ERDC TN-EMRRP-EBA-17
November 2012

Curritituck Sound Estuary Restoration: A Case Study in Objective Setting

by S. Kyle McKay,[1] Charles R. Wilson,[2] and Douglas Piatkowski[3]

OVERVIEW: U.S. Army Corps of Engineers (2000) states, "A clear definition of objectives and constraints is essential to the success of the planning process." Proper articulation of a complete and clear set of objectives paves the way for metric and model development, alternative formulation, and plan comparison. Although the importance of objectives is well-acknowledged, coming to agreement on a set of objectives is challenging for large-scale, multi-faceted ecosystem restoration projects. This technical note briefly reviews techniques to guide objective setting and demonstrates their application to an estuary restoration project in Currituck Sound, North Carolina. Although the objectives developed are project-specific, the approach to setting and structuring the objectives is transferrable to other ecosystem restoration projects.

SETTING RESTORATION OBJECTIVES: A complete and clear statement of objectives informs almost all aspects of restoration project planning from alternative formulation and evaluation to plan comparison and recommendation (Yoe and Orth 1996; Gregory and Keeney 2002; McKay et al. 2010, in preparation). Though the importance of articulating goals and objectives may seem obvious, ecosystem restoration and management efforts often specify poor objectives (Slocombe 1998, Bernhardt et al. 2007). This document defines goals as the end or final purpose and objectives as something aimed at or striven for (Yoe and Orth 1996).

Setting objectives for ecosystem restoration is particularly challenging due to the simultaneous complex interactions that occur among physical, chemical, and biological factors in natural systems. These interactions are further complicated by economic and cultural considerations. Because of this complexity, there is not one single technique for setting objectives, but many sources of guidance from which to draw on (Yoe and Orth 1996; McKay et al., in preparation). A few items of particular note are listed below, and the reader is encouraged to examine referenced materials for additional information. These techniques are intended to provide complementary and alternative viewpoints on objective setting to guide the reader in answering the question, "How will I know that a project is successful?"

- Set structured objectives: Numerous authors encourage the use of a multi-step process for setting objectives. In a review of environmental decision making, Gregory and Keeney

1 Research Civil Engineer, U.S. Army Engineer Research and Development Center (ERDC), Environmental Laboratory (EL), Phone: 601-415-7160, kyle.mckay@usace.army.mil.
2 Biologist, U.S. Army Corps of Engineers (USACE), Wilmington District (SAW), Phone: 910-251-4746, charles.r.wilson@usace.army.mil.
3 Planner/Biologist, USACE-SAW, Phone: 910-251-4908, douglas.piatkowski@usace.army.mil.

(2002) offer the straightforward objective-setting framework outlined below (as adapted by McKay et al. (2010)).

- o *Step 1: Write down the concerns that need to be addressed*. This step involves brainstorming all of the potential elements that may influence the decision and allowing ideas to flow freely among team members.

- o *Step 2: Convert the general concerns into succinct objectives*. This step requires a project team to synthesize a potentially long list of elements from Step 1 into the verb-object format of objectives (e.g., maximize habitat for endangered taxa X).

- o *Step 3: Structure objectives*. This is the process of separating the ends (fundamental goals) from the means (milestones to achieving goals). Objectives are often structured hierarchically to explain how means contribute to ends.

- o *Step 4: Clarify what is meant by each objective*. Assess, refine, collaborate, and iterate. This step requires that the project team critically examine their objectives as well as engaging sponsors, agencies, and stakeholders. It is important to note that objective setting should be considered an iterative process, not a linear activity.

- <u>Apply existing assessments</u>: Ongoing assessments of environmental and ecological status are becoming increasingly available through groups such as non-profit entities (e.g., NatureServe), state departments of natural resources (e.g., Deaton et al. 2006), and other federal agencies (e.g., National Marine Fisheries Service habitat conservation program). These assessments can serve as excellent sources of existing conditions for an ecosystem and the resident taxa as well as problem areas on which to focus restoration objectives.
- <u>Use conceptual models</u>: "Conceptual models are descriptions of the general functional relationships among essential components of an ecosystem. They tell the story of 'how the system works" and in the case of ecosystem restoration, how restoration actions "aim to alter those processes or attributes for the betterment of the system" (Fischenich 2008). Conceptual model development by a project team can provide a forum to discuss system function and potential alternatives as well as goals and objectives.
- <u>Improve ecosystem integrity</u>: Covich et al. (in preparation) promote ecosystem integrity as a basis for setting restoration objectives. They define an ecosystem possessing integrity as a dynamic and resilient unit inclusive of the biotic, abiotic, and social systems in which it is situated. Covich et al. view ecosystem integrity as having six components: hydrogeomorphology; biogeochemistry; biotic systems; socio-economics; cultural, political, and demographic integrity; and landscape character. They suggest that an ecosystem far out of balance in any one component will ultimately become out of balance in other components; thus, all components should be considered when setting objectives for restoration.
- <u>Use reference-based approaches</u>: Along with other restoration scientists, the Society for Ecological Restoration International (SERI) recommends using an appropriate reference system when setting objectives and designing a restoration project (SERI 2004, Palmer et al. 2005, Miller et al. 2012, Pruitt et al. 2012). A reference time (e.g., historical data on the system) or ecosystem (e.g., neighboring watershed) can provide a benchmark against which objectives may be set (e.g., the extent of wetlands prior to the introduction of a stressor).

- <u>Additional notable items</u>: Many other techniques and ideas may be applied to objective setting, but the following concepts are particularly notable.

    - Multi-level objectives: In addition to project goals and objectives, broader objectives stated by funding agencies or sponsors likely exist (e.g., National Ecosystem Restoration account).

    - Structure versus function: Most restoration objective sets will include a combination of structural and functional targets (e.g., restore 50 acres of submerged aquatic vegetation and increase nutrient uptake, respectively).

    - Different types of objectives: Restoration projects often have both primary and secondary objectives as well as goals for how the restoration process should be conducted (e.g., engage stakeholder community, Slocombe 1998).

CASE STUDY – CURRITUCK SOUND ESTUARY RESTORATION: Currituck Sound is a large estuary located in northeastern North Carolina and southeastern Virginia and is part of the Albemarle-Pamlico National Estuary (Figure 1). This system is shallow (typically less than 10 ft deep) with circulation primarily driven by winds rather than tides (Davis and Brinson 1983). Thin barrier islands separate the Sound from the Atlantic Ocean, and the system receives saline inputs primarily through the southern entrance to the Sound. These factors result in low salinity levels throughout the Sound with only the most ocean-connected portions reaching mesohaline (or brackish) salinity levels.

(a)


(b)

Figure 1. Currituck Sound Estuary: (a) project boundary, and (b) typical shoreline marsh community.

Historical observations identify Currituck Sound as having high water quality and significant submerged and emergent aquatic vegetation coverage that provided for a flourishing bird and fish community (Sincock et al. 1965). In the last 50-100 years, significant changes have taken place in the Sound (e.g., increased turbidity, reduced extent of submerged macrophytes), and the health of the ecosystem has declined considerably (Davis and Brinson 1983). To counteract this trend, the North Carolina Department of Environmental and Natural Resources (DENR) has partnered with the U.S. Army Corps of Engineers (USACE) Wilmington District to identify potential restoration actions within Currituck Sound.

Environmental benefits analysis. Although the intent of this technical note is to highlight objective setting, objectives cannot be considered outside of the larger decision framework in which they reside. The purpose of this study is to investigate and recommend appropriate federal actions and plans for ecosystem restoration initiatives in Currituck Sound. To recommend these actions, the team required a suite of techniques for conducting an environmental benefits analysis and trading off economic investment and environmental output. Restoration project planning requires a number of interdependent elements such as objectives, models, alternatives, and monitoring, and the team desired an overarching framework for how the analysis was to proceed. Figure 2 presents an overarching flow of activities associated with analyzing restoration benefits for the Currituck project (adapted from Covich et al., in preparation). The framework is built upon well-tested decision analysis procedures (e.g., Gregory and Keeney 2002; Yoe and Orth 1996) but is modified slightly for specific application to restoration decision making. See also Fischenich et al. (in preparation) for an alternative environmental benefits analysis framework.

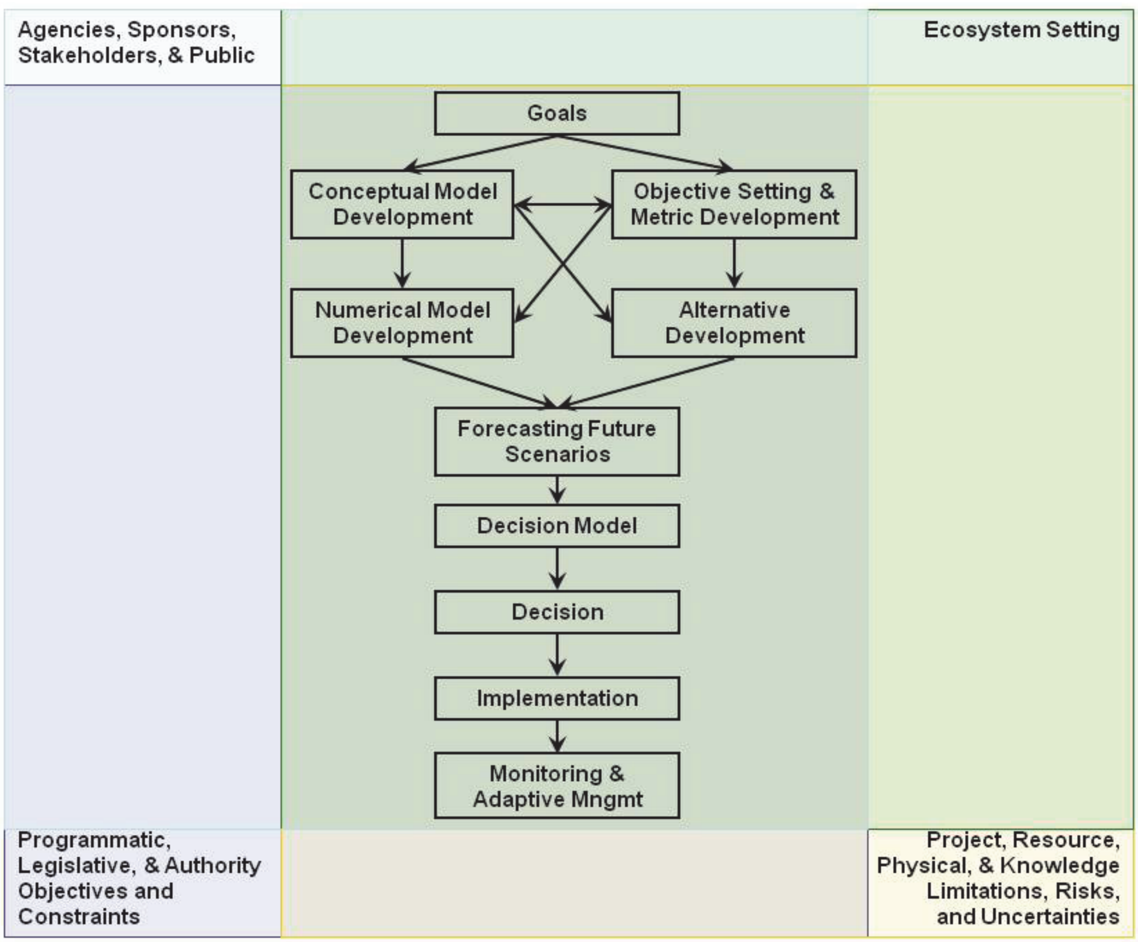

Figure 2. Environmental benefits analysis flow diagram for the Currituck Sound project (Adapted from Covich et al., in preparation). Note that the decision framework is embedded in colored boxes intended to characterize the “context” of the decision.

Objective setting. This section reviews how existing assessments, conceptual modeling, and reference-based targets were combined with the structured, four-step objective-setting framework of Gregory and Keeney (2002) to arrive at project objectives in Currituck Sound.

Step 1: The project team relied heavily on existing assessments, conceptual modeling, and reference-based targets to identify the problems to be addressed by the project.

- Application of existing assessments: Currituck Sound is historically a well-studied ecosystem, and its condition and status have been documented in a number of environmental assessments. These assessments were used to identify specific structural and functional characteristics of the ecosystem that have been degraded. In the peer-reviewed literature, Davis and Brinson (1983) and Carter and Rybicki (1994) both reviewed the status of submerged aquatic vegetation in Currituck Sound and found significant declines. A number of coastal planning and conservation prioritization efforts have also recently been conducted by the State of North Carolina (i.e., Ferguson et al. 1989; Street et al. 2005; Deaton et al. 2006; Vanasse Hangen Brustlin, Inc. (VHB) 2006; North Carolina Division of Marine Fisheries (NCDMF) 2009). In addition to site-specific reviews of condition, the decline of coastal wetlands and submerged aquatic vegetation communities is well-documented in the Mid-Atlantic region (e.g., Shafer and Bergstrom 2010, Cahoon et al. 2009, Orth et al. 2010).
- Use of conceptual models: Given the complex interactions among ecosystem processes in Currituck Sound, a set of conceptual models was developed during the objective-setting process to assist the project team in understanding system processes, diagnose underlying stressors, guide numerical model development, and facilitate communication among team members (Fischenich 2008). The general approach to conceptual model development was to identify significant ecological resources occurring in the basin, the primary state conditions governing these resources, and the drivers and stressors leading to these state conditions. Significant ecological resources (and accompanying objectives) were identified based on literature- and agency-reported declines in specific taxa (e.g., herring; Cahoon et al. 2009), communities (e.g., tree-nesting colonial waterbirds), and ecosystem types (e.g., submerged aquatic vegetation; Davis and Brinson 1983, Orth et al. 2010).
- Referenced-based approaches: As part of early project planning, the USACE team worked with the DENR and an interagency group to identify an appropriate reference condition as the target for restoration actions. This reference condition drew heavily from a historical assessment of the Sound (Sincock et al. 1965). Given social constraints and the uniqueness of Currituck Sound's wind-driven estuarine community, the team agreed that the objectives should center on restoring an estuary system that is disconnected from the ocean during all but large storm events (i.e., assuming any closed inlets remain closed). This "guiding image" (Palmer et al. 2005) provided a consistent reference point against which the team could measure the current ecosystem condition and identify objectives for improvement.

Step 2: From these assessments, a multitude of problems and opportunities were identified. The team then sought to convert these concerns into succinct objectives. A few specific ecosystem types within the Currituck basin offer disproportionate opportunities for restoration due to: (1) their relative scarcity within the Sound, (2) the current and future stressors acting on the system, and (3) their roles as connective habitats. As such, objectives emphasize three ecosystem types as the primary targets for restoration actions: vegetated shallow-water ecosystems, marsh communities, and bird nesting islands. Actions will be pursued in other ecosystem types, but only to the extent that they affect these three primary systems. For instance, if excessive upland loading of nutrients is identified as the limiting factor for submerged aquatic vegetation within a sub-basin, streamside riparian buffer improvement may be an appropriate action.

Step 3: Objectives were then structured into a hierarchy of goals, objectives, and sub-objectives (Table 1). Three project goals were identified for Currituck Sound restoration. Goal 1 emphasizes the restoration of ecosystem structure, function, and dynamic processes and serves as the impetus for plan formulation (USACE 2000). Goal 2 describes secondary benefits offered by the project, which are not the focus of plan formulation but do provide ancillary benefits of particular note (i.e., those associated with USACE "accounts" for National Economic Development, Regional Economic Development, and Other Social Effects). Goal 3 highlights the aims of the project team in carrying out the restoration process (Slocombe 1998). Although Goal 1 is the primary goal and source of National Ecosystem Restoration (NER) benefits, Goals 2 and 3 describe elements of the project that help the USACE team communicate with the USACE chain of command, cost-share sponsor, external agencies, and other stakeholder groups. Each goal was decomposed into objectives and sub-objectives (i.e., a hierarchy) in order to clarify the project direction and purpose to the greatest extent possible.

Step 4: The project team iterated through this process multiple times with each successive application involving a larger audience (e.g., USACE planning team, entire USACE team, combined USACE-DENR team, resource agencies and pertinent parties, and finally the general public) and a different level of detail (e.g., reconnaissance to feasibility). In each round of application, objectives were added, clarified, refined, and greater buy-in was obtained. Because the objective-setting process is iterative and this study is ongoing, the objectives presented should not be perceived as "final," but instead they should be viewed as a set of objectives recently used to communicate with stakeholders at a public meeting.

Letting objectives guide metrics and modeling. In addition to providing a clear road map for the project, objectives are significantly linked to metric and model development. Metrics quantify the degree to which project objectives are achieved (McKay et al. 2010). Thus, objectives serve as the basis for metric development. For instance, given the objective "increase the extent of vegetated shallow-water ecosystems," the obvious, natural metric is aerial extent (or acreage) of this ecosystem type. Moreover, concrete objectives focus model selection and development (Schmolke et al. 2010). For instance, this project could have initially included stream or riparian models. However, after objective setting, it is clear that model selection and development should focus on the three focal ecosystem types (i.e., submerged aquatic vegetation, back-barrier marshes, and bird-nesting islands).

CONCLUSIONS: USACE personnel are often asked to develop objectives for large, complex systems to guide restoration actions. This case study illustrates the process of restoration objective setting for the 153-square-mile Currituck Sound basin. This technical note demonstrates a transparently developed and scientifically defensible objective set that is rooted in ecological assessments, supported by a conceptual model, used a reference system as a template, and was vetted with a diverse group of stakeholders and partners. This technical note presents a condensed view of the project, and more information may be obtained in study documentation (USACE 2011).

Table 1. Summary of preliminary goals, objectives, and sub-objectives.

Goal 1: Restore significant ecosystem structure, function, and dynamic processes contributing to a resilient estuarine system supporting diverse floral and faunal assemblages.

1.1. HABITAT: Provide habitat for a diverse assemblage of floral and faunal taxa.
- Increase the extent of vegetated shallow-water ecosystems
- Increase the extent of estuarine marsh
- Increase the extent of bird-nesting islands
- Promote riparian ecosystems to the extent that they support vegetated shallow-bottom, estuarine marsh, and bird-nesting island systems
- Seek to provide balanced habitat composition relative to Sincock et al. (1965)

1.2. CONNECTIVITY: Promote connectivity of diverse ecosystem types.
- Provide connectivity of habitat types for focal taxa (e.g., waterbirds)
- Provide sufficient connectivity of ecosystem types to maintain a desirable nutrient, sediment, and salinity regime
- Provide an appropriate landscape arrangement of ecosystem types

1.3. SUSTAINABILITY: Promote sustainability of restored ecosystems.
- Promote a self-sustaining hydro-geomorphic regime
- Promote ecosystem processes that are capable of adapting to sea level rise
- Increase system resilience to coastal storm disturbance

Goal 2: Protect existing economic, social, and cultural resources.

2.1. Economically-beneficial resources.
- Support commercial fisheries and shellfisheries
- Provide for commercial and non-commercial recreational opportunities including, but not limited to: hunting, fishing, wildlife observation, guide services for fishing and waterfowl, and boating
- Maintain opportunities for existing navigation volumes and rates
- Do not increase flood risk

2.2. Social resources.
- Establish avenues for public education pertaining to the unique nature of the Currituck Sound ecosystem
- Incorporate recreational features into project designs to the extent appropriate for USACE restoration projects (USACE 2000)

2.3. Cultural resources.
- Highlight unique tribal history of Monkey Island
- Embrace waterfowl hunting heritage in the basin
- Provide for fair treatment and equal involvement of historically disenfranchised communities
- Maintain existing subsistence fishing opportunities

Goal 3: Implement a collaborative, comprehensive, system-wide study.

3.1. Plan and implement the project collaboratively.
- Provide opportunities for interaction with non-federal cost share sponsors, federal- and non-federal resource agencies, and the academic community
- Provide opportunities for public and industry interaction on more than one occasion in more than one location
- Consider ongoing external activities and documented future plans in the planning of this interagency study

3.2. Apply a systems approach to project planning.
- Examine potential restoration actions throughout the watershed
- Consider the potential for project interaction with existing and future infrastructure and land use managed or acted upon by other entities

ADDITIONAL INFORMATION: Research presented in this technical note was developed under the Environmental Benefits Analysis (EBA) Research Program. The USACE Proponent for the EBA Program is Ms. Rennie Sherman and the Technical Director is Dr. Al Cofrancesco. Input from Pamela Castens, Dr. Tomma Barnes, and Jeffrey Lin (USACE Wilmington District) was critical to this effort and is gratefully acknowledged. Technical reviews by Drs. Dave Tazik, Craig Fischenich, Bruce Pruitt, and Deborah Shafer (Environmental Laboratory) greatly improved a prior draft of this document. For additional information, contact the author, S. Kyle McKay (601-415-7160, Kyle.McKay@usace.army.mil), or the manager of the Environmental Benefits Analysis Research Program, Glenn Rhett (601-634-3717, Glenn.G.Rhett@usace.army.mil). This technical note should be cited as follows:

> McKay, S.K., C.R. Wilson, and D. Piatkowski. 2012. *Currituck Sound estuary restoration: A case study in objective setting.* EBA Technical Notes Collection. ERDC TN-EMRRP-EBA-17. Vicksburg, MS: U.S. Army Engineer Research and Development Center. http://cw-environment.usace.army.mil/eba/

REFERENCES

Bernhardt E.S., E. B. Sudduth, M. A. Palmer, J. D. Allan, J. L. Meyer, G. Alexander, J. Follastad-Shah, B. Hassett, R. Jenkinson, R. Lave, J. Rumps, and L. Pagano. 2007. Restoring rivers one reach at a time: Results from a survey of U.S. river restoration practitioners. *Restoration Ecology* 15(3): 482-493.

Cahoon, D.R., S. J. Williams, B.T. Gutierrez, K. E. Anderson, E. R. Thieler, and D. B. Gesch. 2009. The physical environment. In *Coastal sensitivity to sea level rise: A focus on the Mid-Atlantic Region*. The United States Climate Change Science Program, Synthesis and Assessment Product 4.1.

Carter, V., and N. B. Rybicki. 1994. Invasions and declines of submersed macrophytes in the Tidal Potomac River and Estuary, the Currituck Sound Back Bay System, and the Pamlico River Estuary. *Lake and Reservoir Management* 10 (1): 39-48.

Covich, A.P., S. K. McKay, M. A. Kenney, B. A. Pruitt,M. Harberg, J. C. Fischenich, and J. J. Boland. Enhancing aquatic ecosystem integrity with effective objectives and metrics for restoration. In preparation for submission to Ecological Restoration (Special Issue: Environmental Benefits Analysis).

Davis, G. J., and M. M. Brinson. 1983. Trends in submerged macrophyte communities of the Currituck Sound: 1909-1979. *Journal of Aquatic Plant Management* 21:83-87.

Deaton, A., S. Chappell, and K. West. 2006. *Process for identification of strategic habitat areas in coastal North Carolina*. Morehead City, NC: North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries.

Ferguson, R.L., J. A. Rivera, and L. L. Wood. 1989. *Submerged aquatic vegetation in the Albemarle-Pamlico estuarine system*. Project No. 88-10. Department of Natural Resources and Community Development and U.S. Environmental Protection Agency. National Estuary Program, Albemarle-Pamlico Estuarine Study.

Fischenich, J.C. 2008. *The application of conceptual models to ecosystem restoration*. EBA Technical Notes Collection. ERDC TN-EMRRP-EBA-01. Vicksburg, MS: U.S. Army Engineer Research and Development Center. http://cw-environment.usace.army.mil/eba/.

Fischenich, J.C., S. K. McKay, S. J. Miller, D. Price, B. A. Pruitt, L. L. Skaggs, B. Suedel, and D. Tazik *Framework for science-based environmental benefits assessment.* In preparation. Vicksburg, MS: U.S. Army Engineer Research and Development Center. http://cw-environment.usace.army.mil/eba/.

Gregory, R.S., and R. L. Keeney. 2002. Making smarter environmental management decisions. *Journal of the American Water Resources Association* 38 (6):1601-1612.

McKay, S.K., B. A. Pruitt, M. Harberg, A. P. Covich, M. A. Kenney, and J. C. Fischenich. 2010. *Metric development for environmental benefits analysis*. ERDC TN-EMRRP-EBA-04. Vicksburg, MS: U.S. Army Engineer Research and Development Center. http://cw-environment.usace.army.mil/eba/.

McKay, S.K., I. Linkov, J. C. Fischenich, S. J. Miller, and J. Valverde. *Ecosystem restoration objectives and metrics*. In preparation. Vicksburg, MS: U.S. Army Engineer Research and Development Center. http://cw-environment.usace.army.mil/eba/.

Miller, S.J., B. A. Pruitt, C. H. Theiling, J. C. Fischenich, and S. B. Komlos. 2012. Reference concepts in ecosystem restoration and environmental benefits analysis: Principles and practices. ERDC TN-EMRRP-EBA-12. Vicksburg, MS: U.S. Army Engineer Research and Development Center. http://cw-environment.usace.army.mil/eba/.

North Carolina Division of Marine Fisheries Service (NCDMF). 2009. *Strategic Habitat Area Nominations for Region 1: Albemarle Sound to Northeastern Coastal Ocean of North Carolina*. Strategic Habitat Area Regional Advisory Committee.

Orth, R.J., S. R. Marion, K. A. Moore, and D. J. Wilcox. 2010. Eelgrass (*Zostera marina L.*) in the Chesapeake Bay Region of Mid-Atlantic Coast of the USA: Challenges in conservation and restoration. *Estuaries and Coasts* 33:139–150.

Palmer, M.A., E. S. Bernhardt, J. D. Allan, P. S. Lake, G. Alexander, S. Brooks, J. Carr., C. N. Dahm, J. Follstad-Shah, D. L. Galat, S. G. Loss, P. Goodwin, D. D. Hart, B. Hassett , R. Jenkinson, G. M. Kondolf, R. Lave, J. L. Meyer, T. K. O'Donnell, L. Pagano, and E. Sudduth. 2005. Standards for ecologically successful river restoration. *Journal of Applied Ecology* 42: 208-217.

Pruitt, B.A., C. R. Theiling, S. J. Miller, and J. C. Fischenich. 2012. The use of reference ecosystems as a basis for assessing restoration benefits. ERDC TN-EMRRP-EBA-11. Vicksburg, MS: U.S. Army Engineer Research and Development Center. http://cw-environment.usace.army.mil/eba/.

Schmolke, A., P.Thorbek, D. L. DeAngelis, and V. Grimm. 2010. Ecological models supporting environmental decision making: A strategy for the future. *Trends in Ecology and Evolution* 25:479-486.

Shafer, D., and P. Bergstrom. 2010. An introduction to a special issue on large-scale submerged aquatic vegetation restoration research in the Chesapeake Bay: 2003-2008. *Restoration Ecology* 18 (4):481-489.

Sincock, J. L., K. H. Johnston, J. L. Coggin, R. E. Wollitz, J. A. Kerwin, A. W. Dickson, T. Crowell, J. Grandy, J. R. Davis, and R. McCartney. 1965. *Back Bay – Currituck Sound data report*. U.S. Fish and Wildlife Service.

Slocombe, D. S. 1998. Defining goals and criteria for ecosystem-based management. *Environmental Management.* 22 (4):483-493.

Society for Ecological Restoration International (SERI). 2004. *The SER International primer on ecological restoration*. www.ser.org.

Street, M. W., A. S. Deaton, W. S. Chappell, and P. D. Mooreside. 2005. *North Carolina Coastal Habitat Protection Plan (CHPP)*. Morehead City, NC: North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries.

U.S. Army Corps of Engineers (USACE). 2000. *Planning Guidance Notebook*. ER-1105-2-100, Washington, D.C.

U.S. Army Corps of Engineers (USACE). 2011. *Currituck Sound, North Carolina Ecosystem Restoration Feasibility Study, Feasibility Scoping Meeting Report*. U.S. Army Engineer District, Wilmington. www.saw.usace.army.mil/Currituck/.

Vanasse Hangen Brustlin, Inc. (VHB). 2006. *Monkey Island shoreline assessment, Currituck, North Carolina*. Prepared for Whalehead Preservation Trust.

Yoe, C.E., and K. D. Orth. 1996. *Planning manual*. IWR Report 96-R-21. Alexandria, VA; U.S. Army Institute for Water Resources.