Sustainable Fisheries Goal Implementation Team
Oyster Tributary Restoration Decision Framework

Background

While there are many other fish and shellfish (i.e. striped bass, menhaden, and alosines) that spend at least part of their life cycle in the Chesapeake Bay, and whose populations are lower than optimal, most are managed under the Atlantic States Marine Fisheries Commission (ASMFC). The Sustainable Fisheries Goal Implementation Team has decided to focus priorities on those fish and shellfish where the management of the fisheries is entirely within the Chesapeake watershed, starting with oysters and blue crabs.

Oyster management efforts began upon realizing the drastic decline in the native, wild oyster stock. One of the initial reports, the oyster Programmatic Environmental Impact Statement (PEIS; Appendix #1), evaluated oyster restoration alternatives for the Chesapeake Bay, including the use of native and non-native (i.e. *Crassostrea ariakensis*) oysters. Following the decision not to introduce non-native oysters in the Chesapeake Bay, Maryland and Virginia both initiated mechanism to maintain and increase their native oyster populations.

In 2007, Virginia finished their Blue Ribbon Oyster Panel report (Appendix #2), which established the rotational harvest system and proposed oyster sanctuary expansions throughout Virginia. The rotational harvest system is designed to maximize oyster harvest yield and maintain a consistent stock of market sized oysters. Maryland started their oyster sanctuary program (Appendix #3) in September, 2010. This program expanded the oyster sanctuary network in Maryland from 9% to 25% (~9,000 acres) of remaining oyster bar habitat over a broad geographical distribution. Within this enlarged sanctuary network, a number of large areas were selected (up to entire river systems) in strategically located areas for targeted restoration. Without these efforts, the latest large-scale restoration goals would not be possible.

1. **Articulate Program Goal:**

Restore native oyster habitat and populations in 20 tributaries out of 35 to 40 candidate tributaries by 2025. (Current condition: 0 tributaries with fully restored oyster populations; several tributaries with successful living oyster reef habitat.) The primary focus of this decision framework is on ecological restoration leading to sustainable populations that provide beneficial ecosystem services such as habitat and improved water quality.

Target Date	Programmatic Milestone
	OYSTER
December 2012	The Fisheries GIT will continue to adopt and apply oyster restoration performance metrics to existing projects in the Great Wicomico and Lynnhaven rivers. These metrics will be used to guide new tributary restoration planning and monitoring. (NOAA/USACE)
December 2012	Complete native oyster protection and restoration strategy, including a collaborative and agreed-upon federal-state list of priority tributaries targeting four to six tributaries for restoration and lay out steps for expanding aquaculture and evaluating sustainability of wild fishery. The collaborative strategy will document a phased approach for developing tributary scale restoration plans, reef construction, monitoring and performance evaluation. (NOAA)
December 2012	Complete USACE Native Oyster Restoration Master Plan. (USACE)
December 2012	Complete bay-wide Oyster Stock Assessment. (NOAA)

Table 1. Additional Executive Order 13508 2012 Action Plan Milestones for oyster restoration.

2. Describe Factors Influencing Goal Attainment (System-Level Model)

i. Low Population

- The latest research by Wilberg *et al.* (2011) used statistical analyses and states that the current oyster population is 0.3% of its historic level. The main causes for the reduced oyster stock have been the continuation of a commercial oyster fishery and diseases (MSX and Dermo) that stuck in the 1980s. *Figure 1* shows the declines in oyster harvest from 1880-2008 due to reduced populations.

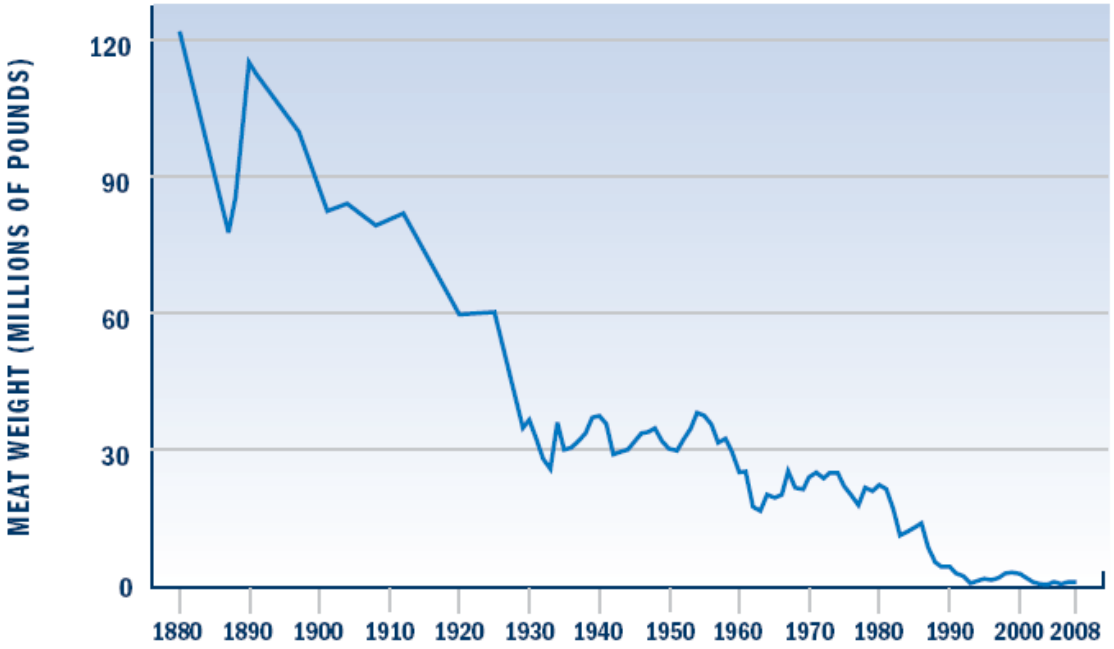

Figure 1. Chesapeake Bay oyster harvest from 1880-2008 (Source: NOAA Chesapeake Bay Office).

ii. Reduced Habitat Area - declined nearly 70% between 1980-2009 (Wilberg *et al*. 2011)

- Without sufficient hard bottom habitat area much of the oyster's natural recruitment goes to waste due to larvae with no suitable locations to settle. This also causes a problem for restoration since there is currently no proven (i.e. "tank-less setting") methods of releasing larvae *in situ* to spat on currently existing hard-bottom structure.

iii. Poor Water quality (i.e. O2 levels, pollution, sedimentation rates, eutrophication, sewage contaminants, salinity swings from massive freshwater inputs, etc.)

- Poor water quality can prevent natural recruitment and even causes mortality among adult oysters. Without the ability to directly improve water quality baywide, restoration efforts are left with an ever reducing efficacy of locations and options. Obviously, tributary criteria will need to be conducive to the survival of planted oysters in locations with the best chances for success.

iv. Restoration approaches vary between Maryland and Virginia

- Virginia's rotational harvest system sets aside certain oyster bars for harvest and rotates between them on a 2-4 year cycle. This process was implemented "to maximize harvest prior to loss from disease and maintain the sequence of growth from spat to market size."

- Maryland's designated sanctuary areas were established to facilitate development of natural disease resistance, protect current reefs, provide essential natural ecological function, serve as reservoirs of reproductive capacity, encompass broad salinity regimes, and increase our ability to deter poaching.

v. Shell Availability
   - The amount of natural shell available for restoration is very limited and under constant competition between restoration and aquaculture practices. Generally, alternative substrates (i.e. concrete reef balls) are not 'ideal' for restoration since they leave the area forever unfishable for not only oystermen, but also finfish fishermen.

vi. Budget Limitations - ability to purchase shell, spawn larvae, produce spat-on-shell and/or reef balls, plant shell/reef balls onto reefs
   - Jurisdictions are currently strained due to tight financial budgets and do not possess the required funds to secure the necessary shell, alternative substrates, or manpower to accomplish oyster restoration on such large scales. Some means additional funding will be necessary in order to accomplish the Executive Order goal.

3. Assess Current Management Efforts – Identify Gaps

Until now, oyster restoration practices have been relatively small scale and not approached on the same scale as are now being implementing. The recently developed oyster restoration metrics report (Appendix #4), finalized in December, 2011, establishes a set of scientifically agreed upon targets, metrics, and monitoring protocols necessary to consider the successful completion of restoration activities for any *sanctuary* reef. Along with this document, the USACE is near completion of a Chesapeake Bay Native Oyster Restoration Master Plan (Appendix #5) that outlines a long-term plan for large-scale native oyster restoration throughout the entire Chesapeake Bay and identifies target tributaries based on a set of environmental criteria.

4. Develop Management Strategy

In 2012, federal and state partners are working toward a collaborative and agreed-upon federal-state list of priority tributaries targeting four to six tributaries for restoration. The collaborative effort is a phased approach for developing tributary scale restoration plans, reef construction, monitoring, and performance evaluation. Utilizing the established oyster restoration success metrics, it is now possible to quantitatively assess the success of oyster restoration efforts on sanctuary reefs at both the tributary and reef scale. Therefore, the next step is to identify priority tributaries to begin implementation of such efforts. The Fisheries GIT is in the process of establishing MD and VA Interagency Workgroups that will lead and monitor the restoration of these priority tributaries. These groups will utilize the latest habitat mapping tools and spatial analyses to assess the restorable bottom in development of 'restoration blueprints' for each selected tributary. *Figure 2* (below; Appendix #6) illustrates an example process for selecting specific restoration sites within a tributary using established criteria and a suite of available restoration options. The resulting restoration blueprints will describe exactly how much potential oyster habitat acreage is available, how much acreage needs to be planted/seeded, and the proper type of substrate necessary. Maryland has already identified Harris Creek, on the Choptank River, as its first targeted tributary. In Virginia continued restoration in the Great Wicomico and Lynnhaven rivers will be evaluated per the oyster metrics and tributary scale efforts are being considered in the Lafayette and Piankatank rivers.

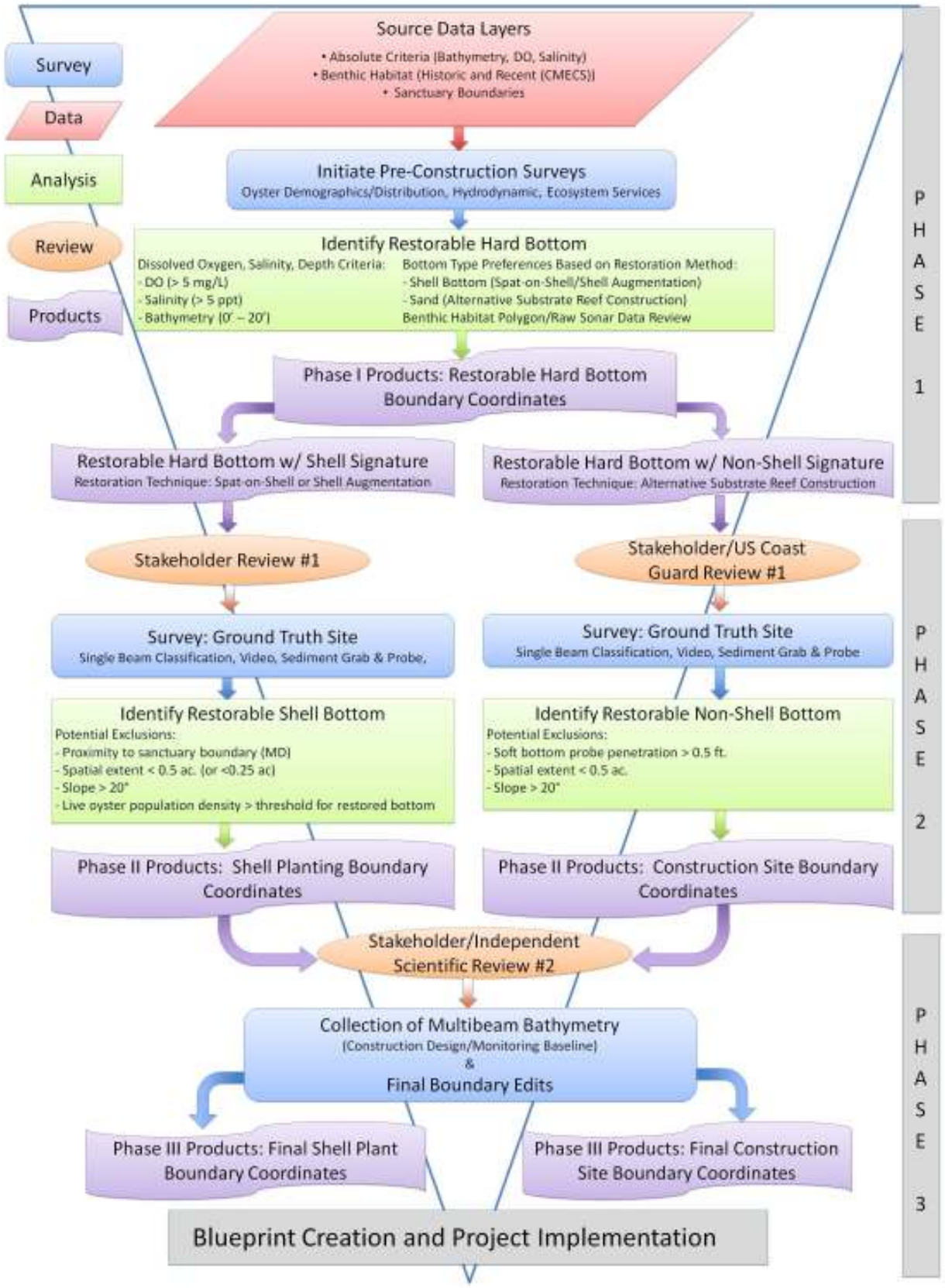

Figure 2. Restoration site selection process diagram based on lessons learned at Harris Creek, MD, in 2011.

5. **Develop Monitoring Program**
    - The Oyster Metrics Report (Appendix #4; pg. 13-21) outlines a monitoring protocol to measure progress towards the established targets and thresholds.

6. **Assess Performance**
    - Success in oyster restoration efforts will need to be evaluated on several levels over varying spatial and temporal scales. Targets and metrics of operational success are required to guide restoration activity, such as what percentage of a historical bar or other area should be planted with shell or spat-on-shell. Monitoring of individual reefs following initial restoration activity will be required to determine success at various stages by evaluating recruitment success, early post-settlement or post-planting survival, natural mortality, disease status, growth, reproduction and shell accumulation. Evaluating success at the tributary level likewise will need to involve operational definitions about the amount of area within the tributary that needs to be rehabilitated and functional measures of the status of those areas several years after the restoration activity. *Table 2* (below) summarizes the goals, assessment protocols and success metrics established by the Oyster Metrics Report.

Table 2. Summary of goals, assessment protocols, assessment frequency and success measures

Goal	Success metrics (targets and/or thresholds)	Assessment Protocol	Minimum Assessment Frequency (assumes pre-restoration survey)
Operational Goals: Defined programmatic and planning outcomes for reef construction and tributary level restoration			
Reef-level 1. Appropriate amount of substrate and/or spat-on-shell was planted. 2. Presence of substrate and/or spat-on-shell within the target area.	Shell, alternative substrate, or spat-on-shell should cover a minimum of 30% coverage throughout the target reef area.	Patent tong or diver grabs	Within 6-12 months of restoration activity
Tributary-level target: 1. Appropriate amount of area within the tributary has met reef-level operational goals.	A minimum of 50% of currently restorable area that constitutes at least 8% of historic oyster habitat within a given tributary meets the reef-level goals defined above.	GIS-based analysis of restoration activity within the tributary	Annual
Functional Goals: The desired ecological outcomes at reef and tributary scales			
Reef-level goals			
Significantly enhanced live oyster density and biomass	Target: An oyster population with a minimum mean density of 50 oysters and 50 grams dry wt/m^2 covering at least 30% of the target restoration area at 3 years post restoration activity. Evaluation at 6 years and beyond should be used to judge ongoing success and guide adaptive management. Minimum threshold: An oyster population with a mean density of 15 oysters and 15 grams dry wt biomass $\cdot$ m^{-2} covering at least 30% of the target restoration area at 3 years post restoration activity. Minimum threshold is defined as the lowest levels that indicate some degree of success and justify continued restoration efforts.	Patent tong or diver grabs	Minimum 1, 3 and 6 years post restoration
Presence of multiple year classes of live oysters	Minimum of 2 year classes at 6 yrs post restoration.	Patent tong or diver grabs	Minimum 3 and 6 years post restoration

Table 2 (cont.)

Positive shell budget	Neutral or positive shell budget.	Quantitative volume estimates shell (live and dead) per unit area	Minimum 1, 3 and 6 years post restoration
Stable or increasing spatial extent and reef height	Neutral or positive change in reef spatial extent and reef height as compared to baseline measurements.	Multi-beam sonar, direct measurement, aerial photography	Within 6 -12 months post-restoration, and 3 and 6 years post restoration
Tributary-level goals			
Expanding oyster population beyond the restored reefs	Will need to be determined as restoration proceeds.	Quantitative assessment of oyster populations throughout the tributary.	Will need to be determined from future assessments.
Return of the oyster population within a tributary to an enhanced stable state.	Specific targets will need to be developed on a tributary-specific basis as restoration proceeds.	Quantitative assessment of oyster populations throughout the tributary.	Will need to be determined from future assessments.
Enhanced ecosystem services in the tributary	Currently unknown. Specific targets will likely be informed by the results of experiments relation ecosystem services to structural metrics.	Determine relationships between structural reef characteristics (e.g., reef size, oyster abundance, or oyster biomass) and the quantity of various ecosystem services via controlled experiments and modeling studies. Use measured values of structural metrics to estimate levels of specific ecosystem services.	Currently unknown

7. Manage Adaptively

"Throughout this document we refer to applying adaptive management principles to restoration techniques and activities (e.g. placing subsequent additions of shell or spat-on-shell as informed by monitoring data). But, adaptive management means more than simply adjusting techniques. It means gathering data to answer specific questions at known decision points. For instance, in areas with only intermittent recruitment, it may mean monitoring shortly after the potential recruitment period to make a decision about the need to use spat-on-shell at that location. More fundamentally, fully adaptive management makes use of knowledge gained through data collection to refine both targets and metrics in route to meeting its ultimate goal. This will almost certainly be the case for oyster restoration in Chesapeake Bay. We have suggested restoration targets that reflect the experiences not only of the workgroup members, but their organizations and the consulting scientists. There was seldom unanimity of opinion and in some cases our recommendations represent compromises between organizations; in others; they can be described as informed guesses. We strongly encourage those organizations involved in efforts to restore oyster populations and the ecosystem services that they provide in Chesapeake Bay to a higher stable state to rigorously evaluate and reassess the targets and the metrics established here as more data becomes available." (Oyster Metrics Report, pg. 24; Appendix #4)

Appendix

1. Oyster PEIS Report:
   http://www.nao.usace.army.mil/OysterEIS/PeerReviews/PRG_Lipton_Economics_Report.pdf

2. 2007 Virginia Blue Ribbon Oyster Panel Report:
   http://www.mrc.state.va.us/fmac/Blue_Ribbon_Oyster_Panel_May_2007.pdf

3. Maryland Oyster Sanctuary Program:
   http://www.dnr.state.md.us/fisheries/oysters/eco_resto/sanctuaries.asp

4. Restoration Goals , Quantitative Metrics and Assessment Protocols for Evaluating Success on Restored Oyster Reef Sanctuaries:
   http://www.chesapeakebay.net/channel_files/17932/oyster_restoration_success_metrics_final.pdf

5. USACE Chesapeake Bay Native Oyster Restoration Master Plan:
   http://www.nao.usace.army.mil/projects/civil%20works%20projects/oyster%20restoration/Native%20Oyster%20Restoration/Master%20Plan/Homepage.asp

6. Tributary Specific Site Selection Process for Native Oyster Restoration*: Oyster Sanctuary Restoration Site Selection_finaldraft_11_29_2011.docx*