractors prior to work on scanning for seals, and to slow down to 5 knots if a seal is sighted within 100yd of the vessel.

For the duration of the restoration, we will supplement this program by placing observers on shore during low tides (<2.5 ft) to monitor the upper sandbar near Bed 7 during rack removal operations. If seals are hauled out, the observer will communicate this to work crew leaders to alter operations to another location until the tide has risen.

For restoration work at near beds 15 and 17, observers will monitor the area for hauled out seals and contact work crew leaders to alter operations to another location until the tide has risen and seals have left.

To minimize impacts to seals, all proposed restoration work is being conducted outside the harbor seal breeding and pupping season (March 1 – June 30). Therefore, seal occupancy on sandbars is low, and we anticipate the impacts to seals will be easily avoided using this protocol.

Wilderness

The wilderness designation and cessation of ongoing mechanized boating operations (with the exception of very limited administrative use for monitoring and patrol is expected), will eliminate potential prop damage to eelgrass resulting in expansive long-term benefits to eelgrass. Any remaining infrastructure could create areas of additional non-native species accumulation and further fouling of the area.

APPENDIX A

Eelgrass and Debris Assessment and Assumptions

The Drakes Estero Restoration Project will have some short-term impacts on eelgrass and seabed habitats. To quantify these impacts (and for project planning), NPS staff collated and collected data consisting of rack locations and conditions, aerial imagery, a sediment map, eelgrass maps, high definition underwater video, site visits to sandbars at low tide, and visual snorkel surveys of racks and rack footprints. This information was used to quantify the area of rack posts and deadmen in eelgrass and the area of debris (shell, plastic, etc.) that lies on the seafloor and is a candidate for removal or treatment. Staff also calculated areas on sandbars where aquaculture equipment and shellfish may be removed.

The NPS initiated an aerial flight of Drakes Estero at a low tide, collected extensive underwater video from snorkeling and alongside the boat, and visited many of the active growing beds on sand bars throughout Drakes Estero. The NPS has also relied on information regarding rack condition, status and use provided by DBOC between 2010 and 2014, as well as sediment type information derived from Anima 1990. NPS has relied on a 30cm aerial image from 2009, a 10 cm aerial image from January of 2015, NPS conducted side-boat video surveys on 59 racks, and reviewed other video on an additional 12 racks [71 of 95 (75%) total racks] to make assumptions used to derive information presented in this impact analysis. Analysis of these various sources has been used to compile and assess information that contributes to our understanding of the rack removal activities as well as the potential impacts associated with this work.

Methods

Quantification of the total eelgrass and debris under racks was done by classifying the proportion of a rack having differing cover classes of eelgrass or debris, and then multiplying the result by the total area of the rack. If eelgrass only surrounded the edge posts of a rack, a multiplier of $2/3$ was used (since racks are 3 posts wide). This was then multiplied by the length of the rack having eelgrass.

Bents and Stringers

The racks are comprised of vertical bent structures sunk into the mud, and horizontal stringers that were used to hang oyster strings. Vertical bent structures consist of three (3) vertical 2x6 inch posts affixed and stabilized by a 14-foot long 2x6 inch horizontal cross-member. Our observations indicate that in some cases, the cross-member is buried below the mud line, but in other cases it is at or above the mud line. The three vertical spars stick down into the mud approximately 5 feet. We have identified four racks representing approximately 80 bents where the posts are 4-inch round poles, which do not appear to have the bottom cross-member.

Based on the rack removal investigation, the area of disturbance to the Estero floor is limited to within 6 inches of the post being removed. Therefore, the anticipated disturbance is between 1 to 1.3 SF per post and 1 SF per lineal foot of bottom cross-member. If the cross member is at or above the mud line, it is anticipated that the disturbance area identified above would be the same.

Table 1. Summary of Cumulative and eelgrass impact areas.

Impact area for posts and deadmen are estimated based on general observations of impact area from the method pull test. The estimate for stingers is based on their dimensional footprint (approx. 4" wide by length of stringer). Deadmen are not included for Racks 4A, 8A, 8B and 8C. Aquaculture debris is included within the Moderate/Heavy debris area calculation, so it is not double counted in the total. The debris experiment area is subtracted from the Shell debris area. All values are estimated from underwater video footage from 71 of the 95 racks. Level of error for eelgrass cover, stringers on the estero floor, shell debris, and plastic/wire is unknown, but is likely less than 25%.

Component	Cumulative Impact Area		Eelgrass Impact Area	
	Sq Ft	Acres	Sq Ft	Acres
<u>Within Rack Footprint</u>				
Posts (assume 1.3 SF/post)	8,713	0.20	3,572	0.08
Bottom Cross-member (assume 1 SF/LF)	30,072	0.69	12,726	0.29
Stringers on Estero Floor (total area of boards covering bed of Estero)	11,928	0.27	6,232	0.14
Moderate/Heavy Aquaculture and Shell Debris	103,830	2.38	0	0.00
Aquaculture Debris – Bag, Tube and String Cleanup*	41,818	0.96	0	0.00
Shell Debris Treatment Experiment*	2,880	0.07	0	0.00
Total Impact Area within Rack Footprint	154,542	3.61	22,530	0.52
Total Project Area within Rack Footprint	308,016	7.07	126,287	2.90
<u>Outside Rack Footprint</u>				
Dock and Anchors [#]	3,200	0.07	1,600	0.04
Oyster Mat Removal	16,988	0.39	0	0.00
Manila Clam Treatment (Bed 17)	21,344	0.49	0	0.00
TOTAL IMPACT AREA	196,075	4.50	24,130	0.55
TOTAL PROJECT AREA	349,549	8.02	127,887	2.94

*areas within Total Moderate/Heavy Shell Debris Area

[#]see text for calculation of eelgrass impact

Eelgrass

Field evaluations, including snorkel and side-boat video collection has informed our base of information regarding presence/absence and potential effects of rack and debris removal on eelgrass within Drakes Estero. From video, we placed areas under racks into one of 5 broad cover classes estimated visually without the aid of test points: 0, <5%, 5-25%, 25-75%, and >75%. It was not feasible to assess shoot density. For reproducibility, cover was always estimated in conditions where eelgrass was floating in low current conditions. Below are examples of each eelgrass coverage class.



No eelgrass. Rack 6E on 1/29/2015



Very Low (<5%) eelgrass coverage. Post in sediment on Rack 11I on 1/30/2015. Note single eelgrass plant approximately 18" from post.



Light (5-25%) eelgrass coverage under rack 11H on 1/30/2015



Moderate (25-75%) eelgrass coverage under rack 8P on 01/28/2015.



Dense (>75% cover) eelgrass. This density only occurred under part of rack 41. All other racks surveyed were <75%, but racks 22E and 22F are close to 75%.

Using the available data, under the 54 racks that were actively used through the fall of 2014, eelgrass is limited to absent within the footprint of the rack. For racks that have long been collapsed (e.g. classified as in poor condition by DBOC in 2010), it is common that there is

eelgrass growing within the footprint of the rack if shell debris is minor or absent (see below). In many cases, just outside the rack footprint, eelgrass coverage is moderate to dense. Similarly, with respect to debris accumulation, we have found that in areas of moderate to heavy accumulation, eelgrass is not present, but in areas of low debris accumulation, we have observed some eelgrass growing between debris and/or shell.

Our calculations for eelgrass are based on the following information. For 71 racks, NPS staff reviewed and identified the number of bents where eelgrass was present around the base of the posts, over buried cross-members, or outside the footprint but within the 1-foot overlap area of the buried cross-member. Based on our assessment, we estimate that approximately 41 percent (2,719 of 6,702) vertical posts are located in areas where eelgrass is present. Additionally we estimate that there are 839 cross-members that are present in areas where eelgrass is present, and would likely result in impacts to eelgrass when the cross-member is pulled out with the bent. In the case where the cross-member is exposed above the sediment line, we have not assumed impacts to eelgrass from the removal of the cross-member.

Debris Accumulation

The same video surveys used to assess eelgrass distribution were used to assess accumulation of shell and other debris beneath the racks. Based on our visual analysis we identified three categories of debris accumulation – heavy, moderate, and low.

Debris is defined as items on the estero floor including pvc tubes (both French tubes and other PVC), wires, rope, oyster shells, loose live Pacific oysters, and bags of oysters. We enumerated fallen wooden oyster racks separately, so they are not included in this cataloging of debris. We also totaled debris from the aquaculture equipment (tubes, wire, strings) separately from oyster shell, since the restoration may require differing methods. We used 3 general categories to describe the cover of debris: low, moderate, and heavy. Examples are provided below.

Low Debris is defined as covering less than <25% of the visible estero floor. This generally consisted of scattered oyster shells under racks, but also may include small amounts of wire and PVC pipe.



Minor debris by post under rack 22D on 1/30/2015. Note plastic spacer tubes with wire and scattered oyster shell.

Moderate Debris is defined as covering approximately 25-75% of the visible estero floor. This generally consisted of numerous oyster shells under racks, but also wire and PVC pipe. Eelgrass is rarely in the moderate debris areas.



Moderate shell debris under rack 9C on 1/1/2015.



Upper end of moderate class of debris under rack 9C on 1/29/2015

Heavy Debris is generally defined as having >75% cover, precluding eelgrass growth and covering most of the estero floor under a rack. This periodically includes large piles of oyster bags or French tubes that have fallen from the rack and almost always includes complete bottom coverage of oyster shell. It is unknown how deep into the sediment this debris may be.



Examples of heavy debris: (Left) oyster shell and French tubes under rack 6B on 1/29/2015, (Right) oyster shell under rack 22B on 1/30/2015.



Heavy debris on rack 9C on 1/29/2015.

APPENDIX B

Experimental Treatment of Oyster Shell Debris Beneath Racks

There is little research demonstrating the efficacy of removing oyster shell from bay sediments to restore eelgrass habitat (E. Grosholz, pers. comm.). Complete removal may lower the seafloor, leaving a trench that could impede eelgrass regrowth (K. Boyer, pers. comm.). It is known that eelgrass can grow well in substrate with coarse pebbles and rocks as long as there is adequate silt or sand in the interstitial places, but the tolerable ratios have not been determined (K. Boyer, pers. comm.). There is no experimental data demonstrating whether eelgrass will grow into a shell/sediment matrix. We are therefore proposing to perform several in-situ (“mix-in”) treatments of both heavy and moderate oyster shell debris coverage with underlying sediment and then monitor the treatments and controls to assess eelgrass growth. Treatments and controls will be in areas where eelgrass already grows adjacent to the treatment plots, providing an opportunity for vegetative growth.

The treatments (3’x3’ plots within the footprint of the oyster rack) will each be replicated 10 times. The treatments include:

1. Heavy Shell cover areas (>95% cover of shell)
 - a. Removal of the majority of shell from the test plot (non-contract divers)
 - b. Mixing the surface shell into the substrate to create a shell/sediment matrix.
 - c. Control plots with heavy shell cover and no manipulation
2. Moderate Shell Cover Areas (25-75% cover of shell)
 - a. Removal of the majority of shell from the test plot (non-contract divers)
 - b. Mixing the surface shell into the substrate to create a shell/sediment matrix.
 - c. Control plots with moderate shell cover and no manipulation

All treatment plots will be conducted in a split plot design in groups of 3 (removal/mixing/control) to minimize location effects. The linear order of the treatments will be randomized and in no case be at the end of a rack, since the ends of racks could have existing eelgrass on 3 sides of the plot, whereas non-end plots would have pre-experiment eelgrass at most on two sides of the plot. Racks suitable for treatment 1, treatment 2, and control split plots are listed in Table 1. There are 11 potential racks that meet the needs for a heavy shell treatments, and 10 potential racks that meet the needs of the moderate shell treatments. Note that there is some variation in shell coverage classes under single racks, meaning that a heavy treatment may occur in one section of a rack, and a moderate in another section. Each plot will have the 4 corners marked with white ¾” PVC pipe that protrudes approximately 1.5 feet above and 3 feet below the bay floor to ensure easy and accurate relocation of plots. The top of the pipe marker will still be 2 feet below the water surface at most low tides. WAAS GPS will also be used to record all plot locations for relocation.

Existing eelgrass

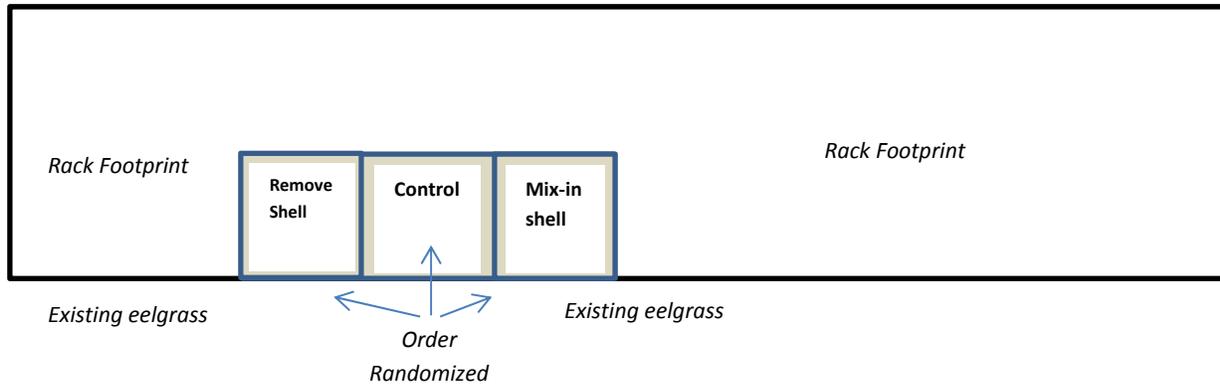


Figure 1. Experimental design showing treatments within the footprint of an oyster rack surrounded by existing eelgrass. Racks are 12' wide and each plot will be 3'X3" (Not to scale). This design will be replicated 10 times each in in areas of heavy and moderate oyster shell coverage.

Each of these test plots (n = 60, length = 180 ft, area = 540 sq ft) will be recorded by non-contract divers (e.g. park or partner snorkelers) using high definition video recordings to calculate percent surface cover of shell (or other debris), eelgrass, bare sediment, and invasive fouling organisms. Down looking videos will be transformed into still images, which will be sewn together in Adobe Photoshop to have a complete image of each plot. Then 100 random points will be overlain on the composite image and number of "hits" for eelgrass, shell debris, other algae, fouling organisms, and substrate will be recorded. Plots will be recorded prior to treatment and one year post treatment. Additional surveys in subsequent years will be conducted if no trends are noted after 1 year.

Table 1. Racks suitable for test plots with heavy or moderate oyster shell debris and adjacent eelgrass coverage. Racks in bold have both heavy and moderate treatment potential. *If we are minimizing travel costs between racks, then work will focus on heavy shell debris on racks 6, 8, and 22.*

Heavy Shell Debris	Moderate Shell Debris
6E	4C
6F	4D
8H	6E
8K	6F
8M	8N
8N	12A
22A	12B
22B	13B
22E	22B
22F	41C
38A	

Percent cover of eelgrass, sediment, shell, algae, and fouling organisms will be compared among treatments using simple generalized linear models with the factor being treatment and the appropriate distribution for percent cover data (which is rarely normal).

The California Department of Fish and Wildlife (CDFW) is conducting a parallel monitoring project assessing eelgrass growth under racks throughout the estero before and after rack removal. This non-manipulative monitoring (other than pre and post oyster rack removal) will provide information on trends in growth of eelgrass in areas of heavy, moderate, light and zero shell cover. K. Boyer (SFSU) has hypothesized that light coverage of oyster shell on the surface may in fact promote eelgrass seed growth by protecting seeds from being carried away by the current. It is not known in Drakes Estero how much eelgrass spreads by seed vs. vegetatively, but these CDFW monitoring a variety of oyster coverage classes (including light oyster shell coverage) will help answer that question since we can compare areas of no shell vs light shell.

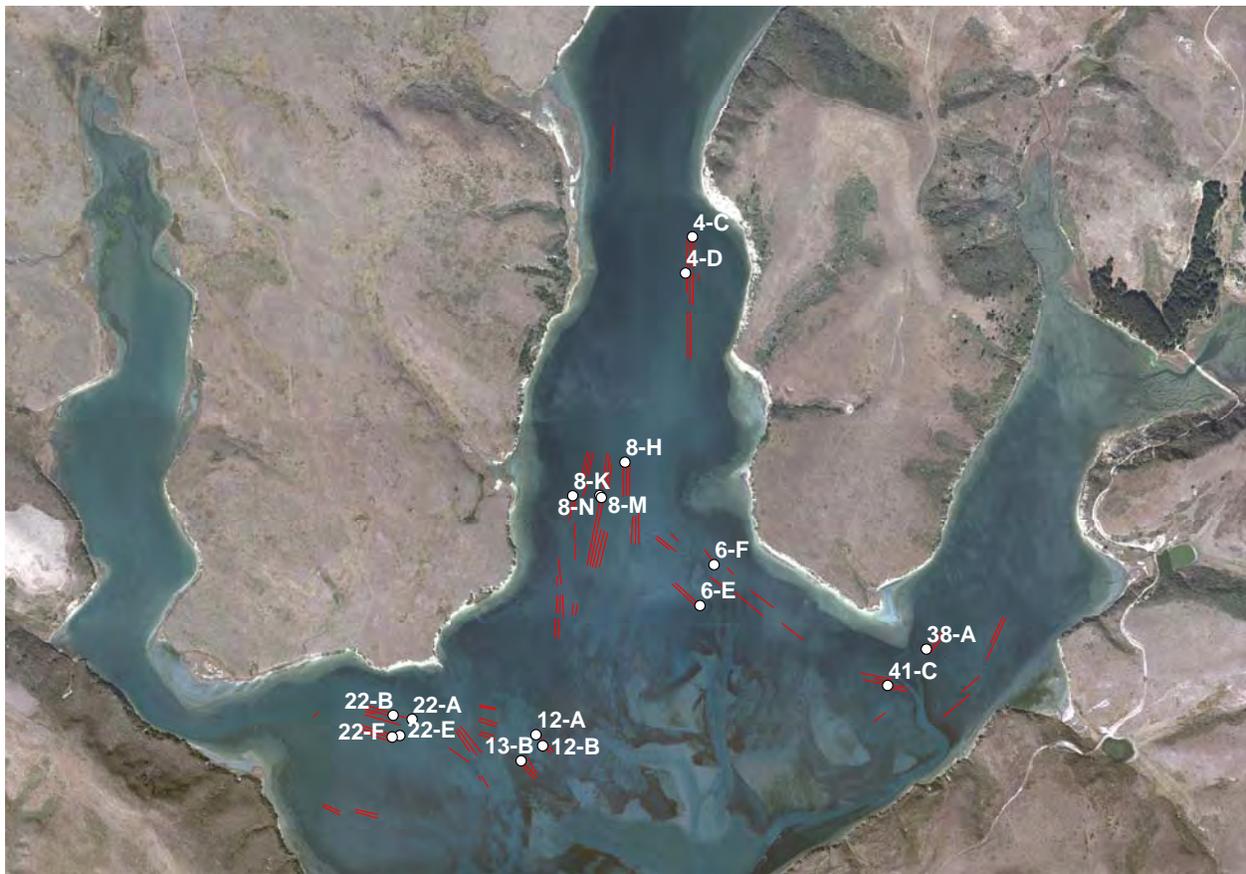


Figure 2: Rack Locations suitable (shell debris under racks and eelgrass growing adjacent) for potential experimental shell removal, shell mixing and controls. See Table 1 and text for details.

APPENDIX C

Drakes Estero Restoration Monitoring Plan for Compliance Package

Part 1. Eelgrass, debris, and fouling organisms.

Oyster racks and associated debris may have had impacts on (1) eelgrass cover, (2) marine debris (oyster shell, wire, plastic) on the estero floor and (3) associated fouling organisms. The California Department of Fish and Wildlife has proposed to monitor and been granted an NPS research permit to assess the response of items 1-3 through time after the removal of oyster racks by NPS.

Objectives

1. Determine response in cover of eelgrass, marine debris, and non-native fouling organisms to oyster rack removal.
2. Calculate the net change in the area of eelgrass cover under racks.

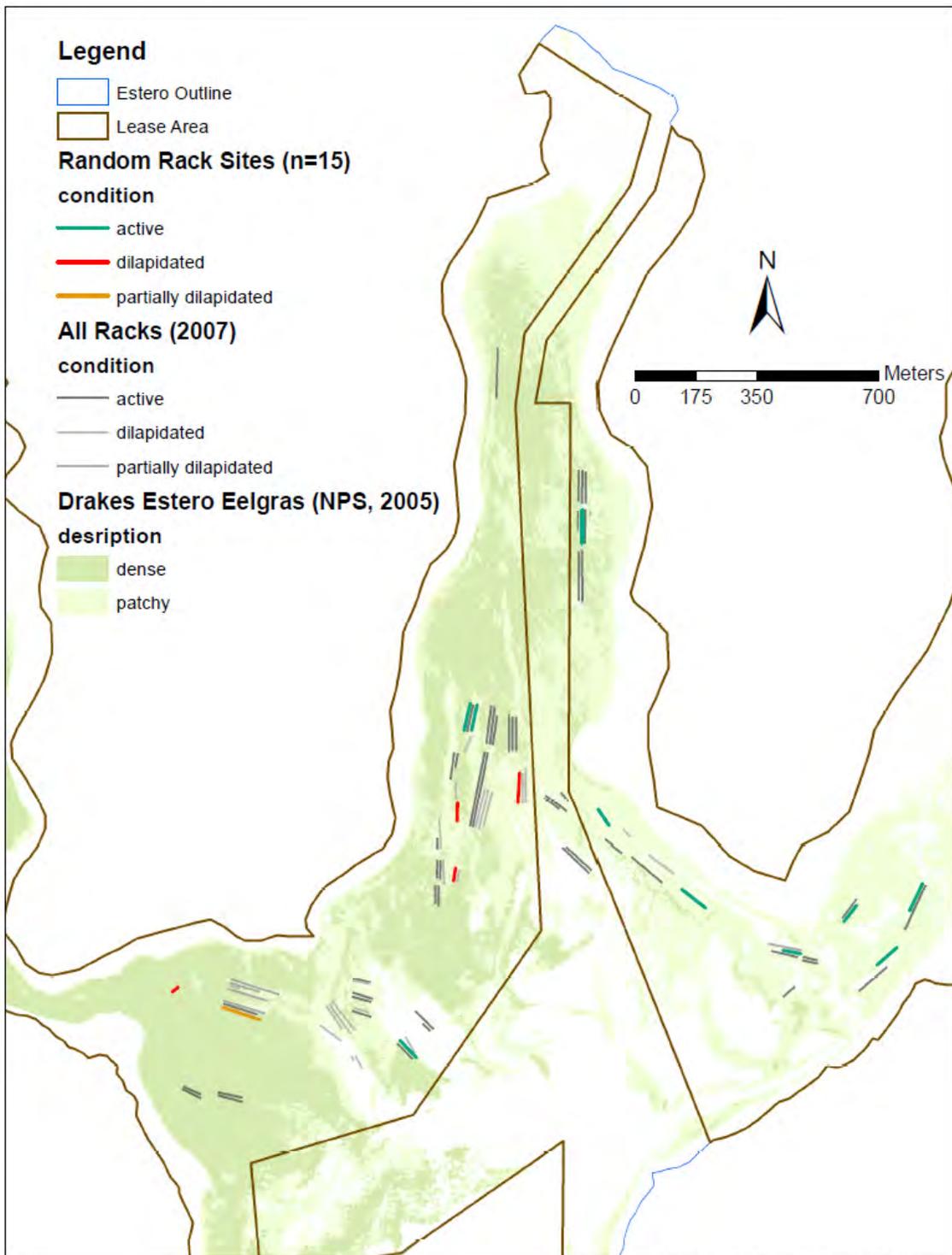
Methods

Scuba and a video camera sled will be used to record baseline (before rack removal) conditions in April 2015 by CDFW staff. Surveys will consist of 15 randomly selected transects running the entire length under existing oyster racks. Divers will travel the length of the rack recording video for post processing into calculations for cover of eelgrass, marine debris, and fouling organisms. Additionally, 15 randomly selected control transects will be established in similar depth and sediment type areas near treatment racks and surveyed in an identical manner. Transect sites will be marked at one end with a completely submerged PVC marker to ensure that sites can be accurately resurveyed after racks are removed.

Percent cover of eelgrass derived from video footage using standard CDFW methods will be transformed to area and extrapolated from the randomly selected racks to the unsampled racks, including an error calculation. This will allow a calculation of acres of eelgrass habitat restored. Due to sample size limitations, summary statistics and tests for changes in cover over time will be presented on a population level and not stratified by existing rack conditions. (e.g., good or poor). This will result in an estimate for changes in eelgrass area, but not for racks that were recently used (generally good condition) vs those not recent used (poor condition). Nonetheless, a robust estimate of change in eelgrass, marine debris, and fouling invasive species will be reported.

The California Department of Fish and Wildlife has extensive experience in underwater surveys to assess marine protected areas and benthic habitats.

An example of a selection of oyster racks for survey is in Figure 1.



Drakes Estero - Draft Study Design - 11/20/2014 - CDFW

Figure 1. An example of 15 randomly selected survey sites including racks in good (Green) and poor (Red) conditions. Control sites will be randomly placed near treatment racks to ensure a valid comparison.

In addition to the 15 treatment and control transect surveys described above, the CDFW's Marine Protected Area Monitoring Program will also establish scuba/video monitoring transects to assess the overall ecosystem trends in the entire estero (not just rack removal areas) given its status as a state marine conservation area. These surveys will not be designed with the rack locations explicitly in mind, but this information will provide context on broad scale changes in the estuary, complement the control transects, and aid in interpretation of the rack removal monitoring data. These surveys will also commence in April-May 2015 with regular revisits by CDFW.

All surveys will be conducted during high tides to maximize water clarity, minimize sediment entrained by tidal currents, ease the use of scuba, and minimize disturbance to hauled out harbor seals. Surveys will be conducted under an NPS research and collection permit and any use of motorized boats required to deploy scuba divers (some surveys) will be authorized under a National Park Service Minimum Tool Authorization.

Timeline

Initial Sampling	April – May 2015 during mid-high tides
Follow up Sampling	Spring/Summer 2016
Final Sampling	Spring/Summer 2017 (CDFW has not committed to final sampling, in which case this will be funded/replicated by NPS)

Products

1. Report with maps detailing changes in area of eelgrass cover, marine debris, and percent cover of fouling non-native species.
2. Database of video observations with metadata.

Part 2. Harbor Seal Monitoring Program.

Since 1997, NPS has had a long term monitoring program (http://www.sfnps.org/download_product/1497/0) to with these relevant objectives:

1. Determine the long-term trends in population size and seasonal distribution of harbor seal populations at primary sites in the SFAN parks during the breeding and molt seasons.
2. Determine long-term trends in reproductive success of harbor seals through annual estimates of pup production at PORE and GOGA.
3. Determine the long-term trends in sources, frequency and level of effects of natural and anthropogenic disturbances on harbor seal haul out use and productivity.

Harbor seals are sensitive to disturbance. Disturbance at haul out sites can negatively affect reproductive success and reduce or eliminate harbor seal use of specific haul outs. Past monitoring has indicated problems with anthropogenic disturbances at harbor seal haul out areas, and management actions have been applied. The MMPA restricts harassment or disturbance of pinnipeds, therefore the monitoring plan involves observation and recording of incidental or intentional disturbance of pinnipeds.

This monitoring will continue both pre and post restoration to identify trends in harbor seal pupping and population numbers relative to other sites in the park. A peer reviewed annual report is produced by the program that will summarize our findings pre and post restoration.

APPENDIX D.

Operational Guidelines for Moving Boats and Barges in Drakes Estero

This restoration project requires working in a highly sensitive Wilderness area. Many specific guidelines and mitigations are detailed in the main body of the Consistency Determination (CD). The additional overarching guidelines presented here must be followed by contractors conducting work in the estero unless explicitly stated in the CD (e.g., floating dock may be authorized to be placed over eelgrass).

1. Eelgrass is a special status species in California.

- a. Do not anchor, trample, cut (with boat props), or destroy eelgrass.
- b. If items to be removed are in eelgrass, carefully remove them to minimize any damage to eelgrass.
- c. Do not allow barges or boats to settle on eelgrass.
- d. If a boat becomes stuck in an eelgrass bed, move the boat out via walking, paddling, poling, or waiting for the incoming tide until the engine can be used without damaging eelgrass or the estero floor.
- e. When departing from the launch site, navigate just to the East of the line of poles. The channel is approximately 15 feet wide.
- f. Use Established Boat Travel Routes as best routes between oyster beds and racks. These are shown in Figure 1 in the CD.
- g. If boats or barges become stuck, do not allow motors to cut estero floor or eelgrass. Use other methods to move the vessel.

2. Harbor Seals are protected by the Marine Mammal Protection Act.

- a. Keep a distance of >100 yards from seals at all times.
- b. If seals are hauled out (beached) on or near a potential work area, work in another area that is at least 100 yards away until the seals have left. NPS Observers will also notify work leaders if there are seals to be avoided.
- c. Do not attempt to flush or scare the seals. This is a violation of federal law.

3. Remove wood, debris, strings of oysters and bags carefully to avoid knocking off fouling organisms.

- a. Many invasive species occupy the oyster shells and bags. We must avoid knocking these species off when removing them.
- b. Do not scrape the oysters, strings or bags against the racks or boats. Lift them carefully to avoid rubbing off the fouling organisms.
- c. Any fouling organisms that fall on barges, should not be swept off into the water, they should be contained and disposed of on land.

4. Drakes Estero is a federally designated Wilderness area.

- a. Federal regulations require minimal noise and vessel use to accomplish this oyster removal. Normally this area has no motorized vehicles. Please use engines sparingly and minimize noise as much as practicable.
- b. The public may be in the area Kayaking. Please use caution and respect when operating near the public.
- c. Only use the far west end of the “Lateral Channel” adjacent to Beds 15 and 17 (Maps to be provided). Do not use the eastern 75% of this channel. This is important seal haul out habitat.

Supplemental Appendix 1

Impacts Avoidance Measures

1. Overall Project Approach

The National Park Service (NPS) has documented that the footprint of the removal activities is approximately 8.02 acres, including 7.07 acres in the footprint of the racks, 0.88 acres of debris areas on sand bars (outside of oyster rack footprint), and 0.07 acres for placement of a temporary dock facility to facilitate removal of debris from Drakes Estero. The NPS has documented areas of heavy/moderate debris accumulation over nearly 2.4 acres of bottomlands beneath the racks, including ~1 acre comprised of fallen tubes, bags and strings. While all agencies were aware of the presence of aquaculture debris below the racks, the areal extent (approximately 1 acre) was not fully understood until extensive reconnaissance surveys in late January 2015. Activities proposed for the 0.88 acres identified as sand bar debris areas includes removal of oyster mats, anchors and lines, and uncontained manila clam from the area documented in the Project Description.

Vessel transit, anchoring and other essential operational activities will be conducted in a manner that avoids or minimizes to the greatest extent possible impacts to eelgrass (see anchoring plan discussion). However, it is anticipated that there will be some level of impact associated with these activities. Other activities integral to the removal operations include vessel transit and anchoring and upland development of a temporary transfer facility to support off-haul of the collected marine debris for disposal at an appropriate location. As noted in the project description, the NPS is evaluating the necessity of a temporary dock or if there are other smaller – lower impact measures that may be used to support offload of materials at the shore.

The nature of the work (removal of infrastructure), the proximity of eelgrass to many of the structures (within and immediately adjacent), and the hydrodynamics of the estuary (high tidal flushing) make the design and evaluation of the project and its potential impacts unique. The removal of infrastructure that is unnatural to the system is beneficial both in the short and long-term. Eelgrass is immediately adjacent to many of the racks and removal of the racks necessitates access to and likely impacts to eelgrass adjacent to the racks. Removal of materials and debris associated with these linear structures will necessitate that the contractor moves along the line quickly. As a result, the duration of work at any one location will be minimal. This coupled with the energetic tidal dynamics and hydrologic turnover, the indirect impacts associated with rack removal and aquacultural debris removal will be minimal.

Project Benefits to Eelgrass

Overall, the NPS has calculated that within the 7.07 acre area of the racks, there are 2.9 acres that currently include some level of eelgrass growth, whether underneath collapsed racks or right at the edges of in-tact structures. It is anticipated that removal of the oyster racks will create approximately 1.8 acres of eelgrass habitat and removal of aquacultural debris will enhance an additional 1 acre of habitat. As described in the project description, the NPS is reevaluating the potential impact/benefit of the proposed in-situ treatments. As a result, the NPS proposes to implement in-situ treatment of

accumulated shell on approximately 0.5 acres and to conduct experimental monitoring to determine effectiveness of this type of treatment.

Estimates from field reconnaissance surveys indicate that the rack removal and temporary dock installation will result in temporary impacts to approximately 0.59 acres of eelgrass. The restoration project, including complete removal of oyster racks and accumulated aquaculture debris (tubes, strings, and bags), will provide 4.5:1 eelgrass benefit. The sandbar treatment areas identified as part of the project are not within, and therefore are not anticipated to impact eelgrass habitat or the impact calculation ratios presented above. Overall, for the purposes of planning, the removal activities would far exceed the eelgrass mitigation threshold of >1.2:1 and therefore no eelgrass mitigation is proposed.

Rack Removal Activities

The impacts identified with the removal of racks and aquacultural debris, and limited in-situ treatment is dependent on duration of work at any single location. Rates of treatment and removal are presented in Table S-1 below. Rack removal, including removal of posts and buried cross-beams will result in temporary intermittent sediment disturbance when the posts are pulled. Observations made during the method tests indicate that turbidity dissipated from the removal sites within a matter of 5 minutes or less. Three-post arrays are distributed in linear fashion at 12-foot intervals. The Preliminary Engineering Report estimates that it will take contractors between 15-20 minutes to complete removal of a 3-post bent, then moving on to the next bent. The only action that will disturb the bottom sediments is the actual removal of the posts and bottom cross member. Removal of racks and bents will have localized turbidity impacts on the order of minutes at each bent site. No additional BMPs are identified as necessary as part of rack removal activities.

Aquaculture Debris Removal and Experimental In-situ Treatment Activities

A second treatment that is proposed as part of this project is tied to the removal of aquacultural debris from approximately 1 acre of the rack footprint and the experimental in-situ treatment of shell on approximately 0.5 acres of area. Images of the debris indicate that the aquaculture debris (primarily tubes, bags, and strings) supports the presence and growth of *Didemnum vexillum* (Dvex). Debris removal will reduce the overall impact and availability of the accumulated debris as an unnatural substrate on the bottom of Drakes Estero and monitoring will be conducted to determine the effectiveness of the differing approaches.

The NPS has further evaluated methods and objectives described in the aquaculture debris removal section to identify what method can most effectively, efficiently, and safely remove the aquaculture debris while minimizing disturbance of Dvex, sediment and indirect impacts to eelgrass as part of the removal. Other bucket types, deployed from an excavator arm may be more effective at picking up the debris, and the NPS is also evaluating whether this scale of work could be achieved by divers removing the debris by hand. While hand-removal methods are being explored, the analysis of the impacts included in these supplemental documents still assumes mechanical removal at the scale presented in the amended project description.

The impacts associated with these removal or treatment activities are linked to the duration of work (disturbance) at any one location. Table S-1 documents that mechanical removal/treatment removal rates range from 432-915 SF/hour, meaning that the focal point of work, and therefore sedimentation generated from any specific activity will not linger in any single location very long. Hand removal of aquaculture debris is currently being evaluated by the NPS. While the rate of area treated using hand removal is much slower, the ability of divers to pick up and reduce breakage and secondary dispersal of materials in contact with the debris is much more discrete and effective.

Table S-1. Rates of debris removal and in-situ treatment of shell.

Substrate	Rate per Hour		
	Sq Ft	Bents	Linear Feet
Mechanized Heavy debris removal	432	3	36
Mechanized Moderate debris removal	720	5	60
Mechanized In-situ treatment of shell	915	6	76
Diver debris removal*	70	0.5	6

*estimated from Title I – Diver suction device operation for removal

The following pages reference NMFS eelgrass guidelines and BMPs to arrive at this determination.

2. Sediment Management and Impacts to Eelgrass

The NMFS

(http://www.westcoast.fisheries.noaa.gov/publications/habitat/california_eelgrass_mitigation/sfb_light_monitoringprotocol.pdf) reports on Zimmerman et al’s (1991) findings that:

“If the period of irradiance-saturated photosynthesis (H_{sat}) decreases below 3-5 hours per day, the maintenance of whole plant carbon balance and growth period is negatively affected (Zimmerman et al. 1991). Due to high turbidity levels in SF Bay, eelgrass plants located at the deeper edges of established eelgrass beds are less likely to accumulate large carbon reserves making them unable to withstand 30 days of reduced light conditions (Zimmerman et al. 1991). This protocol was established to ensure consistent collection of light monitoring data, and to guide users on the appropriate application of such measurements.”

No part of the Drakes Estero Restoration project (post removal, debris removal via bucket, or in-situ shell treatment) will be on any particular site adjacent to a patch of eelgrass for more than 3-5 hours (since contractors plan to work at a 12’ bent site only between 15-20 minutes), and certainly not more than 30 days. Furthermore, Zimmerman et al. 1991 concluded that 30 days of reduced light conditions would affect deeper edges of eelgrass beds (with lower carbon reserves). All work areas in Drakes Estero are approximately 1m deep at 0 tide. These are not deep eelgrass beds and should therefore have adequate carbon reserves (all else being equal). We therefore propose that there is no risk to eelgrass productivity from short term suspended sediment and light reduction. **We therefore conclude that**

there is unlikely to be any detectable effect on eelgrass carbon budgets, survivorship, or density due to light attenuation from suspended sediment.

Nonetheless, considering NOAA's California Eelgrass Mitigation Policy and Implementing Guidelines (October 2014) provides turbidity guidance on P. 12 which states that (*numbers ours*):

- A. To avoid and minimize potential turbidity-related impacts to eelgrass:
 - A.1. Where practical, actions should be located as far as possible from existing eelgrass; and
 - A.2. In-water work should occur as quickly as possible such that the duration of impacts is minimized.

- B. Where proposed turbidity generating activities must occur in proximity to eelgrass and increased turbidity will occur at a magnitude and duration that may affect eelgrass habitat, measures to control turbidity levels should be employed when practical considering physical and biological constraints and impacts. Measures may include:
 - B.1. Use of turbidity curtains where appropriate and feasible;
 - B.2. Use of low impact equipment and methods (e.g., environmental buckets, or a hydraulic suction dredge instead of clamshell or hopper dredge, provided the discharge may be located away from the eelgrass habitat and appropriate turbidity controls can be provided at the discharge point);
 - B.3. Limiting activities by tide or day-night windows to limit light degradation within eelgrass habitat;
 - B.4. Utilizing 24-hour dredging to reduce the overall duration of work and to take advantage of dredging during dark periods when photosynthesis is not occurring; or
 - B.5. Other measures that an action party may propose and be able to employ to minimize potential for adverse turbidity effects to eelgrass.

This project must occur in proximity to eelgrass (#2), however, elevated turbidity levels will be too short lived (<5 minutes) to impact photosynthesis. This is the case whether pulling posts or removing debris from the seafloor with a bucket or divers. Furthermore, BCDC, citing USACE on much larger dredging (this project is not a dredging project) projects in San Francisco Bay concluded that:

“The suspension of sediments during dredging will generally result in localized, temporary increases in turbidity that are dispersed by currents or otherwise dissipate within a few days, depending on hydrodynamics and sediment characteristics (e.g., USACE and Port of Oakland 1998).” From BCDC August 1998 Long-Term Management Strategy for Bay Area Dredged Material Final Environmental Impact Statement/Environmental Impact Report CHAPTER 3.0 DREDGING AND DREDGED MATERIAL CHARACTERISTICS — AN OVERVIEW.

Drakes Estero flushes much of its volume of water each day with the tides, as evidenced by modeling (NRC 2009) and the areas where the majority of racks exist contain primarily of oceanic plankton communities (Buck et al 2014). Thus while observations during rack removal tests indicated that visible sediment dissipated in a few minutes, the tidal cycles and currents of the estero will certainly reduce localized turbidity to times lower than impact thresholds (3-5 hr/d, 30 days to impact on deeper eelgrass) described by Zimmerman et al. (1991)

Proposed BMP - In consultation with NMFS, we have determined that our BMP for sediment impacts to eelgrass is that if operations in the field exceed 5 hours at a single bent, operations must be modified to

increase operational efficiency. Note that after performing test pulls, we currently estimate only 15-20 minutes per bent.

3. Non-Natives Impacts

The primary concern with non-natives in this project is the inadvertent spread of *Didemnum vexillum* (*Dvex*), a colonial tunicate that has invaded much of the east and west coasts of North America over the past 15 years. *Dvex* was first noted in Drakes Estero by Elliot-Fisk et al. (2005) growing on oysters, oyster racks, and experimental settlement plates. In 2010, *Dvex* was also noted growing on eelgrass in Drakes Estero (Grosholz 2010). As of 2015, *Dvex* is an established invader in Drakes Estero which is common, but unquantified, on marine debris, oyster racks, rocky outcrops (at Bull Point), and eelgrass in Drakes Estero (Grosholz 2010, Becker pers. obs.). Removal programs around the world, have attempted methods for removal, with the most successful methods, being either bathing the tunicates in acetic acid (held in place by an encapsulating cover), covering with sheeting to achieve long-term anoxia, bathing in freshwater, or desiccation (summarized in Muñoz and McDonald 2014). Most of these methods are not 100% effective for eliminating *Dvex* nor are currently feasible over a 2500 acre estuary. We therefore suggest that removal of the majority of the preferred substrate and *Dvex* on those substrates is a viable initial approach to *Dvex* control in the estuary. A key motivation for the removal of the oyster racks, oyster shell and marine debris is that it serves as the key substrate for *Dvex*. Thus, by removing the habitat, the *Dvex* population should be reduced, although the apparent increasing use of eelgrass as substrate is worrying and the short and long-term impacts on eelgrass are currently unknown.

Additionally, in most other removal programs, infrastructure (oyster bags, posts, etc) were proposed to be left in place and therefore removal of *Dvex* from the structure was the goal. Conversely, in this project, the goal is to remove the substrate along with the *Dvex*. Discussions with experts (S. Cohen at SFSU) and consulting the literature leads to several broad best management practices (BMPs) when removing debris covered with *Dvex* in Drakes Estero.

- Larval load and reproductive capacity are likely depressed when waters are colder. Water temperatures in Drakes Estero are relatively constant year round, but may be slightly cooler during spring upwelling and slightly warmer during late summer relaxation.
- In general fragmentation of *Dvex* colonies is likely a greater risk for spread than agitating larvae (S. Cohen pers. comm.).
- In estuaries where removal or treatment of *Dvex* has been delayed due to indecision, *Dvex* has spread, making the problem more difficult.
- Any *Dvex* not removed now will live to multiply and spread (via fragmentation or larvae) so by removing colonies now, we are removing future reproductive potential, even if some fragmentation occurs during removal.
- *Dvex* removed from the water should not be allowed to fall back into the water and should be disposed of on land.

- Some programs have encapsulated debris or posts covered with Dvex prior to removal (see review in (Muñoz and McDonald 2014). We do not consider this technique feasible. Encapsulation has worked in Alaska where suspended aquaculture gear could be covered without touching the gear, but in Drakes Estero, divers would need to encapsulate each piece of debris (1000s of pieces) and 1000s of posts to achieve higher (but likely not perfect) levels of containment. Furthermore, the debris on the estuary floor would need to be handled prior encapsulation, and therefore would still be prone to fragmentation and release of larvae. We therefore proposed that simple single handling and removal is most efficient and appropriate to minimized Dvex impacts.

Nonetheless, during removal activities, Dvex colonies on aquaculture debris, posts, and shell will be occasionally disturbed. We will minimize this disturbance and the chance of fragmentation by:

- No scraping or rubbing of lumber or debris so that tunicates are removed whole and no fragments are released into the water.
- No unnecessary agitation of tunicates (e.g. avoid grabbing posts where tunicates are present)
- Marine Debris is often covered with extensive Dvex, however the scooping method or hand picking proposed will simply scoop up debris and place it into the debris boxes. This will agitate some of the tunicate and possibly induce release of larvae. However, as discussed above these larvae would eventually be released if the tunicates were left in place, so while the removal effort may cause some release of larvae, the sum released will be lower than if the Dvex remained in place.

Therefore, while this project may change the timing that Dvex is released into the estuary, it should not add any additional Dvex to the estuary when considered over a full year time scale. **It can be anticipated that most of the Dvex will be removed whole and without agitating larvae, and therefore, the project will be greatly reducing the amount of Dvex larvae and reproductive budding that occurs. While the NPS has documented that removal using mechanized equipment is reasonably acceptable, any decision to employ divers removing material by hand would further reduce the overall potential impact described above.**

4. Spill Plan

A fuel or hydraulic oil spill in Drakes Estero could cause significant damage to eelgrass, fishes, fish eggs, waterbirds, infauna, and visitor enjoyment. The NPS contract requires that the contractor submit a spill prevention/response plan to be reviewed and approved prior to issuing the notice to proceed. The NPS will review the contractor spill plan to ensure that the following topics are addressed adequately:

- Each vessel carrying fuel or hydraulics will carry absorbent boom and pads on board at all times for immediate deployment. Additional boom will be immediately available onshore if additional boom is needed.

- Contractors must be trained in spill prevention and response prior to commencement of work. All spills will be immediately reported to NPS and USCG.
- Boats and hydraulic equipment must be inspected prior to work each day for leaks or potential spill hazards. Any issues must be corrected and approved by the site supervisor prior to work commencement.
- Bilges will not be pumped into the estero.
- Cleaners, solvents, paints, soaps or caustics will not be used on the water.

Additionally, the NPS will maintain a spill response plan for Drakes Estero that follows the following format (Adapted from California Marina and Yacht Club Spill Response Communication Packet: http://www.asmbyc.org/wp-content/uploads/2014/06/Final_Packet_May_2014.pdf).

- A. Assess magnitude of spill
- B. Identify Material spilled
- C. Identify Source
- D. Stop Source if able. Do not use soap or dispersing agents.
- E. Contain spill using containment boom or absorbent pads. Use adequate PPE.
- F. When incident is secured, complete an incident report and contact NPS and USCG.

5. Anchoring Plan

Anchors may damage eelgrass if placed in eelgrass beds, especially if anchors have a leading chain that repeatedly scrapes back and forth across eelgrass. A specific anchoring plan will be developed prior to work by consulting with the contractor. However, the plan will have these general requirements.

- No use of anchors with chains in eelgrass.
- Anchors should be deployed only where the bottom can be sighted to ensure anchors are not placed in eelgrass.
- Long, narrow poles that can be placed into the sediment may be used to stabilize barges without impacting eelgrass.
- Anchoring may occur within the footprint of existing oyster racks.
- In the event of an emergency where there is risk to human safety, running aground on an eelgrass bed, or a fuel spill, anchors may be temporarily deployed in eelgrass. Any such events will be reported to NPS.

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Zimmerman, R. C., J. L. Reguzzoni, S. Wyllie-Echeverria, M. Josselyn & R. S. Alberte. 1991. Assessment of Environmental Suitability for Growth of *Zostera-Marina* L (Eelgrass) in San-Francisco Bay. Aquatic Botany, 39: 353-366.

Links to relevant documents.

http://www.westcoast.fisheries.noaa.gov/publications/habitat/california_eelgrass_mitigation/Final%20CEMP%20October%202014/cemp_oct_2014_final.pdf

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