DRAFT SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT

ENVIRONMENTAL APPENDIX

CHESAPEAKE BAY OYSTER RESTORATION

GREAT WICOMICO RIVER, VIRGINIA

U.S. Army Corps of Engineers
Norfolk District
803 Front Street
Norfolk, Virginia 23510-1096

January 2023

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ADAPTIVE MANAGEMENT & MONITORING PLAN

Updated from Original 2004

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Adaptive Management and Monitoring Plan

Chesapeake Bay Oyster Restoration, Great Wicomico River, Virginia

1.0 Introduction

This document is the updated Adaptive Management and Monitoring Plan (AMMP) for the Chesapeake Bay Oyster Recovery, Great Wicomico River, Virginia. It has been updated since its initial approval in 2004, since there have been significant advances in the construction of oyster reefs and their success criteria. The original AMMP was based on planting seed oysters on the reefs to serve as broodstock to “jumpstart” the oyster population in the Great Wicomico. Due to the successful restoration projects within the river, there are enough broodstock oysters within the system to allow for sustainable recruitment on USACE reefs. The restoration methods are designed to provide more surface area for the oyster larvae to settle, and could be composed of, but are not limited to; shell, concrete, stone and other suitable alternative substrates. The Project Delivery Team (PDT) developed this AMMP plan to describe the updated monitoring and adaptive management for the project and provide metrics for evaluating project success since its original approval.

2.0 Authority and Purpose

Section 2039 of the Water Resources Development Act of 2007 (WRDA 2007) (33 U.S.C. § 2330a) requires that feasibility studies for ecosystem restoration projects authorized by section 704(b) of WRDA 1986 (33 USC § 2263(b) include a plan for monitoring the success of the restoration efforts. Monitoring includes the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether adaptive management may need to attain project benefits. Section 2039 also directs that monitoring plans include a contingency plan (adaptive management plan) “for taking corrective actions in cases in which monitoring demonstrates that restoration measures are not achieving ecological success in accordance with criteria described in the monitoring plan.” (33 USCS § 2330a).

3.0 Project Goals and Objectives

This AMMP is not intended to be a static document, but rather a dynamic document that will be updated as necessary to reflect the science-based restoration goals and strategies that have been developed by the USACE and in collaboration with the Sustainable Fisheries Goal Implementation Team (GIT) of the Chesapeake Bay Program and the Virginia Interagency Oyster Team. The document will be revised to reflect new information such as future cost estimates, modifications made to the design in the Planning, Engineering, and Design phase of this project, and recommendations by the Virginia Interagency Team.

The goal of the project is to restore the oyster population to a self-sustaining level through the enhancement of local oyster recruitment and improvement of the environmental quality in the Great Wicomico River. The project goal contributes to the goals of the Chesapeake Bay Agreements (2000, 2014), Executive Order 13508 -Chesapeake Bay Protection and Restoration (2009), and the USACE Oyster Restoration Master Plan (2012). The Interagency Report entitled, “Restoration Goals, Quantitative Metrics and Assessment Protocols for Evaluating Success on Restored Oyster Reef Sanctuaries: Report of the Oyster Metrics Workgroup 2011,” established metrics for evaluating success of restored Oyster Reef Sanctuaries. Signed by the Sustainable

Fisheries GIT Executive Committee, this document and its recommendations, as well as the best available science, will be used as a guideline to establish metrics for this project. Proposed reefs will also be evaluated in relation to USACE's Oyster Master Plan goals established in 2012 as well as the initial goals of the 2003 study.

4.0 Metrics Used for Measuring Success:

The 2011 Report from the Oyster Metrics Workgroup established metrics for evaluating success on restored Oyster Reef Sanctuaries. Signed by the Sustainable Fisheries Goal Implementation Team (GIT) Executive Committee, this document and its recommendations, as well as the latest oyster restoration science, will be used as a guideline to establish metrics for this project. On a reef level, the established operational, structural, and functional metrics are listed as Table 1. Proposed reefs will also be evaluated in in relation to USACE's Oyster Master Plan and original goals of the initial Great Wicomico Oyster Restoration study.

Table 1 Restoration Goals for Oyster Reef Sanctuaries

Goals	Minimum Threshold	"Restored" Threshold
Operational Goals	• Enhance current population	• Create a self-sustaining native oyster population on restored habitat. • Augment regional (watershed) oyster recruitment.
Structural Goals	• Shell planting and/or spat-on-shell should result in a minimum of 30% coverage of available reef habitat. • Reef spatial extent, reef height, and shell budget should remain neutral.	• Shell planting and/or spat-on-shell should result in a minimum of 30% coverage of available reef habitat. • Reef spatial extent, reef height, and shell budget should remain neutral or increase. • Restore adequate habitat in a given sub-estuary (tributary) to meet restoration areal requirements.
Functional Goals	• 15 grams dry weight/m^2 and a minimum of 15 oysters/m^2 covering 30% of reef with at least 2 year classes present.	• 50 grams dry weight/m^2 and a minimum of 50 oysters/m^2 covering 30% of reef with at least two year classes present

The anticipated biomass for the restored oyster habitat is represented in Table 2. By year three, the minimally functional goal of 15 g/m^2 of oyster biomass should be achieved. By year six, the fully restored goal of 50 g/m^2 should be achieved and maintained. Biomass accumulates over time and may continue to increase past year six. Undisturbed oyster reefs, under ideal conditions, can exceed 100 g DW oyster tissue/m^2. If the overall trend by year three, when the 15 g/m^2 goal should be met and exceeded, does not show an increase in biomass, adaptive management will require corrective action. A second key element that the USACE tracks is the amount of shell available for oyster larval settlement, called "brown" or "oxic" shell. For long-term reef sustainability, shell reefs should hold 10 liters of brown shell per square meter of reef, and – for reefs composed of stone, concrete or other hard substrate – at least 5 liters of brown shell per square meter of reef is recommended. Typically, an oyster population of 50 grams dry weight per square meter of reef is sufficient to produce such a shell volume over time.

Table 2 Oyster Biomass Goals Over Time

Oyster Biomass Goal Over time Restored Reef Habitat	
Year	Biomass (dry weight of oyster tissue in grams per square meter restored reef)
1	5
2	10
3	20
4	30
5	40
6	50

5.0 Monitoring Parameters and Methods

Restoration monitoring contributes to the understanding of complex ecological systems and is essential in documenting restoration performance and adapting project and program approaches when needs arise. Monitoring efforts could be conducted in partnership with other federal agencies, non-profit organizations, academic researchers, private contractors and other organizations that could provide technical assistance. Monitoring of reef habitat will be supervised by USACE Norfolk District. Monitoring programs will address the following structural and functional parameters in order to meet the criteria established by the Oyster Metrics Workgroup: reef height, spatial extent, population densities, year class frequency distributions, biomass, and shell weight and volume. If deemed necessary by unexpected high mortality rates, the monitoring plan will also address oyster disease and poaching status of the reef which could lead to adaptive management actions to restore or enhance reef function.

The first six years of an oyster restoration project is crucial to its success, as trends in monitored parameters tend to stabilize after this period unless the reef is disturbed. Per the methodology established by the Oyster Restoration Working Group, reef evaluations should be conducted immediately following initial reef installation and at year one, year three and year six post construction. Additional annual monitoring could be conducted at year two, year four, and year five, if funding becomes available or is necessary due to observed problems, such as a hypoxia-induced mass mortality event or poaching. Monitoring will be conducted using a variety of methods of measurement such as acoustic mapping, sampling by quadrate, patent tongs, or by diver sampling, from October-April. The use of an oyster dredge to take samples is not recommended as these samples are not quantitative. This time period is preferred for accurate verification of oyster settlement before predation begins in the late spring. Sampling outside this window could introduce error into determinations of the spat settlement numbers. Monitoring will involve taking sufficient samples at each reef site to estimate population density, biomass, size frequency distribution, spat set, reef height, reef spatial extent, reef coverage and shell volume. Post construction surveys will provide confirmation by acoustic mapping of reef height and areal extent before contractors demobilize the site. Adaptive management of reef height will occur at this time to ensure proper height and coverage at initial reef installation.

Monitoring programs will address the following to meet the criteria established by the Oyster Metrics Workgroup.

Table 3 Established Monitoring Parameters

Physiochemical Properties	Water Quality (DO, salinity, TSS, temperature, pH, chlorophyll a, Turbidity, etc.)
Structural Goals	Spatial extent to include reef height and area, percent coverage, shell budget, poaching, biomass, size-frequency distribution

5.1 Monitoring Methodology

At year one, year three and year six, reefs will be sampled using a stratified random survey with sufficient samples to minimize error. In the first round of monitoring, three samples per acre of restored reef will be taken. A 10-meter square grid or quadrate will be drawn over the shell reef area in Arcview, or similar program, and numbers will be assigned to each grid plot. A random number generator will be used to select the random samples for each monitoring event. A combination of samples from the reef edge and interior is preferred. If all samples selected are along the edge of the reef, a re-randomized sample should be selected to ensure the reef is properly assessed. Areas with no placed material can be assessed as control areas but should not be considered part of the restored area. Samples should also be randomized from various heights of the reef. Samples from the lowest portions of the reef can be compared to those found in the higher portions of the reef to assess vertical stratification.

For size-frequency demographics, oysters will be divided into five mm bins. Shell weights will also be determined. The intent is to obtain a shell weight that can be used to estimate live shell volumes and accretion rates more accurately than the “brown” or “oxic” and black or “anoxic” shell measurements in liters used today, though these volumetric measures will also be recorded.

If unexpected high rates of mortality trigger adaptive management due to negative findings of a monitoring event at year one, three, or six, the reef will be evaluated for disease status. A subset of oysters in the size classes from 40 mm to maximum will be assessed for disease. Oysters will be collected in the field from August to early October when disease intensity is still very high. Oysters should be kept live and cool but unfrozen until delivered to a laboratory equipped to conduct oyster disease assay. There are other causes for mortality such as predation, poaching or large freshwater events. All occurrences will be documented and if necessary, adaptive management will take place. See Table 4 for a complete list of monitoring activities and methods.

USACE is primarily responsible for archiving data from projects constructed using USACE funding; however, such data can be shared with other agencies and research institutions at USACE's discretion. All data analyses should be performed by USACE personnel. Any interpretations of data by personnel other than USACE personnel are subject to USACE review and approval. After a monitoring event has taken place and data has been analyzed, a report should be produced for public dissemination and, if possible, published in a peer-review scientific journal.

Table 4 Example Monitoring Methods

	Monitoring Element	**Data Recorded**	**Methods**	**Monitoring Objective**
1	Presence of reef	Substrate quality/unit	Patent tong or diver, initially done at year 0 post-construction via hydro-acoustics	Assess existing bottom conditions. Areal extent of substrate over time in restoration area.
2	Oyster demographics	Oysters /m^2	Patent tong or diver	Determine population numbers of oysters/unit of restored reef area
3	Oyster biomass	Dry weight (DW)	Sub-sampling of oysters from all size classes on restored reefs	Determine oyster biomass/unit reef area
4	Live (Oxic) Shell Weight and Volume	Shell weight and volume of live oysters and other oxic (brown) shell associated with these oysters	Weight and volumetric measure of all live shell material	Determine weight and volume of live shell/unit reef area, determine accretion or loss rate of shell material over time
5	Oyster disease status	MSX and Dermo prevalence and intensity	Laboratory assay	Determine health of oysters on reef, document any further development of disease resistance development over time
6	Secondary production	Dry Weight (DW)	From Oyster biomass and sampling associated reef fauna, which includes motile fish and blue crabs, who forage on the reefs	Determine total productivity of restored oyster reefs
7	Chlorophyll A	chlA	Water quality sampling with standard hydrolab	chlA levels in water to estimate water quality

				improvements from oyster reef
8	TSS (total suspended solids)	TSS levels in water column	Water quality sampling with standard hydrolab	Determine TSS reductions, if any, provided by restored oyster reefs
9	Water Quality Parameters	DO, salinity, temperature, pH, & turbidity	Water quality sampling with standard hydrolab	To identify water quality issues for oyster populations and to assess benefits of oyster restoration.

5.2 Expected Monitoring Duration

The first six years of an oyster restoration project is crucial to its success. Monitoring should be conducted annually in order to assess the need to adaptively manage the site. Reducing the time intervals between monitoring events to one year allows for effective adaptive management that will ensure the success of the federal project and protect the public investment. Periodic monitoring after the first six years will also be necessary to ensure continued performance. Such monitoring could be less intensive than that of the first six years, if results indicate restoration goals have been achieved.

5.3 Monitoring Considerations

The monitoring program should accomplish the following:

- Support adaptive management decisions by providing data on critical stages in the development of the reefs that can guide the next steps in the restoration process. This monitoring should answer crucial questions that affect implementation decisions. Examples: Are there sufficient broodstock oysters to support continued reef development in the Great Wicomico? Are additional seeding events of spat-on-shell needed? Is cultch quality sufficient to support a second year's recruitment? What is the annual recruitment, as measure by counting oysters smaller than 35 mm during the survey?
- Evaluate intermediate conditions that help to track progress towards the final goals. For instance, are enhanced abundances of oyster larvae and new recruits observed in a tributary following restoration activities? Is there any sign of poaching? Or, what is the disease status of oysters on sanctuary reefs? Such a monitoring objective permits setting intermediate goals and evaluating success in reaching those goals.
- Aid in identifying unexpected stresses, environmental conditions, and/or ecological interactions that can affect the overall success of the project. For instance, water quality can be affected by a very wide range of factors; measuring all of which

would be impractical but having a monitoring program in place that could recognize when water quality problems affected the success of a project would be invaluable.

While each of the monitoring considerations are important objectives for a comprehensive monitoring strategy, their proper implementation will be crucial to the overall success of the USACE oyster restoration efforts. It is unlikely that every individual restoration effort will be able to incorporate all of these monitoring objectives. Allocation of the limited resources available for monitoring should be guided by the strategic needs for ensuring success. Incubator systems, which all other stocking efforts will depend upon, will require more extensive monitoring of sites where the goal is simply to establish a stable population of oysters.

The initial goal for the reefs constructed in the Great Wicomico was to serve as the first self-sustaining oyster restoration project and as an incubator system, providing oyster recruits that could potentially be moved to augment other areas (spat on shell, typically moved from non-sanctuary areas as needed. While the densities and age classes will be continually monitored, construction of reefs moving forward will try to increase habitat availability for the larval oysters. This is done by use of construction techniques that maximize surface area above the sediment-water interface and minimizes biofouling and sedimentation to the fullest extent practicable.

6.0 Risk and Uncertainties

Oyster restoration based on modern science is very new, and the scientific rationale is still being developed. Details on how high to build reefs, where to place them in tributaries for maximum recruitment (either providing or receiving), how to influence the stock/recruit relationships, metrics for long-term sustainability and use of alternative materials are still being researched and evaluated for effectiveness. Table 5 describes the inherent risks and uncertainties associated with this action.

Table 5 Risks and Uncertainties

Risks	• Factors outside of USACE control include cataclysmic weather events, hurricanes, freshets, or red tides. Large variations in water quality (encroachment of the Bay “dead zone”) hypoxic waters, for example, can lead to the decrease in restoration benefits due to oyster mortality. Larvae and young oysters are highly vulnerable to hypoxia, large adults can survive hypoxic waters for days, even in summer, when hypoxia is most likely to occur. • Predation of spat and mature oysters by blue crabs, mud crabs, and cow nose rays. • The oyster diseases MSX and Dermo can cause extensive oyster mortality, though resistance to the diseases has been documented and is increasing in oyster populations in the lower Chesapeake Bay. • As with other restoration efforts of reef habitat, the risk of illegal harvest or poaching is always a consideration. Poaching damages the reef structure, removes both large adults, as well as young oysters attached to them, and kills reef fauna. If left unchecked, poaching can completely decimate a restored reef. Poaching on shell reefs has been known to occur in the Great Wicomico River.

Uncertainties	• Sufficient quantities of oyster larvae need to be present at proposed reef sites for successful colonization/oyster recruitment of the newly placed reef structures in the Great Wicomico River. Since this area usually has naturally high recruitment levels, the plan does not include the placement of seeded cultch, which is often required in Maryland. There is, however, uncertainty regarding this expectation. Regional weather patterns significantly influence oyster recruitment on an annual and even seasonal basis, as does standing stocks (including their location and density) of adult oysters in the river. • The integrity of proposed reef habitat to maintain the correct grade from sea floor over time. Materials can compact and settle, and also subside below the surface of sediments. Reefs built at low-relief, a few inches off the bottom, are especially prone to this. • At the project site, there can be higher than expected mortality rates of oyster recruits. This could have many individual or accumulated causes, such as dead zone encroachment, changes in weather patterns, predation, poaching, disease and levels of parasitism that cannot be accurately predicted. • Climate change could impact the project site over time, particularly sea level rise, warming waters, increased salinity in estuaries and ocean acidification. Each are significant scientific uncertainties for all coastal projects. These issues were incorporated in the plan formulation process and will be monitored by gathering data on water levels, salinities, and land elevation. These data will inform adaptive management actions, but future climate change projections remain highly uncertain at this time.

7.0 Adaptive Management

The primary incentive for implementing adaptive management is to increase the likelihood of achieving desired project outcomes given identified uncertainties. Adaptive management provides an organized, coherent, and documented process that suggests management actions in relation to measured project performance compared to desired project outcomes. Adaptive management establishes the critical feedback among project monitoring and informed project management and learning through reduced uncertainty. Adaptive management should also be implemented as unforeseen issues arise that impact the overall success and health of the reef outside of the monitoring years. Circumstances could include but are not limited to; cataclysmic weather events (strong wave action could push the reef off initial planting location or large freshwater inputs could impact oyster survivability), increase in the prevalence of shellfish diseases (spike in MSX or Dermo cases), poaching (illegally harvesting oysters off USACE sanctuary reefs to sell commercially), and higher than typical predation pressure influencing natural mortality additively (rather than a compensatory mechanism). As successful reef restoration occurs throughout the Chesapeake Bay watershed, effective strategies and monitoring techniques will be applied to this project and program. USACE Norfolk District applied experience gained from other restoration projects to develop this project. Significant risk would be avoided by proper design, appropriate site selection, and correct seasonal timing of biotic applications.

Due to inherent uncertainty present in the relatively new technology of science-based oyster restoration, USACE has designed an adaptive management plan to ensure the proposed project provides the National Ecosystem Restoration (NER) benefits over the predicted project life. This includes a series of potential actions to reverse downward trends in reef substrate and the oyster population upon it. A monitoring program of sufficient precision is necessary to determine when adaptive management measures need to be considered and when and where to initiate these measures.

The following are example scenarios that may trigger adaptive management of the restoration project:

7.1 Scenario 1 - Oyster larval recruitment (spat settlement) is not adequate (less than 15-50 spat per m^2) after year one, year three or year six monitoring events:

Monitoring activities:

- Assess population density and year class frequency distributions during year one, year three and year six monitoring events.
- Identify reef areas where oyster population densities are below the 15-50 m^2 range.
- Gather any available data on the stock source supplying larvae to the reefs and determine if it is too low to supply recruits.
- Review the recent history for significant weather events and if there have been any large freshwater inputs that could have limited recruitment.
- Add monitoring component to program that supports assessment and tracking of sedimentation rates at project site by utilizing divers equipped with cameras and GPS equipment or by other methods, such as remote operated vehicle technology (including underwater cameras).

Corrective Actions:

- Apply spat-on-shell during the following reproductive season to the substrate. This spat-on-shell should be produced using local stocks of adult oysters, if possible. It would be applied at a minimum density of approximately 250 spat/m2.
- Place additional shell and large substrate throughout the reef that would increase reef elevation and habitat heterogeneity, plus deter poaching as a secondary benefit.
  - A secondary action to this corrective action is adaptation of the sampling design initially established to monitor oyster metrics—especially for demographic and biomass metrics that require patent tong sampling. The placement of large substrate randomly on reefs may alter or compromise the effectiveness of established patent tong sampling methodology sampling effective. To maximize / maintain consistency in data collected, sampling design and methodology would be adapted in coordination with VMRC. Examples of adaptation include (1) sharing high-resolution coordinates of large substrate locations with VMRC, (2) conducting a pilot study on sampling effectiveness that compares oyster data collected before and after placement of the large substrate, and (3) adding and outlining a component to the monitoring program that evaluates oyster metrics on the newly placed 3-D structures.

7.2 Scenario 2 - From a structural perspective, reef habitat is not maintaining the correct

grade from the sea floor:

Monitoring activities:

- Acoustic mapping will be used to determine reef grade from river bottom post construction, at year one, year three and year six.
- If reef grade is compromised after a monitoring event, employ divers and/or other methods such as remote operated vehicles to assess if the reef has been poached. Poaching can remove substrate material as well as live oysters, from a reef. Large scale weather events (such as hurricanes) can produce strong wave action and blow the reefs, changing grades.

Corrective Actions:

- Reef height will be corrected by installing additional alternative substrate or a combination of alternative substrate and spat-on-shell to reestablish colonization and elevate the reef to the proper grade. The availability and cost of substrate and/or shell will determine which material is applied to correct the grade.
- If determined that poaching is the cause of reef removal, USACE will coordinate with Virginia Marine Resources Commission to identify opportunities for VMRC to strengthen and/or implement active enforcement/management measures. Incorporating larger alternative substrate on the reef would represent an effective passive management measure to deter poaching, particularly substrate that is too large for poaching equipment to remove from reefs; this passive measure is particularly suitable in cases where poor reef performance is also tied to incorrect or low-grade issues that require correction by increasing grade, elevation, and structural heterogeneity and would deter poaching as a secondary benefit.
- Ensure the size appropriate substrate is being placed at the site. For example, an area with strong currents and heavy wave action should not have a shell only reef, because the lightweight shell will not stay in place. Heavier, alternative substrate should be used in high energy systems.

7.3 Scenario 3 – Higher than Expected Mortality of Oyster Recruits

Monitoring activities:

- After each monitoring event, if unexpected high mortality rates are recorded, causes of mortality should be investigated by evaluating findings of prior monitoring years (if applicable) for shell budget, disease, reef height and coverage.
- Other data points that could be gathered depending upon funding are algae growth on reef (determined by a diver), sedimentation rates (determined by a diver), water quality monitoring station reports in the Great Wicomico, and compiling annual reported poaching violations in the Great Wicomico River.

Corrective Actions:

- Additional shelling
- Additional spat-on-shell to compensate for mortality.
- Sample oysters during expected peaks of disease to determine if infection levels of Dermo (*Perkinsus marinus*) and MSX (*Haplosporidium nelsoni*) can be lethal.

- If determined that poaching is a significant cause of mortality, USACE will coordinate with VMRC to identify opportunities for VMRC to strengthen and/or implement active enforcement/management measures. Incorporating larger alternative substrate on the reef would represent an effective passive management measure to deter poaching, particularly substrate that is too large for poaching equipment to remove from reefs; this passive measure is particularly suitable in cases where poor reef performance is also tied to incorrect or low-grade issues that require correction by increasing grade, elevation, and structural heterogeneity and would deter poaching as a secondary benefit.
- Place additional large substrate throughout the reef that would increase reef elevation and habitat heterogeneity, plus deter poaching as a secondary benefit.
    - A secondary action to this corrective action is adaptation of the sampling design initially established to monitor oyster metrics—especially for demographic and biomass metrics that require patent tong sampling. The placement of large substrate randomly on reefs may alter or compromise the effectiveness of established patent tong sampling methodology sampling effective. To maximize and maintain consistency in past and future data collected, sampling design and methodology would be adapted in coordination with VMRC. Examples of adaptation include (1) sharing high-resolution coordinates of large substrate locations with VMRC, (2) conducting a pilot study on sampling effectiveness that compares oyster data collected before and after placement of the large substrate, and (3) adding and outlining a component to the monitoring program that evaluates oyster metrics on the newly placed 3-D structures.

USACE is primarily responsible for archiving data from projects constructed using USACE funding; however, such data can be shared with other agencies and research institutions. Any interpretations of data by personnel other than USACE personnel are subject to USACE review and approval. After a monitoring event has taken place and data analyzed, a report will be prepared describing the monitoring methods, results of the monitoring effort, and recommended adaptive management actions (if any).

8.0 Acronyms and Abbreviations

AMMP – Adaptive Management and Monitoring Plan
DO- Dissolved Oxygen
Dermo – A disease found in oysters caused by the protist, *Perkinsus marinus*.
DW – Dry Weight (measured in grams)
GIT – Sustainable Fisheries Goal Implementation Team, chaired by NOAA
MSX – Multinucleated Sphere X, a disease found in oysters caused by the protist, *Haplosporidium nelsoni*
NER – National Ecosystem Restoration
PDT – Project Delivery Team
TSS – Total Suspended Solids
USACE – U.S. Army Corps of Engineers

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CORRESPONDENCE

CHESAPEAKE BAY OYSTER RESTORATION

GREAT WICOMICO RIVER, VIRGINIA

U.S. Army Corps of Engineers
Norfolk District
803 Front Street
Norfolk, Virginia 23510-1096

From: Thompson-Slacum, Julie
To: Schulte, David M CIV CENAO CENAD (USA)
Subject: [Non-DoD Source] Re: [EXTERNAL] Great Wicomico River, VA, oyster restoration project upgrades
Date: Friday, May 13, 2022 10:06:59 AM

Thanks Dave. We can just provide a FWCA letter, if necessary.

Julie A. Slacum

Division Chief, Strategic Resource Conservation

177 Admiral Cochrane Drive

Annapolis, MD. 21401

410-573-4595 Office

410-215-0260 Cell

From: Schulte, David M CIV CENAO CENAD (USA) <David.M.Schulte@usace.army.mil>

Sent: Friday, May 13, 2022 9:48 AM

To: Thompson-Slacum, Julie <julie_thompson-slacum@fws.gov>

Subject: [EXTERNAL] Great Wicomico River, VA, oyster restoration project upgrades

Hello Julie,

I'm writing to let you know we are currently writing a supplemental EA to the original study/EA, attached. What we're going to propose to do is build up some of the remaining low-relief habitat to high to improve its performance on several of the reefs. Additionally, we are planning to place class VDOT Class 1 granite riprap randomly over the entire reef network at a rate of approximately 60 stones/acre. The stone is an anti-poaching measure. We've recording poaching on many of the reefs since first noted in 2011. After years of trying to do something about it, it looks like I've got everyone on board to finally get these reefs protected. The Draft SEA should be completed this summer. I'm not sure what sort of coordination we need to do, the original study had completed USFWS coordination, so I'm thinking we don't have to do the entire process over again? Maybe just a FWCAR letter? Please let me know what you think.

Dave Schulte

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IPAC REPORT

CHESAPEAKE BAY OYSTER RESTORATION

GREAT WICOMICO RIVER, VIRGINIA

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
Virginia Ecological Services Field Office
6669 Short Lane

Gloucester, VA 23061-4410

Phone: (804) 693-6694 Fax: (804) 693-9032

In Reply Refer To:
Project Code: 2022-0070092
Project Name: Great Wicomico Oyster Reef Enhancements

August 02, 2022

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*). Any activity proposed on National Wildlife Refuge lands must undergo a 'Compatibility Determination' conducted by the Refuge. Please contact the individual Refuges to discuss any questions or concerns.

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the ECOS-IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 *et seq.*), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

http://www.fws.gov/endangered/esa-library/pdf/TOC-GLOS.PDF

Migratory Birds: In addition to responsibilities to protect threatened and endangered species under the Endangered Species Act (ESA), there are additional responsibilities under the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA) to protect native birds from project-related impacts. Any activity, intentional or unintentional, resulting in take of migratory birds, including eagles, is prohibited unless otherwise permitted by the U.S. Fish and Wildlife Service (50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)). For more information regarding these Acts see https://www.fws.gov/birds/policies-and-regulations.php.

The MBTA has no provision for allowing take of migratory birds that may be unintentionally killed or injured by otherwise lawful activities. It is the responsibility of the project proponent to comply with these Acts by identifying potential impacts to migratory birds and eagles within applicable NEPA documents (when there is a federal nexus) or a Bird/Eagle Conservation Plan (when there is no federal nexus). Proponents should implement conservation measures to avoid or minimize the production of project-related stressors or minimize the exposure of birds and their resources to the project-related stressors. For more information on avian stressors and recommended conservation measures see https://www.fws.gov/birds/bird-enthusiasts/threats-to-birds.php.

In addition to MBTA and BGEPA, Executive Order 13186: *Responsibilities of Federal Agencies to Protect Migratory Birds*, obligates all Federal agencies that engage in or authorize activities that might affect migratory birds, to minimize those effects and encourage conservation measures that will improve bird populations. Executive Order 13186 provides for the protection of both migratory birds and migratory bird habitat. For information regarding the implementation of Executive Order 13186, please visit https://www.fws.gov/birds/policies-and-regulations/executive-orders/e0-13186.php.

We appreciate your concern for threatened and endangered species. The Service encourages

Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Project Code in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment(s):

- Official Species List
- USFWS National Wildlife Refuges and Fish Hatcheries
- Migratory Birds

Official Species List

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

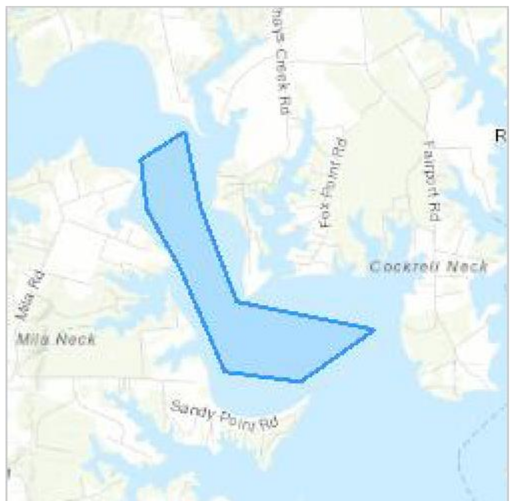
Virginia Ecological Services Field Office
6669 Short Lane
Gloucester, VA 23061-4410
(804) 693-6694

Project Summary

Project Code: 2022-0070092
Project Name: Great Wicomico Oyster Reef Enhancements
Project Type: Modification Stream or Waterbody
Project Description: Upgrading of various low relief oyster reefs to high relief, expansion of reef 16, placement of anti-poaching stones over entire reef network.

Project Location:

Approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@37.835207499999996,-76.32046622114572,14z



Counties: Northumberland County, Virginia

Endangered Species Act Species

There is a total of 3 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

Mammals

NAME	STATUS
Northern Long-eared Bat *Myotis septentrionalis* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9045	Threatened

Insects

NAME	STATUS
Monarch Butterfly *Danaus plexippus* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9743	Candidate
Northeastern Beach Tiger Beetle *Habroscelimorpha dorsalis dorsalis* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/8105	Threatened

Critical habitats

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

USFWS National Wildlife Refuge Lands And Fish Hatcheries

Any activity proposed on lands managed by the National Wildlife Refuge system must undergo a 'Compatibility Determination' conducted by the Refuge. Please contact the individual Refuges to discuss any questions or concerns.

THERE ARE NO REFUGE LANDS OR FISH HATCHERIES WITHIN YOUR PROJECT AREA.

Migratory Birds

Certain birds are protected under the Migratory Bird Treaty Act[1] and the Bald and Golden Eagle Protection Act[2].

Any person or organization who plans or conducts activities that may result in impacts to migratory birds, eagles, and their habitats should follow appropriate regulations and consider implementing appropriate conservation measures, as described below.

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1. The Migratory Birds Treaty Act of 1918.
2. The Bald and Golden Eagle Protection Act of 1940.
3. 50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)

The birds listed below are birds of particular concern either because they occur on the USFWS Birds of Conservation Concern (BCC) list or warrant special attention in your project location. To learn more about the levels of concern for birds on your list and how this list is generated, see the FAQ below. This is not a list of every bird you may find in this location, nor a guarantee that every bird on this list will be found in your project area. To see exact locations of where birders and the general public have sighted birds in and around your project area, visit the E-bird data mapping tool (Tip: enter your location, desired date range and a species on your list). For projects that occur off the Atlantic Coast, additional maps and models detailing the relative occurrence and abundance of bird species on your list are available. Links to additional information about Atlantic Coast birds, and other important information about your migratory bird list, including how to properly interpret and use your migratory bird report, can be found below.

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to migratory birds on your list, click on the PROBABILITY OF PRESENCE SUMMARY at the top of your list to see when these birds are most likely to be present and breeding in your project area.

NAME	BREEDING SEASON
American Oystercatcher *Haematopus palliatus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/8935	Breeds Apr 15 to Aug 31
Bald Eagle *Haliaeetus leucocephalus* This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities. https://ecos.fws.gov/ecp/species/1626	Breeds Oct 15 to Aug 31

NAME	BREEDING SEASON
Black Skimmer *Rynchops niger* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/5234	Breeds May 20 to Sep 15
Chimney Swift *Chaetura pelagica* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds Mar 15 to Aug 25
Kentucky Warbler *Oporornis formosus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds Apr 20 to Aug 20
Lesser Yellowlegs *Tringa flavipes* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9679	Breeds elsewhere
Prairie Warbler *Dendroica discolor* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds May 1 to Jul 31
Red-headed Woodpecker *Melanerpes erythrocephalus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds May 10 to Sep 10
Short-billed Dowitcher *Limnodromus griseus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9480	Breeds elsewhere
Willet *Tringa semipalmata* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds Apr 20 to Aug 5
Wood Thrush *Hylocichla mustelina* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds May 10 to Aug 31

Probability Of Presence Summary

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds. Please make sure you read and understand the FAQ "Proper Interpretation and Use of Your Migratory Bird Report" before using or attempting to interpret this report.

Probability of Presence (■)

Each green bar represents the bird's relative probability of presence in the 10km grid cell(s) your project overlaps during a particular week of the year. (A year is represented as 12 4-week months.) A taller bar indicates a higher probability of species presence. The survey effort (see below) can be used to establish a level of confidence in the presence score. One can have higher confidence in the presence score if the corresponding survey effort is also high.

How is the probability of presence score calculated? The calculation is done in three steps:

1. The probability of presence for each week is calculated as the number of survey events in the week where the species was detected divided by the total number of survey events for that week. For example, if in week 12 there were 20 survey events and the Spotted Towhee was found in 5 of them, the probability of presence of the Spotted Towhee in week 12 is 0.25.
2. To properly present the pattern of presence across the year, the relative probability of presence is calculated. This is the probability of presence divided by the maximum probability of presence across all weeks. For example, imagine the probability of presence in week 20 for the Spotted Towhee is 0.05, and that the probability of presence at week 12 (0.25) is the maximum of any week of the year. The relative probability of presence on week 12 is 0.25/0.25 = 1; at week 20 it is 0.05/0.25 = 0.2.
3. The relative probability of presence calculated in the previous step undergoes a statistical conversion so that all possible values fall between 0 and 10, inclusive. This is the probability of presence score.

Breeding Season (■)
Yellow bars denote a very liberal estimate of the time-frame inside which the bird breeds across its entire range. If there are no yellow bars shown for a bird, it does not breed in your project area.

Survey Effort (|)
Vertical black lines superimposed on probability of presence bars indicate the number of surveys performed for that species in the 10km grid cell(s) your project area overlaps. The number of surveys is expressed as a range, for example, 33 to 64 surveys.

No Data (–)

A week is marked as having no data if there were no survey events for that week.

Survey Timeframe
Surveys from only the last 10 years are used in order to ensure delivery of currently relevant information. The exception to this is areas off the Atlantic coast, where bird returns are based on all years of available data, since data in these areas is currently much more sparse.

■ probability of presence ■ breeding season | survey effort _ no data

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

Additional information can be found using the following links:

- Birds of Conservation Concern https://www.fws.gov/program/migratory-birds/species
- Measures for avoiding and minimizing impacts to birds https://www.fws.gov/library/collections/avoiding-and-minimizing-incidental-take-migratory-birds

- Nationwide conservation measures for birds https://www.fws.gov/sites/default/files/documents/nationwide-standard-conservation-measures.pdf

Migratory Birds FAQ

Tell me more about conservation measures I can implement to avoid or minimize impacts to migratory birds.

Nationwide Conservation Measures describes measures that can help avoid and minimize impacts to all birds at any location year round. Implementation of these measures is particularly important when birds are most likely to occur in the project area. When birds may be breeding in the area, identifying the locations of any active nests and avoiding their destruction is a very helpful impact minimization measure. To see when birds are most likely to occur and be breeding in your project area, view the Probability of Presence Summary. Additional measures or permits may be advisable depending on the type of activity you are conducting and the type of infrastructure or bird species present on your project site.

What does IPaC use to generate the list of migratory birds that potentially occur in my specified location?

The Migratory Bird Resource List is comprised of USFWS Birds of Conservation Concern (BCC) and other species that may warrant special attention in your project location.

The migratory bird list generated for your project is derived from data provided by the Avian Knowledge Network (AKN). The AKN data is based on a growing collection of survey, banding, and citizen science datasets and is queried and filtered to return a list of those birds reported as occurring in the 10km grid cell(s) which your project intersects, and that have been identified as warranting special attention because they are a BCC species in that area, an eagle (Eagle Act requirements may apply), or a species that has a particular vulnerability to offshore activities or development.

Again, the Migratory Bird Resource list includes only a subset of birds that may occur in your project area. It is not representative of all birds that may occur in your project area. To get a list of all birds potentially present in your project area, please visit the Rapid Avian Information Locator (RAIL) Tool.

What does IPaC use to generate the probability of presence graphs for the migratory birds potentially occurring in my specified location?

The probability of presence graphs associated with your migratory bird list are based on data provided by the Avian Knowledge Network (AKN). This data is derived from a growing collection of survey, banding, and citizen science datasets.

Probability of presence data is continuously being updated as new and better information becomes available. To learn more about how the probability of presence graphs are produced and how to interpret them, go the Probability of Presence Summary and then click on the "Tell me about these graphs" link.

How do I know if a bird is breeding, wintering or migrating in my area?

To see what part of a particular bird's range your project area falls within (i.e. breeding, wintering, migrating or year-round), you may query your location using the RAIL Tool and look at the range maps provided for birds in your area at the bottom of the profiles provided for each bird in your results. If a bird on your migratory bird species list has a breeding season associated with it, if that bird does occur in your project area, there may be nests present at some point within the timeframe specified. If "Breeds elsewhere" is indicated, then the bird likely does not breed in your project area.

What are the levels of concern for migratory birds?

Migratory birds delivered through IPaC fall into the following distinct categories of concern:

1. "BCC Rangewide" birds are Birds of Conservation Concern (BCC) that are of concern throughout their range anywhere within the USA (including Hawaii, the Pacific Islands, Puerto Rico, and the Virgin Islands);
2. "BCC - BCR" birds are BCCs that are of concern only in particular Bird Conservation Regions (BCRs) in the continental USA; and
3. "Non-BCC - Vulnerable" birds are not BCC species in your project area, but appear on your list either because of the Eagle Act requirements (for eagles) or (for non-eagles) potential susceptibilities in offshore areas from certain types of development or activities (e.g. offshore energy development or longline fishing).

Although it is important to try to avoid and minimize impacts to all birds, efforts should be made, in particular, to avoid and minimize impacts to the birds on this list, especially eagles and BCC species of rangewide concern. For more information on conservation measures you can implement to help avoid and minimize migratory bird impacts and requirements for eagles, please see the FAQs for these topics.

Details about birds that are potentially affected by offshore projects
For additional details about the relative occurrence and abundance of both individual bird species and groups of bird species within your project area off the Atlantic Coast, please visit the Northeast Ocean Data Portal. The Portal also offers data and information about other taxa besides birds that may be helpful to you in your project review. Alternately, you may download the bird model results files underlying the portal maps through the NOAA NCCOS Integrative Statistical Modeling and Predictive Mapping of Marine Bird Distributions and Abundance on the Atlantic Outer Continental Shelf project webpage.

Bird tracking data can also provide additional details about occurrence and habitat use throughout the year, including migration. Models relying on survey data may not include this information. For additional information on marine bird tracking data, see the Diving Bird Study and the nanotag studies or contact Caleb Spiegel or Pam Loring.

What if I have eagles on my list?
If your project has the potential to disturb or kill eagles, you may need to obtain a permit to avoid violating the Eagle Act should such impacts occur.

Proper Interpretation and Use of Your Migratory Bird Report
The migratory bird list generated is not a list of all birds in your project area, only a subset of birds of priority concern. To learn more about how your list is generated, and see options for identifying what other birds may be in your project area, please see the FAQ "What does IPaC use to generate the migratory birds potentially occurring in my specified location". Please be aware this report provides the "probability of presence" of birds within the 10 km grid cell(s) that overlap your project; not your exact project footprint. On the graphs provided, please also look carefully at the survey effort (indicated by the black vertical bar) and for the existence of the "no data" indicator (a red horizontal bar). A high survey effort is the key component. If the survey effort is high, then the probability of presence score can be viewed as more dependable. In contrast, a low survey effort bar or no data bar means a lack of data and, therefore, a lack of

certainty about presence of the species. This list is not perfect; it is simply a starting point for identifying what birds of concern have the potential to be in your project area, when they might be there, and if they might be breeding (which means nests might be present). The list helps you know what to look for to confirm presence, and helps guide you in knowing when to implement conservation measures to avoid or minimize potential impacts from your project activities, should presence be confirmed. To learn more about conservation measures, visit the FAQ "Tell me about conservation measures I can implement to avoid or minimize impacts to migratory birds" at the bottom of your migratory bird trust resources page.

IPaC User Contact Information

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Phone: 7572017007

DRAFT SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT

ENVIRONMENTAL APPENDIX

EFH ASSESSMENT

CHESAPEAKE BAY OYSTER RESTORATION

GREAT WICOMICO RIVER, VIRGINIA

U.S. Army Corps of Engineers
Norfolk District
803 Front Street
Norfolk, Virginia 23510-1096

ENVIRONMENTAL APPENDIX

CHESAPEAKE BAY OYSTER RESTORATION PROGRAM, GREAT WICOMICO RIVER SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT, VIRGINIA

SUPPLEMENTAL ESSENTIAL FISH HABITAT ASSESSMENT

JANUARY 2023

US Army Corps of Engineers ®

VIRGINIA MARINE RESOURCES COMMISSION

Submitted To:

National Oceanographic and Atmospheric Administration National Marine Fisheries Service

Greater Atlantic Field Office

U.S. Army Corps of Engineers Norfolk District

803 Front Street

Norfolk, Virginia 23510

Table of Contents

1.0 INTRODUCTION

The purpose of this document is to present the findings of the Essential Fish Habitat (EFH) assessment conducted for the proposed rehabilitation and additional construction in the Great Wicomico River and any associated adaptive management, as required by the Magnuson-Stevens Fishery Conservation and Management Act of 1976 (Magnuson-Stevens Act), as amended through 1996 (MSA). The Great Wicomico restored oyster reefs Project consists of eight distinct reefs covering 85 acres. A mix of high (≥ 12") and low (2-4") relief reefs were built as a field experiment to determine the most effective construction methods. All of these reefs were built out of dredged "fossil" oyster shell from formerly productive oyster reefs long covered by sediment and abandoned. The objectives of this EFH Assessment are to describe in detail how the actions of rehabilitation and an expansion of the most downriver reef may affect EFH, federally managed species and their prey, designated by the National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA Fisheries) and the regional Fisheries Management Council (FMC) for the Region of Influence (ROI) of the project. The FMC, with assistance from NOAA Fisheries, is required to delineate EFH in fisheries management plans for all federally managed fisheries to conserve and enhance those habitats. The EFH is defined in the MSA as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity."

2.0 PURPOSE, AND NEED

The purpose of the SEA associated with this EFH assessment is to consider modifications of an oyster reef restoration project first constructed in the Great Wicomico River in 2004. High and low-relief reefs were constructed, and since monitoring began in 2006, the high-relief reefs have consistently, significantly out-performed the low-relief reefs. The furthest downriver reef site (reef 16) has consistently been the best performing reef in the river system. Further, several low-relief reef areas were scraped of live oysters and most of the shell used to construct them during a prior modification of the reefs in 2015 and have little shell or live oysters on them at present. Poaching, which removes oysters and damages the reefs, has been documented on many of the restored reefs and continues to this day.

There is a need to improve the function of several areas of low-relief reef and to protect the reef system from poaching. Reef 16 can be expanded, as it currently occupies only a small portion of the public ground it is located in. All of these actions would significantly improve the reef sanctuary network, ensuring their long-term sustainability and maintaining the Great Wicomico River's status as "fully restored" as defined by the Chesapeake Bay Program's Goal Implementation Team (GIT). This goal is to restore at least 50% of currently restorable oyster habitat in a given tributary river. This goal is in agreement with the restoration goals based on the scale of the waterbody restoration was to be done in the USACE Oyster Restoration Master Plan (USACE 2012).

3.0 PROJECT SCOPE

The Action Alternative will address these problems and consists of the following:

- Placing 60 stones/acre over all reef surfaces. Stones will be class II granite riprap, averaging 20-22" in size. This is for habitat enhancement and an anti-poaching measure.
- Building up low-relief reef areas on reefs 1-2, 8, and 9 to a height of 12-18" by adding small stone (3-6") and/or shell on top of present reef footprints. All live oysters will be moved (if

found at densities greater than 10/m2 and placed on other sanctuary reefs prior to construction.

- Expand the footprint of Reef 16 by building along the eastern end of it. The new reef area will be approximately 14 acres in size and constructed of small stone (3-6”), or shells if available.

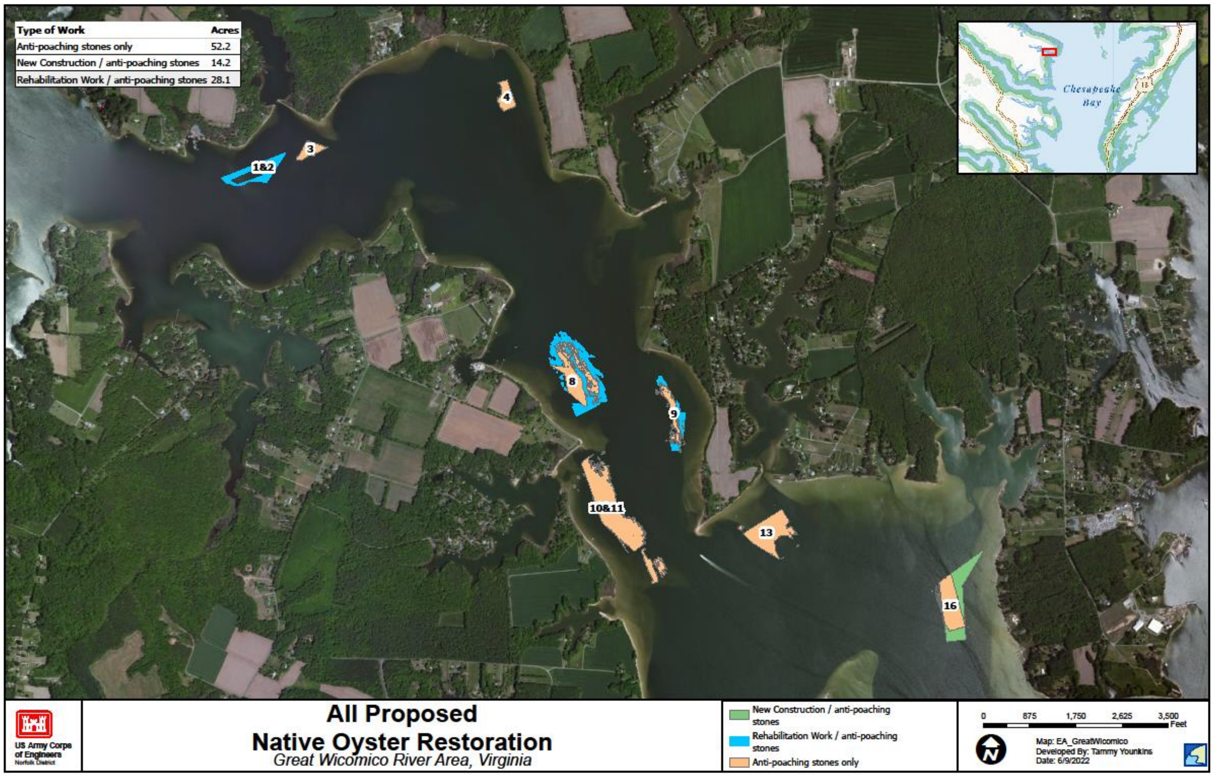

Figure 1. Location of the oyster reefs in the Great Wicomico River that is the subject of this Supplemental Essential Fish Habitat Assessment.

4.0 Current Reef Conditions

For an assessment of current reef conditions, please see the attached monitoring report (Lipcius et al 2022).

5.0 Project Schedule

The proposed modifications to the reefs would occur in 2023.

In general, construction operations will occur during normal business hours to reduce noise disruptions. It is expected that a mechanical bucket and associated support craft such as barges and tugs, will be on site to do the proposed reef enhancements. Construction is estimated to take approximately two months.

6.0 Region of Influence/Action Area

The ROI or Action Area is defined as those areas to be impacted directly or indirectly by the federal action and not merely the immediate area involved in the action. The ROI or Action Area consists of the areas where construction would occur and surrounding waters of the Great Wicomico River.

7.0 ESSENTIAL FISH HABITAT AND MANAGED SPECIES

The 1996 amendments to the Magnuson-Stevens Act set forth a mandate for NOAA Fisheries Service, regional Fisheries Management Councils (FMC), and other Federal agencies to identify and protect EFH of economically important marine and estuarine fisheries. To achieve this goal, suitable fish habitats need to be maintained.

Essential Fish Habitats in the Action Area were identified by utilizing the EFH Fish Habitat Mapper – available at https://www.fisheries.noaa.gov/resource/map/essential-fish-habitat-mapper (assessed 14 July 2022). A total of 11 federally managed species with EFH designations have been identified in the project area, one species as critical habitat (HAPC) in the area.

Table 1. Species with Essential Fish Habitat/HAPC in the local area.

Species/Management Unit	**Lifestage(s) Found at Location and HAPC status**	**Management Council**	**FMP**
Little Skate	Adult	New England	Amendment 2 to the Northeast Skate Complex FMP
Winter Skate	Adult	New England	Amendment 2 to the Northeast Skate Complex FMP
Red Hake	Adult/Eggs/ Larvae/Juvenile	New England	Amendment 14 to the Northeast Multispecies FMP
Windowpane Flounder	Adult/Juvenile	New England	Amendment 14 to the Northeast Multispecies FMP
Clearnose Skate	Adult/Juvenile	New England	Amendment 2 to the Northeast Skate Complex FMP
Atlantic Herring	Adult/Juvenile	New England	Amendment 2 to the Northeast Skate Complex FMP
Bluefish	Adult/Juvenile	Mid-Atlantic	Bluefish
Atlantic Butterfish	Adult/Eggs/Larvae	Mid-Atlantic	Atlantic Mackerel, Squid & Butterfish Amendment 11
Scup	Adult/Juvenile	Mid-Atlantic	Summer Flounder, Scup, Black Sea Bass
Black Sea Bass	Adult/Juvenile	Mid-Atlantic	Summer Flounder, Scup, Black Sea Bass
Summer Flounder	Adult/Juvenile/HAPC	Mid-Atlantic	Summer Flounder, Scup, Black Sea Bass

8.1 Water column

The water column is the medium which connects all aquatic habitats and can act as a corridor between differing essential habitats for managed species. Many managed species rely on different portions of the water column for different life stages. The Preferred Alternative for the Great Wicomico oyster reef rehabilitation and enhancement, the Action Alternative, will consist of actions in the water column that may affect surface, pelagic, and benthic EFH.

8.2 Surface Waters

Surface waters are all waters naturally open to the atmosphere; this includes seas and estuaries. Oceanic and estuarine surface waters are subject to frequent shifts in wind direction and speed, temperature, and salinity. This EFH is generally used by the egg and larval life stages of many fish species, and surface currents aid in the distribution of planktonic fishes throughout a given habitat range. This EFH occurs in the ROI, as dredge vessels transiting to and from dredging locations must move through both estuarine and marine surface waters.

Managed species with EFH in surface waters of the ROI include the egg and/or larval life stages for red hake and Atlantic butterfish. Other species only include adults and juveniles in the project ROI.

8.3 Pelagic Waters

Pelagic waters for EFH refers to habitat and associated managed species in the water column as opposed to the sea floor; this EFH generally occurs anywhere from the surface to 1,000 meters. Pelagic waters make up the habitat located between surface and benthic waters, and its variable depths and temperatures provide habitat for the vast majority of both estuarine and marine managed fish species. The egg, larval, juvenile and adult life stages for numerous managed species occur in pelagic waters. In the ROI, managed species with EFH in pelagic waters include, all species listed in Table 1.

8.4 Benthic Waters

Benthic waters provide EFH for managed demersal species. Demersal species are those fishes living in close relation with the bottom and depending on it. Cods, groupers, crabs, and lobsters are demersal resources. Managed species with EFH for one or more life stage in benthic waters include, but are not limited to, Atlantic herring, red hake, summer flounder, windowpane flounder, winter flounder, scup, winter skate, clearnose skate and little skate.

The composition of benthic substrates affect EFH for managed species. Within the action area, sand, both coarse and silty, along with oyster reefs are the most commonly occurring benthic substrates within the local area, with the exception of the expansion of reef 16, all construction will occur on present shell reef habitat. The bottom at the reef 16 expansion is sparse shell with mostly hard silty sand bottom with clay.

8.5 Wetlands

Wetlands are defined by the Clean Water Act regulations as, “those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (USEPA 2016). Estuary environments can be altered with the combined stress of inundation, desiccation, and changes in salinity. These conditions limit the types of vegetation that can survive within the ROI, and the plant communities within this dynamic ecosystem have evolved the capacity to thrive in the ever-changing environment.

Wetlands are resources that combine shallow water, high levels of nutrients, and primary productivity, which is ideal for the development of organisms that form the base of the food web and provide foraging sites for fish, amphibians, shellfish and insects. Dead plant leaves and stems break down in the water to form detritus, which feeds many small aquatic insects, shellfish and small fish that are food for larger predatory fish, reptiles, amphibians, birds and mammals. Many species of birds and mammals rely on wetlands for food, water, and shelter, especially during migration and breeding.

The Preferred Alternative will not result in any impacts to jurisdictional wetlands, therefore this EFH is not further evaluated in the document.

9.0 MANAGED FISH SPECIES

The seasonal and year-round locations of the designated EFH for the managed fisheries are described below. The EFH determination is based on species distribution and habitat range and, where possible, abundance. Species covered under the prior (2003) EFH assessment will not be re-assessed here, to consult their information and findings, please see the prior EFH assessment that is an appendix to the original (2003) study and EA.

9.1 Atlantic Butterfish (*Peprilus tricanthus*)

Essential fish habitat for two life stages (juvenile, and adult) of the Atlantic butterfish occurs in the project area. Pelagic waters over the continental shelf are essential habitat for this species, and each life stage has a depth preference. Butterfish eggs are found from near-shore waters to depths of 600 feet, the larvae are collected in depths between 33 and 6,000 feet, while juveniles and adults are found between 33 and 1,200 feet. Preferred water temperature for each life stage also varies. Eggs have been found at water temperatures between 11° and 17°C; larval butterfish are found in temperatures varying from about 9°to 19°C. Juvenile and adult fish are generally found at temperatures between 3°and 28°C (NMFS 2014). Juvenile and adult butterfish are pelagic and overwinter along the 100 fathom contour of the continental shelf from late autumn through early spring. The diet of the Atlantic butterfish is largely composed of plankton. Both juveniles and adults are common in the high salinity and mixing zones of estuaries from Massachusetts Bay to the Mid-Atlantic during warmer months.

Indirect impacts are those resulting from the temporary loss of forage organisms and/or forage habitat and the alteration of existing habitat related to the rehabilitation of various reefs and the expansion of reef 16. Because Atlantic butterfish juveniles feed primarily on ctenophores and macro-zooplankton and adults on mollusks, the potential indirect impacts associated with the loss of forage species are minimal as other habitat outside of the immediate construction area is available for foraging and the construction area will recover quickly.

Cumulative impacts are also expected to be negligible because of the species' mobility and available habitat throughout the Great Wicomico River, and the proposed work will enhance the prey availability for this species, a positive benefit. Therefore, no more than minimal direct impacts on Atlantic butterfish EFH are anticipated as a result of the proposed project.

9.2 Atlantic Herring (*Clupea harengus*)

EFH has been identified within the Great Wicomico River for the juvenile and adult life stages of Atlantic herring. Atlantic herring is a pelagic species that is only seasonally abundant within the project area. Potential impacts to EFH will therefore be limited to the late winter and spring (February through May), when migrating juveniles and adults are common to the estuary.

Because juveniles and adults are pelagic, potential direct impacts to Atlantic herring EFH will be limited to temporary disturbances within the water column such as placement of stone and/or shell on the reefs. These impacts are localized and may include increased turbidity by settling sediments within the water column.

Since this species feeds within the water column, turbidity resulting from construction activities may have some short-term impact on feeding success in the immediate construction area, as no significant sediment plumes are expected due to the nature of the construction, which is the placement of clean material over present reef footprints with the exception of the expansion at reef 16. However, the exposed individuals are likely to move to adjacent waters where feeding will be less problematic during dredging operations.

These impacts will be further minimized whenever possible through BMPs as well as through seasonal restrictions for anadromous fish, as recommended.

Indirect impacts are those resulting from the temporary loss of forage organisms and/or forage habitat during construction. Because Atlantic herring are planktivorous and feed primarily on zooplankton, the indirect impacts associated with the loss of forage species are expected to be minimal as there is other viable habitat and food sources available outside of the construction area, which is small relative to the entire River.

Cumulative impacts are also expected to be negligible because of the species' mobility and the availability of other EFH throughout the River, as well as the short duration of construction. Therefore, no more than minimal direct, indirect and cumulative impacts on Atlantic herring EFH are anticipated as a result of the proposed expansion and deepening of Gravesend Anchorage.

9.3 Bluefish (*Pomatomus saltatrix*)

The proposed dredging site occurs within an area designated as EFH for juvenile and adult life stages of bluefish. Adults and juveniles may be found in the action area of the proposed construction. This species is the sole representative of the family Pomatomidae and is closely related to jacks, pompanos, and roosterfish (USACE 2014). Bluefish inhabit the continental shelf waters of temperate zones and is commonly found in large bays and estuaries. Generally, juvenile bluefish occur in Mid- Atlantic estuaries from May through September in the local project area; adults enter estuaries beginning in April (NMFS 2014). Both adults and juveniles are opportunistic feeders and will forage on available food. The adults and juveniles prefer warm water temperatures (above 14 - 16°C) and migrate south of Cape Hatteras in the winter months. Juveniles are generally found in salinities ranging from 23 to 33 ppt but can tolerate salinities as low as 3 ppt. Adults generally prefer salinities greater than 25 ppt. Bluefish eggs are generally found in the open ocean at temperatures ranging from 18° to 22°C and salinities greater than 31 ppt. Larvae are most often found at the edge of the continental shelf in waters ranging from 18° to 24°C and salinities from 30 to 32 ppt (Fahay et al. 1999).

The seasonal occurrence and pelagic behavior of bluefish greatly limits any potential impacts due to the proposed construction in the Great Wicomico River, oyster reefs are not typically constructed during the late spring-summer timeframe. Impacts to bluefish will not be significant. Therefore, only minor, temporary and adverse impacts are expected on local bluefish. No significant direct, indirect and cumulative impacts to bluefish EFH are anticipated as a result of the proposed construction.

9.4 Clearnose Skate (*Raja eglanteria*)

The proposed action occurs within an area designated as EFH for the juvenile and adult life stages of the clearnose skate. This is a small species, with lengths averaging between 49 and 60 centimeters, and is characterized by the translucent tissue on either side of the rostrum (Fitz and Daiber 1963; Smith 1997). The dorsal surface of the clearnose skate is tan to dark brown with darker spots and bars and has medially located boney spines that extend the length of the tail (Smith 1997). EFH for juvenile and adult life stages of this species is found across much of the Atlantic seaboard, ranging from the Gulf of Maine to the Cape Hatteras, North Carolina (NMFS 2017b). Juvenile clearnose skates are found from near-shore waters to depths approximately 500 meters, while adults are found from near-shore waters to approximately 400 meters in depth (NMFS 2017b). Both the juvenile and adult life stages are found at temperatures between 9 and 30°C, though, in more southern areas of their range, optimal temperatures for clearnose skates are between 19° and 30°C (NMFS 2017b). Both juveniles and adults are found in areas with either soft or gravel substrate. The preferred diet of the clearnose skate consists of crustaceans, bivalves, polychaetes, squids, and fishes (Stehmann and McEachran 1978).

Potential indirect impacts to clearnose skate EFH are related to impacts to benthic prey resources. These indirect impacts are temporary and limited to the area of bottom disturbance during construction. Post construction this species will benefit significantly from enhanced prey availability. The potential loss of prey resources within the construction area may induce individual skates to relocate to alternative foraging areas. Given the limited extent of the impact area and the low abundance of clearnose skates in the project area, no direct, long-term, indirect impacts or cumulative impacts are anticipated as a result of the proposed construction.

9.5 Little Skate (*Raja erinacea*)

The proposed action occurs within an area designated as EFH for the juvenile and adult life stages for the little skate. This is a small species, with average adult lengths ranging from 32 to 43 centimeters, and is typically light brown with darker spots on the ventral surface (Richard et al. 1963). This species is oviparous, meaning females lay eggs. EFH for the egg life stage ranges from Georges Bank to the Mid-Atlantic Bight, while EFH for juvenile and adult life stages range from Georges Bank to Cape Hatteras, North Carolina (NMFS 2017c). Little skate eggs are generally found at depths less than 27 meters, while juveniles and adults can be found from near-shore waters to depths of 137 meters (NMFS). Eggs are generally found in water greater than 7°C, while juveniles prefer water between 4° and 15°C, and adults can tolerate temperatures from 2° to 15°C (NMFS 2017c).

Little skates prefer benthic substrates composed primarily of sand or gravel, where they can effectively forage on benthic prey species. Their diet is largely composed of benthic organisms, including crabs, shrimp, polychaetes, sea squirts, and mollusks, though little skates are also known to consume squid and bony fishes (Murdy et al. 1997).

Little skate do not typically feed on oyster reefs, preferring sand or gravel bottoms. The expansion of reef 16 will reduce sand habitat in the river, however, the proposed expansion will return this current sand bottom area back to its original oyster reef bottom. Outside of the reefs, most of the bottom in the Great Wicomico River is sandy, so no significant impacts to the little skate are expected. The reefs could provide increased prey items for the skate when they move off the reefs or along the edges of reefs, which could benefit the skate.

9.6 Red Hake (*Urophycis chuss*)

The action is located within areas designated as EFH for the egg, larval, and juvenile, and adult life stages of red hake. Red hake are relatively short-lived, demersal gadoid species that inhabit the Atlantic coastline from southern Newfoundland, Canada (Gulf of St. Lawrence) to North Carolina (Steimle et al. 1999a). The life span of red hake is typically eight years with a maximum of 14 years. A typical red hake grows to about 50 centimeters long with a maximum of 63 centimeters in length. Both sexes reach maturity by two years of age, with southern populations maturing earlier.

The preferred substrate for red hake is loose mud or soft sand. They feed on a variety of benthic species, including crustaceans, invertebrates, squid, crabs, and other fish species (Smith and Link 2010; Steimle et al. 1999a). Their diet changes seasonally depending on food availability.

Red hake seasonally migrate from cold, offshore deep waters (below 100 meters) to warmer, shallow waters to spawn. In the spring and summer months, red hake are commonly found in the top 100 meters of the water column as they migrate onshore towards their spawning grounds (Steimle et al. 1999a). In the winter months, red hake can be found in deeper waters, below 100 meters, along the edge of the continental shelf.

Spawning occurs along the continental shelf between May and November in southern New England and in the Georges Bank area (Traver and Col 2006), and peak spawning occurs from May through June. Because they spawn offshore, no direct impacts are expected to red hake egg and larvae EFH. Spawning occurs at water temperatures between 5° and 10°C. Eggs and larval red hake are planktonic and very buoyant. Larvae remain planktonic for one to two months until they descend to the benthos. Juvenile red hake have a commensal relationship with sea scallops (Placopecten magellanicus); juveniles use the scallops for shelter and take refuge in and amongst the shells (Steiner et al. 1982). It is unlikely that juvenile red hake would be found in the local waters of the ROI, and no impacts are expected to this life stage.

Potential direct impacts to adult EFH are limited to the short-term disruption of bottom habitat during construction, but these impacts should be negligible due to the habitat preference of this species. Any potential impact is seasonally limited during juvenile and adult inshore migrations.

Potential indirect impacts to red hake EFH will be limited to the disturbance and temporary loss of benthic species included in the juvenile and adult diets. Indirect impacts to EFH, however, would be short-term and very limited due to the construction not taking place on their preferred habitat.

Cumulative impacts are expected to be minimal because red hake eggs and larvae are pelagic and juveniles and adults typically forage in shallower waters with soft to sand bottom, not reef habitat.

9.7 Winter Skate

The ROI is located within EFH for the juvenile, and adult life stages of the winter skate. Essential habitat for the juvenile and adult life stages occurs in the lower Great Wicomico River including waters of the project area. This species of skate generally ranges in size from 73 to 76 centimeters but have been documented to reach sizes up to 110 centimeters total length (Robins and Ray 1986). The coloration of the dorsal surface of the winter skate is light tan to brown with numerous dark spots. Their diet is composed of benthic species such as dollarfish, as well as other fishes and squid. The range for the juvenile and adult life stages extends from Cape Cod Bay on Georges Bank to North Carolina (NMFS 2017d). The juvenile life stage is found from the shoreline to a depth of approximately 400 meters but are most abundant at depths less than 111 meters (NMFS 2017d). Juveniles tolerate temperatures ranging from -1.2° to 21˚C but prefer water between 4° and 16°C (NMFS 2017d). The adult life stage is found from shoreline to a depth of 371 meters but are most commonly found at depths less than 111 meters; adults are found water from -1.2° to 20°C with greater abundance from 5° to 15°C(NMFS 2017d).

Currently, no data is available with regard to habitat associations or the distribution of the egg life stage for this species.

Minimal direct impacts are anticipated as a result of the proposed construction. Prey will be temporarily unavailable during construction but there is extensive reef habitat throughout the River that can be used. Post construction, the increased benthic habitat quality will be a positive impact on this species. Potential indirect impacts to winter skate EFH are related to direct impacts to benthic prey resources. These indirect impacts are temporary and limited to the area of bottom disturbance. The potential loss of prey resources within the construction area during construction may induce individual skates to relocate to alternative foraging areas. Given the limited extent of the impact area and the relatively low abundance of winter skates in the project area, no direct, long-term indirect or cumulative negative impacts are anticipated as a result of the proposed construction.

9.8 Summer Flounder

The proposed project area occurs within EFH for the egg, larval, juvenile, and adult stages of summer flounder. The eggs of summer flounder are commonly found at depths ranging from 10 to 70 meters, depending on the season, and are most abundant within 45 km of shore off the coast of Chesapeake Bay. The juveniles prefer a sandy/mixed substrate over a mud/silt substrate. Juvenile and Adult densities were highest in the late spring. Adults are most commonly found in sandy substrates but are also present in a variety of substrates with both mud and sand, including marsh creeks, seagrass beds, and sand flats. The summer flounder’s optimal salinity range is between 10 and 30 ppt.

In general, summer flounder larvae are most abundant nearshore (12 - 50 miles from shore) at depths between 9 and 70 meters. They are most frequently found in the southern part of the Mid-Atlantic Bight from November to May. Juveniles inhabit estuarine habitats, including salt marsh creeks, seagrass beds, mudflats, and open bay areas, which are used as nursery areas. Juveniles prefer water temperatures greater than 3°C. Adult flounder are found in shallow coastal and estuarine waters during warmer months and move offshore to the outer continental shelf at depths of about 152 meters during the colder months (NMFS 2014). Fall migration of flounder out of the Chesapeake Bay begins in October.

Burying behavior of summer flounder is affected by substrate type, water temperature, tides, salinity concentrations, and the presence or absence of prey species; while they do not tend to seek cover in vegetated areas, there is an “edge effect” in which flounder bury themselves close to vegetation and reef structure to ambush prey. This species is a bottom-dwelling predator, relying on its flattened body, agility, sharp teeth, and ability to change color and pattern on its dorsal surface. Small fishes, squid, worms, shrimp, and other crustaceans make up the bulk of the summer flounder’s diet. Summer flounder can live up to 20 years with females living longer and growing larger than males (up to 95 centimeters total length) (USACE 2014).

Potential direct impacts to summer flounder EFH from the project include the temporary disruption and direct loss of summer flounder habitat. However, the reefs are not their preferred habitat so these impacts are minimal, temporary and not significant to summer flounder EFH. There is extensive SAV and reef edge habitat outside of proposed construction to accommodate the local population while construction is occurring.

Potential indirect impacts to summer flounder EFH include the slight, temporary increase in turbidity associated with the placement of even clean material. These impacts are minimal, temporary and not significant to summer flounder EFH.

Potential cumulative impacts, including both direct and indirect are expected to be negligible, as little additional bottom modification is expected. The reefs will provide additional prey items for foraging summer flounder, a positive benefit.

10.0 PREY SPECIES

10.1 Benthic Invertebrates

The typical Chesapeake Bay ecosystem includes benthic communities of epifauna (organisms that live attached to surfaces on the Bay bottom), such as oysters, sponges, sea squirts, seas stars, and barnacles. Infauna are benthic animals that burrow into bottom sediments like worms, clams, and other tunneling organisms.

Benthic communities have varied roles in the Bay ecosystem. Filter feeders such as clams, oysters, and sponges clarify and clean the waters of the Bay through their biological processes that remove particulate matter and potentially toxic materials, providing for a healthy marine environment. As primary and secondary consumers, these organisms pass the energy of primary producers (phytoplankton) to higher levels of the food web. Many benthic species are food sources for managed species and their prey.

10.2 Atlantic menhaden (*Brevoortia tyrannus*)

Atlantic menhaden are a pelagic, obligate filter-feeding species found along the Atlantic seaboard from Nova Scotia to Jupiter Inlet, Florida. Menhaden are a commercially important resource in Chesapeake Bay (Wenner and Sedberry 1989). Menhaden feed primarily on phytoplankton and small crustaceans (Lewis and Peters 1994). Atlantic menhaden are seasonally abundant in the Chesapeake Bay region, there is a reduction fishery still operating in the lower Bay and associated offshore waters.

Atlantic menhaden spawn in the ocean from March to May and again in September and October. Their eggs are demersal and usually hatch within 48 hours. Larvae migrate from the ocean to the upper portions of the estuary during the spring months. Juveniles typically migrate to sea in the fall after spending their first year in the estuary. Large numbers of menhaden may congregate along shoaled areas in coastal bays and estuaries in the summer and move to deeper ocean waters as the temperatures cool.

10.3 Bay Anchovy (*Anchoa mitchilli*)

The bay anchovy is a year-round resident species found in all parts of the Chesapeake Bay and its tributaries. The bay anchovy is typically found near the surface in open water habitats (Orth and Heck 1980). Within Chesapeake Bay, the bay anchovy is one of the most abundant fish species, providing an important food base for many piscivorous species.

Spawning occurs over a wide salinity range, with peak spawning at 13 - 15 ppt. The spawning season is approximately from May to August (Monteleone 1992). The eggs are demersal. This species moves to deeper waters off Chesapeake Bay during the winter months or when water temperatures fall below 14°C).

10.4 Silversides (*Menidia menidia*)

The geographic range of the silverside extends from Nova Scotia and the Magdalen Islands, Canada to Volusia County, Florida. Silversides prefer tidal creeks with submerged grasses but will move to deeper channel waters in the winter. Larvae and juveniles are most abundant in areas with relatively low salinity (1 – 14 ppt). Even so, it is possible that all life stages, especially adults, may be present in the project area due to this species' abundance in Chesapeake Bay.

The diets of both juvenile and adult silversides consist of a variety of copepods, insects, worms, mollusk larvae, algae, diatoms, mysids, cladocerans, detritus, and amphipods (Orth and Heck 1980; Fay et al. 1983). Silversides provide an important forage species for striped bass, Atlantic mackerel, and bluefish. Silversides reach maturity by age one, with most adults not surviving to two years of age (Fay et al. 1983).

The spawning season for silversides is between April and August, with an average of four or five spawning events during the season (Fay et al. 1983). They spawn in schools around shallow, pooled areas of water along the low tide area. The eggs are sticky with filaments so they have a tendency to cling to vegetation and one another. They are protected from many predators by their shallow water habitat.

10.5 Blue Crab (Callinectes sapidus)

The blue crab is an important benthic prey source for a variety of predators, including striped bass (Manooch 1973, Walter and Austin 2003, Walter et al. 2003), American eel (Wenner and Musick 1975), Atlantic croaker (Overstreet and Heard 1978a, Overstreet and Heard 1978b), and red drum (Jaworski 1972, Bass and Avault 1975, Scharf and Schlicht 2000, Guillory and Prejean 2001). They can tolerate a wide range of salinity in Chesapeake Bay from near 0 to 32 ppt. Gravid females extrude fertilized eggs as a mass, called a sponge, from their aprons (Pyle and Cronin 1950). As the embryos in the sponge develop, female crabs. They then migrate towards the mouth of Chesapeake Bay during the summer as the embryos develop to spawn in these high-salinity waters of the Atlantic Ocean, while males remain in the less saline waters (Van Engel 1958, Millikin and Williams 1984, McConaugha 1988). Eggs hatch most successfully at salinities of 20 to 32 ppt (Sandoz and Rogers 1944, Costlow and Bookhout 1959, Davis 1965), and planktonic blue crab larvae, or zoeae, develop in coastal waters above the continental shelf (Epifanio et al. 1989, Epifanio 2007). After about six to eight weeks and several molts, zoeae metamorphose into benthic megalopae, which reinvade the Bay (Epifanio and Garvine 2001), and eventually undergo metamorphosis into the juvenile stage after reaching nursery grounds (Metcalf and Lipcius 1992, Etherington and Eggleston 2000). Megalopae and juveniles migrate up Chesapeake Bay and into all of its tributaries (DeVries et al. 1994, Forward et al. 1997, 2003). Adult crabs of both sexes overwinter in the muddy bottoms of deeper channels (Van Engel 1958, Schaffner and Diaz 1988), while juveniles more often overwinter in shallower areas (Van Engel 1958). There is a large, economically valuable commercial fishery for blue crabs in the Chesapeake Bay, as well as recreational fishing for blue crabs in these same waters.

10.6 Weakfish (*Cynoscion regalis*)

Weakfish are found along the Atlantic seaboard, from Massachusetts to Florida (Mercer 1989), with highest abundance between New York and North Carolina. Weakfish are a valuable recreational species. Habitat use within the estuary varies by age of the fish, time of year, and vertical location within the water column. However, they predominately inhabit shallow waters with sandy to sandy mud substrates.

All populations of weakfish reach maturity at age one; however, the length of mature fish varies by geographic region. Mature individuals from southern populations generally grow to a larger size at maturity than northern populations. Adults migrate between inshore and offshore waters seasonally, prompted by the increase in water temperatures during the spring and summer months. As water temperatures increase the adults will move inshore or further north from their overwintering habitats in the south Atlantic (Mercer 1989). The warm spring continental shelf waters stimulate the adults to return to the bays and estuaries in the spring, and they are most commonly found in Chesapeake Bay waters from May to September. As water temperature declines in the fall, adults congregate and move offshore and southward towards oceanic waters and the wintering grounds (Chao and Musick 1977; Mercer 1989). The primary wintering grounds are hypothesized to be along the continental shelf from the Chesapeake Bay to Cape Lookout, North Carolina (Mercer 1989).

Spawning occurs near the mouth of Chesapeake Bay and the adjacent nearshore and estuarine waters, shortly after their migration inshore. Preferred spawning habitat of weakfish consists of areas with high salinity immediately adjacent to inlets or creeks (Luczkovich et al. 1999; Luczkovich et al. n.d.). In the Chesapeake Bay region, weakfish have an extended spawning season from approximately May to August (Monteleone 1992). The duration of the spawning season varies geographically, with southern populations having an earlier and longer season than northern populations. Multiple spawning events can occur during one spawning season (Mercer 1989).

Larvae are found throughout the lower Bay in the late summer, and young begin to appear in low salinity habitats in August (Chao and Musick 1977). By October, juveniles begin to move down river to higher salinity waters and eventually into the ocean. Two year and older fish appear in Chesapeake Bay in April and May with yearlings becoming more abundant in the summer.

10.7 White Perch (*Morone americana*)

White perch are found along the Atlantic coast from New Brunswick, Nova Scotia, and Prince Edward Island, Canada to South Carolina, USA (Stanley and Danie 1983). White perch are commonly found in the tributaries of the Chesapeake Bay along the fresh water and saltwater interface zone. Juvenile white perch favor shallow areas at and above the tidal freshwater interface (Fay et al. 1983).

Spawning transpires between April and June, with migrations to spawning areas triggered by seasonal temperature changes (Hewitt et al. n.d.). Spawning occurs in fresh or brackish marshes, rivers, lakes, or estuaries with low salinity (under 4.2 ppt) (Hardy 1978). Spawning occurs in freshwater areas from April to May, and in estuarine environments spawning occurs between May and July. Spawning habitat substrate consists of gravel, clay, sand, or crushed shell (Stanley and Danie 1983). Some white perch spawn in their resident body of water, while others migrate up to 90 km. Adults and juveniles move to deeper waters (30 - 40 ft.) as winter approaches. Overwintering habitat is typically in deeper waters averaging 40 - 60 ft. but can reach depths in excess of 130 ft.

As white perch grow, they gradually move downstream. At two years of age, regardless of sex, most white perch are considered adults. Any remaining juveniles will reach maturity no later than age four. Growth and development of white perch is most rapid during the first year but is dependent on availability of food, population density, and water temperature (Stanley and Danie 1983).

White perch are a widespread and abundant species in the Chesapeake Bay region. White perch can survive in a large variety of habitats and environmental conditions. They feed on a diverse array of prey, including zooplankton, insects, crustaceans, amphipods, snails, crayfish, and other fish species.

10.8 Killifish/Mummichog/Mud Minnow (*Fundulus* spp.)

Fundulus species frequent both salt and brackish waters. *Fundulus* spp. are generally very tolerant of temperature and salinity fluctuations. *Fundulus heteroclitus*, the common killifish or mummichog, spawns in July in the local region (Monteleone 1992). It is common in the shallow brackish coves of inlets of the Chesapeake Bay tributary waters. Mummichogs prefer muddy bottoms in areas with some *Spartina* spp. Coverage as habitat, while some killifish species prefer more sandy sediments. Fundulus spp. use a wide variety of food sources, including organisms found within the water column or in the intertidal and subtidal benthos (Abraham 1985). The diet of *Fundulus* spp. includes algae, crustaceans, polychaetes, snails, insects, small fishes, and shrimp. *Fundulus* spp. are a common prey species of a wide variety of birds and predatory fishes.

11.0 POTENTIAL IMPACTS TO ESSENTIAL FISH HABITAT

This section will discuss the potential impacts associated with implementation of the Preferred Alternative on EFH and associated managed species in the Action Area. Impacts to water quality and habitat will be described as well as potential impacts caused by underwater noise and

Following this section, best management practices/mitigation measures that reduce potential impacts to EFH and managed species will be described as well as potential cumulative impacts that could impact EFH and managed species.

11.1 Potential Impacts to the Water Column

The reef rehabilitation and associated construction have the potential to both directly and indirectly affect the EFH occurring throughout the water column, from benthic to surface waters.

Turbidity and Total Suspended Solids. Due to the construction consisting of the placement of clean stone on existing reef areas, and placement on sand bottom with the proposed expansion of reef 16, there will be a very minor, temporary increase in TSS. This should result in no significant impacts to the water column.

Concentrations of TSS that may adversely impact fishes range from 580 mg/L (for the most sensitive species) to 1,000 mg/L (Burton 1993). Increases in TSS and turbidity can impact the ability of prey species to avoid predators due to visual impairment caused by decreased water clarity (Gregory and Northcote 1993; Wilbur and Clarke 2001). Turbid waters can also visually impair predator species that rely on sight to forage, including coastal pelagic fishes, highly migratory fishes, and sharks. As noted, very minor increases to turbidity in the immediate area where materials will be placed on the reefs is expected due to the fact that clean material will be used for construction. This includes both the rehabilitation work and the proposed expansion of reef 16.

Salinity and Dissolved Oxygen. Increased turbidity can impact primary productivity and respiration of organisms within the Action Area. By limiting light availability in the water column, the rate of primary productivity has the potential to drop and may ultimately and indirectly reduce the availability of dissolved oxygen (DO). If dissolved oxygen levels drop significantly, anoxic conditions may ensue, which can result in stress-induced sublethal and lethal effects to fishes inhabiting a particular habitat. Due to the recommended project consisting of the placement of stone and/or clean shell over reef surfaces and remnant reef habitat, there should be no effect to salinity or DO. Therefore, anoxia, hypoxia, or harmful algal blooms following construction operations are extremely unlikely either during or after proposed construction.

Nutrient/Contaminant Release. Due to the project consisting of the placement of stone and or shell, and very limited bottom disturbance , no significant nutrient release or contaminant release of any sort is expected. No effect to EFH.

Underwater Noise. Underwater soundscapes are of vital importance to numerous species of estuarine and coastal fishes. Soundscapes are characterized by the ambient sound created by both the physical and biological processes at a specific location, such that the soundscape of an oyster reef is considerably different than that of a seagrass bed or an open expanse of sand (Lillis et al. 2014). In shallow water communities, soundscapes are affected by a variety of factors, such as bathymetry, waves, and animal activities (e.g. intra-specific and defense communications and foraging) (Lillis et al. 2014). Sound transmits efficiently through water, making it particularly important to aquatic communities, and studies indicate that sound plays a role in a multitude of ecological processes, including reproductive behavior, navigation, defense, territoriality displays, foraging, and orientation and timing of larval settlement (Cotter 2008; Nichols et al. 2015; Lillis et al. 2014). Over the past century, as human maritime and coastal activity has increased exponentially, oceanic noise has also risen.

Sounds created by human activities fall into two categories: sounds that are an unintentional byproduct and sounds that are used as a measurement tool (Slabbekoorn et al. 2010). The first category includes low-frequency noises from small or large water craft (e.g. container shipping, public transportation, and fishing/recreation) (Slabbekoorn et al. 2010). The second category of anthropogenic noise is generated largely by sonar, which enables humans to map the benthos and locate objects and resources (e.g. sunken ships, oil, natural gas, etc.) in the ocean; this generates both low and high frequency sound (Slabbekoorn et al. 2010). Although there are a variety of noise inputs, it is hypothesized that motorized vessels, particularly in coastal environments, produce the largest proportion of anthropogenic noise (Slabbekoorn et al. 2010; Nichols et al. 2015).

For the proposed project to rehabilitate some oyster reefs and expand reef 16, various marine vessels will be used. Due to the fact that commercial and non-commercial navigation is already significant in the local area, this should not significantly increase noise. The placement of the stone and/or shell is not expected to significantly increase local noise beyond the construction footprint, and will be temporary and minor during construction. The USACE does not expect any significant impacts to EFH due to construction noise associated with the proposed construction.

11.2 Effects to Habitat Area of Particular Concern

The summer flounder has HAPC in the Great Wicomico River region, these areas are found throughout much of the lower river excluding the main channel and includes where the current reefs are found as well as the proposed expansion of reef 16. It is generally found on sand bottom, not hard reef so would not be found in large numbers on oyster reefs. This is a more shallow water species, however, and it typically spawns in waters > 20 feet deep offshore, with juveniles and adults found in the project area. The proposed construction will occur within the footprints of current or former oyster reefs, and the USACE does not expect any negative impacts to summer flounder HAPC due to the nature of this project, which is ecosystem restoration. There is extensive acreage of suitable sand bottom habitat in the River, and the reefs will likely increase the supply of small organisms the flounder can feed upon.

11.3 Potential Impacts to Benthic Habitats

The proposed project is an ecosystem restoration project modification. There will be a loss of any not-motile benthos that remains after as many live oysters are removed prior to construction as possible. For the reef 16 expansion of 7 acres, the existing benthos will be lost as the new reef is constructed but, this is a return to its historical condition as reef. Temporary impacts will result due to placement of new reef material over 28.1 acres, which will reduce the quality of the oyster reefs they are placed on temporarily. This impact will be temporary and minor, as only degraded habitat is proposed for upgrading and live oysters and attached fauna will be removed from the reefs to be rehabilitated prior to upgrading with new material. The expansion of reef 16 by adding 7 more acres to it will be a return of a former reef area to a high functioning oyster reef. Anti-poaching stones will not have impacts different from the rest of the construction materials, but will provide benthic habitat higher in the water column than the majority of the reefs, post construction. Within a year post-construction, these areas should establish an extensive population of young oysters and associated benthic fauna, and long term, the rehabilitated reefs will provide significantly more ecological benefits and higher quality benthic habitat that these areas were producing prior to project implementation. Overall benefits will be significant, positive and permanent to benthic habitats and associated EFH.

12.0 Cumulative impacts to Essential Fish Habitat and Managed Species

In the future, with or without implementation of the Preferred Alternative, continued development, shipping and other navigation operations, and stormwater discharges will continue to negatively impact water quality within the ROI and adjacent areas. These impacts are minor, as water quality in the Great Wicomico River is currently good and due to the expected lack of urbanization over time, will continue to be so. The proposed project, if fully constructed, will improve local water quality, which will improve the local EFH and HAPC.

While commercial fishing in the River damages oyster reefs where fishing occurs, the placement of the anti-poaching stones should discourage illegal fishing on these sanctuary reefs. If left undisturbed, the reefs will aid in the development of disease resistant older, larger oysters by permitting them to survive instead of be removed by the fishery, and they will also enhance recruitment further in the River. These cumulative benefits will increase over time and are positive towards local EFH, as many local fish species feed on oyster juveniles or adults.

Climatic changes such as sea level rise and increasing global temperatures are predicted to continue. Predicted climate change impacts such as increased ocean temperatures, ocean acidification, sea level rise, and changes in currents, upwelling and weather patterns, have the potential to cause changes in the nature and character of the estuarine ecosystem in the ROI. The pH within surface waters will likely drop as ocean acidification occurs. Climate change is anticipated to potentially increase winter and spring nutrient loading into the Chesapeake Bay watershed due to several additional inches of precipitation (Cornell, 2019). Higher temperatures, lower dissolved oxygen levels, and increased phytoplankton productivity may result in alterations to the local ecosystem, hypoxic conditions in the deep channel waters may worsen due to climate change impacts. Higher pH may negatively impact shell-forming benthos, including oysters, as they will have increased difficulty forming their shells under a higher pH environment (Talmage et al., 2010), a negative impact to any shell-forming organism in the region that will also impact finfish, as their prey items change in abundance and distribution (Frank et al., 1990). Species distribution will likely change due to shifts in salinity and temperature (Kleisner, 2017) as water temperature warms, bringing into the local ROI more southern species and displacing local cold-water preferring species to the North. However, implementation of the Preferred Alternative, along with other past, present, and future actions, is not anticipated to significantly contribute to those increased impacts. The oyster shells are likely to provide a minor buffering against pH decreases due to the calcium carbonate structure of the shells. While some of these cumulative impacts will negatively affect local EFH, oyster reefs will act to help buffer against these negative impacts.

Cumulative threats to managed species, including exposure to contaminants and fuel spills, have the potential to impact fish populations and their habitats, but implementation of the Preferred Alternative is not anticipated to significantly contribute cumulatively to injuries and mortalities resulting from these impacts.

No further restoration other than an expansion of reefs upriver of the present project is under consideration, and the river is considered fully restored for oysters as of 2021. Current leaseholds are active and cover significant portions of the River bottom, this is likely to continue into the future without changes to the extent, as most of the suitable bottom is leased at present. Harvested areas would continue to be shelled as they require maintenance due to the damage harvesting does to reefs. This activity would continue as long as a public fishery is desired. Oyster reefs provide a hard, complex habitat unique to Chesapeake Bay and add to the quality of local EFH. Species that do not directly inhabit reefs, such as skates and flounder, should see increases in prey on nearby sand bottom due to the increased secondary production that oyster reefs provide, a positive benefit to their EFH. The impacts to EFH from the proposed construction would be minor and temporary. Cumulatively, they would act to further restore the oyster reef network that once existed in the River prior to commercial dredging and tonging for oysters began in the 1800s. Overall cumulative impacts to local EFH, considering that these reefs were once high relief and that is their original condition, would be positive and permanent improvement to local EFH.

13.0 BEST MANAGEMENT PRACTICES/MITIGATION MEASURES

Measures would be implemented to minimize disturbances to the environment.

- All construction materials will be inspected prior to placement to ensure they are clean, free of any debris, and has been washed to eliminate soils entering the marine environment.

- To minimize air emissions associated with dredging vessels and dredge-related equipment, vessels and equipment will not be allowed to run idle and will be shut off to the extent practical when not in use.

- If a sea turtle is observed within 100 yards (300 feet) of the active daily construction operation or vessel movement, all appropriate precautions shall be implemented to ensure its protection. These precautions shall include cessation of operation of any moving equipment closer than 50 feet of a sea turtle. Operation of any mechanical construction equipment shall cease immediately if a sea turtle is observed within a 50-foot radius of the equipment. Activities may not resume until the sea turtle has departed the project area of its own volition.

- Any collision with and/or injury to a sea turtle shall be reported within 24 hours to the NMFS's Protected Resources Division.

14.0 CONCLUSIONS

Implementation of the Preferred Alternative may adversely impact essential habitats and managed species due to increased TSS levels, sedimentation, direct removal of habitat, and underwater noise. These effects are expected to be temporary, minor and not significant. Effects to HAPC for the summer flounder are also expected to be negligible.

The USACE concludes that implementation of the Preferred Alternative is anticipated to result in minor adverse impacts to EFH, managed species, and their prey. Impacts would be temporary, with long-term, significant benefits expected due to the increased habitat value of the rehabilitated oyster reef habitat. No substantial adverse impacts to EFH or managed species are anticipated and best management practices will aide in reducing potential impacts to essential habitats utilized by managed species in the Action Area.

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DRAFT SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT

ENVIRONMENTAL APPENDIX

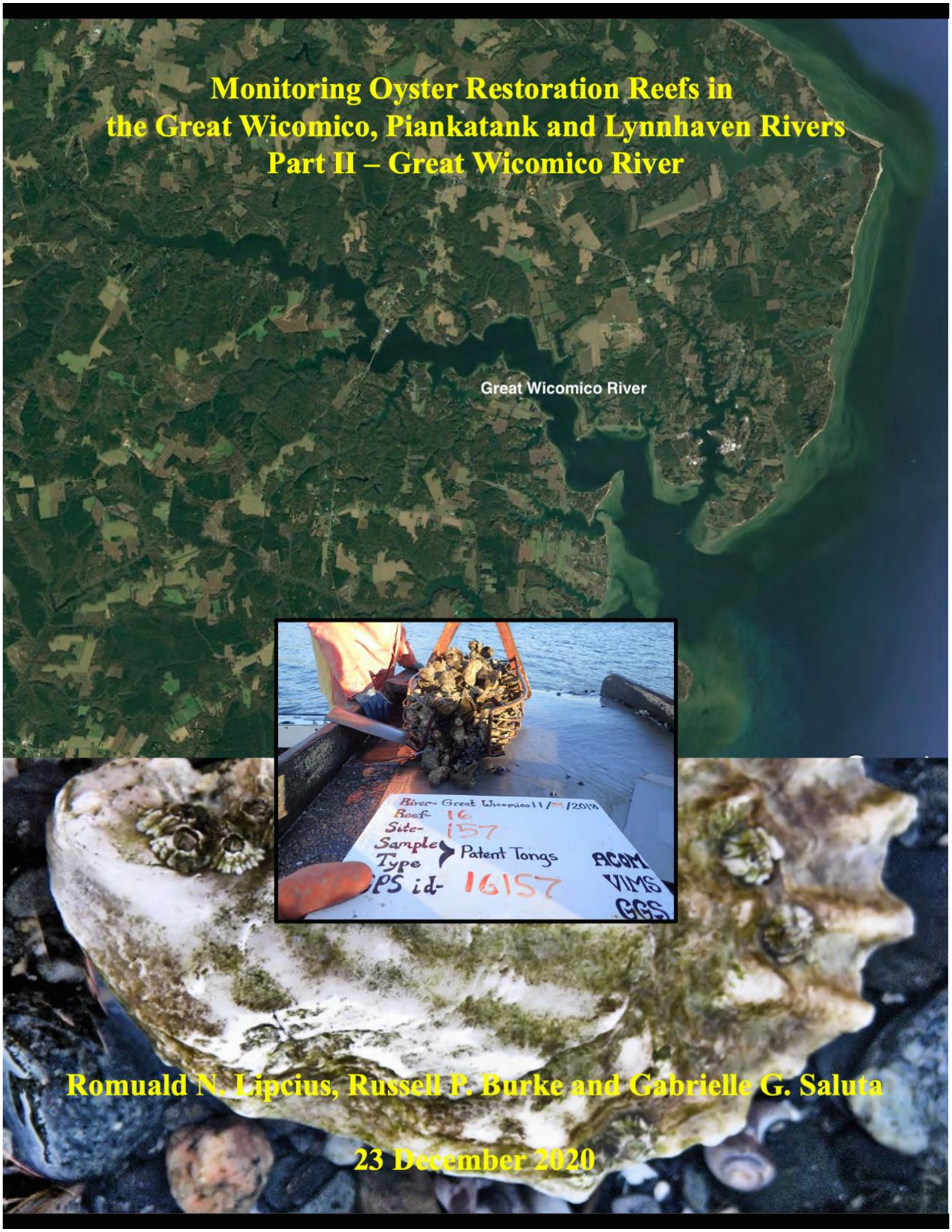
LATEST MONITORING REPORT

CHESAPEAKE BAY OYSTER RESTORATION

GREAT WICOMICO RIVER, VIRGINIA

U.S. Army Corps of Engineers
Norfolk District
803 Front Street
Norfolk, Virginia 23510-1096

Monitoring Oyster Restoration Reefs in the Great Wicomico, Piankatank and Lynnhaven Rivers
Part II – Great Wicomico River



Romuald N. Lipcius, Russell P. Burke and Gabrielle G. Saluta

23 December 2020

Contents

1 Inside Cover

**CHESAPEAKE WATERSHED CESU W912HZ-18-
SOI-0006**

MONITORING OYSTER RESTORATION REEFS IN THE GREAT WICOMICO, PIANKATANK AND LYNNHAVEN RIVERS

*

FINAL REPORT: PART II - GREAT WICOMICO RIVER

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December 2020

* Citation: Lipcius, Romuald N., Burke, Russell P. and Saluta, Gabrielle G. 2020. Monitoring Oyster Restoration Reefs in the Great Wicomico, Pi- ankatank and Lynnhaven Rivers. Chesapeake Watershed CESU W912HZ- 18-SOI-0006 Final Report: Part II - Great Wicomico River. US Army Corps of Engineers, Norfolk, Virginia.

2 Summary

We assessed the performance of reefs constructed in 2004 by USACE in the Great Wicomico River in 2018 and 2019, 15 y after construction. Monitoring objectives included assessing abundance and biomass, oyster demographics (live and dead) including age classes, and accretion rates on the restored reefs. Generalized linear models were used to analyze 6 response variables: spat density, adult density, total density, biomass, live shell volume and brown shell volume. Independent variables included water depth as a continuous variable, sediment type (mud or muddy sand) as a categorical factor, and reef type (Original High-Relief Reef, OHRR; Rehabilitated High-Relief Reef, RHRR; and Original Low-Relief Reef, OLRR) as a categorical factor. Nine statistical models representing alternative hypotheses were developed to ana- lyze the 6 response variables as a function of water depth, sediment type and reef type, and the best model was selected using Information Theory with Akaike's Information Criterion. In addition, we analyzed the relationship between spat density on oyster patches as a function of adult density.

Sanctuary reefs in the Great Wicomico River (GWR) have performed ex- ceptionally well over the past 15 years, except for a few sites that have been poached or where reef was originally constructed on poor habitat, specifi- cally deep mud bottom. Oyster size ranged from 3.1 to 132.2 mm SH (Shell Height = Shell Length) with most oysters being 40 to 90 mm SH. Larger oysters comprised at least 2 to 3 year classes.

Spat density was low due to poor recruitment in 2018, inversely related to depth and higher in muddy sand than in mud, but did not differ significantly by reef type. Spat density was highest on OHRR at 43.1 m^{-2} on OHRR, intermediate on RHRR at 31.2 m^{-2}, and lowest on OLRR at 27.2 m^{-2}. The lack of a reef type effect resulted from the extremely poor spat set of 2018, which was due to high streamflow in 2018, and which precluded accumulation of spat on OHRR and RHRR reefs. This was also evident in the high volume of brown shell without spat.

Adult and total density were high in 2018 and 2019, also inversely related to depth and higher in muddy sand than in mud, though depth interacted significantly with reef type. OHRR reefs had a steeper negative slope than RHRR and OLRR reefs, such that the difference in density between OHRR and the other reef types was greatest at depths shallower than 12 feet; by 16 feet in depth, density was relatively low and differed little among the 3 reef types. This was likely due to the negative effect of depth on spat recruitment in combination with effects of reef height on recruitment and survival.

To assess population-level differences in oyster density, we first determined whether depth differed by reef type. It did not, which allowed us to generate mean population-level densities as a function of reef type. In contrast to spat density, both adult density and total density differed significantly by reef type. OHRR supported the highest densities (adult: 258.9 m^{-2}; total: 301.0 m^{-2}), followed by RHRR (adult: 151.8 m^{-2}; total: 182.0 m^{-2}), and OLRR with the lowest (adult: 91.7 m^{-2}; total: 118.0 m^{-2}), though all reef types greatly exceeded the GIT target of 50 oysters m^{-2}. Spat density was significantly and positively correlated with adult density.

Total oyster biomass was high in 2018 and 2019, also inversely related to depth and higher in muddy sand than in mud, though depth interacted significantly with reef type. As with adult and total oyster densities, OHRR reefs had a steeper negative slope than RHRR and OLRR reefs, such that the difference in biomass between OHRR and the other reef types was greatest at depths shallower than 12 feet; from 12 to 16 feet in depth, biomass declined and differed little among the 3 reef types. Given that depth did not differ by reef type, we generated mean population-level biomass as a function of reef type. OHRR harbored highest total biomass (173.0 g dry weight (DW) m^{-2}), RHRR was nearly as high (164.0 g DW m^{-2}), whereas OLRR was substantially lower (57.0 g DW m^{-2}), though all reef types exceeded the GIT target of 50 g DW m^{-2}.

Live shell volume was high in 2018 and 2019, inversely related to depth and higher in muddy sand than in mud; depth again interacted significantly with reef type. As with adult density, total oyster density and biomass, OHRR reefs had a steeper negative slope than RHRR and OLRR reefs, such that the difference in live shell volume between OHRR and the other reef types was greatest at depths shallower than 12 feet. In contrast, brown shell volume was positively related to depth, did not differ by sediment type, and depth did not interact with reef type such that RHRR reefs had the highest volume of brown shell. The change in slope with depth from negative for live shell volume to positive for brown shell volume resulted from the reduction of spat and adult densities with depth, as well as the addition of RHRR shell during reef rehabilitation.

Again, given that depth did not differ by reef type, we generated mean population-level live shell volume and brown shell volume as a function of reef type. Live shell volume differed significantly by reef type. OHRR harbored highest live shell volume (8.302 L m^{-2}), RHRR was intermediate (6.650 L m^{-2}), whereas OLRR was substantially lower (2.657 L m^{-2}). Conversely, brown shell volume was highest on RHRR (16.537 L m^{-2}), followed by OHRR (12.843 L m^{-2}) and then OLRR with lowest volumes (10.638 L m^{-2}). When live shell volume and brown shell volume were combined by reef type, all reef types exceeded an assumed value for self-sustaining reefs of 5 L m^{-2}.

Given that multiple year classes inhabited the reef network, and that density and biomass exceeded GIT metrics, we conclude that all GWR reefs are performing successfully. In addition, the high volume of live oysters and brown shell are indicative of positively accreting reefs.

Population abundance across all reef types was estimated at 76.2 million live oysters, most of which were adults. Of all oysters, OHRR reefs harbored 36.3 million, RHRR reefs 22.0 million, and OLRR reefs 17.9 million. Poaching was evident on 6 of the 64 samples across the reef network with 3 on reef 8, 2 on reef 9 and 1 on reef 3. We identified poached samples by the occurrence of profuse broken shell pieces and lack of large oysters either live or dead (boxes). In unpoached samples, legal-size oysters comprised a substantial portion of the population, whereas in poached samples very few oysters were of legal size. Poached samples also greatly reduced the number of oysters in clusters.

In summary, multiple year classes inhabited the reef network, and density and biomass greatly exceeded GIT metrics. Consequently, the GWR reef net- work exceeded restoration reef performance metrics established by the GIT. Accretion rates of live and brown oyster shell volume were well above those necessary for long-term, self-sustaining oyster populations. Despite poaching on some reefs and low spat densities reflecting poor recruitment in 2018, the sanctuary oyster reef network remains self-sustaining and resilient due to high densities of adults, biomass and accreted shell volume. Adaptive man- agement whereby poorly-performing reefs were rehabilitated was successful and raised the quality of those reefs to be self-sustaining. The sanctuary oys- ter reef network harbors the longest-lasting (15 years) self-sustaining restored oyster metapopulation of any native oyster species worldwide, and serves as a model for native oyster restoration globally.

3 Preface

This report is Part II of a two-part report, and was prepared as a stand-alone document. Hence, sections of the report may repeat what was stated in Part I of the report (Lipcius et al., 2020).

4 Introduction

The native Eastern oyster *Crassostrea virginica* and its habitat have been severely depleted in Chesapeake Bay, as in many other regions of the world (Beck et al., 2011). Current populations in the Bay are estimated at ap- proximately 1% (Wilberg et al., 2011) and while a limited recovery of the wild fishery is occurring at present, the overall recovery of the oyster stocks, fishery and associated reef habitat has been limited by poor habitat quality, low stock and continued low recruitment when compared to historical levels (Rothschild et al., 1994; Schulte, 2017). An aggressive restoration effort was undertaken by the U.S. Army Corps of Engineers (USACE) as part of a larger commitment to restore the Chesapeake Bay ecosystem in response to the Ex- ecutive Order by President Obama in 2009. For oysters, more specific goals were established with the 2014 Chesapeake Bay Agreement, which requires 10 tributary rivers be restored by 2025. The Chesapeake Bay Program Goal Implementation Team (GIT) established standard reef location, abundance and biomass metrics to be applied at reef sites to monitor their status and assess their success over time. The USACE is a member of the GIT and has adopted the GIT standard metrics to assess the status of constructed reefs.

A large-scale, multi-agency team involving both federal and state agen- cies as well as academia has been conducting large-scale oyster restoration projects in both Maryland and Virginia waters of the Bay and its tributaries. Tributaries were prioritized according to their chance for success of a large- scale restoration project. Goals include: significant stock enhancement, ex- pansion of oyster reef habitat, enhanced oyster recruitment, establishment of a network of sanctuary oyster reefs free from oyster fishing pressure, improve- ments to local ecology including secondary production, Submerged Aquatic Vegetation (SAV) expansion and water quality improvement, and enhance- ment of the oyster fishery in areas set aside for the fishery. As part of the Chesapeake Bay Native Oyster Recovery Project, the USACE constructed a subtidal granite reef at the Piankatank River and subtidal shell reefs at the Lynnhaven River and the Great Wicomico River.

This report deals with the restoration reefs in the Great Wicomico River, which is the first major tributary on the western shore of the Bay south of the Potomac River. USACE reefs in the Great Wicomico River were sampled in 2006-2007, and again in six different years spanning 2008 through 2017. We established the protocol for effective and efficient sampling of restoration reefs with patent tong gear; validated the method with underwater remotely operated vehicle (ROV) video observations, and determined the efficiency of patent tong gear (Schulte et al., 2018). A Habitat Suitability Index was generated for oyster reef restoration in the Great Wicomico River (Theuerkauf and Lipcius, 2016).

5 Objectives

In this report, we assessed the performance of reefs constructed by USACE in the Great Wicomico River (Figure 1). Monitoring objectives included assess- ing abundance and biomass, oyster demographics (live and dead) including age classes, and accretion rates on the restored reefs. All work was performed in accordance with applicable local, state, and federal regulations.

The period of performance was 15 September 2018 through 14 April 2020. The original period of performance was extended due to circumstances be- yond the control of the investigators. Surveys were conducted in Fall and Winter 2018, and Spring and Summer 2019. Additional video surveys were to be conducted Winter 2020, but the COVID-19 pandemic precluded their completion. As required by the contract, specific tributary sampling plans were reviewed with USACE personnel prior to the actual surveys, and ad- justments made to suit USACE needs.

6 Methods

6.1 Field Survey

Reefs built by the USACE in the Great Wicomico River were sampled using a survey of randomly selected sites over the reef surface with sufficient samples to minimize the standard error of the mean (SE), an estimate of sampling precision. For the Great Wicomico River, the reefs had consisted of 2 distinct strata, high-relief reefs (HRR) and low-relief reefs (LRR) at each of 9 reef locations (USACE reef numbers 1&2, 3, 4, 8, 9, 10&11, 13 and 16). Recently, various poorly performing LRR were refurbished to HRR status and were renamed RHRR, while the original high-relief reefs were renamed OHRR and remaining low-relief reefs were renamed OLRR. To sample the reefs, a 10-m^2 grid was drawn by the USACE over the entire reef area and assigned numbers. A random number generator computer application was used by the USACE to produce the random samples for each monitoring event. All sampling point coordinates were provided by the USACE, as well as sampling maps with the reefs sub-divided into 10 x 10 m^2 grids. Random samples were taken from a single station within each of the randomly selected 10 x 10 m^2 areas as indicated by the USACE. GPS was used during monitoring to ensure samples were taken from these points, and the exact GPS location of each station was recorded. Details of patent tong sampling methods are provided in Schulte et al. (2018).

To obtain subtidal bottom samples across the diverse bottom conditions, a commercial 'deadrise' vessel containing an oyster patent tong was employed. The captain navigated the vessel to each set of designated coordinates using a Garmin 76 GPS. Upon reaching each sample site, a large chain anchor was lowered to keep the vessel on site. The captain then lowered the patent tong to the sediment/reef surface and manipulated the tongs to ensure a deep, full grab; each grab sampled approximately one square meter of river bottom. Upon raising the sample to the surface and placement on a sorting table, but prior to any processing, a photograph was taken of the sample with a dry-erase board displaying the site information. Then, a complete 0.5 or 0.25 m^2 section of the sample was retained, cleaned of most sediment, placed in pre-labeled freezer bags, transported in a large cooler, stored in freezers at the lab at VIMS, and processed at a later date. Each sample was partitioned into two separate bags. The first bag contained all live oysters, while the second bag contained all dead shell and base shell material.

Physical variables (water clarity, temperature, salinity, dissolved oxygen) were taken at each reef. For each station within a reef, a chain anchor was de- ployed prior to collecting patent tong samples to ensure an accurate location with GPS. Depth and sediment type were recorded at every station.

6.2 Laboratory Processing

Laboratory processing was required because (i) spat cannot be sampled accu- rately in the field without a lengthy examination onboard the project vessel, and (ii) it is more cost-efficient to use the vessel time to sample, rather than both sample and process the material. Each sample was thawed and rinsed over a 1-mm sieve, enabling the removal of any excess mud and fine solids. Shell Height (SH, mm), equivalent to Shell Length, was measured using dig- ital calipers for all live oysters, and for dead oysters both of box (both valves attached at the hinge) and of half-box (single disarticulated valve) shells. For half-box shells, only the bottom valves were measured to avoid overestimation of dead oyster density. Biomass was measured on a subset of oysters. Live oyster volume (LOV) was determined in the lab with graduated (premarked and accurate to 0.5 L) 20-L buckets or smaller graduated cylinders (accurate to 0.1 L or 0.01L), where appropriate. LOV included live oysters, dead bot- tom valves, and dead top valves. Dead oyster volume (DOV), containing all of the base reef material, was determined using the same water displacement procedure.

To determine biomass, soft tissue dry mass (DM = Dry Weight [DW]) from a subset of live oysters spanning the height range was used to derive reef and site specific biomass regressions (Figures 2 and 3). Simple linear regressions of $\log_{10}$DM versus $\log_{10}$SH were back-transformed to generate each equation as:

$$DM = aSH^{\beta}. \tag{1}$$

The most plausible regression with the finest resolution was used. Site- specific regressions were used when sufficient individuals were available from that site to generate precise biomass estimates. If this regression was unavail- able due to low numbers of oysters, a reef-specific regression was used based on individuals from the reef. If both of these regressions were unavailable due to low sample sizes, the regression based on all individuals from the Great Wicomico River was used.

Reef structure characteristics (i.e., density, biomass, and volume) were corrected for sample fraction taken, sampling efficiency (81%) and patent tong size (1.03 m^2).

6.3 Statistical Analysis

Generalized linear models using the Gamma family and log link were con- ducted due to the heavily right-skewed distributions of the 6 response vari- ables: spat density (Figure 4), adult density (Figure 5), total density (Figure 6), biomass (Figure 7), live shell volume (Figure 8) and brown shell volume (Figure 9). Independent variables included water depth as a continuous variable, sediment type (mud or muddy sand) as a categorical factor, and reef type (OHRR, RHRR and OLRR) as a categorical factor.

Nine models (g_1 – g_9) were developed to analyze the 6 response variables as a function of water depth, sediment type and reef type (Table 1). Each model produced a log-likelihood value, which was then used to calculate Akaike's Information Criterion (AIC) Anderson (2008). AIC_c values were used to correct for bias due to low sample size Anderson (2008). From these, Δ_i values and model probabilities (w_i) were generated to compare the fit of the candidate models (g_i) with the model having the lowest AIC_c. A model was eliminated if its w_i was less than 0.10 Anderson (2008); the individual parameter estimates of the best model (i.e., model with the highest w_i) were then evaluated.

7 Results and Discussion

7.1 Physical Variables

Physical variables during sampling were well within the dissolved oxygen (10.8 – 14.8 mg per L), thermal (7.6 – 9.7 $^\circ$C) and salinity (8.0 – 8.7 [ppt]) tolerance of the Eastern oyster (Theuerkauf and Lipcius, 2016). Salinity was extremely low in 2018 through mid-2019 due to abnormally high streamflow. Water depth ranged from 1.4 – 6.6 m and Secchi depth from 1.4 - 2.6 m. Shallow Secchi depth readings corresponded with shallow water depth and were not indicative of turbidity. The vast majority of substrate sampled was muddy sand (n = 58), followed by mud (n = 18), with one sample not evaluated. Some of the mud samples were eliminated from the analysis because they were in areas where either the reef had been scraped or where reef had not been constructed.

7.2 Oyster Size Structure

Size ranged from 3.1 to 132.2 mm SH (Shell Height = Shell Length) with most oysters being 40 to 90 mm SH (Figure 10). An adult oyster was classified as any live oyster over 35.0 mm SH. An age-0 year class, which recruited in 2018, ranged in size from 3.1 to to 35 mm SH with a mean at about 20 mm SH. Larger oysters comprised at least 2 to 3 year classes.

7.3 Oyster Density

7.3.1 Total Density per Reef Sample

Of the 68 samples taken across the reef network, 4 were in locations (Figure 11, red dots) where the reef had been scraped to translocate the oysters from unsuitable bottom to reefs on suitable bottom. The remaining 64 samples were distributed among the reef types with n = 14 for OHRR, n = 17 for OLRR and n = 31 for RHRR. All samples exceeded the GIT threshold of 15 oysters m^{-2} (Figures 11 and 12, yellow and green dots). The GIT target (50 oysters m^{-2}) was exceeded by 81% (52 of 64) of the samples.

7.3.2 Spat, Adult and Total Density

Spat density was low due to poor recruitment in 2018, inversely related to depth (Figure 13) and higher in muddy sand than in mud, but did not differ significantly by reef type (Table 2). Spat density was highest on OHRR at 43.1 m^{-2} on OHRR, intermediate on RHRR at 31.2 m^{-2}, and lowest on OLRR at 27.2 m^{-2} (Figure 13). The lack of a reef type effect resulted from the extremely poor spat set of 2018, which was due to high streamflow in 2018, and which precluded accumulation of spat on OHRR and RHRR reefs. This was also evident in the high volume of brown shell without live oysters (see below).

Adult and total density were high in 2018 and 2019, also inversely related to depth (Figures 14 and 15) and higher in muddy sand than in mud, though depth interacted significantly with reef type (Tables 3 and 4). OHRR reefs had a steeper negative slope than RHRR and OLRR reefs, such that the difference in density between OHRR and the other reef types was greatest at depths shallower than 12 feet; by 16 feet in depth, density was relatively low and differed little among the 3 reef types (Figures 14 and 15). This was likely due to the negative effect of depth on spat recruitment in combination with effects of reef height on recruitment and survival.

To assess population-level differences in oyster density, we first determined whether depth differed by reef type. It did not (GLM, $p > 0.4$), which allowed us to generate mean population-level densities as a function of reef type (Figure 16). In contrast to spat density, both adult density and total density differed significantly by reef type (GLM, $p < 0.05$). OHRR supported the highest densities (adult: 258.9 m^{-2}; total: 301.0 m^{-2}), followed by RHRR (adult: 151.8 m^{-2}; total: 182.0 m^{-2}), and OLRR with the lowest (adult: 91.7 m^{-2}; total: 118.0 m^{-2}), though all reef types greatly exceeded the GIT target of 50 oysters m^{-2} (Figure 16).

7.4 Oyster Biomass

Total oyster biomass was high in 2018 and 2019 (Figure 17), also inversely related to depth (Figure 18) and higher in muddy sand than in mud, though depth interacted significantly with reef type (Table 5). As with adult and total oyster densities, OHRR reefs had a steeper negative slope than RHRR and OLRR reefs, such that the difference in biomass between OHRR and the other reef types was greatest at depths shallower than 12 feet; from 12 to 16 feet in depth, biomass declined and differed little among the 3 reef types (Figure 18). Given that depth did not differ by reef type, we generated mean population-level biomass as a function of reef type (Figure 19). Total biomass differed significantly by reef type (GLM, $p < 0.05$). OHRR harbored highest total biomass (173.0 g DW m^{-2}), RHRR was nearly as high (164.0 g DW m^{-2}), whereas OLRR was substantially lower (57.0 g DW m^{-2}), though all reef types exceeded the GIT target of 50 g DW m^{-2} (Figure 19).

7.5 Oyster Shell Volume

Live shell volume was high in 2018 and 2019 (Figure 20), inversely related to depth (Figure 21) and higher in muddy sand than in mud; depth again interacted significantly with reef type (Table 6). As with adult density, total oyster density and biomass, OHRR reefs had a steeper negative slope than RHRR and OLRR reefs, such that the difference in live shell volume between OHRR and the other reef types was greatest at depths shallower than 12 feet; from 12 to 16 feet in depth, live shell volume declined and differed little among the 3 reef types (Figure 21). In contrast, brown shell volume was positively related to depth (Figure 22), did not differ by sediment type, and depth did not interact with reef type such that RHRR reefs had the highest volume of brown shell (Table 7). The change in slope with depth from negative for live shell volume to positive for brown shell volume resulted from the reduction of spat and adult densities with depth, as well as the addition of RHRR shell during reef rehabilitation.

Again, given that depth did not differ by reef type, we generated mean population-level live shell volume and brown shell volume as a function of reef type (Figure 23). Live shell volume differed significantly by reef type (GLM, $p < 0.05$). OHRR harbored highest live shell volume (8.302 L m^{-2}), RHRR was intermediate (6.650 L m^{-2}), whereas OLRR was substantially lower (2.657 L m^{-2}) (Figure 23). Conversely, brown shell volume was highest on RHRR (16.537 L m^{-2}), followed by OHRR (12.843 L m^{-2}) and then OLRR with lowest volumes (10.638 L m^{-2}) (Figure 23). When live shell volume and brown shell volume were combined by reef type, all reef types exceeded an assumed value for self-sustaining reefs of 5 L m^{-2} (Schulte et al., 2009).

7.6 Oyster Abundance

Population abundance across all reef types was estimated at approximately 76.2 million live oysters (Figure 24), most of which were adults (Figure 10). Of all oysters, OHRR reefs harbored 36.3 million, RHRR reefs 22.0 million, and OLRR reefs 17.9 million (Figure 24).

7.7 Spat Density as a Function of Adult Density

As with previous studies in the Great Wicomico River (Schulte et al., 2009) and Lynnhaven River (Lipcius et al., 2015) with sanctuary reefs, spat density was positively and significantly a function of adult density (Figure 25):

$$S = 4.20 + 176.03(1 - e^{-0.001A}) \qquad (2)$$

where S = Spat density and A = Adult density.

7.8 Poaching

Poaching was evident on 6 of the 64 samples across the reef network with 3 on reef 8, 2 on reef 9 and 1 on reef 3. We identified poached samples by the occurrence of profuse broken shell pieces and lack of large oysters either live or dead (boxes). In unpoached samples, legal-size oysters comprised a substantial portion of the population, whereas in poached samples very few oysters were of legal size. In terms of population metrics, poaching reduced biomass, adult density, oyster size and live shell volume, though it varied by reef. Poached samples also greatly reduced the number of oysters in clusters. Consistent with our predictions, brown shell volume was greater on poached samples than on unpoached samples, most likely due to the breakage of whole shells due to poaching by dredges.

8 Conclusions

- Multiple year classes inhabited the reef network, and density and biomass greatly exceeded GIT metrics. Consequently, the GWR reef network exceeds all restoration reef performance metrics established by the GIT (Figure 26).
- Accretion rates of live and brown oyster shell volume were well above those necessary for long-term, self-sustaining oyster populations.
- Despite poaching on some reefs and low spat densities reflecting poor recruitment in 2018, the sanctuary oyster reef network remains self-sustaining and resilient due to high densities of adults, biomass and accreted shell volume.
- Adaptive management whereby poorly-performing reefs were rehabili- tated was successful and raised the quality of those reefs to be self-sustaining.
- The sanctuary oyster reef network harbors the longest-lasting (15 years) self-sustaining restored oyster metapopulation of any native oyster species worldwide, and serves as a model for native oyster restoration globally.

9 Tables

Table 1: **Information theoretic framework Anderson (2008) of 9 models (g_i) using water depth (D), sediment type (S) and reef type (R) as predictors of oyster density, biomass and shell volume, where k is the number of parameters in a model.**

Model number	Model	k	Description
g_1	D	3	Main effect of D
g_2	S	3	Main effect of S
g_3	R	4	Main effect of R
g_4	D + S	4	Additive model, 2 main effects
g_5	D + R	5	Additive model, 2 main effects
g_6	D * R	7	Interaction model of D and R
g_7	D + S + R	6	Additive model, all main effects
g_8	D * R + S	8	Global model
g_9	1	2	Null model

Table 2: Estimate, SE, *t* value and *p* value of the parameters from model g_7 using water depth (D), sediment type (S) and reef type (R) as predictors of spat density. The parameters are based on a log transformation. The intercept reflects the baseline condition with R = OHRR and S = Mud. Model g_7, with 59 degrees of freedom, explained 14.5% of the null deviance, whereas the best model g_4, with 61 degrees of freedom, explained 12.1% of the null deviance. Model g_7 was selected because it includes the effects of reef type.

Parameter	Estimate	SE	*t* value	*p*
Intercept (OHRR)	3.96	0.77	5.1	<<0.001
D	-0.09	0.04	-2.1	0.040
S (Muddy Sand)	0.93	0.43	2.2	0.035
RHRR	-0.41	0.33	-1.2	0.23
OLRR	-0.42	0.38	-1.1	0.28

Table 3: Estimate, SE, *t* value and *p* value of the parameters from model g_8 using water depth (D), sediment type (S) and reef type (R) as predictors of adult density. The parameters are based on a log transformation. The intercept reflects the baseline condition with R = OHRR and S = Mud. Model g_8, with 57 degrees of freedom, was the best model and explained 30.3% of the null deviance.

Parameter	Estimate	SE	*t* value	*p*
Intercept (OHRR)	7.25	0.94	7.7	<<0.001
D	-0.20	0.07	-2.7	0.010
S (Muddy Sand)	0.69	0.33	2.1	0.041
RHRR	-2.55	1.04	-2.5	0.018
OLRR	-4.30	1.32	-3.2	0.002
D * RHRR	0.17	0.08	2.1	0.043
D * OLRR	0.29	0.11	2.6	0.014

Table 4: Estimate, SE, *t* value and *p* value of the parameters from model g_8 using water depth (D), sediment type (S) and reef type (R) as predictors of total oyster density. The parameters are based on a log transformation. The intercept reflects the baseline condition with R = OHRR and S = Mud. Model g_8, with 57 degrees of freedom, was the best model and explained 30.0% of the null deviance.

Parameter	Estimate	SE	*t* value	*p*
Intercept (OHRR)	7.29	0.93	7.9	<<0.001
D	-0.20	0.07	-2.7	0.010
S (Muddy Sand)	0.78	0.33	2.4	0.020
RHRR	-2.37	1.03	-2.3	0.026
OLRR	-4.05	1.31	-3.1	0.003
D * RHRR	0.16	0.08	1.9	0.060
D * OLRR	0.27	0.11	2.5	0.017

Table 5: Estimate, SE, t value and p value of the parameters from model g_8 using water depth (D), sediment type (S) and reef type (R) as predictors of total oyster biomass. The parameters are based on a log transformation. The intercept reflects the baseline condition with R = OHRR and S = Mud. Model g_8, with 57 degrees of freedom, was the best model and explained 34.4% of the null deviance.

Parameter	Estimate	SE	t value	p
Intercept (OHRR)	6.12	0.86	7.1	<<0.001
D	-0.15	0.07	-2.3	0.028
S (Muddy Sand)	0.92	0.30	3.0	0.004
RHRR	-1.61	0.96	-1.7	0.096
OLRR	-3.69	1.21	-3.0	0.004
D * RHRR	0.13	0.08	1.7	0.100
D * OLRR	0.23	0.10	2.2	0.031

Table 6: Estimate, SE, t value and p value of the parameters from model g_8 using water depth (D), sediment type (S) and reef type (R) as predictors of live oyster shell volume. The parameters are based on a log transformation. The intercept reflects the baseline condition with R = OHRR and S = Mud. Model g_8, with 57 degrees of freedom, was the best model and explained 33.6% of the null deviance.

Parameter	Estimate	SE	t value	p
Intercept (OHRR)	10.35	0.81	12.7	<<0.001
D	-0.16	0.06	-2.4	0.018
S (Muddy Sand)	0.57	0.29	2.0	0.053
RHRR	-1.65	0.90	-1.8	0.073
OLRR	-3.43	1.15	-3.0	0.004
D * RHRR	0.12	0.07	1.7	0.102
D * OLRR	0.20	0.10	2.1	0.042

Table 7: Estimate, SE, t value and p value of the parameters from model g_5 using water depth (D) and reef type (R) as predictors of brown oyster shell volume. The parameters are based on a log transformation. The intercept reflects the baseline condition with R = OHRR. Model g_5, with 60 degrees of freedom, was the best model and explained 20.0% of the null deviance.

Parameter	Estimate	SE	t value	p
Intercept (OHRR)	8.93	0.24	36.5	<<0.001
D	0.04	0.02	2.4	0.019
RHRR	0.27	0.14	1.9	0.064
OLRR	-0.14	0.16	-0.9	0.398

10 Figures

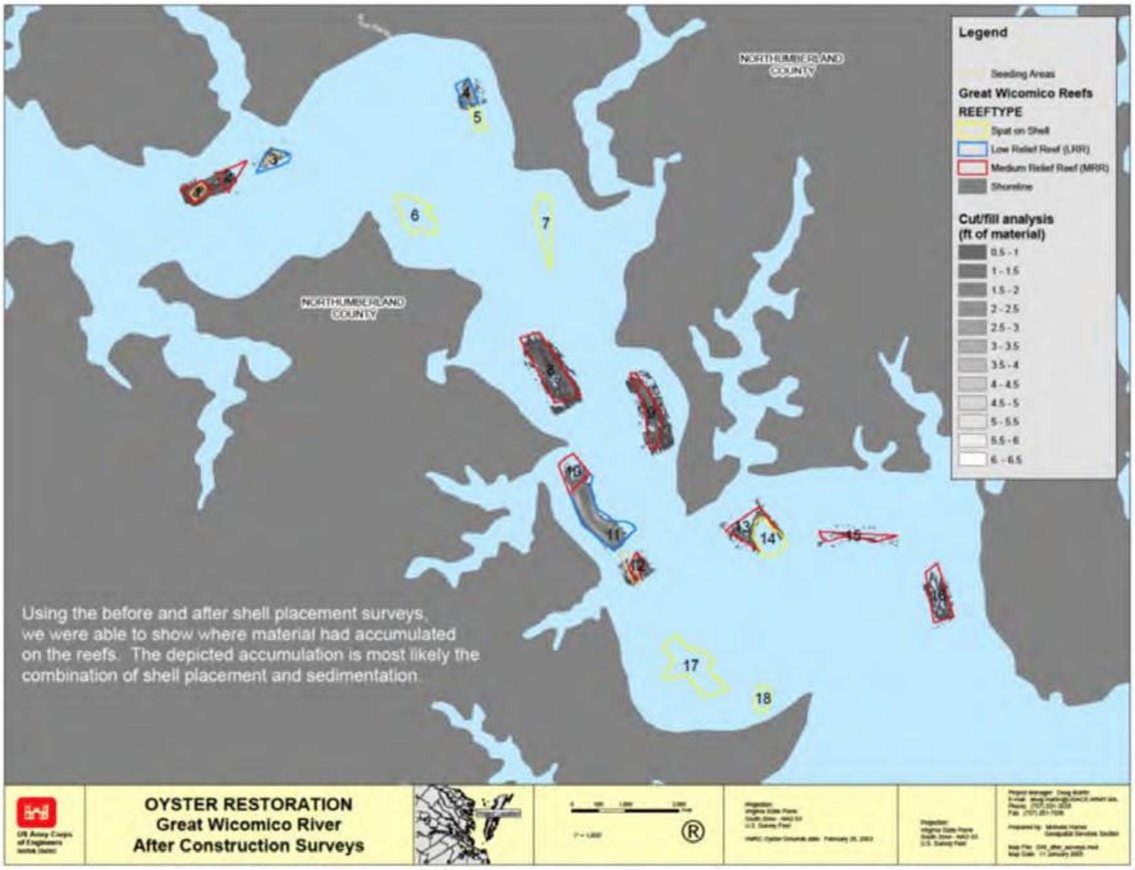

Figure 1: **Great Wicomico River showing USACE reefs.**

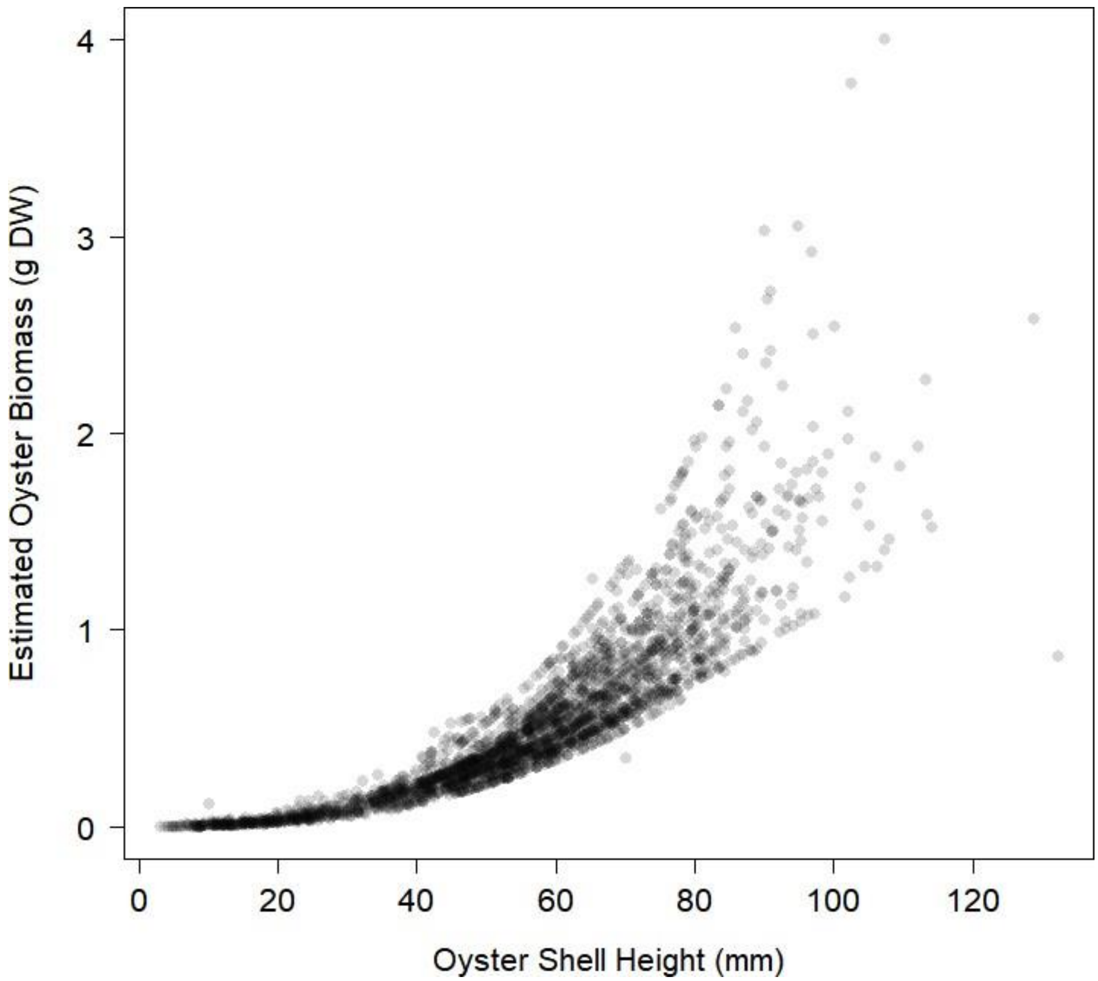

Figure 2: **All data of DW vs. SH used to generate $\log_{10}$-transformed regressions of DW vs. SH by site, reef and river.**

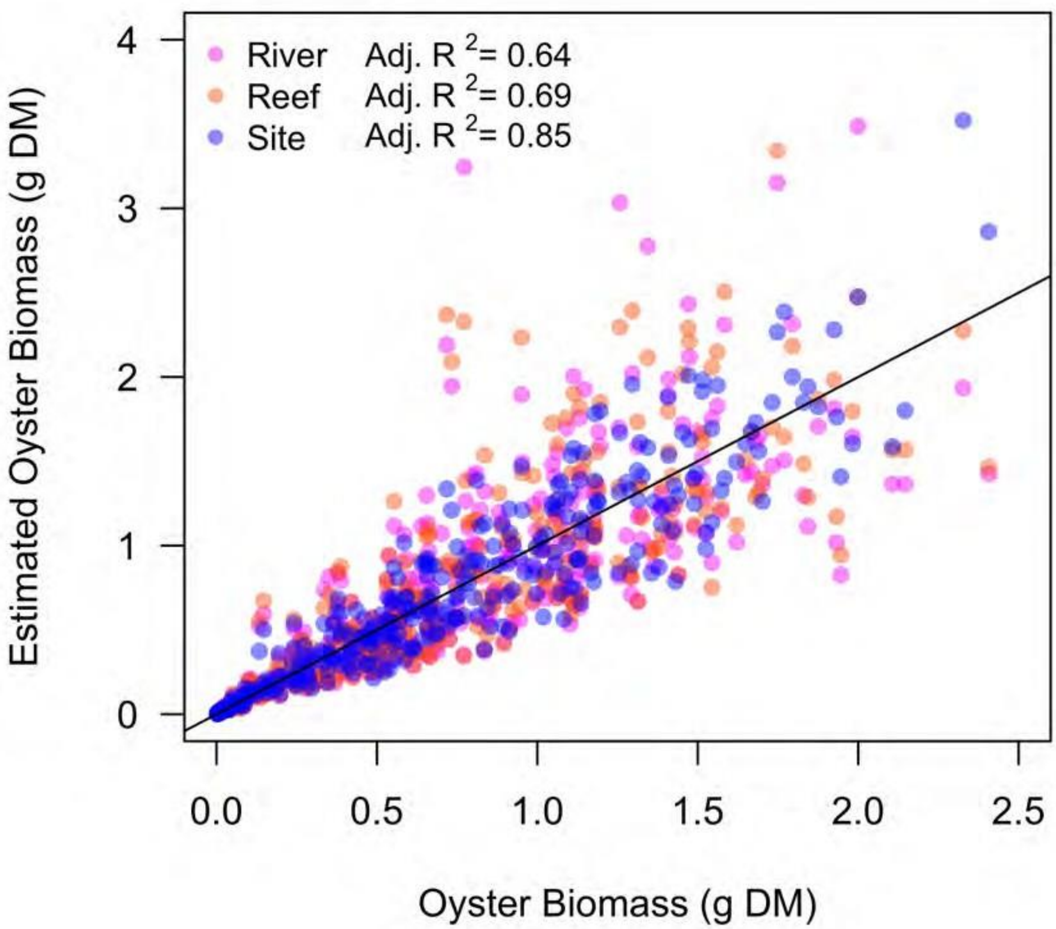

Figure 3: **Biomass regressions.**

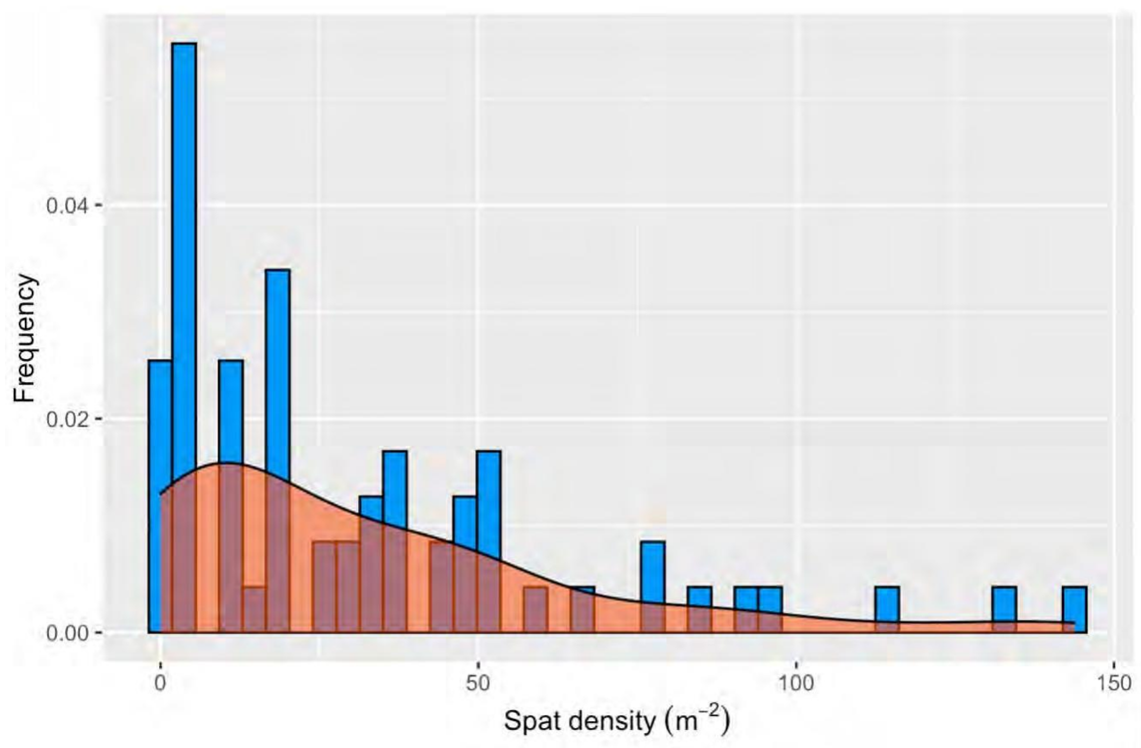

Figure 4: **Frequency histogram (blue) of spat densities. The smoothed continuous distribution is overlaid in orange.**

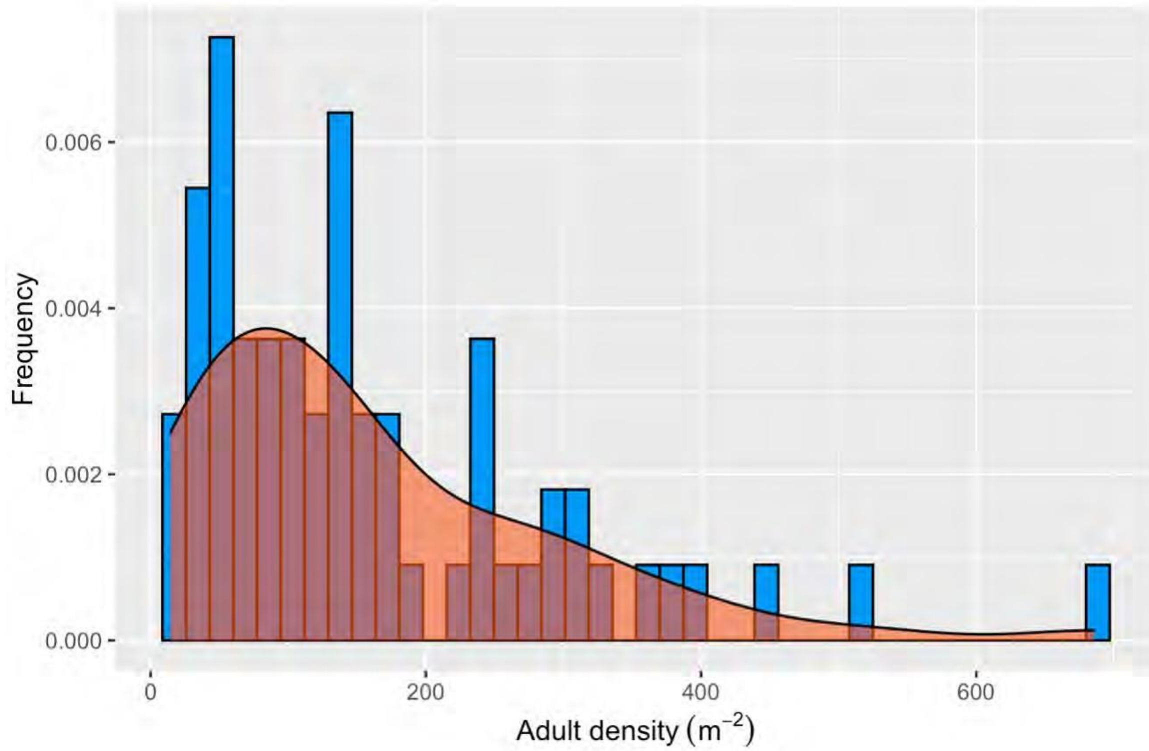

Figure 5: **Frequency histogram (blue) of adult densities. The smoothed continuous distribution is overlaid in orange.**

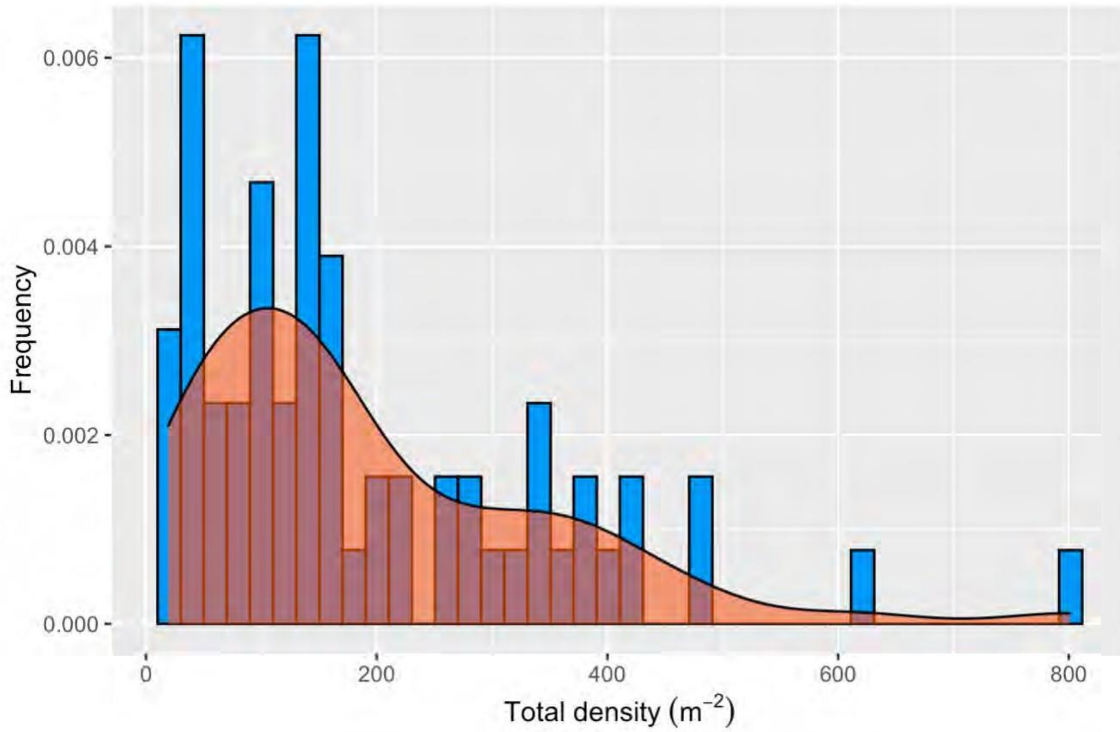

Figure 6: **Frequency histogram (blue) of total (spat + adult) densities. The smoothed contin- uous distribution is overlaid in orange.**

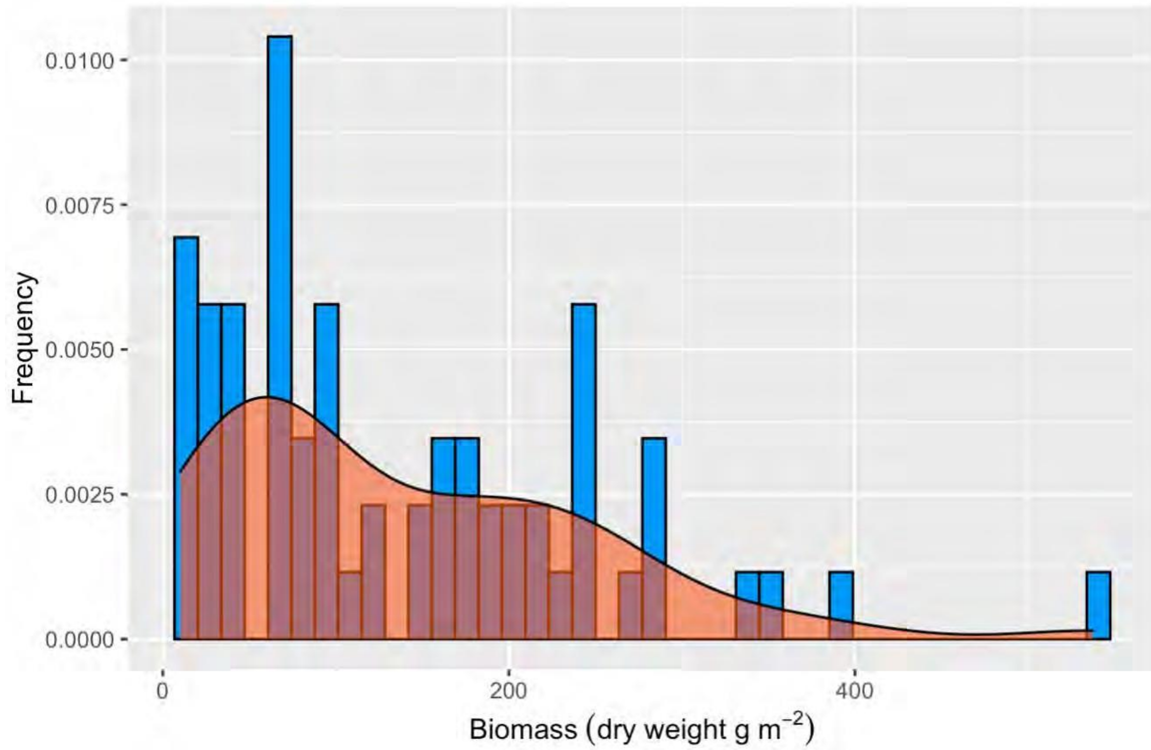

Figure 7: **Frequency histogram (blue) of total biomass values. The smoothed continuous distribution is overlaid in orange.**

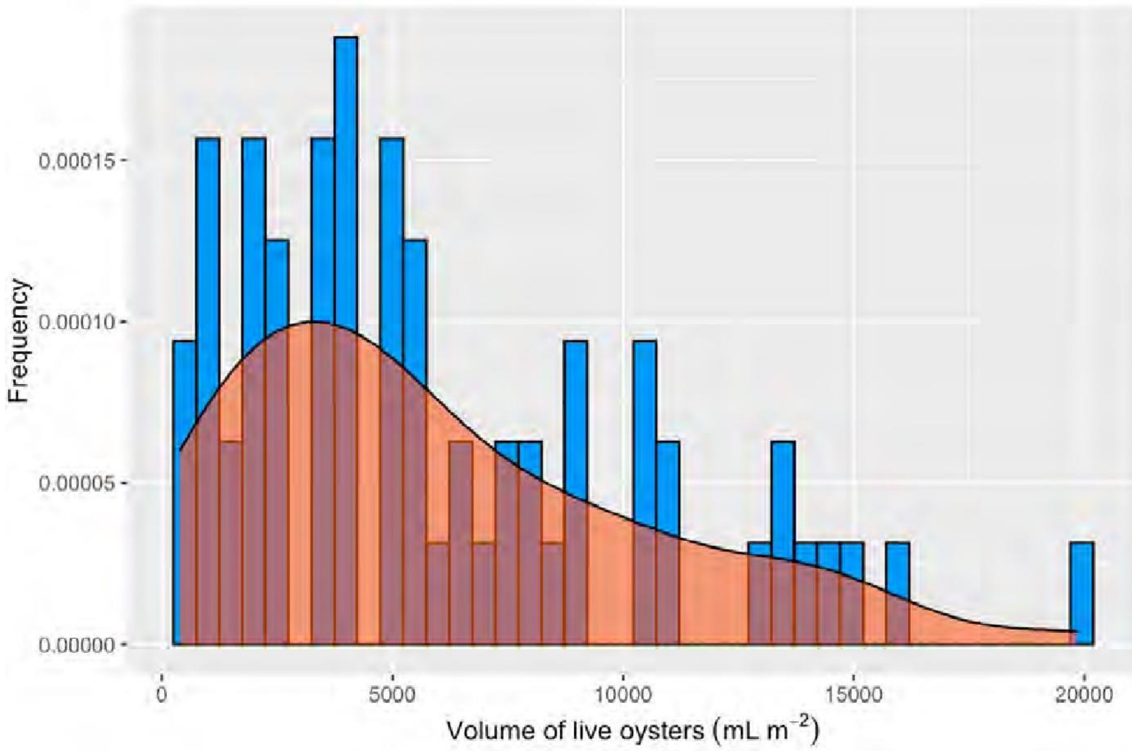

Figure 8: **Frequency histogram (blue) of live shell volumes. The smoothed continuous distri- bution is overlaid in orange.**

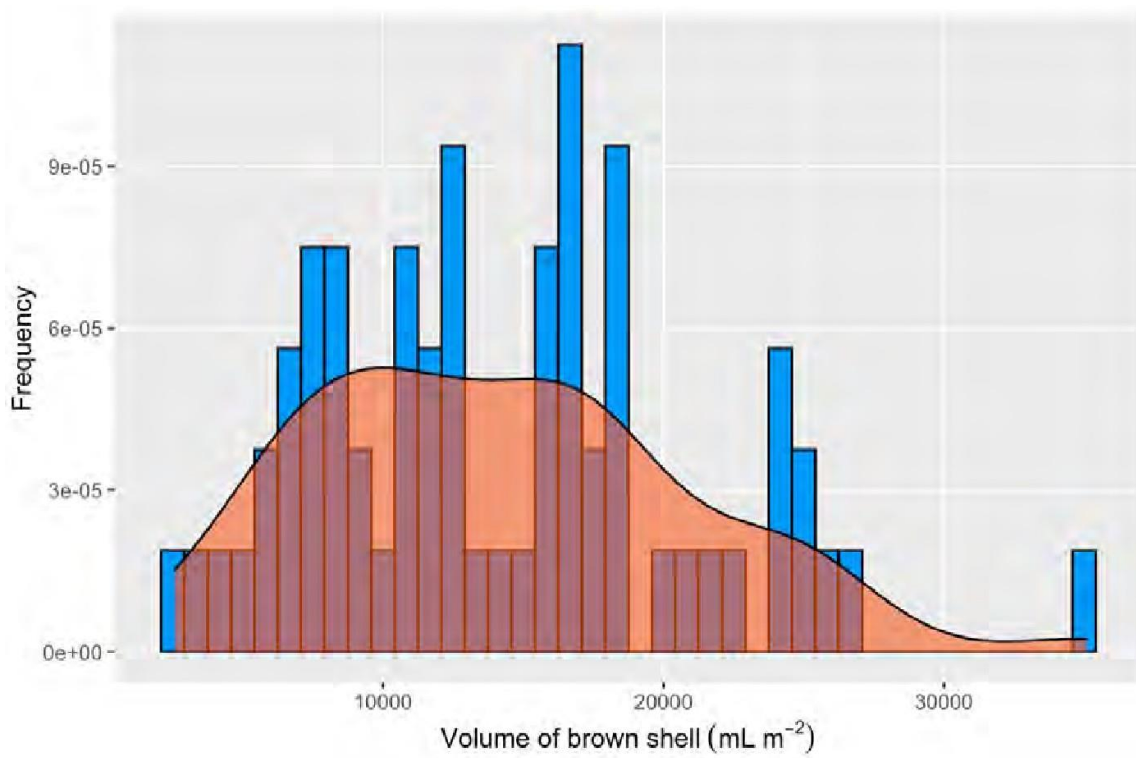

Figure 9: **Frequency histogram (blue) of brown dead shell volumes. The smoothed continuous distribution is overlaid in orange.**

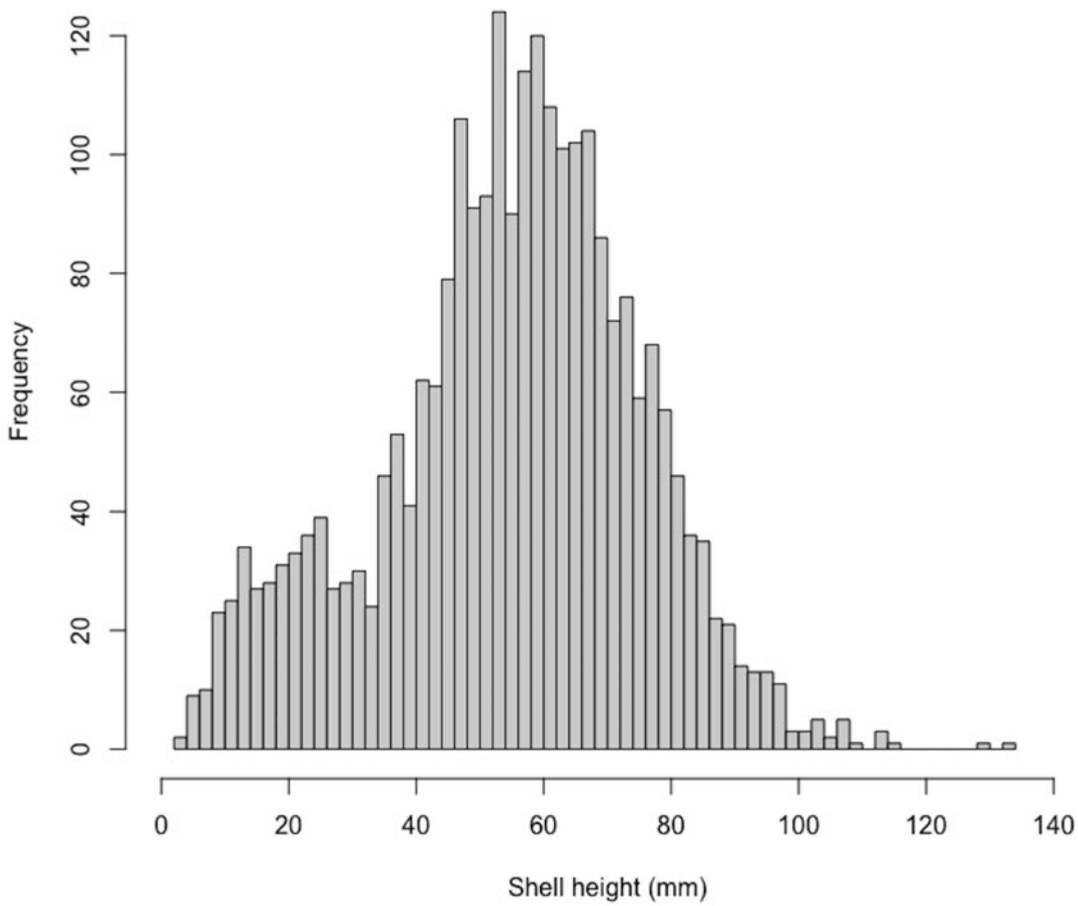

Figure 10: **Size frequencies of all oysters across the reef network.**

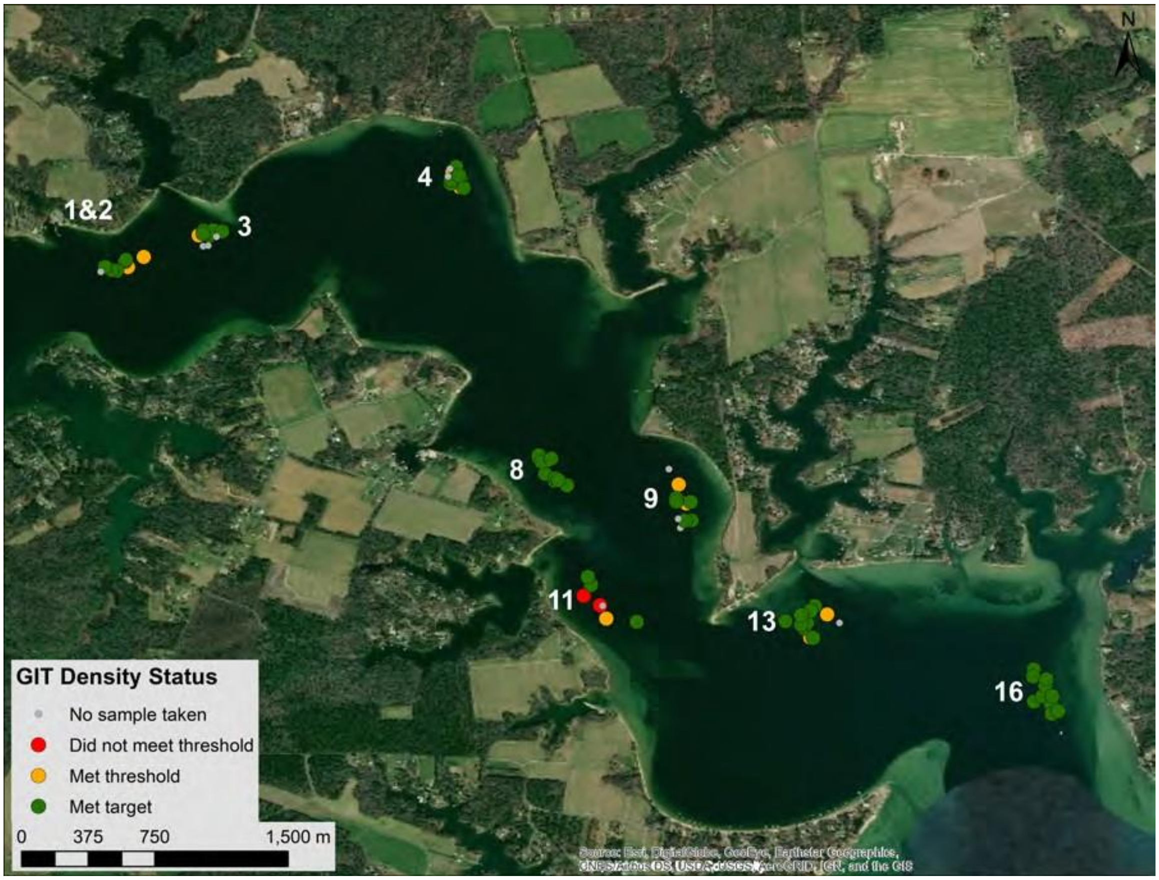

Figure 11: **Oyster density by sample.**

Figure 12: **Oyster densities for spat, sublegal and legal-size oysters by sample for each reef.**

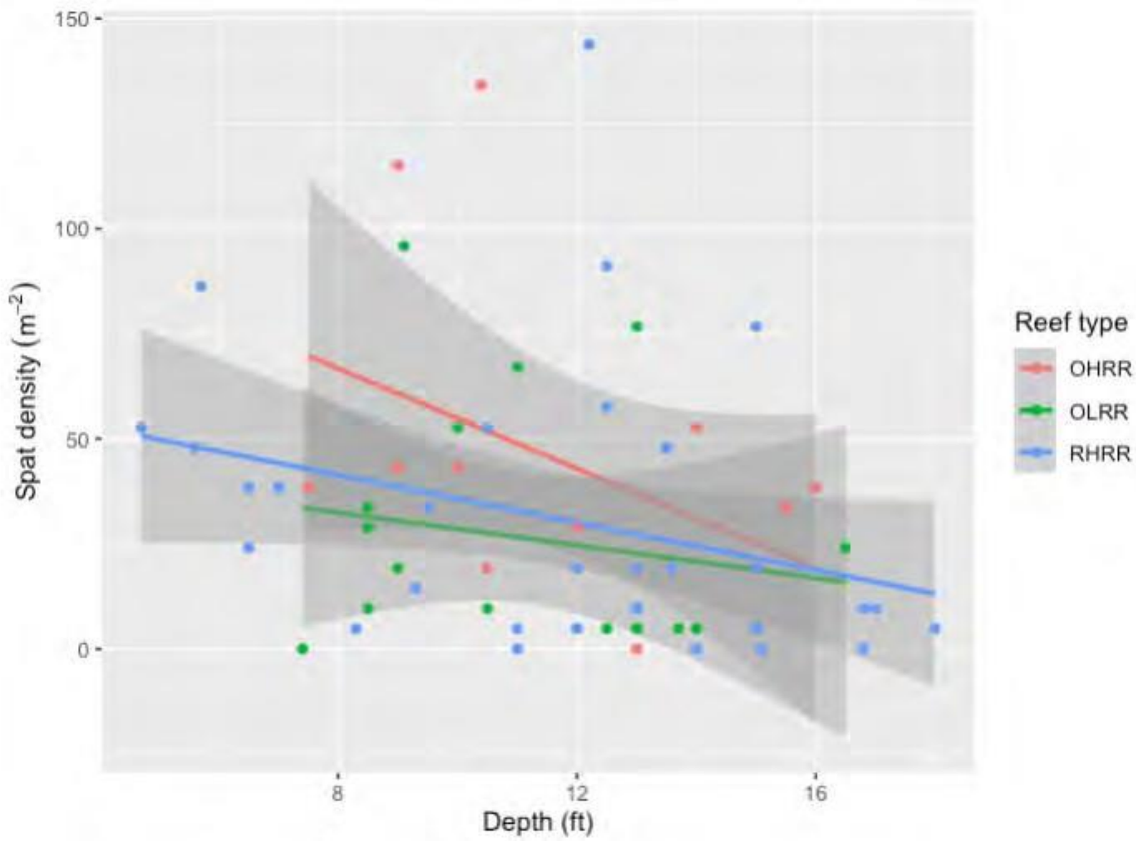

Figure 13: **Spat density by depth and reef type.**

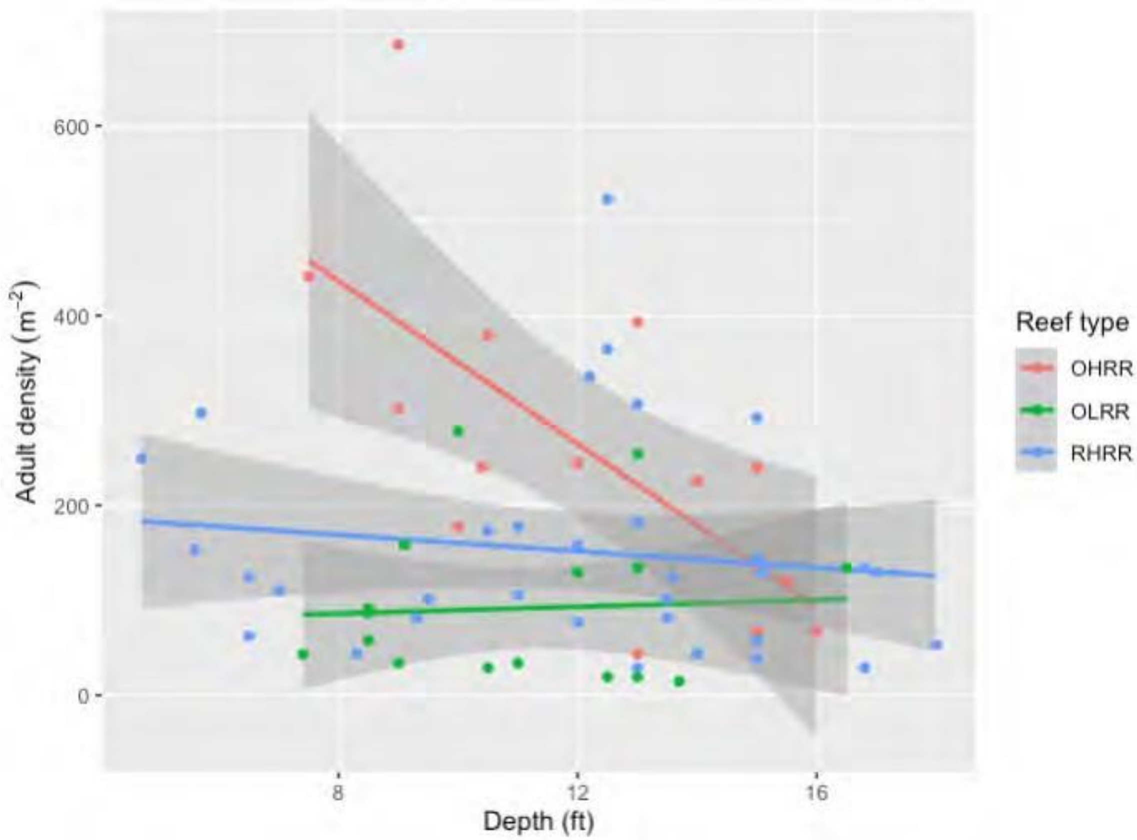

Figure 14: **Adult density by depth and reef type.**

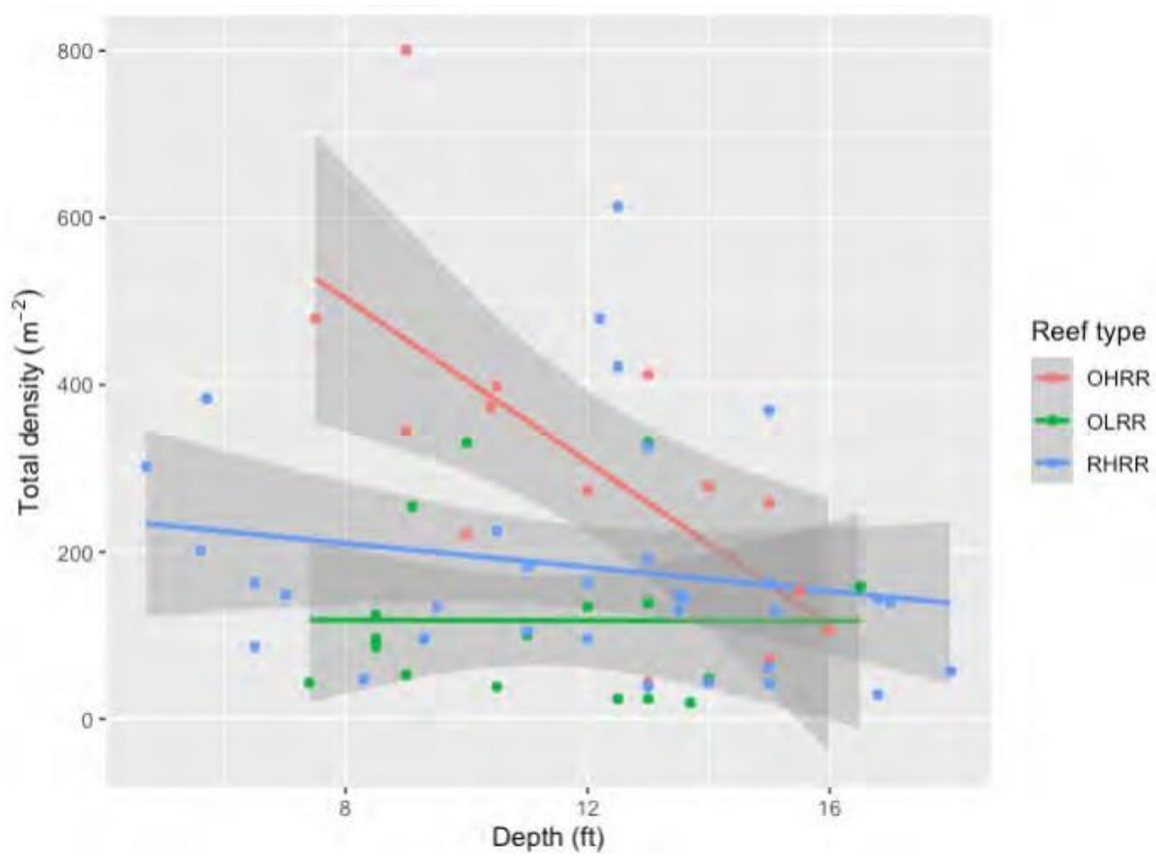

Figure 15: **Total oyster density by depth and reef type.**

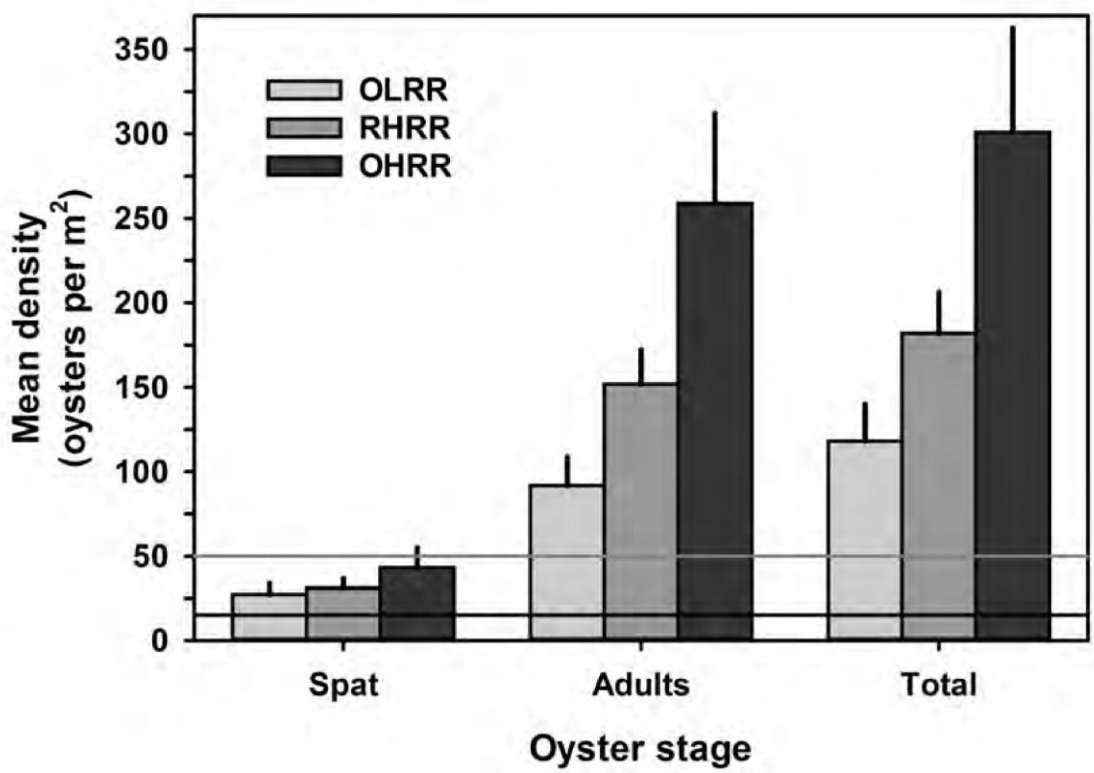

Figure 16: **Oyster density by reef type. The grey and black horizontal lines demarcate the GIT target (50 oysters per m^2) and threshold (15 oysters per m^2), respectively, for total density. Sample sizes were n = 14 for OHRR, n = 17 for OLRR and n = 31 for RHRR. Error bars represent 1 SE.**

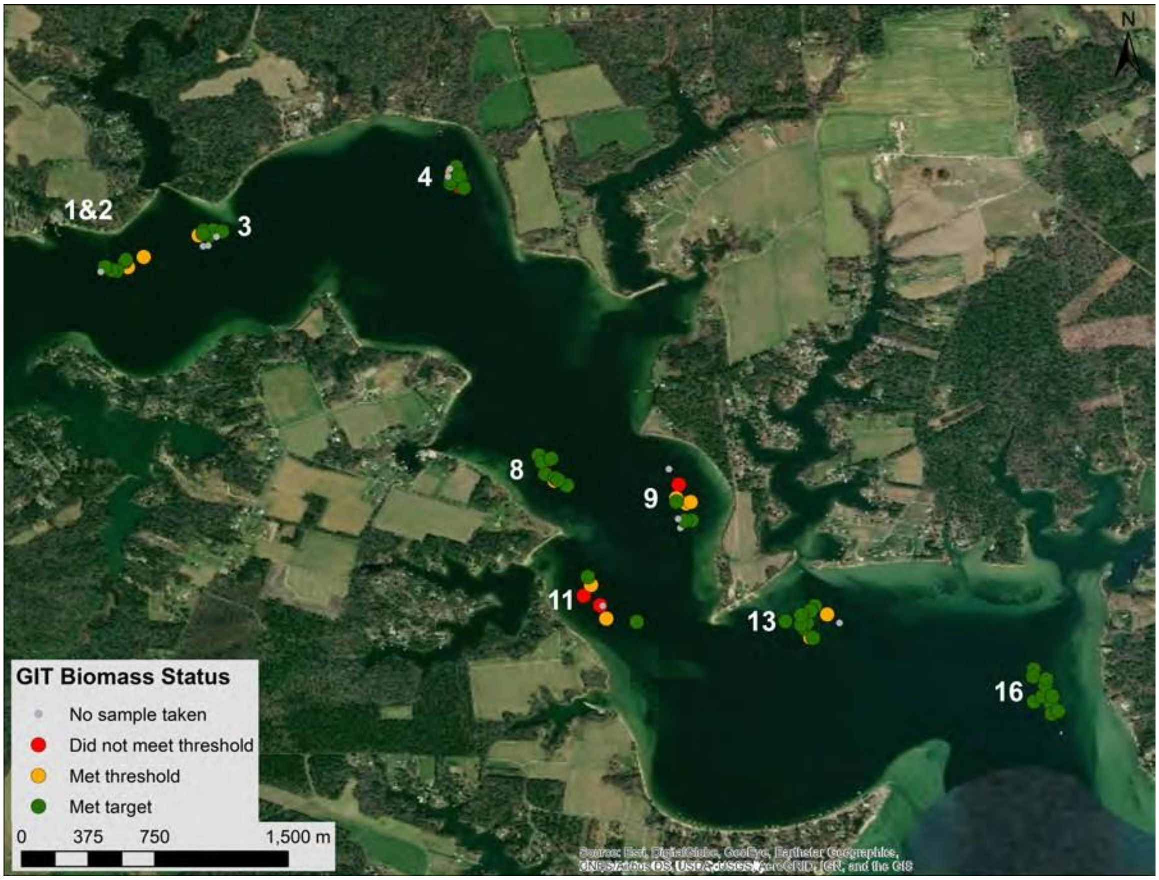

Figure 17: **Oyster biomass by sample for each reef.**

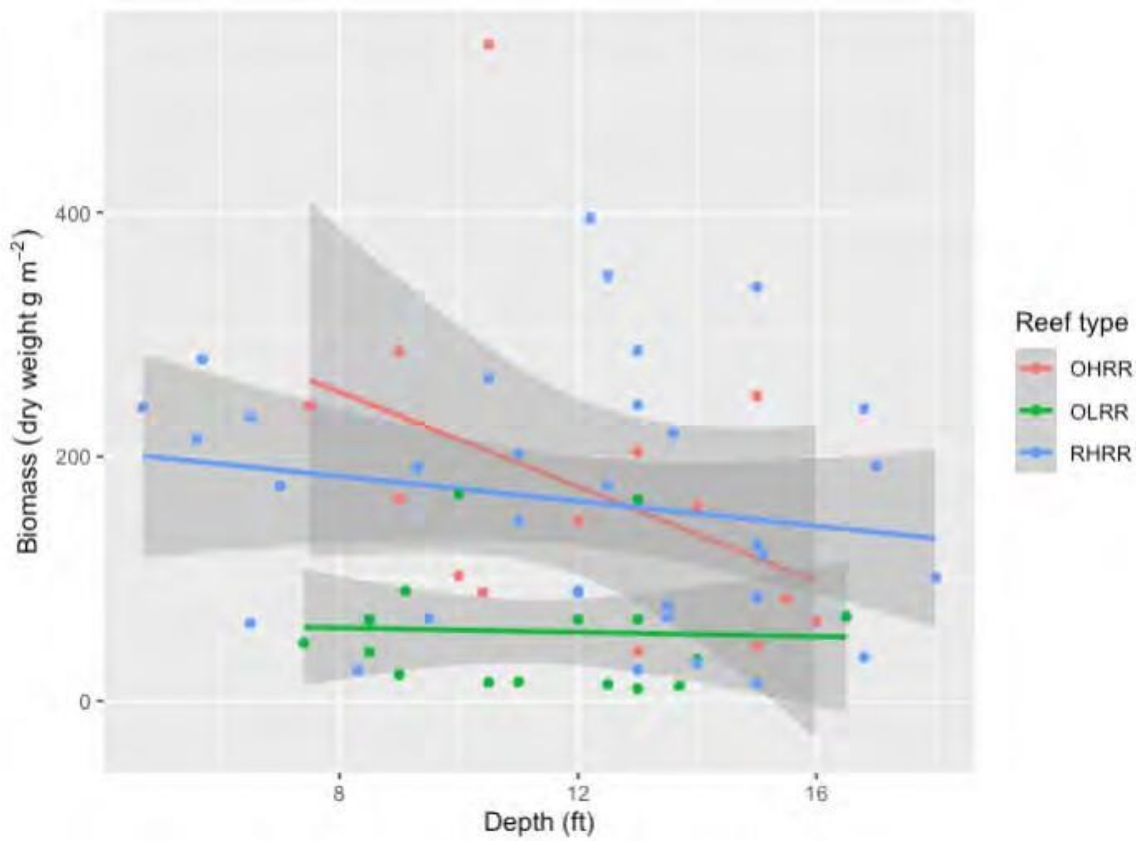

Figure 18: **Total oyster biomass by depth and reef type.**

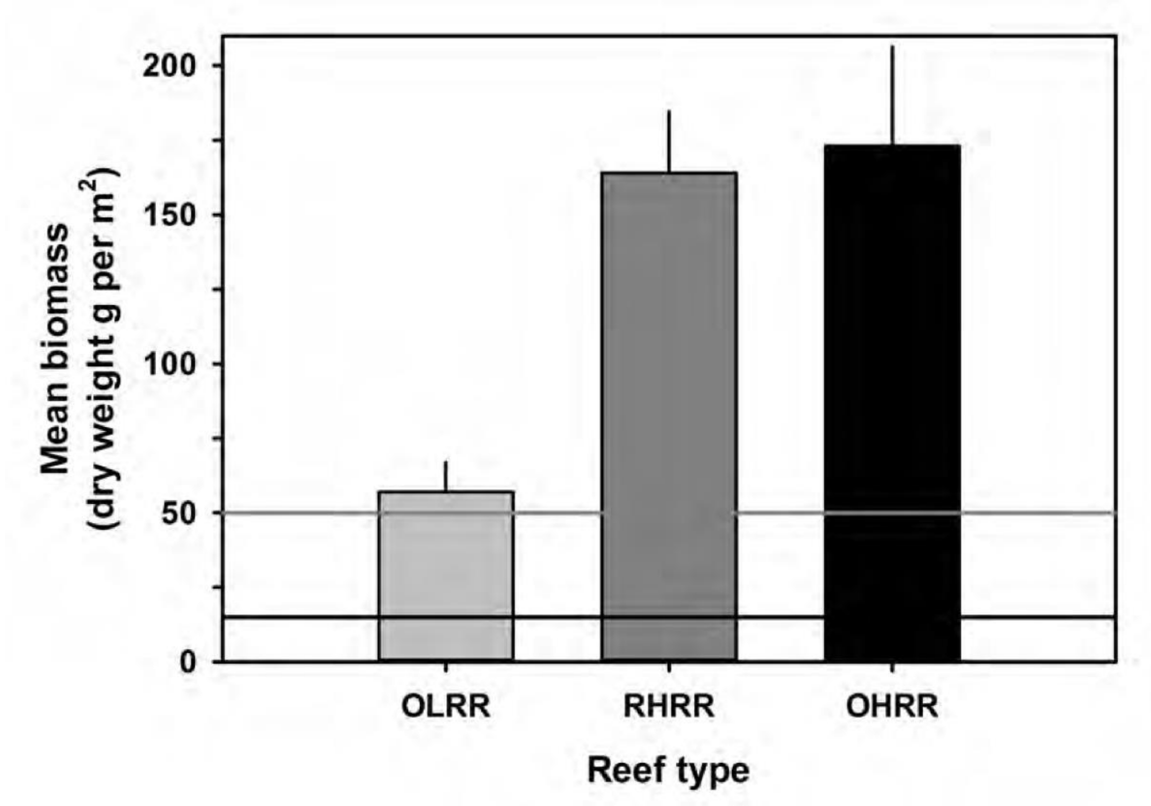

Figure 19: **Oyster biomass by reef type. The grey and black horizontal lines demarcate the GIT target (50 g dry weight per m^2) and threshold (15 g dry weight per m^2), respectively, for total biomass. Sample sizes were n = 14 for OHRR, n = 17 for OLRR and n = 31 for RHRR. Error bars represent 1 SE.**

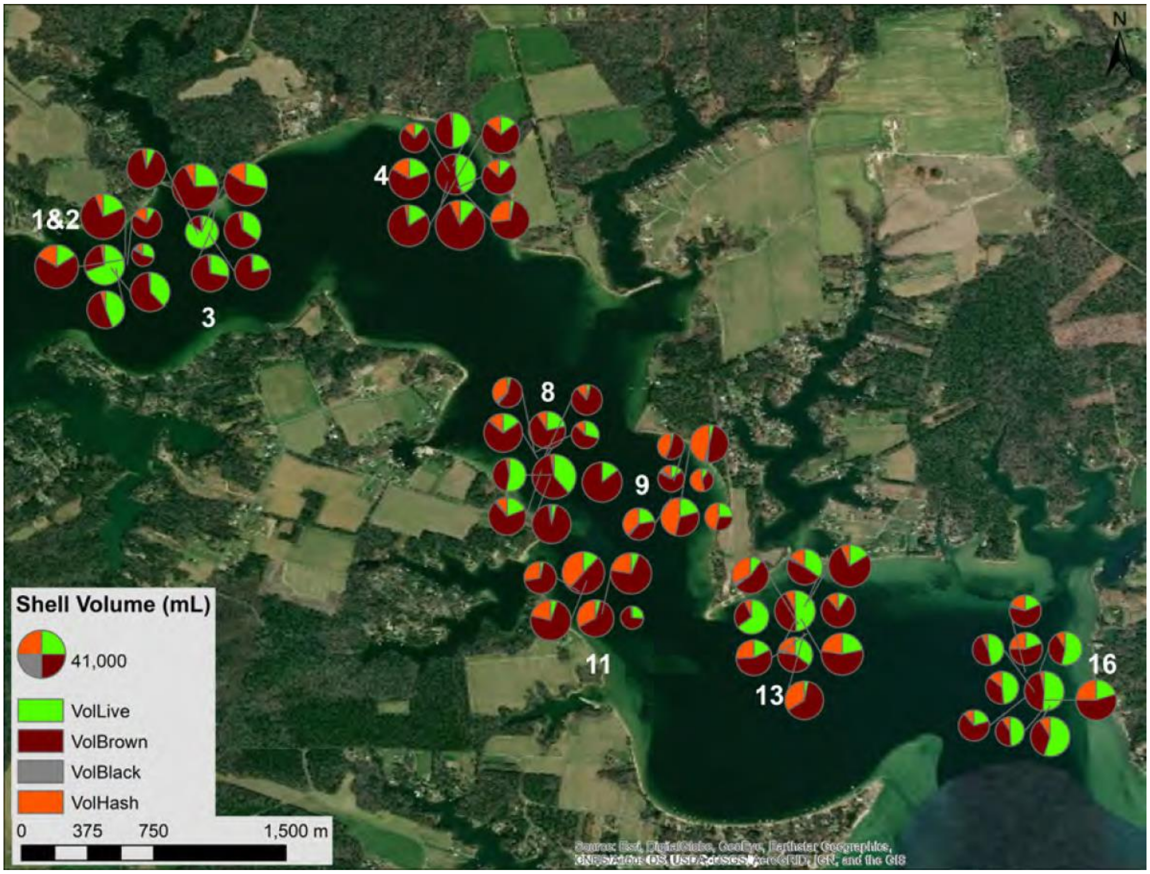

Figure 20: **Oyster volume by sample for each reef.**

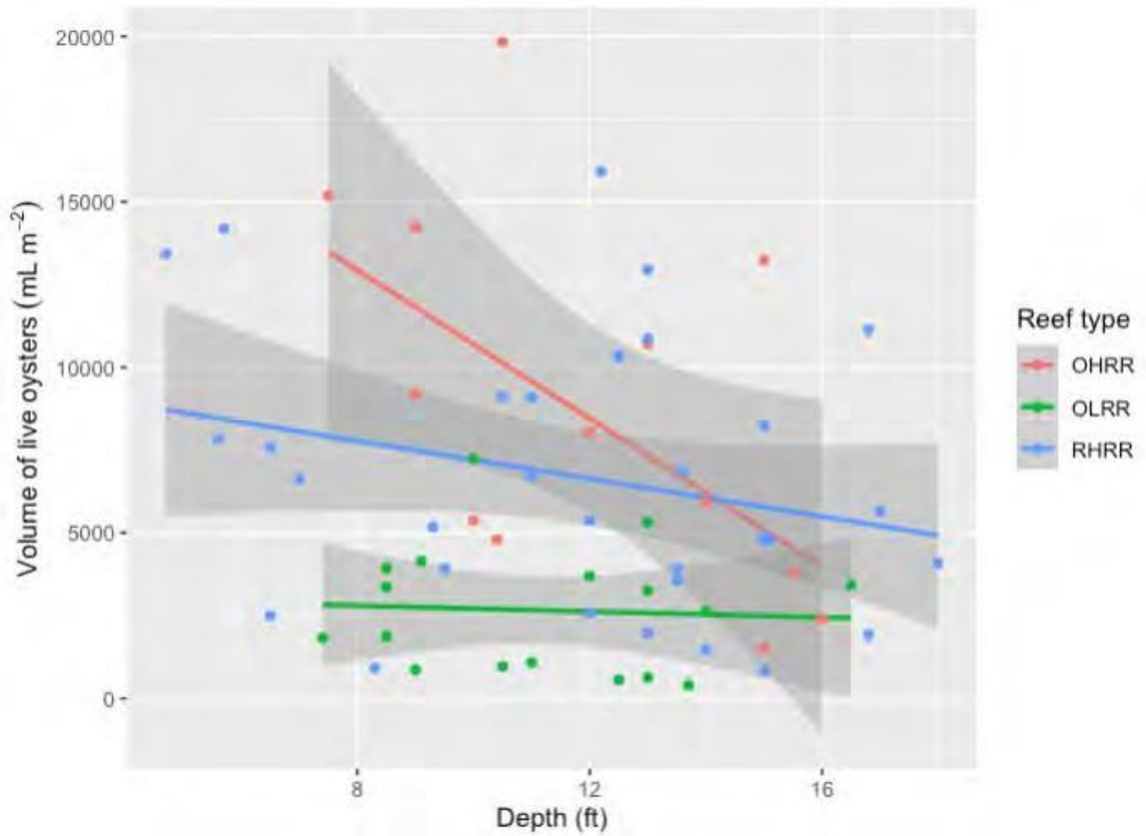

Figure 21: **Live oyster shell volume by depth and reef type.**

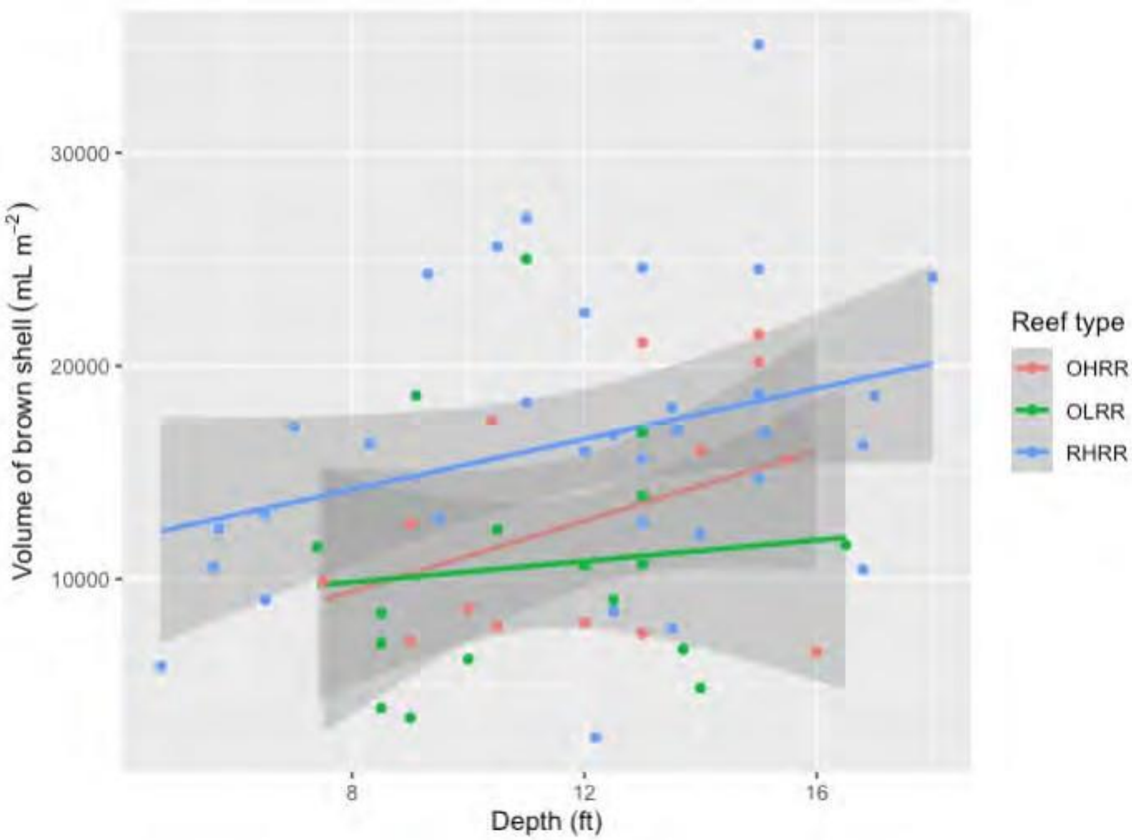

Figure 22: **Brown oyster shell volume by depth and reef type.**

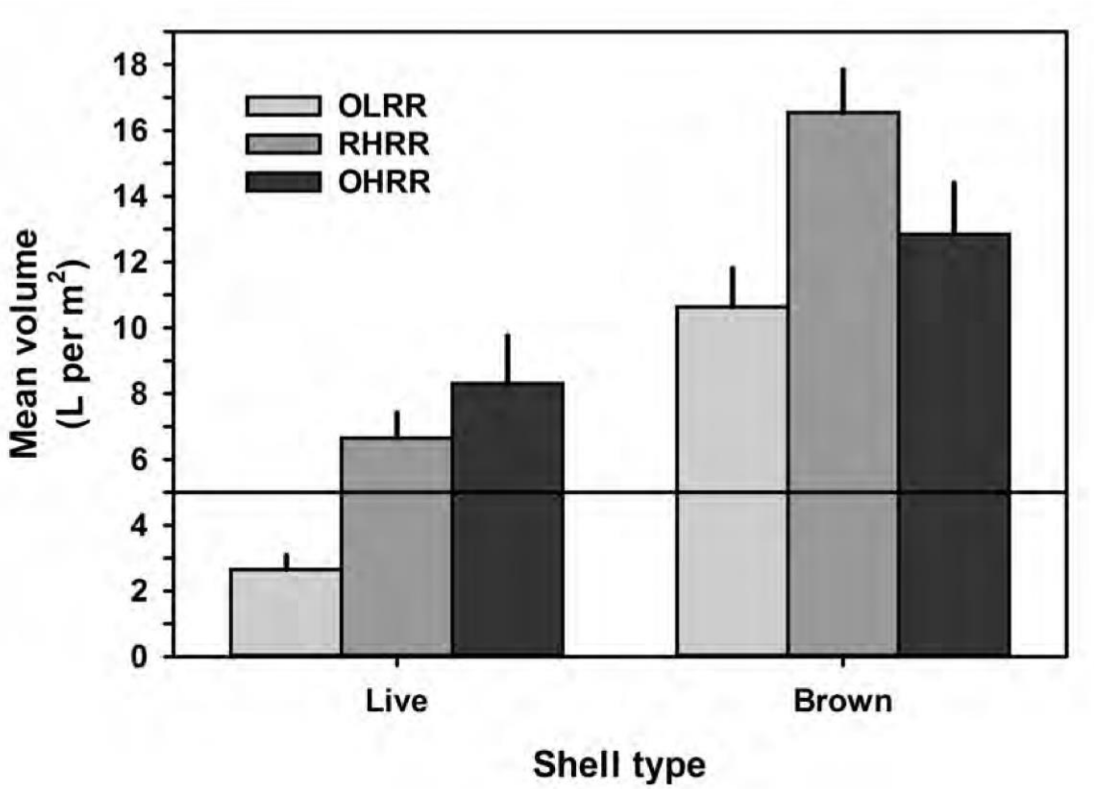

Figure 23: **Live and brown oyster shell volume by reef type. The black horizontal line demar- cates an assumed value for self-sustaining reefs (5 L per m^2). Note that this value includes the sum of live and brown shell volume, such that all reef types exceeded 5 L per m^2. Sample sizes were n = 14 for OHRR, n = 17 for OLRR and n = 31 for RHRR. Error bars represent 1 SE.**

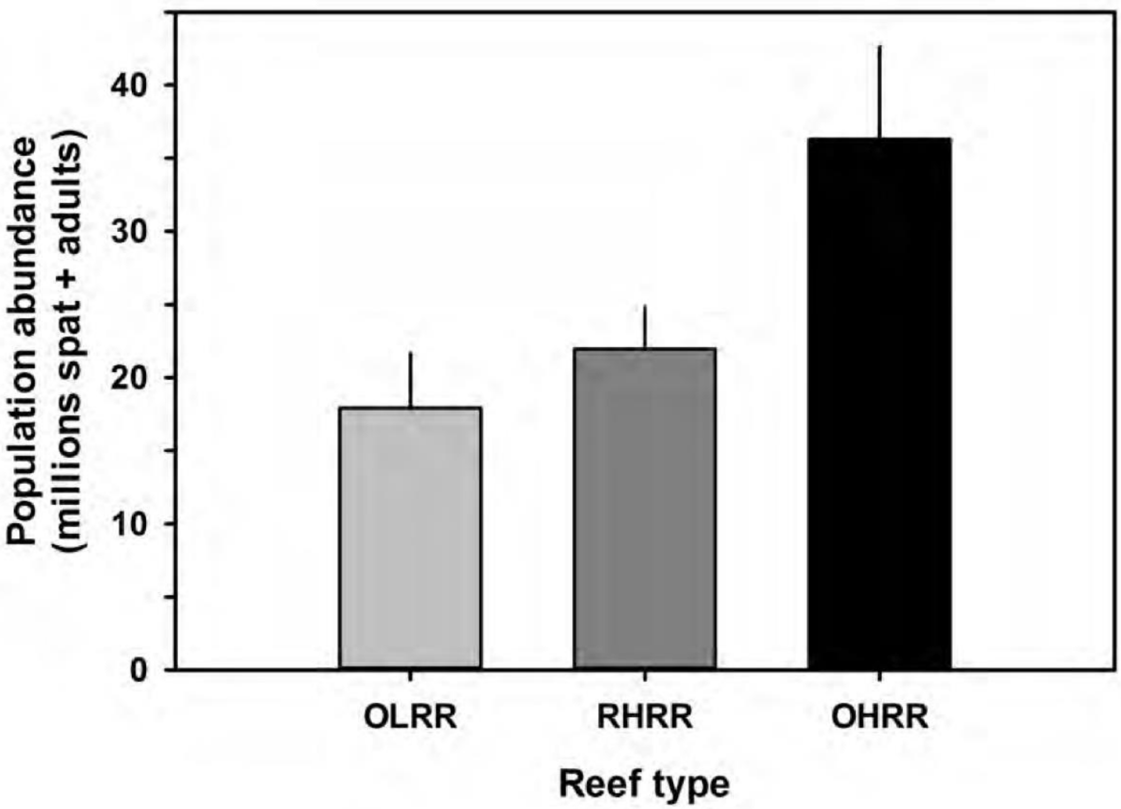

Figure 24: **Total abundance (spat + adults) by reef type. Population abundance across all reef types is estimated at approximately 76.2 million live oysters, most of which are adults. Error bars represent 1 SE.**

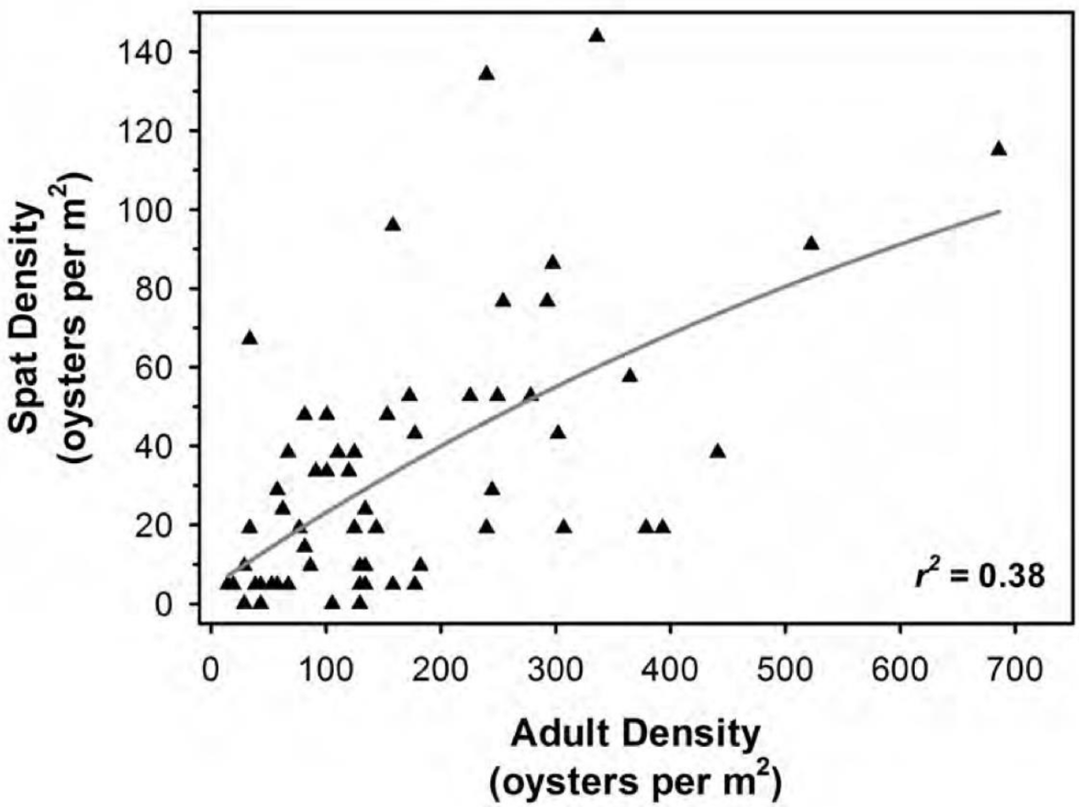

Figure 25: **Spat density as a function of adult oyster density on sampled reef patches.**

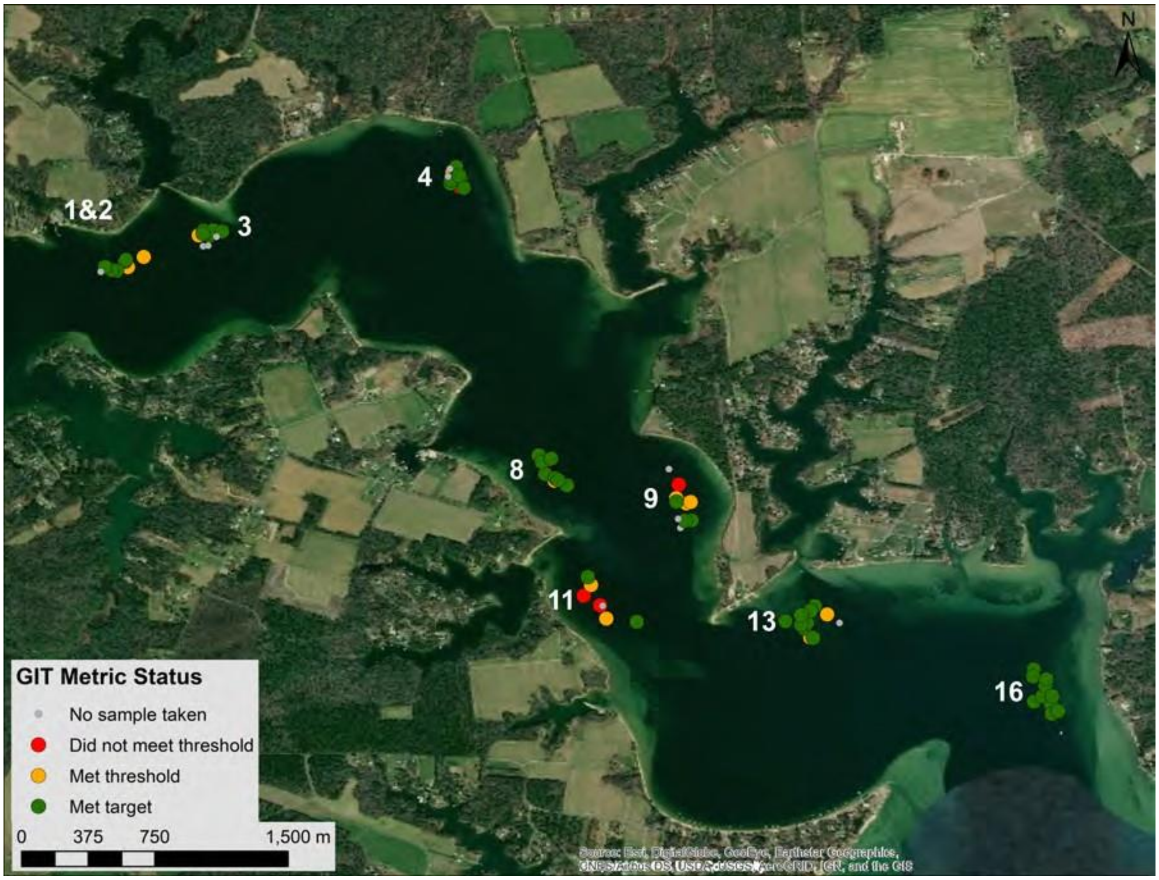

Figure 26: **GIT metrics by sample for each reef.**

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DRAFT SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT

ENVIRONMENTAL APPENDIX

ORIGINAL 2003 DECISION DOCUMENT & ENVIRONMENTAL ASSESSMENT

CHESAPEAKE BAY OYSTER RESTORATION

GREAT WICOMICO RIVER, VIRGINIA

U.S. Army Corps of Engineers Norfolk District
803 Front Street
Norfolk, Virginia 23510-1096

FINAL

DECISION DOCUMENT AMENDMENT

SECTION **704(b)** AS AMENDED

CHESAPEAKE BAY OYSTER RECOVERY PHASE III

GREAT WICOMICO RIVER, VIRGINIA

U.S. Army Corps of Engineers
Norfolk District
803 Front Street
Norfolk, Virginia 23510-1096

July 2003

DEPARTMENT OF THE ARMY
NORFOLK DISTRICT, CORPS OF ENGINEERS
FORT NORFOLK, 803 FRONT STREET
NORFOLK, VIRGINIA 23510-1096

REPLY TO
ATTENTION OF:

OYSTER RECOVERY PROJECT PHASE III,

GREAT WICOMICO RIVER, VIRGINIA

DECISION DOCUMENT AMENDMENT

FINAL DECISION DOCUMENT AMENDMENT
SECTION 704(b) AS AMENDED
CHESAPEAKE BAY OYSTER RECOVERY PHASE III
GREAT WICOMICO RIVER, VIRGINIA
EXECUTIVE SUMMARY

Oyster populations in the Chesapeake Bay have experienced a severe decline beginning in the late 1800's. Today, oyster population levels and biomass are less than 1 percent of historic levels. This decline has been primarily due to overharvesting, parasitic diseases, and loss of habitat. Oysters are a keystone species in the Chesapeake Bay ecosystem. First, oysters are filter feeders and have the potential to significantly increase water quality by removing suspended solids, organic particles, and phytoplankton from the water, which directly increases water clarity and quality. Second, they provide important structure and habitat in the form of oyster reefs, which attract a wide variety of fish species and other aquatic life. Finally, oysters are a commercial species of importance, and their culture and harvest once were a lucrative industry that supported many citizens of the Commonwealth of Virginia and the State of Maryland. This undertaking is so critical to the Chesapeake Bay ecology and economy that it has been described in US News and World Report (Zimmerman, 1997) as one of "Sixteen Smart Ideas to Save the World."

A final Environmental Assessment has been prepared for this project and has been circulated for review. The proposed project is supported by Federal and State resource agencies and has been endorsed by them. The plan is in agreement with goals stated by a scientific consensus (Chesapeake Research Consortium, 1999) and related documents, such as the year 2000 Chesapeake Bay Agreement. Its implementation represents the Corps of Engineers 2003 contributions towards meeting the goals stated in the year 2000 Chesapeake Bay Agreement of increasing the biomass of oysters 10-fold by 2010 (1994 baseline) and to set aside and restore as sanctuaries 10 percent of the historic public ground acreage.

Section 704(b) of the Water Resources Development Act (WRDA) of 1986, as amended by Section 342 of WRDA 2000, authorized the Corps of Engineers to implement projects that include "the construction of reefs and related clean shell substrate for fish habitat, including manmade 3-dimensional oyster reefs, in the Chesapeake Bay and its tributaries in Maryland and Virginia if the reefs are preserved as permanent sanctuaries by the non-Federal interests, consistent with the recommendations of the scientific consensus document on Chesapeake Bay oyster restoration dated June 1999."

The Norfolk District, in cooperation with VMRC (the local sponsor's representative), the Virginia Institute of Marine Science, and other interested Federal and State agencies, oyster scientists, and other individuals assisted in the development of this Decision Document and all recommend it be implemented. The project presented in this report is a portion of a larger multi-year plan of integrated activities throughout waters of the Chesapeake Bay and its tributaries. It also incorporates significant changes in oyster restoration strategy; genetic rehabilitation of the native oyster is now the primary goal. It is widely accepted as the best chance for success in Virginia waters.

Upon completion and signing of the Project Cooperation Agreement in the fall of 2003 and provision of future funding, seeding efforts could begin in fall 2003. This study is an amendment to the prior Decision Document completed by Norfolk District in 2001 that addressed a project built in Tangier and Pocomoke Sound, Virginia. This amendment to the prior Decision Document addresses oyster reef construction in a different geographic location within the Chesapeake Bay - the Great Wicomico River (Figure 3). The total costs are expected to be $2.34 million and will restore approximately 109 acres of oyster habitat and by year 5 are predicted to have an associated oyster biomass of approximately 78,000 kg on the restored habitat alone. The subsequent genetic rehabilitation stocking should magnify this biomass by at least an order of magnitude (current estimates for the Virginia total oyster biomass vary from 2,160,000 kg to 245,000,000 kg). Under a cost-share agreement, the local sponsors, Virginia and Maryland, provide a 25 percent match to any Federal dollars spent on restoration efforts in their respective waters. This plan describes the next phase of the Virginia portion of Chesapeake Bay Oyster Recovery.

FINAL DECISION DOCUMENT AMENDMENT
SECTION 704(b) AS AMENDED
CHESAPEAKE BAY OYSTER RECOVERY PHASE III
GREAT WICOMICO RIVER, VIRGINIA

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FINAL DECISION DOCUMENT AMENDMENT
SECTION 704(b) AS AMENDED
CHESAPEAKE BAY OYSTER RECOVERY PHASE III
GREAT WICOMICO RIVER, VIRGINIA

1.0 INTRODUCTION

This report describes activities that will contribute to the restoration of oyster biomass and populations in the Virginia portion of the Chesapeake Bay and its tributaries by the creation of oyster habitat and related activities. In the previous projects, only one site was considered, and this plan will also recommend construction activities within one specific area of the Chesapeake Bay, the Great Wicomico River (Figure 3).

The proposed project will require subsequent movement of millions of naturally produced "spat-on-shell" to other areas of the Chesapeake Bay in the future. Spat-on-shell are young oysters that have attached themselves, or "set," on oyster shells, their natural substrate, and have metamorphosed from their mobile planktonic larval phase to sessile juveniles. The spat-on-shell movement to other sites and the next phase of construction proposed within the Piankatank River (Figure 2) will be fully addressed in an amendment to this Decision Document. These other areas will be prior USACE- built oyster restoration sites and possibly others. The Commonwealth of Virginia is the local sponsor for this effort with the Norfolk District.

PROJECT PURPOSE

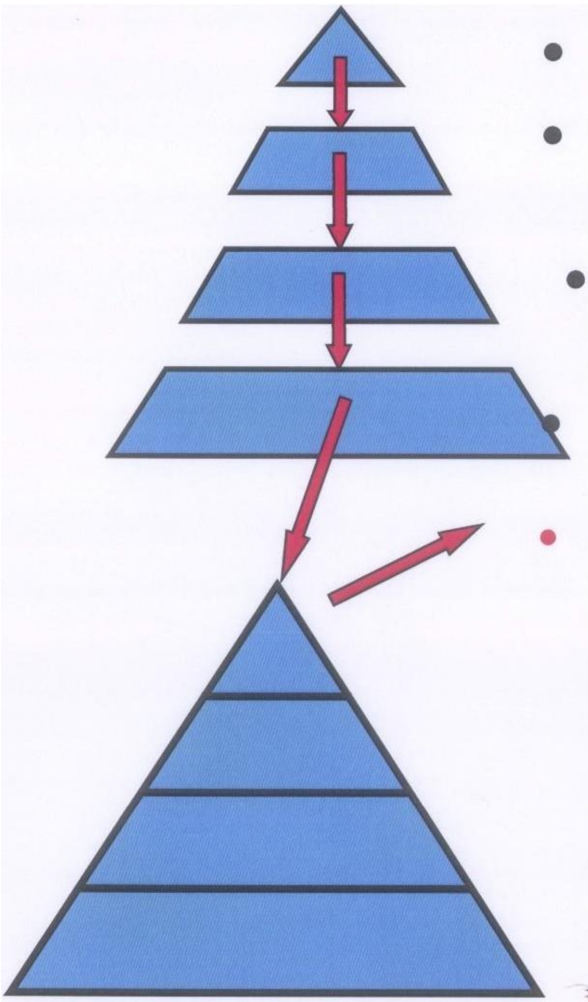
The purposes of the Chesapeake Bay oyster restoration project are to restore oyster habitat and populations to help meet the goal of increasing the biomass of the eastern oyster *(Crassostrea virginica)* 10-fold by 2010, from a 1994 baseline, by the best technically feasible and economically justifiable solutions. This goal was established by the Chesapeake Bay Program (CBP), a multi-State partnership under the aegis of the Environmental Protection Agency, that involves all States and Federal agencies within the Chesapeake Bay watershed (CBP, 2000). To achieve this goal, oyster habitat must be restored and populations of oysters must increase substantially. Construction and related activities to be undertaken in the proposed project could include, but are not limited to, the following: creating new oyster habitat, including high, moderate, and low relief three-dimensional (3-D) reefs out of oyster shell and other appropriate materials; purchasing disease-free spat or disease-resistant adult "broodstock" (reproductively capable) oysters from hatcheries owned by the State or privately owned hatcheries; planting spat or adult broodstock oysters on restored oyster habitat; light shelling, which is the addition of a thin layer of shell to replace shell removed during spat-on-shell movement operations; moving disease-resistant spat-on-shell to other sites within Virginia waters of the Chesapeake Bay to implement the genetic rehabilitation strategy; and supporting efforts to increase disease resistance in the eastern oyster. An adaptive management/monitoring plan has been prepared for this project, and its guidance will be followed in order to ensure the required National Ecosystem Restoration (NER) benefits are achieved and sustained.

Monitoring and adaptive management will continue with joint Federal-local sponsor cooperation throughout the 10-year 704(b) authorization limit and will continue after that under local sponsor funding. Construction of new oyster habitat will create ideal habitat for oysters to settle and grow upon, as well as other organisms associated with oyster reef communities. Planting of restored oyster habitat, when necessary, with disease-free spat or disease-resistant adult broodstock oysters will further help increase oyster populations and biomass, as well as enhance the ecology of the Chesapeake Bay. It is important to note that in order to implement the new genetic rehabilitation strategy, seeding Corps-built oyster reef bases with selected strains of oysters that have some disease resistance, such as the CROSBreed and DEBY strains, will be required, among other actions.

Improving oyster disease resistance via scientific experimentation and genetics may prove to be an important undertaking for the long-term recovery of oyster populations Chesapeake Bay-wide. Seeding the constructed reefs will prove to be of critical importance to restore local oyster populations in areas where the local oyster populations are severely depleted and incapable of producing sufficient numbers of oyster larvae to settle on the newly-constructed reefs. Repeated seeding may be necessary, and it is probable that reseeding will be desired as better strains of disease-tolerant oysters are developed by scientific research. It is critical that a living veneer of oysters be established on the restored reefs to prevent their degradation by fouling organisms, sedimentation, and/or boring sponges. This is especially important in moderate and lower salinity waters, where natural spatset is poor even in good years. Even in high salinity waters, such as much of the Virginia portion of the Chesapeake Bay, oyster larvae abundance is lower than in historic times, due to low local spawning populations, and reefs built in high salinity waters also need to be seeded with juvenile or broodstock oysters. The oysters are the most critical component of a restored reef; however, since current local populations of oysters will not provide sufficient reproductive output or NER benefits, stocking is crucial. To implement the new strategy of genetic rehabilitation (see Figure 1), seeding with selected strains of native oysters will be necessary (Allen, Brumbaugh, and Schulte, 2003; Allen and Hillbish, 2000).

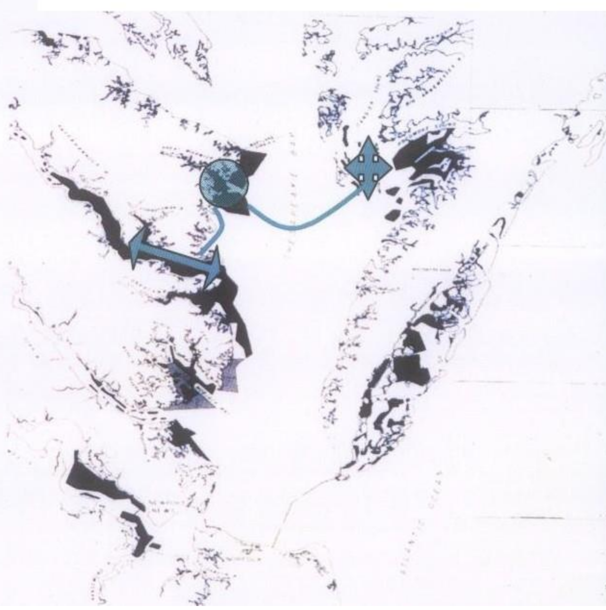
The reef base structures are placed on historic oyster reef footprints, mimic historical oyster reefs, and have proven to be ideal habitat for oyster growth, spawning success, and juvenile protection and survival. For example, in a similar reef construction project in the Great Wicomico River, VA, increases in spatset (young-of-year oyster recruitment) of 250 to 26,000 percent were reported from adjacent harvest areas following reef construction (Wesson, 1998). This reef was seeded with broodstock oysters. Also, this approach to oyster restoration has been endorsed by a consensus of experts in oyster restoration research (Chesapeake Research Consortium, 1999). When unseeded, many constructed reefs may not be able to establish viable oyster populations due to low natural recruitment. An additional technique that will further enhance the oyster restoration effort, and one that will be required for success inVirginia waters, is seeding the restored oyster habitat with either disease free spat or disease-resistant native adult "broodstock" oysters (see Figure 2). This would allow for quicker oyster colonization of the restored oyster habitat areas and enhance whatever natural spatset is occurring in the area. Given current historically low spatsets throughout the Chesapeake Bay, this technique will be considered in following sections of this plan.

Figure 1. GENETIC REHABILITATION -BUILDING THE BIOMASS PYRAMID.



- Step 1 - Develop disease resistant strain of native oyster- DEBY selected strain.
- Step 2 - Seed restored reef with disease resistant selected strain of native oysters - this is the "incubator reef."
- Step 3 - Trap estuary becomes "incubator system" naturally producing millions of disease resistant spat-on-shell.
- Step 4 - Move spat-on-shell for Chesapeake Bay-wide stock enhancement program.
- It is estimated that the increase in biomass from initial stocking to first spat on shell movement could easily increase from 5,000 kg oyster biomass at initial stocking to 1,500,000 kg within the incubator system

Great Wicomico River - First Incubator System



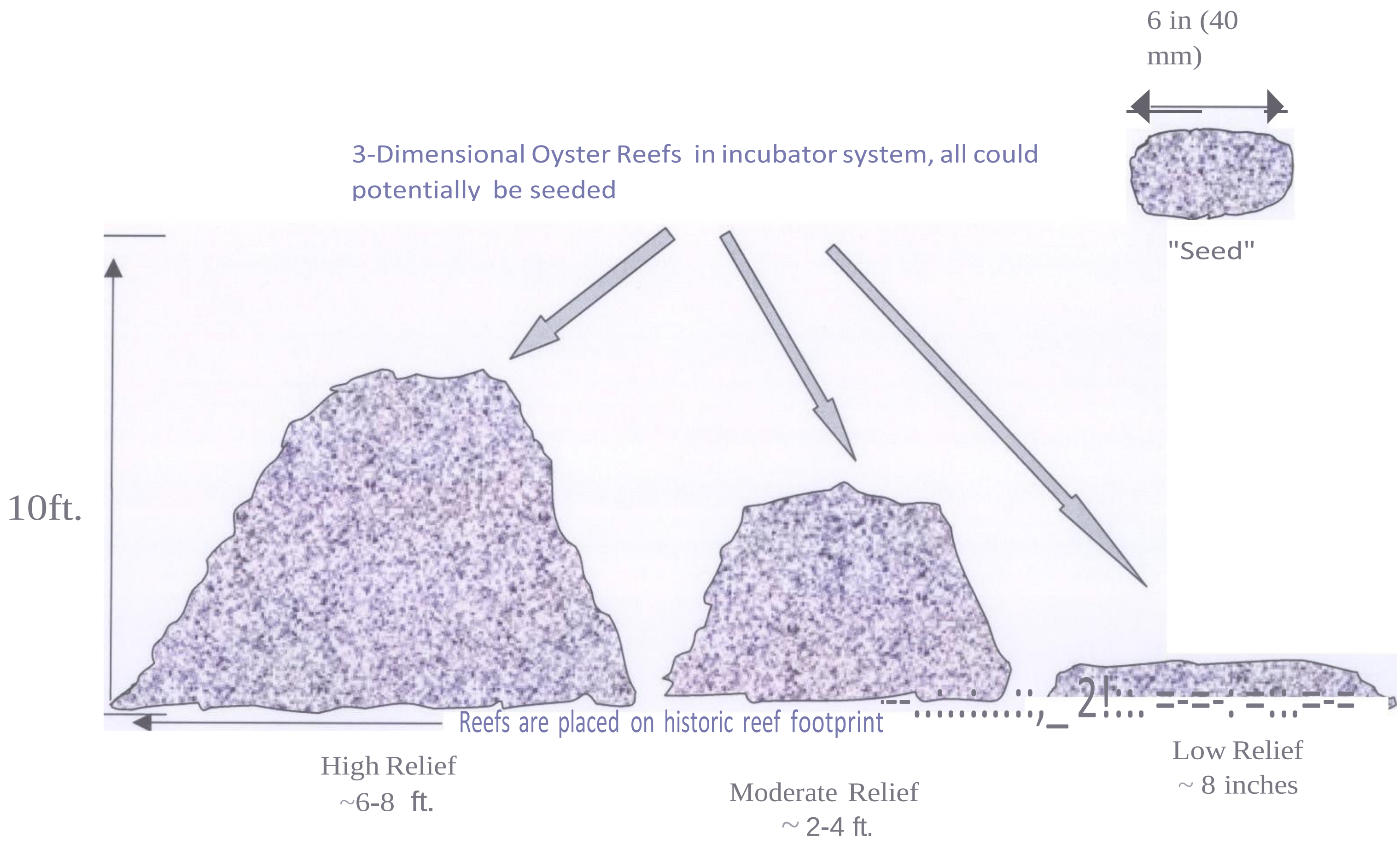


Figure 2. DIAGRAM OF DIFFERENT TYPES OF RESTORED OYSTER HABITAT.
All of these structures could potentially serve as breeder reefs in an incubator system. Spat-on-shell from nearby production areas created by thin-shelling could potentially be moved to other sites in the Chesapeake Bay.

PROJECT AUTHORITY AND SCOPE

The project is authorized under Section 704(b) of the Water Resources Development Act (WRDA) of 1986, as amended through Section 505 of WRDA 1996, which included the Virginia part of the Chesapeake Bay area eligible for environmental improvement. This study is an amendment to a prior Decision Document completed by Norfolk District in 2001. Under the most recent re-authorization of Section 704(b), Section 342 of **WRDA** 2000, the following statements provide guidance on the current effort:

(a) *"The Secretary shall investigate and study the feasibility of utilizing the capabilities of the United States Army Corps of Engineers to conserve fish and wildlife (including their habitats) where such fish and wildlife are indigenous to the United States, its possessions, or its territories.*

(b) *"The Secretary is further authorized to conduct projects of alternative or beneficially modified habitats for fish and wildlife, including but not limited to manmade reefs for fish. Such projects shall include the construction of reefs and related clean shell substrate for fish habitat, including manmade 3-dimensional oyster reefs, in the Chesapeake Bay and its tributaries in Maryland and Virginia if the reefs are preserved as permanent sanctuaries by the non-Federal interests, consistent with the recommendations of the scientific consensus document on Chesapeake Bay oyster restoration dated June 1999.*

(c) *"In carrying out paragraph (b), the Chief of Engineers may solicit participation by and the services of commercial watermen in the construction of the reefs."*

The proposed Section 704(b) project is to restore oyster habitat, populations, and biomass through the creation and rehabilitation of oyster habitat in waters in the Great Wicomico River, including the movement of spat to other areas throughout Chesapeake Bay and its tributaries. According to Paragraph B, above, the US Army Corps of Engineers (USACE) efforts are authorized are to be in agreement with a scientific consensus document. The document, "Chesapeake Bay Oyster Restoration: Consensus of a Meeting of Scientific Experts," Chesapeake Research Consortium, 1999, and amendments to it, require a brief explanation, as the restoration philosophy and goals described therein are critical in determining how the USACE will implement this project. As described in the consensus document, the restoration goal should be to construct and protect a sufficient number of permanent reef sanctuaries Chesapeake Bay-wide that provide the following benefits:

- Restored habitat and ecological function;
- Decreased water quality will improve and anoxia; and
- Sustained fishery existing with no addition of public funds.

Also, a goal was recommended that 10 percent of traditional oyster bar acreage for formerly high-yielding harvest locations, which are public grounds in Virginia and Maryland, be set aside and restored as permanent sanctuaries. This goal has since been refined to include increasing oyster biomass 10-fold by 2010 from a 1994 baseline. Biomass is derived from an estimate of total population that includes all small (<76mm) and market (>76mm) but excludes all spat (young-of-the-year oysters). For Virginia, the current population estimate varies between 2.16 x 10"6 and 2.45 x 10"8 kg (Mann et al., 2003), which equates to a population between 5.31 x 10"9 to 6.00 x 10" 11 oysters.

PROJECT APPROPRIATION

Under the most recent authorization of Section 704(b), as amended Section 342 of WRDA 2000, the total authorization limit is set at $20 million. The Norfolk and Baltimore USACE Districts are working cooperatively and will execute these funds approximately 50-50 for efforts in Virginia and Maryland waters of the Chesapeake Bay and its tributaries. The appropriated funds may be spent between 2001 and 2011. It is expected that while primary construction within the Great Wicomico River will take place in 2003, subsequent activities, including spat-on-shell movement and adaptive management, will take place throughout this timeline.

STUDY SPONSORS, PARTICIPANTS, AND COORDINATION

The Commonwealth of Virginia is the local sponsor for the proposed project, and the Virginia Marine Resources Commission (VMRC) is the local sponsor's representative. Norfolk District has also worked closely with scientists at the Virginia Institute of Marine Science **(VIMS),** the technical advisor to the Commonwealth of Virginia, in the preparation of this Decision Document. Due to the highly technical nature of the proposed project, which includes implementing the results of the latest scientific advances in oyster biology, a collaboration was developed between VIMS and USACE to prepare the formulation methodology and proposed construction activities. The non-profit Chesapeake Bay Foundation (CBF) also provided technical assistance in preparation of the proposed plan.

PROJECT AREA

The Chesapeake Bay watershed covers about 64,000 square miles, which includes portions of six States and the District of Columbia. The Chesapeake Bay encompasses a total of 2,200 square miles and is approximately 200 miles in length. The Chesapeake Bay is a relatively shallow estuary, with an average water depth of about 20 feet, although there are deeper areas up to 174 feet in depth (Lippson and Lippson, 1984). Initial project activities will occur in the Great Wicomico River (see Figure 3) with movement of spat-on-shell to other areas including, but not limited to, prior USACE constructed projects in Tangier Sound and the lower Rappahannock River (see Plate 1 and Plate 2, respectively). An amendment will address most subsequent spat-on-shell movement and additional construction in the Piankatank River. This plan represents the third phase of the 10-year Oyster Recovery effort in Virginia.

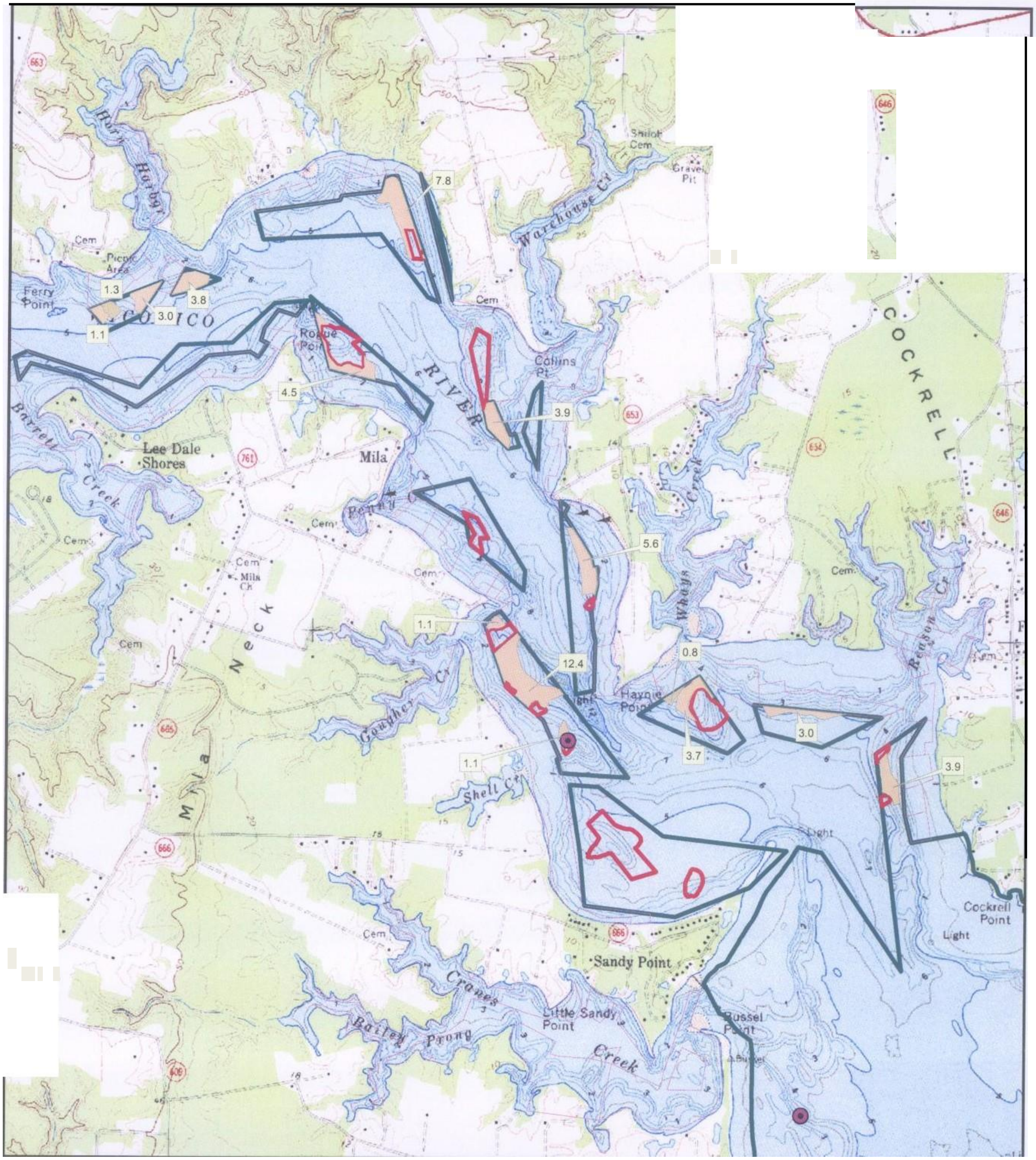


Figure 3. Map of the Great Wicomico River showing potential restoration areas.

PROJECT HISTORY

COMPLETED AND ONGOING PROJECTS

On July 14, 1994, the Department of Defense signed the "Agreement of Federal Agencies on Ecosystem Management in the Chesapeake Bay." Even prior to this agreement, the Department of Defense had been actively involved in restoration activities in the Chesapeake Bay. Department of Defense initiatives have included pollution prevention, water quality assessment, toxics reduction, threatened and endangered species protection, habitat restoration, waste minimization, and ecosystem management (Baltimore District USACE, 1996).

USACE has been actively involved in oyster restoration in the Chesapeake Bay since 1996. The Virginia efforts are shown in the following table. Several reports on these projects are cited in the Reference section. The last project cited is the first project completed under Section 342 of WRDA 2000, and represents the first stage of the 10-year effort under the most recent authorization of Section 704(b), as amended.

Table 1. CHESAPEAKE BAY OYSTER RESTORATION IN VIRGINIA

PHASE	LOCATION	YEAR CONSTRUCTED	AUTHORITY
1	Rappahannock River	2000 and 2001	Section 510
2	Tangier/Pocomoke Sound	2002	Section 704(b)
3	Great Wicomico River	2003	Section 704(b)

LIMITS OF SCOPE

This plan represents the proposed Norfolk District USACE efforts for the next phase of oyster restoration and a significant part of the USACE contribution towards the Chesapeake Bay Agreement (2000) goal of increasing the biomass of the Eastern Oyster 10-fold by 2010 from a

1994 baseline. This goal is further defined with the recommendation that 10 percent of traditional oyster bar acreage in formerly high-yielding harvest areas be set aside and restored as permanent sanctuaries (Chesapeake Research Consortium, 1999). The current proposed project and related activities will be designed and implemented with these two goals in mind. The primary emphasis of the USACE plan is to restore oyster habitat that will be designated permanent sanctuaries. Sanctuary habitat will not be open to commercial harvest, and its closure will be enforced by the Commonwealth of Virginia. If the goals of achieving a 10-fold biomass increase of oysters and 10 percent of the historic oyster grounds set aside and restored as permanent sanctuaries are met, or appear to be achievable within current funding constraints, it may be possible for USACE to engage in other types of oyster restoration that could involve a fishery component in the future. It is important to note that spat-on-shell production areas are not sanctuaries but are needed to produce young oysters for restoration stock enhancement efforts throughout Virginia Chesapeake Bay waters. The current plan proposes a number of acres of spat-on-shell production areas. In addition, the USACE efforts will be directed only at restoring waters within the Chesapeake Bay and its tributaries. While there were formerly significant populations of oysters and oyster reefs that formed extensive public grounds along the ocean side of the Eastern Shore of Virginia and Maryland, the USACE efforts will not address these areas under the current authorizations and plans.

2.0 EXISTING CONDITIONS

WITHOUT PROJECT CONDITION

One High-Relief Reef was constructed in the Great Wicomico River in 1996 by VMRC. This reef is one acre in size, and consists of a series of 6-foot-tall oyster shell mounds over a 1-acre footprint. Another reef was constructed near the mouth of the Great Wicomico River subsequently by VMRC in 1998. This latter reef, although it lies within the Great Wicomico River, lies outside of the area of influence of the proposed project and will not be discussed further.

The particular area of the Great Wicomico River under consideration lies above a spit of land that projects from the southern bank of the river (Sandy Point). This spit, and the angle at which the river flows towards the Chesapeake Bay upstream of Sandy Point, create a gyre that results in the area upstream of Sandy Point to be classed as a trap estuary. Such bodies of water have low tidal exchange rates. Currently, there are 48 acres of oyster reef footprints classed as oyster rock by a 2002 survey. Oyster rock consists of oyster shell and shell pieces, known as fines. Another 78 acres are classed as shell-sand or shell-mud, also historic oyster reef footprints but in a slightly degraded condition compared to the oyster rock areas and are potentially restorable. All lie within the proposed project's area of influence. Current oyster populations, other than on the reef constructed in 1996, are low, due to their poor condition and low levels of natural oyster recruitment and survival to market size. The VMRC-constructed reef was seeded with approximately 750,000 DEBY strain disease-tolerant native oysters in 2002 as part of a scientific research project.

FUTURE WITHOUT PROJECT CONDITION

In the event this project is not implemented, it is highly unlikely that significant recovery of the native oyster will occur in the Great Wicomico River. The one reef that lies within the gyre cannot produce enough larvae to recolonize the surrounding bottom unless it is heavily seeded with broodstock oysters. In addition, the current oyster habitat is in such poor condition that recruitment is limited due to lack of attachment sites for planktonic oyster larvae. The wild stocks of oysters in the local area have demonstrated little resistance to the diseases known as Dermo and/or **MSX,** and the population resulting from the wild stocks, therefore, consists of mostly smaller individuals that are impacted by disease, which as pointed out, compromises their fecundity. The wild stock is also at low density, which further reduces reproductive efficiency. Due to poor survival of the wild stocks, only low population densities are likely to persist on all available oyster habitat throughout the Great Wicomico River, unless the proposed project is implemented. No additional oyster recovery efforts are planned for the Great Wicomico River by other Federal, State, or local entities.

3.0 PROBLEM IDENTIFICATION

Oyster restoration is viewed as critical to the overall environmental health, ecology, and economy of the Chesapeake Bay. It is so important, in fact, it has been described as one of "Sixteen Smart Ideas to Save the World" in US News and World Report (Zimmerman, 1997). According to health indices examined by the CBF, oysters, biomass, populations, and overall health are at extremely low levels. In addition, most of the extant population is made up of small oysters infected with disease. Many of these oysters will die before their third year and before attaining a size much larger than 60 mm shell height. The legal size for commercial harvest is 76.4 mm (3 inches). This disease-related mortality has far more critical ecological ramifications than the decline of the Chesapeake Bay oyster fishery, which is essentially defunct in Virginia waters today. Small oysters provide considerably less environmental benefits via their filter feeding and have much lower fecundity than larger oysters. For example, an oyster with a dry tissue weight of 0.3 grams (about 40 mm shell height) can produce, on average, about 2 million eggs, whereas an oyster weighing 1.0 grams (about 70 mm shell height) can produce, on average, 45 million eggs. This is due to the fact that, as an oyster grows larger, it directs more energy to gamete production. The CBF noted oysters as being in the poorest condition of all ranked parameters in the Chesapeake Bay in the year 2000, which include various types of habitat, fisheries, and water quality parameters. And, in 2001, the CBF rated oysters at a 2 out of 100, with 100 representing the oysters at pre-colonial levels.

Oyster populations have declined dramatically Chesapeake Bay-wide since the tum of the century, largely due to overharvesting, parasitic diseases, loss of habitat due to shell mining, oyster harvesting practices that destroyed oyster reefs, and declines in water quality (Figure 4). Current oyster populations are at 1 percent of historical levels (Newell, 1988). This destruction of Chesapeake Bay's oysters has resulted in considerable adverse ecological effects, as well as the near-total collapse of Virginia's and Maryland's commercial oyster industries.

OVERHARVESTING

Persistent overharvesting, with its concomitant impacts on broodstock size and composition, oyster habitat, and oyster genetics, has been the single most important factor in reducing oyster numbers to their currently extremely low population and biomass levels throughout the Chesapeake Bay. As stated earlier, the CBF rates oyster health and populations as 2 out of 100 in 2001, which equates to a population level at l percent of historic levels (Newell, 1988). Low population levels have persisted for decades and show little, if any, signs of natural recovery. Ongoing harvest of market sized oysters continues to impact oyster populations (Hargis and Haven, 1999).

During pre-colonial times, oysters were abundant, which was the normal oyster population level in the Chesapeake Bay. During the early colonial period, settlers adapted harvest techniques used by Native Americans and began to use up to 18-foot-long hand-held tongs to harvest oysters from reefs throughout the Chesapeake Bay. Oysters were an important food source for the colonists; in fact, during the Revolutionary War, oysters were a staple food for soldiers (CBF, 2000). While harvests of oysters likely had an effect on oyster populations within the Chesapeake Bay, little hard data are available from this period. Overall, harvest pressure on oysters was relatively low until late in the 18th century.

Harvest pressure on oysters began increasing as more people settled in the area and the development of sterile canning and more advanced transportation systems, such as railroads, which enabled oysters to be packed and shipped long distances. Various technological advances in oyster harvest techniques, such as use of mechanical oyster dredges brought in by New England oystermen, steamboats, and steam engine operated equipment enabled harvest levels to increase tremendously. Unfortunately, these larger dredges and more advanced equipment also "mined" the large 3-D oyster reefs, destroying their complex structure, resulting in flat beds of oysters distributed on thin layers of shell or "cultch" scattered over the open bottom of the Chesapeake Bay. The conflicts between the local watermen using tongs to harvest oysters and the newly-arrived oyster dredgers, at times, escalated into fights that were the beginning of events that have been referred to as "The Oyster Wars."

In the mid-1800's total oyster harvests in the Chesapeake Bay approached, and sometimes exceeded, 20 million bushels per year. However, by the mid-1800' s, the poor condition of the oyster reefs was noticed, and legislative attempts, including seasonal restrictions and gear limitations, were made to reduce the damage. Attempts were also made to assess oyster stocks. For example, the US Coast Guard extensively surveyed Maryland waters in the late 1870's, and the result of this survey was the first real indication the oyster fishery was in trouble. It was noted in the survey that oyster beds in Tangier and Pocomoke Sound, some of the most productive areas in the Chesapeake Bay, were severely depleted from the previous 30 years' level.

During a survey of Tangier sound performed in 1878, only 1 oyster to 3 square yards of beds was found. The surveyor, Francis Winslow, who had also served as an officer in the Maryland oyster police, prepared detailed reports. These reports documented that lax enforcement of culling laws that prevented harvest of oysters less than 3 inches in length, as well as that the failure to reseed the oyster beds with oyster shells, would soon doom the oyster harvest industry to failure.

Oysters were being taken out of the Chesapeake Bay at a rate far greater than they could be replenished by natural reproduction (Wennersten, 1981). Despite these early warnings, harvest activity continued virtually unrestricted, due to mismanagement, lack of enforcement, and the lack of the political will to address the problem in an effective fashion. Again, warnings about potential problems with the high (and unsustainable) harvest levels were made, this time by the foremost oyster biologist of his day, William K. Brooks. In 1891, he published a book entitled "The Oyster," which took a strong stand against the public fishery and argued for oyster aquaculture as a means of establishing a sustainable oyster fishery. Williams stated "It is a well-known fact that our public beds have been brought to the verge of ruin by the men who fish them... all who are familiar with the subject have long been aware that our present system can have only one result-extermination." His advice was largely ignored. In fact, at this time, the oyster fishery was so valuable that watermen dubbed them "Chesapeake Gold" (CBF, 2000). These were the peak years for the Chesapeake Bay oyster fishery.

Shortly after, in the late 1800's and early 1900's, harvest levels began to fall, despite efforts of watermen to maintain their high harvest of the oysters. Neither the watermen nor the States of Virginia and Maryland were willing to cooperate on a policy that would conserve the rapidly diminishing oyster populations of the Chesapeake Bay (Wennersten, 1981).

It was only after harvest levels began to fall significantly over successive years that Maryland and Virginia attempted to address the problem. Aquaculture, the planting of seed oysters in private grounds, began to be encouraged. In 1894, Virginia set aside 110,000 acres of barren ground for leasing and 143,000 acres to remain as public oyster grounds. Virginia also passed legislation to encourage oyster aquaculture on the private, leased grounds. Maryland followed in 1906 with the passage of the Haman Oyster Act, which allowed private planters to lease 30 acres in the tributaries, 100 acres in Tangier Sound, and 500 acres in the Chesapeake Bay's open waters. Unfortunately, the oyster planters, as people in the oyster aquaculture business were called, found their leased grounds under constant threat of poaching by oystermen. The resulting conflicts that pitted oystermen against oyster planters, the law, and each other, often escalated into pitched battles, sunken ships, and lost lives, have been called the "Oyster Wars" of the late 1800's and early 1900's.

By the early 1900's, total oyster harvests were less than half of the peak years of the late 1800's, and seemed somewhat stable. In Virginia, this harvest equated to about 4 million bushels of oysters per year (Virginia Department of Environmental Quality [VDEQ], 2000). At this time, however, the complex 3-D structure of all oyster reefs were long destroyed, and most oysters in the public grounds were widely distributed over very thin layers of cultch. This was due to destructive harvest practices, and the condition of the beds would continue to worsen. By the early 1930's, oyster harvest levels began to decline again and continued steadily through the early 1980's, when harvest levels seemed to stabilize, though at a lower level than the early 1900's (National Marine Fisheries Service [NMFS] website). At this time, even though far reduced from the peak harvest levels of prior years, the oyster fishery was still the most important fishery in the Chesapeake Bay. For example, the 1987 Virginia oyster harvest had a dockside value of almost $12 million dollars.

During the late 1980's, oyster harvests began to decline again, and current oyster harvests Chesapeake Bay-wide declined precipitously to less than 100,000 bushels per year in Virginia waters and about 500,000 bushels per year in Maryland waters, for a total dockside value of approximately $10 million dollars. Harvest levels continue to decline Chesapeake Bay-wide and the modem-day oyster fishery is but a tiny remnant of its historic levels. The most recent year that data was available, 1999, showed an oyster harvest of approximately 16,320 bushels from Virginia waters. The current extremely low harvest level is directly related to the current low oyster population levels Chesapeake Bay-wide. Today, the majority (90 percent or more) of the oyster meats packed by the few (40 in 2000, mostly small-scale operations) shucking and packing operations left in Virginia are imported from out-of-State. Shucking houses in Virginia have declined in number and size along with the harvests. According to the latest data available, harvest operations in Virginia waters can employ only 7 watermen on a full-time basis. In the year 2000, 255 licenses of various types were sold to harvest oysters, the majority (205) being for hand tongs, with the next largest category (34) being for dredge.

To summarize the impact of overfishing, in 1904 Virginia's public ground harvest of oysters was about 7.6 million bushels of oysters; by 1930 the public ground harvest was approximately 1,000,000 bushels; by 1957 the harvest was about 586,000 bushels; and a steady decline has continued. It is important to note the vast majority of this decline occurred before either of the two diseases that had a significant negative impact on Chesapeake Bay oyster populations, Dermo and MSX, were discovered in the Chesapeake Bay, and they began to take their toll on the native oyster. In conclusion, as an economic entity Virginia's public oyster resource outside of the James River seems economically defunct (Hargis, 1994), and this decline can be attributed primarily due to overfishing (see Figure 4).

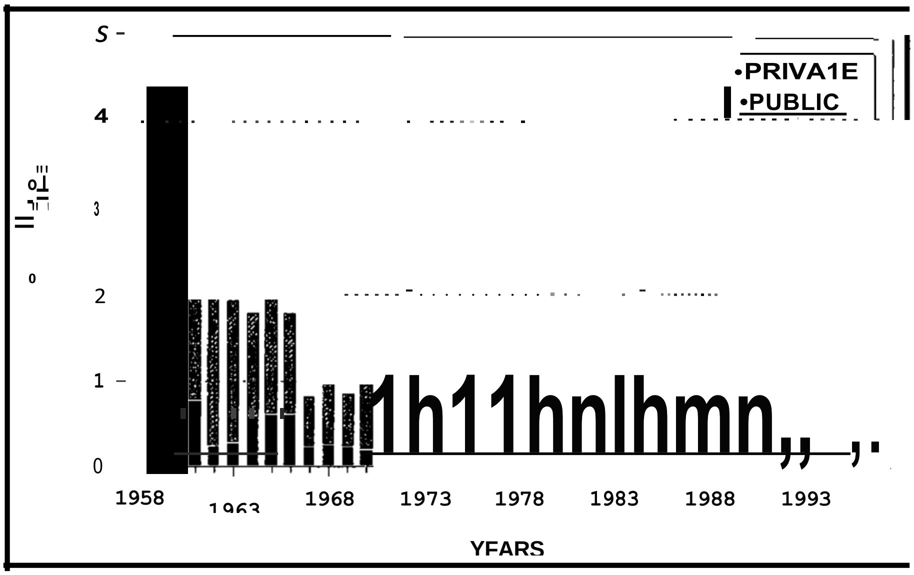


Figure 4. ILLUSTRATION OF THE DECLINE OF THE STATE OF VIRGINIA'S OYSTER LANDINGS. Of interest is the private leased grounds, which were managed in a more sustainable fashion, were overall much more productive than the "commons" public fishery. This suggests a more managed approach may well be required for any future fishery that develops as a result of oyster restoration.

WATER QUALITY

Oysters are filter feeders, and an adult oyster (75 mm shell height) is capable of filtering up to 60 gallons of water a day, possibly more under good conditions (Jordan, 1987). This filter feeding improves water quality by removing suspended sediments, phytoplankton, nutrients, and organic particles from the water column, which promotes water quality and clarity. Water clarity was once far better than it is today in the Chesapeake Bay, and this was to a significant degree due to the historic oyster populations. A return of this filtering capacity would allow other important habitat types, such as submerged aquatic vegetation (SAV) to proliferate. The decline of SAV has adversely affected many of the remaining Chesapeake Bay fisheries, including the most lucrative today, the blue crab fishery. Many species of both commercial and noncommercial species utilize SAV beds as nursery areas during their life cycle. Healthy populations of oysters form reefs that provide food and habitat for many organisms, including crabs, clams, mussels, and other invertebrates. Many of these organisms, in tum, attract a wide variety of finfish species that prey upon them.

Water quality in the Chesapeake Bay today is much lower than it was during the early colonial period, where it was possible to see the Chesapeake Bay bottom in many areas shallower than 20 feet. This was in part due to the abundant oyster populations in the Chesapeake Bay, which have been estimated to have been able to filter the entire 18 trillion gallons of water in the Chesapeake Bay in 3 to 6 days. Today, present oyster populations take over a year to filter this same volume of water. According the CBF website, overall water quality in the Chesapeake Bay is fairly low, though it is showing signs of improvement in recent years. A wide variety of chemicals, toxins, and nutrients introduced into the watershed by industrial, agricultural, and residential areas have contributed to the current water quality problems. CBF rated water clarity at a 15 out of 100, phosphorous at a 15 out of 100, dissolved oxygen at 15 out of 100, toxics at 30 out of 100, and nitrogen levels at 15 out of 100. These low ratings are indicative of the low water quality present in the modem Chesapeake Bay.

Nitrogen and phosphorus are both added to the Chesapeake Bay and its tributaries through a variety of pathways, i.e., run-off of fertilizer from agricultural and residential properties, sewage treatment plant outflows, groundwater discharge, and atmospheric deposition. Excess levels of these two nutrients leads to algal blooms in the Chesapeake Bay. Typically, phosphorus is limiting to algal production in fresher water, and nitrogen is limiting in higher salinity areas. These algal blooms have two negative consequences in the Chesapeake Bay and its tributaries. Initially, blooms greatly reduce light penetration through the water column, which can shade SAV and contribute to its demise. Subsequently, if algae remains ungrazed by oysters or other consumers, bacterial decomposition of the bloom contributes to anoxic water conditions, especially in the summer, and potentially to fish kills. These anoxic events kill any oyster larvae in the water column, and if they last longer than several days, can also kill adults. Sites prone to these events may no longer be suitable for oyster restoration.

Steps have been taken to reduce both nitrogen and phosphorus loading to the Chesapeake Bay and tributaries. Nitrogen levels were reduced after sewage treatment plants upgraded their technology in the 1970's, but currently, nitrogen levels appear to be relatively stagnant. Reduction of phosphorus levels has been more successful. Steps have been taken to reduce phosphorus levels in detergents, most importantly a ban on phosphorus-containing detergents and better management practices employed by farmers. These strategies have reduced phosphorus levels in the Chesapeake Bay over the last two decades. The most recent data indicates that phosphorus concentrations are continuing to drop in the Patuxent River, Rappahannock River, Mattaponi River, James River, and portions of the Susquehanna River. Recently, scientists have begun to speculate that increasing the algal grazer populations in the Chesapeake Bay (i.e., oysters, zooplankton, and menhaden) may reduce some of the harmful effects of excess nutrients and successive algal blooms.

Another important water quality problem that has developed is the increased probability and severity of freshets in tributaries. While adult oysters can survive brief periods of exposure to freshwater, more frequent and longer lasting freshets can have a profound negative impact on oyster populations in the upper reaches of the oysters' range. Increased intensity and frequency of freshets is similarly rooted in watershed processes that have been significantly altered by human land use. As increasing amounts of land are covered by impervious surfaces, more of the rainfall that previously would have entered the ground water table is delivered directly to surface waters. The rapid delivery of freshwater runoff to tributaries temporarily reduces salinity, often to levels lethal to oysters. In the upper Potomac River, a I-inch rainfall event today results in a freshet equivalent in severity to that of a 2-inch rainfall 30 years ago. Because freshets are now caused by smaller rain events, they also occur more frequently. Increasingly frequent and severe freshets have essentially eliminated oyster habitat from the upstream portions of many tidal tributaries. Freshets, if brief in duration, can actually provide benefits to oysters. Diseases can be reduced or eliminated during freshet events, as MSX and Dermo are intolerant of freshwater. Also, the boring sponge, *Cliona* spp., which can severely degrade oyster shell and essentially destroy an oyster reef if oyster biomass is insufficient to repair the damage by depositing new shell material into the reef, is killed by brief exposure to freshwater. On the other hand, freshets can have significant negative impacts to oysters. A freshet will kill any oyster larvae present, and ifit occurs during warmer weather when oysters are metabolically active, can also kill adults if longer than a few days in duration. Sites prone to freshets should be approached with caution in oyster restoration.

LOSS OF HABITAT

Prior to human colonization of the Chesapeake Bay watershed, oyster populations had experienced a natural reduction in some areas due to increasing amounts of freshwater entering many of the Chesapeake Bay tributaries. Large populations of oysters were impacted by this event, and oyster populations today are limited to the lower portions of Chesapeake Bay tributaries. This situation is likely to continue for the foreseeable future, and no oyster restoration activities would be appropriate in these mostly freshwater portions of Chesapeake Bay tributaries. This natural process, however, resulted in the deposition of great amounts of shell in former oyster bed areas. In some cases, this shell is in areas saline enough to support oyster populations but is deeply buried under soft, fine sediments and is unavailable for establishment of oyster populations. This "fossil shell" can today be dredged out of these now uninhabitable areas and used for oyster reef construction in more saline waters. In fact, fossil shell will be used extensively in all USACE proposed restoration efforts. In Virginia, these fossil shell sites lie in the James and Elizabeth Rivers.

True oyster reefs no longer exist in Chesapeake Bay. What are called oyster grounds today are actually remnants or footprints of the historic reefs. The initial loss of oyster reefs due to human activities is attributable to the massive harvests of the late 1800's and early 1900's. The impacts of harvest during this time were threefold: 1) unsustainable harvest levels greatly reduced oyster populations by removing tremendous numbers of individuals, as approximately 75 percent of the oyster population was removed from the Chesapeake Bay between 1860 and 1920; 2) removal of shell and failure to return this material to the bottom substantially reduced available substrate for oyster settlement; and 3) harvest gear, especially dredges, physically destroyed the fabric of the reef habitat and changed the pattern of oyster distribution from dense aggregations to diffusely scattered individuals. The only complex, 3-D oyster habitat that exists in the Chesapeake Bay today has been the sanctuary reefs recently constructed through prior oyster restoration efforts. This habitat is currently a tiny fraction of 1 percent of its former extent.

Two relatively modem phenomena, high sedimentation rates and the increased severity and frequency of freshet events, compound the problem of oyster habitat loss. Sediment loads delivered to the Chesapeake Bay by an increasingly human-dominated watershed bury shell at rates too fast for the greatly-reduced oyster populations to keep pace, resulting in a severe and ongoing decline in habitat suitable for oyster larval settlement. Most of the oyster shell substrate in Chesapeake Bay is now covered by sediment. For example, new acoustic techniques for surveying the bottom suggest that less than 1 percent of Maryland's historic oyster grounds can be classified as clean or lightly sedimented shell. The vast majority of these suitable substrates are within areas where the State has recently planted shell. However, shell plantings typically last only 3-5 years before becoming buried by sediment, requiring a constant input of resources to maintain that tiny fraction of the historic habitat. It is important to note that oyster larvae will not settle and transform into spat-on-shell covered with significant amounts of sediment. Shell covered with sediment is unusable by oyster larvae as attachment sites to metamorphose into spat, and it is critical to ensure that all restored sites experience good spatset before they are fouled by sediment. The best method to develop a living veneer of oysters on a restored site is to employ the new genetic rehabilitation strategy, involving heavy seeding of disease-tolerant strains of native oysters, which will result in vastly increased oyster biomass and reproduction in Virginia waters of the Chesapeake Bay.

DISEASES

Perkinsus marinus, commonly known as Dermo, and *Haplosporidium nelsoni,* or **MSX,** are the two diseases that have devastated remaining oyster stocks in the Chesapeake Bay in recent years. Dermo was first documented as the cause of massive oyster mortalities in the Gulf of Mexico during the 1940's. Dermo infections causing significant oyster mortalities have since been documented along the Atlantic Ocean, from the Gulf of Mexico to Cape Cod. Dermo has been present in the Chesapeake Bay since approximately 1950 and has expanded its range in the Chesapeake Bay over time (see Figure 5). Dermo may have spread rapidly throughout the

Chesapeake Bay in the early 1950's and was only noticed as oyster populations decreased, and the disease increased in virulency. The frequency and intensity of Dermo infection in Chesapeake Bay oysters varies seasonally, with the most oyster mortality occurring during the warmer months. Dermo infections are highly transmissable and infective stages can cover areas of several miles in a single season. The highest infection and mortality rates in the Chesapeake Bay occur when the water temperature exceeds 20 degrees Celsius (°C) (Chu, F. and J.P. La Peyre, 1993). Dermo is more prevalent and virulent in the higher salinity waters of the lower Chesapeake Bay. Although Dermo is able to survive in salinities as low as 3 parts per thousand (ppt), lethal infections tend to develop only in waters that are at least 8 to 9 ppt (Chu, F. and J.P. La Peyre, 1993; Ragone, C. and E. Burreson, 1994). Historically, movement of oysters with Dermo infections into lower salinity waters as a management technique may have spread Dermo over a wider range in the Chesapeake Bay and increased its ability to survive in lower salinity waters.

Dermo parasites out-compete the host oyster for stored nutrients (Newell et al., 1994), and the infected oyster often slows or ceases to grow and lay down new shell (Paynter and Burreson, 1991). Dermo also suppresses oyster reproduction as the infection intensifies (Kennedy, 1995), which results in lower than expected egg production by larger, disease infected females. Therefore, restoration efforts that consider oyster biomass and recruitment must consider both the expected time of death of any stock of oyster on the restored reef as well as the rate and progression of Dermo infection. Desired characteristics of oysters on restored reefs would include both the ability to survive long enough to produce many eggs and the ability to resist Dermo long enough to do so. Overall, Dermo commonly kills infected oysters after an extended period of time. Dermo infected oysters typically survive for some time (2 years), but often die shortly before reaching market size (3 inches in shell height).

Currently, the main technique of Dermo control is to avoid moving infected seed oysters and to refrain from planting disease-free seed near sources of infection, such as native populations on natural beds, pilings, bridges, or piers (Andrews and Ray, 1988). There is some evidence that disease resistance to Dermo is developing in the eastern oyster (Andrews, J.D., 1954; Bushek et al., 1994). Further work will be needed to document any resistance of the eastern oyster to Dermo, and also to selectively breed any documented Dermo resistant oysters for possible placement in the Chesapeake Bay. Such work is being done currently, and selectively bred disease-resistant oysters (such as the CROSbreed and DEBY lines) will form an important component of the oyster restoration effort. Recent work has also demonstrated that *Crassostrea virginica* from southern populations, in particular from Louisiana, may have considerable resistance to Dermo. Continued progress in developing disease tolerance and/or resistance is ongoing, and lines of oysters with increased resistance to Dermo and MSX will be deployed on USACE oyster restoration sites throughout the duration of restoration activities in the Great Wicomico River.

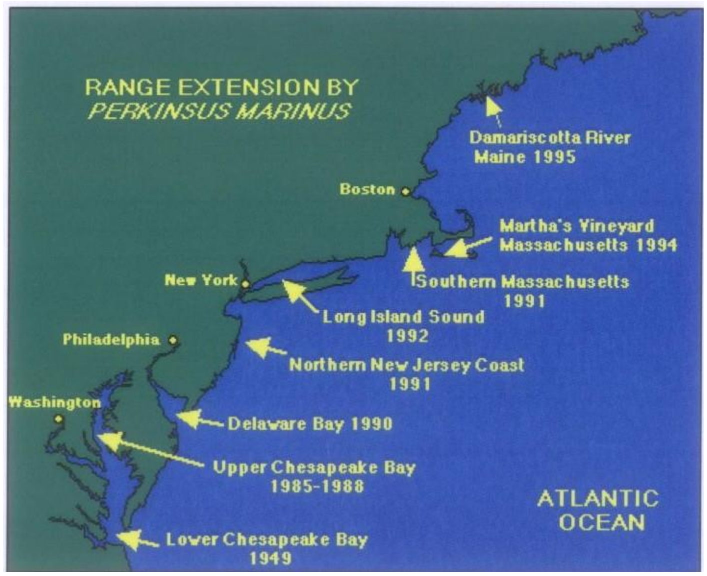


Figure 5. RANGE EXTENSION OF DERMO. It has moved steadily northward since first documented in the Chesapeake Bay in 1949. It has been documented in more southern oyster populations for many decades prior to its discovery in the Chesapeake Bay. More southern populations of the Eastern Oyster, such as from Louisiana, have more resistance to Dermo than the Chesapeake Bay strains, indicating that natural selection can improve resistance to Dermo over time.

Another oyster disease causing organism, *Haplosporidium nelsoni,* commonly known as MSX (for multinucleated sphere "X"), has been responsible for massive oyster mortalities in Chesapeake Bay waters. MSX was first documented in 1957, where it was the cause of massive mortalities in the lower Delaware Bay. MSX is a non-native parasite that was introduced into Delaware Bay by illegal introductions of a non-native oyster, *Crassostrea gigas*, brought in from the Pacific Northwest but originating in Asia. Two years later, it had spread to the Chesapeake Bay, where massive oyster mortalities were documented (Andrews, 1967). Since it was first documented, MSX has been located in coastal waters from Maine to Biscayne Bay, FL. Mortalities due to MSX in the native Eastern oyster have been restricted, however, from Cape Cod waters to North Carolina. In contrast to Dermo, MSX seems to be a more virulent infection. An MSX infection typically spreads rapidly throughout the infected oyster's tissues, and the oysters begin to die within a month of initial infection. More resistant infected oysters typically stop growing a few weeks before death and often appear emaciated. MSX can also greatly educe egg production from 13 percent to 81 percent, with less egg production as the infection intensity increases (Ford et al., 1988).

MSX is much more active in warmer months, infections in oysters in the Chesapeake Bay are typically seen first in mid-May, and numbers of oysters infected with MSX increase rapidly throughout early summer. Oyster mortalities begin soon after infection, and oysters continue to die from MSX infections from July through October. MSX infections can remain intense once established in an area, which can cause a second mortality period in an infected oyster bed in late winter and spring (Kennedy et al., 1996).

MSX infections and associated mortality drop during peak summer water temperatures of above 20 °C. MSX is most active in waters of salinity of 10 ppt and above, similar to Dermo. In fact, MSX infections can be reduced or eliminated by oysters in waters of less than 10 ppt (Ford, 1985). Current control measures for MSX are to use certified MSX-free hatchery-produced seed oysters when possible. Other techniques include rearing oysters in low salinity waters, such as the James River, and moving the oysters to high salinity waters for a short period of time prior to marketing for growth and conditioning, as oysters in low salinity waters grow at a considerably slower rate than those reared under higher salinity conditions. Care must be taken to avoid the prime MSX infection time periods when moving oysters to high salinity waters.

Both of these diseases typically kill oysters before or shortly after they reach the minimum legal market size of 3 inches (7.6 centimeters [cm]) in shell height. The fecundity of the female oyster increases exponentially with size (Brumbaugh, 2000; Cox and Mann, 1992). For example, a female oyster about 4 cm shell in height produces about 2 million eggs, while a 7-cm-shell height oyster can produce up to 45 million eggs. Therefore, the negative impact of Dermo and MSX on oyster fecundity is another major impact of these diseases on long-term oyster population and biomass recovery.

Dermo and **MSX,** due to their impacts on population dynamics, further suppress oyster population and biomass recovery by changing the population structure to favor smaller, younger and less fecund female oysters. The common oyster harvesting practice of only taking oysters

3 inches in shell height and larger compound the problem by tending to eliminate any native oysters that develop any natural resistance to these two diseases. It may be critical for the Virginia oyster restoration effort to address these diseases by exploring the development and production of hatchery-reared disease-resistant oysters. Another possible method may be to use large(> 3 inch shell height), older native oysters found during restoration site selection as possible broodstock in a hatchery operation or to seed oyster reef restoration sites, as these native oysters, especially if found in waters where Dermo and MSX are present, may have some natural disease resistance.

5.0 PLANFORMULATION

INTRODUCTION

Plan formulation is an integral and critical part of USACE planning process. It determines the level of Federal interest in proceeding with a proposed project, and determines the USACE preferred restoration plan. It also provides the basis for developing the NER Plan for determining the most effective means of accomplishing the ecosystem restoration goals, in this case of native oyster restoration to waters of the Chesapeake Bay. The USACE Restoration Focus is defined as: "Ecosystem restoration activities examine the condition of existing ecosystems, or portions thereof, and determine the feasibility of restoring degraded ecosystem structure, function, and dynamic processes to a less degraded, natural condition." The formulation and evaluation of possible alternatives is conducted in accordance with the US Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, dated 10 March 1983, and related guidance, including Engineer Regulation (ER) 1165-2-501, dated 30 September 1999 (Civil Works Ecosystem Restoration Policy), and ER 1105-2-100, dated April 2000 (USACE Planning Guidance).

In accordance with the policies and planning principals required by the above references, various alternatives were considered, including those alternatives preferred by the local sponsor. These alternatives were then evaluated and screened to develop options and plans that would have the highest probability of achieving the stated goals of the oyster restoration effort. A number of models were developed and used to make these determinations, primarily the NER model, which takes on the greatest importance in ecosystem restoration initiatives. According to USACE planning guidance (EP 1165-2-502 paragraph e.), the ecosystem approach is stated as following: "The goal of the ecosystem approach is to restore and sustain the health, productivity, and biological diversity of ecosystems and the overall quality of life through a natural resources management approach that is fully integrated with social and economic goals." Other factors are also given consideration.

PLANNING FORMULATION PROCESS

The purpose of this section is to provide background for understanding the criteria used in the plan formulation process of environmental restoration alternatives for the Chesapeake Bay Oyster Restoration effort. This section also states how the NER Plan was selected. The formulation process involved a number of steps. The first included defining the nature of the problem and establishing goals for the project. Then plan formulation rationale were developed, along with identifying and screening methods to achieve restoration goals. A series of models were developed in order to assess the resulting plans in achieving the project goals. Primary among these is an Oyster Biomass model tailored to local conditions in the Great Wicomico River, VA, the selected site for primary construction. An adaptive management plan was written to ensure that the NER benefits of the proposed ecosystem restoration project are achieved and maintained over time. This was necessary due to the difficult challenges presented by oyster restoration in the Chesapeake Bay and the necessity of applying adaptive management to USACE projects in order to ensure project success.

Ecosystem Restoration - Federal Objectives

The guidance provided in ER 1105-2-100 and ER 1165-2-501, as it applies to ecosystem restoration and other project related activities, has been and will be used in formulating and evaluating various types of oyster restoration projects throughout the Chesapeake Bay and its tributaries. Plans to address ecosystem restoration will be formulated and recommended, based on NER (non-monetary environmental benefits). Cost effectiveness and incremental cost analysis will determine the "Best Buy" plan likely to provide the most NER benefits per dollar spent. Unlike traditional civil works water resources projects, the ecosystem restoration efforts for native oyster restoration, undertaken by USACE in the Chesapeake Bay and its tributaries, does not need to exhibit net National Economic Development (NED) benefits. The Federal objective of ecosystem restoration is the production of Environmental Quality (EQ) benefits, as defined in the NER Plan.

For this project, an incremental cost analysis was performed to determine the most cost-effective ecosystem restoration methodology and project using the following documents: "Cost Effectiveness Analysis for Environmental Planning: Nine Easy Steps," Institute of Water Resources (IWR) Report 94-PS-2, and "Evaluation of Environmental Investments Procedures Manual: Cost Effectiveness and Incremental Analysis," IWR Report 95-R-1.

The priority of this plan is to assist in the restoration of the Chesapeake Bay ecosystem and associated ecosystem functions, in this case that of the native oyster and those ecosystem functions provided by it. Consistent with the analytical framework established by the principals and guidelines for water resources studies, plans will be recommended based on their non-monetary benefits.

ER 1165-2-501, dated 30 September 1999, states "... ecosystem restoration is one of the primary missions of the Civil Works program. The purpose of Civil Works ecosystem restoration activities is to restore significant ecosystem function, structure, and dynamic processes that have been degraded." EP 1165-2-502, dated September 30 1999 (paragraph 7 c.), further states "... civil works ecosystem restoration initiatives attempt to accomplish a return of natural areas or ecosystems to a close approximation of their conditions prior to disturbance, or to a less degraded, more natural condition. In some instances a return to pre-disturbance conditions may not be feasible. However, partial restoration may be possible, with significant and valuable improvements made to degraded ecological resources."

The current study will only consider projects that will be oyster sanctuaries free from commercial or recreational fishing pressure, with the exception of spat-on-shell production areas. These spat-on-shell production areas will be harvested for ecosystem restoration stocking efforts to augment the genetic fitness and populations at other oyster restoration sites. This is a key component of the new "genetic rehabilitation" strategy that is explained in detail in the Plan Formulation sections of this document. The current study will not build any "harvest grounds" for the commercial or recreational fishery. The joint NAO-NAB (Norfolk District-Baltimore District) 10-Year Oyster Restoration Plan currently under development will address the potential for projects, or portions of projects, designed to augment the oyster fishery and will be a multiple purpose plan. Due to the critical need to increase oyster biomass at this time, the current project will not include a fishery component or analysis.

PLANNING PROCESS

The primary emphasis of this ecosystem restoration study is to evaluate various alternatives to determine their ability to meet the study goals and to display a range of costs and benefits resulting from the various measures that could be utilized to produce the outcomes to address the restoration goals. Through these evaluations and associated coordination process, which includes the partnership of the USACE Norfolk District and scientists at VIMS, the cost-sharing sponsor (the Commonwealth of Virginia), and with the CBP and its developing Comprehensive Oyster Management Plan, USACE will develop a range of appropriate alternatives to produce benefits that address the restoration goals and fit within the USACE mission. The outputs are measured as the net difference between the future with and the future without project conditions for the various alternatives.

STUDY OBJECTIVE

The overall objectives of this plan are to:

1. To examine and determine the restoration potential of the native oyster, *Crassostrea virginica*, to open waters of the Chesapeake Bay and its tributaries. Primary construction focuses on the Great Wicomico River.

2. To undertake native oyster restoration activities in keeping with a number of objectives. USACE participation towards achieving any of the following objectives is dependent on plans identified by NER models and that are within the USACE authority and mission. These objectives, as described in the Chesapeake Bay 2000 Agreement and the CBP's "Comprehensive Oyster Management Plan" are as follows:

   A. Achieve a 10-fold increase in native oyster biomass by 2010 (1994 baseline).

   B. Establish functional oyster sanctuaries throughout the Chesapeake Bay comprising 10 percent of the historical oyster habitat in the Chesapeake Bay.

   C. Achieve sustainable, cost-effective oyster production, through a combination of wild fisheries and aquaculture. The current project will have regional benefits outside the actual construction sites that will assist in recovery of the fishery. However, no restored oyster reefs in the present study will be constructed to directly augment the fishery by allowing commercial or recreational oyster harvest on them.

   D. Restore and manage oyster reefs in a manner that supports the rehabilitation of ecological services including:
      - Increasing habitat for organisms, including oysters, finfish, crustaceans, and sessile invertebrate species.
      - Enhancing oyster broodstocks and the genetics of those stocks for supporting regional oyster populations.

- Improving water quality through filtration by oysters and their impacts on nutrient cycling.

E. Conduct all restoration activities in a manner that reduces the overall impacts of disease on oyster populations throughout the Chesapeake Bay.

F. Restore and manage native oysters and their habitat such that a genetically viable sustainable population can be maintained.

G. Undertake all individual restoration projects with clearly defined, specific objectives that can be evaluated. Incorporate monitoring for adaptive management and systematic investigations that will improve our ability to achieve our objectives as integral parts of restoration projects.

3. To determine the feasibility of, and Federal Interest in, implementing the proposed solutions for native oyster restoration in Chesapeake Bay waters.

4. To ensure that the plans developed are environmentally and socially acceptable, technically feasible, and economically efficient.

PLANNING CONSTRAINTS AND PROBLEMS

Planning constraints are any policies, technicalities, or other considerations that have the capacity to apply limitations, restrictions, or other impacts on the planning process. There are a number of significant constraints and problems that must be considered to complete the USACE mission of Oyster Restoration in the Chesapeake Bay.

Public Fishery Augmentation

Oyster restoration, due to the commercial value of the oyster and the ability of oyster harvests to provide income, employment, and other economic benefits to the Chesapeake Bay region, has had a number of necessary planning constraints applicable. Virginia and Maryland both have a keen interest in augmenting the public fishery in their respective States. This interest is reflected in the desire of both States to construct oyster restoration sites specifically for augmenting the commercial harvest of oysters from the Chesapeake Bay. However, USACE policy is to construct projects under ecosystem restoration initiatives primarily for NER benefits. An important component of the NER Plan will be permanent sanctuaries, which are oyster restoration areas where no commercial or recreational harvest of oysters will ever take place and can be high (HRR), moderate (MRR), low relief (LRR) reefs and related structures. Sanctuaries can also be seeded with native oysters, either wild or produced in a hatchery. Use of disease-resistant native oysters, which includes use of selected strains developed by oyster scientists, such as DEBY, CROSBreed, and others, as well as any wild stock that has demonstrated significant disease resistance, will also be considered and will be a key part of the native oyster restoration strategy. Upon achieving the restoration goals of a 10-fold biomass increase in native oysters, and setting aside and successfully restoring 10 percent of the historic public ground acreage as permanent sanctuaries, other restoration options could possibly be considered. Such options could include efforts to enhance the commercial fishery for oysters. Due to the challenges involved in native oyster restoration, and the necessity of adaptive management in order to meet the primary goals of achieving the 10-fold increase in biomass, it will be difficult to estimate when projects designed to augment the commercial fishery could be constructed. The main problem such projects present is they are unlikely to contribute significantly to long-term restoration of the native oyster population or provide significant benefits to the ecosystem.

There is a great deal of interest from the local sponsors in restoring a commercial fishery. Such plans are identified as Locally Preferred Plans. USACE can implement Locally Preferred Plans using Federal funds if they are also the USACE selected plan. If not, USACE can implement any or all elements of the Locally Preferred Plan; however, the local sponsors must bear the full financial responsibility for any deviations from the USACE selected plan. To have a sustainable fishery, the population of animals to be fished must be allowed to recover. The available economic data suggests that oyster reefs constructed in Virginia waters of the Chesapeake Bay today for the commercial fishery do not justify the return on investment (Coen and Luckenbach, 2000; Luckenbach et al., 1999). The commercial fishery also damages the reef base with harvesting equipment, and it has been noted that such projects can have a short life, as short as 3-5 years. All proposed construction in the present Decision Document Amendment will be designated as sanctuary area(s), with the exception of spat-on-shell production areas needed for ecosystem restoration stock enhancement efforts, a key component of the new genetic rehabilitation strategy.

Potential Non-Native Oyster Introduction

Another issue that could potentially have a severe impact on restoration of the native oyster is the introduction of the Suminoe Oyster, *Crassostrea ariakensis*, a non-native oyster from Asian waters (the South China Sea and Japan), into the Chesapeake Bay. As of the writing of this plan, the Suminoe oyster is in the Virginia waters of the Chesapeake Bay in significant numbers, 60,000 in 2001, and 1,000,000 has been approved for 2003 and are going into the water at 10 sites in Virginia waters of the Bay, under various experimental and containment regimes to assess their fitness for introduction to open waters of the Chesapeake Bay, market suitability, use in aquaculture, and resistance to diseases that have severely impacted the native oyster. Preliminary results have been quite impressive; the Suminoe oyster is demonstrating faster growth rates and greater disease resistance to MSX and Dermo than the native oyster (Calvo et al., 2000).

The potential effects of the Suminoe oyster on the USACE native restoration efforts must be considered. Current efforts are being undertaken in Virginia waters and are supported by the Virginia Seafood Council, local watermen, related fishery industry interests, and VMRC. These efforts involve a manmade "sterile" triploid oyster. Triploid organisms have three sets of chromosomes, as opposed to the typical two sets (diploid), and are almost totally sterile. However, triploid organisms can undergo "reversion," where they are able to at least partly revert to diploid condition over time. A diploid organism can reproduce normally. This has been documented to occur in the Suminoe oysters used in experiments within the Chesapeake Bay (US Fish and Wildlife Service [USFWS], 2001). It is highly likely that continued work in waters of the Chesapeake Bay with the Suminoe oyster will eventually result in establishing a reproductive population of non-native oysters to the Chesapeake Bay. It remains to be seen what effects such an introduction will have. The Suminoe oyster has similar, though not identical, habitat preference, food, and lifestyle compared to the native oyster. The differences could be that it is not a reef builder like the native species and that it may feed on zooplankton in addition to phytoplankton. The native does not feed to any great extent on zooplankton. These two possible differences could have considerable potential to alter the Chesapeake Bay ecosystem. The Suminoe oyster also has the ability to interfere reproductively with the native oyster. It does so by the ability of its gametes (sperm and egg) to fertilize those of the native oyster, *Crassostrea virginica.* However, this hybrid does not develop past the larval stage and dies shortly after fertilization. Thus, the Suminoe oyster could serve as a gamete "sink" for the native oyster and inhibit the reproductive output of the native oyster (Allen et al., 1993). This would slow the native oyster population recovery, which is likely to reduce the population of the native oyster further over time.

In addition to its competitive advantages provided by its disease resistance and related faster growth rate, it is reasonable to assume the Suminoe oyster, if allowed to establish a reproductive population in the Chesapeake Bay, will out compete and possibly extirpate the native oyster from the Chesapeake Bay. Many in the scientific community expect the Suminoe oyster could colonize much or all of the native Eastern oyster's range along the East Coast of America. In the event the Surninoe oyster is able to establish a diploid reproductive population in the Chesapeake Bay, either by deliberate introduction or by accident, USACE should reevaluate its restoration efforts and determine if further native oyster restoration efforts should continue.

Additional Constraint -- USACE Requirements

There are a number of additional constraints common to most USACE studies. A summary of the formulation and evaluation criteria for ecosystem restoration options for native oyster restoration is presented in following paragraphs. These criteria involve biological, environmental, geophysical, economic, and social factors that can, in varying degrees, constrain the options and/or selection of viable restoration options and the preferred plan for native oyster restoration in the waters of the Chesapeake Bay. Several additional key factors or constraints are summarized as follows:

1. Restoration projects should have a useful life span of about 25 years.
2. Costs associated with a restoration plan should be minimized; a "Best Buy" plan should be selected.
3. Impact to wetlands, coastal zones, and wildlife resources in the Chesapeake Bay and its tributaries should be minimized to the fullest extent practicable.
4. Restoration projects should be designed to provide the maximum overall net benefits to the EQ of the Chesapeake Bay and its tributaries.
5. Any potential adverse social and historical impacts associated with constructing the proposed restoration projects should be minimized.

6.0 EVALUATION PROCESS

EVALUATION CRITERIA

Technical, environmental, and economic criteria, in addition to intangible considerations, permit the development and selection of a plan that best responds to the stated problems and needs of the proposed undertaking. Criteria assessed and developed for the purpose of this analysis are discussed in the following paragraphs.

USACE, Norfolk District, is participating in various restoration activities to augment the habitat, populations, and genetic fitness of the oyster, *Crassostrea virginica,* native to the Chesapeake Bay and its tributaries. USACE is part of a multi-agency coalition, including Federal and State agencies, non-profit organizations, scientists, and various stakeholders operating within the Environmental Protection Agency (USEPA) run CBP. All USACE projects are formulated to be consistent with guidance provided by ER 1105-2-100 (Plan Formulation), Ecosystem Restoration in the Civil Works Program and ER 1165-2-500 (Civil Works Ecosystem Restoration Policy). These activities are also consistent with Section 704(b) of WRDA of 1986, as amended, and the 1999 Scientific Consensus document on Oyster Restoration cited therein.

Ecosystem Restoration

Section 704(b) of the Water Resources Development Act (WRDA) of 1996, entitled: "Study of Corps Capability to Conserve Fish and Wildlife" authorizes the Secretary of the Army to investigate and study the feasibility of utilizing the capabilities of USACE to conserve fish and wildlife (including their habitats) where such fish and wildlife are indigenous to the US. The scope of such study shall include the use of engineering or construction capabilities to create alternative habitats, or to improve, enlarge, develop, or otherwise beneficially modify existing habitats of such fish and wildlife. Further amendments authorize USACE to construct reefs and related clean shell substrate, including oyster reefs. These amendments include Section 505 of WRDA 1996, which was further modified by Section 342 of WRDA 2000, which provides the most recent guidance language for USACE oyster restoration. This language allows the USACE to construct oyster reefs and related clean shell substrate in the Chesapeake Bay and its tributaries.

The outputs for the oyster restoration project must be appropriate and consistent with the intent of ER 1165-2-501 to utilize appropriate indicators and units to measure the quality and/or quantity of the habitat related outputs and associated benefits. The primary output for this project will be increased oyster habitat and oyster biomass. Also important will be the establishment of a living veneer of oysters on the habitat sufficient to become biogenic, which is to accrue additional oyster biomass and associated oyster shell such that the reef is maintained. Adaptive management principles will be applied in order to ensure the biogenic nature of the reefs and attainment of NER benefits. In addition, due to the continuous intensity of the MSX and Dermo oyster diseases in Virginia waters of the Chesapeake Bay, this project will also be the first to consider the "genetic rehabilitation strategy" for the native oyster. The genetic rehabilitation strategy will be explained in detail in subsequent sections of this document and is a key component of this project (see Figure 1). Past difficulties in native oyster restoration have led USACE to take the lead in implementing this strategy, which may be the only way to establish biogenic oyster reefs in the Virginia waters of the Chesapeake Bay. In addition to applying these procedures to measure outputs, a recommendation for USACE involvement was justified based on an overall determination that the benefits of the project will exceed the costs. This determination was based on an assessment of the project, as outlined in ER 1165-2-501:

1. Establish the importance and value of the ecosystem and the study objectives;
2. Estimate costs and benefits in monetary and non-monetary terms;
3. Evaluate alternatives via application of cost effectiveness and incremental cost analysis (CE/ICA); and
4. Apply the principles of adaptive management to ensure benefits are achieved.

Technical Criteria

The following technical criteria, within a planning framework, were adopted for the use in plan formulation.

a. The plan should be consistent with local, regional, and State goals to the extent practicable and within the framework of USACE Planning guidance.
b. The plan should be technically feasible to implement.

Economic Criteria

The economic criteria that were applied in the formulation of the alternative plans are as follows:

a. In accordance with the overall objectives of the study, the plan should:
    1. Minimize the total cost including investment, operations, maintenance (including adaptive management), and replacement.
    2. Minimize the negative economic impact on the surrounding area.
    3. Maximize the positive environmental impacts on the surrounding area.

b. Alternative plans will be compared on the basis of a CE/ICA. Costs to be considered in the analysis should include, but not be limited to, the following:
    1. Construction cost;
    2. Interest during construction;
    3. Lands and damages, easements, rights-of-way, relocations, and disposal areas;
    4. Average costs of the operations and maintenance and/or major replacement costs.
    5. The costs associated with adaptive management strategies;

6. The costs of implementing the "genetic rehabilitation" strategy for accelerating development of disease resistance in the native oyster; and
7. Monitoring regimes required evaluating the effectiveness of various adaptive management measures.

c. The typical project life for a Federal navigation or shoreline protection project is 50 years. This, however, is an ecosystem restoration project with a predicted useful project life of 25 years. The biogenic component of the oyster reef, the oysters, are potentially subject to numerous threats. These threats include inundation with freshwater during storms (freshets), disease outbreaks, competition with other sessile organisms for food and space, and predation. All of these threats are potentially lethal for living oysters. The reef base, if constructed of oyster shell, is subject to physical degradation by boring sponges, *Cliona truitti*. The boring sponge dissolves the oyster shell matrix as it grows into the shell. In a living oyster, this damage is repairable; however, on non-living shell it results in the creation of numerous pits, weakening the shell and ultimately breaking it into small pieces useless for successful oyster recruitment (Pomponi and Merrit, 1985). While oyster larvae can set on tiny pieces of shell grit, many predators can simply pick them up and consume them, grit and all. Whole shell, preferably in a solid reef matrix, greatly reduces predation efficiency (MacKenzie, 1970; Eggleston, 1990). Sedimentation can also render a reef base unusable by larval oysters attempting to set and metamorphose into spat, which are unable to recruit to the reef base if more than several (3-4) millimeters of sediment have been deposited on top of it by either natural or manmade causes. Adaptive management will be employed to the fullest extent justifiable in order to maximize project lifespan and benefits while keeping the overall project cost-effective. It is possible the effective lifespan of a reef could well exceed the expectations if it remains biogenic.

Environmental and Social Criteria

Environmental and social criteria considered throughout the study include the following:

a. The plan should maximize the restoration of EQ in the Chesapeake Bay by increasing oyster habitat, biomass, and disease resistance of the native oyster, *Crassostrea virginica*, considering environmental, economic, and engineering criteria.

b. The available sources of expertise should be used to identify any environmental resources that might be endangered, damaged, or destroyed by plan implementation. Such expertise lies in agencies such as USFWS, USEPA, NMFS, VMRC, and the Virginia Department of Historic Resources.

c. Measures, such as Best Management Practices should be incorporated into the recommended plan to protect, preserve, restore, or enhance EQ in the project area.

d. The plan should be capable of being integrated into local or regional planning for water and air pollution abatement, transportation, recreation, and land use.

e. To the extent practicable, the plan should minimize noise, dust, odor, unsightliness, and potential health risks.

f. The plan should meet existing public health and environmental control standards.

g. To the extent practicable, the plan should be esthetically pleasing to the public.

h. The plan should not displace, devalue, or destroy important historical and cultural landmarks or sites.

1. The adverse impacts on area recreation resources should be minimized.

J. The plan should be publicly acceptable.

The degree to which any environmental restoration project meets these criteria is taken as a measure of its relative merits. However, no restoration option could meet all of these criteria fully. This project has the additional complication of restoration of the habitat, population, and biomass of a commercially-important species that is the most important filter-feeding species of the Chesapeake Bay. The environmental benefits provided by the oyster depend on its filter feeding abilities, which increase as the population grows in numbers, age, and biomass. If enough oyster biomass accumulates on a particular reef, the oysters can add significant shell structure to the reef base. Such a reef is sustainable and "biogenic," which is able to grow in size over time, and maintain itself. The primary goal of the present project is to attempt to restore the Great Wicomico oyster population and recruitment to historical levels, create oyster reefs that are biogenic, and implement the genetic rehabilitation strategy. While there have been encouraging signs that native oyster restoration is beginning to work in some areas on a limited scale, no large scale project has demonstrated biogenic reef development. The current project will provide the best chance to demonstrate that this can be done.

EVALUATION STRATEGY

Site Prioritization in Virginia

As stated earlier, there are three main problems facing the native oyster; disease, habitat loss, and overfishing have reduced the native oyster to a disease-prone remnant population that covers less than 1 percent of its historic range with any appreciable density. This loss of oyster biomass has created a secondary problem of declining water quality. Although decreased water quality is due to increases in pollutants entering the system, the native oyster population was once able to filter these pollutants out, thus maintaining a high level of water quality. All four of these problems must be addressed in the plan in order to implement the project with the highest chance for success. To do this, it is important to consider the oyster's biology and the local site conditions. But first, a brief description of the Zone strategy, a key component of oyster restoration, is necessary. Table 2, seen below, describes the basics of the different zones.

Table 2. ZONE STRATEGY - SALINITY INTERACTIONS WITH THE NATIVE OYSTER, *CRASSOSTREA VIRGIN/CA*

ZONE STRATEGY PARAMETERS		
Disease Interactions		
Zone 1	**Zone2**	**Zone3**
5 to 12 ppt.	12 to 14 ppt.	> 14 ppt.
Low disease, good survival, poor recruitment	Moderate disease, survival, and recruitment	High disease, poor survival, good recruitment

Freshwater is O ppt saline, and seawater is 35 ppt saline. Zone 1 waters are waters of between 5 and 12 ppt on average during the summer months of June, July, and August. These waters are the lower limit that the native oyster can survive and grow in. Disease pressure from Dermo and MSX is typically low, which significantly increases the chances of oyster survival over time. Unfortunately, natural oyster reproduction and recruitment are typically very low in these areas. Zone 2 waters are on average from 12 to 14 ppt during the summer. Disease pressure and mortality on adult oysters is much higher than in Zone 1, as both Dermo and MSX increase in virulence with increasing salinity. Natural recruitment is higher, however, and the result is a larger population of smaller oysters on reefs in these areas. Zone 3 waters are considered to be all Chesapeake Bay waters of greater than 14 ppt during the summer. There is near constant pressure from the oyster diseases Dermo and MSX in these waters, and the mortality of juvenile and adult oysters can be very high. Oysters that survive to grow up to 70 mm shell height and larger may have some natural disease tolerance. Zone 3 waters do have one advantage in that oysters reproduce much more effectively and larval survival is much higher. This results in, on average, much higher recruitment in Zone 3 waters. As noted, in the CBP plan, most of Virginia waters lie within Zone 3.

Another important aspect of site selection is to choose a site that is not prone to warm-season freshets, huge influxes of freshwater during storm events that can kill very young oysters. It is important to note that freshets are much more likely to occur during months where oysters are not metabolically active, and that adults are capable of tolerating freshets during the colder months of the year far more aptly than juveniles. Freshets kill oyster larvae outright, and oyster larvae are typically in the water column only during the summer months when the chance for a freshet is small. Low saline conditions have a benefit of reducing or eliminating oyster diseases and competitors, however, and low saline areas with the risk of an occasional freshet can be important sites for oyster restoration in terms of accumulating biomass.

Many areas, typically in urbanized watersheds, are condemned for shellfish harvesting due to high levels of *E. coli,* a bacterium that is transported into Chesapeake Bay waters by sewage, septic systems, and wild animals. *E. coli* is not harmful to the oyster itself, but people who consume oysters that have the bacterium present in their tissues can become ill. For designated sanctuary projects, such sites could actually be advantageous due to the State-mandated prohibition on all shellfish harvesting.

Nutrient inputs to the local watershed must be considered. Oysters are filter feeders that consume the phytoplankton that allows them to grow. In this way, oysters can be said to "fix" these nutrients by using these nutrients, originally captured by phytoplankton, to fuel their own growth. This process is similar in concept to a tree fixing carbon dioxide in its woody tissue, taking this greenhouse gas out of the atmosphere. In today's Chesapeake Bay, the return of the oyster could have significant water quality benefits. The natural processing of the oyster's psuedofeces in shallow water can result in denitrification under aerobic conditions, which is the direct removal of nitrogen from the Chesapeake Bay (Newell et al., 2002). As an example, the historic population of oysters in the Choptank River, which once covered about 5,000 acres, might have had the capacity to remove 30 percent of all the nitrogen entering the river today, if they were still present (Blankenship, 2002). However, if nutrient levels are too high, it can encourage toxic dinoflagellate blooms ("mahogany" or "red" tides), which have the potential to kill oysters. Oyster larvae are far more vulnerable to dinoflagellate blooms than are adults. Careful consideration must be given to this possibility, and sites with minimal risk of toxic dinoflagellate blooms should be given priority.

A final consideration is the hydrodynamics of the site. Selecting sites with good larval retention is a key component of the genetic rehabilitation strategy in Zone 3 waters of the Chesapeake Bay. The main advantage Zone 3 waters have over Zones 1 and 2 is that oyster reproduction reaches its maximum potential in Zone 3. Such waters are called "trap estuaries" and allow restored oyster habitat areas a much higher chances to auto recruit and become biogenic than waters in more open systems.

Habitat Loss

Due to the magnitude of the problems faced in restoration of the native oyster, and the need to meet USACE ecosystem benefit criteria, this project only considers plans that will be preserved as permanent sanctuaries or activities to increase the benefits of sanctuaries. USACE is committed to restoring the native oyster, and, therefore, those projects most likely to be successful oyster restoration attempts from a biomass standpoint are to be maintained as sanctuaries.

USACE recently received copies of the latest oyster ground charts for Virginia waters of the Chesapeake Bay. Currently, there are 11,469 acres out of almost 200,000 acres of public oyster ground that is currently in a condition that would allow restoration. It is believed that only a portion of the 200,000 acres ever had oyster reefs, and the result is that about 10 percent of the public grounds are in a restorable condition. These areas were classed as "oyster rock" in the last complete survey of the Virginia public grounds (Haven, 1981). Oyster rock indicates the substrate is mostly oyster shell and is the footprint of a former three-dimensional HRR. Additional acreage for restoration may lie outside the 11,469 acres. In the Haven survey, such areas were listed. These areas were once oyster reefs; however, years of overfishing have reduced them to other bottom types, primarily mixtures of oyster shell, clays, sand, and mud. The present study will consider such areas for restoration.

It is important to maximize the oyster biomass and recruitment, especially in trap estuaries that could be utilized in spat-on-shell production for stocking in other areas. In waters with good larval retention hydrodynamics, the acreage of potentially restorable habitat seems small. To address this problem, USACE has undertaken a bottom survey that looked at areas documented as "shell sand" and "shell mud" in the Haven survey. Such areas could also provide firm substrate for construction of oyster reefs and also represent the footprints of former natural HRR's or smaller oyster reefs. While the substrate may not be as conducive to restoration, if such areas can be restored with an acceptable increase in construction expenses (in relation to expected NER benefits), these areas could significantly increase the amount of acreage the USACE could restore in a trap estuary. Such habitat could then result in much greater biomass and ecosystem benefits. To address habitat loss, USACE will consider a variety of HRR's, MRR's, smaller reefs that vary in height from 1-4 feet in height, and LRR's that are uniformly 8 inches in height. LRR's are built in the typical configuration that harvest grounds were constructed in the past. A new technique, thin shelling, will also be considered. This technique shall be used mainly to increase the potential of an area to provide attachment sites for oyster larvae.

TERRAFORMING CHESAPEAKE BAY - THE NEW USACE STRATEGY

USACE has been attempting to restore oyster habitat and populations in the Virginian waters of the Chesapeake Bay since 1999. These projects were built under various premises. The main assumption was the proper substrate, oyster reef base, was a primary limiting factor for the Chesapeake Bay oyster population in Virginia waters. While this is true, the resultant projects have demonstrated that other problems are of equal magnitude and must be addressed on order to implement successful restoration projects with sufficient NER benefits to justify the Federal investment. Two other primary problems of the native oyster, its vulnerability to the two diseases MSX and Dermo, along with low recruitment compared to historic levels, must somehow be addressed in order to implement successful projects. Both the short-term and long-term success of all USACE projects are much more likely to occur upon implementation of the genetic rehabilitation strategy, which addresses these two additional problems. This strategy was formed in a collaborative partnership between USACE, VIMS, CBF, VMRC, and various stakeholders. It's an effort that deserves the term, "terraforming," or, designing and engineering the oysters as well as the reefs (Allen, Brumbaugh, and Schulte, 2003).

Disease was always recognized as an important limiting factor; however, it was believed that recruitment from the remnant breeding population of wild native oysters in the Chesapeake Bay would be sufficient to colonize the constructed reef bases and become self-sustaining and biogenic, despite disease caused mortality. A biogenic reef is one that accumulates additional oyster shell faster than it is degraded by sedimentation, biofouling, or destroyed by boring sponges. A biogenic reef would grow in volume, surface area, and biomass over time. Such reefs existed throughout the Chesapeake Bay in historic times. In fact, many reefs, prior to their removal by man, were estimated at being thousands of years old. Unfortunately, disease has proven to be such a difficult obstacle to overcome that few reefs built in Virginia waters of the Chesapeake Bay, including USACE built reefs, have developed a living veneer of oysters over their surface. Without this veneer, the reef is not biogenic and is subject to degradation. As most of the NER benefits to be derived from oyster restoration rely on the presence of a vibrant, healthy oyster population on a restored site, NER benefits were inadequate. These reefs have been reliant on recruitment from wild stocks of oysters. To continue USACE involvement in oyster restoration, this problem had to be addressed. Table 3, on the following page, gives a brief summary of the problems facing native oyster restoration and illustrates how the USACE Norfolk District has proposed to address them.

Table 3. PROBLEMS AND USACE-PROPOSED SOLUTIONS FOR NATIVE OYSTER RESTORATION

MAJOR PROBLEMS FACING OYSTER RESTORATION		
DISEASE	**LOW RECRUITMENT**	**FISHING PRESSURE**
Dermo - tends to be chronic and kill oysters shortly before they reach 3 inches in length.	Low populations of adult oysters means low recruitment.	Removes adults, which have the highest fecundity, from the population.
MSX- tends to kill oyster quickly is not as prevalent as Dermo in some areas.	Disease infections lower fecundity of adults, further suppressing recruitment.	Damages reef base and suppresses natural selection for disease resistance.

SOLUTIONS - FACTORS TO ENHANCE LONG-TERM RESTORATION SUCCESS		
COMBAT DISEASE	**ENHANCE RECRUITMENT**	**REDUCE FISHING PRESSURE**
Broodstock seeding- enhance native oyster population.	Stocking will enhance potential fecundity.	Structures built to be sanctuaries.
Use disease-tolerant selected strains of native oysters.	Stocking in "trap estuaries" with good larval retention will greatly enhance local recruitment.	If oyster population recovers, manage fishery in a sustainable fashion.
Intrograde genes for disease tolerance into wild stocks via large stocking effort.	Bay-wide stocking of spat-on-shell from trap estuaries will enhance recruitment Bay-wide.	Provide employment to watermen to help restore oyster. USACE will need assistance in stocking, spat-on-shell moving, and site preparation.

Recent studies (Paynter, 2002; Gaffney, 2002; Reece et al., 2002 [in press]) and data from other ongoing studies have indicated that oyster stocks selectively bred for disease resistance have developed significant tolerance to the two diseases, Dermo and **MSX,** which have devastated the Chesapeake Bay oyster population since 1960. Wild stocks are significantly more vulnerable to Dermo and MSX than the selected strains of native oysters currently available. While not immune to Dermo and **MSX,** the selected strains survive significantly longer and grow larger before they become heavily infected and succumb to Dermo and/or MSX. What is the potential outcome of using selected strains of native oysters on USACE built oyster reefs? An example illustrating the difference between a selected strain and current wild stock can be seen in the following figure.

Figure 6. COMPARISON OF SELECTED VS. UNSELECTED STRAINS OF NATIVE OYSTERS. Survival and growth over one season of a seventh generation selected strain compared to an unselected strain, with both starting out with the same number at the same size and age. (S. Ford, unpublished.)

he difference in oyster survival and biomass can be markedly superior for the selected strains. With the disease problems faced in most of Virginia waters, use of such selected strains will be a key part of the oyster restoration strategy. Such selected strains of native oysters will be planted or "seeded" on oyster restoration areas in order to establish biogenic reefs. Oyster survival in the face of Dermo and MSX diseases will be significantly improved by using these "engineered" oysters, as opposed to relying on disease susceptible wild oysters (Allen, Brumbaugh, and Schulte, 2003). This will enable USACE projects over the short-term to be more successful. Long-term success still must be addressed.

A closely related problem that inhibits the oyster reefs' becoming biogenic is low recruitment levels. Past projects have been constructed under a "build it and they will come" philosophy. That is, construct a reef base, which is prime oyster habitat, and oysters will naturally recruit in numbers sufficient to establish a self-sustaining population. Further recruitment events and growth of the first recruits will then form a biogenic reef that increases biomass over time. While it is acknowledged that natural recruitment of wild oyster larvae upon restored oyster habitat constructed in Virginia waters is significantly higher than in most lower salinity waters, such as in much of the Maryland oyster grounds, and also much higher than on unrestored sites, these recruitment levels are a fraction of what they were historically. For example, in the James River, VA, larval concentrations per cubic meter of water were from 300-800 as late as 1965, which was after the onset on MSX mortality but before Dermo began taking its toll. This was at least a 90 percent reduction from previous years; based on the drop in spatsetting rates after MSX-induced mortalities began (Haven et al., 1981). After Dermo further devastated the already depleted James River stocks, larval concentrations were measured in the same area as the previous study at 12-113 larvae per cubic meter (Mann, 1998). The James River is in large part a lower salinity tributary of the Chesapeake Bay, and all of these larval concentrations are low compared to what might be expected in more saline waters. To give a perspective on what a good level of larval density should be, in the Delaware Bay, prior to any disease impacts, larval concentrations varied from 125,000 to 660,000 per cubic meter of water. In order to achieve sufficient recruitment to establish a biogenic reef, additional oysters must be added to the local spawning stock to increase larval production. The question then is: Can

USACE achieve such levels of larval production by applying science and engineering principles to the problem of oyster restoration?

According to a few recent studies (Brumbaugh et al.; 2000; Southworth and Mann, 1998) the answer is: it is possible. In the 1998 study, a single acre of HRR's was constructed in the Great Wicomico River and seeded with wild native oysters bought back from watermen originally harvested in Tangier Sound. These adult broodstock oysters were then seeded at high density, approximately 300 per square meter, over the reef surface. These oysters then spawned, and larval concentrations were measured in the Great Wicomico at a density of 17,000-37,500 per cubic meter of water, which was several orders of magnitude higher than had been seen for many years in this river. Subsequent recruitment was also much higher than previously seen in the Great Wicomico. The year prior to the spawning of the seeded reef, the spatset in the Great Wicomico was less than 100 per square meter. After the relocated Tangier oysters spawned, spatset was close to 900 per square meter (Southworth and Mann, 1998).

In the 2000 study two reefs were stocked with a wild stock demonstrated to have limited resistance to Dermo. A mere 65,000 oysters were stocked, divided equally between the two reefs. The resultant recruitment events on nearby oyster habitat and the reefs were over an order of magnitude higher than years prior to stocking. These results are positive, though not as great as in the 1998 study. The reason is simple: the stocking effort was not great enough to increase it several orders of magnitude. USACE can reasonably expect that seeding reefs with broodstock oysters will provide a base population that will be greatly enhanced with the subsequent recruitment that occurs when the broodstock oysters spawn. The seeded reefs are referred to as "incubator reefs," as they are essentially the seed source for the oyster population within the Great Wicomico trap estuary. Long-term success is much more likely in this scenario. USACE Norfolk District designed an Oyster Biomass Model in order to determine this the level of broodstock seeding to achieve this.

There is an additional factor that can further enhance the long-term success of oyster restoration projects, hydrodynamics of the local waters in which restoration is attempted. Tidal action can act to retain oyster larvae, or flush them downstream, possibly even out of the local area entirely. Areas considered for restoration should be assessed for hydrodynamics. To further enhance recruitment and maximize the benefits of broodstock seeding, oyster restoration projects should first be constructed in what are termed "trap estuaries." These are smaller tributaries or other embayments that have circular gyres or small outlets into the Chesapeake Bay proper. Oyster larvae produced by local spawning stocks tends to remain in the area. The Great Wicomico is a trap estuary and enabled many of the larvae produced by the seeded reef to remain in the area, set, and metamorphose to spat on the reef and nearby suitable habitat. USACE will carefully assess the hydrodynamics of the areas considered for oyster restoration and preferentially select trap estuaries to increase the chances of auto recruitment from the reefs USACE constructs and seeds in the area. As a combination of seeded and unseeded reef bases may be built, good recruitment of larvae spawned by disease-tolerant strains of native oysters approaching or exceeding historical levels will be necessary for project success. An Oyster Biomass Model has been prepared to aid in the planning effort. Questions, such as how many reefs should be built, how many should be seeded with broodstock oysters, what strain of oyster, what size, and how many should be applied to each seeded reef, all needed to be answered in order to maximize chances for success and NER benefits.

One last component of the genetic rehabilitation strategy involves a new technique, spat-on-shell production and relocation. Within trap estuaries, a thin layer of shell will be applied to certain areas prior to spawning of seeded disease-resistant oysters stocked on nearby reefs. These thin-shelled areas will recruit large numbers of spat. Once these spat grow large enough to survive handling, the thin-shelled areas will be harvested using traditional methods by local watermen, and moved to areas outside the trap estuary in order to plant them on other reef bases. Trap estuaries are referred to as "incubator systems," as they will be essentially the seed source for the enhanced Virginia population of native oysters throughout the Chesapeake Bay. These bases that the spat are planted on will be chosen because they have been subject to either failure to recruit sufficiently to become biogenic, been poached, been subjected to a lethal freshet, had exceptionally high disease intensity, had red tide, or been exposed other event that caused significant oyster mortality. Such reefs could be degraded natural reefs or newly-constructed reefs. This will enable such reefs to be rehabilitated at minimum cost, substantially increase the biomass of oysters throughout Virginia waters of the Chesapeake Bay, and more importantly, begin to integrate the disease-resistant genes throughout the Chesapeake Bay population of *Crassostrea virginica*. This will be essential for the long-term recovery of the native oyster. Overall, it is expected to hugely magnify the initial disease-resistant oyster biomass seeded on the incubator reefs by this three-step process, which is referred to this as building the biomass pyramid (see Figure 1).

This change in strategy by USACE will provide the highest chance for success, both short- and long-term, on USACE projects throughout the higher salinity Zone 3 waters of the Chesapeake Bay. This strategy was developed in collaboration with a team of VIMS scientists and based on recommendations contained in "Genetic Considerations for Hatchery-Based Restoration of Oyster Reefs," and is a summary from the September 21-22, 2000 Workshop held at VIMS. It is fully examined and explained in "Terraforming the Chesapeake Bay," currently in press in the Virginia Marine Resource Bulletin (Allen, Brumbaugh, and Schulte, 2003). Key points of the genetic rehabilitation strategy include:

- Stocking programs will be important for jumpstarting biogenic potential of newly constructed or depopulated reefs in some areas.

- The diseases MSX and Dermo are a major limitation for development of large, highly fecund, spawning stocks throughout most of the Chesapeake Bay, especially the southern, high, and moderate salinity areas.

- Selectively-bred disease-resistant strains may have widespread potential for "genetic rehabilitation" of southern, highly-disease impacted oyster populations.

- Increased spatset is an implicit outcome to reef stocking programs and has the consequence of spreading genes from hatchery stocks.

- Progeny from the reef stocked with disease-resistant strains of oysters, called "incubator reefs," could then be used as part of a larger secondary stocking program by collecting spat and relocating them to other areas.

- The desired outcome is introgression (a form of genetic assimilation) of disease-resistant genes into the natural population. Some wild strains, if they have any significant level of disease resistance, may have limited use in direct stocking efforts in conjunction with selected strains to assist in introgression and help maintain overall genetic diversity.

- Reefs stocked with oysters for the purpose of restoration must be permanent sanctuaries.

- The "wild oyster," especially where diseases were prevalent (Zone 3 waters), are in a downward spiral, and that implementation of this new strategy is warranted. This effort, which amounts to "terraforming" the Chesapeake Bay, is the only strategy that provides a reasonable chance for project success, and USACE fully supports this.

7.0 DEVELOPING A NATIONAL ECOSYSTEM RESTORATION PLAN

For ecosystem restoration projects, the NER Plan is the plan that maximizes the ecosystem benefits relative to the costs, consistent with the Federal objectives. The proposed plan must be shown to be both cost-effective and justifiable, which is, likely to achieve the desired level of environmental benefits. The NER Plan meets planning objectives and constraints, as well as reasonably maximizes environmental benefits, while passing tests of CE/ICA, significance of outputs, acceptability, completeness, efficiency, and effectiveness.

DESCRIPTION OF BENEFITS

The first step of the NER Plan was to identify the main objective, or goal, for the proposed project. Four possible goals were identified, and a model scoring these goals, using a variety of potential environmental benefits, was developed with the assistance of scientists from VIMS and the University of Maryland. The four possible objectives were to construct projects for harvest areas to augment the public commercial fishery, to maximize oyster biomass, to encourage development of disease tolerance of selected strains with field test sites, and to implement the new strategy of genetic rehabilitation. For each goal, the environmental benefits that would be gained from implementing that strategy were determined for years 1, 5, 10, 20, and 25. These environmental benefits were the production of spat for export, the development of disease resistance within the local population, the creation of better habitat to retain and recruit more oysters (creation of a biogenic reef), and the creation of habitat for other invertebrate organisms. The ability to improve water quality, determined by the number of oysters filtering out nutrients, the benefits to SAV, and the ability to improve habitat and food to fish populations were also included in this benefit analysis. For each environmental benefit, under each strategy, a ranking from Oto 1 was given for each year. A score of O was given if the stated strategy would not produce that benefit by that year, and a score of 1 was given if the maximum expected benefit would be reached in that year by implementing that goal. These scores were then added together to derive an overall product score. As shown in the table below, the genetic rehabilitation goal scored the highest. Given the difficulties facing the native oyster, this conclusion is fully supported by USACE and all stakeholders. The primary goal of the proposed project is, therefore, genetic rehabilitation of the native oyster.

Table 4. NER BENEFIT SCORING

Benefits	Goals																			
	A. Harvest Areas					B. Maximize Biomass					C. Disease Tolerance					D. Genetic Rehabilitation				
Year	1	S	10	20	50	1	S	101	20	SO	I	5	10	20	50	1	5	IC	20	SO
Spat for Export	0	0.25	0.25	0.251	0.25	0l	0.1	0.75i	I	I	0	0.05	0.31	o.sl	0.5	0.I	0.75	11	I	I
Disease Resistance	0l	0	0	0	0	0	0.05	0.1;	0.2	0.25	0	0.075	0.8	-91	I	0.05	0.75	0.8	0.91	I
Better Oyster Habitat for Retention	0.1	0.1	0.1	0.1	0.1	0.25	0.5	0.9!	I	I	0.1	0.4	0.5	0.6	0.75	0.25	0.6	I	I	I
Water Quality	0	0.15	0.2	0.251	0.25	0	0.1	0.75;	1	I	0	0.1	o.51	0.75	0.75	0	0.25	0.751	1	I
Submerged Aquatic Vegetation	0	0	0	0.01	0.1	0	0.05	0.1	0.25	0.25	0	0.03	0.1	0.1!	0.2	0	0.05	0.1 1	0.25	0.25
Increase Fish Production	0.051	0.25	0.25	0.25	0.25	0.1	0.5	I	I	I	0.1	0.4	0.75	0.75	0.75	0.1	0.5	I	I	I
Invertebrate Habitat	0.1	0.25	0.25	0.2sl	*0.15*	0.11	0.sl	I	I	I	0.1	0.31	0.->'l	0.751	0.75	0.1	0.51	:!	I	I
Totals	0.251	I	1.05	I.I I	1.2	0.45	1.8	4.6j	5.451	5.5	0.3	1.355	3.451	4.451	4.7	0.6	3.41	5.651	6.15	6.25
NER Total Score	**4.61**					**17.8**					**14.26**					22.05				

A brief description of the other three goals follows. The harvest area goal would be to restore oyster habitat primarily for use in the commercial fishery. These would be "harvest grounds." Harvest grounds could be constructed in any salinity zone in the Chesapeake Bay. This goal scores the lowest from an NER perspective for several reasons. First, commercial fishing activity removes the largest oysters, greatly reducing biomass. Additionally, removing the largest oyster also reduces the reproductive potential of the reef, as fecundity and oyster size are directly related. Such structures are therefore unlikely to contribute significantly to the overall goal of a 10-fold increase in oyster biomass by 2010. As many benefits provided by oyster reefs are dependent on oyster biomass, they are significantly lower on a harvest ground. Finally, the project life is shortest on a harvest ground due to the damage caused to it by commercial fishing apparatus - tongs and dredges. However, if managed in a sustainable fashion, the NED benefits from harvest grounds could make such structures worthwhile. Reefs built under the harvest goal would be the only USACE reefs open to harvest. All reefs built under the other three goals will be maintained as permanent sanctuaries or closed harvest reserve areas. Such harvest reserves could not be opened until a sustainable population was achieved. This would be determined in the future, and will be covered in the adaptive management plan of the long-term, NAO-NAB Feasibility study.

The maximize biomass goal would entail building a project in the Zone 1 waters of the Chesapeake Bay. This strategy scored high under the benefit analysis and such a project would make a substantial contribution to the 10-fold goal. Although this goal will be one of the best strategies to utilize in low salinity waters, there are some drawbacks to implementing this plan. First, such populations would have low recruitment and slow growth rates; therefore, it would take considerably more time to achieve a living veneer of oysters on such a reef. Such populations are likely to be stable over time, but their potential for recruitment is low, which would only allow for large-scale recovery of the oyster population Chesapeake Bay-wide over a long period of time. Establishment of stable oyster populations is a worthy goal, and this strategy will be utilized in some low salinity waters. Disease resistance has not been documented to develop in Zone 1 oyster populations, and this strategy, if it were the only one adopted, would be of limited use in Chesapeake Bay-wide native oyster recovery.

The test sites of selected disease-resistant strains would entail building isolated reefs in Zone 3 waters and seeding them with the best disease-tolerant strains of native oysters available. These reefs would then be monitored and survivors removed to be used in the lab for further selective breeding for increased disease tolerance. A large amount of mortality would be expected on these reefs, especially in the first years after it was constructed, as the selected strains would be subjected to high disease pressure. However, those individuals that did survive would be important for developing future disease-resistant strains. It is unlikely such a reef would contribute as much biomass as a reef built in Zone 1 water, due to the high disease pressure, but the disease resistance that would be developed would be beneficial to the future of oyster restoration. Overcoming disease will be required for full recovery of the native oyster. Continued experimentation and selection of especially fit oysters that have survived exposure to MSX and Dermo will be essential to the overall restoration effort.

Through discussions with oyster experts at VIMS, VMRC and CBF, it was determined that the goal of genetic rehabilitation should be the first step undertaken in achieving oyster restoration in the Virginia portion of the Chesapeake Bay. Not only will it produce the greatest amount of NER benefits, but also the spat produced by this strategy will allow the USACE to increase the NER benefits on USACE constructed reefs, both built in the past and in the future. The next step in the NER Plan development is to determine an appropriate site to implement a project that is most conducive to the genetic rehabilitation strategy.

SITE SELECTION

Site selection is one of the most critical aspects that determines whether an individual oyster restoration project is successful or not. As stated earlier, most of Virginia's waters that can be considered for oyster restoration activities lie within Zone 3. Table 5 outlines the preferred parameters for a successful Zone 3 oyster restoration site. Although there is constant pressure from the oyster diseases Dermo and MSX in these waters, and the mortality of juvenile and adult oysters can be very high, those oysters that do survive grow up to 70 mm shell height and larger and may have some natural disease tolerance. Zone 3 waters also have an advantage in that oysters reproduce much more effectively, and larval survival.is much higher. This results in, on average, much higher recruitment in Zone 3 waters. The typical oyster reef today has a scattered population of adults with a larger population of young juvenile oysters, called spat. Zone 2 and 3 waters provide the highest probability of implementing genetic rehabilitation, with Zone 3'shaving a small edge over Zone 2.

Other factors need also be considered in selecting a site, especially sedimentation rates. In the Chesapeake Bay today, sedimentation rates are higher than they were historically. This has a negative impact on oyster reefs, as it takes only 3-4 mm of fine sediment to accumulate on a shell reef to make it unsuitable as an attachment site for oyster larvae. A site that has low rates of erosion from the surrounding watershed is more likely to be successful. Due to this, sub-estuaries of the Chesapeake Bay that are relatively undeveloped would rate higher than more urbanized watersheds. However, high levels of agriculture or forestry harvest (logging) could negate the benefits provided by lack of urbanization.

Another factor to consider is biofouling. Various marine organisms will colonize any hard substrate in Chesapeake Bay waters and compete with the oyster for space on restored reef sites. Some of the organisms include barnacles, *Balanus improvisus;* sea squirts, *Mogula manhattensis;* mussels, *Mytilus edulis;* anemones, *Diadumene leucolena;* and boring sponges, *Cliona celata* and *C. truitii.* Anemones also eat oyster larvae and can effect recruitment adversely. The boring sponges settle on oyster shell, bore into it, and dissolve the shell structure, physically degrading the oyster shell reef base. This damage can be considerable and negatively impact the project lifespan. Little can be done to prevent biofouling, as most of these organisms live in similar salinity ranges to the oyster. However, some, such as the anemone and boring sponge, can be eliminated by brief periods of low salinity, which can occur in even lower Chesapeake Bay waters during the winter. Such sites, if they exist in Virginia and have potentially restorable habitat, may rate higher than others.

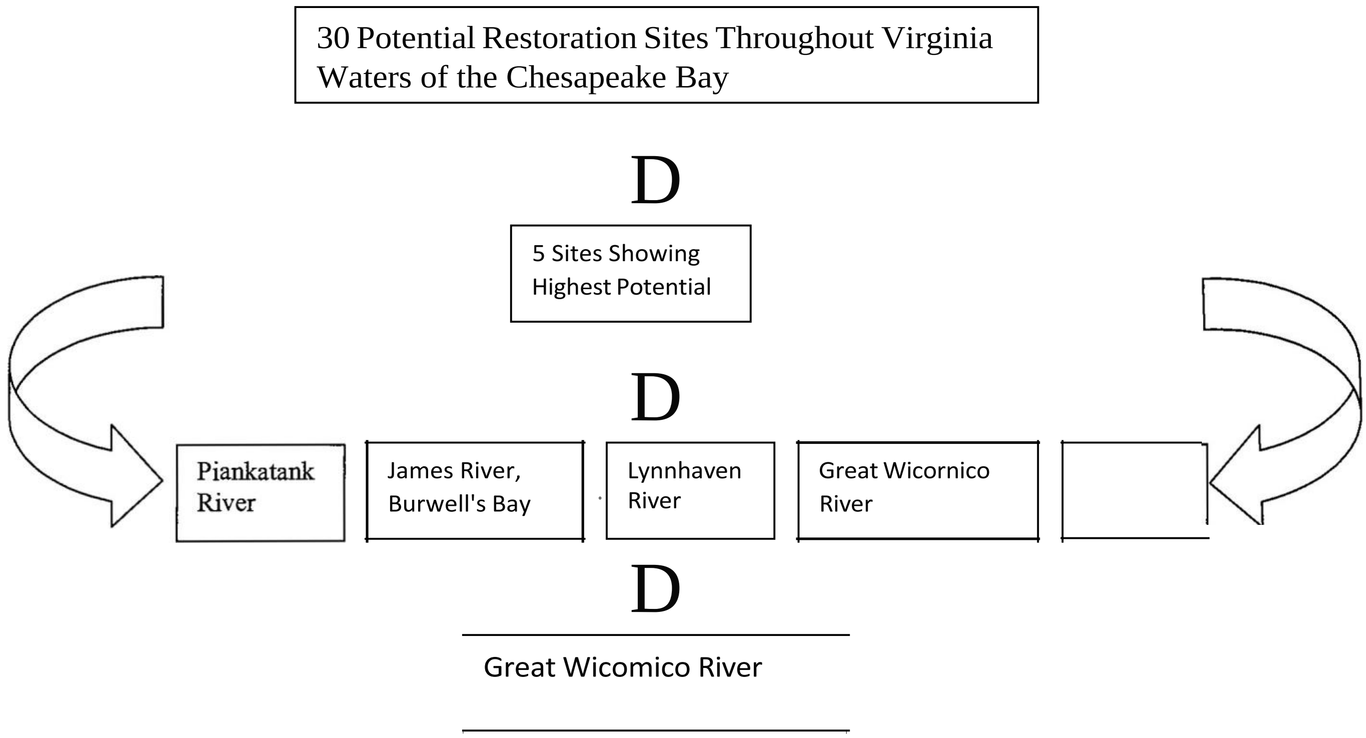
Table 5. SCREENING FACTORS FOR SITE PRIORITIZATION

Factor	Remedy
High potential recruitment	Select Zone 3 waters
Sedimentation Rates	Select areas with little urbanization
Biofouling	Select areas with occasional winter freshet to kill some fouling organisms
Localized recruitment	Select "Trap Estuaries"

INITIAL SCREENING OF POTENTIAL OYSTER RESTORATION SITES

Clearly, oyster restoration faces a host of difficult problems, and several prior USACE projects reflect this. Restoration sites must be carefully selected to maximize project benefits and lifespan in the face of the negative impacts discussed above. First, a series of maps covering Virginia's entire oyster habitat were developed. These 30 maps, or "boxes," were then assessed for their oyster restoration potential and prioritized. The map showing the 30 "boxes" can be seen on Plate 3. The joint NAO-NAB 10-year oyster restoration plan will include a full evaluation of all 30 boxes in Virginia waters and the equivalent analysis for MD waters. The current study will occur only in Virginia waters. While all potential oyster restoration habitats could be restored, several boxes showed a great deal of restoration potential, and five of these were subject to initial screening. For this short-term study, these boxes are Box 6, the Great Wicomico River; Box 13, the Piankatank River; Box 23, the Elizabeth and Lafayette Rivers; Box 26, James River-Burwell's Bay; and Box 27, Lynnhaven Rivers and Broad Bay. The NER model discussed earlier was used to assess these four sites. The four potential activities were considered, including commercial harvest, maximize biomass, test sites of selected strains, and genetic rehabilitation, for each of the possible sites. However, the top priority for the proposed project is genetic rehabilitation. Figure 7 illustrates the screening process used for potential genetic rehabilitation sites.

Figure 7. GENETIC REHABILITATION SITE SCREENING PROCESS



Great Wicomico River Advantages:

- Low sedimentation rates due to little urbanization and small watershed
- High water quality in proposed construction areas
- Low chance for summer freshet, winter freshets should be short duration due to small watershed

The Great Wicomico River, Box 6, has several advantages that make it an attractive site. It is one of the least-developed watersheds in the Chesapeake Bay and has lower sedimentation rates as a result. Overall water quality is high, though in drought years there is a small chance of a red tide, which can adversely affect recruitment. The chances for freshets are lower than in a more urbanized watershed or a Zone 1 site, due to its small watershed (70 square miles) and lack of urbanization. Low oxygen levels can sometimes occur in the summer in the deeper parts of the main channel, but these areas do not contain any restorable oyster habitat, and will not be considered for restoration. The Great Wicomico lies within Zone 3 waters; therefore, disease pressure and mortality is moderate to high, but the recruitment potential is also high. Salinity can drop low enough in the winter for oysters to reduce disease parasite burden, which can increase survival rates during non-drought years. The potential restoration substrate is in good condition due to decades of shelling by VMRC. Reef bases should be stable and not subject to heavy sedimentation. Current wild oyster population is low, and shows no significant disease resistance. Recruitment is currently low compared to historic levels, due to few adults present in area.

The Great Wicomico is a "trap estuary" (Southworth and Mann, 1998; VIMS, 2002). In trap estuaries, the hydrodynamics are such that loss of oyster larvae due to tidal advection is lower than any other areas within the Chesapeake Bay watershed. As a result, oyster recruitment can be much higher, as setting is more intensive and localized due to a circular, closed movement pattern (Andrews and Ray, 1988). Recruitment would originate in the local population of oysters in the Great Wicomico. This is contrast to the large flushing type rivers like the Rappahannock or open bay waters, such as in Tangier and Pocomoke Sounds. Prior research has demonstrated these properties of the Great Wicomico River. An experimental oyster reef was constructed in the Great Wicomico in 1996. This reef was then seeded with adult broodstock during December of 1996 with oysters from Tangier Sound (a wild stock that shows some minimal disease tolerance) at a density of approximately 300 per square meter. These broodstock oysters spawned in 1997. The resultant concentration of larvae in the Great Wicomico, though not of the same order of magnitude seen in historical times, it is still several orders of magnitude higher than that found in the James River, which is considered to be the most important oyster-producing river in the Chesapeake Bay (Southworth and Mann, 1998). It is extremely high when compared to natural larval production documented for years after the onset of disease and decimation of broodstock oyster populations throughout the Chesapeake Bay and all tributaries that can support oysters. In addition, prior to this reef and broodstock seeding, recruitment in the Great Wicomico had been less than 100 spat per square meter for many years. The spatset in the Great Wicomico subsequent to the broodstock spawning was, on average, close to 900 spat per square meter (Brumbaugh et al., 2000). The Great Wicomico River is highly suited for the goal of genetic rehabilitation.

The Piankatank River, Box 13, is a larger sub-estuary of the Chesapeake Bay than the Great Wicomico River and lies a short distance south of the mouth of the Rappahannock River. The Piankatank is also a trap estuary; typically it has moderate natural recruitment, and a relatively undeveloped drainage area (rural-farmland and forested). This estuary's water is the least modified of all of Virginia's waters. Its headwaters include a large expanse of blackwater and cypress swamp. The total area of its watershed is 222 square miles, considerably larger than the Great Wicomico. Salinity varies within the river from 12 to 19.0 ppt. Oyster growth rates are considered normal, and MSX and Dermo are at moderate to high levels year round. Blue crab numbers are abundant and prey on small oysters (spat). Historically high, but currently moderate, natural recruitment levels have been seen. There are 295 acres that could be rehabilitated within the Piankatank River, and it appears to be an excellent site to attempt implementation of the genetic rehabilitation strategy.

The Elizabeth and Lafayette Rivers, Box 26, also show considerable promise. The Lafayette River is a small branch of the Elizabeth River that once supported extensive natural oyster reefs. Today, it holds only a remnant oyster population and has been condemned for market oyster production due to high coliform bacteria levels. This condemnation would prevent poaching of restored oyster reefs. The Lafayette has a poor tidal exchange rate, which allows for strong auto recruitment from local oysters, and functions essentially as a trap estuary. It is a heavily-urbanized watershed and may be subject to freshets; however, the location of the Lafayette in the lower Chesapeake Bay reduces the probability of a freshet, as the waters are quite saline (Zone 3 year round). Little information currently exists for the bottom conditions in the Lafayette River, except that there are at least eight acres of potentially-restorable habitat that lie within the Lafayette River. The Lafayette may be an excellent site to implement oyster restoration, according to recently-collected data (VMRC, 2002). Spatset has been very low in the entire Elizabeth River system for decades. Several small reefs were recently built in the Lafayette and seeded with disease-tolerant broodstock oysters (CROSBreed and DEBY strains), grown by CBF. The fall 2002 spatset seen in the Lafayette on some of the new reefs was over 2,000 per square meter. This spatset matches historical levels and has not been seen in any waters of the Chesapeake Bay in decades. The USACE Oyster Biomass Model has determined that it will take comparable levels of recruitment to achieve a biogenic restored reef.

The Lafayette may not have as suitable a salinity regime for genetic rehabilitation. The total restorable area within the Lafayette may only be 30 acres or less. Due to the USACE need to restore a site greater than 30 acres in size, the more variable salinity, and the uncertainty of restoring any additional acreage other than the 8 acres already known to be in good enough condition to attempt oyster reef base construction, the Lafayette has been rated at a lower priority than the Great Wicomico River. It is highly likely that a large-scale oyster restoration project will be implemented in the Lafayette during the IO-year period that USACE expects to conduct oyster restoration. It may be better suited as a test site for selected strains as its primary goal.

Burwell's Bay in the upper James River, Box 26, is another area initially considered for oyster restoration. It was historically Zone 1 water, though several years of drought have caused higher salinity waters to move further up the Bay tributaries, and it is classed as Zone 2 water today. In Zone 2 water, disease pressure from MSX and Dermo can be considerable, and some oyster mortality can occur. If rainfall conditions return to normal, this area will likely become Zone 1 water once again. Under normal conditions, disease pressure is low in Zone 1 waters. Due to the low salinity, oyster growth rates are also low, as is reproductive output. Currently, spatset was higher than expected due to the larvae's being transported upstream from higher salinity areas and the presence of a gyre, which serves to retain the few larvae produced by oysters in the area, rather than transporting them over a wider area. Extensive areas are available for restoration (1,921 acres of oyster rock present). According to VIMS, this area has the potential to sustain self-maintaining populations. This is a good site for attempting to create significant oyster biomass with oyster reef restoration and seeding. Due to the low reproductive output, recruitment, and slow growth rates, however, this area is not conducive to creating seed for subsequent movement to other locations in the Chesapeake Bay. Due to the specific needs of the current project, this area was eliminated from further consideration for the present study. Current research (Mann, 2002) has indicated that this is one of the few areas **in** Virginia waters of the Chesapeake Bay that has a self-sustaining population of native oysters. Restoration of oyster reef bases **in** this area along with the construction of breeder reefs downstream could result in significant oyster biomass increase throughout the lower James River system. The breeder reefs would be placed so a significant portion of the larvae they produce would be swept further up the James River. This is an excellent site to attempt to build a slow growing, self-sustaining population of native oysters and will likely be restored in the future. The goal of Biomass maximization would be best suited for this site.

The Lynnhaven River and Broad Bay, Box 27, was the final area initially screened for potential restoration activities. The Lynnhaven River and Broad Bay once held among the best oyster reef areas in the entire Chesapeake Bay. This area had a long history of providing some of the best market oysters from the Chesapeake Bay and Eastern Shore area. It is a small sub-estuary with a restricted opening to the Chesapeake Bay main stem. As a trap estuary, it has good larval retentive capabilities. The Lynnhaven is Zone 3 water, and oysters are subject to constant disease pressure. Recruitment has high potential, however. Recent efforts to restore oyster reefs by CBF have also shown the area to hold considerable promise. Prior to any restoration, the Lynnhaven River had a typical spatset of about 10 per square meter, a tiny fraction of historic levels. The first oyster shell reefs constructed in 1998 provided clean substrate and increased spatset to about 180 spat per square meter. Recent seeding of disease-tolerant strains of native oyster have significantly increased the spatset on some reefs in the Lynnhaven, to a record of over 1,600 spat per square meter (VMRC, 2002). Unfortunately, the Lynnhaven River bottom is currently almost entirely in the hands of private leaseholders and almost no public ground acreage exists. The VMRC has the right to buy back such leases, but this process takes quite a while and will take some time to resolve. There is no guarantee that VMRC will be successful in buying back any of these leases; therefore, action from the Virginia General Assembly may be necessary. Due to this uncertainty, the Lynnhaven River was eliminated from further consideration in this short-term plan. It will be examined again in the joint NAO-NAB 10-Year Oyster Restoration Plan, as it is likely this issue will be favorably resolved and some acreage will be available for implementation of the genetic rehabilitation strategy in the future.

A small model was developed to score these different sites. This model rated four factors known to be critical to oyster larval survival and recruitment: salinity, tidal exchange, the available area for attachment (actual or potential), and the urbanization of the watershed. Highly urbanized watersheds can be more prone to freshets. Weighting factors were assigned to the different regimes, and the regimes have been described in the above text. The results are presented in the table below.

Table 6. SITE PRIORITIZATION RANKINGS

Wei2htin2 Factors (1)								
Site Screened	**Salinity**	**Tidal exchange suitability**	**Restoration area**	**Watershed** (3)	**Weighting factors (added together)**	**Genetic rehabilitation NERscore**	**Site Selection Score**	**Priority**
Burwell's Bay	Low	Medium	High	Low	1.9	22.05	41.90	5
Great Wicomico River (2)	Medium -High	High	Medium-High	High	3.6	22.05	79.38	2
Lafayette River	High	High	Low	Low	2.4	22.05	52.92	3
Lynnhaven River	High	High	None	Low	2.2	22.05	48.51	4
Piankatank River	Medium -High	High	High	High	3.8	22.05	83.79	1

Sites were ranked based on their capability to implement a genetic rehabilitation based project.

(1) Weighting factors have a value of from 0.0 to 1.0, low is 0.2, medium is 0.5, medium-high is 0.8, and high rates 1.0. These factors represent the suitability of the site.

(2) The Great Wicomico was ultimately selected due to an ongoing stocking effort (non-USACE) that has placed significant numbers of disease-tolerant DEBY-selected strain oysters in this river.

(3) Watershed suitability reflects the amount of urbanization and/or agricultural activity. These types of developments can adversely affect water quality.

Due to the project goals, which include establishing extensive acres of biogenic oyster reefs, spat-on-shell production, and minimal risk of project failure, the Great Wicomico River and the Piankatank River have been selected as the sites for further consideration in this short-term study. Activities will be in the Great Wicomico River in 2003 and in the Piankatank River in 2004. The Great Wicomico River was chosen for the first restoration effort due to the fortuitous seeding of the present HRR's with 750,000 DEBY strain oysters as part of an ongoing, non-USACE funded rehabilitation/restoration effort. These oysters will add considerable benefits to the proposed USACE project.

NER OYSTER BIOMASS MODEL

The NER benefits of the proposed project depend primarily upon the establishment of a population of living oysters over the surface of the USACE-constructed restoration area. In addition, without this living veneer of oysters, the restored oyster habitat will degrade over time due to biofouling, sedimentation, and physical degradation by boring sponges.

The previous two phases of the USACE oyster restoration effort, the projects constructed in the Rappahannock River and Tangier/Pocomoke Sound, VA, had a very simple biological model. These models assumed certain levels of recruitment from nearby wild oyster populations and the growth of certain numbers of the resultant recruits into "markets," adult oysters of 76.4 mm shell height (3 inches long). These were very simple fishery metrics and levels of production desired for a fishery. They had little to do with determining what is a functional oyster reef with a living veneer of oysters that accumulates biomass over time. They also made no estimate of the population of oysters necessary on a restored reef to produce additional shell faster than the reef structure is degraded by various factors already mentioned, such as sedimentation, biofouling, and degradation by boring sponges. The genetic rehabilitation strategy requires a much more scientific modeling approach to determine what a desired oyster population is and also needs to determine how much and what type of broodstock oyster is necessary within any given project area to provide an oyster population sufficient to attain the NER benefit score described in the table above.

Such a model has been developed for the new project. The Oyster Biomass Model, attached as Appendix B, is able to determine the expected oyster population on an oyster reef based on various parameters. All of the model parameters, and the equations USACE Norfolk District used to develop the model, were obtained from the scientific literature, current unpublished research, and in consultation with the scientific community (Mann et al., 1998; Southworth and Mann, 1998; Powell et al., 1993, Lavitan, 1991). The model is a Leslie Matrix, a biological model used to project population dynamics.

ADAPTIVE MANAGEMENT AND MONITORING PROGRAM

Great Wicomico River Oyster Recovery, 2004

The probability of achieving the project NER benefits is high enough to proceed; however, there is a chance that the project will fail to provide the estimated benefits. Factors outside the control of the USACE include, but are not limited to, cataclysmic weather events, such as hurricanes and freshets, both of which can eliminate all oyster larvae in a wide area, as well as red tides, which can kill oyster larvae if severe enough. A strong storm could potentially flush the oyster larvae out of the Great Wicomico into the main stem of the Chesapeake Bay, greatly decreasing recruitment. The proposed project has taken into account these possibilities to the extent such things can be predicted. Due to inherent uncertainty present in the relatively new technology of oyster restoration, USACE Norfolk District has designed an adaptive management plan to ensure the proposed project provides the NER benefits over the predicted project life. As stated before, the NER biomass model was used to determine the initial level of broodstock oyster stocking necessary to "jumpstart" the Great Wicomico incubator system. This level was determined to be 5 million DEBY broodstock oysters of a minimum size of 40 mm shell height at initial stocking. This level should ensure sufficient recruitment to the incubator reef, surrounding sanctuary areas, and spat-on-shell production areas. If it does not, additional seeding may be done following guidance in the adaptive management plan. The spat-on-shell production areas should receive a spatset high enough to make moving the spat-on-shell highly beneficial in the Chesapeake Bay-wide stocking effort, as well as making it economical due to the low cost per spat.

It is also possible that the project may perform better than anticipated. In this case, additional application of disease-tolerant broodstock oysters to reefs within the Great Wicomico incubator system may not be needed. This will depend entirely on continued recruitment to the incubator reefs and surrounding areas sufficient to develop self-sustaining and biogenic oyster reefs. The NER Biomass model has determined that a minimum of 327 grams ash free dry weight of oysters, which includes all oyster size classes, should be on the incubator reef in the Great Wicomico incubator system by year 5. The progression of biomass should proceed as listed in the table below.

Table 7. OYSTER BIOMASS ACCUMULATION {SEEDED)

Oyster Biomass Over time - Seeded Incubator Reefs	
Year	Biomass (ash free dry weight in grams per square meter of incubator reef)
1	150 (based on initial stocking)
2	210
3	288
4	320
5	327

It is expected that a similar trend and biomass distribution on the unseeded habitat within the trap estuary. The unseeded habitat would, of course, start with a biomass of zero. The expected biomass for the unseeded restored oyster habitat is represented in the table below.

Table 8. OYSTER BIOMASS ACCUMULATION (UNSEEDED)

Oyster Biomass Over time - Unseeded Habitat	
Year	Biomass (ash free dry weight in grams per square meter of incubator reef)
1	0
2	60
3	138
4	170
5	177

Another important aspect to note is that biomass accumulates over time. If the overall trend by year 5 does not show an increase in biomass within the Great Wicomico River, adaptive management will require corrective action. It is important to note that the NER benefits that were used to determine the "Best Buy" plan are directly related to this accumulation of biomass over time, and all adaptive management measures are to help ensure this biomass is achieved. To determine if these levels of biomass are being achieved, a monitoring program will first be required. The monitoring program should accomplish the following:

- It should support *adaptive management* decisions by providing data on critical stages in the development of the reefs that can guide the next steps in the restoration process. This monitoring should answer crucial questions that affect implementation decisions. Examples: Did sufficient numbers of transplanted broodstock survive and spawn to support continued reef development? Is cultch quality sufficient to support a second year's recruitment?

- It should evaluate intermediate conditions that help to *track progress* towards the final goals. For instance, are enhanced abundances of oyster larvae and new recruits observed in a tributary following seeding with broodstock oysters? Or, what is the disease status of oysters on sanctuary reefs? Such a monitoring objective permits setting *intermediate goals* and evaluating success in reaching those goals.

- It should measure specific elements necessary to evaluate *success criteria* established for the project. For instance, numbers and sizes of oysters are needed to evaluate the filtration capacity of an oyster reef. Monitoring to track progress towards a biodiversity goal is more difficult because of not having a quantitative relationship between oyster density and the habitat value of a reef. However, if such a relationship is established by future research, it could provide a basis for tracking progress towards this goal.

- It should aid in *identifying unexpected stresses*, environmental conditions, and/or ecological interactions that can affect the overall success of the project. For instance, water quality can be affected by a very wide range of factors; measuring all of which would be impractical, but having a monitoring program in place that could recognize when water quality problems affected the success of a project would be invaluable.

While each of these are important objectives for a comprehensive monitoring strategy, and their proper implementation will be crucial to the overall success of the USACE oyster restoration efforts, it is unlikely that every individual restoration effort will be able to incorporate all of these monitoring objectives. Allocation of the limited resources available for monitoring should be guided by the strategic needs for ensuring success. Incubator systems, which all other stocking efforts will depend upon, will require more extensive monitoring of sites where the goal is simply to establish a stable population of oysters. The proposed project in the Great Wicomico River is an incubator system, as will the next project proposed for the Piankatank River (to be covered in an amendment to this document). Sites where the goal is a stable population of oysters include the previous two projects constructed in Virginia waters, the lower Rappahannock and Tangier Sound oyster recovery projects.

Monitoring will provide data that will be used to employ the principles of adaptive management to the proposed project. The table below provides a brief summary of how the monitoring program relates to adaptive management and outlines various adaptive management measures. Possible adaptive management measures include additional stocking of selected strains of disease-tolerant native oysters within the incubator system(s), additional moving of disease-tolerant spat-on-shell (seed) to sites throughout Chesapeake Bay to implement the genetic rehabilitation strategy, applying of additional fresh oyster shell to restored habitat sites to enhance recruitment, and improving handling/transporting protocols.

Table 9. MONITORING PROGRAM WITHIN ADAPTIVE MANAGEMENT

Monitoring Element	Monitorin2 Objective
1. Early survival rate of oysters after transplanting.	*Adaptive management.* Supports decisions related to handling and planting protocols.
2. Abundance and fecundity of transplanted broodstock oysters.	*Adaptive management.* Evaluates need for additional stocking. *Tracking progress.* Facilitates comparison with predicted values in the biomass model.
3. Abundance of oyster larvae.	*Tracking progress/Intermediate goals.* Supports comparisons with historical data and biomass model comparisons.
4. Abundance of new recruits to restoration sites.	*Adaptive management.* Evaluation of sufficient stocking density.
5. Substrate quality.	*Adaptive management.* Assess the need for additional cultch planting.
6. Growth and survival of oysters at restoration sites.	*Success criteria.* Evaluate progress of the primary success criteria for the project.
7. Disease status of: a. oysters before transplanting. b. on sanctuary reefs.	a. *Adaptive management.* Evaluation of seed oyster source. b. *Adaptive management.* May suggest the need for further seeding or indicate a cause for observed mortality. *Tacking progress.* There is an expectation under the genetic rehabilitation model that, on average, disease pressure will decline over time.
8. Genetic identification of stocks.	*Tracking progress* toward the *intermediate goal* of observing a genetic signal from the transplanted stocks and toward the final *success criteria* of altering the population's genetic make-up.
9. Ancillary water quality data.	*Identifying unexpected stresses.* Aids in identifying non-disease-related mortality sources.

ECONOMIC ASSUMPTIONS

Introduction

This section summarizes the assumptions and procedures used in developing the costs for all of the considered construction alternatives, including HRR's, MRR's, LRR's, and thin shelling. Additionally, the costs for the proposed seeding with cultchless oysters are discussed. All prices used in this analysis are in Fiscal Year (FY) 2003 dollars, with a 5-7/8 percent interest rate used in the present value and annualization calculations. The project planning period is 25 years, with construction beginning in the third quarter of FY 2004. A 25-year life was used, as that is common among marine construction sites, and the benefits are expected to be maintained by the State sponsor for 25 years. If not before, it is assumed that after 25 years all of the constructed reefs should be self-sustaining. As the project costs and benefits are in current values, no inflation factor was added to the cost estimates. The base year is 2003.

Reef Construction - Cost Assumptions

In February 2003, VMRC provided the Norfolk District with dredged shell placement costs for two types of activities in the Great Wicomico River. These were for shell placed in mounds, which would create both HRR's and MRR's, and shell placed as flats, which would create LRR's and thin-shelled areas. Norfolk District Civil Works engineers then provided construction costs for each of the three alternatives looked at in the Great Wicomico River. These costs were revised and adjusted by the Norfolk District Cost Engineering Section (attachment 1, Appendix C). Cost estimates were based on a unit price of $17.50 per cubic yard for shells placed in mounds, and $16.50 per cubic yard for all shell used to construct flats. These unit prices include markups, dredging, cleaning, hauling, and placing of shells. A 15 percent contingency was added to shell placement costs. In addition, the dredging location was assumed to be approximately 85 miles from the restoration site. All costs associated with reshelling are assumed to be at a cost of $16.50 per cubic yard, as the flat areas will be reshelled.

Cultchless Seeding Efforts - Cost Assumptions

All cultchless seeding of HRR's sites within the Great Wicomico River are assumed to be of the DEBY strain. The minimum size to be placed on any USACE-funded reef is 40 mm, but it is assumed that the larger the size, the more benefits will be derived. Broodstock oysters of 40 mm size are assumed to cost $0.085 per oyster. Larger oysters will cost proportionally more. These costs include transportation and placement.

Other Cost Assumptions

Total project costs include construction, design, study, and monitoring. In order to complete this project, there were study costs of $400,000, of which was a $90,000-contract with VIMS for help with data collection and scientific input. Monitoring costs were assumed to be $60,000 in year 1, and $15,000 in year 2, and $5,000 per year until year 5, for all alternatives. The monitoring funds are higher than usual for an ecosystem restoration project, but this level of monitoring is essential in order to implement the alternative management plan that will be required for this project's success. Not only will more monitoring be required to ensure the project meets the NER goals, but there needs to be the flexibility to change future construction or monitoring activities to ensure project success. As this is a design and construct project, the design costs of $25,000 are included in the construction costs. Any future costs needed to implement the adaptive management plan will be addressed in future amendments to this plan.

Additionally, Operation, Maintenance, Replacement, Repair, and Rehabilitation (OMRR&R) costs were developed for each alternative. These costs cover all of the maintenance of each alternative from the end of construction in year 5 for the 25-year life of the project. Included in the OMRR&R costs is $5,000 per year for continued monitoring, $5,000 per every other year for reshelling, and 2 events of reseeding at a cost of $425,000 per event. This is needed to implement the adaptive management plan for the life of the project. **OMRR&R** costs may be lower than expected, depending on how much spat-on-shell is removed from the Great Wicomico, thus changing the amount of reshelling that would be needed. Additionally, reseeding with broodstock oysters may not be necessary after year 5, which would substantially lower the maintenance costs. All costs for removing spat-on-shell and placing on reefs throughout the Chesapeake Bay and its tributaries is considered a cost of that project and is not included in this project's total costs. However, all costs for reshelling reefs built within the Great Wicomico are considered to be included in this project's costs. For all activities that take place after year 5, reshelling costs are included in OMRR&R. A breakdown of all the costs can be found in Table 1 in Appendix C, Cost Estimates and Economic Analysis.

CONSTRUCTION ALTERNATIVES ANALYSIS

Three construction alternatives were developed, in addition to the No Action plan. Alternatives were based upon varying designs of HRR's, MRR's, LRR's; thin shelling; and broodstock oyster seeding regimes. All alternatives are assumed to have a 5-year construction window, with primary reef construction occurring the first year. Subsequent reshelling of spat-on-shell production areas and reseeding the breeder reef(s) will occur later. The No Action plan, while having no cost, was assumed to provide no NER benefits under the NER benefit model, as discussed previously. The environmental benefits were determined by the ability of an alternative to reach a goal, with each goal providing a product score of NER benefits. Two of the alternatives provided all of the benefits derived from the genetic rehabilitation goal, while the third alternative provided a combination of the genetic rehabilitation goal and the biomass maximization goal. It is assumed that the NER benefits will be fully realized in year 5 for all alternatives, and exponential interpolation is assumed until year 5.

DESIGN CRITERIA

Design criteria were defined for the proposed 2004 activities in the Great Wicomico and Piankatank Rivers, respectively. The Great Wicomico is a small trap estuary, and it is imperative that this sub-estuary, as the first project designed with the genetic rehabilitation goal in mind, produce sufficient spat-on-shell derived from disease-tolerant broodstock oysters for movement out to previous projects in the lower Rappahannock River and Tangier/Pocomoke Sounds. Several activities will be necessary to accomplish this:

1. Seed the existing HRR in the Great Wicomico River with disease-tolerant oysters sufficient to increase recruitment to historical levels (pre-1960) within the sub-estuary.

2. Survey the existing potential oyster habitat to determine the full extent of restorable acreage in the Great Wicomico River.

3. Rehabilitate sufficient habitat to the extent possible to ensure that larval oysters have a good substrate to set and metamorphose. Spat-on-shell production sufficient to affect large scale stocking of the Tangier/Pocomoke Sound oyster habitat, the lower Rappahannock River oyster habitat, and possibly other areas is required. Ensure sufficient reefs are within the system such that recruitment throughout the sub-estuary is maximized. Not all restored habitat will be used for spat-on-shell production. Many areas must be left undisturbed in order for additional populations of mature, reproductive disease-tolerant oysters to grow and add to the breeding population in the Great Wicomico beyond that on the HR.R's. These areas, whether they are HR.R's, MRR's, LRR's, or thin-shelled, will be designated as sanctuary areas.

4. Thin shell any areas where spat-on-shell are removed in order to maintain their effectiveness as attachment sites for additional oyster larvae in the future.

5. In 2004, seed the HR.R's in the Piankatank River with disease-tolerant broodstock oysters to begin use of the Piankatank River as the second site for spat-on-shell production to increase our capacity to "terraform" the Chesapeake Bay. This will also involve thin shelling and/or LRR construction to rehabilitate the present oyster habitat areas. The area to be restored will depend on a survey of the bottom area; USACE expects to restore, at a minimum, 295 acres of oyster habitat. Additional movement of spat-on-shell from this area, post construction, is anticipated to take place to further implement the genetic rehabilitation strategy.

DESCRIPTION OF ALTERNATIVES

Proposed Activities in the Great Wicomico River

The first design criterion involves seeding the HR.R's in the Great Wicomico River with disease-tolerant broodstock oysters. There are a number of varieties that could be used. In order to determine what variety should be used in the Great Wicomico, several strains were evaluated, based on the latest scientific data available. Several strains were considered, including wild stocks that have some disease tolerance.

The graphic information displayed illustrates the latest results on the research in Virginia on disease-tolerant strains of wild oyster stocks, as well as selected strains of native oysters. Comparisons were made between the DEBY selected strain, the Tangier Sound wild stock, and the Mobjack Bay wild stock. As shown, the DEBY strain clearly out-performs both Mobjack Bay and Tangier Sound wild stocks. While both wild stocks have demonstrated some disease resistance and are reported to be among the most disease-resistant wild stocks in the Chesapeake Bay, the DEBY selected strain is clearly superior. Although not shown, comparisons were made between the CROSBreed strain and various wild stocks. The CROSBreed oysters perform only slightly better than a wild Virginia stock with some disease resistance. This is due primarily to the fact that CROSBreed oysters have excellent resistance to only one of the two diseases that plague the native oyster, MSX. They have only been selected for resistance to Dermo for a few generations, while the DEBY strain has been selected for both MSX and Dermo resistance. Out of all four oyster stocks that are documented to have some disease tolerance, the Tangier Sound and Mobjack Bay wild stocks, CROSBreed, and DEBY selected strains, the DEBY strain is best suited for genetic rehabilitation in the Great Wicomico River, since it performed the best against both MSX and Dermo. Additionally, the DEBY strain has already been stocked and tested on the present HR.R's in the Great Wicomico and has done very well to date.

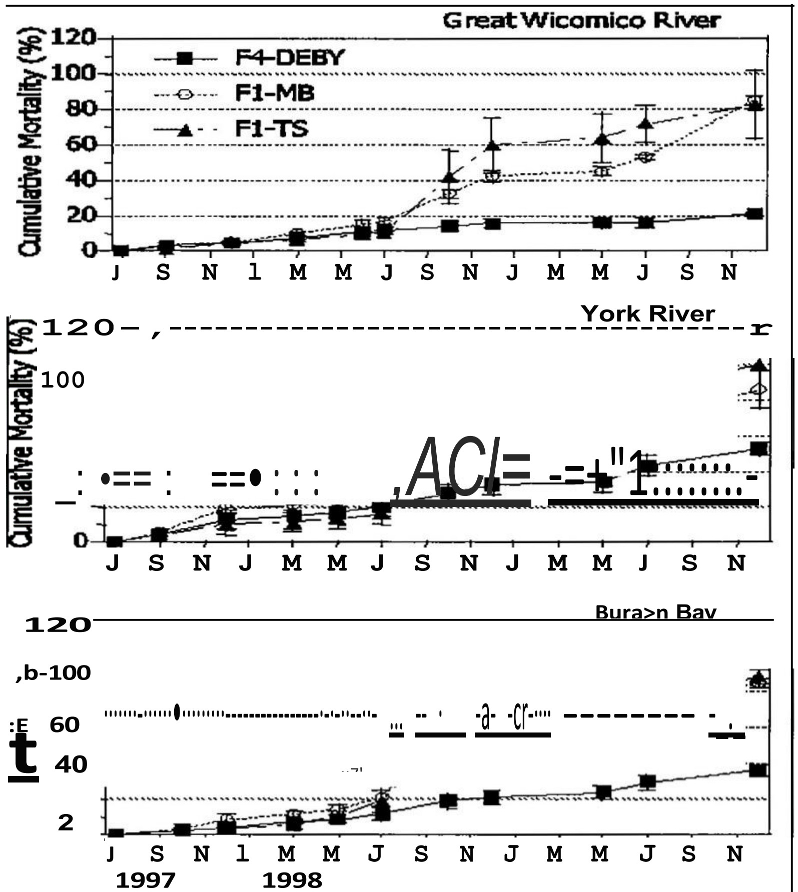


Figure 8. COMPARISON OF SELECTED STRAINS OF NATIVE OYSTER. The DEBY selected strain of native oyster was evaluated in three different sites against two wild stocks, the Tangier Sound (TS), known to have developed some disease resistance through natural selection, and a stock from Mobjack Bay (MB). As shown, the DEBY strain significantly outperforms both wild stocks and does particularly well within the Great Wicomico River.

After meeting with scientists at VIMS and VMRC, it was determined that the existing 48 acres of "oyster rock" in the Great Wicomico were suitable for spat-on-shell production and/or reef construction. However, additional acres are needed to achieve the total volume of spat-on-shell production desired for future stocking efforts, as well as to increase the oyster biomass via additional permanent sanctuaries in the Great Wicomico. The second part of the alternative formulation phase was to conduct additional surveys to determine the total restorable acreage in the Great Wicomico. These surveys were performed in winter 2003. An additional 78 acres were determined to be suitable from an engineering standpoint to be capable of supporting oyster reef construction. These 78 acres will be restored to the extent practicable. The total restoration acreage available then may be up to 126 acres. Initial construction will likely occur on the highest quality acreage first, which was determined to be 109 acres based on the survey data analysis.

Several construction alternatives were considered. The available construction options include seeding with broodstock oysters as well as, constructing HR.R's, MRR's, LRR's, and thin shelling. An activity considered is spat-on-shell movement, which is the gathering of juvenile oysters from restored bottom and moving them to other sites, such as restored oyster habitat in Tangier/Pocomoke Sound. The value of this activity was explained in the genetic rehabilitation strategy. The resultant disease-tolerant spat-on-shell for each alternative is proposed for additional stocking efforts throughout the Chesapeake Bay. These are not considered an activity of this project and will be covered in the long-term Decision Document. The first priority after additional stocking in Tangier Sound sufficient to attain the potential reproductive capacity of the USACE-constructed Tangier Sound sanctuary reefs is to stock the oyster reefs constructed by USACE in 2000 and 2001 in the lower Rappahannock River. To fully implement the genetic rehabilitation strategy, most or all available oyster restoration habitat may need to be seeded. The USACE-restored oyster habitat in the Rappahannock River, lying as it does in an area with constant, high disease pressure, is a prime candidate in Virginia waters. It has the advantages of being large in extent, fairly contiguous, and in excellent condition. A brief description of the possible options is in the table below.

Table 10. CONSIDERED CONSTRUCTION OPTIONS

Construction Option	**Description**	**Cost**	**Unit**	**Notes**
HR.R's (1)	Series of shell mounds from 6-8 feet tall over a I-acre footprint.	$100,000	1 acre	Same as "3-D" reefs in previous plans.
MRR's (2)	Series of shell mounds or flats from 1-4 feet tall over a 1-acre footprint.	$ 15-50,000	**1** acre	
LRR's (3)	A 6-10 inch layer of shell with a base of shell fines over a 1-acre footprint.	$10,000	1 acre	Same as "2-D" reefs in previous plans.
Thin-Shelling	Application of a 1-4 inch thick layer of oyster shell over a 1 acre footprint.	$ 1,000-5,000	1 acre	Can only be done in areas with oyster rock already present; done for spat-on-shell production.
Broodstock Seeding	Application of reproductively-mature oysters to a restored site.	Varies with size, a 40 mm oyster **(minimum** acceptable size) is $0.085/oyster.	From 1 to 10 million seed oysters/ acre on an incubator reef.	Disease tolerant strains must be used.
Spat-on-shell transport	Gathering of juvenile oysters using traditional methods, transport, and placement on other suitable oyster habitat throughout the Chesapeake Bay.	Price is by bushel of spat-on-shell transported; this will vary from$ 10-15 per bushel.	1 bushel	A minimum of 350-500 juvenile oysters/bushel, more is preferred.

(1) HRR = High-Relief Reef (6-8 feet tall).
(2) MRR = Medium-Relief Reef (2-4 feet tall).
(3) LRR = Low-Relief Reef (- 8 inches tall).

No Action Alternative

A No-Action Alternative was considered. Under this alternative, USACE would undertake no restoration activities of any sort in the Great Wicomico River. The No Action plan is acceptance of the existing conditions. With regard to native oyster populations and habitat, this would mean that oyster habitat would remain in poor condition and likely to decline further in the Great Wicomico River. This is due to the low native oyster population in the Great Wicomico River's being unable to provide sufficient recruitment and survival to maintain the current oyster habitat. It also assumed that an oyster population at 1 percent of its historic level is acceptable. The genetic rehabilitation strategy now addresses habitat restoration and augmenting the fitness and numbers of native oysters throughout Virginia waters of the Chesapeake Bay. The No Action plan is selected when the other considered alternatives are not found to be feasible on the basis of environmental, economic, or engineering criteria. The No Action Alternative would result in a continuation of existing conditions and is assumed to provide none of the NER benefits under our benefit model.

Alternative 1

Alternative 1 would take a similar approach to past projects, constructing several HR.R's and surrounding them with LRR's. With the total acreage to be considered, and that there is 1 acre of HRR already in the system, the option would be to construct 3 additional acres of HR.R's and the remaining 123 acres as LRR's. HR.R's would be placed to take advantage of the Great Wicomico hydrodynamics to distribute their larvae onto the restored oyster habitat to the extent possible. All other available acreage would be constructed as LRR's. All HR.R's would be seeded with cultchless broodstock DEBY strain oysters in year 1 and year 5. Spat-on-shell would be removed from the LRR's as needed for the genetic rehabilitation stocking effort, which would be repaired by thin shelling afterwards for future spat-on-shell production. Overall, this alternative would provide 3 acres of HRR' s as permanent sanctuary and 123 acres of LRR's spat-on-shell production areas (see Table 11). The goal set for the seeding effort with disease-resistant stocks is to bring the spat-on-shell count per bushel up to 2,000 spat-on-shell/bushel. This would far exceed the capacity of any manmade seed oyster producing facility in the Chesapeake Bay, thus achieving the genetic rehabilitation goal and NER benefits of 22.05 by year 5.

Table 11. ALTERNATIVE 1 - PROPOSED CONSTRUCTION

ALTERNATIVE 1- Total Construction Costs= $2,485,000; NER Benefit Goal= 22.05					
Construction Option	**Description**	**Cost**	**Unit**	**Total costs**	**Notes**
LRR's	A 6-10 inch layer of shell with a base of shell fines over a 1-acre footprint.	$ 10,000/ acre	123 acres	$1,230,000	Same as "2-D" reefs in previous plans, sanctuary areas.
HR.R's	Series of shell mounds from 6-8 feet tall over a 1-acre footprint.	$ 100,000/ acre	3 acres	$300,000	Same as "3-D" reefs in previous plans.
Broodstock Seeding	Application of reproductively-mature oysters to a restored site.	Varies with size, a 40-mm oyster (minimum acceptable size) is $0.085/ oyster	1.25-2 million/ acre on an incubator reef (HRR).	$425,000 in year 1 and $425,000 in year 5.	Disease-tolerant strains must be used.
Reshelling	Replacement of shell after spat-on-shell is removed.	$1.07/ bushel	14,000 bushels in year 2 28,000 bushels year 3-5.	$15,000 in year 2; $30,000 in years 3, 4 and 5.	Bushels of shell replaced is equal to bushels shell removed.

Alternative 2

Alternative 2 involves the construction of several new options not used before by USACE. First, the one HRR already present in the Great Wicomico River would be seeded with broodstock oysters in year **1** and year 5. This **HRR** will serve as the incubator reef for the system and the **MRR,** which may also receive some of the 5 million broodstock oysters recommended in the stocking option of this alternative. The present 48 acres of "oyster rock" would then be thin-shelled, as needed, to prepare the entire area primarily for spat-on-shell production. The thin shelling would be applied at a rate of approximately 2,500 bushels per acre over the 48 acres of oyster rock present. This area historically served as a spat-on-shell production area, and USACE will return this area to its full potential production capacity. The remaining 78 acres of presently marginal oyster habitat would be restored as follows: A total of 20 acres of MRR's, 41 acres of LRR's, and 17 acres of thin-shelling. These 20 acres of MRR's are proposed in several areas in the Great Wicomico and most will be unseeded initially; future seeding, if needed, would be covered by the adaptive management fund. The goal is for these 20 acres of MRR's to auto recruit with DEBY strain larvae, produced from the USACE-seeded HRR in segment Bl4. It is possible that some of the 5 million oysters suggested for the initial stocking effort will be planted on some of the constructed MRR. These MRR's will then develop additional populations of adult oysters, many of which will be DEBY strain or a mix of DEBY strain and wild stock. These MRR's could also serve as additional cultchless broodstock seeding sites, if adaptive management requires such action.

The 41 acres of **LRR'**s will be constructed and maintained as sanctuary areas. The remaining 17 acres will be rehabilitated by thin shelling as needed for additional spat-on-shell production areas.These reefs are anticipated to further augment recruitment by year 5 of construction and to increase recruitment to levels that existed prior to 1960. It is hoped, at this time, that the broodstock oyster stocking will increase subsequent recruitment and allow spat-on-shell production to increase to 2,000 spat per bushel. This level of recruitment would allow the system to far exceed the production capacity of any manmade hatchery. This will be necessary to fully implement the genetic rehabilitation strategy.

The sanctuary area could increase, depending on the need for spat-on-shell stocking throughout the Chesapeake Bay and if construction is attempted in the future in the Great Wicomico River. It is anticipated that areas rehabilitated by thin shelling that have sufficient recruitment could, if left alone, begin forming biogenic oyster reefs that grow in size over time. All areas in this alternative are sanctuary areas, with the exception of the 65 acres of spat-on-shell production areas. While considerable spat-on-shell production is anticipated, which involves removal of shell and oysters, these areas will be maintained by additional thin shelling over time. Similar to Alternative 1, the expected return of these 65 acres would be 2,000 bushels of spat-on-shell per acre. Under ideal conditions, the spat count per bushel would be

2,000 spat-on-shell per bushel. This would provide 40 million oysters per acre, or 260 million oysters, thus achieving, at a minimum, the NER benefits of 22.05. The construction for Alternative 2 is represented in the following table:

Table 12. ALTERNATIVE 2-PROPOSED CONSTRUCTION

ALTERNATIVE 2- Total construction costs = $2,079,010; NER Benefit Goal = 22.05					
Construction Option	**Description**	**Cost**	**Unit**	**Total costs**	**Notes**
MRR's	Series of shell mounds from 1-4 feet tall over a I-acre footprint	$25,000/acre (average)	20 acres	$500,000	20 acres proposed, sanctuary areas, may be seeded under adaptive management.
LRR's	A 6-10 inch layer of shell with a base of shell fines over a I-acre footprint.	$10,000/acre	41 acres	$410,000	Same as "2-D" reefs in previous plans, sanctuary areas.
Thin-Shelling	Application of a 1-3 inch thick layer of oyster shell over a I-acre footprint.	$2,5000/acre	48 acres	$120,000	Can only be applied in areas with oyster rock already present; done for spat-on-shell production.
Thin Shelling	Application of a 2-5 inch thick layer of oyster shell over a 1 acre footprint	$5,530/acre	17 acres	$94,010	Rehabilitation of marginal habitat will require more shell than the current oyster rock areas.
Broodstock Seeding	Application of reproductively mature oysters to a restored site.	Varies with size, a 40 mm oyster (minimum acceptable size) is $0.085/oyster.	5 million/acre on an incubator reef	$425,000 in year 1 and $425,000 in year 5.	Disease tolerant strains must be used.
Reshelling	Replacement of shell after spat-on-shell is removed.	$1.07/bushel.	14,000 bushels in year2 28,000 bushels year 3-5	$15,000 in year 2; $30,000 in years 3, 4, and 5.	Bushels of shell replaced is equal to bushels shell removed.

Alternative 3

Alternative 3 involves the construction of a variety of oyster reefs, stocking, and spat-on-shell movement to implement the genetic rehabilitation strategy, as well as the goal of achieving the 10-fold biomass goal. For this reason, the NER benefits from the genetic rehabilitation goal and the biomass maximization goal were combined. It is assumed that at a minimum, the genetic rehabilitation NER benefits of 22.05 would be reached with this alternative. However, the additional HHR would also increase the biomass and add to the biomass goal, which has NER benefits of 17.8. It is assumed that the total benefits derived from this alternative will not be 39.85 (22.05 + 17.8) but should be higher than just the NER benefits derived from the genetic rehabilitation goal, or 22.05. For this reason, the total score of 39.85 was divided by 1.5 to get a score of 26.57. It is assumed that this level of NER benefits (26.57) reflects the total benefits achieved from both the biomass maximization and genetic rehabilitation goals that result from the construction of this alternative.

There are 126 acres of available habitat for restoration, and 1 acre of HRR sanctuary reef present. The proposed alternative would be to construct 12 additional acres of HRR's and rehabilitate the remaining 114 acres as LRR's. The 12 acres of USACE HRR's, and the 1 acre of HRR's already present, would be seeded with cultchless broodstock DEBY strain oysters, in years 1 and 5. The remaining 114 acres would be used for spat-on-shell production. All areas in this alternative are sanctuary areas. While considerable spat-on-shell production is anticipated, which involves removal of shell and oysters, these areas will be maintained by additional thin shelling over time. The construction is represented in the following table.

Table 13. ALTERNATIVE 3 - PROPOSED CONSTRUCTION

Alternative 3- Total construction costs = $3,295,000; NER Benefit Goal = 26.57					
Construction Option	**Description**	**Cost**	**Unit**	**Total Costs**	**Notes**
HR.R's	Series of shell mounds from 6-8 foot tall over a 1 acre footprint	$ 100,000/ acre	12 acres	$1,200,000	Same as "3-D" reefs in previous plans.
LRR's	A 6-10 inch layer of shell with a base of shell fines over a 1 acre footprint	$ 10,000/ acre	114 acres	$1,140,000	Same as "2-D" reefs in previous plans.
Broodstock Seeding	Application of reproductively mature oysters to a restored site	Varies with size, a 40 mm oyster (minimum acceptable size) is$ 0.085/oyster	0.5 million/ acre on an incubator reef	$425,000 in year 1 and $425,000 in year 5.	Disease-tolerant strains must be used.
Reshelling	Replacement of shell after spat-on-shell is removed	$1.07/ bushel	14,000 bushels in year 2 28,000 bushels year 3-5	$15,000 in year 2 $30,000 in years 3, 4, and 5.	Bushels of shell replaced is equal to bushels shell removed.

Adaptive Management

Alternatives 1, 2, and 3 have the option of applying adaptive management, which could be applied to any of these alternatives. Adaptive management uses monitoring information to select certain management measures that, when implemented, will help to sustain benefit outputs. As improved disease-tolerant strains of oysters are developed by the scientific community, USACE may wish to stock them upon the incubator reef(s), in order to accelerate native oyster recovery and increase NER benefits beyond what can be reasonably expected by use of the currently-available disease-tolerant strains of native oyster. This, and other adaptive management options, is further discussed in the adaptive management plan. Additionally, the costs for reshelling after the removal of spat-on-shell is assumed to be the same for the three alternatives, even though the amount of acreage in LRR's and thin shelling differs among alternatives. This is due to the assumption that, no matter which alternative is chosen, the same amount of spat-on-shell will be removed from the Great Wicomico. Therefore, the same amount of shell will be needed to replace that removed from the system, under each of the alternatives.

Proposed Activities in the Piankatank River

USACE proposes to seed the four HR.R's previously constructed by VMRC with a selected strain of native oyster. In addition to this, it is proposed to thin-shell the present 295 acres of "oyster rock" to bring these areas up to their full potential as oyster habitat. USACE will also conduct a survey of the marginal habitats, identified on Plate 4 as "shell-sand" and "shell-mud," to determine the extent of these areas that can be restored. It is proposed to thin-shell and/or construct LRR's over this acreage, once identified, to bring these areas up to their full potential as oyster habitat. All restored oyster habitat will be sanctuary areas.

In addition, USACE proposes moving large quantities of spat-on-shell from the Great Wicomico for genetic rehabilitation stocking efforts in other areas of the Chesapeake Bay. The full construction alternative will be evaluated in an amendment to this Decision Document, which is an amendment to the first Norfolk District 704(b) project constructed in Tangier and Pocomoke Sounds.

DESCRIPTION OF COSTS

Each alternative restoration plan was characterized in terms of implementation costs and expected benefits (project goal). The implementation costs consist of all costs needed for construction, including design; supervision and administration (S&A); shell placement and broodstock seeding; monitoring; and OMRR&R. As previously stated, the per unit cost for shell included placement costs. For each of the 3 alternatives, partial implementation costs were calculated and average annual equivalent costs were derived, based on a 25-year project life, using a 5-7/8 percent discount rate, and FY 2003 price levels. Partial implementation costs were used in the plan formulation, since it is assumed that design, monitoring, S&A, OMRR&R, and interest during construction (!DC) costs were all proportionally the same regardless of which alternative is evaluated. Therefore, only shell placement and seeding costs during the 5-year construction period were considered in plan formulation.

DESCRIPTION OF ENVIRONMENT AL BENEFITS

Each alternative is assumed to achieve one or more of the four project goals outlined earlier. Once an alternative is able to achieve that goal, the benefits (product score) attributable to that goal are assumed to be realized. For example, an alternative constructed for genetic rehabilitation will provide 22.05 NER benefits, once it is fully able to provide the genetic rehabilitation goal. These NER benefits (product scores) were converted to an average annual value to reflect the fact that the realization of these goals (NER benefits) are assumed to be achieved by year 5 for each of the alternatives. Exponential interpolation of benefits is assumed prior to year 5. For the Alternatives 1 and 2, the NER Benefit goal is 22.05; therefore, a total of 513.73 NER benefits accrued over the life of the project, which gives an average annual benefit score of 20.55. For Alternative 3, which had a NER benefit goal of 26.57, there are a total of 619.03 NER benefits accrued over the life of the project, which gives an average annual benefit score of 24.76. Under the No Action Alternative, NER benefits are expected to be zero, as none of the four goals would be met under without project conditions. The total construction costs, average annual construction costs, total NER benefits, and average annual benefits for each of the alternatives are summarized in the following table.

Table 14. GREAT WICOMICO CONSTRUCTION ALTERNATIVES -TOTAL AND AVERAGE ANNUAL COSTS AND BENEFITS

Alternative	Total Costs ($)	Average Annual Costs (1) ($)	Total NER Benefits (product score)	Average Annual Benefits (2) (product score)
No Action	0	0	0	0
Alternative 1	2,485,000	184,230	513.73	20.55
Altemati ve 2	2,079,010	152,847	513.73	20.55
Alternative 3	3,295,000	246,843	619.03	24.76

(1) Average annual equivalent costs derived using an interest rate of 5-7/8 percent.
(2) Full realization of the benefits is anticipated in year 5. Exponential interpolation of benefits is assumed between years 1 and 5.

COST EFFECTIVENESS AND INCREMENTAL COST ANALYSIS

In order to make more informed decisions with regard to the development and eventual selection of the NER Plan, the study team has utilized two decision-making techniques called cost effectiveness analysis and incremental cost analysis, as required by USACE Planning Guidance. Cost effectiveness analysis identifies that plan, or plans, that produces the greatest level of environmental output for the least cost. The environmental outputs, however measured, in tum reflect the environmental benefits such as biological diversity, fish and wildlife habitat, or nutrient cycling, provided by the plan or plans. Incremental cost analysis examines the changes in costs and the changes in environmental outputs for each additional increment of environmental output. The "Best Buy" plans represent those cost-effective plans that produce the greatest increases in environmental outputs for the least increases in costs. The Norfolk District Planning Resources Branch, using the software program !WR-Plan, accomplished these two analyses in-house. IWR, a Field Operating Activity FOA of the USACE, produces the IWR-Plan software. The average annual equivalent costs and average annual benefits (product scores of the goals reached) were used to conduct CE/ICA for the four construction alternatives. As the four plans are mutually exclusive, the two analyses were relatively straightforward.

Cost effectiveness analysis indicated that the Alternative 1 was the only alternative that was not cost-effective. That is because both Alternative 1 and 2 met the genetic restoration goal, and provided 22.05 NER benefits. However, Alternative 1 was more expensive to implement than Alternative 2; therefore, Alternative 1 was not cost-effective, as it did not produce the greatest amount of environmental benefits for the least cost. Alternatives 2, 3, and the No Action Alternative were all cost-effective plans. The following table shows the average annual benefits (product scores), annual costs, and average annual costs per product score for each of the four alternatives. Figure 9 shows the cost-effective analysis results, showing average annual environmental benefits (horizontal axis) and average annual costs (vertical axis) of the three construction alternatives and the No Action plan. The plan that was not cost effective, Alternative 1, can be seen in this figure just outside of and above the cost effective curve.

Table 15. GREAT WICOMICO CONSTRUCTION ALTERNATIVES - RESULTS OF COST EFFECTIVENESS ANALYSIS

Alternative	Average Annual Benefits (1) (Product Score)	Average Annual Costs (2) ($)	Average Cost (Cost/Benefit)($)
No Action	0	0	NIA
Alternative 1	20.55	184,230	8,964.96
Alternative 2	20.55	152,847	7,437.81
Alternative 3	24.76	246,843	9,969.43

(1) Full realization of the benefits is anticipated in Year 5. Exponential interpolation of benefits is assumed between years 1 and 5.
(2) Average annual equivalent costs derived using an interest rate of 5-7/8 percent.

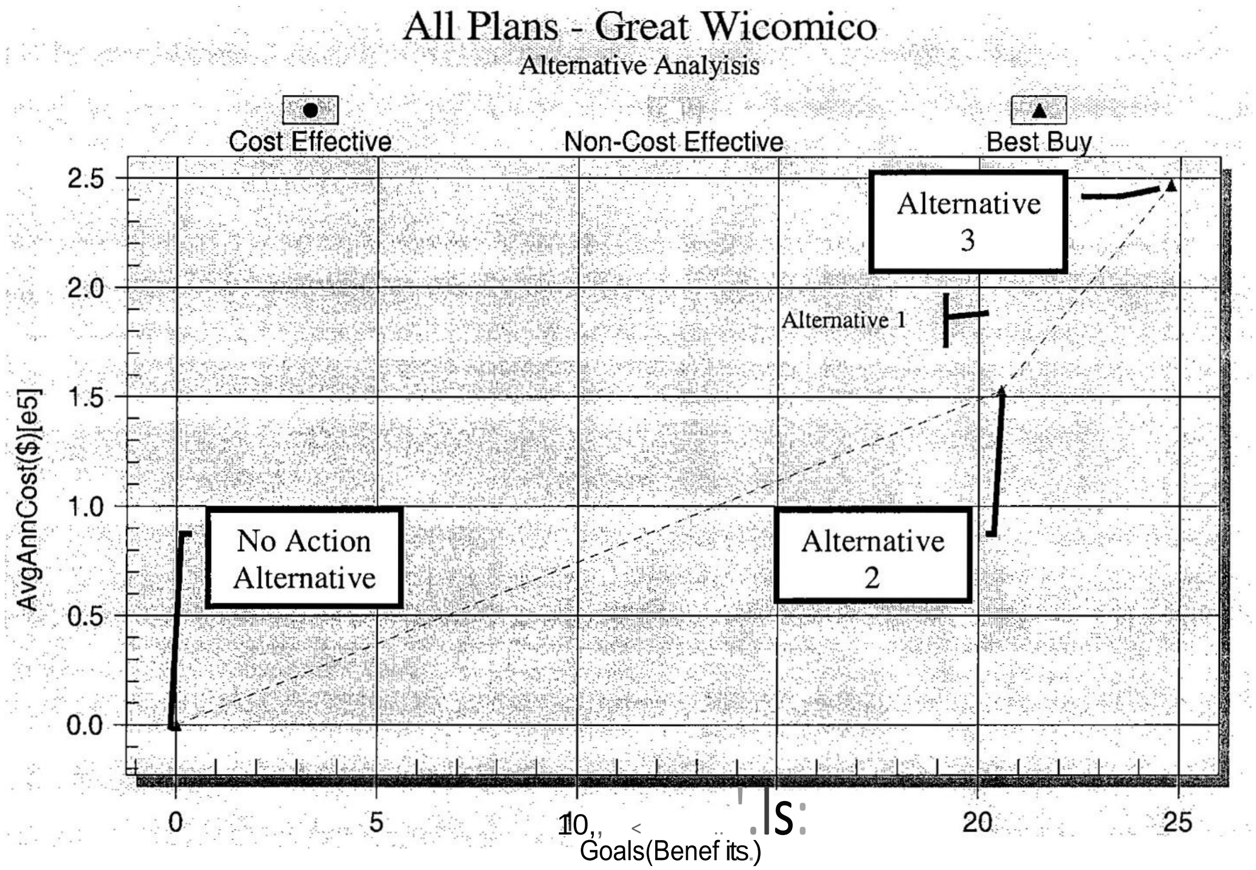


Figure 9. COST EFFECTIVE PLANS - GREAT WICOMICO CONSTRUCTION ALTERNATIVES.

After conducting the cost effectiveness analysis, incremental cost analysis examines the changes in costs and changes in benefits (product score) for each additional increment of output. The first step is, starting with the No Action Alternative, to calculate the incremental change in costs and the incremental change in benefits of moving from the No Action plan to each of the cost-effective plans. The No Action Alternative is used as a baseline; although it can be considered cost-effective, it provides no benefits. The change in costs is divided by the change in benefits (outputs) to generate an average cost per unit of output for each of the cost-effective plans. The plan with the lowest overall average cost per unit of output, moving from the No Action plan, is the first "Best Buy" plan. Referring to the following table, it can be seen that in this case, the Alternative 2 is the first "Best Buy" plan, as it had the lowest overall average cost with $7,438 per functional unit of output. Therefore, Alternative 2 provides 22.05 **NER** benefits at the lowest per unit cost.

The second step of the incremental cost analysis is to repeat step one, but instead of using the No Action plan as a baseline, the first "Best Buy" plan is used, or Alternative 2. All of the remaining (and larger) plans are evaluated in this step. Since there is only one more cost-effective plan to be evaluated, that plan, in this case Alternative 3, is also going to be a "Best Buy" plan, as it provides the most NER benefits (26.57). Changes in costs are divided by the changes in outputs for each increment to identify the plan with the next lowest incremental cost per unit of output, in relation to the first "Best Buy" plan. The second "Best Buy" plan, Alternative 3, costs $93,996 over Alternative 2, provides an additional 4.21 NER benefits, and costs $22,327 per NER benefit point for those additional 4.21 points. Therefore, there are two "Best Buy" plans in the Great Wicomico River, Alternative 2 and Alternative 3. The following table summarizes the infonnation from the incremental cost analysis, and Figure 10 displays the information graphically.

Table 16. GREAT WICOMICO CONSTRUCTION ALTERNATIVES - RESULTS OF INCREMENTAL COST ANALYSIS ("BEST BUY" PLANS)

Alternative	Product Score (1) (average annual)	Annual Costs (2) ($)	Average Cost ($/product score)	Incremental Cost($)	Incremental Product Score	Incremental Cost per Unit ($/product score)
No Action	0	0	NIA	0	0	NIA
First "Best Buy" Plan: Alternative 2	20.55	152,847	7,438	152,847	20.55	7,437.81
Second "Best Buy" Plan: Alternative 3	24.76	246,843	9,969	93,996	4.21	22,326.84

(1) Full realization of the benefits is anticipated in year 5. Exponential interpolation of benefits is assumed between years 1 and 5.
(2) Average annual equivalent costs derived using an interest rate of 5-7/8 percent.

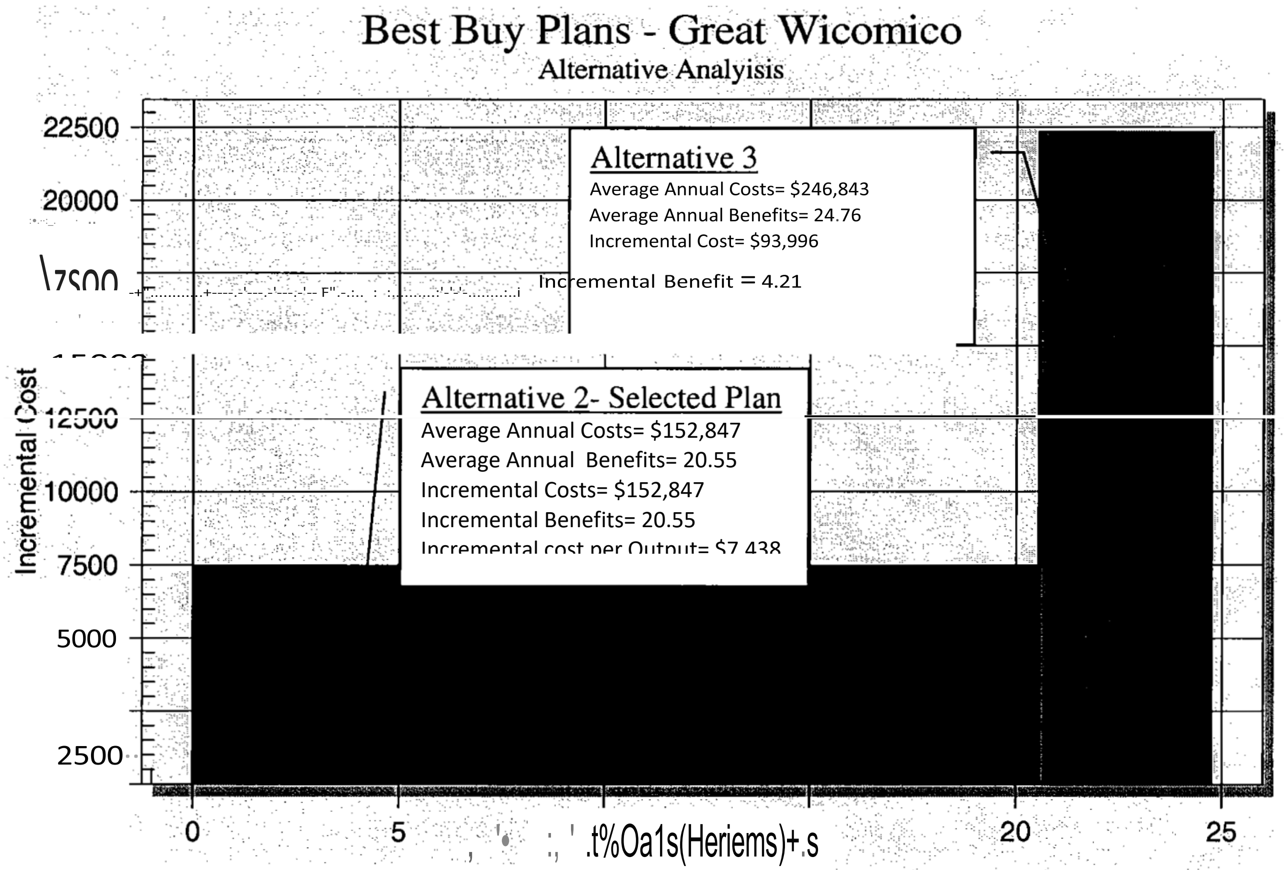


Figure 10. GREAT WICOMICO CONSTRUCTION ALTERNATIVES - "BEST BUY" PLANS.

SUMMARY

As evident from Tables 15 and 16, as well as Figures 9 and 10, the CE/ICA analyses resulted in two cost-effective plans, which were also both "Best Buy" plans, in addition to the No Action Alternative. However, there is a significant breakpoint between the first and second "Best Buy" plans. The first one, Alternative 2, gives a large amount of benefits (20.55), for relatively little cost, while the second "Best Buy" requires a large increase in incremental cost ($22,327) in order to achieve relatively few additional benefits (4.21). For this reason, the Norfolk District Planning Resources team feels that Alternative 2 is worth it, while Alternative 3 is not worth the incremental _cost increase. For this reason, the selected plan for construction in the Great Wicomico River is Alternative 2.

8.0 THE NATIONAL ECOSYSTEM RESTORATION PLAN

FEDERAL INTEREST

For ecosystem restoration projects, the NER Plan is defined as the plan that reasonably maximizes ecosystem restoration outputs and associated benefits compared to the costs and must be consistent with the Federal objective. The selected plan must be shown to be cost-effective and justified to achieve the desired level of output. The NER Plan meets planning objectives and constraints, as well as reasonably maximizes environmental benefits, while passing tests of CE/ICA, significance of outputs, acceptability, completeness, efficiency, and effectiveness.

SENSITIVITY ANALYSIS

A sensitivity analysis was conducted on the acreage restored in the NER Plan. There are 78 acres of presently marginal oyster habitat that have been proposed for restoration under the NER Plan. Of those 78 acres, 17 acres are to be thin-shelled for spat-on-shell production. Those 17 acres are in addition to 48 acres of oyster rock (not presently marginal) that will be used for spat-on-shell production. However, since the 17 acres are marginal, they will cost more than twice what it will cost the 48 acres to be brought into production. It is possible that the 48 acres of spat-on-shell construction will be enough to attain the NER benefits of 22.05, but they may not be enough or may produce so many benefits in the form of spat that USACE would want to capture more benefits by bringing the additional 17 acres into production. For this, a sensitivity analysis was conducted to determine if those 17 acres should be restored during the first year of construction.

In order to determine the difference in the benefits received from constructing 126 or 109 acres of oyster habitat, the number of acres proposed was divided by the total benefits received (22.05) to find the benefits received per acre. The benefits per acre for the 126 acres are 5.71, while the benefits per acre for 109 acres are 4.94. The difference between these benefits per acre are 0.77, which was then subtracted from the total benefits (22.05) to find the benefits received from constructing just the 109 acres. Then the cost per benefit was found for each of the two plans. The following table summarizes this analysis. Since there was only a 1.05 percent difference between the cost per benefit between the two plans, the Norfolk District feels there is not a significant difference in the plans. Therefore, the Norfolk District recommends that only the 109 acres be constructed, with the remaining 17 acres to be constructed at some time in the future. The criteria for future construction on those 17 acres of marginal habitat will be to fully capture the NER benefits of 22.05, or to increase spat-on-shell production for future projects.

Table 17. SENSITIVITY ANALYSIS -ACRES OF SPAT-ON-SHELL PRODUCTION IN NER PLAN CONSTRUCTED

Criteria	Alternative 2 (A)	Alternative 2 (B)
Acres	126	109
Benefit	22.05	21.28
Costs	$2,079,010	$1,985,000
Cost per benefit	$94,286	$93,297

NER PLAN DESCRIPTION

The Selected Plan will achieve the environmental goal of genetic rehabilitation over the 5-year construction time frame. Initially, 2 areas of 10 acres each will have MRR's constructed, as will 41 acres of LRR's. Both the MRR's and the LRR's will be maintained as permanent sanctuaries and will not be used for spat-on-shell production. The existing 48 acres of "oyster rock" will be thin shelled and used as spat-on-shell production areas. Additionally, there are 17 acres of marginal habitat that could be thin-shelled, although more shell will be needed than used on the existing "oyster rock," as the area is marginal. These 17 acres will only be thin-shelled and brought into production if the full NER benefits are not realized, or more spat-on-shell production areas are needed. Also, in the first year of construction, the existing HRR, and possibly some of the MRR, will be seeded with a total of 5 million broodstock DEBY oysters in order to jumpstart the genetic rehabilitation goal.

In 2004, 14,000 bushels of shell will be placed on the 48 acres of thin-shelled areas in order to replace the shell taken out from the spat-on-shell that is moved throughout the Chesapeake Bay and also to improve the marginal habitat. In years 3, 4, and 5, 28,000 bushels of shell will be needed to improve the thin-shelled areas. More shell is needed than in year 2, and it is expected that less spat-on-shell will be removed in year 2, as the broodstock oysters will be spawning for the first time in year 2, and, therefore, production of spat-on-shell will be minimal. The existing HRR, and possibly some of the MRR, will also be reseeded with a total of 5 million broodstock oysters between them in year 5. Monitoring of the reefs will be conducted every year, with more in the first 2 years to fully assess conditions and continued monitoring being needed in order to implement the adaptive management plan.

NER PLAN EVALUATION

The recommended plan is worth the costs, as this project will be the first step in restoring one of the Chesapeake Bay's most valuable resources, the native oyster. The recommended plan is acceptable, efficient (cost-effective), complete, and supported not only by the non-Federal sponsor, but also by other State, Federal, and non-profit agencies, such as the USEPA, CBF, VDEQ, NOAA, VIMS, and USFWS. The plight of the native oyster has received national attention, with the species' being nearly ecologically and commercially non-existent in the Chesapeake Bay. Populations throughout the southeastern waters of the US have prevented it from being endangered, but within the Chesapeake Bay the oyster is scarce. Along with the loss of this important resource within the Chesapeake Bay, there has been a loss of an important culture and industry that surround the native oyster. The goal of genetic rehabilitation is the first step in a massive effort to populate the Chesapeake Bay with enough oysters that a self-sustaining population will result. The Great Wicomico will provide more oysters to be used to repopulate the Chesapeake Bay than any manmade hatchery would ever be able to produce, at a fraction of the cost. This plan, along with further steps taken in the long-term plan, still being developed, is intended to produce a self-sustaining population of native oysters in the Chesapeake Bay over the next 10 years. See Plate 5 for details on the logistics of how the proposed project will ultimately increase the oyster populations and fitness in many areas of the Chesapeake Bay.

Significance

The importance of the native oyster as a resource to both the people of the Chesapeake Bay area, and to the Chesapeake Bay itself and the organisms that reside within it has been recognized locally, regionally, and Nationally. Oysters are considered keystone organisms in the ecology of the Chesapeake Bay, both for the habitat they create and for their water filtering capacity. The need to restore the native oyster throughout the Chesapeake Bay and its tributaries has been documented for many years now, with the first study to determine how best to do so being the Chesapeake Research Consortium in 1999. Additionally, the USEPA heads a joint, Chesapeake Bay-wide plan within the CBP (Comprehensive Oyster Management Plan, 2002 [draft]) that recognizes the importance of restoring the native oyster. The decline of the oyster has had a significant negative impact on the entire ecology of the Chesapeake Bay.

Additionally, it is estimated that the historical population of oysters was once able to filter the volume of the Chesapeake Bay every 3 days. The current population takes well over a year to filter the same volume, while at the same time point and non-point pollution is increasing and further degrading the Chesapeake Bay.

Scarcity

Less than 1 percent of the historical population of native oysters exists in the Chesapeake Bay today. Decades of harvesting activity and loss of shell material have resulted in an almost complete elimination of oyster reef features and habitat. In the 1950's, commercial watermen harvested more than 4 million bushels of market-sized oysters from the Chesapeake Bay's Virginia waters per year; however, the 2001 harvest produced a mere 26,000 bushels. Clearly, this important resource is in danger of being lost completely, which will only adversely affect the people and organisms that depend on them to provide jobs, livelihoods, habitat, and food.

Acceptability

USACE, CBF, VMRC, VIMS, USEPA, NOAA, USFWS, VDEQ, and local entities, such as the Norfolk Rotary Club and the City of Virginia Beach, have endorsed oyster restoration. These efforts have resulted in the construction of over 50 reefs in various parts of the Chesapeake Bay and its tributaries. Although some of these restoration efforts have shown small-scale success, the scale of restoration has been limited by available funding. This plan, in conjunction with the long-term plan currently being complied, will allow for a large scale, Chesapeake Bay-wide restoration effort that all of the sponsors and interested parties have agreed is needed. Additionally, oyster restoration has been widely accepted in Maryland, on both a State and Federal level through State and USACE projects constructed by the Baltimore District.

Views of the Non-Federal Sponsor

Under the auspices of the Virginia Oyster Heritage Program, a multi-agency effort formed by VMRC and VDEQ in 1999, a series of strategically located sanctuary and harvest areas, some of which have been constructed, are planned Statewide in an effort to restore historical oyster populations. This project is a part of this plan and a continuation of those already built in the Rappahannock River and Tangier-Pocomoke Sound. Although the State initially felt that building harvest areas would be justified, the State has agreed that Federal dollars should not be spent for harvest areas at this time. At some point in the future, if the State is economically justified the USACE will look into opening reserve areas and/or building harvest areas. Until that time, the non-Federal sponsor has agreed that all Federal money should be spent on sanctuary areas, with non-USACE project related State funds being spent on the public fishery. That being said, the non-Federal sponsor is in full support of oyster restoration, as any efforts to return the native oyster to its historical populations will contribute to a public fishery in the future, and the restored habitat will augment other fisheries, such as crabs and finfish resources.

Effectiveness

The recommended plan is effective, as it will provide the spat-on-shell needed to restore other oyster reefs throughout the Virginia waters of the Chesapeake Bay at a more cost-effective rate than any manmade hatchery that could be built. The benefits from restoring the Great Wicomico River as a spat-on-shell production area will not only directly affect the Great Wicomico but will be spread throughout the Virginian portion of the Chesapeake Bay. It has been agreed to by a panel of oyster experts, composed of representatives from VMRC, CBF, and

VIMS, that this genetic rehabilitation goal is the most effective technique to jumpstart the long-term restoration efforts that will restore the native oyster to historic populations.

Efficiency

The recommended plan passes tests of CE/ICA. As shown through the preceding section on CE/ICA, Alternative 2 will provide the most cost-effective means to implement the genetic rehabilitation goal. Additionally, Alternative 2 is also a "Best Buy" plan, as it has the lowest incremental cost per unit of output to achieve the benefit goal of 22.5. This restoration goal of genetic rehabilitation could not be produced more efficiently by any other institution or agency.

AVERAGE ANNUAL COST SUMMARY

The following table displays the total and average annual cost summaries for the recommended NER Plan, Alternative 2(B). Monitoring, S&A, contingency, IDC, design, and OMRR&R costs were assumed to be proportional for all alternatives, and were, therefore, insensitive to plan selection. These costs were only considered in the total cost of the recommended plan. Additionally, the total costs of the recommended plan reported in this document are for the NER Plan without construction of 17 acres of marginal oyster habitat for spat-on-shell production. A sensitivity analysis was conducted, and results show that the benefits provided by constructing the NER Plan less the 17 marginal acres are 1 percent less than the benefits provided by constructing the entire project. Therefore, the Norfolk District recommends that 109 acres be constructed in year 1, while maintaining the option of future construction on the 17 acres if the benefits are not fully realized or additional spat-on-shell production areas are needed.

Interest During Construction

IDC for the selected plan is estimated to be $4,178, based upon a construction period of 1 month and a 5-7/8 percent interest rate. One month will be needed to develop design, while construction is anticipated to occur within FY 2004. IDC was calculated for the initial placement of shell, the initial seeding of the existing HRR with broodstock oysters, design costs, S&A costs, and monitoring costs in year 1. Future monitoring, reshelling, and reseeding over the

5 years was not included in the IDC, as it will be spent after the base year and has been discounted. IDC was assumed to be proportional among all alternatives for plan formulation. Plan selection was, therefore, insensitive to these costs, and IDC was only included in the total cost of the recommended plan.

Table 18. EQUIVALENT TOTAL AND AVERAGE ANNUAL COSTS AND BENEFITS OF THE NER PLAN (FY2003 Price Level, 25-Year Period of Analysis, 5.875 Percent Discount Rate, Base Year 2003)

First Costs:		**Annual Costs:**	
Initial Construction	$1,030,000	Interest and Ammoritization of Investment	$172,576
S&A (7% of initial construction)	$72,100		
Contingency (15%)	$165,315		
Initial Seeding	$425,000		
Monitoring Year 1	$60,000	Total OMRR&R	$1,026,150
Design	$25,000	Discounted over 20 years	$527,535
Total	$1,777,415		
IDC	$4,178	Interest and Ammoritization of OMRR&R	$40,778
Reshelling Year 2	$15,000		
Monitoring Year 2	$15,000	**Total Average Annual Costs:**	**$213,355**
Reshelling Year 3	$30,000		
Monitoring Year 3	$5,000		
Reshelling Year 4	$30,000		
Monitoring Year 4	$5,000		
Reshelling Year 5	$30,000		
Monitoring Year 5	$5,000		
Reseeding Year 5	$425,000		
Total Investment Cost	$2,341,593		
Discounted over 5 years*	$2,232,552		
Total Restoration Benefits:		**Average Annual Restoration Benefits:**	**20.55**
MRR Habitat	20 acres		
LRR Habitat	41 acres		
Thin Shelling, Productive	48 acres		
Thin Shelling, Marginal	0 acres		
Genetic Rehabilitation Score	22.05		

- Total Investment cost less IDC

ECONOMIC IMPACTS

For the NER Plan, the estimated investment of initial implementation cost in year 1 (plus IDC) is $1,781,593 (see the following table). This cost includes year 1 placement of shell, seeding, monitoring, and implementation costs. The investment for the next 4 years of construction (reshelling, reseeding, and monitoring) is estimated to be $560,000; therefore, the combined total investment is $2,341,593. This is equivalent to average annual costs of $172,576. Average annual operation and maintenance costs are estimated to be $40,778, for a total average annual cost of $213,355. **OMRR&R** costs may be lower than expected, depending on how much spat-on-shell is moved out of the Great Wicomico River over the 20 years. Additionally, reseeding with broodstock oysters may not be needed after year 5. The genetic rehabilitation goal in the Great Wicomico River is expected to provide a NER benefit score of 22.05, with an average annual functional value of 20.55.

Table 19. TOTAL ECONOMIC COSTS - NER PLAN

NER Plan	Construction Costs Year 1	IDC	Construction Costs Years 2-5	Total Investment	Average Annual Maintenance Costs	Total Annualized Costs
Alternative 2(B)	$1,777,415	$4,178	$560,000	$2,341,593	$40,778	$213,355

COST SHARING

The non-Federal sponsor for the proposed oyster restoration project is the Commonwealth of Virginia. Under Section 704(b), as amended, the non-Federal sponsor will provide 25 percent of the project costs. The Commonwealth of Virginia has agreed to furnish the non-Federal share (see the letter of intent in Appendix A). Section 113 of the Energy and Water Development Appropriations Act for Fiscal Year 2002, Public law 107-66, provides that the non-Federal sponsor's 25 percent share of the cost of a project under Section 704(b) as amended, may be provided through in-kind services, including shell stock material provided by the non-Federal sponsor if the Chief of Engineers determines the shell stock material is suitable for use in carrying out projects. The "fossil shell" that the non-Federal sponsor has offered from various locations in the lower Chesapeake Bay can be suitable shell stock material and will likely provide the majority of the proposed project's required local sponsor match.

The NER Plan has a total project costs, over the 5 years, of $2,337,415. Including IDC of $4,178, total project investment is $2,341,593. The study costs are $400,000, and the discounted cost of OMRR&R is estimated to be $527,535. The local sponsor is responsible for 100 percent OMRR&R costs. At a construction cost sharing of 75 percent Federal, 25 percent non-Federal, except for OMRR&R, the local sponsor is responsible for $1,211,900, with an average annual equivalent of $93,680. The Federal Government is responsible for $2,053,100, or $158,705 annually. The following table summarizes the cost sharing requirements.

Table 20. ECONOMIC AND FINANCIAL DATA RECOMMENDED PLAN
{All costs in thousands of dollars)

a. Estimated Construction Costs:
(March 2003 price level, Base Year 2003)

Federal (75%)	$1,753.1
Non-Federal (25%)	$584.4
Total	$2,337.5

b. Economic Data:
(5-7/8%, 25-year life)

Annual Charges: $213.4
(Includes $40.8 OMRR&R;
Fed **OMRR&R =** $0.0)

Annual Benefits (Product Score): 20.55
BCR: *NIA*

	Federal	Non-Federal
c. Cost Allocation:		
Project Purpose		
Ecosystem Restoration	$1,753.1	$584.4
d. Allocations to Date:		
Feasibility	$300.0	$0.0
e. Remaining Requirements:		
Feasibility	$0.0	$100.0
Design	$18.7	$6.2
Construction	$1,734.4	$578.2
Total	$1,753.1	$684.4
f. OMRR&R (100% Non-Federal)	$0.0	$527.5
g. Total Allocations:	$2,053.1	$1,211.9

SCHEDULE FOR PROJECT IMPLEMENTATION

Following approval of this report, the Norfolk District will prepare a final design for the project. Once this is complete, the project can proceed towards construction. At that time, the PCA between the Federal and non-Federal sponsors can be signed and executed. A construction bid advertisement will be issued and the 25 percent non-Federal share will be required. After the construction contract is awarded, construction can begin. The tentative project schedule based on several pending actions * (PCA execution and provision of Federal and non-Federal contributions) is:

Submit Decision Document to North Atlantic Division Headquarters - July 2003.

Receive Project Approval - August 2003.

Complete Final Design - July 2003.

*Execute PCA - October 2003.

*Advertise for Construction Bids - includes shell placement, spat-on-shell movement, and cultchless oyster seeding - October 2003.

*Receive Federal and non-Federal Construction (Contribution) Funds - October 2003.

*Award Construction Contracts - December 2004.

*Complete Initial Construction, spat-on-shell movement, and cultchless oyster seeding - May-August 2004.

*Initiate Adaptive Management and Monitoring Program - May 2004.

*Continue Monitoring, Reshelling, and Apply Adaptive Management Construction Options as Needed - May 2004 through June 2008.

CONCLUSIONS

USACE has the opportunity to attempt to implement an oyster restoration project in Virginia waters of the Chesapeake Bay that is based on the best science and latest research. The new genetic rehabilitation strategy, the particular site selected, and use of the best available disease-tolerant selected strains of native oysters are much-needed advances in the oyster recovery effort. This amendment to two USACE oyster projects, the Rappahannock River and Tangier/Pocomoke Sound, will produce disease-tolerant selected strains of oysters that can be placed on the oyster habitat provided by the previous projects, as well as any future projects. As a result, all oyster recovery efforts, past, present, and future, will have much higher chances for success and have become a fully integrated oyster recovery effort that applies the best scientific information to the year 2000 Chesapeake Bay Agreement goal of achieving a 10-fold increase in oyster biomass by 2010.

RECOMMENDATIONS

I have considered all potential impacts and effects in terms of the overall public interest, which includes environmental, social, and economic effects, as well as the overall engineering feasibility of the proposed project. Bearing these considerations in mind, I recommend that, under the authority of Section 704(b) as amended of the WRDA 2000, USACE will restore oyster habitat and populations in the Great Wicomico River in accordance with the NER Plan with such modifications as in the discretion of the Commander, HQUSACE, may advise. The project will initially restore up to 109 acres of oyster habitat, and the subsequent genetic rehabilitation based stocking efforts will have a widespread beneficial effect on oyster populations in many of Virginia's Chesapeake Bay waters as determined by the NER Plan, which is included within this Decision Document Amendment.

My recommendation is subject to the implementation policy guidance that was provided by the Office of the Assistant Secretary of the Army for Civil Works (ASA[CW]). Also, this recommendation is subject to the non-Federal sponsor agreeing to comply with all applicable Federal laws and policies and other requirements, including, but not limited to:

a. Provide a contribution equal to 25 percent of the first cost of construction, including LERRD's. The total estimated cost of the project is $2.34 million, of which$ 1,753,061 would be the Federal cost, and the Commonwealth of Virginia would provide $584,354.

b. Assume responsibility for OMRR&R, currently estimated at $40,778 annually, of the project or completed functional portions of the project, including mitigation features without cost to the Government, in a manner compatible with the project's authorized purpose, and in accordance with applicable Federal and State laws and specific directions prescribed by the Government in the OMRR&R manual and any subsequent amendments thereto.

c. Give the Government a right to enter, at reasonable times and in a reasonable manner, upon land that the local sponsor owns or controls for access to the project for the purpose of inspection, and if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project.

d. Pay all Government costs to accomplish any project betterments or other features requested by the Sponsor that cost in excess of the Government-recommended plan.

e. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of WRDA 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element.

f. Hold and save the Government free from all damages arising for the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to fault or negligence of the Government or the Government's contractors.

g. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as will properly reflect total project costs.

h. Perform, or cause to be performed, any investigations for hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements or rights-of-way necessary for the construction, operation, and maintenance of the project; except that the non-Federal sponsor shall not perform such investigations on lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude without prior specific written direction by the Government.

1. Assume complete financial responsibility for all necessary clean-up and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Government determines necessary for the construction, operation, or maintenance of the project.

J. Agree that; as between the Federal Government and the non-Federal sponsor, the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and, to the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA.

k. Prescribe and enforce regulations to prevent obstruction of or encroachment on the Project that would reduce the level of environmental restoration that it affords or that would hinder operation and maintenance of the Project.

I. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR part 24, in acquiring lands, easements, and rights-of-way, and performing relocations for construction, operation, and maintenance of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act.

m. Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352, and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondisc1imination on the Basis of Handicap in Programs and Activities Assisted or Conducted by Department of the Army," and Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), requiring non-Federal preparation and implementation of flood plain management plans.

n. Do not use Federal funds to meet the non-Federal sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is authorized by statute.

Federal participation in the recommended project is endorsed provided that, prior to construction, the non-Federal sponsor will execute the final PCA with the Federal Government.

The recommendations contained herein reflect the information available at this time and current departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the sponsor, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

[redacted]

David L. Hansen
Colonel, District Engineer
Commanding

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Plate 1. SPAT-ON-SHELL STOCKING SITES ON RESTORED OYSTER HABITAT IN TANGIER AND POCOMOKE SOUND.VA. Approximately 160 acres are available for genetic rehabilitation stocking efforts. All were constructed by USACE.

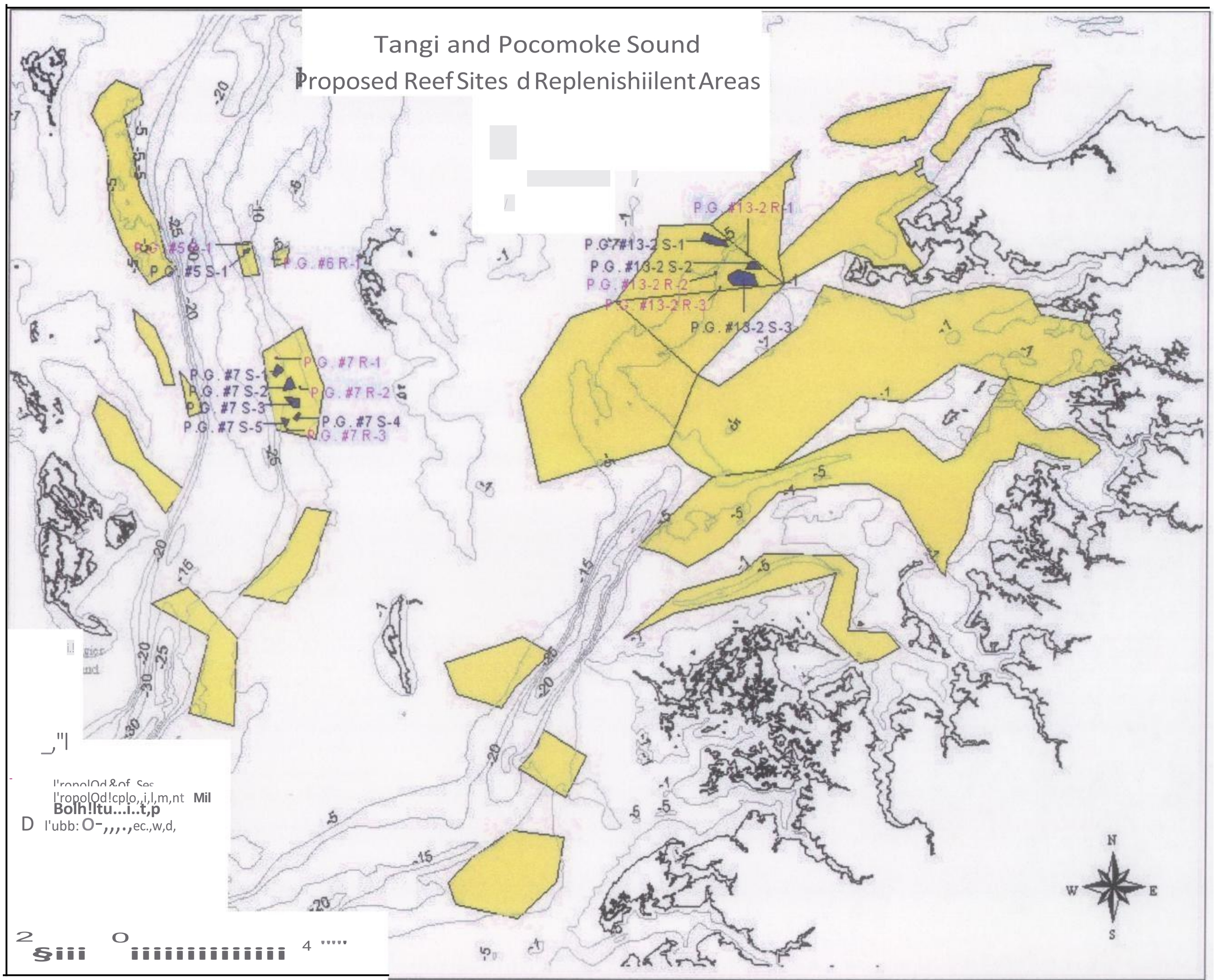


Plate 2. SPAT-ON-SHELL STOCKING SITES IN THE LOWER RAPPAHANNOCK RIVER, VA. Approximately 180 acres is available for genetic rehabilitation stocking efforts. Most were constructed by USACE; some were constructed by NOAA.

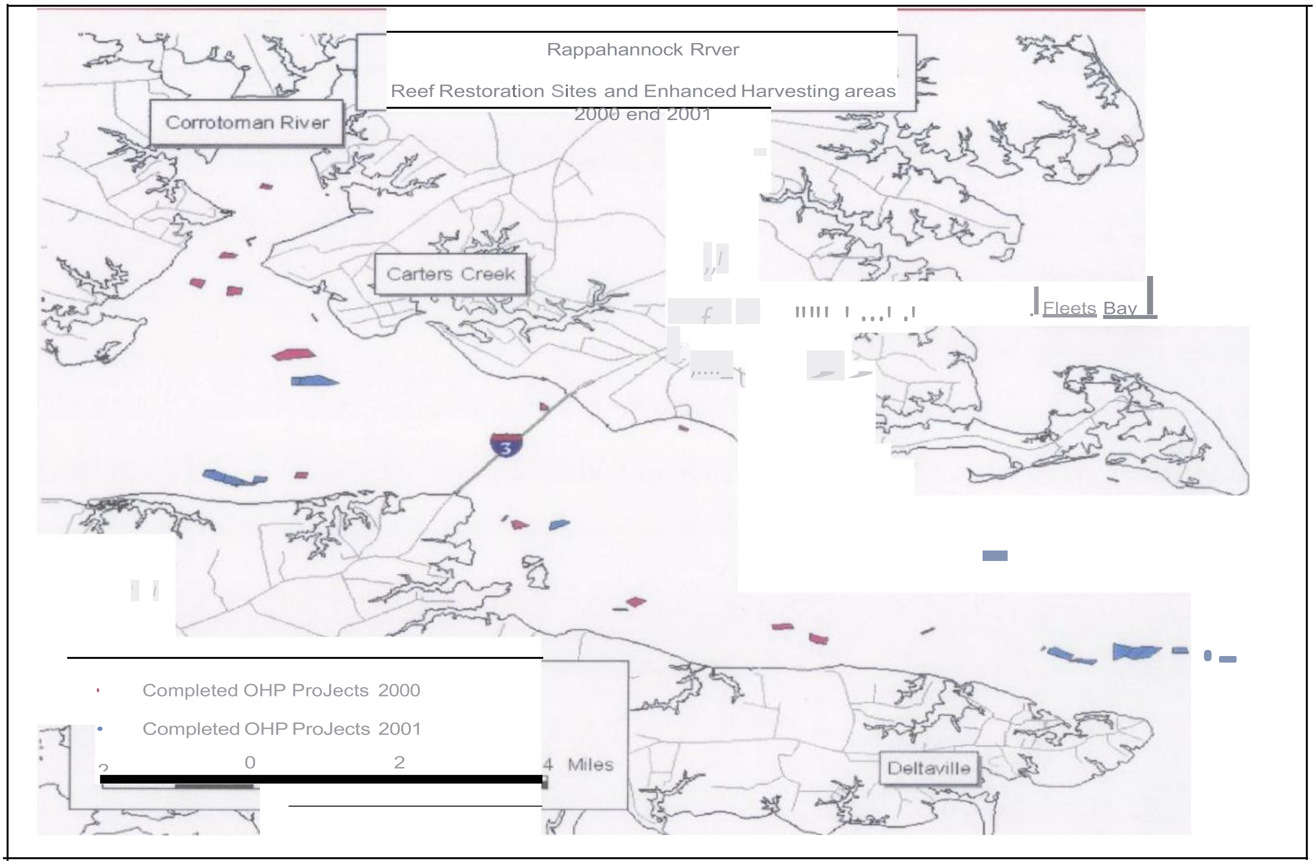
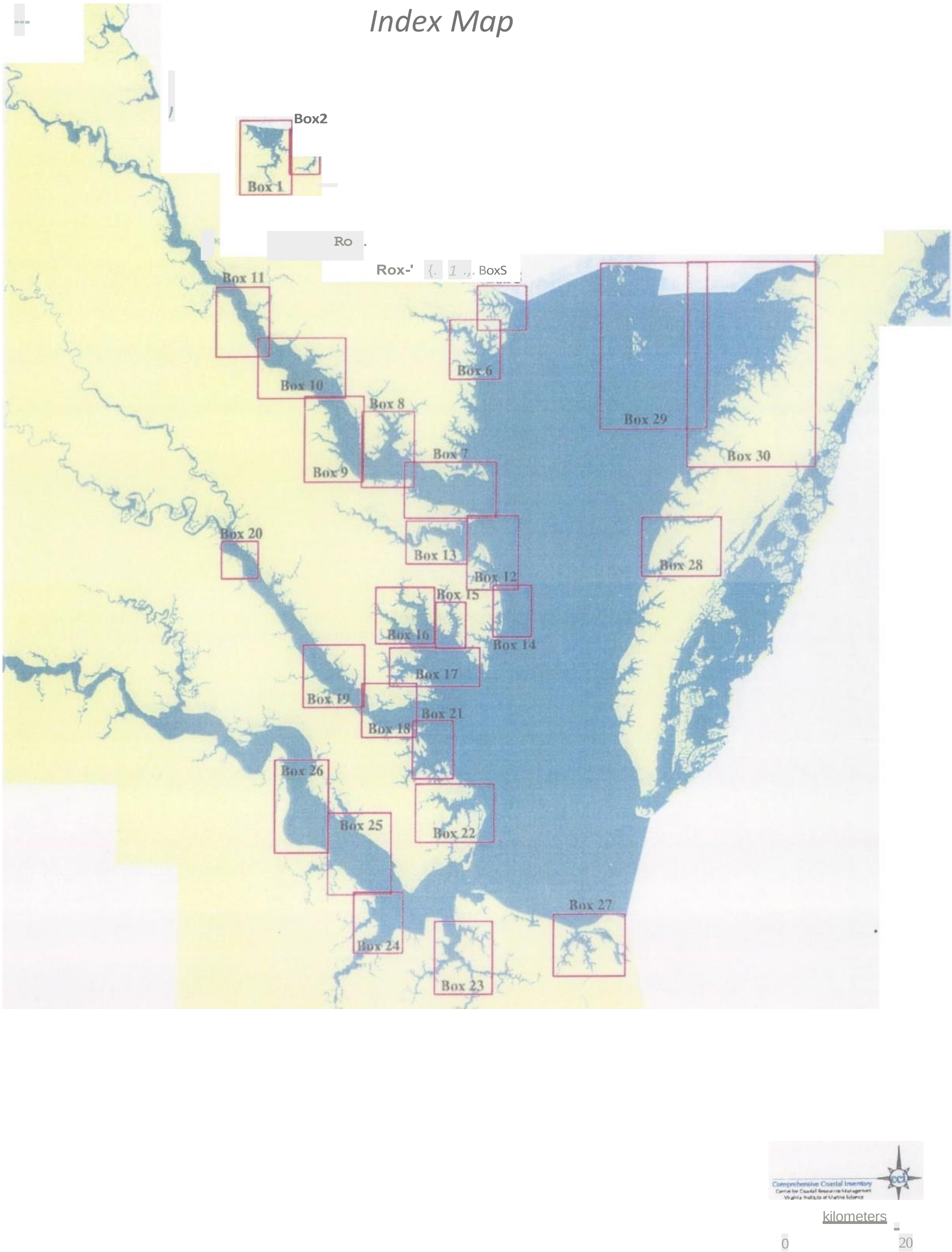


Plate 3. MAP OF BOXES IN THE VIRGINIAN PORTION OF THE CHESAPEAKE BAY.
Each Box contains potential Oyster Restoration Habitat.

Oyster Reef Restoration Targe1 ing

Index Map



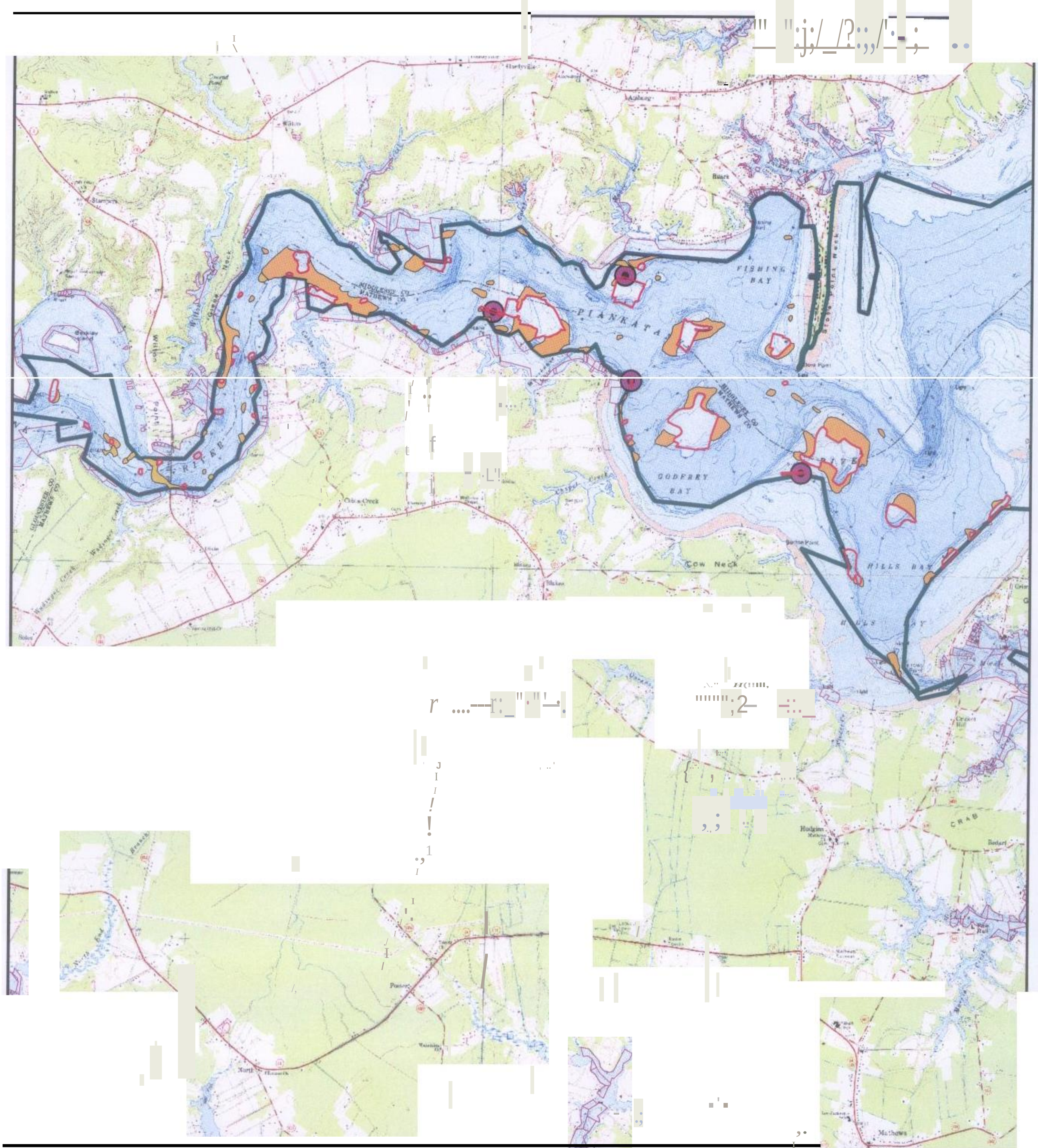


Plate 4. Potential Restoration Areas in the Piankatank River, Virginia

Legend

Potential Restoration Areas

Shell & Mud

Shell & Sand

Private Leases

Baylor Grounds

Oyster Restoration

700 0 700 1,400 Meters

Plate 5. SHORT-TERM PLAN TO RESTORE OYSTERS IN VIRGINIA-CHESAPEAKE BAY AND TRIBUTARIES

Phase 1 (2001/02)

Habitat Restoration

90 ac LRR*

3 ac HRR*

:t -- it;

(Rappahannock River

Phase 3 (2003 Projected)

Genetic Rehabilitation Incubator System

Phase 1:

Thin-Shelling

Move spat-on-shell

HRR seeded with disease-resistant strains (Deby)

Phase 2:

HRR breeder reefs

MRR* receive natural spatset

***Phase** 3:*

LRR Construction

Thin-Shelling

Phase 2 (2002)

Habitat Restoration

150 ac LRR

8 ac HRR

Tangier/ Pocomoke Sound

Move disease-resistant Spat-on-

Great Wicomico River

*LRR = Low Relief Reefs (8 inches); MRR = Medium Relief Reefs (2-4 ft); HRR = High Relief Reefs (6-8 ft)

APPENDIX A

ENVIRONMENTAL APPENDIX

APPENDIX A

ENVIRONMENT AL APPENDIX

OYSTER LIFE HISTORY

The Chesapeake Bay is one of the largest and most productive estuaries in the world. Fresh water, supplied by over 150 rivers and streams, along with salt water from the Atlantic Ocean combine to create the unique conditions and essential nutrients to support over 2,700 species of plants and animals. The overall health of the Chesapeake Bay has declined significantly since first colonized by European settlers, and the Chesapeake Bay Foundation currently rates the overall health of the Chesapeake Bay at 27 out of a possible100, the 100 representing the health of the Chesapeake Bay when European settlers first arrived in America (Chesapeake Bay Foundation, 2003).

The Chesapeake Bay is a shallow water estuary providing ideal conditions for the Eastern Oyster, *Crassostrea virginica,* in all but the tidal fresh water portions of Chesapeake Bay tributaries. In fact, the name of the Bay, "Chesapeake," is derived from a Native American word, "Tschiswapeki," meaning great shellfish bay (Chesapeake Bay Foundation, 2000). Oysters were abundant throughout the Chesapeake Bay prior to European settlement and early colonial period. Historical accounts by colonists reflect this, and their writings even tell of accidentally running ships aground on oyster bars, which at the time were very numerous throughout the Chesapeake Bay system. For example, the Swiss writer, Michel, wrote in 1701:

"The abundance of oysters is incredible. There are whole banks of them so that the ships must avoid them. A sloop, which was to land us at Kingscreek, struck an oyster bed, where we had to wait about two hours for the tide. They surpass those in England by far in size, indeed they are four times as large. I often cut them in two, before I could put them in my mouth" (Wharton, 1957).

These bars, or reefs, were three-dimensional structures that once often exceeded 10 feet in height and were composed primarily of oysters and oyster shells. These reefs often formed in areas of the Chesapeake Bay with considerable bottom relief; thus, they often have grown over a raised base of bottom sediments that may form the core of some reefs. They were historically common throughout Virginia waters of the Chesapeake Bay. The lower-salinity waters of the Maryland portion of the Chesapeake Bay typically resulted in somewhat lower growth rates of oysters, and few, if any, intertidal reefs higher than a few feet were historically documented in Maryland waters. However, oysters were abundant in Maryland waters, which historically had higher commercial harvests of oysters than Virginia. The eastern oyster is considered an ecosystem engineer, which is an organism that literally builds much of the physical fabric of the ecosystem, such as canopy forming trees in a forest or, more similarly, a coral reef. Other than the hard structure provided by the oyster bars, the Chesapeake Bay is an estuary in which the bottom is dominated by fine mud, silt, and sands with very little bottom relief.

The eastern oyster, *Crassostrea virginica*, also known as the Atlantic oyster, is a sessile, filter-feeding, bivalve mollusc that ranges along the coast of North America from the Gulf of St. Lawrence to the Gulf of Mexico, and tolerates a wide range of environmental conditions (Kennedy et al., 1996). The eastern oyster is well-adapted to estuarine conditions and can tolerate wide ranges in temperature, salinity, dissolved oxygen, turbidity, and other environmental factors. Adult oysters can be found in waters where the annual temperature range is from -2 to 36 degrees Celsius (°C) (Galstoff, 1964) and can tolerate salinity ranges from Oto 42.5 parts per thousand (ppt) (Ingle and Dawson, 1950). The eastern oyster cannot survive for more than a few months in waters below about 5 ppt, however. In addition, larval oysters cannot develop and grow successfully in waters less than about 6 ppt (Loosanoff, 1953), and the optimal salinity for larval development is considerably higher, 18 to 22 ppt in the Chesapeake Bay (Virginia Tech Biology Department, 2003). Oyster larval growth is inhibited in salinity in waters below 12.5 ppt (Abbe, 1986). Waters of intermediate salinities between 15 to 18 ppt seem to represent a physiological optimal range for oyster reproduction, growth, and survival. The Chesapeake Bay is near the center of the eastern oyster's geographical distribution and provides optimal environmental conditions for the eastern oyster in a large portion of its waters.

It is important to note that the eastern oyster was historically a protandric organism, usually spawning as a male at first and changing sex to female in a successive spawning season as it grows larger in size. As a result, in the older age classes of oysters, which are also the larger oysters, females tend to predominate. Also the larger the female oyster grows, proportionally more resources are directed into egg production by the oyster. In waters of the Chesapeake Bay, oysters typically spawn in the spring as water temperatures near 20 °C. Oyster typically spawn en masse, similar to coral reefs. The result is a huge amount of eggs and sperm enter the water column simultaneously from an oyster reef, which increases the chances for successful fertilization. The closer oysters of opposite sex are to each other, the higher the rates of fertilization. Oyster reefs, therefore, provide optimum reproductive conditions. Distance apart of more than a few centimeters begins to lower the fertilization efficiency of the oyster (Paynter, 2002). This has important ramifications to any application of broodstock oysters to a constructed reef base. The eggs remain in the water column, where they hatch into planktonic larvae. The larvae transform from a mobile planktonic form known as a veliger to a sessile juvenile known as a "spat" in a process called spatset, or setting, over a period of time of up to 3 weeks. Oysters can spawn more than once per season, and this often results in two spat setting peaks, the largest in early summer and a smaller setting event in late summer. During the veliger, or free-swimming stage, the larvae can be transported by currents considerable distances, and this increases genetic diversity in the Chesapeake Bay populations of oysters.

Virginia typically has a much better spatset than the upper Chesapeake Bay waters in Maryland, primarily due to the higher salinity of Virginia waters. However, in recent years, this has not been the case, primarily due to the fact that the few remaining oysters in Virginia are widely scattered, which lowers fertilization efficiency during the spawning season. Infection with disease also reduces fecundity. Oyster growth rates are affected by temperature, salinity, phytoplankton (food) levels, and prevalence of parasitic infection. In Chesapeake Bay waters, oysters typically reach the current minimum marketable size of 3 inches shell height in 3 years after spatset.

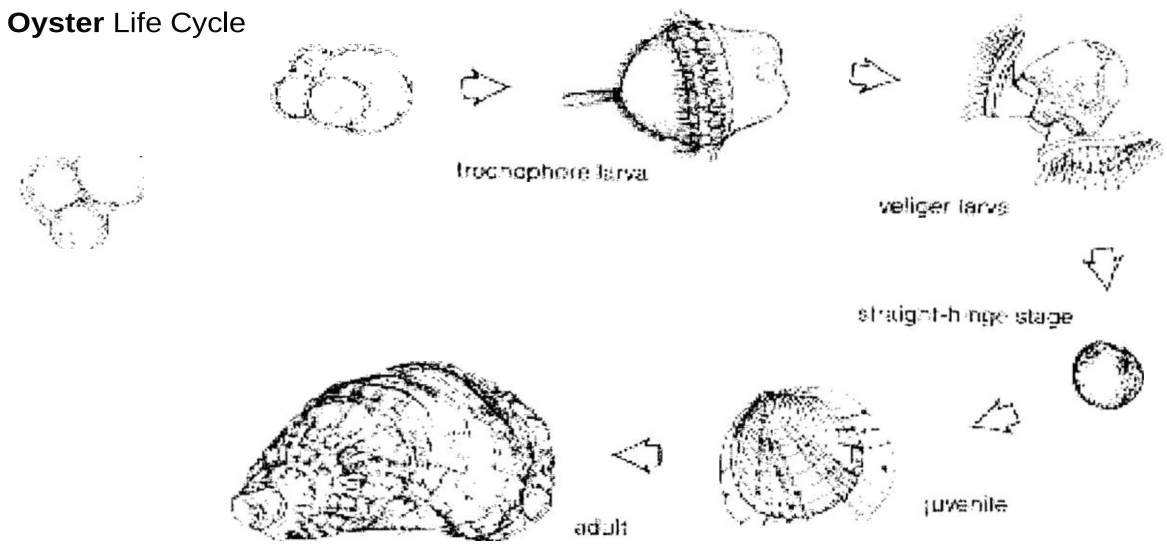


Figure 1. OYSTER LIFE CYCLE.
Source: http://clab.cecil.cc.md.us/faculty/biology/Chesapeake/oyster.html

Oyster populations and biomass have declined precipitously since colonial times. This decline is primarily due to overharvesting of Chesapeake Bay oysters. Additional factors that have contributed to the decline of oyster populations and biomass are environmental degradation, which lowers water quality, and two diseases caused by MSX *(Haplosporidium nelsoni)* and Dermo *(Perkinsus marinus).* Oyster harvesting by Native Americans and colonial Americans typically had little impact on oyster populations. With increasing populations and the advent of mechanical dredges, oyster harvests grew substantially over time and eventually began to negatively impact oyster populations. During the late 1800's oyster harvests throughout the Chesapeake Bay peaked at approximately 20 million bushels of oysters per year, and the largest harvest recorded was 24 million bushels in 1887 (Chesapeake Research Consortium, 1999). This peak could not be sustained for various reasons but primarily because at this level of fishing pressure the Chesapeake Bay oysters were overharvested. Many of the oysters removed at this time were from populations far upstream in tributaries that would have taken many years to recover due to low recruitment and growth rates due to low salinity in these waters. Harvest levels dropped quickly after these peak years. By 1930, annual harvests of oysters from the Chesapeake Bay were about 5 million bushels per year. Today, only a few hundred thousand bushels of oysters per year are harvested, mostly from Maryland waters.

The public fishery in Virginia waters today is virtually non-existent (Hargis and Haven, 1994). The harvest in Maryland has been sustained at this level due to an extensive oyster seed production operation in the State, and the current oyster population in Maryland resembles that of "put in and take" fishery, similar to a stocked lake. Many areas in Maryland also have somewhat lower salinity than much of Virginia waters, which lowers MSX and DERMO infection rates and intensity. Maryland spends considerable effort in maintaining active public beds by adding new shell to them, which replaces shell damaged or removed by fishery harvesting practices. Without this shell replenishment program, the public fishery in Maryland would quickly collapse. In Virginia, the oyster fishery and oyster populations have essentially collapsed.

MSX and Dermo directly impact oysters, often causing death of the oysters before they reach 3 inches in shell height. Declines in water quality can cause anoxic conditions, algal blooms, and large increases in suspended sediments in Chesapeake Bay waters that have a variety of effects on oysters. Anoxic conditions can kill sessile oysters, high levels of suspended sediments can lower their feeding rates, which stresses them and leaves them more vulnerable to infection with MSX and/or Dermo. Sedimentation can also reduce recruitment; a layer as thin as 3-4 millimeters over an oyster reef base can significantly decrease recruitment and spatset.

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APPENDIXB

OYSTER BIOMASS MODEL

APPENDIXB

OYSTER BIOMASS MODEL

The Oyster Biomass Model determines the expected oyster population on an oyster reef based on various parameters. All of these parameters, and the equations US Army Corps of Engineers, Norfolk District, used to develop the model, were obtained from the scientific literature, current unpublished research, and in consultation with the scientific community (Mann et al., 1998, Southworth and Mann, 1998, Powell et al., 1994, Lavitan, 1991). The model created is a Leslie Matrix, a biological model used to project population dynamics. There are four basic steps in creating this model:

1. Collect demographic data.
2. Analyze the data to obtain age and sex specific survivorship and fecundity rates.
3. Use age-specific survivorship and fecundity rates to project population dynamics by developing a matrix.
4. Incorporate variance to shift from deterministic to stochastic model.

This basic stochastic projection model assumes exponential growth; the final step is to incorporate limiting factors. The steps taken to develop the model are as follows, including a brief description of each:

1. Population demographics at the beginning are O for unseeded reefs and oyster density per square meter for seeded reefs.

2. Egg production for individual oysters was then estimated using the following formula: Fecundity= 39.06 *Weight/\ 2.36. Egg production increases at a greater than linear rate compared to length. Larger oysters are far more productive than smaller individuals.

3. Next simultaneous spawning with a defined sex ratio was assumed, and the sex ratios were derived from the literature. Oysters tend to spawn as male first, and the probability of spawning as a female increases with age. When in dense populations, even large oysters tend to be close to a 1: 1 sex ratio. This is all accounted for within the model to the extent such knowledge is available.

4. Fertilization efficiency was then estimated by using the following equation: Fertilization % = 0.49 * OD" 0.72. OD is oyster distance, the distance between individual oysters. Oysters are sessile invertebrates that broadcast spawn into the water. The closer mature individual oysters are physically to each other; the more gametes will successfully encounter one another.

5. The loss of oyster larvae was then estimated over their planktonic phase. Oyster eggs typically hatch into mobile larvae within 8 hours of fertilization. Survival= (1 - Lmort)"21, where Lmort is larval mortality rate of 0.05 to 0.1/day, and the exponent is the larval period in days.

6. The tidal exchange rate is a critical component of larval dispersion and significantly effects recruitment within a project area. This was estimated as survival= (1 - tide)"42 where tide= 5% to 20% loss, and 42 is the number of tidal cycles during the typical larval period. Salinity in this model is an average of the time of year the oysters are larvae.

7. The survival of larvae to the metamorphic phase was then estimated, followed by the percent that successfully metamorphose to spat, which is dependent on several factors, mainly substrate availability and spat mortality to the first size class.

8. The survival to older age classes was then estimated, based on expected predation rates and ability of the oysters to tolerate MSX and DERMO disease.

9. The model conducts these calculations for a 10-year period, and the output is the expected population level on a reef over this time. Biomass is easily calculated once expected population age, size, and numbers are known. It was taken into account that this model every year assumes ideal conditions for larval survival and estimates what the actual population will be. This expected population forms the basis for determining the National Ecosystem Restoration benefits, which are expected to be achieved under ideal conditions.

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APPENDIXC

COST ESTIMATES AND ECONOMIC ANALYSIS

APPENDIXC

COST ESTIMATES AND ECONOMIC ANAYLSIS

Table 1 shows the breakdown of total construction and implementation costs for the alternatives. Design, reseeding, reshelling, monitoring, and Operation, Maintenance, Replacement, Repair, and Rehabilitation (OMRR&R) costs were assumed to be the same for all alternatives. Only shell placement, contingency, and supervision and administration (S&A) costs were different among alternatives. However, since contingency and S&A costs were assumed to be 15 and 7 percent (respectively) of the total placement costs, they are proportional among alternatives.

Table 2 shows the total and average annual costs for each alternative that were used in the NER Plan selection process. As implementation costs were proportional among alternatives, only shell placement and broodstock seeding costs were used in the analyses.

Table 3 illustrates how the average annual equivalent costs were derived for the NER Plan (Alternative 2), while Table 4 shows how the Interest During Construction (IDC) costs were derived. Values were based on a 25 year project life, using a 5-7/8 percent discount rate and are shown in October 2003 price levels. The base year is 2004.

Table 5 illustrates how the average annual benefits were calculated. For each alternative, the NER benefits realized in the first 5 years grew exponentially. After year 5, the benefits are assumed to be fully realized.

Attachment 1 is the MCASES or cost estimates from the Norfolk District Cost Estimating Section.

Table 1. TOTAL CONSTRUCTION AND IMPLEl\.1ENTATION COSTS FOR ALL ALTERNATIVES

Costs	Alternative 1	Alternative 2	Alternative 3	Alternative 2(8;
Desiqn	$25,000	$25,000	$25,000	$25,000
Initial placement of shell	$1,530,000	$1,124,010	$2,340,000	$1,030,000
S&A (7% of initial placement costs)	$107,100	$78,681	$163,800	$72,100
Continqency (15% construction)	$245,565	$180,404	$375,570	$165,315
Initial broodstock seedinQ	$425,000	$425,000	$425,000	$425,000
Monitorinq year one	$60,000	$60,000	$60,000	$60,000
Reshellinq year 2	$15,000	$15,000	$15,000	$15,000
Reshellinq year 3	$30,000	$30,000	$30,000	$30,000
Reshelling year 4	$30,000	$30,000	$30,000	$30,000
Reshelling year 5	$30,000	$30,000	$30,000	$30,000
ReseedinQ year 5	$425,000	$425,000	$425,000	$425,000
Monitorinq year 2	$15,000	$15,000	$15,000	$15,000
Monitorinq year 3	$5,000	$5,000	$5,000	$5,000
Monitorinq year 4	$5,000	$5,000	$5,000	$5,000
Monitorinq year 5	$5,000	$5,000	$5,000	$5,000
Study costs	$400,000	$400,000	$400,000	$400,000
AveraQe Annual OMRR&R costs	$527,535	$527,535	$527,535	$527,535
Total construction costs (shell and seeding efforts only)	**$2,485,000**	**$2,079,010**	**$3,295,000**	**$1,985,000**
Total year one costs	$2,392,665	$1,893,094	$3,389,370	$1,777,415
Total Implementation costs (less IDC	$2,952,665	$2,453,094	$3,949,370	$2,337,415
Total Costs	**$3,880,200**	**$3,380,629**	**$4,876,905**	**$3,264,950**

Table 2. TOTAL AND AVERAGE ANNUAL CONSTRUCTIONS COSTS FOR EACH ALTERNATIVE

Alternative 1	
Total Construction Costs (FY 2003)	$2,485,000
Base Year	2004
Present Value Factor Year 1	0.945
Capital Recovery Factor	0.0773
Present Value[1] of Total Cost	$2,383,316
Average Annual Cost	$184,230

Alternative 2	
Total Construction Costs (FY 2003)	$2,079,010
Base Year	2004
Present Value Factor Year 1	0.945
Capital Recovery Factor	0.0773
Present Value[1] of Total Cost	$1,977,326
Average Annual Cost	$152,847

Alternative 3	
Total Construction Costs (FY 2003)	$3,295,000
Base Year	2004
Present Value Factor Year 1	0.945
Capital Recovery Factor	0.0773
Present Value[1] of Total Cost	$3,193,316
Averaqe Annual Cost	$246,843

[1] Present value discounted over 5 years of construction

Table 3. AVERAGE ANNUAL EQUIVALENT COST CO:MPUTATIONS - NERPLAN

Great Wicomico Oyster Restoration Project
Section 704 (B)

NER Plan - Alternative 2

Interest Rate = 0.05875

Project Year	Contract Cost (2003 $)	Present Value Factor	Present Value	Present Worth
0	$1,777,415	1	$1,777,415	$1,777,415
1	$30,000	0.944510035	$28,335.30	$28,335
2	$35,000	0.892099207	$31,223.47	$31,223
3	$35,000	0.842596654	$29,490.88	$29,491
4	$460,000	0.795840995	$366,086.86	$366,087
5	$5,000	0.751679807	$3,758.40	$3,758
6	$10,115	0.709969121	$7,181.34	$7,181
7	$5,000	0.670572959	$3,352.86	$3,353
8	$10,115	0.63336289	$6,406.47	$6,406
9	$450,000	0.598217605	$269,197.92	$269,198
10	$10,115	0.565022532	$5,715.20	$5,715
11	$5,000	0.533669451	$2,668.35	$2,668
12	$10,115	0.504056152	$5,098.53	$5,099
13	$5,000	0.476086094	$2,380.43	$2,380
14	$435,115	0.449668094	$195,657.33	$195,657
15	$5,000	0.424716027	$2,123.58	$2,124
16	$10,115	0.40114855	$4,057.62	$4,058
17	$5,000	0.378888831	$1,894.44	$1,894
18	$10,115	0.357864303	$3,619.80	$3,620
19	$5,000	0.338006426	$1,690.03	$1,690
20	$10,115	0.319250461	$3,229.22	$3,229
21	$5,000	0.301535264	$1,507.68	$1,508
22	$10,115	0.284803083	$2,880.78	$2,881
23	$5,000	0.26899937	$1,345.00	$1,345
24	$10,115	0.254072605	$2,569.94	$2,570
25	$5,000	0.239974125	$1,199.87	$1,200
			Total=	$2,760,086
			Total Maintenance =	$527,535
			Capital Recovery Factor	0.0773
			Average Annual Cost	**$213,400**
			Average Annual Maintence	**$40,778**
			Average Annual Construction	**$172,576**

Table 5. AVERAGE ANNUAL NER BENEFITS

Alternatives 1 and 2 Genetic Rehabilitation Goal (22.05)		Alternative 3 Genetic Rehabilitation/Biomass Goal (26.57)	
Year	**NER** Benefits	Year	**NER** Benefits
1	2.9	1	3.5
2	6.41	2	7.72
3	19.78	3	23.83
4	21.59	4	26.01
5	22.05	5	26.57
6	22.05	6	26.57
7	22.05	7	26.57
8	22.05	8	26.57
9	22.05	9	26.57
10	22.05	10	26.57
11	22.05	11	26.57
12	22.05	12	26.57
13	22.05	13	26.57
14	22.05	14	26.57
15	22.05	15	26.57
16	22.05	16	26.57
17	22.05	17	26.57
18	22.05	18	26.57
19	22.05	19	26.57
20	22.05	20	26.57
21	22.05	21	26.57
22	22.05	22	26.57
23	22.05	23	26.57
24	22.05	24	26.57
25	22.05	25	26.57
Total **NER** Benefits	513.73	Total NER Benefits	619.03
Average Annual Benefits	**20.5492**	**Average Annual Benefits**	**24.7612**

Table 4. AVERAGE ANNUAL DESIGN AND IDC COSTS FOR THE NER PLAN

Total Const. Periods: (months) =			2
	Begin Month	End Month	
Period Expenditures will occur	1	2	2
Expenditures per month			$876,208

INTEREST DURING CONSTRUCTION

FV = PMT ((l+i) N-1)

Compute Future Value (FV)		
Total Constr Cost=	$1,752,415	
Interest Rate (i) =	5.875%	
Future Periods, (N)	2	(to constr. completion date)
Expenditure periods (n)	2	
Expenditure/month (PMT)	$876,208	(assumed to occur on last day of the month)

n	PMT	{l+i)	"N	{l+i)"N-1	FV
1	$876,208	1.004768748	1	0.004768748	$4,178
2	$876,208	1.004768748	0	0	$0
				TOTAL IDC	**$4,178**

PED PHASE COST ESTIMATE .... TOTAL PROJECT COST SUMMARY ••••

PROJE Oyster Recovery Project Phase Ill
LOCATION: GREAT WICOMICO RIVER, VIRGINIA

DISTRICT: NORFOLK, VIRGINIA
P.O.C.: ALAN ELLINWOOD, CHIEF, COST ENGINEERING

		MCACES EST. PREPARED: JUL FY 03 EFFECTIVE PRICING LEVEL: JUL FY 03				AUTH/BUDGET YR: FY 04 EFFECT. PRICING LEVEL: OCT FY 04				FULLY FUNDED ESTIMATE				
ACCT NUM	FEATURE DESCRIPTION	COST($KI	CNTG ($KI	CNTG (%I	TOTAL ($KI	0MB (%I	COST ($KI	CNTG ($KI	TOTAL ($KI	FEATURE MD PT	0MB (o/ol	COST ($KI	CNTG ($KI	FULL ($KI
17	OYSTER SHELL PLACEMENT	1,124,024	168,604	15.0%	1,292,628	1.4%	1,139,760	170,964	1,310,724	Aug-04	0.0%	1,139,760	170,964	1,310,724
	TOTAL CONSTRUCTION COSTS	1,124,024	168,604	15.0%	1,292,628		1,139,760	170,964	1,310,724			1,139,760	170,964	1,310,724
01	L.ANDS AND DAMAGES	-	·	15.0%	·	1.4%	·	-		Aug-03	0.0%	-		
30	PRECONSTR., ENGINEERING AND DESI(	21,739	3,261	15.0%	25,000	1.4%	22,043	3,307	25,350	Aug-04	0.0%	22,043	3,307	25,350
31	CONSTRUCTION MGT	68,419	10,263	15.0%	78,682	1.4%	69,377	10,407	79,783	Aug-04	0.0%	69,377	10,407	79,783
	TOTAL PROJECT COST	1,214,182	182,128	15.0%	$1,396,310		1,231,181	184,677	$1,415,858			1,231,181	184,677	$1,415,858

DISTRI VED:

HIEF, ENGINEERING SUPPORCr

HIEF, CONSTRUCTION

CHIEF, ENGINEERING

CHIEF, OPERATIONS

PLANNING

TSD

CHIEF, PPMD

Great Wicomico River
Construction of Oyster Reefs and
Habitat Areas at Great Wicomico
River Restoration Sites

Designed By: Norfolk District
Estimated By: Norman T. Malbon, P.E.

Prepared By: Norman T. Malbon, P.E.

Preparation Date: 07/10/03
Effective Date of Pricing: 07/10/03

Sales Tax: 4.5%

Attachment
1

Great Wicomico River Oyster Restoration:

Concept Design Cost Estimate based upon the 2003 plans prepared by the Norfolk District.

Great Wicomico River: Includes Reefs and 2D Habitat Areas. Dredging location is approximately 85 miles from the restoration site.

Estimate includes a unit price of $16.50/cy for 2-D oyster shells and $17.50/cy for 3-D oyster shells. This unit price includes a markups, dredging, cleaning, hauling, and placement of shells. Unit price based upon conversations with Mr. Jim Wesson of MRC and recent procurement for similar projects.

No Backup Reports...

END TABLE OF CONTENTS * * *

•• PROJECT DIRECT SUMMARY - Contract ••

	QUANTY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
15 Preferred Option 1			0	0	0	0	1124024	1,124,024	
TOTAL Great Wicomico River	1.00	EA	0	0	0	0	1124024	1,124,024	1124024

		QUANTY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
15. Preferred Option 1									
USR	< > Dredged shell placed as 2-D flats			0.00	0.00	0.00	0.00	16.50	16.50
		37819	CY	0	0	0	0	624,014	624,014
USR	< > Dredged shell placed as 3-D Mounds			0.00	0.00	0.00	0.00	17.50	17.50
		28572	CY	0	0	0	0	500,010	500,010
	TOTAL Preferred Option 1			0	0	0	0	1124024	1,124,024
	TOTAL Great Wicomico River			0	0	0	0	1124024	1,124,024

APPENDIXD

ENVIRONMENTAL ASSESSMENT

FINAL

Environmental Assessment

OYSTER RECOVERY PROJECT PHASE III, GREAT WICOMICO RIVER, VIRGINIA

Prepared by

Norfolk District
U.S. Army Corps of Engineers
Norfolk, Virginia

July 2003

OREAT WICOMICO RIVER, VIRGINIA
OYSTER HABITAT RESTORATION PROJECT
ENVIRONMENTAL ASSESSMENT

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9.0 TABLES

FINDING OF NO SIGNIFICANT IMPACT
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I have reviewed and evaluated the Environmental Assessment for this project in tenns of the overall public interest. The possible consequences of the alternatives (including the no action plan) were considered in tenns of probable environmental impact, social well-being, and economic factors. The proposed project involves the construction of 128 acres of oyster reefs of various dimensions, combined with an aggressive stocking of disease-resistant native oysters and related "genetic rehabilitation strategy" in the lower Great Wicomico River, Virginia.

During this study, the environmental impacts of the proposed project were not found to be significant. There would be some loss of the existing benthos at the reef sites. This habitat is not unique and would be replaced by productive oyster habitat. This conversion actually represents a return to more historical conditions. Water quality impacts are expected to be minor and short-tenn; long-tenn impacts are expected to be positive after the establishment of the oyster community.

Since the no action alternative would lead to continued loss and demise of oyster populations, this alternative was not chosen. The other structural alternatives were not selected, as they involved higher costs for the same environmental benefit. The expected long-tenn positive environmental effects from reef construction are greater than the negative impacts resulting from construction activities. Due to of lack of significant impacts, an Environmental Impact Statement will not be required.

25 July 2003
Date

David L. Hansen
Colonel, Corps of Engineers
District Engineer
Colonel, U.S. Anny District Engineer

1.0 THE PROPOSED ACTION

Description

Section 704(b) of the Water Resources Development Act (WRDA) of 1986, as amended by Section 342 of WRDA 2000, authorizes the USACE to implement projects that include "the construction of reefs and related clean shell substrate for fish habitat, including manmade 3-dimensional oyster reefs, in the Chesapeake Bay and its tributaries in Maryland and Virginia if the reefs are preserved as permanent sanctuaries by the non-Federal interests, consistent with the recommendations of the scientific consensus document on Chesapeake Bay oyster restoration dated June 1999." The proposed Section 704 (b) project involves oyster restoration in the lower Great Wicomico River, a Virginia tributary to the Chesapeake Bay. Oysters are pivotal organisms in the ecology of the Chesapeake Bay both for the habitat they create and for their water filtering capacity. In addition, their numbers have supported a substantial commercial fishery. Years of habitat destruction, overharvesting, pollution, and disease-induced mortalities have severely impacted oyster populations throughout the Chesapeake Bay and its tributaries. Recent restoration efforts by the Virginia Marine Resources Commission (VMRC) and the US Army Corps of Engineers (USACE) have shown much promise, but the scale of the efforts is limited by available funding and is not enough to reverse the long period of population decline.

This project will involve the rehabilitation of up to 128 acres of currently degraded oyster habitat through the construction of various methods of bottom enhancement (shelling), combined with an aggressive seeding strategy. The proposed project includes the construction of a combination of high-relief reefs (HR.R's), all-shell structures ranging from 6-8 feet in height; medium-relief reefs (MRR's), all-shell structures ranging 2-4 feet in height; low-relief reefs (LRR's), all-shell structures ranging from 6-10 inches in height; and thin-shelled areas, which will be several inches in thickness. Any of the restored reefs could be heavily seeded with the best available disease-resistant genetic stocks to serve as broodstock. The project will also involve the transportation of resident spat-on-shell from the Great Wicomico to recently restored oyster reef structures in Tangier Sound. Additionally, in the later phases of the project as the thin-shelled areas are colonized by larvae from the disease resistant broodstock oysters, the resultant spat-on-shell will be moved to existing reef structures in the lower Rappahannock River, the Piankatank River, and possibly other estuaries as well.

Construction of HRR reefs involves purchasing, hauling, and, finally, deploying shell to create mounds rising off the river bottom. Increased reef height allows for optimized spawning success, as the broodstock oysters are located higher in the water column. Similarly, MRR areas are created by the placement of shell 10 inches high within historical reef footprints in proximity to the HRR reefs. Additional acreage will be thin-shelled; these low profile areas are large areas of reconditioned river bottom that will provide successful settling substrate for the set derived from spawning broodstock oysters on the nearby seeded reefs.

The proposed project is a cooperative effort involving Norfolk District, VMRC, the Virginia Institute of Marine Science (VIMS), and other interested Federal and State agencies, oyster scientists, and other individuals. The proposed project is in agreement with goals stated by scientific consensus (Chesapeake Research Consortium, 1999) and related documents, such as the Year 2000 Chesapeake Bay Agreement. Its implementation represents USACE 2003 contributions toward meeting the goals stated in the Year 2000 Chesapeake Bay Agreement of increasing the biomass of oysters 10- fold by 2010 (1994 baseline) and setting aside and restoring 10 percent of the historic public ground acreage as sanctuaries.

The project presented in this report is part of a multi-year plan of integrated activities throughout waters of the Chesapeake Bay and its tributaries. It also incorporates significant changes in oyster restoration strategy, as genetic rehabilitation of the native oyster is now the primary goal. Such genetic rehabilitation involves actively seeding disease-resistant strains of native oysters *(Crassostrea virginica)* and is widely accepted as the best chance for successful restoration of the native oyster in Virginia waters.

Purpose and Need

The purpose of this effort is to ensure the implementation of technically sound and economically designed and constructed sanctuary reef structures, which will ultimately serve to restore lost oyster habitat and improve the environmental quality of the Chesapeake Bay and the living resources that inhabit the Chesapeake Bay. The seeding aspect of this project will serve to jumpstart the oyster spat production in this trap estuary and eventually serve to produce much-needed disease-resistant native seed for relocation to other estuaries, namely Tangier Sound, the Piankatank, and lower Rappahannock River. It is likely that selected strains of disease resistant native oysters will also be planted on four HRR already constructed in the Piankatank River.

2.0 ALTERNATIVE PLANS

No Action Plan

A no action alternative was also evaluated. Under this scenario, no sanctuary reef structures of any design would be constructed, nor would any seeding program be implemented. The project area will not naturally return to a productive state for oysters and will instead remain as degraded oyster habitat. As this scenario will not meet the needs of the project and feasible alternatives do exist, the no action plan was dropped from further consideration.

Alternative Plans

An earlier design considered the use of dredged material as the basis for oyster reef cores in the James River (USACE, 1996). However, the cost of implementing this design was not acceptable to the non-Federal sponsor, VMRC, who withdrew support of the James River project at the conclusion of the feasibility phase. Use of dredged material was, therefore, not considered further in the design of this project. A design implementing a concrete-core reef covered with a veneer of shell was also considered. However, this design was not acceptable to VMRC's permitting authority and was, therefore, eliminated from further consideration.

Other plans involve constructing only HRR, only MRR or only thin-shelled areas. It was determined that a combination of these construction techniques would provide the greatest environmental benefit for the costs. Without stocking, however, the population of native oysters likely to develop on these restored sites is likely to be small and the resultant benefits few. A larger construction alternative was considered involving many more HRR reefs, all of which would be stocked. While the benefits would be considerable, the cost is such that the selected plan was chosen. In addition, the selected plan, due to the stocking proposed in it, will provide benefits very close to the more extensive construction alternative proposed.

Selected Plan

A plan for the construction of a combination of all-shell sanctuary oyster reefs with adjacent shell plantings was selected based upon the calculations performed by USACE scientists and economists (see the Plan Formulation , Main Report). Additionally, the plan is consistent with recommendations made by a group of oyster experts who met on **18** January 1999 (Chesapeake Research Consortium, 1999). The project is proposed to be constructed in several phases, with the number of phases implemented each year dependent upon the annual budget for the project. This Environmental Assessment (EA) assumes that full funding will be secured, and the project will be built in its entirety. A number of all-shell oyster reef structures of various heights, each constructed of dredged fossil oyster shell, will be constructed as sanctuary reefs. The heights will depend on the historic information available on the original configuration of the reefs, as well as the capability of construction equipment to access the proposed restoration areas.

Norfolk District proposes to construct 6 acres of MRR reefs. These will resemble an inverted egg carton, with a series of mounds within the footprint. A previously constructed HRR reef will be seeded with 5-10 million disease tolerant selected strain DEBY oysters *(Crassostrea virginica),* which, based on the latest research, outperform any Chesapeake Bay wild stock of native oysters, *Crassostrea virginica.* The adjacent areas will consist of shell plantings approximately 4-10 inches deep (see Figure 1). These LRR's (8-10 inch deep shell layer) and thin-shelled (4-inch thick shell layer) areas will provide suitable substrate for the set derived from the natural spawning oysters on the reefs, and some will serve as spat-on-shell production areas for genetic rehabilitation stocking efforts throughout the Virginia waters of the Chesapeake Bay (see Figures 3, 4). Other sites will likely be stocked in the future, beyond those seen in Figures 3 and 4. The overall goal of this strategy is to increase the fitness of the Chesapeake Bay stocks of native oysters by genetic introgression of disease tolerance into the general population. While this will take time, this strategy is seen as the best chance of success by the scientific community. Future stocking with disease-resistant selected strains of native oysters upon four previously constructed HRR in the Piankatank River is also part of the selected plan (Figure 2).

3.0 AFFECTED ENVIRONMENT

Location

The project area is located entirely within the Great Wicomico River basin, which is one of the Northern Neck coastal basins occupying the eastern tip of the Northern Neck peninsula, Virginia. These basins are located between the Potomac and the Rappahannock river basins and flow directly into the Chesapeake Bay. The basins occupy 130 square miles, which represents less than 0.4 percent of the area of Virginia and less than 0.2 percent of the Chesapeake Bay watershed.

The Northern Neck coastal basin's major tributaries are the Great Wicomico River, Cockrell Creek, Mill Creek, Dividing Creek, Indian Creek, Dymer Creek, Tabb Creek, and Antipoison Creek. These tributaries cover an area of 5.7 miles. Land use in the basins is primarily forested and agricultural. Forested land comprises 64 percent of the land use, agricultural about 30 percent, and urban about 6 percent (Virginia Department of Environmental Quality [VDEQ], 1999).

Northumberland County, Virginia, encompasses 192 square miles and supports a population of 12,400 people, with no metropolitan areas reported (Northumberland County, 2002; US Census Bureau, 2002). The entire project area is located within Northumberland County.

Climate

The climate of Northumberland County, Virginia may be considered temperate, humid, and subtropical. Northumberland County is in the belt of prevailing west and southwest winds. The region is also in the path of winter storms that cross this part of the country and is affected by moist, tropical air that flows from the Atlantic Ocean or Gulf of Mexico. Daily weather is influenced by the mountains in the west and by adjoining water bodies. Average annual temperature is reported as 56.4 ° Fahrenheit (F), with February, the coldest month, having and average temperature of 36.8 °F and July, the warmest month, having an average temperature of 76.8 °F. Average annual precipitation is approximately 42 inches, with August being the wettest month and November the driest. Average annual snowfall is 13.6 inches (US Department of Agriculture [USDA], 1959).

Physiography, Relief, and Drainage

The project area lies entirely within the Coastal Plain Province. Northumberland County consists of geological terraces that can be divided into upland and neckland. The terraces in the area nearest the project area are related to neckland, namely Princess Anne, 0 to 15 feet above sea level; the Dismal Swamp (Pamlico), 10 to 25 feet above sea level; and the Chowan, 30 to 45 feet above sea level. The neckland in Northumberland County borders the Chesapeake Bay, Potomac River, and Rappahannock River. The neckland consists of broad stretches of flat land with small gentle to steep slopes near the primary drainageways. In some areas, the neckland can be as much as 50 feet above sea level. Large areas of the neckland are wet due to a high water table. While secondary drainage is not well established, primary drainage is through numerous tidal creeks and rivers. Artificial drainage is required on much of the cultivated neckland (USDA, 1959). The Great Wicomico River has a drainage basin of approximately 70.6 square miles, which results in relatively little freshwater inflow (Hyer and Jacobson, 1976).

Geology and Soils

In geologic terms, the Chesapeake Bay is young. During the latter part of the Pleistocene epoch, which began 1 million years ago, the area encompassing the Chesapeake Bay was alternately exposed and submerged as massive glaciers advanced and retreated up and down North America. This movement caused sea levels to rise and fall in response to glacial expansion and contraction. The region still experiences small-scale changes in sea level, which have been easily observed over the past century.

The most recent retreat of the glaciers, which began approximately 10,000 years ago, marked the end of the Pleistocene epoch and resulted in the birth of the Chesapeake Bay. The melting glacial ice caused an increase in sea level that submerged the coastal regions, including the ancient Susquehanna River Valley along with many of the river's tributaries. The resulting complex of drowned stream beds now forms the Chesapeake Bay and its tidal tributaries, which includes the Rappahannock River (US Environmental Protection Agency [USEPA], 1989).

While the entire project is to be constructed on subaqueous lands, adjacent soils in Northumberland County along the northern and southern shores of Great Wicomico River are mapped generally as Mattapex-Bertie association, Matapeake-Mattapex association, and Sassafras-Sandy land association. The Mattapex-Bertie association includes moderately well-drained, and somewhat poorly drained, moderately fine textured soils on broad, flat neckland. This association includes a highly-mixed pattern of well-drained to poorly-drained soils. The Mattapex soils occupy moderately well drained positions, and the Bertie occupy somewhat poorly drained positions. This association covers 10 percent of Northumberland County.

The Matapeake-Mattapex association consists of well drained and moderately well drained, moderately fine textured soils on broad, flat neckland. This association consists mainly of well-drained and moderately well-drained soils, with the Matapeake soils occupying well-drained positions, and the Mattapex occupying moderately well-drained positions. Both have mainly a silt loam surface soils underlain by sandy deposits. This association also contains the somewhat poorly drained Bertie, the well-drained Sassafras, and the moderately well-drained Woodstown soils. Small areas of tidal marsh, coastal beach, and mixed alluvial land are also in this association. Approximately 7 percent of Northumberland County is covered by the Matapeake-Mattapex association.

The final association is the Sassafras-Sandy land association, which consists of well-drained soils on nearly level to gently sloping broad ridgetops and excessively drained soils on moderately steep to steep side slopes. The well-drained Sassafras soils occur on ridgetops and are underlain by sandy and loamy sand. Sand land occurs on side slopes and is excessively drained. This association covers approximately 50 percent of Northumberland County and covers the most land in the vicinity of the proposed project. In the immediate area of the proposed project, the banks of the Great Wicomico River are mapped mostly as tidal marsh and coastal beach, with some areas of sloping to steep sandy land, well-drained Sassafras soils, and moderately well-drained Matapeake soils. The southern shoreline of the Great Wicomico in the area of the proposed project also contains significant linear footage of escarpments bordering the well-drained Sassafras soils and Mattapeake soils (USDA, 1963).

Subsurface Stability

Subsurface borings were performed as part of this proposed project, both to determine subsurface stability, as well as to characterize bottom type. The results of the surveys were analyzed and after such analysis, the limits of the reefs and shellplant areas were determined (see Figures 3 and 4). The avoidance of "soft bottoms" and the presence of oyster rock, sand, and shell or sand were considered during the siting process. Reefs and shellplant areas correspond to productive areas of public ground that have received plantings in the past.

Tides

The astronomical tides affecting the project area are semi-diurnal, which means a tidal cycle consisting of two high tides and two low tides each lunar day, where consecutive high tides are of similar height, and consecutive low tides are of similar height. The closest tidal station is at the Great Wicomico River Light (37° 48" N, 76° 16" W). Based on the Hampton Roads, Virginia, reference site, mean tidal range is 1.10 feet, mean high high water is 1.30 feet, and mean tide is 0.50 foot (website: http://www.essex-virginia.org/ec_tide.htm).

Wetlands

The entire project wilJ be constructed within the open water habitat and State-owned bottom of the lower Great Wicomico River. Therefore, no jurisdictional wetlands exist within the footprints for the proposed reefs and productions areas. Materials wilJ be barged in, and staging areas are not required.

Many small tidal marshes exist along the northern and southern shorelines of the Great Wicomico River in the general vicinity of the proposed project. A tidal marsh inventory prepared by VIMS delineates and characterizes 113 marshes, totaling 227 acres within the Great Wicomico River system in Northumberland County. Silberhorn (1975) describes the marshes of the Great Wicomico as small (most only a fraction of an acre in size) but functionally important. According to studies cited by Silberhorn (1975), small marshes such as pocket and cove marshes support great numbers of minnows and juvenile fish, as well as serve as important nursery areas. Additionally, the small fringing marshes of the Great Wicomico are important dissipaters of wave energy, particularly from sources such as boat wakes and tidal currents. Silberhorn (1975) notes that significant erosion has occurred along much of the shoreline of the Great Wicomico, particularly in the area of Bull Neck, which is eastward of the project location. Therefore, while the remaining small marshes in the area are not effective barriers to high-energy waves, they do serve a critical erosion-control function.

In the immediate project area, small marshes are present sporadically on the shoreline of the Great Wicomico and its tributaries. On the southern shoreline, small spit, pocket, and cove marshes are located along Shell Creek, Gougher Creek, Penny Creek, Barrett Creek, and Tipers Creek. Similarly, small spit, pocket, and cove marshes are located along Reason Creek, Whays Creek, Warehouse Creek, Hom Harbor, Coles Creek, and the northern shoreline of the Great Wicomico River, with the headwaters of the small tidal creeks supporting the largest marshes. Marsh vegetation is dominated by mostly saltmarsh cordgrass *(Spartina altemiflora)*, black needlerush *(Juncus roemerianus)*, and saltmeadow grasses *(Spartina patens* and *Distichlis spicata)*, with smaller but varying amounts of saltbushes *(lvafrutescens* and *Baccharis halimifolia).*

Submerged Aquatic Vegetation

No submerged aquatic vegetation (SAV) is present within the footprints of the proposed sanctuary reefs and surrounding shellplant areas. According to the most recent final report by VIMS on the 2001 distribution of SAVin the Chesapeake Bay (Orth et al., 2002), several elongated beds exist in the vicinity of Whays Creek and Warehouse Creek (Figure 6). Two small SAV beds are located along of the northern shoreline of the Great Wicomico River near Haynie Point and are 750 to 1,000 feet away from the closest boundary of one of the restoration locations. Species composition of the beds is reported from a VIMS field survey as widgeon grass *(Ruppia maritima).* Larger, denser beds of eelgrass *(Zostera marina)* and widgeon grass are reported further south of the project site, near Dameron Marsh and Ball Creek, approximately 3.5 miles away from the project site (Orth et al., 2001).

This area of the Great Wicomico River appears to be fairly dynamic, showing increases and decreases of SAV, mostly due to the cyclic nature of widgeon grass. For example, 2000 data from VIMS for the Reedville quad indicates 244.70 hectares of SAV, while 2001 preliminary data reports 426.12 hectares, which meets the Tier 1 goal set for that quad. Since 1971, total distribution has generally increased, from a high of 426.12 hectares in 2001 to a low of 12.75 hectares in 1980, with several fluctuations reported during the period of record.

Water Quality

Water quality in the Great Wicomico River Basin is generally considered good. Four VDEQ water quality stations are located in the Great Wicomico River in the vicinity of the proposed project. However, these stations are located in deeper waters than the proposed project, with the shallowest station off of Sandy Point in 6 meters (m) of water. During sampling events in June and August 1995, salinity at the four stations ranged from 17 parts per thousand (ppt) to 19 ppt. Bottom dissolved oxygen (DO) readings ranged from 4.76 milligrams per liter (mg/I) to 7.17 mg/I, with the lower readings recorded later in the summer.

The primary water quality problem within the Great Wicomico is seasonal hypoxia. Low DO levels in deeper waters near the mouth of the river have created a hypoxic environment for benthic organisms and a marginal environment for fish. Such events occur during the summer months when water stratification and eutrophic conditions are most pronounced. Problems appear to be most severe in Cockrell Creek and the mainstem of the Great Wicomico River. The proposed reef structures will be sited in shallow waters (less than 10 feet deep), thereby avoiding the effects of long lasting seasonal hypoxic/anoxic events due to stratification. However, seasonal occurrences of anoxia/hypoxia may occur on a short-term term basis.

Several tributaries of the Great Wicomico River have been condemned by the Virginia Department of Health for the direct harvesting of shellfish. Condemnation is based upon high levels of bacterial contamination. However, no condemned areas exist within the Great Wicomico River in the immediate vicinity of the proposed project, although areas exist within Whays Creek, Warehouse Creek, Betts Mill Creek, Balls Creek, and Tipers Creek (Condemned Shellfish Area Number 89).

According to data supplied by USEPA's Envirofacts Warehouse, five companies in Northumberland County have Virginia Pollution Discharge permits. The two closest outfalls are associated with the Reedville Sanitation District Sewage Treatment Plant and Omega Protein Incorporated, both of which discharge to Cockrell Creek, greater than 2 miles away from the proposed project location (http: oaspub.epa.gov/enviro).

Wild and Scenic Rivers

No portion of the Great Wicomico River is considered either a national or State wild and scenic river.

Fauna of the Project Area

Commercial Benthos

Oysters are components of the benthic community. Although free-swimming as larvae, once they settle on an appropriate substrate, a process known as setting, they are, henceforth, sessile creatures. Areas of the Great Wicomico River were evaluated in terms of suitability for harvesting commercial benthos, primarily oysters and soft clams *(Mya arenaria)*, by Haven et al. of VIMS in 1981. In the area of the proposed project, salinities range from 14 ppt at the mouth to 11 ppt at Glebe Point in the summer (Haven et al.), although higher salinities have been reported. Therefore, salinities are favorable to average oyster growth rates, and the area is recommended for use for growing seed oysters to maturity. Haven et al. (1981) assessed the area of the proposed project as being relatively free of predators (i.e., blue crabs) and not heavily impacted by MSX and Dermo. Today, however, Dermo is found throughout much of the Great Wicomico River. The use of selected strains of native oyster with high tolerance to disease is especially warranted.

Haven et al.'s report also mentions the seasonal hypoxia/anoxia that occurs in this region. As DO values less approximately 0.8 parts per million (ppm) may kill oyster larvae and spat, and values below 0.5 ppm over a period of weeks may be lethal to adult oyster, avoidance of bottoms deeper than 30 feet is highly recommended (Haven et al., 1981). Oysters employ several mechanisms to survive hypoxic/anoxic conditions. Studies have shown that larvae avoid areas of low DO by swimming upwards toward the surface where hypoxia is minimal. Additionally, larval swimming rates in waters with DO levels as low as 0.5 ml/L were not significantly different than rates in oxygen-saturated waters. Due to larval avoidance to hypoxic conditions, as well as spat and adult resistance to low concentrations of DO, short-term intrusions of hypoxic or anoxic waters over shallow (5-10 m) oyster beds are probably not deleterious (Kennedy, 1991).

Predation must be considered during any species restoration effort. The effects of the oyster drill *(Urosalpinx)* were significant prior to 1972. Oyster drills are becoming re-established in the Great Wicomico River today and are now found in considerable numbers throughout most of their former range. Floodwaters associated with Tropical Storm Agnes were responsible for the decrease in oyster drill populations; however, they are expected to return to previous levels, although this has not yet occurred. Reproducing populations of oyster drills have been recently observed in the seedbeds of the Piankatank River and Pocomoke Sound (Wesson, 1998). The boring sponge *(Cliona truitti)* has a negative impact on oysters by physically degrading the oyster shells. This is especially problematic on restored reefs that fail to develop significant populations of living oysters, which build new shell.

According to the Virginia Oyster Heritage Program, the peak of Virginia's oyster harvesting occurred in the 1900's, when annual catches exceeded 9 million bushels. By 1958, landings had decreased to 4 million bushels. Total landings for the 1997-1998 season were 14,295 bushels, only 1 percent of the catch only a few decades ago (Virginia Oyster Heritage Program, 1999).

While not as important commercially, the soft clam *(Mya arenaria)* may exist as scattered populations. The Great Wicomico is located toward the southern limit of the soft clam's range, and populations of commercial size may develop during certain years (Haven et al., 1981).

Noncommercial Benthos

The importance of the benthos cannot be understated. The health and structure of benthic communities typically defines the health and structure of higher trophic levels. Subsequently, the benthic community, particularly the invertebrate component, is used in EA's as a kind of "barometer" in determining presence of environmental stress. Currently, degree of environmental stress can be estimated using a Benthic Index of Biotic Integrity (Weisberg, et al., 1997).

Benthic resources within the footprints of the proposed reef structures have not been sampled as part of the ongoing benthic monitoring of the Chesapeake Bay. The Chesapeake Bay Monitoring Program has no fixed benthic monitoring stations in the lower Great Wicomico. However, a random station was sampled recently near the mouth of the Great Wicomico, although those data are not available at this time.

Therefore, based on sediment and salinity characteristics, it may be assumed that the benthic communities in the areas of the proposed reef and shellplant areas in the lower Great Wicomico River are comparable to those of other areas within the lower Rappahannock River and Chesapeake Bay tributaries with similar sediment and salinity characteristics. Several random stations have been sampled within the Rappahannock River as part of the Chesapeake

Bay Monitoring Program. With data supplied by Old Dominion University Benthic Ecology Laboratory manager Anthony Rodi, the most representative of these are stations were further analyzed, as they were located in shallow depths and had sediments with rather high percentages of sand. Taxonomic identification of samples from station 03R02 off of Parrott Island (5-m-depth, 82 percent sand) indicate species abundance dominants as the polychaetes *Mediomastus ambiseta*, *Paraprionospio pinnata*, and *Glycinde solitaria*, as well as the amphipod *Leucon americanus* with biomass dominated by the polychaete *Nereis succinea*. Station 03R08 off of Towles Point (2 m depth, 96.6 percent sand) is characterized by species abundance dominants as the polychaetes *Heteromastus filiformis*, *Nereis succinea*, *Streblospio benedicti*, and *Glycinde solitaria* with biomass dominated by the polychaetes *N. succinea*, *H.filiformis*, as well as *Scolecolepides viridis*. Both of these stations were sampled in August 1996. In the absence of site-specific data for the proposed reef and shell plant sites, it may assumed that the benthic communities are similar in structure and composition to these station in the lower Rappahannock River.

The emphasis of the analysis of the benthic communities in the lower Rappahannock River and other similar systems has mainly been in response to the seasonal anoxic events that occur annually in the deep "holes" in the river, hence the presence of a "fixed" station as part of the Chesapeake Bay Monitoring Program. Smith (1994) performed a study of the benthic community response to hypoxic conditions in the lower Rappahannock River. The study area was defined as the lower Rappahannock River, from the confluence to the mouth of the Corrotoman River. The purpose of her study was to document intermediate depth responses, rather than those at the deep water stations, which always experience seasonal anoxia. Smith found that anoxic events did indeed occur in the shallower depths (5 m depth) and were responsible for a shift in benthic community composition. In some ways, the 5 m depth station may be fairly representative of the shallower areas within the vicinity of the proposed project. Abundance dominants include large, deep dwelling clam, *Macoma balthica*, the bivalve *Mulinia lateralis*, and a dense population of *Streblospio benedicti*. After an anoxic event, the benthic community at the 5 m station contained a more even distribution of opportunistic polychaetes, including *Glycinde solitaria*, *Nereis succinea*, and *Paraprionospio pinnata* (Smith, 1994), which correlates well with results from the summer sampling event reported by Old Dominion University. Therefore, benthic community structure is profoundly affected by anoxic events, and benthic composition subsequently varies throughout the year. Table 1 lists species collected in the lower Chesapeake Bay during Smith's study. No oysters were identified during this study, although oysters are known to survive periods of hypoxia/anoxia, which may prove lethal to other benthic organisms.

It may be assumed that the benthic community in the area of the proposed project is influenced by several factors. In her study, Smith refers to the well-documented influence of grain size on the benthic infauna! community (Bloom et al., 1972; Fresi et al., 1983; Gaston et al., 1988). Sandier sediments often support communities with higher species diversity than those found in finer-grained habitats. Explanations for this observation include the increase in niche space for epifaunal and deposit feeding infauna} species (Boesch, 1973; Hyland et al., 1991). Also, due to increased permeability and porosity, coarser grained sediments typically display deeper Redox Potential Discontinuity layers than finer grained habitats due to the downward diffusion of oxygen. However, it should be noted that anoxic and hypoxic conditions can overwhelm the high permeability associated with sandy sediments (Levin et al., 1991).

Another important influence on the benthic community structure in shallow depths is increased predation pressure. Common predators of the mesohaline Chesapeake Bay include spot, Atlantic croaker, winter flounder, hogchoker, blue crab, and mud crab *(Rhithropanopeus harrisii)* (Holland et al., 1980).

Nekton

According to the Virginia Department of Game and Inland Fisheries (VDGIF) online database, Fish and Wildlife Information Service, two species of anadromous fish may occur in the lower Great Wicomico River in the vicinity of the proposed project. These include Atlantic sturgeon *(Acipenser oxyrhynchus),* a Virginia species of special concern, and sea lamprey *(Petromyzon marinus)* (VDGIF, 2003).

Other fish either documented or expected to occur within the project area include Altantic croaker *(Micropogonias undulatus),* largemouth bass *(Micropterus salmoides),* spot *(Leiostomus xanthurus),* and chain pickerel *(Esox niger).* Table 2 lists species identified within 2 miles of the area off Sandy Point (Latitude 37° 49' 27"; Longitude 76°18' 04") (VDGIF, 2003).

The Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), requires all Federal agencies to consult with the National Marine Fisheries Service (NMFS) on all actions, or proposed actions, permitted, funded, or undertaken by the agency, that may adversely affect Essential Fish Habitat (EFH). The proposed oyster habitat restoration project contains EFH for various life stages of 12 species: winter flounder, windowpane flounder, black sea bass, scup, king mackerel, Spanish mackerel, cobia, red drum, sand tiger shark, Atlantic sharpnose shark, dusky shark, and sandbar shark (National Oceanic and Atmospheric Administration/NMFS, 1999). The area is also designated as a Habitat Area of Particular Concern (HAPC) for larval, juvenile, and adult sandbar sharks. Appendix A lists species and EFH associated with each species.

Avian Resources

The Rappahannock River and surrounding areas are well known for their rich avian resources. The open water, marshes, and bottomland hardwoods of the region provide excellent habitat for most North American waterfowl species. According to the 1994 EA prepared by the US Fish and Wildlife Service (USFWS) for the establishment of the Rappahannock River Valley National Wildlife Refuge, tens of thousands of ducks, geese, and swans winter on the Rappahannock River. In addition to providing habitat for waterfowl, marshes and bottomland hardwood wetlands in the region also provide excellent habitat for a variety of birds, including wading birds, rails, and shorebirds (USFWS, 1994).

Similar species are found in the lower Great Wicomico. More than 200 species of birds have been either documented or determined likely to occur in the project area. These include a variety of shorebirds, wading birds, waterfowl, rails, and passerines. Table 3 lists species identified within 2 miles of the area off Sandy Point (Latitude 37° 49' 27"; Longitude 76°18' 04") (VDGIF, 2003).

Mammals

A diverse assemblage of mammals utilize the area of the proposed project. Wetland habitats support an abundance of furbearers, including muskrat *(Ondatra zibethica),* raccoon *(Procyon lotor),* beaver *(Castor canadensis),* and mink *(Mustela vison).* Larger mammals more closely associated with uplands include white-tailed deer *(Odocoileus virginianus),* gray squirrel *(Sciurus carolinensis carolinensis),* red fox *(Vulpes vulpes fulva),* and opossum *(Didelphis marsupialis)* (USFWS, 1994). Table 4 lists other mammals that may occur in the project area, including a variety of bats, mice, rats, squirrels, shrews, muskrat, squirrels, voles, bobcat, chipmunk, woodchuck, and weasel (VDGIF, 2003).

Reptiles and Amphibians

An abundant variety of reptiles and amphibians are reported to occur within the project area. Table 5 lists approximately 60 species of frogs, toads, treefrogs, salamanders, skinks, snakes, and turtles that may be found within 2 miles of the area off Sandy Point (Latitude 37° 49' 27"; Longitude 76°18' 04") (VDGIF, 2003).

Threatened and Endangered Species and State Species of Special Concern

Federal Species

The bald eagle *(Haliaeetus leucocephalus),* a Federally-threatened species, is reported as nesting along the banks of Great Wicomico and its tributaries. Correspondence from the VDGIF indicates that the bald eagle has been documented within 2 miles of the proposed project in the area of Ferry Point.

VDGIF has also documented the occurrence of the Federally-threatened Northeastern beach tiger beetle *(Cicindela dorsalis dorsalis)* in the project area near Haynie Point and Cockrell Point. Additionally, the loggerhead turtle *(Caretta caretta)* has been documented approximately 1.5 miles from the easternmost portion of the proposed project area (Cockrell Point).

The bottlenose dolphin, while not a threatened or endangered species, is listed as "depleted" under the Marine Mammal Protection Act. It is listed as occurring within the vicinity of the proposed project (VDGIF, 2003).

VDGIF's online database, Fish and Wildlife Information Service, lists several Federally-listed species that may potentially occur in the project area. These species include the Federally-endangered/State-endangered Kemp's Ridley sea turtle *(Lepidochelys kempii)* and the Federally-endangered/State-endangered Atlantic green sea turtle *(Chelonia mydas),* along with several species of both Federal and State concern, including the northern diamondback terrapin

(Malaclemys terrapin terrapin), black rail *(Laterallus jamaicensis),* cerulean warbler *(Dendroica cerulean),* and Atlantic sturgeon *(Acipenser oxyrhynchus).*

State Species

VDGIF lists the upland sandpiper *(Bartramia longicauda),* a State-listed threatened species, as potentially occurring within the project area. Additionally, the great Egret *(Ardea alba egretta),* Forster's tern *(Stemaforsteri),* and least tern *(Stema albifrons},* all of which are species of concern in Virginia, are listed as documented within 2 miles of the project area (VDGIF, 2003). Eighteen avian species of special concern may occur in the project area according to VDGIF, including brown creeper *(Certhia americana),* dickcissel *(Spiza americana),* purple finch *(Carpodacus purpureus),* northern harrier *(Circus cyaneus),* little blue heron *(Egretta caerulea caerulea),* tricolored heron *(Egretta tricolor),* golden-crowned kinglet *(Regulus strapa),* common moorhen *(Gallinula chloropus cachinnans),* yellow-crowned night-heron *(Nyctanassa violacea violacea),* red-breasted nuthatch *(Sitta canadensis),* barn owl *(Tyto alba pratincola),* brown pelican *(Pelecanus occidentalis carolinensis),* saltmarsh sharp-tailed sparrow *(Ammodramus caudacutus diversus),* Caspian tern *(Stema caspia),* hermit thrush *(Catharus guttatus),* magnolia warbler *(Dendroica magnolia),* sedge wren *(Cistothorus platensis),* and winter wren *(Troglodytes troglodytes).*

The river otter *(Lontra canadensis canadensis)* is also a State species of special concern that may potentially occur in the project area (VDGIF, 2003). Table 6 lists species that may be found within 2 miles of the area off Sandy Point (Latitude 37° 49' 27"; Longitude 76°18' 04"), including both Federal- and State-protected species (VDGIF, 2003).

Cultural Resources

The area of the proposed project has been cultivated by watermen for many years for shellfish harvest. VMRC has been placing shell in these areas to stimulate shellfish harvest throughout the lower Greater Wicomico River. Therefore, due to the continual disturbance of the sediments in the project area, archaeological resources are presumed either not to exist or to be sufficiently disturbed as to no longer retain their significance. Correspondence from the Virginia Department of Historic Resources (VDHR) indicates that the proposed oyster habitat restoration is not likely to affect historic properties.

Socio-Economic Resources

Data from the US Census Bureau reports an estimated 2001 population of 12,417 for Northumberland County. From 1990 to 2000, Northumberland County's population increased by 16.5 percent. The population is approximately 72 percent white (non-Hispanic), 27 percent black, with the remaining 1 percent reported as American Indian/Alaskan Native, Asian, Hispanic/Latino, multi-racial, or other. Historically, the local economy in the area of the proposed project has been dominated by fishing industries, including menhaden processing and agriculture.

Recreational Resources

Northumberland County is part of the Northern Neck Planning District, which also encompasses the counties of Lancaster, Richmond, and Westmoreland. There are numerous water-related and other recreational resources within this district. The Virginia Outdoor Survey (1996) indicates that the most popular outdoor activities are sailing, canoeing, and water-skiing, as well as walking, driving for pleasure, and bicycling. Many dock and marina facilities and industries are present, particularly along the shoreline of the Cockrell's Creek and other small tributaries to the Great Wicomico. A fishing pier was recently constructed off of Glebe Point, near the western end of the proposed project area.

Coastal Zone Resources and Permits

In accordance with the Coastal Zone Management (CZM) Act of 1972, as amended, and the approved Coastal Management Program of the Commonwealth of Virginia, the proposed project has been evaluated for consistency with coastal development policies. VDEQ serves as the lead agency for Virginia's networked CZM program. Circulation of this National Environmental Policy Act (NEPA) document and receipt of appropriate permits by the non-Federal sponsor will ensure compliance with the CZM Act. In addition, a consistency determination has been submitted to VDEQ concurrently with this final EA.

Permits will be acquired by VMRC for the reef sites via the Joint Permit Application (JPA) process. VMRC will acquire a USACE Norfolk District State Program Regional Permit, which covers construction of artificial oyster reefs, and a VMRC permit for encroaching on State bottom pursuant to Title 28.2 and 62.1 of the Code of Virginia. The requirement for a Virginia Water Protection permit pursuant to Section 401 of the Clean Water Act has been waived by the VDEQ due to the project's coverage under a Regional Permit. VMRC has indicated that permits are not required for the flatter shell plant areas (Jim Wesson, personal communication, 2000). Copies of permits will be included in the final document as an appendix.

Air Quality

Northumberland County, Virginia, is located within the Northeastern Virginia Intrastate Air Quality Control Region (9VAC5-20-200). Northumberland County is not included in any designated maintenance (9VAC5-20-203) or nonattainment area (9VAC5-20-204) for criteria air pollutants. Therefore, air quality in the project area is assumed to be in compliance with current USEPA criteria for ozone, sulfur dioxide, nitrogen oxides, carbon monoxide, airborne lead, and inhalable particulate matter.

Hazardous, Toxic, and Radioactive Waste

Preliminary research indicates that the proposed project is not located near any documented Superfund sites. Within Northumberland County, two hazardous waste generator permits have been issued. Both permit holders are located in Reedville along Cockrell Creek, which is located several miles downstream from the proposed project. Considering the historical and current usage of the proposed sites for shellfish harvesting, it is highly unlikely that reef construction would result in the further identification of any sites within the vicinity of the proposed project.

4.0 ENVIRONMENTAL CONSEQUENCES

Wetlands

No jurisdictional wetlands will be impacted by this project as all construction will occur on subaqueous lands.

Submerged Aquatic Vegetation

An indirect benefit of this project will be increased water clarity, which will positively contribute to the Chesapeake Bay-wide effort to re-establish SAV, decline of which is attributed to poor water quality and increased sedimentation. Oyster restoration may never be truly successful without SAV restoration, as it is likely that SAV beds historically protected oyster rocks from siltation, and the oyster helped keep the water clear, which maintained the SAV (Wesson, 1998). No SAV beds will be impacted by the construction of this project due to the depths at which the project will be constructed.

Water Quality

Due to their distance away from the proposed project, discharges from permitted outfalls are not anticipated to have an effect on oyster colonization and survival. Previous shellplanting activities undertaken by VMRC in these areas have not suffered due to discharges.

Minor, temporary increases in turbidity may be created by resuspension of bottom sediments during reef and shellplant construction. Increased turbidity has the potential to lower DO; however, due to the short duration of construction activities and the shallow depths of the proposed project area, these effects will be minor and short-lived.

The re-creation of historical conditions will improve water quality as well as ecological integrity. While estimates vary, a single oyster is reported as being able to filter up to 60 gallons of water a day. It is estimated that before their decline, the Chesapeake Bay's oyster population could filter an amount of water equal to the volume of the entire Chesapeake Bay in 3 to 6 days. Today's population would require a year or more to filter the same volume (Virginia Oyster Heritage Program, 1999). Although the exact figures for oysters filtering ability have been debated, there is no doubt that filtering the waters of the Chesapeake Bay today takes significantly longer than in the 1870's (VIMS, 1996).

Fauna of the Project Area

Potential adverse effects associated with reef and shellplant area construction and post-construction include direct encounters during placement of shell, substrate changes, and increased turbidity. The process of shell placement could adversely affect fish throughout the water column by direct encounters with falling shells during the placement process, as well as adversely affect benthic fauna by burial. Only those benthic organisms unable to avoid burial from the placement of shell will be impacted.

Approximately 128 acres of subaqueous habitat are proposed to be covered with layers of shell ranging from several inches to several feet thick. In areas where presently no or little shell exists, this action essentially will result in the conversion of a soft substrate habitat to a hard substrate habitat. However, as shell will be placed in areas of where historical oyster reefs were located, placement of shell in this manner would cause the river bottom to return to a more natural state, as was present prior to the recent anthropogenic influences of increased sedimentation and overharvesting. Moreover, studies of other substrate changes that occur during jetty and breakwater construction, indicate a net biological productivity gain due to the presence of hard substrate (Van Dolah et al., 1987; Manny et al., 1985). Similar to the effect of rock placement, the three-dimensional nature of the oyster reef and the layer of oyster cultch will provide species refuge from predators and/or foraging areas. Additionally, impacts to the existing living oysters will be minimized by area watermen, who will be contracted by VMRC to remove all live oysters prior to construction.

All areas proposed for reef and shellplant construction are public oyster grounds, as identified by Baylor Survey. While there will be a net total loss of approximately 128 acres of public ground converted to sanctuary reef, where harvesting will be prohibited, there will be positive effect on these grounds. Additionally, as broodstock oysters from the sanctuary reefs reproduce, all available substrate, public and private, will benefit.

The proposed project also involves a "genetic rehabilitation strategy," whereby native oysters that are genetically predisposed to increased diseased tolerance will be placed on the sanctuary reef structures. Therefore, in addition to increasing available oyster habitat, another hopeful outcome of this project is that enough progeny of these broodstock oysters will be produced so as to ultimately augment the disease-resistance of the native population in various parts of the Chesapeake Bay through future movement of spat-on-shell originating from the Great Wicomico. It is hoped that the genetic fitness developed in the selected strains of native oyster will intrograde with the remnant wild stocks to increase the fitness of the Chesapeake Bay stocks of the native oyster, *Crassostrea virginica.* No negative impacts are anticipated from the implementation of the genetic rehabilitation component of the project.

The overall impacts will be positive for the fauna of the lower Great Wicomico River and areas receiving the spat-on-shell originating from the Great Wicomico, such as the lower Rappahannock River, Tangier Sound, and other tributaries. The establishment of a healthy oyster community will in tum promote usage by higher trophic level organisms. A study of the ichthyofauna of living oyster reefs in the Piankatank River, a small Chesapeake Bay subestuary, indicate that high species richness is associated with these reefs (Harding and Mann, 1999). According to Harding and Mann, success of lower trophic levels enhances production at higher trophic levels, thereby enfusing the oyster reef with the resources to support a complex trophic network that has high potential for long-term productivity. The resulting increased productivity in the vicinity of oyster reefs may have ramifications for recreationally and commercially valuable finfish communities.

Essential Fish Habitat

The 1996 amendments to the Magnuson-Stevens Fishery Management and Conservation Act require Federal action agencies to consult with the NMFS regarding the potential effects of their actions on EFH, which is defined as those waters and substrates necessary to fish for spawning, breeding, feeding, or growing to maturity. Step 1 of the consultation process was accomplished by notifying NMFS that this EA was being prepared. Step 2 is the preparation of an EFH Assessment by the Federal agency proposing the action. The EFH assessment shall include: (1) a description of the proposed action; (2) an analysis of the effects of the action on EFH and associated species; (3) the Federal agency's views regarding the effects of the action on EFH; and (4) a discussion of proposed mitigation, if applicable. Step 3 of the consultation process is completed after NMFS reviews the draft EA for which NMFS provides EFH Conservation Recommendations during the established comment period. The fourth and final step in the consultation process is the Federal agency's response to the EFH Conservation Recommendations within 30 days. This response, in writing, must either describe the measures proposed by the agency to avoid, mitigate, or offset the impacts of the action on EFH pursuant to NFMS recommendations, or it must explain its reasons for not following NMFS recommendations. NFMS has concurred that there will be no significant impacts to EFH (in correspondence appendix).

(1) Description of proposed action: See Section 1 of this EA.

(2) Analysis of the effects of the action on EFH: Appendix A describes the 12 species and at which life stage EFH has been determined by NMFS in the vicinity of the project. A HAPC designation is present within the project area for the sandbar shark. HAPC are described in regulations as subsets of EFH that are rare, particularly susceptible to human-induced degradation, especially ecologically important, or located in an environmentally-stressed area. Potential adverse effects to EFH species result from the construction aspects of the proposed project, namely increased turbidity, direct encounters with shell as it is being placed, and impacts to prey items. Increased turbidity has the potential to lower DO. However, turbidity increases will be of short-duration, and DO levels, if affected at all, will return to pre-construction levels quickly. Although motile, the potential exists for fish to be impacted throughout the water column by direct encounters with shell as it is being placed. Adverse effects on prey items will occur if such organisms are buried during the construction of the reefs and production areas. Conversion of habitat may negatively impact some opportunistic prey items, although the primary effects of the oyster reefs will be positive, with benefits in increased productivity realized at higher trophic levels, such as the finfish community.

(3) Department of the Army's views regarding the effects of the action on EFH: Adverse effects on EFH species due to construction will be temporary and minimal. It is highly unlikely that any adverse effects will be caused by the construction of the sanctuary reefs and production areas due to the nektonic mobility of the EFH designated species. In fact, many studies documenting the effects of turbidity resulting from dredging operations, which are of a much longer duration, indicate that high levels of turbidity and suspended particulate matter at the time of breakwater construction and channel dredging had no lasting detrimental effects in biota near

project sites (Van Dolah et al., 1987; Manny et al., 1985). In addition, previous reef construction projects have not resulted in unacceptably high turbidity levels (Wesson, 2000).

(4) Discussion of proposed mitigation: Not applicable.

Threatened and Endangered Species and Species of Special Concern

Further coordination with VDGIF, Virginia Department of Conservation and Recreation (VDCR), and USFWS has occurred regarding avoidance of impacts to eagles, loggerhead turtles, and northeastern beach tiger beetles. No adverse effects on threatened and endangered species are foreseeable with project implementation. All activities will occur within the waters of the lower Great Wicomico, therefore, avoiding impacts to the northeastern beach tiger beetle and nesting eagles. While sea turtles may forage in the area of the proposed project, they are highly mobile and would be able to avoid impacts due to construction. As the benefits of the proposed project include benefits to higher trophic levels, such as fish, the implementation of the proposed project may increase population of prey items for eagles and sea turtles. Correspondence with the appropriate State agencies and USFWS has been included in the correspondence appendix.

Cultural Resources

No impacts to cultural resources are anticipated as a result of the implementation of this project. The proposed oyster restoration sites have been disturbed by fishing activities for well over a century. Correspondence from VDHR indicates that no further efforts within the Corps Area of Potential Effect are warranted. As requested by VDHR, if unidentified properties are discovered during project implementation, VDHR will be notified immediately.

Socio-Economic Resources

The proposed project will not have a significant effect on the socio-economic resources of the area. No changes are expected in the area's population distribution, community cohesion, or land use as a result of the construction of the reefs and harvest areas. Positive economic impacts may be expected for local watermen.

Recreational Resources

Recreation resources will not be adversely impacted by the proposed project. In fact, positive impacts to the area may be realized as recreational fishermen may find an increase in finfishes in the vicinity of the reefs. All water-related recreation will benefit from the increase in water quality resulting from the filtering ability of oysters. Aids to navigation are included in project design to warn boaters of the submerged reefs, if any of the reefs are close enough to the water surface to require them, and the aids will be furnished by VMRC.

Air Quality

Increased noise levels, barge traffic, and air pollution are to be expected in the project area; however, all of these effects would occur only during the actual period of construction, which is estimated to be approximately 2 weeks. Increases in air emissions would be associated with the tugboat for the barge and the hydraulic equipment on board to place the shells, and would include temporary increases in volatile organic compounds, nitrogen oxides, sulfur dioxide, and carbon monoxide. Since Northumberland County, Virginia, is in compliance with the National Ambient Air Quality Standards and is not located in a designated nonattainment or maintenance area, a formal Clean Air Act conformity determination for this proposed project is not required (9VACS-160-30). The emissions produced during construction are not expected to exceed ambient air quality standards.

Hazardous, Toxic, and Radioactive Waste

Construction of the sanctuary reefs and adjacent harvest areas would not be expected to result in the identification and/or disturbance of hazardous, toxic, and radioactive waste.

Cumulative Impacts

Cumulative impact assessment is the evaluation of the effects that other past, present, or reasonably foreseeable future actions, alternatives, or plans might have on the environment when considered in conjunction with the proposed impacts that could result from implemented the selected plan.

Cumulative impacts can be either additive or interactive. Additive impacts are impacts of a similar nature that can collectively have a profound effect on a given resource due to the collective magnitude of the effect. Interactive impacts are impacts that accrue as a result of assorted similar or dissimilar actions, alternatives, or plans that tend to have similar effects, relevant to the resource in question.

Past actions that have occurred in the project area include the dredging of navigation channels in the Great Wicomico River. Other actions undertaken by local citizens include construction of various boat piers and slips, along with development along the shoreline. These activities have had a negative impact on the natural ecosystem of the area. However, the proposed project is an ecosystem restoration project and will return significant areas of the Great Wicomico River bottom to its natural condition by restoring oyster reefs. Due to this, the proposed alternative would not result in any significant (measurable) cumulative impacts, either additive or interactive, to the local Great Wicomico River ecosystem.

Present and reasonably foreseeable future actions could include additional development in the Great Wicomico watershed, including conversion of farmland and natural areas into urban areas. This could also include construction of additional piers and boat launches. These activities, if they occur, could have negative impacts on the Great Wicomico River ecosystem. The proposed project is an ecosystem restoration project. If implemented, it would be highly unlikely to attract new development to the area, as it occurs in open waters of the Great Wicomico River, below mean low water and outside of any navigation channels.

This project is part of a larger project being implemented Chesapeake Bay-wide by the Commonwealth of Virginia, State of Maryland, Norfolk District USACE, and Baltimore District USACE, in order to meet the goals of the Year 2000 Chesapeake Bay Agreement. These goals include increasing the biomass of oysters IO-fold by the year 2010 (1994 baseline) and setting aside 10 percent of the historic public ground acreage to restore as sanctuaries. The entire endeavor involves the construction of sanctuary reefs throughout the Chesapeake Bay, involving rehabilitation of approximately 10,000 acres of currently degraded oyster habitat. The genetic rehabilitation strategy will involve further positive impacts to over 300 acres of restored oyster habitat throughout Virginia waters of the Chesapeake Bay in addition to the restored habitat within the Great Wicomico River. Therefore, this proposed project accounts for nearly a 5 percent of the Chesapeake 2000 goal. Impacts that would be of a cumulative nature include the conversion of soft to hard bottom habitat as well as the impact on resident benthic communities. While species composition of the benthic community may change, productivity of the area is anticipated to increase significantly. The three-dimensional nature of a layer of oyster cultch provides niches, or refuges, that may not otherwise be available.

No Action

Under a no-action scenario, no sanctuary reefs would be constructed, and no areas would be seeded. The project area will not naturally return to a productive state for oysters and will instead remain as degraded oyster habitat. Subsequently, benefits to water quality and ecosystem productivity will not be realized if a no-action plan were implemented.

5.0 ENVIRONMENTAL STATUES

Preliminary coordination with USFWS has yielded no formal consultation requirements pursuant to Section 7 of the Endangered Species Act. The proposed project is located in Northumberland County, Virginia. As these counties are not included in any designated nonattainment or maintenance areas for air pollutants, a conformity determination is not required (9VAC5-160-30), although air emissions have been considered.

A Section 404 (b) (1) Evaluation (Public Law 92-500, as amended) has been prepared for this project and appears following this assessment. The evaluation describes the impact to water quality as required by the Clean Water Act. VMRC submitted the permit application for this project through the JPA process. A Norfolk District Regional Permit was received, as well as a VMRC Permit to encroach on State-owned subaqueous bottoms. State Water Quality Certification under Section 401 of the Clean Water Act, as amended, has been waived by VDEQ.

The relationship of the proposed oyster restoration efforts in the lower Great Wicomico River to various environmental requirements and protection statutes is summarized in the following narrative.

COMPLIANCE WITH ENVIRONMENTAL
FEDERAL STATUTES AND EXECUTIVE ORDERS

1. Preservation of Historic and Archaeological Data Act of 1974, as amended, 16 U.S.C. 469 et seq.

Compliance: VDHR has been coordinated with concerning historic and/or archaeological resources in the project area. Continued coordination with VDHR, where required, signifies compliance.

2. Clean Air Act, as amended, 42 U.S.C. 7401 et seq.

Compliance: Submission of this EA to the Regional Administrator of USEPA for review pursuant to Sections 176 (c) and 309 of the Clean Air Act signifies compliance. As the proposed project is located in Northumberland County, Virginia, which currently is in attainment, a formal conformity determination is not required.

3. Clean Water Act of 1977 (Federal Water Pollution Control Act Amendments of 1972 and Water Quality Act of 1987) PL 100-4, 33 U.S.C. 1251 et seq.

Compliance: A Section 404(b)(l) Evaluation and Compliance Review has been incorporated into this report. Norfolk District USACE Regional Permits and VMRC permits will be acquired via the JPA process. The requirement for a Virginia Water Protection Permit pursuant to Section 401 of the Clean Water Act will be waived.

4. CZM Act of 1972, as amended, 16 U.S.C. 1431 et seq.

Compliance: Submission of this document to VDEQ, VMRC, and the State agencies that oversee CZM and the issuance of applicable permits and concurrence of no impact (consistency determination) signifies compliance. Additionally, a consistency determination was submitted to VDEQ concurrently with the circulation of the draft EA.

5. Endangered Species Act of 1973, as amended, 16 U.S.C. 1531 et

Compliance: Preliminary coordination with USFWS and NMFS has yielded no formal consultation requirements pursuant to Section 7 of the Endangered Species Act.

6. Estuarine Areas Act, 16 U.S.C. 1221 et seq.

Compliance: Coordination of this document with appropriate Federal and State resource agencies signifies compliance with this act.

7. Federal Water Project Recreation Act, as amended, 16 U.S.C. 4601-12 et seq.

Compliance: Coordination with the National Park Service (NPS) and VDCR, relative to the Federal and State comprehensive outdoor recreation plans, signifies compliance with this act.

8. Fish and Wildlife Coordination Act, as amended, 16 U.S.C. 661 et seq.

Compliance: Coordination with USFWS, NMFS, and VDGIF signifies compliance with this act.

9. Land and Water Conservation Fund Act of 1965, as amended, 16 U.S.C. 4601-4 et seq.

Compliance: Submission of this report to the NPS and VDCR relative to the Federal and State comprehensive outdoor recreation plans signifies compliance with this act.

10. Marine Protection, Research, and Sanctuaries Act of 1972, as amended 33 U.S.C. 1401 et seq.

Compliance: Not applicable; project does not involve the transportation or placement of dredged material in ocean waters pursuant to Sections 102 and 103 of the Act, respectively.

11. National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470 et seq.

Compliance: Coordination with the VDHR and agency concurrence with the findings of this EA signifies no impact.

12. NEPA of 1969, as amended, 42 U.S.C. 432 et seq.

Compliance: Preparation of this EA and public coordination and comment signifies partial compliance with NEPA. Full compliance is noted with the signing and issuing of the Finding of No Significant Impact (FONSI).

13. Rivers and Harbors Appropriation Act of 1899, as amended, 33 U.S.C. 401 et seq.

Compliance: Exempt.

14. Watershed Protection and Flood Prevention Act, as amended, 16 U.S.C. 1001 et seq.

Compliance: No requirements for USACE activities.

15. Wild and Scenic Rivers Act, as amended, 16 U.S.C. 1271 et seq.

Compliance: Project has been evaluated in reference to this act. The proposed project would not adversely impact any component of the Virginia Scenic Rivers System. Coordination with NPS and VDCR, relative to the Virginia Scenic Rivers System signifies compliance with this act.

16. Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 42 USC 9601-9675.

Compliance: Project has been evaluated in reference to this act. No hazardous substances on subaqueous lands necessary for project construction, operation, and maintenance have been currently identified. Project is in compliance with this act following State and Federal agency concurrence with the findings of this EA.

Executive Orders

1. Executive Order 11988, Floodplain Management, 24 May 1977, as amended by Executive Order 12148, 20 July 1979.

Compliance: The proposed project would not stimulate development in the floodplain. Circulation of this report for public review fulfills the requirements of Executive Order 11988, Section 2(a)(2).

2. Executive Order 11990, Protection of Wetlands, 24 May 1977.

Compliance: Impacts to wetlands have been avoided. Circulation of this report for public review fulfills the requirements of Executive Order 11990, Section 2(b).

3. Executive Order 12114, Environmental Effects Abroad of Major Federal Actions, 4 January 1979.

Compliance: Not applicable; project is located within the US.

4. Executive Order 12898, Environmental Justice in Minority Populations and Low-Income Populations, 11 February 1994.

Compliance: No impacts are expected to occur to any minority or low-income communities in the project area. The draft EA was made available for comment to all individuals who have an interest in, or may be affected by, the proposed project.

Executive Memorandum

1. Analysis of Impacts of Prime or Unique Agricultural Lands in Implementing NEPA, 11 August 1980.

Compliance: Not applicable; project does not involve or impact agricultural lands.

The following table summarizes effects of the proposed project on environmental resources having National, State, and local significance:

SIGNIFICANT ENVIRONMENTAL QUALITY EFFECTS

Significant resources	Effects on Environmental Quality attributes
Vegetated Wetlands	No impact.
Water Quality	Temporary turbidity increases would not be in violation of Section 401 of the Clean Water Act.
Benthic Habitat	Permanent loss of infauna} benthos in footprint of reef areas; rapid colonization of reef and shellplant areas anticipated due to seeding.
Oyster & Clamming Grounds	No loss of leased oyster grounds. Approximately 128 acres of Baylor grounds will be converted to sanctuary grounds.
Cultural	No historic or archaeological sites affected; no disturbance.

6.0 CONCLUSIONS

The conclusions of this assessment are based on an evaluation of the effects that the proposed action would have on the human environment, as well as study area ecosystems including the land, air, and water systems of the lower Great Wicomico River.

A permanent substrate change from sandy bottom to oyster shell will occur in the vicinity of the sanctuary reefs and adjacent shell plant areas; however, this conversion is actually a restoration of historical conditions. While the existing resident benthic infauna} community may be adversely affected, overall productivity is expected to increase. Water quality benefits of reefs due to the filtering capabilities of oysters will be realized as well. Therefore, although adverse short-term impacts will occur to some organisms associated with sandy substrate due to burial by shell, long-term benefits associated with restoring degraded habitat will compensate for such impact. The conclusion of this assessment finds that the proposed action would not have a significant adverse effect on the environment and, therefore, does not require an Environmental Impact Statement.

7.0 COORDINATION

The draft EA was circulated for a 30-day review and comment period with (at least) the following State and Federal agencies and local interests. Their comments and USACE responses appear in Appendix C of the final report.

NMFS
NPS
USEPA
USFWS
VDCR
VDCR, Division of Soil and Water Conservation
VDEQ, Office of Environmental Impact Review
VDEQ, Water Division
VDGIF
Virginia Department of Health
VDHR
Virginia Department of Transportation
V™S
VMRC
Northern Neck Planning District Commission

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9.0 TABLES

Table 1. LIST OF BENTIDC SPECIES COLLECTED IN LOWER RAPPAHANNOCK RIVER

Polychaeta			
Ancistrosyllis jonesi	*Eteone hereteropa*	*Glycinde solitaria*	
Gyptis brevipalpa	*Harmothoe extenuata*	*Heteromastus filiformis*	
Hobsonia florida	*Leoimia medusa*	*Leitoscoloplos spp.*	
Mediomastus ambiseta	*Nereis succinea*	*Paraprionospio pinnata*	
Pectinaria gouldii	*Polydora ligni*	*Pseudeurythoe ambigua*	
Sabella microphthalma	*Scolecolepides viridis*	*Sigambra tentaculata*	
Streblospio benedicti			
Oligochaeta			
Tubificoides spp Group I			
Bivalvia			
Bivalvia spp.	*Ensis directus*	*Lyonsia hyalina*	
Macoma balthica	*M. mitchelli*	*Mulinia lateralis*	*Tellina agilis*
Gastropoda			
Acteocina canaliculata	*Nassarius vibex*	*Odostomia spp.*	
Rictaxis punctostriatus			
Amphipoda			
Ampelisca abdita	*Gammarus mucronatus*	*Leptocheirus plumulosus*	
Other Anthropoda			
Chironumus spp.	*Edotea triloba*	*Leucon americana*	
Neomysis americana	*Ogyrides alphaerostris*	*Oxyurostylis smithi*	
Other Phyla			
Hemichordata spp.	*Phoronis psammophila*		

Source: Smith, 1994

Molgula lutlulenta

Turbellaria spp.

Nemertea spp.

Table 2. FISH OCCURRING OR POTENTIALLY OCCURRING WITHIN 2 MILES OF THE GREAT WICOMICO RIVER NEAR SANDY POINT

COMMON NAME	SCIENTIFIC NAME
Alewife	*Alosa pseudoharengus*
Bass, largemouth	*Micropterus salmoides*
Bluegill	*Lepomis macrochirus*
Bullhead, yellow	*Ameiurus natalis*
Chubsucker, creek	*Erimyzon oblongus*
Croaker, Atlantic	*Micropogonias undulatus*
Dace, rosyside	*C/inostomus funduloides*
Eel, American	*Anguilla rostrata*
Fallfish	*Semotilus corpora/is*
Lamprey, sea	*Petromyzon marinus*
Madtom, margined	*Noturus insignis*
Minnow, eastern silvery	*Hybognathus regius*
Mosquitofish, eastern	*Gambusia holbrooki*
Mudminnow, eastern	*Umbra pygmaea*
Perch, pirate	*Aphredoderus sayanus sayanus*
Pickerel, chain	*Esox niger*
Pumpkinseed	*Lepomis gibbosus*
Shiner, golden	*Notemigonus crysoleucas*
Spot	*Leiostomus xanthurus*
Sturgeon, Atlantic	*Acipenser oxyrhynchus*
Sunfish, bluespotted	*Enneacanthus gloriosus*

Source: Virginia VDGIF Online Database (latitude 37°49'27" and longitude 76°18' 04"), VDGIF, 2002.

Table 3. AVIAN RESOURCES OCCURRING OR POTENTIALLY OCCURRING WITHIN 2 MILES OF THE GREAT WICOMICO RIVER NEAR SANDY POINT

COMMON NAME	SCIENTIFIC NAME
Bittern, least	*lxobrychus exilis exilis*
Blackbird, red-winged	*Agelaius phoeniceus*
Bluebird, eastern	*Sialia sialis*
Bobwhite, northern	*Colinus virginianus*
Brant	*Branta bernicla brota*
Bufflehead	*Bucephala albeola*
Bunting, indigo	*Passerina cyanea*
Bunting, snow	*Plectrophenax nivalis nivalis*
Canvasback	*Aythya valisineria*
Cardinal, northern	*Cardinalis cardinalis*
Catbird, gray	*Dumetella carolinensis*
Chat, yellow-breasted	*lcteria virens virens*
Chickadee, Carolina	*Poecile carolinensis*
Chuck-will's-widow	*Caprimulgus carolinensis*
Coot, American	*Fulica americana*
Cormorant, double-crested	*Phalacrocorax auritus*
Cormorant, great	*Phalacrocorax carbo*
Cowbird, brown-headed	*Molothrus ater*
Creeper, brown	*Certhia americana*
Crossbill, white-winged	*Loxia /eucoptera*
Crow, American	*Corvus brachyrhynchos*
Crow, fish	*Corvus ossifragus*
Cuckoo, black-billed	*Coccyzus erythropthalmus*
Cuckoo, yellow-billed	*Coccyzus americanus*
Dickcissel	*Spiza americana*
Dove, mourning	*Zenaida macroura caro/inensis*
Dove, rock	*Columba livia*
Dowitcher, short-billed	*Umnodromus griseus*
Duck, American black	*Anas rubripes*
Duck, ruddy	*Oxyura jamaicensis*
Duck, wood	*Aix sponsa*
Eagle, bald	*Ha/iaeetus leucocephalus*
Egret, cattle	*Bubulcus ibis*
Egret, great	*Ardea alba egretta*
Egret, snowy	*Egretta thula*
Eider, king	*Somateria spectabilis*
Finch, house	*Carpodacus mexicanus*
Finch, purple	*Carpodacus purpureus*
Flicker, northern	*Colaptes auratus*
Flycatcher, Acadian	*Empidonax virescens*
Flycatcher, great crested	*Myiarchus crinitus*
Gadwall	*Anas strepera*
Gnatcatcher, blue-gray	*Polioptila caerulea*
Goldeneye, common	*Bucepha/a clangula americana*

Table 3. AVIAN RESOURCES OCCURRING OR POTENTIALLY OCCURRING WITHIN 2 MILES OF THE GREAT WICOMICO RIVER NEAR SANDY POINT (Cont'd)

Goldfinch, American	*Carduelis tristis*
Goose, Canada	*Branta Canadensis*
Goose, lesser snow	*Chen caerulescens caerulescens*
Goose, snow	*Chen caerulescens atlanticus*
Grackle, boat-tailed	*Quiscalus major*
Grackle, common	*Quisca/us quiscula*
Grebe, horned	*Podiceps auritus*
Grebe, pied-billed	*Podilymbus podiceps*
Grebe, red-necked	*Podiceps grisegena*
Grosbeak, blue	*Guiraca caerulea caeru/ea*
Grosbeak, evening	*Coccothraustes vespertinus*
Gull, great black-backed	*Larus marinus*
Gull, herring	*Larus argentatus*
Gull, laughing	*Larus atricilla*
Gull, ring-billed	*Larus delawarensis*
Harrier, northern	*Circus cyaneus*
Hawk, Cooper's	*Accipiter cooperii*
Hawk, broad-winged	*Buteo platypterus*
Hawk, red-shouldered	*Buteo lineatus lineatus*
Hawk, red-tailed	*Buteo jamaicensis*
Hawk, rough-legged	*Buteo lagopus johannis*
Hawk, sharp-shinned	*Accipiter striatus velox*
Heron, great blue	*Ardea herodias herodias*
Heron, green	*Butorides virescens*
Heron, little blue	*Egretta caerulea caerulea*
Heron, tri-colored	*Egretta tricolor*
Hummingbird, ruby-throated	*Archilochus colubris*
Jay, blue	*Cyanocitta cristata*
Junco, dark-eyed	*Junco hyemalis*
Kestrel, American	*Falco sparverius sparverius*
Killdeer	*Charadrius vociferus*
Kingbird, eastern	*Tyrannus tyrannus*
Kingfisher, belted	*Cery/e a/cyan*
Kinglet, golden-crowned	*Regulus satrapa*
Kinglet, ruby-crowned	*Regulus ca/endula*
Lark, horned	*Eremophila alpestris*
Loon, common	*Gavia immer*
Loon, red-throated	*Gavia stel/ata*
Mallard	*Anas platyrhynchos*
Martin, purple	*Progne subis*
Meadowlark, eastern	*Sturnel/a magna*
Merganser, common	*Mergus merganser americanus*
Merganser, hooded	*Lophodytes cucullatus*
Merganser, red-breasted	*Mergus serrator serrator*
Mockingbird, northern	*Mimus polyglottos*

Table 3. AVIAN RESOURCES OCCURRING OR POTENTIALLY OCCURRING WITHIN 2 MILES OF THE GREAT WICOMICO RIVER NEAR SANDY POINT (Cont'd)

Moorhen	*Gallinula chloropus cachinnans*
Night-heron, black-crowned	*Nycticorax nycticorax hoactii*
Night-heron, yellow-crowned	*Nyctanassa vio/acea violacea*
Nighthawk, common	*Chordeiles minor*
Nuthatch, brown-headed	*Sitta pusilla*
Nuthatch, red-breasted	*Sitta Canadensis*
Nuthatch, white-breasted	*Sitta carolinensis*
Oldsquaw	*Clangu/a hyemalis*
Oriole, Baltimore	*Icterus ga/bu/a*
Oriole, orchard	*Icterus spurious*
Osprey	*Pandion ha/iaetus carolinensis*
Ovenbird	*Seiurus aurocapi/lus*
Owl, barn	*Tyto alba pratinco/a*
Owl, barred	*Strix varia*
Owl, great horned	*Bubo virginianus*
Owl, short-eared	*Asio flammeus*
Oystercatcher, American	*Haematopus palliatus*
Parula, northern	*Parula Americana*
Pelican, brown	*Pelecanus occidentalis carolinensis*
Pewee, eastern wood	*Contopus virens*
Pheasant, ring-necked	*Phasianus co/chicus*
Phoebe, eastern	*Sayornis phoebe*
Pintail, northern	*Anas acuta acuta*
Pipit, American	*Anthus rubescens*
Rail, black	*Lateral/us jamaicensis*
Rail, clapper	*Ral/us /ongirostris crepitans*
Rail, king	*Ral/us elegans*
Redhead	*Aythya Americana*
Redstart, American	*Setophaga ruticilla*
Robin, American	*Turdus migratorius*
Sandpiper, least	*Calidris minutilla*
Sandpiper, spotted	*Actitis macu/aria*
Sandpiper, upland	*Bartramia longicauda*
Sapsucker, yellow-bellied	*Sphyrapicus varius*
Scaup, greater	*Aythya marila*
Scaup, lesser	*Aythya affinis*
Seater, black	*Melanitta nigra Americana*
Seater, surf	*Melanitta perspicillata*
Seater, white-winged	*Melanitta fusca deg/andi*
Screech-owl, eastern	*Otus asio*
Shoveler, northern	*Anas clypeata*
Siskin, pine	*Cardue/is pinus*
Snipe, common	*Gal/inago gal/inago*
Sparrow, Nelson's sharp-tailed	*Ammodramus nelsoni*
Sparrow, chipping	*Spizella passerina*
Sparrow, field	*Spizella pusilla*

Table 3. AVIAN RESOURCES OCCURRING OR POTENTIALLY OCCURRING WITHIN 2 MILES OF THE GREAT WICOMICO RIVER NEAR SANDY POINT
(Cont'd)

Sparrow, fox	*Passerella iliaca*
Sparrow, grasshopper	*Ammodramus savannarum pratensis*
Sparrow, house	*Passer domesticus*
Sparrow, saltmarsh sharp-tailed	*Ammodramus caudacutus*
Sparrow, savannah	*Passercu/us sandwichensis*
Sparrow, seaside	*Ammodramus maritimus*
Sparrow, song	*Me/ospiza melodia*
Sparrow, swamp	*Me/ospiza Georgiana*
Sparrow, vesper	*Pooecetes gramineus*
Sparrow, white-throated	*Zonotrichia albicollis*
Starling, European	*Sturnus vu/garis*
Swallow, bank	*Riparia riparia*
Swallow, barn	*Hirundo rustica*
Swallow, northern rough-winged	*Stelgidopteryx serripennis*
Swan, tundra	*Cygnus columbianus co/umbianus*
Swift, chimney	*Chaetura pe/agica*
Tanager, scarlet	*Piranga o/ivacea*
Tanager, summer	*Piranga rubra*
Teal, blue-winged	*Anas discors orpha*
Teal, green-winged	*Anas crecca caro/inensis*
Tern, Caspian	*Sterna caspia*
Tern, common	*Sterna hirundo*
Tern, Forster's	*Sterna forsteri*
Tern, least	*Sterna antillarum*
Tern, royal	*Sterna maxima maximus*
Thrasher, brown	*Toxostoma rufum*
Thrush, hermit	*Catharus guttatus*
Thrush, wood	*Hylocich/a mustelina*
Titmouse, tufted	*Baeo/ophus bicolor*
Towhee, eastern	*Pipilo erythrophtha/mus*
Turkey, wild	*Meleagris gal/opavo si/vestris*
Vireo, red-eyed	*Vireo olivaceus*
Vireo, white-eyed	*Vireo griseus*
Vireo, yellow-throated	*Vireo f/avifrons*
Vulture, black	*Coragyps atratus*
Vulture, turkey	*Cathartes aura*
Warbler, Canada	*Wilsonia canadensis*
Warbler, cerulean	*Dendroica ceru/ea*
Warbler, Kentucky	*Oporornis formosus*
Warbler, Nashville	*Vermivora ruficapilla*
Warbler, black-and-white	*Mniotilta varia*
Warbler, black-throated blue	*Dendroica caeru/escens*
Warbler, black-throated green	*Dendroica virens*
Warbler, blackpoll	*Dendroica striata*
Warbler, blue-winged	*Vermivora pinus*
Warbler, chesnut-sided	*Dendroica pensylvanica*

Table 3. AVIAN RESOURCES OCCURRING OR POTENTIALLY OCCURRING WITHIN 2 MILES OF THE GREAT WICOMICO RIVER NEAR SANDY POINT
(Cont'd)

Warbler, hooded	*Wilsonia citrina*
Warbler, magnolia	*Dendroica magnolia*
Warbler, palm	*Dendroica palmarum*
Warbler, pine	*Dendroica pinus*
Warbler, prairie	*Dendroica discolor*
Warbler, prothonotary	*Protonotaria citrea*
Warbler, worm eating	*Helmitheros vermivorus*
Warbler, yellow-rumped	*Dendroica coronata cornata*
Warbler, yellow-throated	*Dendroica dominica*
Warbler, yellow	*Dendroica petechia*
Waterthrush, Louisiana	*Seiurus motacilla*
Waterthrush, northern	*Seiurus noveboracensis*
Waxwing, cedar	*Bombycilla cedrorum*
Whip-poor-will	*Caprimulgus vociferous*
Wigeon, American	*Anas Americana*
Wigeon, Eurasian	*Anas Penelope*
Willet	*Catoptrophorus semipalmatus semipalmatus*
Woodcock, American	*Scolopax minor*
Woodpecker, downy	*Picoides pubescens medianus*
Woodpecker, hairy	*Picoides villosus*
Woodpecker, pileated	*Dryocopus pileatus*
Woodpecker, red-bellied	*Melanerpes carolinus*
Woodpecker, red-headed	*Melanerpes erythrocephalus*
Wren, Carolina	*Thryothorus ludovicianus*
Wren, house	*Troglodytes aedon*
Wren, marsh	*Cistothorus palustris*
Wren, sedge	*Cistothorus platensis*
Yellowthroat, common	*Geothlypis trichas brachidactylus*

Source: VDGIF Online Database Source: VDGIF Online Database Database (latitude 37°49'27" and longitude 76°18' 04"), VDGIF, 2002.

Table 4. MAMMALS OCCURRING OR POTENTIALLY OCCURRING WITHIN 2 MILES OF THE GREAT WICOMICO RIVER NEAR SANDY POINT

COMMON NAME	SCIENTIFIC NAME
Bat, big brown	*Eptesicus fuscus tuscus*
Bat, eastern red	*Lasiurus borealis borealis*
Bat, evening	*Nycticeius humeralis humeralis*
Bat, hoary	*Lasiurus cinereus cinereus*
Bat, little brown	*Myotis lucifugus lucifugus*
Bat, silver-haired	*Lasionycteris noctivagans*
Beaver	*Castor Canadensis*
Bobcat	*Lynx rufus rufus*
Chipmunk, Fisher's eastern	*Tamias striatus fisheri*
Cottontail, eastern	*Sylvilagus floridanus mallurus*
Deer, white-tailed	*Odocoi/eus virginianus*
Fox, eastern gray	*Urocyon cinereoargenteus cinereoargenteus*
Fox, red	*Vu/pes vu/pes fulva*
Mink, common	*Mustela vison mink*
Mole, eastern	*Sea/opus aquaticus aquaticus*
Mole, star-nosed	*Condylura cristata cristata*
Mouse, common white-footed	*Peromyscus /eucopus /eucopus*
Mouse, eastern harvest	*Reithrodontomys humulis virginianus*
Mouse, house	*Mus muscu/us muscu/us*
Mouse, meadow jumping	*Zapus hudsonius americanus*
Muskrat, large-toothed	*Ondatra zibethicus macrodon*
Myotis, northern long-eared	*Myotis septentrionalis septentrionalis*
Opossum, Virginia	*Didelphis virginiana virginiana*
Pipistrelle, eastern	*Pipistrellus subflavus subflavus*
Raccoon	*Procyon lotor lotor*
Rat, Norway	*Rattus norvegicus norvegicus*
Rat, marsh rice	*Oryzomys pa/ustris pa/ustris*
Shrew, least	*Cryptotis parva parva*
Shrew, pygmy	*Sorex hoyi winnemana*
Shrew, southeastern	*Sorex /ongirostris longirostris*
Shrew, southern short-tailed	*Blarina carolinensis caro/inensis*
Skunk, striped	*Mephitis mephitis nigra*
Skunk, striped	*Mephitis mephitis*
Squirrel, northern gray	*Sciurus carolinensis pennsylvanicus*
Squirrel, southern flying	*Glaucomys vo/ans vo/ans*
Vole, dark meadow	*Microtus pennsy/vanicus nigrans*
Vole, pine	*Microtus pinetorum sca/apsoides*
Weasel, long-tailed	*Mustela frenata noveboracensis*
Woodchuck	*Marmota monax monax*

Source: VDGIF Online Database Database (latitude 37°49'27" and longitude 76°18' 04"), VDGIF, 2002.

Table 5. REPTILES AND AMPHIBIANS OCCURRING OR POTENTIALLY OCCURRING WITHIN 2 MILES OF THE GREAT WICOMICO RIVER NEAR SANDY POINT

COMMON NAME	SCIENTIFIC **NAME**
Bullfrog	*Rana catesbeiana*
Frog, Brimley's chorus	*Pseudacris brim/eyi*
Frog, eastern cricket	*Acris crepitans crepitans*
Frog, northern green	*Rana clamitans melanota*
Frog, pickerel	*Rana pa/ustris*
Frog, southeastern chorus	*Pseudacris feriarum*
Frog, southern leopard	*Rana sphenocephala utricularius*
Frog, wood	*Rana sylvatica*
Newt, red-spotted	*Notophthalmus viridescens viridescens*
Peeper, northern spring	*Pseudacris crucifer crucifer*
Salamander, eastern mud	*Pseudotriton montanus montanus*
Salamander, four-toed	*Hemidactylium scutatum*
Salamander, marbled	*Ambystoma opacum*
Salamander, northern dusky	*Desmognathus fuscus*
Salamander, northern red-backed	*Plethodon cinereus*
Salamander, northern red	*Pseudotriton ruber ruber*
Salamander, southern two-lined	*Eurycea cirrigera*
Salamander, spotted	*Ambystoma maculatum*
Salamander, three-lined	*Eurycea guttolineata*
Salamander, white-spotted slimy	*Plethodon cylindraceus*
Siren, greater	*Siren lacertina*
Toad, American	*Bufo americanus*
Toad, Fowler's	*Bufo fowleri*
Toad, eastern narrow-mouthed	*Gastrophryne carolinensis*
Treefrog, Cape's gray	*Hy/a chrysoscelis*
Treefrog, green	*Hy/a cinerea*
Cooter, northern red-bellied	*Pseudemys rubriventris rubriventris*
Copperhead, northern	*Agkistrodon contortrix mokason*
Kingsnake, eastern	*Lampropeltis getula getula*
Kingsnake, mole	*Lampropeltis calligaster rhombomaculata*
Lizard, northern fence	*Sce/oporus undu/atus hyacinthinus*
Racer, northern black	*Coluber constrictor constrictor*
Racerunner, six-lined	*Cnemidophorus sexlineatus sexlineatus*
Skink, broadhead	*Eumeces laticeps*
Skink, five-lined	*Eumeces fasciatus*
Skink, little brown	*Scincel/a lateralis*
Skink, southeastern five-lined	*Eumeces inexpectatus*
Snake, black rat	*Elaphe obsoleta obsoleta*
Snake, corn	*Elaphe guttata*
Snake, eastern garter	*Thamnophis sirtalis sirtalis*
Snake, eastern hognose	*Heterodon platirhinos*
Snake, eastern milk	*Lampropeltis triangulum triangulum*
Snake, eastern ribbon	*Thamnophis sauritus sauritus*

Table 5. REPTILES AND AMPHIBIANS OCCURRING OR POTENTIALLY OCCURRING WITHIN 2 MILES OF THE GREAT WICOMICO RIVER NEAR SANDY POINT (Cont'd)

Snake, eastern smooth earth	*Virginia valeriae valeriae*
Snake, eastern worm	*Carphophis amoenus amoenus*
Snake, northern brown	*Storeria dekayi dekayi*
Snake, northern red-bellied	*Storeria occipitomaculata occipitomaculata*
Snake,northernringneck	*Diadophis punctatus edwardsii*
Snake, northern scarlet	*Cemophora coccinea copei*
Snake, northern water	*Nerodia sipedon sipedon*
Snake, rainbow	*Farancia erytrogramma erytrogramma*
Snake, rough green	*Opheodrys aestivus*
Turtle, common snapping	*Chelydra serpentina serpentina*
Turtle, eastern box	*Terrapene carolina carolina*
Turtle, eastern mud	*Kinosternon subrubrum subrubrum*
Turtle, eastern musk (= stinkpot)	*Sternotherus odoratus*
Turtle, eastern painted	*Chrysemys picta picta*
Turtle, spotted	*Clemmys guttata*
Turtle, Kemp's Ridly sea	*Lepidochelys kempii*
Turtle, green sea	*Che/onia mydas*
Turtle, loggerhead sea	*Caretta caretta*

Source: VDGIF Online Database Database (latitude 37°49'27" and longitude 76°18' 04"), VDGIF, 2002.

Table 6. THREATENED AND ENDANGERED SPECIES AND SPECIES OF SPECIAL CONCERN OCCURRING OR POTENTIALLY OCCURRING WITHIN 2 MILES OF THE GREAT WICOMICO RIVER NEAR SANDY POINT

STATUS	CONFIRMED	COMMON NAME	SCIENTIFIC NAME
FE/SE	No	Turtle, Kemp's Ridley sea	*Lepidochelys kempii*
FT/ST	No	Turtle, Atlantic green sea	*Chelonia mydas*
FT/ST	Yes	Turtle, loqqerhead sea	*Caretta caretta caretta*
FT/ST	Yes	Eagle, bald	*Haliaeetus leucocephalus leucocephalus*
FT/ST	Yes	Beetle, northeastern beach tiger	*Cicindela dorsa/is dorsa/is*
FS/SS	No	Terrapin, northern diamondback	*Malaclemys terrapin terrapin*
FS/SS	No	Rail, black	*Lateral/us jamaicensis*
FS/SS	No	Warbler, cerulean	*Dendroica cerulea*
FS/SS	No	Sturgeon, Atlantic	*Acipenser oxyrhynchus*
ST	No	Sandpiper, upland	*Bartramia longicauda*
SS	No	Creeper, brown	*Certhia americana*
SS	No	Dickcissel	*Spiza americana*
SS	Yes	Egret, great	*Ardea alba egretta*
SS	No	Finch, purple	*Carpodacus purpureus*
SS	No	Harrier, northern	*Circus cyaneus*
SS	No	Heron, little blue	*Egretta caerulea caerulea*
SS	No	Heron, tricolored	*Egretta tricolor*
SS	No	Kinglet, golden-crowned	*Regulus satrapa*
SS	No	Moorhen, common	*Gal/inula chloropus cachinnans*
SS	No	Night-heron, yellow-crowned	*Nyctanassa violacea violacea*
SS	No	Nuthatch, red-breasted	*Sitta canadensis*
SS	No	Owl, barn	*Tyto alba pratincola*
SS	No	Pelican, brown	*Pelecanus occidenta/is caro/inensis*
SS	No	Sparrow, saltmarsh sharp-tailed	*Ammodramus caudacutus diversus*
SS	No	Tern, Caspian	*Sterna caspia*
SS	Yes	Tern, Forster's	*Sterna forsteri*
SS	Yes	Tern, least	*Sterna antillarum*
SS	No	Thrush, hermit	*Catharus guttatus*
SS	No	Warbler, magnolia	*Dendroica magnolia*
SS	No	Wren, sedge	*Cistothorus platensis*
SS	No	Wren, winter	*Troglodytes troglodytes*
SS	No	Otter, river	*Lontra canadensis lataxina*
DEP*	Yes	Dolphin, bottlenose	*Tursiops truncates*

Key: FE= Federally-Endangered , FT= Federally-Threatened, FS = Federal Species of Concern

SE= State-Endangered, ST= State-Threatened, SS = State Species of Concern, DEP = Depleted status under the Marine Mammal Protection Act (*status is not listed by VDGIF).

Source: VDGIF Online Database Database (latitude 37°49'27" and longitude 76°18' 04"), VDGIF, 2002.

10.0 FIGURES

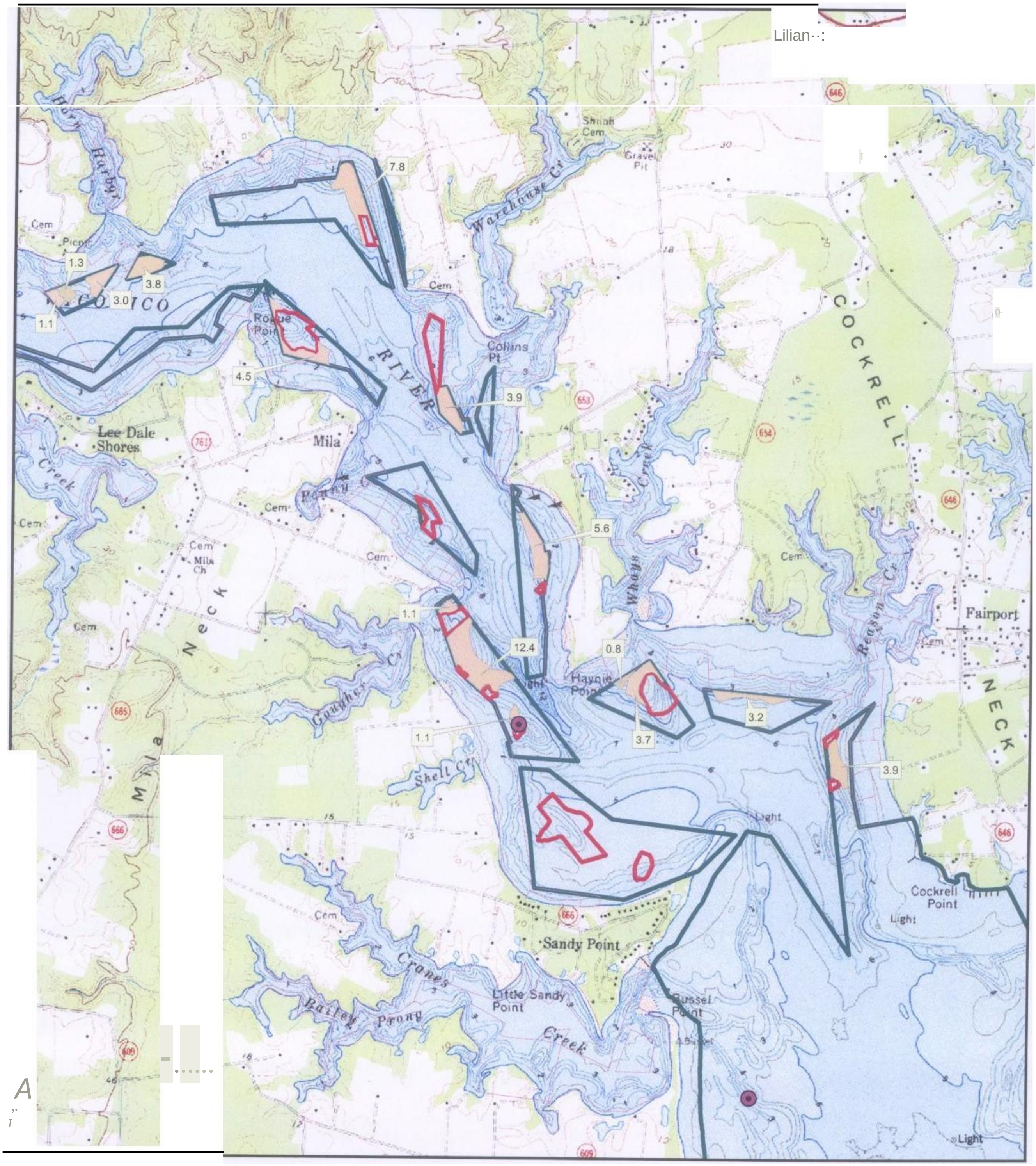


Figure 1. The Proposed Construction Sites in the Great Wicomico River.

The total area of potential restoration sites is 104 acres.

Legend

Potential Restoration Areas

Oyster Rock (VIMS)

Shell & Mud

Shell & Sand

Oyster Reefs

Private Leases

Baylor Grounds

Oyster Restoration

Great Wicomico River

N W E

300 0 300 600 Meters

Oyster Restoration

Piankatank River

700 350 0 700 1 ·1 eters

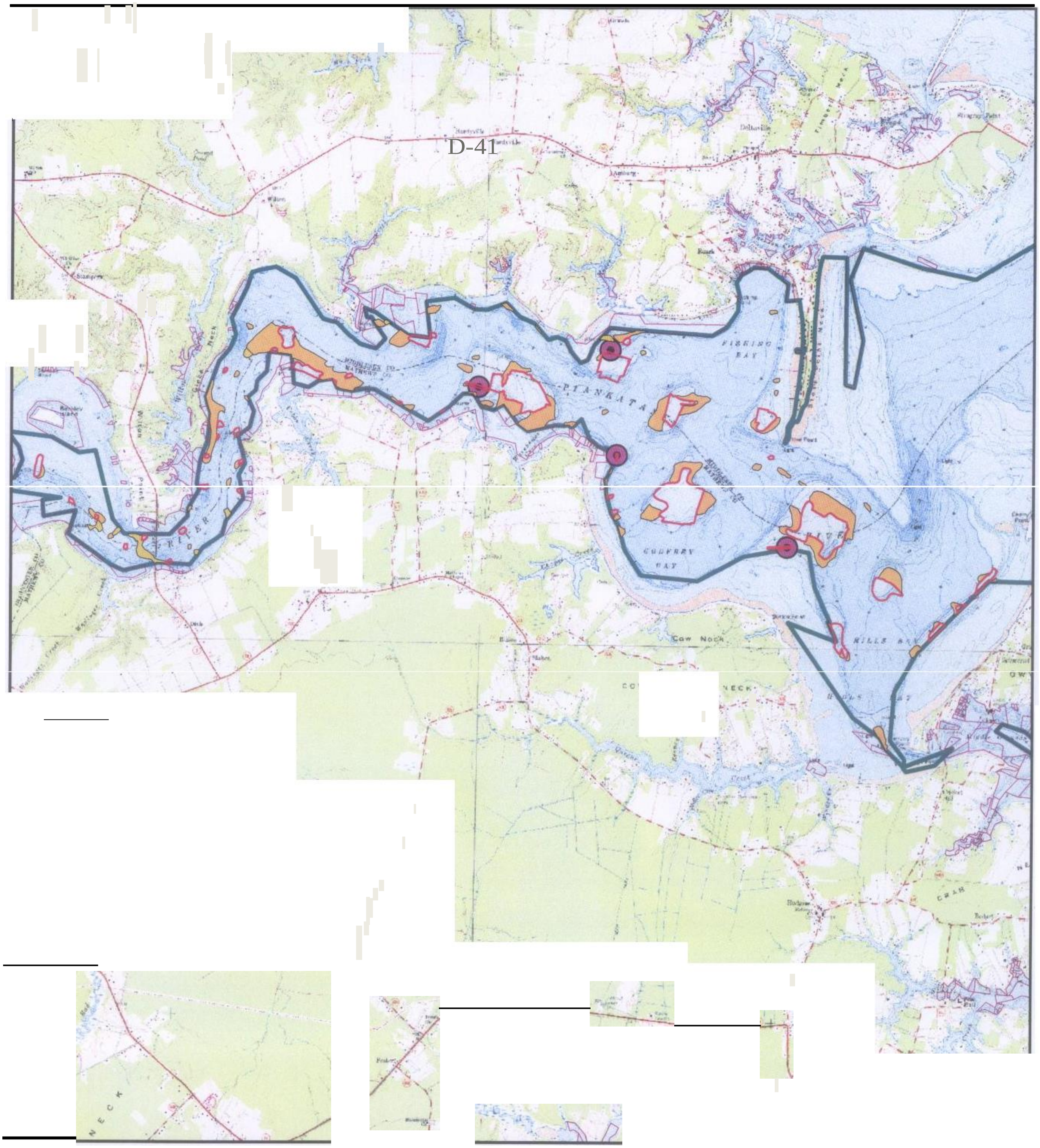


Figure 2. The Piankatank River.

The total area of potential restoration sites is 672 acres.

Legend

Potential Restoration Areas

- Oyster Rock (VIMS)
- Oyster Reefs
- Shell & Mud
- Private Leases
- Baylor Grounds

Figure 3. STOCKING SITES IN THE TANGIER AND POCOMOKE SOUNDS

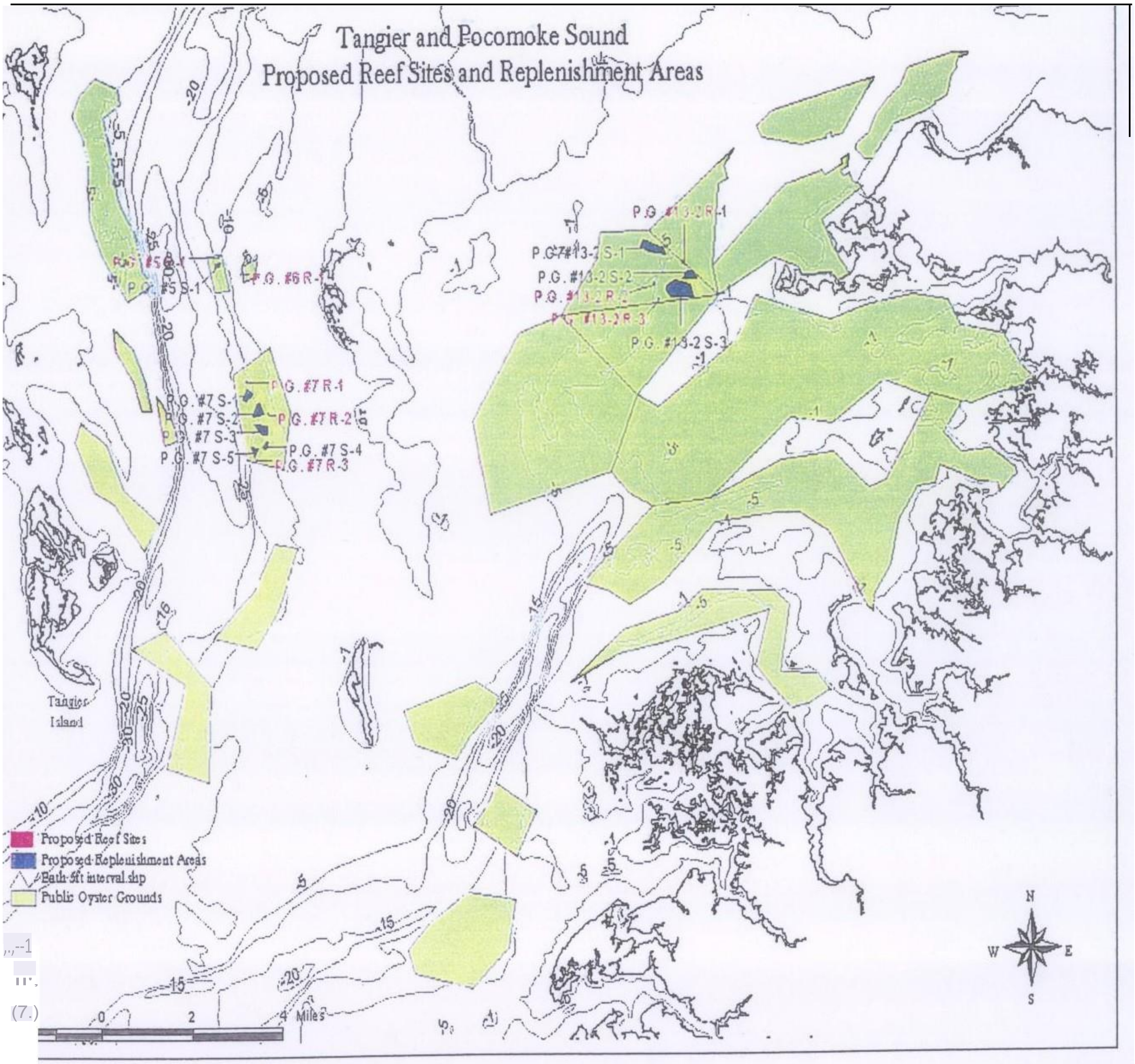


Figure 4. STOCKING SITES IN THE LOWER RAPPAHANNOCK RIVER

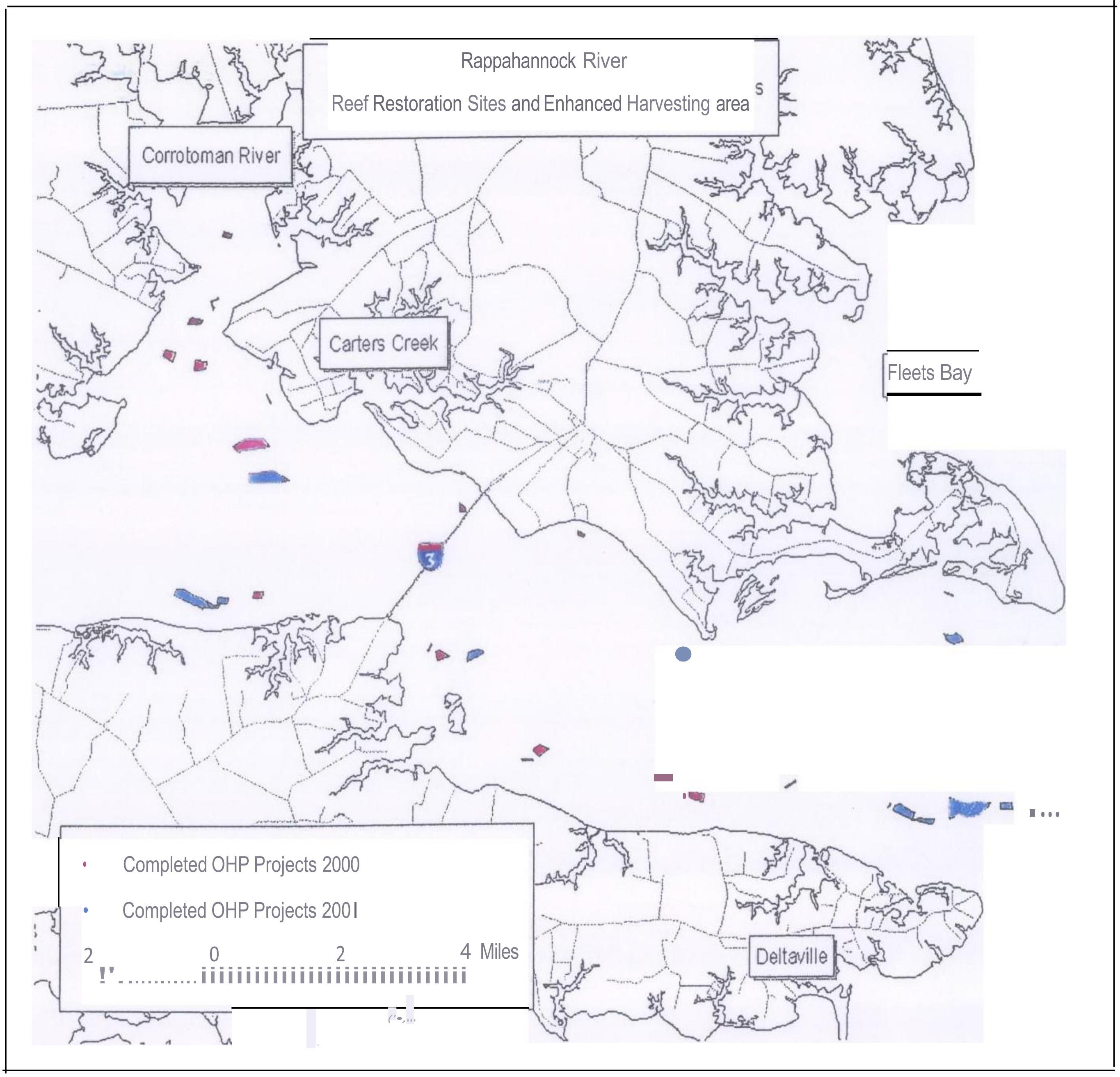
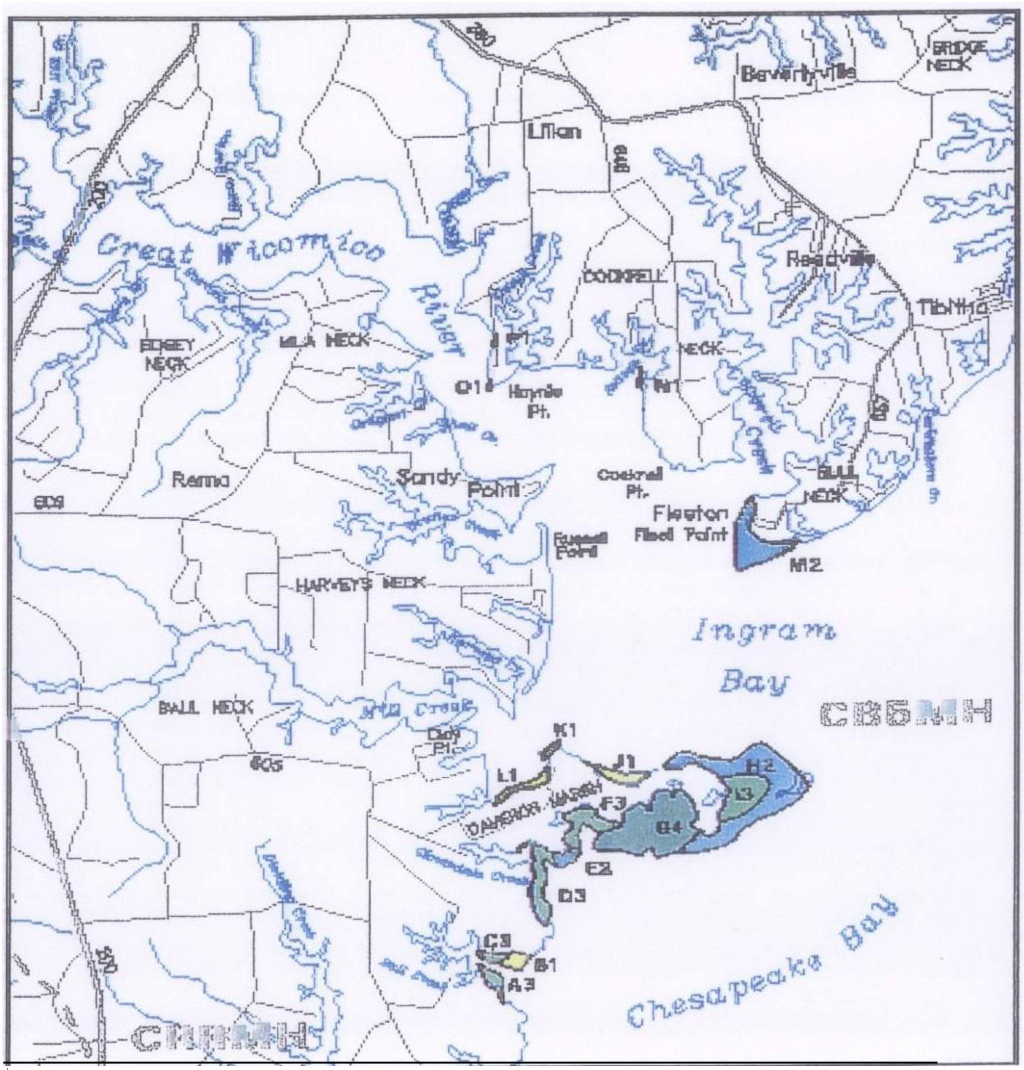


Figure 5. SUB:MERGED AQUATIC VEGETATION 2001-REEDVILLE QUADRANGLE



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11.0 SECTION 404 (b)(l) EVALUATION

SECTION 404(b) (1) EVALUATION
Section 704 (b) Oyster Recovery Project
Lower Great Wicomico River, Virginia

I. Project Description

a. Location - Lower Great Wicomico River, Virginia (Figure 1).

b. General Description - Approximately 128 acres of currently degraded oyster habitat in the lower Great Wicomico River will be rehabilitated through the construction of all-shell structures, ranging in height from several inches to several feet off the bottom. Some structures will be seeded with selected strains of disease-resistant native oysters, while other structures will serve as available substrate to catch spat from the spawning oysters on the nearby seeded "breeder" reefs. In the future, the spat-on-shell resulting from the broodstock oysters will be moved to other suitable oyster habitat in the Chesapeake Bay, namely previously-constructed reefs in the Rappahannock River, Tangier Sound, and other appropriate sites. Four previously-restored oyster reefs in the Piankatank River are proposed to be seeded with disease-resistant oysters to begin genetic rehabilitation of that watershed upon completion of the proposed oyster seeding and construction within the Great Wicomico River.

c. Authority and Purpose - Project is being designed and constructed under the authority of Section 704 (b), as amended by Section 342 of WRDA 2000.

d. General Description of Dredged or Fill Material - Dredged material consists of dredged fossil oyster shells that will be deposited as sanctuary reefs and shell-plantings, ranging from several inches to 8 feet deep.

e. Description of the Proposed Discharge Site

(1) Location (map) - See figures.

(2) Size - Approximately 128 acres.

(3) Type of site - Historical oyster reef.

(4) Type of habitat-Subaqueous lands.

(5) Timing and duration of discharge - Construction of the oyster reefs and shell plantings is scheduled to take place August 2003.

f. Description of Placement Method - Shell material will be barged in and river water will be used to hydraulically blow shell overboard in designated areas. Higher relief reef structures will be constructed by barge-mounted equipment.

II. Factual Determination

a. Physical Substrate Determinations

(1) Substrate elevation and slope - Very gentle slope (less than 1 percent slope); 1.7-foot tidal range.

(2) Sediment type - Predominantly shell and sand.

(3) Dredged/fill material movement - Minor.

(4) Physical effects on benthos - Loss of benthos at reef and shell plant site; rapid recovery.

(5) Other effects - Minor and short-term changes.

(6) Actions taken to minimize impacts - None required.

b. Water Circulation, Fluctuation, and Salinity Determinations.

(1) Water. Consider effects on:

(a) Salinity - No effect.

(b) Water chemistry - Minor and temporary effect on DO and biological oxygen demand during construction; temporary turbidity increase.

(c) Clarity - Minor and temporary turbidity may be generated during construction.

(d) Color - Minor and temporary change due to turbidity.

(e) Odor - No change.

(f) Taste - No change.

(g) Dissolved gas levels - Minor and temporary reduction in DO.

(h) Nutrients - Minor and temporary increase.

(i) Eutrophication - No change.

(j) Temperature - Minor or no changes anticipated.

(k) Others as appropriate - None.

(2) Current patterns and circulation.

(a) Current patterns and flow - On microscale, currents around reef structures may be altered from existing patterns. No cumulative or macroscale effects anticipated.

(b) Mean velocity - No effect anticipated.

(c) Stratification - No change.

(d) Hydrologic regime - Estuarine, no change.

(3) Normal water level fluctuations - No change.

(4) Salinity gradients - No change.

(5) Actions that would be taken to minimize impacts - none.

c. Suspended Particulates/Turbidity Determinations.

(1) Expected changes in suspended particulates and turbidity levels in vicinity of construction - Minor and temporary during construction.

(2) Effects (degree and duration) on chemical and physical properties of the water column - Temporary during construction.

(a) Light penetration - Minor decrease during construction; temporary effect. Increase expected due to filtration abilities of oysters

(b) DO - Minor decrease during construction; temporary effect.

(c) Toxic metals and organics - None present; no effect.

(d) Pathogens - None present; no effect.

(e) Aesthetics - Minor degradation during construction.

(3) Effects on biota.

(a) Primary production, photosynthesis - Temporary increase in suspended solids would reduce light transmission and photosynthesis.

(b) Suspension/filter feeders - Would be temporarily affected by minor increase in suspended solids.

(c) Sight feeders - Would be temporarily affected by minor increase in suspended solids.

(4) Actions taken to minimize impacts - None.

d. Contaminant Determinations - No reason to suspect presence of contaminants (i.e., no heavy industry or agriculture in project area).

e. Aquatic Ecosystem and Organism Determinations.

(1) Effects on plankton - Would be temporarily affected by increases in suspended solids.

(2) Effects on benthos - Loss of existing benthos at construction sites. Oysters will benefit.

(3) Effects on nekton - Would be temporarily affected by increase in suspended solids and minor disturbance to benthic feeding areas. Fishes will derive long-term benefits from productive oyster reefs.

(4) Effects on aquatic food web - Would be temporarily affected by minor loss of benthos and increase in suspended solids in water column. Post-construction, effects will be positive.

(5) Effects on special aquatic sites.

(a) Sanctuaries and Refuges - None affected.

(b) Wetlands - No effect.

(c) Mudflats - No effect

(d) Vegetated shallows - None present at site.

(e) Riffle and pool complexes - *NIA.*

(6) Threatened and endangered species - No impact.

(7) Other wildlife - Resident wildlife (including aquatic life) may be disturbed at the reef and shell plant. Colonization of the reef and shell plant sites will be rapid.

(8) Actions to minimize impacts - None.

f. Proposed Disposal Site Determinations.

(1) Mixing zone determinations.

(a) Depth of water - Reefs: Approximately 8-15 feet.

(b) Current velocity - Variable.

(c) Degree of turbulence - Negligible.

(d) Stratification - Negligible.

(e) Discharge vessel speed and direction - NIA.

(f) Rate of discharge - NIA.

(g) Dredged material characteristics - Fossil oyster shell.

(h) Number of discharge actions per unit time - NIA.

(2) Determination of compliance with applicable water quality standards - All applicable water quality standards will be complied with.

(3) Potential effects on human use characteristic.

(a) Municipal and private water supply - Proposed project would not affect municipal or private water supply.

(b) Recreational and commercial fisheries - Short-term and minor turbidity increases and minor impact to benthos from construction would minimally affect fisheries. Recreational and commercial fishing vessels may benefit from the fish attracted to the oyster reefs and shell plant areas.

(c) Water-related recreation - No impact.

(d) Aesthetics - No impact, proposed improvements would not change aesthetic quality of project area.

(e) Parks, national and historical monuments, national seashores, wilderness areas, etc. - None affected.

g. Determination of Cumulative Effects on the Aquatic Ecosystem - The proposed project involves placement of dredged fossil oyster shell as reef structures of various thickness.

Approximately 128 acres of soft-bottom benthic habitat will be disturbed with construction; however, organisms should colonize the shell structures rapidly. No leased oyster grounds would be lost. Approximately 128 acres of historical oyster grounds should be restored.

h. Determination of Secondary Effects on the Aquatic Ecosystem - None anticipated.

III. Findings of Compliance or Non-Compliance with the Restrictions on Discharge.

1. The evaluation of the proposed oyster habitat restoration project in the lower Great Wicomico River, Virginia, was made consistent with 404 (b) (1) Guidelines.

2. The proposed plan was selected because of its ability to meet the needs expressed by VMRC, as the environmental impacts associated with the recommended plan were either comparable to, or less than, impacts associated with other alternatives, and because the environmental benefits associated with the recommended plan were comparable to, or greater than, benefits associated with other alternatives. There were several alternatives evaluated in the final array, as described in the accompanying EA. The recommended plan was selected based on its acceptability from an environmental, social, and economic perspective.

3. The planned construction of the sanctuary oyster reef structures/shellplants will not violate any applicable State water quality standards. VMRC, who will the permit application for this project through the JPA process, received correspondence from VDEQ that the 401 Virginia Water Protection Permit has been waived. There would be a short-term increase in suspended solids in the water column during construction. Construction activities would not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

4. Use of the selected sites for construction would not harm any endangered species or their critical habitat.

5. The proposed construction would not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreational and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. The life stages of aquatic life and other wildlife would not be adversely affected. Effects on aquatic ecosystem diversity, productivity, and stability would be limited and localized; significant adverse impacts to recreational, aesthetic, and economic values would not occur. Positive impacts to the aquatic ecosystem will be realized.

6. Appropriate steps would be taken to minimize potential adverse impacts to aquatic systems resulting from construction activities.

7. On the basis of the guidelines, the proposed sites for construction of oyster reefs and production areas are specified as complying with the inclusion of appropriate and practical conditions to minimize pollution or adverse effects to the aquatic ecosystem.

ENVIRONMENTAL ASSESSMENT
APPENDIX A

NMFS ESSENTIAL FISH HABITAT DESIGNATIONS

SPECIES HAV[NG ESSENTIAL FISH HABITAT DESG[NATED IN LOWER GREAT WICOMICO RIVER, VA.

SPECIES	EGG	LARVA	JUVENILE	ADULT
Windowpane Flounder (Scophthalmus aquosus)			X	X
Winter Flounder (Pleuronectes americanus)			X	X
Black Sea Bass (Centropristis striata)			X	X
Scup (Stenotomus chrysops)	N/A	N/A	X	X
King Mackerel (Scomberomorus cavalla)	X	X	X	X
Spanish Mackerel (S.maculatus)	X	X	X	X
Cobia (Rachycentron canadum)	X	X	X	X
Red Drum (Sciaenops occelatus)	X	X	X	X
Sand tiger shark (Odontaspis taurus)		X		X
Atlantic sharpnose shark (Rhizopriondon terraenovae)				X
Dusky Shark (Carcharhinus obscurus)			X	
Sandbar Shark (C. plumbeus)				X
Sandbar Shark (C. plumbeus)		HAPC*	HAPC*	HAPC*

* HAPC= Habitat Area of Particular Concern.
"X" indicates that EFH has been designated within the square for a given species and life stage. "n/a" indicates that the species either have no data available on the designated lifestages, or those lifestages are not present in the species' reproductive cycle. A blank square means that there could be an EFH designation.
Source: NOAA/NMFS, 1999.

ENVIRONMENTAL ASSESSMENT
APPENDIXB

CORRESPONDENCE

W. Tayloe Murphy, Jr.
Secretary of Natural Resources

COMMONWEALTH *of* VIRGINIA

Department of Game and Inland Fisheries

William L. Woodfin, Jr.
Director

February 19, 2003

Michele Cleland
Department of the Anny
Norfolk District, Corps of Engineers
Fort Norfolk, 803 Front Street
Norfolk, Virginia 23510-1096

RE: ESSLOG #18556, Proposed Oyster Restoration, lower Great Wicomico River, Northumberland County, VA

Dear Ms. Cleland:

This letter is in response to your request for information related to the presence of threatened or endangered species in the vicinity of the above referenced project.

1. **·westernmost point of project area, near Ferry Point (Lat./long.: 37,50,55 76,20,46):**
   The *federal threatened/state threatened* bald eagle *(Haliaeetus leucocephalus)* has been documented approximately 2 miles from this portion of the project site. Therefore, the applicant should coordinate with this Department by contacting Brian Moyer at (804) 367-6913 to evaluate potential impacts to this species.

2. **VIMS ID# V4, near Haynie Point (Lat./long.: 37,50,06 76,18,59):**
   Data provided by the Virginia Department of Agriculture and Consumer Services (VDACS) indicate that the *federal threatened/state threatened* northeastern beach tiger beetle (*Cicindela dorsalis dorsalis)* has been documented approximately 0.25 mile from this portion of the project area. Therefore, the applicant should coordinate with Keith Tignor, VDACS, Office of Plant Protection at (804) 786-3515 and the U.S. Fish and Wildlife Service concerning potential impacts to this species. Also, a block survey of an area encompassing this portion of the project area documented the following during the breeding season: *federal threatened/state threatened* bald eagle *(Haliaeetus leucocephalus)* and *state special concern* great egret *(Ardea alba egretta).* These species may occur in this portion of the project area if appropriate habitat exists, but no coordination is necessary at this time.

3. **VIMS ID# B9, near Sandy Point (Lat./long.: 37,49,16 76,18,44):**
   A block survey of an area encompassing this portion of the project area documented

EA-Appendix B

the following during the breeding season: *federal threatened/state threatened* bald eagle *(Haliaeetus leucocephalus)*, *state special concern* great egret *(Ardea alba egretta)*, and *state special concern* least tern *(Sterna atillarum)*. These species may occur in this portion of the project area if appropriate habitat exists, but no coordination is necessary at this time.

4. **Easternmost point of the project area, VIMS ID# VlO, northwest of Cockrell_Point (Lat./long.: 37,49,41 76,17,56):**
   The *federal threatened/state threatened* loggerhead sea turtle *(Caretta caretta)* has been documented approximately 1.5 miles from this portion of the project area. Therefore, the applicant should coordinate with this Department by contacting Brian Moyer at (804) 367-6913 to evaluate potential impacts to this species. Also, data provided by the Virginia Department of Agriculture and Consumer Services (VDACS) indicate that the *federal threatened/state threatened* northeastern beach tiger beetle *(Cicindela dorsalis dorsalis)* has been documented approximately 0.75 mile west of and 1.5 miles east of this portion of the project area. Therefore, the applicant should coordinate with Keith Tignor, VDACS, Office of Plant Protection at (804) 786-3515 and the U. S. Fish and Wildlife Service concerning potential impacts to this species.

Information about fish and wildlife species was generated from our agency's computerized Fish and Wildlife Information System, which describes animals that are known or may occur in a particular geographic area. Field surveys may be necessary to determine the presence or absence of some of these species on or near the proposed area. Also, additional sensitive animal species may be present, but their presence has not been documented in our information system.

Endangered plants and insects are under the jurisdiction of the Virginia Department of Agriculture and Consumer Services, Bureau of Plant Protection. Questions concerning sensitive plant and insect species occurring at the project site should be directed to Keith Tignor at (804) 786-3515.

This letter summarizes the likelihood of the occurrence of endangered or threatened animal species at the project site. If you have additional questions in this regard, please contact me.at (804) 367-1185. Please note that this response does not address any other environmental concerns; these issues are analyzed by our Environmental Services Section, in conjunction with interagency review of applications for state and federal permits. If you have any questions in this regard, please contact Brian Moyer at (804) 367-6913.

Please note that the data used to develop this response are continually updated. Therefore, if *significant changes are made to your project or if the project has not begun within 6 months of receiving this letter, then the applicant should request a new eview of our data.*

The Fish and Wildlife Information Service, the system of databases used to provide the information in this letter, can now be accessed via the Internet! The Service currently provides access to current and comprehensive information about all of Virginia's fish and wildlife resources, including those listed as threatened, endangered, or special concern; colonial birds; waterfowl; trout streams; and ,all wildlife. Users can choose a geographic location and generate a report of species known or likely to occur around that point. From our main web page, at www.dgif.state.va.us, choose the ,Jiyperlink to "Wildlife", then "Wildlife Information & Mapping Services" and then "Wildlife Information Online Service". For more information, please contact Amy Martin, Online Service Coordinator, at (804) 367-2211.

Thank you for your interest in the wildlife resources of Virginia.

Sincerely,

Susan H. Watson

Research Specialist Senior

cc: R.T. Fernald, VDGIF
E. Davis, USFWS
K. Tignor, VDACS

W. Tayloe Murphy. Jr.
S.:cTctary of'salural
Resources

Joseph H. Maroon
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COMMONWEALTI-1*of* VIRGINIA

DEPARTMENT OF CO SERVATION AND RECREATION

203 Governor Street
Richmond. Virginia 23219-2010
TDD /804) 786-2121

27 February 2003

Ms. Michele Cleland
·. Department of the Army
Norfolk District, Corps of Engineers
-,.fort Norfolk, 803 Front Street
Norfolk, Virginia 23510-1096

Re: Lower Great Wicomico River Oyster Restoration, Northumberland County

Dear Ms. Cleland,

The Department of Conservation and Recreation (DCR) has searched its Biological and Conservation Data System (BCD) for occurrences of natural heritage resources from the area outlined on the submitted map. Natural heritage resources are defined as the habitat of rare, threatened, or endangered plant and animal species, unique or exemplary natural communities, and significant geologic formations.

BCD documents the presence of the federally threatened Northeastern beach tiger beetle *(Cicindela dorsalis dorsalis,* G4T2/S2/L TINS) at the project site. Disturbance to dynamic, sandy beaches in this area may detrimentally impact tiger beetles through habitat degradation and individual mortality. To ensure compliance with the Endangered Species Act, DCR recommends coordination with the United States Fish and Wildlife Service (USFWS). We recommend that pennit issuance be contingent upon the results of this coordination.

To more accurately assess potential impacts to tiger beetles from the proposed project and develop protection recommendations if appropriate, the USFWS may request a tiger beetle **survey** of the project area. OCR-Division of Natural Heritage biologists are qualified and available to conduct inventories for rare, threatened, and endangered species. Please contact J. Christopher Ludwig, Natural Heritage Inventory Manager, at (804) 371-6206 to discuss arrangements for field work.

Any absence of data may indicate that the project area has not been surveyed, rather than confirm that the area lacks natural heritage resources. New and updated information is continually added to BCD. Please contact DCR for an update on this natural heritage information if a significant amount ohime passes before it is utilized.

Based on the submitted information the proposed project is not anticipated to have any adverse impacts on existing or planned state recreational facilities. Nor will it impact on any streams on the National Park Service Nationwide Inventory, Final List of Rivers, potential Scenic Rivers or existing or potential State Scenic Byways.

Thank you for the opportunity to comment on this project.

Sincerely,

Derral Jones
Planning Bureau Manager

cc: Jolie Harrison, USFWS

COMMONWEALTH of VIRGINIA

Department of Historic Resources

2801 Kensington Aven Richmond, Virginia 23221

W. Tayloe Mu,phy. Jr,
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Kazlllccn S. Kilpllrick
Dinclo,,

Tel: **(804)** 367•2323
Fa: (I04) 367•1391
TDD: (IOI) 367-2386
www.dhr.lllle.YI..DS

MEMORANDUM

.,.. **DATE::l/. r le/oJ** *7\-1A:.ee •* **DHRlileNo. oo3-Cltf,.** Cl.• ,...,*1/J* **COEPmnitNo.**

TO: Norfolk District, Corps ofEnginecrs, ATI'N: CENAO-TS-G, **803 Front 5u=t. Norfalk, VA** 23510-1096

FROM:

APPLICANT:'

LOCATION: Great Wicomico River, Westmoreland Co.

X No further identification effom within the Corps' Ara of Potential Effect are Should unidentified historic propenies be discovered during implementation of the project, please notify the OHR immediately.

We have pn:viously reviewed this project. Atmched is a copy of our correspondence.

Additional information is rcqund in order to complete our review of the project:

USGS quad sheet with the project boundmies and Ara of Potential Effect clearly marked.

More detailed description of the projeet mul anticipated ground dismrbance.

lnfunnation concerning Historic Properties within the project area. This infonnation can be obtained though our Data Sharing System (DSS) or 'from at our archives.

Other:

COMMENTS:

FROM : SHELLFISH PHONE NO. : 804+435+6948 Feb. 11 2003 06:48AM P1

VIRGINIA DEPARTMENT OF HEALTH
DIVISION OF SHELLFISH SANITATION
White Stone Field Office
P. 0. Box 241
482 Chesapeake Drive
White Stone, VA 22578

804/435-1095 (Phone)
804/435-6948 (Fax)

Date: 2-11-03

To: Michelle Cleland

From: C.T. VanLandingham

Message:

This area will be re-evaluated in April.

Total number of pages sent (including cover page) 4

COMMONWEALTH *of* *VIRGINIA*

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NOTICE AND DESCRIYIION OF SHELLFJSH AREA CONDEMNATION l'\t:MBER 89, GREAT WICOMICO RIVER

EFFECTIVE 3 APRIL 2002

Pu:-suanttc Title 28.2, Chapter 8, § 28.2-803 tilrot..gh 28.2-808, §32.1-20. and §9-6.14:4.1 ; B.16 of the *Code of Virginie:*

1. The "Notice d Descriptic:1 ofSheUfishAreaConcemnationNumber 89, Great Wicomico River," effective 15 ::vlarch.2001, is c-ancelled effective 3 April 2002.

2. Cond m.ned S":l llfish Ar= Numbo: 89, Gre:.it Wicomico River, i. established, effective 3 April 2002. It shall be UI1ia.wful for an,· persor,, firm, r co.rpora.tion to tz.ke shellfish fr.:nn area #89 for any purpose, except by permit granted by the Marine Resources Commission, as provided in Section 28.2·8 l 0 of the *CtJde of Vu-rinia.* The hnundaries of the area areshown on map titled "Great Wiccmico Rlv:r, Condemned Shellfish Numba- 89, 3 April 2002" which is part *of* this notice.

3. Toe Department ofHealU: will re eive, consider and respond to petitions by any interested person at any time with respect to rer.onsideratlon or re\;h:ion of this order.

BOUNDARIES OF CONDEMNED AREA NUMBER 89

A. The conccmned area shail iuclude all of that portion oithe Great Wicomico River and itS tributaries lying upstr of a line drawn between Marine Resources Commission survey markers ..Cedar Pt. \'PC' and "Richardson VFC."

B. The condemned area shall include all of that portion ofBalls Creek and its tributaries lying upstream of a-line drawn froin Marine Resources Conucission &urvey marker "Clay" due scuth 10 the opposite shcre.

C. The conden:ned arc3 shall include all of that portion of Tipeni Creek and its tributaries !ying upstream oi a 1i:le dra"-11 from Marine Resources Commission survey marker ..Northern 98 due west 10 lh oppo\:i:e shore.

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment
www.vdh.state.va.us

Shellfisr. Area Condcm."l.ation
Numbe!" 89
PQgeTwo

D. The condemned ari:a shall include all cf that ponior; of\.Vhays Creek and its t:ributari:s lying upstream of a line drawn due wesi to the opposite shore from the point of land located 320 feet (straight line distance) along the shore upstrea.-n of Marine Resouit:es Commission s1.m.-ey ;narker "TRAV 1."

E. Thi: condemned area shall include all of that portion of Warehowc Creek and its tributaries lying upstrea.--n nf a line drawn from Marine Resources Commis&iQn survey marke!" "Moor" southeastarly through_ corner 331 of ;,lat 11460 to the opposite shore.

F. The conder.med area shall include all of Hom Harbor and its tributaries lying upstream of a line drawn from arine Resources Conuniiision survey marker "M:arsh" due west to the opposite shore.

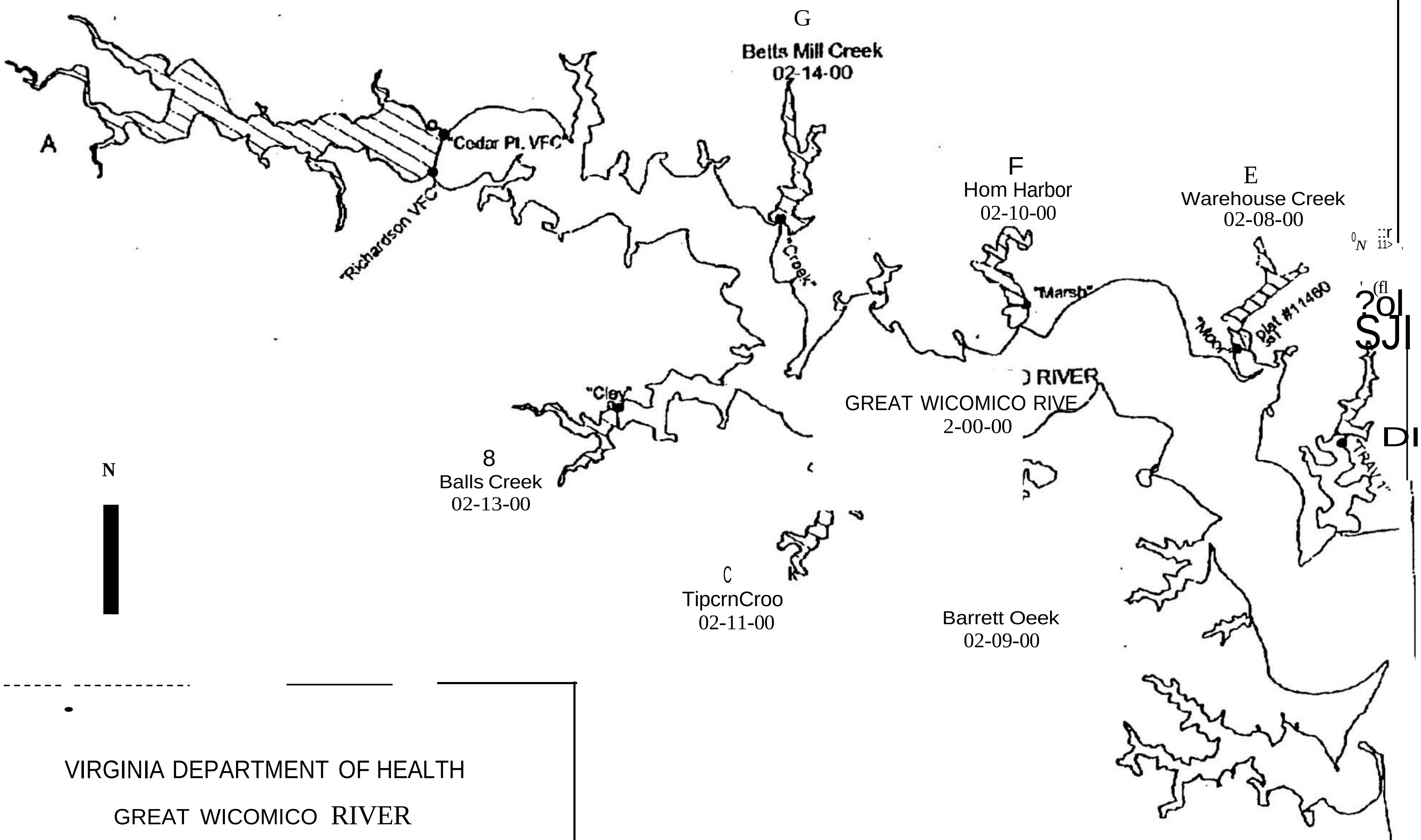
G. TI1c cor.demneu area shalt include all ofthar portion of Betts Mill Creek and i s tributaries lying upstream of a line c1ra,vn from Manne Resources Coa1unis.sion survey m k.t::r "Creak" southwesterly to the promir.ent point ofland on th opposite shore.

Recommended by: ______________________________

Director, Divisio:n of Shellfish Sanitation

Ordered by: ______________________ ______________

Actir.g State Health Cotn1T.issior.er Date



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VIRGINIA DEPARTMENT OF HEALTH

GREAT WICOMICO RIVER

CONDEMNED SHELLFISH AREA NUMBER 89

3 APRIL 2002

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ENVIRONMENTAL ASSESSMENT
APPENDIXC

COMMENT/RESPONSE SECTION

APPENDIXC

Comment/Response Section
Chesapeake Bay Oyster Recovery Phase III
Great Wicomico River, Virginia

1. US Fish and Wildlife Service, April 28, 2003.

Comment: USFWS recommends the impacts for shell dredging be briefly summarized and the assement included by reference.

Response: USACE will attach the permits that the Virginia Marine Resources Commission has obtained to dredge shells and the associated reports from the Virginia Institute of Marine Science (VIMS) to this EA.

Comment: USFWS recommends a better description of the disease resistant capability of the selected strain of native oyster (DEBY) USACE proposes to use in the project. USFWS is concerned that there is potential for reduced genetic variability in the wild population with their use.

Response: USACE included sufficient information to conclude the DEBY strain is best suited for the proposed project. The remnant wild population will interbreed with the DEBY progeny as they settle throughout the Great Wicomico River. This introgression is desired to increase the fitness of the wild population and is an important component of the genetic rehabilitation strategy.

Comment: USFWS believes the stocking of five million DEBY oysters on one reef is too high and may result in competition among these oysters that could reduce growth and survival.

Response: While it has been recommended to USACE by the scientific community that we can stock up to 5 million oysters on a 1 acre reef, USACE will likely stock several acres of restored reefs with the 5 million oysters, which will reduce their density.

Comment: USFWS believes that in Alternative 3, the total cost for broodstock seeding is incorrect and that it should be$ 552,500 instead of$ 425,000.

Response: Concur; changed for Final EA.

Comment: USFWS recommends that the document sets forth a consistent definition of what it means by sanctuary.

Response: While all areas are sanctuaries, and sanctuaries are areas protected from commercial or recreational harvest for the purpose of human consumption, some areas are meant for spat-on-shell production areas. These areas will be harvested, but the spat-on-shell will be used for further oyster restoration stocking efforts throughout the

Virginia waters of the Chesapeake Bay and not for fishery purposes. USACE will make this distinction clear.

Comment: USFWS believes that poaching could be a significant problem that could impact the project.

Response: USACE agrees and all sanctuary areas shall be clearly marked as such. To the extent practicable, sanctuary areas shall be located as far from harvest areas as possible in order to assist in enforcement of the sanctuaries as fishing-free areas.

2. National Marine Fisheries Service (NMFS), May 2, 2003.

Comment: NMFS is concerned that the genes of the DEBY oysters may become too diluted by the remnant wild stock to successfully intrograde their superior disease tolerance into the wild population. No impacts to EFH are expected, the project should have positive impacts to EFH.

Response: USACE will undertake a monitoring program that will assess this as part of the proposed monitoring/adaptive management program for this project. If genetic dilution occurs such that the fitness of the native oyster is not significantly increased, it will likely trigger the requirement to re-seed the incubator reefs with additional disease tolerant oysters. Agree with EFH assessment by NMFS.

3. Commonwealth of Virginia, Department of Historic Resources (DHR).

Comment: DHR completed its review of the Draft Environmental Assessment, paying special attention to the section on cultural resources and the enclosed maps showing proposed oyster reef site locations. Based on this information, DHR concluded with a finding of no effect on historic properties.

Response: None required.

4. Virginia Department of Environmental Quality (DEQ).

Comment: The DEQ office of Environmental Impact Review states that no wetlands will be impacted as part of the proposed project. They also stated that issues surrounding sediment disturbance during shell harvesting to address the possibility of contaminated sediments in the James and Elizabeth Rivers should have been done. The EA did not address solid waste or pollution prevention. The proposed project is consistent with the Virginia Coastal Program (VCP) pursuant to the Coastal Zone Management Act (CMZA) of 1972, as amended, as long as any permit requirements are complied with.

Response: The issues of contaminated sediments were addressed during the permitting process for the "fossil" shell dredging sites in the James and Elizabeth Rivers. No significant impacts were found, according to the permits and associated environmental reports attached to this Final EA. For clarification, the shell dredging process involves separating, washing, and sorting the shells on site. The discarded sediments and shell hash is then pumped back into the dredged bed, minimizing the transport of possibly contaminated sediments into the Chesapeake Bay. The shells, being cleaned on site, have little chance of bringing any contaminants with them to the site of deployment. Solid waste is not a significant or potentially significant issue with the proposed project; therefore, it was not addressed. While pollution prevention was not specifically addressed, all contractors involved in the project adhere to Best Management Practices, as required by the Federal Government. These practices include measures to minimize the chances of any fuel spills, and other practices designed to minimize any harm to the environment. The project represents a significant enhancement to the environment. USACE will comply with any permit requirements during construction, if any permits are in fact required.

5. Virginia Institute of Marine Science (VIMS).

Comment: Concur with the plan.

Response: None required.

6. Virginia Department of Conservation and Recreation (VDCR).

Comment: The Federally Threatened Northeastern beach tiger beetle is found near the project site. No proposed project will not effect any wild or scenic rivers on the National Park Service's Nationwide Inventory, Final List of Rivers, potential Scenic Rives or existing or potential State Scenic Byways.

Response: The Northeastern beach tiger beetle is a species that is typically found on beaches with little human activity. The proposed project will be in open waters of the Great Wicomico River, far from any beach. All construction equipment will be barge deployed. No potential for impacts to the Northeastern beach tiger beetle are expected.

7. Northern Neck Planning District Commission

Comment: The commission concurs that any short term negative impacts on the aquatic ecosystem from reef construction are more than offset by the long term positive impacts that the proposed project would produce.

Response: None required.

Schulte, David M NAO02

From: Tim Goodger [Tim.Goodger@noaa.gov]
Sent: Friday, May 02, 2003 7:56 AM
To::· Schulte, David **M**
Subject: Re: Great Wicomico River, VAnative oyster restoration - EFH correspondence

E=1

Card for Tim Goodger

Hi Dave,

NMFS encourages your efforts to restore native oyster populations to Virginia waters, and concur that there will be no substantial adverse affect of the proposed activity to Essential Fish Habitat. Consequently, we have no Conservation Recommendations to offer. As we discussed, however, we are concerned that gametes produced by existing populations of diseased oysters may dilute the gene pool of disease resistant oysters that are to be introduced. You may want to consider having local watermen harvest existing oysters to minimize the potential effect of gene dilution.

Tim

David.M.Schulte@NAO02.USACE.ARMY.MIL wrote:

\>
\>
\> Hi Tim,
\>
\> As per our phone conversation, the basic background of the project is
\> to construct a series of shell reefs of various heights (8" to 6' tall
\> mounds) over approximately 126 acres of former historic oyster reef
\> footprints. This river is a trap estuary, with a gyre that tends to
\> create a water circulation pattern that retains oyster larvae produced
\> within this river. We will also seed some of these reefs with
\> disease-resistant DEB\' selected strain native oysters. This strain is
\> the top performer so far against the oyster diseases DERMO and MSX.
\> We then hope these oysters will reproduce and auto recruit back onto
\> our restored reefs, and ultimately increase the genetic fitness of the
\> local population. This strategy, genetic rehabilitation, is viewed at
\> this time by the VA scientific community, including USACE, as our best
\> chance for success. Here is a link to an article that fully explains
\> what we're trying to do:
\>
\> <http:/ /www.vims.edu/GreyLit/SeaGrant/vmrb35-1.pdf>
\>
\> Because we are working within historic oyster reef footprints, and
\> restoring them to functioning oyster reefs, we do not anticipate any

> significant impacts to Essential Fish Habitat (EFH).
>

> Could you please reply to this email so I can complete my required
> coordination with NMFS on **EFH?** Thanks.
>
> Dave

Tim Goodger - Fishery Biologist
NOAA/NMFS/NERO/Habitat Conservation Division
904 South Morris Street
Oxford, MD 21654
ph: (410) 226-5771 fax:(410) 226-5417
e-mail: Tim.Goodger@noaa.gov

U.S.
FISH It WILDLIFE
SERVICE

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Chesapeake Bay Field Office
177 Admiral Cochrane Drive
Annapolis, MD 21401

April 28, 2003

Colonel David L. Hansen
District Engineer
Norfolk District, Corps of Engineers
Fort Norfolk, 803 Front Street
Norfolk, VA 23510-1096

Attn: David Schulte

Re: Great Wicomico River Oyster Recovery Project

Dear Colonel Hansen: _

This responds to Mr; Mansfield's letter dated Ma;rch28,2_003, eq esting comments on the draft Decision Document Amendment, entitled "Chesapeake Bay Oyster Recovery Project Phase III, Great Wicomico River, Virginia." The document includes the Environmental Assessment and Finding of No Significant Impact. The main objective of the project is "genetic rehabilitation" of the native oyster *(Crassostrea virginica)* population in Virginia. The first step is to establish fill "incubator system" in the Great Wicomico River by enhancing bottom habitat for oysters by depositing shell in various configurations and stocking the area with adult oysters that have been selectively bred for disease tolerance. The Great Wicomico River was specifically chosen because its circulation tends to retain larvae in the area. An additional incubator system may be established in the Piankatank River inthe future. The second step would involve collecting the offspring and relocating them fo various locations throughout the Virginia portion of Chesapeake Bay in an effort to widely disseminate the strain's disease resistance traits.

We support efforts to improve habitat and to develop and use disease resistant strains of the Eastern oyster with the hope that this will advance the prospects for oyster recovery in Chesapeake Bay. We believe that this project will be an important step in this direction.

The document notes that the project would obtain shell by dredging "fossil shell" deposits in the James River and/or Elizabeth River, but it does not identify the potential impacts of this operation. Typically the operation would involve excavating the bottom, straining out the shell, and discharging the sediment overboard. At a minimum, this will cause localized increases in turbidity and sedimentation, and possibly disruption to the benthic invertebrate community. If sensitive communities such as oyster grounds or submerged aquatic vegetation exist in the area, they also may be affected. The Elizabeth River bottom sediments are known to have a substantial chemical contamination. This type of dredging operation could spread the contaminants and increase the exposure for biota. If the impacts of this operation have been evaluated in a separate environmental assessment for a permit action, we recommend that the impacts be briefly summarized and the assessment document included by reference.

We further recommend that the document provide a better description of the disease resistance capability of the selected strain (DEBY). The document presents the results of a 2.5-year long field evaluation at three sites that showed that the DEBY strain displayed much lower mortality than two wild stocks. The document should clarify this impression by noting that most of these oysters will in fact contract disease if placed in areas with high disease pressure and will likely die by the 5^{th} or 6^{th} year. This delay in mortality is critically important because it allows increased reproduction and attainment of market size oysters. However, disease will remain an important factor in the population.

One of the concerns that arises with the use of selectively bred hatchery produced oysters is the potential for reduced genetic variability that results. It would have been helpful if the document had addressed this issue.

The recommended plan proposes to stock 5 million mature oysters (at least 40 mm in size) on an exiting high relief reef site approximately one acre in area. This would produce a density of 1,236 oysters per square meter. We consider this to be a high density that may result in heavy competition that could reduce growth and survival. As a result of previous stocking, it also is likely that this reef already has some oysters present. We recommend that the reason for the high stocking density be addressed. From our viewpoint, the stocking would be more effective if the oysters were put out at a lower density by extending the stocking to some of the proposed medium relief reefs.

The total cost for the broodstock seeding for Alternative 3 given in Table 13, page 84 appears to be incorrect. If 13 acres are stocked with 0.5 million oysters per acre at a cost of $0.085 per oyster, the cost would be $552,500 instead of $425,000.

The establishment of oyster sanctuaries is obviously a very important objective of the project. Section 704(b) of the Water Resources Development Act (WRDA) of 1986, as amended through Section 505 of WRDA 1996, which provides the authorization for the project, includes a condition that "the reefs are preserved as permanent sanctuaries by the non-Federal interests". The Decision Document also references recommendations for oyster sanctuaries made in the scientific consensus document, "Chesapeake Bay Oyster Restoration: Consensus of a Meeting of Scientific Experts", by Chesapeake Research Consortium 1999, in the Chesapeake Bay 2000 Agreement, and in the Chesapeake Bay Program's "Comprehensive Oyster Management Plan." However, the Decision Document does not clearly indicate what form the sanctuaries should take, and, unfortunately, the issue is left unclear by giving a variety of differing interpretations. Page 32 states "all proposed construction in the Decision Document Amendment will be designated as sanctuary area(s)." Page 11 states, "Sanctuary habitat will not be open to commercial harvest." One could infer that recreational harvest would be permitted. Page 51 states, "Reefs stocked with oysters for the purpose of restoration must be permanent sanctuaries." This seems to leave open the possibility that areas that are enhanced for oysters by shell deposition, but not actually stocked with oysters, would not necessarily be sanctuaries. The discussion of alternative 1 on page 79 states, "This alternative would provide 3 acres of HRR's as permanent sanctuary and 123 acres of LRR's spat-on-shell production areas." This seems to imply that only the HRR areas would be sanctuaries. On page 81, when referring to the proposed 65 acres that would get "thin shelling", it states, "Five acres of this amount will never be harvested for spat-on-shell production and will be maintained as a permanent sanctuary area." This seems to imply that the remaining 60 acres would not have sanctuary status. However, later in the same paragraph it states, "All areas in this alternative are sanctuary areas." Page 16 states: "All reefs built under the other three goals will be maintained as permanent sanctuaries or closed harvest reserve areas. Such harvest reserves could not be opened until a sustainable population was achieved." This seems to indicate that the sanctuaries would not necessarily be permanent. A similar interpretation is given on page D-16 where it states, "128 aces of public ground converted to sanctuary reef, where harvesting will be prohibited at least until the native oyster population recovers sufficiently to allow fishing once again." We recommend that the document set forth a consistent definition of what it means by sanctuary.

It may be difficult to enforce harvesting prohibition on isolated small sanctuaries which lie within an area where harvesting is permitted. Enforcement would be much easier if a comprehensive region of the waterway could be made off limits to harvesting. We do recognize that this may run counter to the concept that harvest areas should be allowed close to the sanctuaries where they could benefit from enhanced recruitment. However, poaching could be a significant problem that would seriously threaten the success of the project. We believe that this is an important issue that needs careful consideration.

Thank you for the opportunity to review the document. If there are any questions, please contact George Ruddy, Chesapeake Bay Field Office at (410) 573-4528 or William Hester, Virginia Field Office at (804) 693-9032 ext. 134.

Sincerely,

John P. Wolflin
Supervisor

COMMONWEALTH *of* VIRGINIA

DEPARTMENT OF ENVIRONMENTAL QUALITY

Street address: 629 East Main Street, Richmond, Virginia 23219
Mailing address: P.O. Box I0009, Richmond, Virginia 23240
Fax (804) 698-4500 TDD (804) 698-4021
www.deq.state.va.us

W. Tayloe Murphy, Jr.
Secretary of Natural Resources

Robert G. Burnley
Director
(804) 698-4000
1-800-592-5482

May 7, 2003

Mr. Mark T. Mansfield
Chief, Planning Branch
Corps of Engineers, Norfolk District
ForT Norfolk
803 Front Street
Norfolk, Virginia 23510-1096

RE: Environmental Assessment and Consistency Determination on the Chesapeake Bay Oyster Recovery Project, Phase III, Great Wicomico River, Virginia (DEQ-03-061F)

Dear Mr. Mansfield:

The Commonwealth of Virginia has completed its review of the Environmental Assessment (EA) and Consistency Determination for the above-referenced project. The Department of Environmental Quality (DEQ) is responsible for coordinating Virginia's review of federal environmental documents and responding to appropriate federal officials on behalf of the Commonwealth. In addition, as you are aware, pursuant to the Coastal Zone Management Act of 1972, as amended, federal actions that can have foreseeable effects on Virginia's coastal uses or resources must be conducted in a manner which is consistent, to the maximum extent practicable, with the Virginia Coastal Program (VCP). The Department of Environmental Quality (DEQ) is responsible for coordinating Virginia's review of federal consistency determinations and responding to appropriate officials on behalf of the Commonwealth. The following agencies and planning district commission participated in the review of this EA and consistency determination:

Department of Environmental Quality
Department of Conservation and Recreation
Department of Health
Department of Historic Resources
Virginia Institute of Marine Science
Northern Neck Planning District Commission

The Department of Game and Inland Fisheries, the Marine Resources Commission and Northumberland County were also invited to comment.

Project Description

The U.S. Anny Corps of Engineers proposes to rehabilitate up to 128 acres of currently degraded oyster habitat in the lower Great Wicomico River. The project involves the construction of a combination of high-, medium- and low-relief reefs, and light shellplant areas. Construction of these reefs involves the dredging of fossil oyster shell from the James and Elizabeth Rivers, as well as cleaning, hauling and deploying the shell to create the oyster habitat. Some reefs are proposed to be restored; these reefs would be heavily seeded with the best available disease-resistant genetic stocks serving as broodstock.

This proposed project is a part of a multi-year plan of integrated activities throughout Chesapeake Bay and its tributaries. It also incorporates significant changes in oyster restoration strategy, as genetic rehabilitation of the native oyster is now the primary goal. Genetic rehabilitation involves actively seeding with disease resistant strains of *Crassostrea virginica.*

Environmental Impacts and Mitigation

J. Wetlands and Water Quality. The EA (page D-6) states that the project will be constructed within open water habitat and State-owned bottom of the lower Great Wicomico River. No jurisdictional wetlands will be impacted by the project. The action may increase turbidity in the project area, but the turbidity should dissipate quickly due to the short duration of construction activities and the shallow depths of the proposed project area.

2. Subaqueous Lands. The "Summary Consistency Determination" (page 2) states that the Corps will obtain a permit from the Virginia Marine Resources Commission for encroachment on state-owned bottom. The EA (page D-7) states that no submerged aquatic vegetation is present within the footprint of the proposed sanctuary reefs and surrounding shellplant areas. The Virginia Institute of Marine Science commented that they concur with the plan in general and encourage the adoption of mitigation measures identified as necessary during the permit process. The Northern Neck Planning District Commission states that the long term benefits derived from the construction of native oyster reefs outweighs any short-term, negative impacts from the reef construction. ·

3. Natural Heritage Resources. The (EA (Appendix B) includes correspondence with the Department of Conservation and Recreation (DCR). The Department of Conservation and Recreation (DCR) has searched its Biological and Conservation Data System (BCD) for occurrences of natural heritage resources in the project area. Natural heritage resources are defined as the habitat of rare, threatened, or endangered animal and plant species, unique or exemplary natural communities, and significant geologic communities. In their letter (February 27, 2003), DCR states that the BCD documents the presence of the federally threatened Northeastern beach tiger beetle at the project site. They recommend coordination with the U.S. Fish and Wildlife Service and that permit issuance be contingent upon the results of the coordination. If the U.S. Fish and Wildlife Service requests a survey of the project area, contact J. Christopher Ludwig, Natural Heritage Inventory Manager at (804) 371-6206 to discuss arrangements for field work.

***4. Wildlife** Resources.* The EA (Appendix B) includes correspondence with the Department of Game and Inland Fisheries (DGIF). Under Title 29.1 of the Code of Virginia, DGIF is the primary wildlife and freshwater fish management agency in the Commonwealth. DGIF has full law enforcement and regulatory jurisdiction over all wildlife resources, inclusive of state and federally endangered or threatened species, but excluding listed insects. The letter (February 13, 2003) from DGIF to the Corps states that given the scope of the project additional coordination with DGIF and the Department of Agriculture and Consumer Services is necessary (See "Regulatory and Coordination Needs," item #4 below).

5. Solid and Hazardous Wastes. The EA (page D-14) states that the proposed project is not located near any documented Superfund sites. The DEQ-Waste Division states that the EA addresses hazardous waste issues and sites but does not address solid waste. The Waste Division did a cursory review of its data files and did not find any sites that might impact this project. In addition, the Waste Division states that the EA should have included a discussion of sediment disturbance during shell harvesting and shell planting in order to address the issue of possible contaminated sediments in the James and Elizabeth Rivers.

6. Wild and Scenic Rivers. The Department of Conservation and Recreation indicates that the proposed project will not affect any streams on the National Park Service's Nationwide Inventory, Final List of Rivers, potential Scenic Rivers or existing or potential State Scenic Byways.

Regulatory and Coordination Needs

J. Water Quality. Please contact the DEQ-Piedmont Regional Office for information on the Virginia Water Protection Permit Application process (telephone (804) 527-5020).

2. Subaqueous Lands. A permit from the Marine Resources Commission may be required for construction of the oyster reefs. For further information on the status of your application, contact the VMRC at (757) 247-2200.

3. Solid and Hazardous Waste. Any soil or sediment encountered during site activities that is suspected of contamination must be tested and disposed of in accordance with applicable federal, state and local laws and regulations. Should contamination be discovered, please contact the Piedmont Regional Office of the DEQ at (804) 527-5020. Also, all solid waste, hazardous waste, and hazardous materials must be managed in accordance with all applicable federal, state, and local environmental regulations.

4. Wildlife Resources. To ensure compliance with protected species legislation, coordinate the project with the Department of Game and Inland Fisheries (Brian Moyers, telephone (804) 367-6913) and the Department of Agriculture and Consumer Services (Keith Tignor, telephone (804) 786-3515.

5. ***Historic Resources.*** In the event that unidentified archaeological undeiwater resources are discovered, the Corps must cease project activities immediately and contact the Department of Historic Resources (Ethel Eaton, telephone, (804) 367-2323, ext. 112).

6. Federal Consistency. Pursuant to the Coastal Zone Management Act of 1972, as amended, federal activities with reasonable foreseeable effects on coastal uses and resources must be constructed and operated in a manner that is consistent, to the maximum extent practicable, with the VCP. Based on the information provided in the consistency determination that the applicant would obtain and comply with all applicable permits and approvals listed under the enforceable policies of Virginia's Coastal Program and comments received from agencies administering the enforceable programs, we concur with the finding that this proposal is consistent with the VCP. However, other state approvals, which may apply to this project, are not included in this response. Therefore, the Corps must ensure that this project is constructed in accordance with all applicable federal, state, and local laws and regulations.

Thank you for the opportunity to review the Environmental Assessment and Consistency Determination. Detailed comments of reviewing agencies are attached for your review. If you have any questions, please contact Anne Newsom at (804) 698-4135.

Sincerely,

Ellie Irons
Program Manager
Office of Environmental hnpact Review

Enclosures

Cc: Martin Ferguson, WPS
Mark Alling, DEQ-PRO
Kotur Narasimhan, DEQ-Air
Tom Modena, DEQ
Derral Jones, DCR
Brian Moyers, DGIF
Keith Tignor, VDACS
Tom Barnard, VIMS
Tony Watkinson, VMRC
Ethel Eaton, DHR
Jerry Davis, NNPDC

Review Instructions:

A. Please review the document carefully. If the proposal has been reviewed earlier (i.e. if the document is a federal Final EIS or a state supplement), please consider whether your earlier comments have been adequately addressed.

B. Prepare your agency's comments in a form which would be acceptable for responding directly to a project proponent agency.

C. Use your agency stationery or the space below for you comments. If **you use the space below, the form must be signed and dated.**

Please return your comments to:

Ms. Anne B. Newsom
Dept. of Environmental Quality
Office of Environmental Impact Review
629 East Main Street, Sixth Floor
Richmond, VA 23219
Fax: (804) 698:.4319

RECEIVED

APR 2·9 2DDJ

DEQ{Jff,ceof EnVironmenlal Impact Review

Amie B. Newsom
Environmental Program Planner

Comments:

VWPP: The report states that no wetlands will be impacted as part of the proposed project. Contact the DEQ Piedmont Regional Office regarding final permit determination. (SB)

VPDES: No comments.

Name: Martin Ferguson

Date: April 29, 2003

Signature:

Title:

Agency: DEQ - Water Permits Support

Project: 03-061F

Electronic Version Revised: 7/2002

construction projects and facilities to implement pollution prevention principles, including the reduction, reuse, and recycling of all solid wastes generated.

If you have any questions or need further information, please let me know.

Newsom,Anne

From: Synthia Waymack [swaymack@dcr.state.va.us]
Sent: Monday, April 28, 2003 8:48 AM
To: Newsom.Anne
Subject: Re: Due Date Correction, DEQ # 03-061F

Anne,
OCR submitted comments on this oyster restoration project to the Norfolk District in February 2003.
A copy of our letter is included in the Environmental Assessment (EA).
At this time, we have no additional comments to offer.
Thank you for the opportunity to offer comments on the EA.
Have a nice week,

Synthia Waymack
Environmental Review Coordinator
Department of Conservation and Recreation
swaymack@dcr.state.va.us <mailto:swaymack@dcr.state.va.us>

If **you cannot meet** the **deadline, please notify ANNE B.NEWSOM at 804/698-4135 prior to the date given. Arrangements will be made to extend the date for your review** if **possible. An agency wi]l'J!h8c!'\.'ledW1 not be considered to have reviewed a document** if **no commen U!lli,j1M1::no [11]n-rr10 received (or contact is made) within the period specified.**

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REVIEW INSTRUCTIONS:

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A. Please review the document carefully. If the proposal has been reviewed earlier (i.e. if the document is a federal Final EIS or a state supplement), please consider whether your earlier comments have been adequately addressed.

B. Prepare your agency's comments in a form which would be acceptable for responding directly to a project proponent agency.

C. Use your agency stationery or the space below for your comments. **IF YOU USE THE SPACE BELOW, THE FORM MOST ;BE SIGNED AND DATED.**

Please return your comments to:

MS. ANNE B. NEWSOM
DEPARTMENT OF ENVIRONMENTAL QUALITY
OFFICE OF ENVIRONMENTAL IMPACT REVIEW
629 EAST MAIN STREET, SIXTH FLOOR
RICHMOND,VA 23219
FAX #804/698-4319

- -- 4-AA)

ANNE B. NEWSOM
ENVIRONMENTAL PROGRAM PLANNER

COMMENTS

No effect on historic properties. However, in the event that unidentified archaeological resources (underwater) are discovered during implementation of this project, please ~~notify~~ cease work & notify the DHR immediately.

(signed) ______________________ (date) __________

(title) ______________________

(agency) ______________________

PROJECT #03-061F 8/98

RECEIVED

NORTHERN NECK
PLANNING DISTRICt'PR 2 2 2003
COMMISSION DEO-Off:te of EnvironmentiA Imp3ctReview

P. O Box 1600, Warsaw, Virginia 22572
Telephone: 804/333-1900 Fax: 804/333-5274

April I8, 2003

Anne B. Newsom
Department of Environmental Quality
Office of Environmental Impact Review
629 East Main Street, Sixth Floor
Richmond, VA 23219

RE: Environmental Assessment 03-06IF: Chesapeake Bay Oyster Recovery Project, Phase II, Great Wicomico River, Virginia

Dear Ms. Newsom:

After review of the **Environmental Assessment 03-061F: Chesapeake Bay Oyster Recovery Project, Phase** II, **Great Wicomico River, Virginia,** the Northern Neck Planning District Commission concurs that the short term negative impacts on the aquatic ecosystem from reef construction are more than offset by the long term positive impacts that this project would produce. Replenishment of native oyster reefs is essential to improving water quality, and clarity in the Chesapeake Bay and its Tributaries.

Sincerely,

/erry W. Davis, AICP
Executive Director

Schulte, David M NAO02

From: Keith Tignor [ktignor@vdacs.state.va.us]
Sent: Monday, May 19, 2003 3:59 PM
To::.· Schulte, David **M**
Subject: Re: USACE-VMRC Oyster restoration project in Great Wicomico River, VA

Dave,

To date, Virginia Department of Agriculture and Consumer Services records indicate that no state-listed threatened or endangered plant or insect species have been documented in the project areas indicated on the map you provided. We do not anticipate significant adverse impacts upon plant or insect species under our jurisdiction to result from this project.

As discussed during our telephone conversation, several populations of the Federal-listed Northeastern beach tiger beetle, Cincindela dorsalis dorsalis, occur on beaches near the project. The off-shore activities of this project should not affect these population. However, if you have not already done so, you should contact the U.S. Fish and Wildlife Service office in Gloucester, VA, for a definitive determination of the project's influence on these populations.

Sincerely,
Keith Tignor
State Apiarist/Endangered Species Coordinator

VA Department of Agriculture and Consumer Services
Office of Plant and Pest Services
P.O. Box 1163
Richmond, VA 23218

Phone: (804) 786-3515
Fax number: (804) 371-7793
Website: www.vdacs.state.va.us

COMMONWEALTH *of* VIRGINIA

DEPARTMENT OF TRANSPORTATION
1401 EAST BROAD.STREET
RICHMOND, VIRGINIA 23219-2000

PHILIP A. SHUCET
COMMISSIONER

EARL T. ROBB
STATE ENVIRONMENTAL ADMINISTRATOR

April 24, 2003

Mr. Mark T. Mansfield
Department of the Army
Norfolk District, Corps of Engineers
Fort Norfolk
803 Front St.
Norfolk VA 23510 - 10096

Dear Mr. Mansfield:

The Virginia Department of Transportation has reviewed the information provided for the proposed Great Wicomico River Oyster Recovery Project. Our review covers impacts to existing and proposed transportation facilities.

The proposed project will not adversely impact the existing or future transportation system.

Thank you for the opportunity to comment and please call (804) 786-6678 should you have any additional questions.

m

David Grimes
Environmental Specialist II
VDOT
1401 East Broad St.
Richmond, VA 23219
804-786-6678 - 0
804-786-7401 - FAX

ENVIRONMENTAL ASSESSMENT
APPENDIXD

PERMITS/WAIVERS

APPENDIXE

SUPPORTING DOCUMENTATION

COMMONWEALTH *of* VIRGINIA

W. Tayloe Murphy, Jr.

Secretary of Natural Resources

Marine Resources Commission

2600 Washington Avenue
Third Floor
Newport News, Virginia 23607

William A. Pruitt

Commissioner

July 28, 2003

Mr. Doug Martin, Project Manager
U.S. Anny Corps of Engineers, Norfolk District
803 Front Street
Norfolk, VA 23510-1096

Dear Mr. Martin:

Your project team has been working with staff of the Virginia Marine Resources Commission and Virginia Institute of Marine Science concerning two issues; (1) development of a decision document supporting the construction of oyster habitats in the Chesapeake Bay as authorized by Section 342 of the Water Resources Development Act 2000, Public Law 106-541, and (2) a project for the construction of oyster habitats at the Great Wicomico River as authorized by the same authority.

The purpose of this letter is to express the Commonwealth of Virginia's intent to participate in the development of the decision document and to cost share in the construction of the oyster habitat project mentioned above subject to our review and concurrence of a Project Cooperation Agreement.

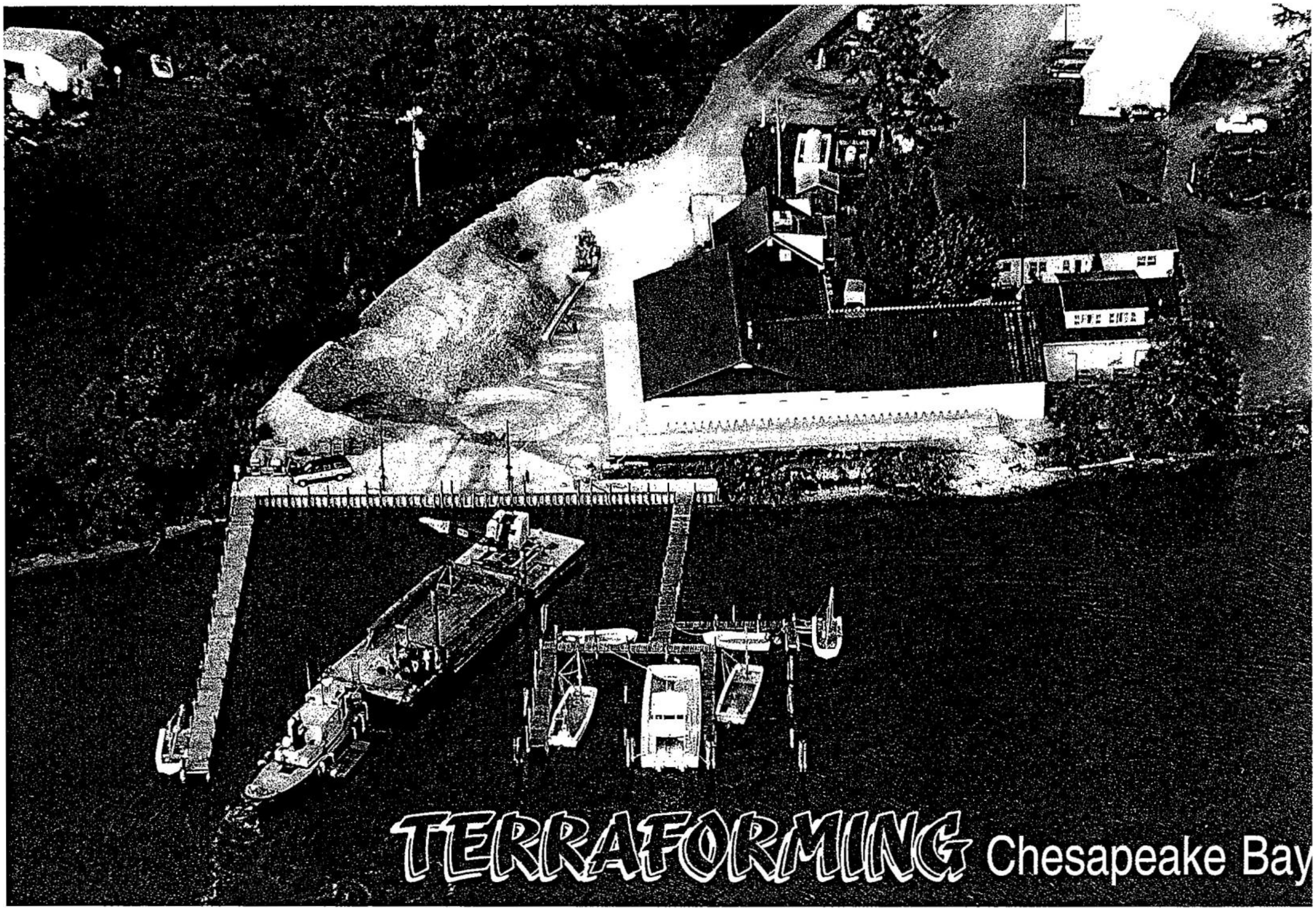
Thank you for your continued support of the Chesapeake Bay Oyster Restoration Program.

Sincerely,

/J t!

William A. Pruitt

WAP:jw
cc: Jack Travelstead
James Wesson
Jane McCroskey
VIMS



By Standish K. Allen, Jr., Robert Brumbaugh, & David Schulte

Conditions for success

"Set the conditions for success." These were the marching orders of Col. David "Hurricane" Hansen, District Commander of the U.S. Army Corps of Engineers in Norfolk, as he prepared his staff for a new assault in the war on oyster diseases. Now, through an extraordinary collaboration among the Virginia Institute of Marine Science (VIMS), the U.S. Army Corps of Engineers (USACE), the Virginia Marine Resources Commission (VMRC), the Chesapeake Bay Foundation (CBF), the Virginia Seafood Council (VSC), and the oyster industry in general, an ambitious 10-year plan is on the table to restore oysters in the bay. There is little doubt that an effort of this magnitude is required if we want our native oyster back: This season will be the worst on record for Maryland harvests, approaching the dismal numbers that Virginia has seen for the past decade.

Authored by the USACE, the plan is scheduled to begin in 2003 with an ambitious escalation of effort over the next decade. Of course, oyster restoration and reef building efforts are not new. The VMRC (with funds and support from the Virginia Coastal Program), CBF, and VIMS have had active programs to construct, stock, and monitor sanctuary reefs for nearly a decade. What is outstanding about this new effort is the degree of coordination among partners and the potential for applying new federal funds to a large, totally integrated plan to give oysters the maximum opportunity for a successful comeback.

The plan focuses upon two primary objectives: (1) increase oyster biomass to restore the ecological functions they provide; and (2) promote disease resistance within such oyster populations. It is fair to say that if we were simply trying to restore oysters without interference from diseases, we would be well on our way to achieving the 2010 goal of increasing biomass ten-fold. In fact, there is evidence that in some smaller, restricted areas, oysters have responded to restoration ai:tempts by re-populating adjacent shores. In general, however, attempts to date have failed to make significant progress at a scale necessary to restore cer_tain ecological functions oysters provide to the bay-and necessary to revitalize the oyster industry. To restore the entire baywide oyster population, and thus turn the devastated oyster fishery around, however, is a formidable task that requires significant financial resources and a long-term commitment from stakeholders. It's an effort that deserves the term, "terraforming," or designing and engineering the reefs as well as the oysters.

To those involved in oyster restoration, it seems pretty clear how to increase biomass. The initial step involves restoring habitat to allow oysters to colonize, aggregate, and reproduce. These activities have been at the core of previous attempts, but in many cases have yielded only short-term successes. For example, in 1996, thousands of bushels of Tangier oysters were transplanted to a reef system in the Great Wicomico River. Over the ensuing spawning season, this artificial aggregation of large adults generated a "wrap-up" set, populating the reef anew as well as surrounding areas where substrate was available. Stocking reefs seems to be critical in the overall strategy for increasing biomass due to low adult oyster population densities in most areas. Significant sets also have accompanied oyster reef construction and seeding of juvenile oysters by CBF in the Ly,rinhaven, Elizabeth, and Lafayette rivers. Aggregation and reproduction, in fact, are the mechanisms by which oysters maintain population size.

In a natural system, reproduction is usually so successful that oysters compete with each other for space and other resources in a race for survival of the fittest. In the case of the Chesapeake Bay today, however, that race for survival is ag st diseases, not other oysters. The ultimate effect on new recruits (as new oyster set are called) is rapid mortality, with barely enough adults surviving to reproductive size to breed again. Simply put, they die too soon at the hands of disease to propagate and sustain their biomass. This is what happened in the Great Wicomico River.

· Promoting disease resistance in oysters is not as straightforward as simply building sanctuary reefs - a cornerstone of Virginia's restoration programs for some time. Indeed, broadening the restoration effort to include large-scale stock enhancement for the purpose of developing disease resistance is a significant departure from previous restoration efforts. Disease resistance is one of the most sought-after traits in all of agriculture, and more recently, aquaculture. In agriculture, significant efforts have been made to produce disease-resistant and herbicide-resistant varieties by selective (artificial) breeding and genetic modification (gene transfer). At the Aquaculture Genetics and Breeding Technqlogy Center (ABC) of the VIMS, selection for disease resistance in oysters and clams is ongoing, although through selective breeding techniques only (see *v'MRB,* Vol. 33, No. 3).

The advantages of developing disease-resistant crops - in this case, oysters - are apparent. They would survive longer and potentially make aquaculture of the C. *virginica* oyster commercially feasible. Less clear is the success that artificially selected, disease-resistant oysters will realize on reefs where · populations are less controlled and at the mercy of natural, climatological and ecological events. In fact, propagating domesticated lines of oysters to produce seed for planting on newly created reefs seems a bit artificial for restoration, given that restoration normally strives to obtain a *natural* outcome. Yet planting *disease-susceptible* oysters seems futile, so disease-resistant oysters have been selected for use in public oyster restoration programs like those sponsored by Maryland's Oyster Recovery Partnership (ORP) and CBR So far, resistant oysters have found homes in the Lynnhaven, Lafayette, Great Wicomico and Piantatank rivers, but still on a relatively small scale.

Genetic rehabilitation

The role of disease-resistant strains in restoration was discussed during a workshop held by ABC in the fall of 2000. Two conclusions from the workshop are notable. First, there seems little value in conducting such restoration programs in the Virginia portion of Chesapeake Bay based primarily on hatchery production from wild brood stock. In Virginia, where disease pressures are acute, oyster longevity becomes a formidable challenge. Stocking wild seed produced in the hatchery has the undesirable effects of both constraining genetic variation as well as multiplying disease-susceptible brood stock.

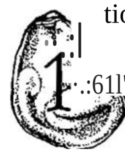
A second notable conclusion of the workshop was the recognition that, having suffered a number of assaults over the last 50 years, wild oyster populations, were deemed in need of rehabilitation through the use of disease-resistant strains. At this point in time, it's an act of faith that the upside of disease resistance in selectively bred stocks outweighs the downside of decreasing genetic variability through hatchery propagation.

In all systems but the most de-populated, disease-resistant seed used for restoration will eventually lead to hybridization with wild populations. The desired outcome of hybridization is introgression (a form of genetic assimilation) of disease-resistant genes into the natural population. Introgression will have a positive benefit if it contributes to the fitness of oysters in subsequent generations; specifically, disease resistance, which will presumably give rise to increased longevity and higher fecundity. Despite limited understanding of the overall dynamics of genetic rehabilitation, or even its prognosis for success, there was a sense of congruence in the workshop that the so-called wild oyster was in a downward spiral and that trial implementation of a genetic rehabilitation strategy, with selective breeding at its core, was warranted.

. The USACE plan fully embraces the concept of genetic rehabilitation and focuses on the logistical details of implementing it in the lower Chesapeake. The logistics are staggering and only possible to overcome through collaborative means. Of course, work only progresses as federal funds, matched by non-federal state and private resources, can be brought to bear on the problem.

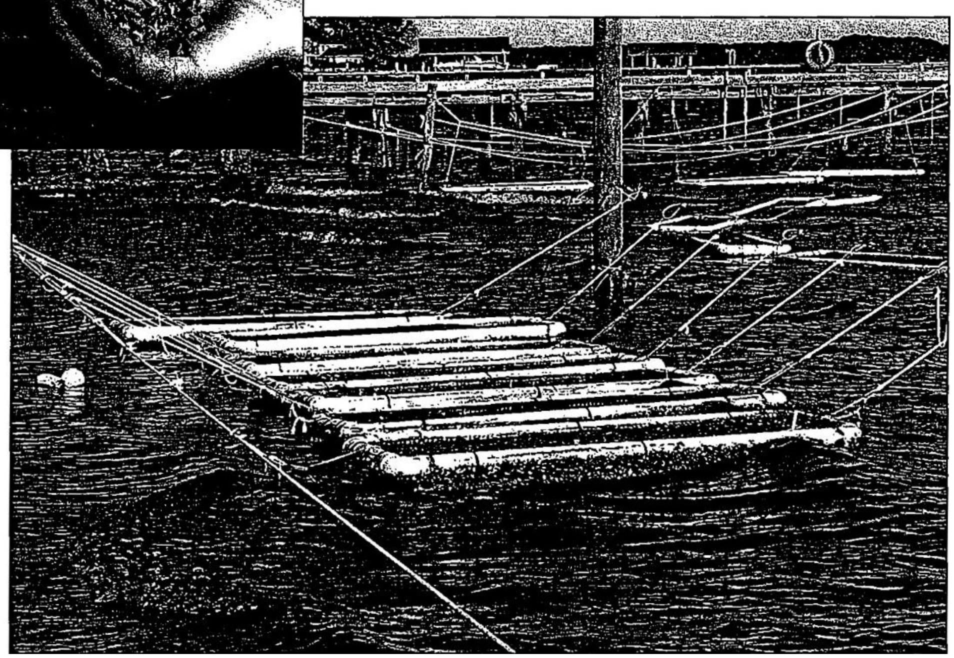
The calculus of biomass accretion

In a genetic rehabilitation strategy, hatcheries will take a primary tole in boosting specific stocks with disease resistance. However, at present there are serious limitations on the extent to which disease-resistant strains can be amplified through hatchery propagation; for example, magnified from a few hundred brood stock to a few hundred million or even billions of spat that might be required for "jump starting" populations throughout the lower estuary. It's necessary to conceptualize the amplification of biomass needed for restoration as a step-wise process (see page 7).



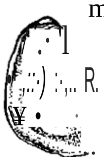
The process begins when superior brood stock developed in a controlled breeding program is selecteq for propagation at the breeding station. At this point in time, that breeding station is the ABC hatchery at Gloucester Point. Because it is a research hatchery, a limited number of seed oysters can be produced, and an even more limited number of brood stock can be maintained to adulthood. Nonetheless, expanding from a hundred select brood stock to perhaps 10,000 or so disease-resistant oysters (a total derived from all resistant lines currently under development) is realistic - and represents a hundred-fold amplification.

At present, 6 or 7 disease-resistant strains are under development. Two have been released to hatcheries over the last few years, the so-called Haskin CROSBreed™ and Andrews DEBY™ lines.



Parental strains of disease-resistant oyster are propagated and raised at the oyster farm at VIMS.

These represent decades of effort. The other lines under development have specific attributes, such as • Dermo disease resistance imported from Louisiana oysters that were interbred with our own. The process of selective breeding is continuous, but the methods and starting populations necessary for genetic rehabilitation are available today.



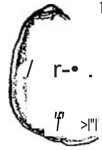
The second step involves amplification of the disease-resistant brood stock in commercial, public, or public-private hatcheries. This is accomplished by the release of brood stock to hatcheries for spawning and propagation. At present there are a few commercial hatcheries in place to perform this step. It is likely that more capacity is needed, because from the thousands of brood stock that would be available for release, there may be enough demand among oyster restoration partners for 100,000,000 seed. This represents a 10,000-fold increase in biomass over what was received as brood stock

Seed produced from the hatchery will need to be nurtured to a size adequate to be put onto artificial reefs, constructed by the USACE, VMRC, or other groups. The USACE is presently the lead agent for reef construction because of the release and likely continuation of federal funds allocated for this purpose. There is still a running debate about the most appropriate way to set and nurture hatchery-produced seed oysters destined for reef planting, centered around the use of cultchless or cultched (spat-on-shell) seed. Cultchless seed is produced when oyster larvae are induced to set as single individual oysters, using tricks such as allowing them to set on tiny shell chips. Cultchless set can be handled with great efficiency and put into artificial upwellers, raceways, or even plastic mesh spat bags. The possible downside of cultchless oysters is that they may become snack food for crabs if they are planted too small - generally considered so at less than 40 mm (about 1½").

Cultched seed is made by allowing larvae in the hatchery to attach to some form of hard material or substrate. Seed produced in this way has the advantage that it initially grows faster and is partially protected from predators by the cultch itself. The best cultch is oyster shell, although other materials have been tried with varying degrees of success. Larval oysters set on the cultch and grow rapidly because they essentially only have to build one shell Moreover, they can be planted when they are about 25 mm (about 1") instead of 40 mm because surrounding cultch material protects them from predators, and it is more difficult for a crab to manipulate an oyster shell and)Jrey upon the attached spat. The major downside to cultched seed is that bulk handling is necessary for nurturing the seed until it reaches 25 mm. That is, besides the seed, the cultch itself has to be moved several times. Compared to the seed itself, cultch is thousands of times more voluminous.

The decision to use cultchless oysters or spat-on-shell for brood stock enhancement for any given project will be based on the ecological, return for the economic investment. In all likelihood, some of both will find their way onto the terraformed bottom.

One idea that might be considered at this scale is barge culture. Conceptually, the entire process of setting, nurturing, and delivering seed could be accomplished in one efficient step. The idea is to put a retrofitted barge (or fleet of them) into the restoration scheme. A barge would contain bags of shell, stacked in a configuration for receiving eyed larvae - the stage at which they are competent to settle. Oyster larvae are easily transported vast distances at the end of their larval cycle for setting in areas distant from the hatchery, a process called remote setting. Eyed larvae then would be transported to the restoration barge, which would be flooded with water filtered from the bay by onboard filters. (Filtration is necessary to eliminate predators until larvae can settle.) Larvae released into the hopper of the barge would set on the shell after several days. At that point, pumps would engage to keep a constant circulation of raw water flowing over the newly settled spat. The spat would grow in the barge to the appropriate size for planting. Finally, the barge could be towed to the reef site and dumped directly onto the ree£ The economics of this idea need tobe considered, because the logistics are potentially elegant.



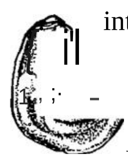
The seed amplified by hatcheries and purchased and nurtured by nurseries will ultimately be planted on artificial reefs. In this new approach of coupling broodstock enhancement with genetic rehabilitation, the first reefs the young oysters are bound for are called "incubator reefs." This is where some of the most important science in reef restoration comes in, relying on the . Institute's long-standing expertise. Sites for incubator reefs are intentionally chosen in water bodies known as trap estuaries, where larval recruitment is generally retained within the system. Estuaries that act as traps include the Great Wicomico River, Piankatank River, and Lynnhaven River, among others. Several of these systems are well studied and will be employed for the genetic rehabilitation strategy.

By stocking incubator reefs with disease.:resistant seed from commercial or public hatchery programs, the rivers become places where distinct strains of oyster are amplified in situ. An incubator reef becomes, in effect, a "natural hatchery" based within a natural system. One advantage of using natural systems in this way is their capacity for providing enormous numbers of next-generation oysters from selected stocks through so-called wrap-up sets in the surrounding estuary. A disadvantage of natural systems is that they are far less predictable than man-made hatcheries. Nonetheless, the potential exists for incubator reefs to accomplish the next round of amplification of disease-resistant stocks.

For genetic rehabilitation, areas surrounding the incubator reefs must be managed by placement of 2-dimensional reefs of fresh cultch material to catch the set. If successful, this round of biomass amplification will take us from millions of hatchery seed to hundreds of millions of natural hatchery seed, or perhaps more depending on Mother Nature.

Just as in step two, step three provides an economic opportunity for participation by the commercial oyster industry. Two-dimensional reefs built around incubator reefs to catch seed could be privately or publicly held. Either way, the attached seed are useful for the next step in the process. When they reach suitable size, they can be harvested and used to plant additional reefs located in other rivers, creeks, or the main stem of the bay. No need for the cultch versus cultchless debate here. This approach is an obvious way to obtain very large quantities of oysters set on cultch if genetic rehabilitation, with nature's help, works as intended. Taking up seed and moving it throughout the bay is an activity that commercial oystermen have been doing for generations. Essentially, instead of planting oysters for eventual harvest and sale to restaurant;s and shucking houses, watermen will be planting them for genetic rehabilitation. In this scheme, they will be paid for their work immediately instead of moving seed on speculation for later harvest - an activity that recently has been extremely unprofitable. Initial estimates of payment for this work range around $12 per bushel.

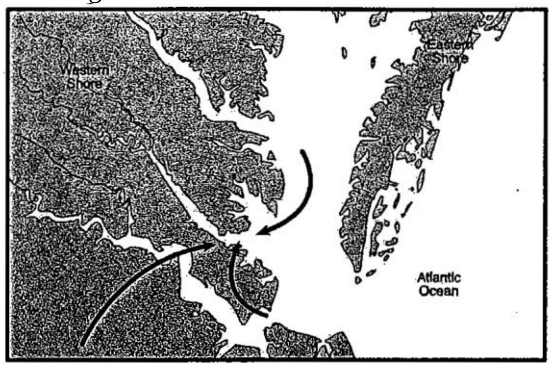
One intriguing potential for using incubator reefs has to do with the way they could be managed over the long haul. First, only a few incubator reef systems are needed because it is the seed *from* these reefs that will become the bulk of the planting programs for reefs that are built in other parts of the bay. Second, a series of incubator reefs located in specific tributaries could be managed separately for propagating distinct genetic stocks. for example, one might be managed for a disease-resistant stock that excels in Dermo resistance but not MSX. Seed from that reef could be used for one particular zone of the bay. Seed from another strain that might be more suitable for dual disease resistance could be used for another zone of the bay, and so on. In this way, costly seed produced in hatcheries (step 2) would be more appropriately applied to the more predictable incubator reefs and not the less predictable ones in the main stem of the bay. For the immediate future, it seems wise to plan on stocking incubator reefs continually with hatchery seed to best assure the constant flow of disease-resistant seed from these trap systems. Additionally, superior strains of disease-tolerant native oysters are likely to be developed in the future. Continual stocking will be necessary to incorporate these more robust genes into the native oyster population.



The final step in genetic rehabilitation is the movement of seed from the perimeter of incubator reefs to other, newly built reefs located in larger systems like Tangier and Pocomoke sounds or the lower Rappahannock River, where we are less certain about the circulation patterns and retention of spat. Presumably, a steady flow of seed from the incubator reefs will repopulate these reefs with disease-resistant progeny, interbreed with wild to make a more fit oyster, or hopefully, both. Ultimately, it is hoped that the reefs in these larger systems also will become productive and contribute more hearty seed to surrounding areas through higher oyster reproduction within those systems, us completing the final phase of genetic rehabilitation. In this step, oyster stocks would grow from hundreds of millions to billions.

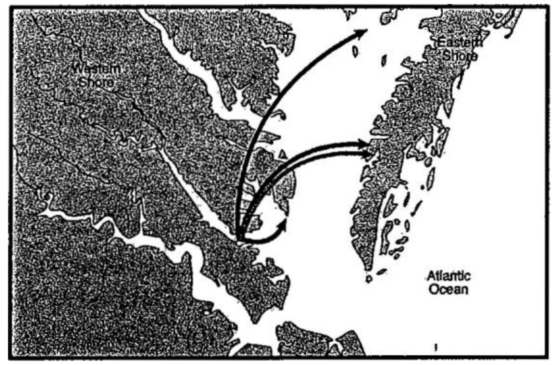
Six-step Program for Genetic Rehabilitation of Oysters

Breeding



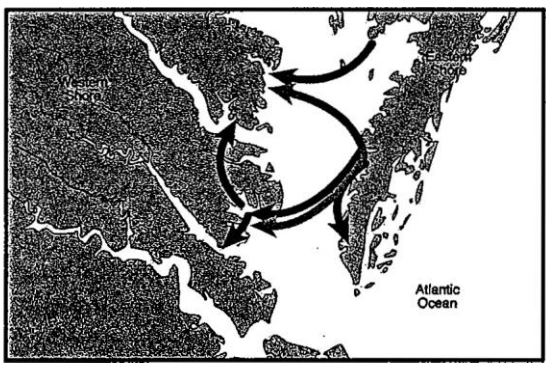
1) Natural stocks or varieties already developed are housed, selected, and propagated at the ABC Gloucester Point hatchery.

Brood Stock Distribution



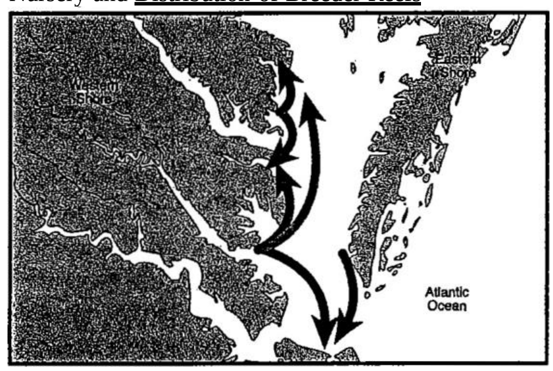
2) Select brood stock are distributed to commercial hatcheries for raising seed.

Seed Sales



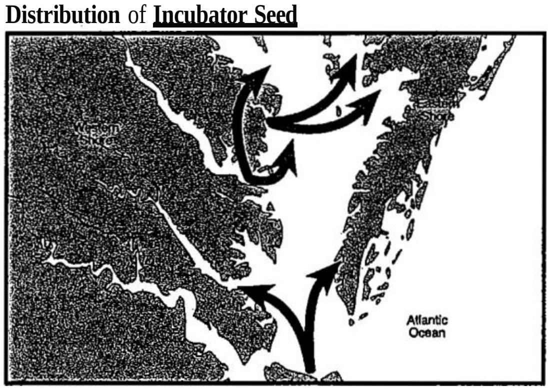
3) Seed raised at hatcheries is too small/or deployment on reefs and must be distributed to commercial nurseries.

Nursery and Distribution of Breeder Reefs



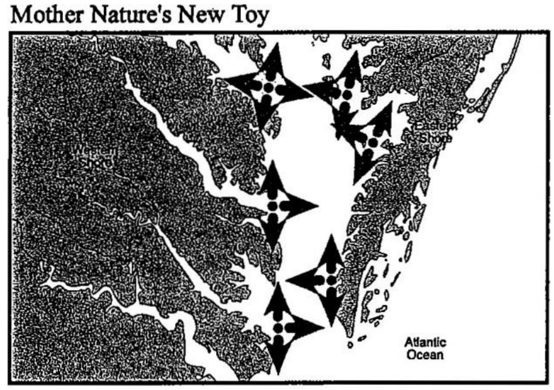
4) Once the seed obtain refuge size, they can be distributed to targeted breeder reefs. Each reef receives only one strain.

Distribution of **Incubator Seed**



5/ Once spawning and settlement from breeder reefs have occurred, the new generation of seed can be harvested and moved to larger reef assemblages by the industry.

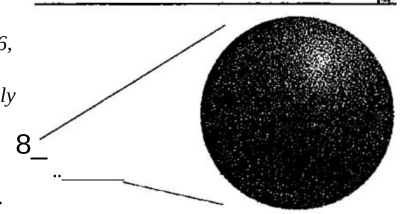
Mother Nature's New Toy



6) At this point, it is Mother Nature's role to distribute, via larval dispersal, the enhanced stocks to surrounding areas.

Note: Arrow colors represent different lines of oysters.

Between Step I and Step 6, the volume of oyster biomass increases roughly the equivalent to the comparison between a golfba/1 and a 12-foot-diameter sphere.



Overall, starting with the few hundred selectively bred brood stock distributed to hatcheries in step 1, we (hypothetically) have amplified the number of oysters by about six orders of magnitude - that is to say, one-million-fold! In fact, the figure on page 7 illustrates the actual scale of this increase - from golf-ball size to a 12-foot-diameter sphere. The final step depends primarily on nature, and accounts for 90% of the gain in this process. Yet, billions of oysters in the bay is not an unrealistic expectation based upon what researchers believe must have been out there at one time. Even now, at what many would consider the nadir of oyster resource in the bay, the standing stock in Virginia may range from about 5 billion to as many as 600 billion, although scientists contend that almost 80% of those are below market size (!6 mm, or 3").

Summary

Through new federal funding initiatives, the USACE in collaboration with many partners has been given the opportunity to "terraform" the bay. An integrated plan involves the expertise of nearly all constituent groups. Perhaps most importantly, there is ample opportunity for the commercial sector to be involved in the process. Llke any big picture idea, it will be essential to keep all elements working together with an appropriate dedication of resources to the project.

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See page 21 for references cited.

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Parallels

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·We need to bring in the right stocks of non-natives (or "select" the right stocks of natives).

·We still have to use hatcheries as the first amplification step.

·We still have to nurse either species to a size that predators won't devastate them – past hors d'oeuvre size for crabs.

·We still need to seed reefs that are built in strategic locations to foster

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Differences

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Chesapeake Bay Oyster Restoration

Consensus of a Meeting of Scientific Experts
Virginia Institute of Marine Science
Wachapreague, Virginia

"The abundance of oysters is incredible. There are whole banks of them so that the ships must avoid them. They surpass those in England by far in size, indeed they are four times as large."

Francis Louis Michel
after a visit to Virginia in 1701

Chesapeake Research Consortium
June 1999

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Produced by

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Executive Summary

A small group of oyster experts from Maryland, Virginia and North Carolina met at the Virginia Institute of Marine Science Eastern Shore Laboratory, Wachapreague, VA on January 18, 1999 to recommend measures to restore and protect the oyster resource of the Chesapeake Bay.

Restoration Philosophy

- The goal for Chesapeake Bay oyster restoration should be to restore and manage oyster populations for their ecological value in such a way that a sustainable fishery can exist while maintaining the essential ecosystem functions of oyster reefs.

Protection Philosophy

- The oyster fishery should be managed regionally based on stock assessments.
- Proper disease management means minimizing, or even prohibiting, movement of infected oysters.

Essential Components of Oyster Restoration Efforts

- Three-dimensional reefs, standing substantially above the bottom, are essential for oyster reproductive success, for predator protection and to create habitat for other organisms.
- Permanent reef sanctuaries permit the long-term growth and protection of large oysters that provide increased fecundity and may lead to development of disease resistant oysters.
- For success, both components, three dimensional reefs as permanent sanctuaries, are necessary; neither component alone w.ill be sufficient.

Reef Siting and Design

- Sanctuary reefs must be placed on hard bottom in areas of natural spatset. Three-dimensional structure equa to at least one-half the water depth is recommended.
- Adult oysters may need to be added to reefs to "jumpstart" recruitment.
- Oyster shell is a limiting resource in all areas and availability may affect recruitment around reefs.

Goals

- Long-term goals are to set aside and restore 10% of historic productive oyster reef acreage for its habitat and ecological value and to restore a sustainable public fishery that would not require additional public momes.
- Short-term goals are to increase spatset, increase the number of adult oysters and to increase habitat and fish utilization of that habitat in tributaries where reef sanctuaries have been established.
- Intermediate goals (4-8 years) are to demonstrate the effectiveness of reef sanctuaries in selected tributaries in Maryland and Virginia.

The Consensus

Restoration Philosophy

Overfishing in the late 1800s and early 1900s reduced Chesapeake Bay market oyster landings from a peak of about 24 million bushels in 1887 to a more-or-less steady state of about 5 million C'ushels by 1930. This high harvest pressure also mined the oyster reefs themselves, greatly reducing the reef habitat in the Bay. In the last four decades two protozoan diseases (MSX disease caused by *Haplosporidium nelsoni* and Denno disease caused by *Perkinsus marinus)* have combined to further reduce oyster populations throughout Chesapeake Bay to about 1% of historical levels.

Restoration and proper management of oyster populations in the Chesapeake Bay are critical, but we must move away from the concept of restoring and managing oysters strictly to support an industry. The primary impetus for oyster restoration should be because their filter-feeding lifestyle is an important ecological component in the Bay ecosystem and because their reef-building nature provides valuable habitat for oysters themselves and for other organisms. Oysters can improve water quality because they consume phytoplankton that contribute to anoxia in bottom waters and they also reduce suspended particulate matter, thereby improving water clarity and light penetration critical for aquatic plants. Oyster reefs support a diverse macrofaunal community that provides shelter and food for crabs and fish. An increase in oyster reefs will increase habitat and food for other important species in the Bay.

The restoration philosophy must be to restore and manage oyster populations for their ecological value, but in such a way that a sustainable fishery can exist. The restoration philosophy must not be to manage oysters just to support a fishery. Oysters should be managed on a regional basis with regional quotas established for a fishing season based on stock assessments.

Essential Components of Any Restoration Effort

1. Permanent Reef Sanctuaries

There are really two parts to this component-reefs and permanent sanctuaries. It is clear from historical documents that three-dimensional oyster reefs were a dominant feature of the Chesapeake Bay when colonists arrived in t New World. Oyster reefs provide aggregations of oysters that maximize reproductive success and the resulting structure enhances recruitment and growth of young oysters and provides protection from predators. In Chesapeake Bay, oyster densities are currently so low at most historical reef sites that reproductive success is likely low'. Further, the lack of reef structures results in sub-optimal habitat for oyster growth and survival. Three-dimensional reefs are critical for reproductive success, predator protection and, of course, for the habitat they provide for other estuarine fauna.

Permanent sanctuaries are critical for a number of reasons. Pennanent sanctuaries will allow for the development and protection oflarge oysters. It is well documented that fecundity in oysters increases exponentially with length. Thus, a small number of very large oysters can produce many more eggs than a large number of small oysters. In addition, large oysters in disease-endemic areas have a demonstrated ability to survive diseases, a characteristic that is, at least in part, inherited by their offspring. Natural disease resistance has not developed in Chesapeake Bay for two reasons. First, there has been historically a large unselected gene pool in low salinity that diluted any selected gene pool. Second, the fishery harvested all the large oysters that were surviving in disease-endemic areas and that may have been disease resistant. We cannot guarantee that disease resistant oysters will become widespread in the Bay with the protection of large oysters, but certainly disease resistance will never become widespread without the protection of large oysters.

Reef sanctuaries are also critical for habitat and ecological value. The reef structure provides important habitat for myriad organisms that contribute to the overall health of the Bay and provide food for recreationally and commercially important fish and shellfish species. In short, reef sanctuaries contribute to ecosystem restoration. Large oysters may be important for the structural integrity of a reef and it has been documented that a range of oyster sizes, including large individuals, is important for the ecological role of reefs (e.g. nesting sites for small fishes). Reefs must be considered "ecological sanctuaries." Harvesting must not be allowed on reef sanctuaries or the community of organisms important for reef structure and function will never fully develop.

Thus, the combination of restored three-dimensional reefs and permanent sanctuaries is critical to the success of oyster restoration. Restored reefs where harvesting is allowed will be unsuccessful as will sanctuaries alone. It is the combination of the two concepts that is important.

Areas around reef sanctuaries can be managed for harvest. Shells planted around reefs to catch spat can be harvested eventually in place or the small oysters can be moved to other areas for growout and harvest. However, a long-term goal should be to create a sustainable regional fishery and thereby reduce the necessity to move oysters. Properly placed reef sanctuaries will likely reduce or eliminate the need to move oysters for harvest because the reefs will be a source oflarvae that will settle on local harvestable beds.

2. Proper Disease Management

One of the basic tenets of disease management is that infected organisms should not be moved into areas where the disease is not present or is present at lower levels. Much of the spread of Dermo throughout the Bay resulted from moving infected oysters. Managers argue that because Dermo is.now present throughout the Bay it doesn't hurt to move infected seed oysters into low salinity because the disease is already there. However, the historical distribution of Dermo was restricted to the lower Bay and the mouths of major tributaries. Prior to the severe droughts of the late 1980s Dermo was not present in most Maryland tributaries and there is reason fo expect that if rainfall patterns return to normal Dermo will eventually return to its historical range. It is well documented that Dermo is not pathogenic below about 12 ppt, so managers argue that it doesn't make any difference if infected seed oysters are moved to salinities.below that level. However, if a drought occurs Dermo will multiply rapidly, kill oysters and spread to other oysters, thereby perpetuating the disease in the area.

At the very least, a policy must be established against moving any infected oysters into salinities lower than where they set or into areas where disease levels are low. However, there was strong sentiment among most committee members that infected oysters should _not be moved at all.

Issues

There are many other issues involved with the successful implementation of a reconstructed oyster reef sanctuary program. Issues that the committee felt were important are discussed briefly below.

1. **Reef** Siting

Reef sanctuaries should be placed in areas that historically supported productive oyster bars if there has been no subsequent change in hydrography or sedimentation patterns. To be self-sustaining they must be placed on stable, hard bottom and in areas where natural spatset occurs. Ifreefs are to be a source of spat for shell plantings, and for sustainability of the reef itself then salinity, flow regime and basin morphology will be important considerations. Hydrodynamic models or drifter studies will be useful in determining fate of larvae from any proposed reef site.

2. Reef Design Criteria

A reef is defined here as a three-dimensionally-complex biogenic structure that rises substantially from the seafloor. Verticality is critical and reefs should have sufficient vertical relief that recruitment and growth of the reef will outpace sedimentation. Substantial three-dimensional structure equal to at least one-half the water depth is recommended. Historically, some reefs may have broken the surface at low water and the goal should be to reproduce historical reefs to the best of our ability.

The core of the reef may be composed of any substrate that will provide stability to the vertical structure. There should be a veneer of oyster shell or other suitable substrate for spat settlement. The veneer must have a three-dimensional matrix sufficient to allow spat settlement and provide protection for the spat from predators.

Optimal size of reef sanctuaries has not been determined and will likely be dictated by funding constraints. In Virginia, reefs as small as one acre have substantially increased spat set in the surrounding area. An archipelago of small reefs may be more effective than a single large reef.

3. Reef Protection

It is critical that reef sanctuaries be protected from poaching. They should be sited such that enforcement of the sanctuary will be feasible. Community awareness can be important for enforcement so reefs should be sited, if possible, in areas where community oversight can develop.

4. Broodstock Supplementation on Reefs

It will probably be important to add adult oysters to some restored reefs to enhance recruitment to the reef arid to the surrounding area. Large natural oysters can be harvested and aggregated on reefs to enhance fertilization success. This strategy worked successfully in Virginia where large, but scattered, oysters from Tangier Sound were aggregated on a reef in the Great Wicomico River. Spatset on and around the reef increased dramatically the following year. If natural recruitment is low then it may be necessary to add adults to a reef in high density to "jumpstart' recruitment.

Where possible and when available, progeny from genetically selected oysters could be stocked on reefs. There are a number of programs underway to select oysters for a variety of traits including growth in low salinity, fast growth, or disease resistance. These strains will require evaluation for their effectiveness for use on reef sanctuaries.

5. Shellpl:i'nts Around Reefs

An important component of the restoration strategy will be to plant shell around reef sanctuaries to enhance spatset, although the need for shell planting will likely be site specific. Good quality oyster shell is a limiting resource for spatset around reefs in all areas. Shallow buried and fossil shell are currently available, but more emphasis needs to be placed on returning harvested shell to the Bay. After spatfall, the shell could be left in place for future harvest or it could be moved to other areas to develop sanctuaries or for future harvest. The oysters moved to other areas would contribute ecological value until they were harvested. However, as stated above, a long-term goal is to use reef sanctuaries to provide a sustainable regional source of spat to reduce or eliminate the need to move seed oysters.

Siting of shellplants will be important to maximize spatset. Circulation models may help determine current patterns and where best to plant shell.

Restoration Goal

The long-term restoration goal should be to construct and protect a sufficient number of reef sanctuaries bay-wide such that I) habitat and ecological function will be restored, 2) water quality will improve and anoxia will decrease, and 3) a sustainable fishery can exist with no addition of public funds. In lieu of specific data on the required sanctuary area necessary to meet this goal, we recommend that 10% of traditional oyster bar acreage in formerly high-yielding harvest locations be set aside and restored as permanent sanctuaries. As additional data become available it may be possible to refine this estimate.

The short-term goal will be to increase spatset, increase the number of adult oysters, and increase habitat and fish utilization of that habitat in specific tributaries where reef sanctuaries have been constructed.

Over the next four to eight years the intermediate goal should be to demonstrate effectiveness of reef sanctu- aries for ecological improvement in one or two selected tributaries in each state. The tributaries will have to be monitored to evaluate success, using criteria listed above under short-term goals.

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Genetic Considerations for Hatchery-Based Restoration of Oyster Reefs

A summary from the September 21-22, 2000 Workshop

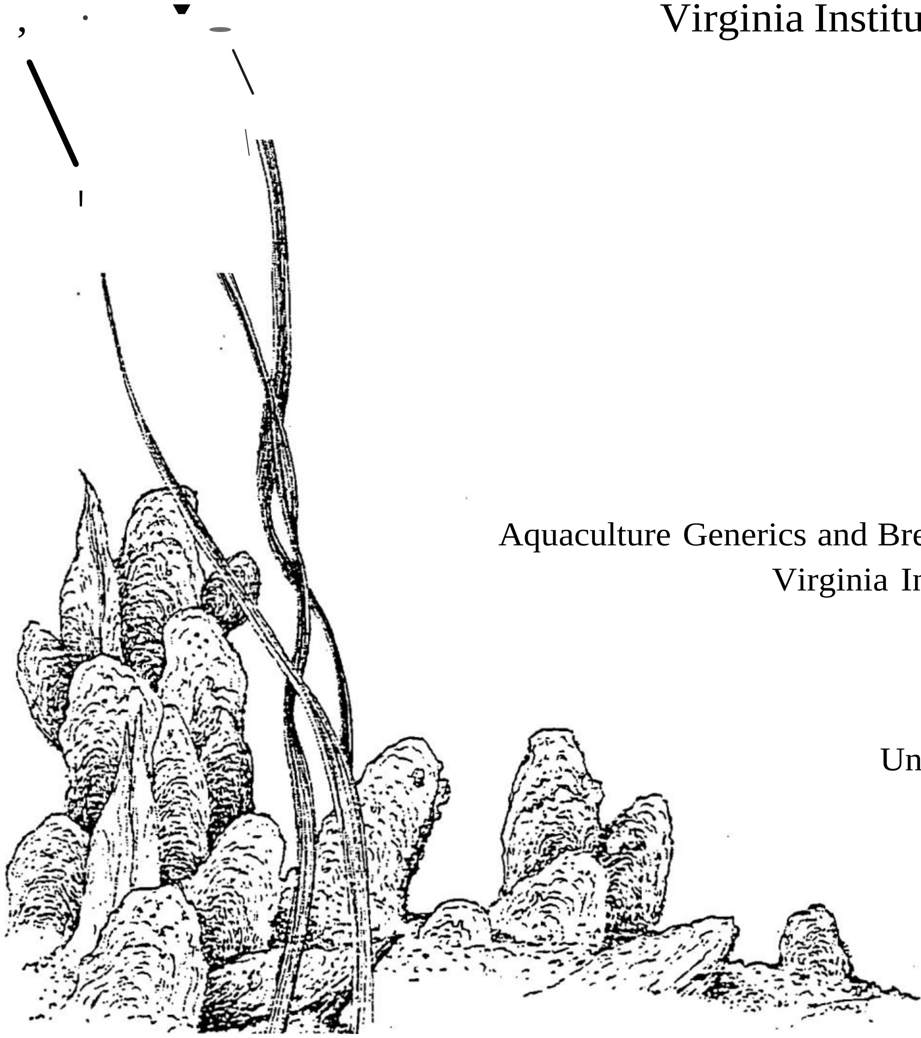
Virginia Institute of Marine !: !:;

,.'\\Aquaculture Genetics and Breeding Technolo;dcs!'n :

Chesapeake Bay Foundation

Chesapeake Research Consortium

Virginia Institute of Niarine Science



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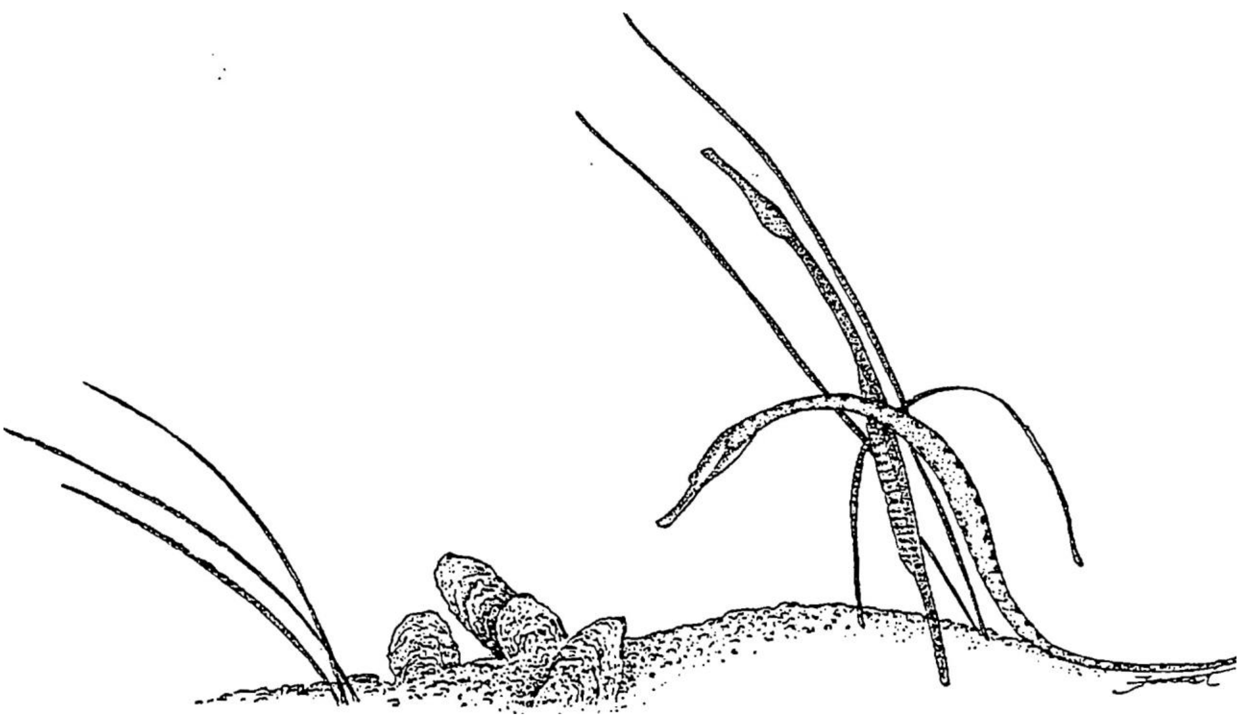
"Genetic Considerations for Hatchery-Based Restoration of Oyster Reefs"

A summary from the September 21-22, 2000 Workshop

The following is a summary of issues and considerations surrounding the use of hatchery stocks for restoration of public oyster reefs. This summary stems from a workshop conducted at the Virginia Institute of l\farine Science (VIlVIS). The original goal of the workshop was to try to develop a consensus, or at least a general agreement, on genetic policy(ies) for stocking oyster reefs. To do this, the first day of the workshop was devoted to placing the genetic concerns "on the table" in the context of both lvfaryland and Virginia oyster replenishment and restoration programs. The conclusions from the first day of presentations revealed that there are a number of scenarios for hatchery-based restoration/ replenishment and that the genetic considerations varied among them. Other genetic considerations were common to the whole Bay. This document summarizes a great deal of discussion, and consequently some detail is omitted.



Main Points and Conclusions

Operating assumptions:

The Workshop members endorse and adopt the principles set forth in the "Chesapeake Bay Oyster Restoration" consensus document (Chesapeake Research Consorti.um, June 1999, 5 pp.). Specific issues addressed in the CRC consensus that are parallel to the genetic considerations of the workshop are as follO\vs:

- Three-dimensional reefs are important for oyster reproductive success and hatchery produced seed can be used to initiate recruitment.
- Reefs stocked v,-ith oysters for the purposes of restoration must be permanent sancruaries.
- The goal of setting aside and restoring 10% of historic productive reef acreage is supported, with the implicit assumption that massive hatchery production may be necessary to accomplish this goal.
- Increased spat set is an implicit outcome to reef stocking programs (a goal in CRC, 1999) and has the consequence of spreading genes from hatchery stocks.
- Demonstrating the effectiveness of reef sanctuary programs (a goal in CRC, 1999) can be realized by monitoring, using genetic markers from hatchery populations.

Consensus points:

- Stocking programs ·will be important for jump starting biogenic potential of newly constructed or depopulated reefs in some areas.
- The diseases MSX and Dermo are a major limitation for development of large, highly fecund spawning stocks throughout most of the Bay, especially the southern, high and moderate ··salinity areas.
- Selectively bred disease-resistant strains may haYe widespread potential for *"genetic rehabilitation"* of southern, highly disease-impacted oyster populations.
- Continued development and use of selected disease resistant stocks is warranted for the purposes of restoration (as well as for use in oyster aquaculture).
- It is appropriate to zone restoration/rehabilitation efforts according to ecological parameters, primarily salinity and disease prevalence.
- Effective population size of wild populations is an essential parameter to predict genetic effects, but is unknO\vn.

Implications for hatchery operation stemming from genetic considerations:

- Use of hatchery stocks for restoration and replenishment will entail careful selection of brood stocks chosen for specific applications, genetic characters (diversity, disease resistance, etc.), or both.
- High effective population size in the hatchery needs to be m.:i.i.ntained through carefully· controlled spawning procedures.
- Amplification of brood stocks for spawning is critical to hatchery operations, and therefore, advance anticipation of the numbers and types of stocks is essential
- Levels of hatchery production today are generally an order of nugnitude or two too low to effectively provide the stocking power needed for restoration/ replenishment.

Descriptive Summary

Conclusions from background presentations:

There are two primary objectives to hatchery supplementation, and these are not mutually exclusive- restoration of functional oyster reefs for their ecological value and restoration of the traditional oyster fishery. Hatchery supplementation to restore functional oyster reefs (as in Virgi.ni2) .requires that .reefs themselves receive sanctuary status to enable recruitment to the surrounding areas for development of a fishery. Supplementation for replenishment (1.e., on public oyster grounds as in Maryland) is "put-and-take." Nonetheless, hatchery supplementation for either purpose engenders long-·te.rm genetic consequences beca e hatchery stocks have signific:i.nt spawning potential before death by harvest o.r disease.

Maryland and Virginia have different problems defined primarily by salinity and responses of oyster populations to Dermo- and MSX-disease during high salinity intrusions. Maryland, by and large, has less need for disease resistant stocks than Virginia does, although in years of high salinity, diseases can cause nujor mortality. Most Virginia waters are constantly subject to one or both diseases.

Areas of the Bay differ dr.:unatically in whether they can retain a self-sustaining population through auto-recruitment. Some areas have documented auto-recruitment (can seed themselves), othe:s are thought to be reasonably well identified, but for most, it is unclear whether they are open or closed and whether they depend on auto- or allo-recruitment.

For generic purposes, the Bay should be divided (zoned) based on salinity characteristics. Further are:is of special interest--especially areas that reuin larvae and are auto-recruiting-should be idenci.fied and set aside as preserves.

Arly restoration effort, for whatever purpose, depends on the av:i.ihbility of suitable habitat. For replenishment, bottom must be prepared. For reef restoration, reefs must be constructed or rehabilitated. If spawning and recruitment are expected, surrounding areas must be prepared accordingly. Therefore, habitat restoration is an essential element of any and all possible programs.

Recw::rent stocking on newly formed or depopulated reefs may be necessary to get the system started. The hatchery capability for this scale of effort is generally lacking, especially in Virginia..

Recovery strategies:

There seem to be a number of ways to look at oyster stocking approaches militated by the salinity considerations in the Bay and the general divergent philosophies in Maryland and Virginia about hatchery supplementation.

Hatchery production using wild brood stock for replenishment

Focus: Maintain genetic diversity

Presently, wild brood stocks from various sources are being used for replenishment efforts in low salinity areas in Maryland. There was considerable concern about the nature of this activity because of underlying genetic concerns. In short, these concerns center on reducing the genetic variability of wild stocks by swamping them with alleles from hatchery stocks with reduced genetic variation. To quantify the risk of "genetic pollution" by hatchery stocks, an estimate of the numbers of wild parents contnbuting to the overall oy ter population is needed, in both the hatchery and in the wild. At present, this is unknown. Our recommendations are couched with the caveat that these are interim recommendations for Maryland stocking programs and for a more precise strategy, an estimate of numbers of wild breeders is required.

Recominendations:.

1. Oyste stocked into replenishment areas, despite the fact that they are destined for harvest, must be considered a *in ntu* brood stock source.
2. The effective population me (a calculation of the genetic contribution that breeding parents are making to the next generation) of spawns produced in the hatchery must be kept as high as possible.
3. Effective population size in the hatchery can be maintained by using as man.y spawners as possible in equal ratio of male to female, and endeavoring to keep family sizes equal
4. Brood stock should not be obtained from sites where replenishment is underway. Th.at is, brood stocks should come from sites and systems outside the recruitment shadow of stocked areas. Using alternative stocks will prevent matings among related individuals and prevent inadvertent fi.ution of alleles in the population.
5. Replenishment areas should be stocked by progeny from parents of multiple stocks. A set of 3-6 stocks derivmg from various locations might be considered as sources of brood stock for the hatchery. Each year, a different brood stock could be spawned with the seed destined for a specific replenishment area. Stocks would be rotated every year. Use of multiple stocks will help prevent loss of rare alleles and help maintain overall genetic diversity in the replenishment area.
6. This strategy is more appropriate to areas with low disease pressure.

Issues in need of clari.icatiorr.

1. Effective popuhtion size in wild oyster populations figures prominently in determining the effect of hatchery supplementation on wild popuhtions and this *is* unknown at present.
2. What *is* the range of genetic variability in so-called natural popuhtions of oysters and does it differ among locales within the Bay?
3. What levels of effective population size are practicable in the hatchery?
4. Is there a correspondence between the estitru.ted effective popuhtion size calculated from the number of parents used and the actual effective popuhtion size of the spat after larval rearing and setting? In other words, does differential survival among families significantly effect effective population by the time the oysters are ready for planting?

Wild set enhancement for replenishment or restoration

Focus: Maintain genetic diversity

Another strategy for stocking oyster reefs or replenishment areas *is* the use of natural set from the wild. *This* strategy *is* essentially equivalent to what commercial oystermen do when they gather seed and distribute it to their oyster grounds for grow out. A variation on this theme could include the intentional collection of spat on artificial collectors, followed by a period of cultivation before moving them to a designated reef area. In *this* way, recruitment on "restored habitats" could be jump started with populations that are genetic:illy wild and unperturbed from their natural state. Technic:illy, wild set enhancement *is* not complicated, however it would require significant expansion of current efforts and pe:chaps development of some new bulk handling techniques for large scale replenishment or restoration. Wild set enhancement is more appropriate for areas with low levels of disease pressure since wild oysters likely will succumb where diseases are prevalent.

Recommendati_ons:

1. A cost-henefi.t analysis of *this* strategy versus hatchery supplementation is needed. If it turns out that hatcheries are more expensive per spat than large-scale collection and movement of wild seed, then serious consideration should be given to expanding *wild set enhancement.* Cost-benefit must include an evaluation of the likelihood of obuining wild set in predictable fashion.
2. Careful analysis of where *wild set enhanmnmtwould* be most useful, vis a vis salinity and disease prevalence regimes, *is* required.
3. Genetically speiling, wild set enhancement *is* the more conservative approach and obviates the problems associated with effective population size in the hatchery.

Issues in need of dari.icatiorr.

1. Are there portions of the Bay-specific:tlly in are!ls whe::e *wild set enhancemmt is* w:u:r:uiced- that have predicuble nat:ur:tl sets that would allow spat collection?
2. Is technology for c:i.tching, handling, and nursery care sc:i.lable to levels needed for *wild set enham·ement?*

Hatchery production using wild brood stock for restoration

Focus: Ineffectiveness of wild stocks

There seems little value in restoration programs in the Chesapeake Bay based primarily on hatchery production from wild brood stock. In Virginia., longevity of oysters becomes a major issue. Stocking seed produced in the hatchery has the double whammy of limiting genetic variability and producing disease-susceptible oysters. Disease susceptible spat will yield adults with lower fecundity, countering the objective of self-sustaining, reef based brood stock. The use of wild set may be more cost effective and avoids potential genetic pitfalls.

Recommendations:

1. Unless proven of value for their longevity in the face of disease pressures (1.e., naturally disease-resistant populations), wild brood stock likely will be of limited use for restoration in disease prone areas of the Bay.
2. From a genetic perspective, recurrent stocking of seed derived from wild brood stock is identical to "Hatchery production using wild brood stock for replenishment" above. If wild stocks are used for restoration, stocks from various origins should be rotated.

Issues in need of dari.icatJ.on:

1. Effective population size in wild oyster populations figures prominently in determining the effect of hatchery supplementation on wild oysters and this is unknown at present.
2. Jue there "naturally disease resistant" stocks in the wild?

Disease-resistant, hatchery based enhancement *(genedc rehabilitadon)* for restoration

The most creative discussion in the workshop arose from our discussions of the issues sw:rounding *gen,etic rehabilitation.* That is, the wild oyster populations, having suffered a number of insults over the last 50_years especially, were deemed in need of rehabilitation through the use of disease resistant strains. A good de!ll of progress has been made in developing disease resistant strains and they are generally avaihble for aquaculture. Now it seems they may play a significant role in some pares of the Bay, particularly where disease pressures are persistent.

For *genetic rehabilitation,* the value of programs relying heavily on hatcheries is to amplify specific stocks with disease resistance. The advantage of using disease resist:tnt stocks is that they potentially forward the goals of restoration by enabling functional oyster reefs as well as the traditional fishery. Disease resistant hatchery stocks would promote ecologic:i.l restoration somewhat by enabling oysters to fu-e longer, re-establishing overlapping year classes of adults; fisheries restoration would be served because oysters would be longer fu-ed for harvesting and provide spat for continuing recruitment to designated fishing zones.

Iri most systems but the most depopulated, stocking disease resistant seed will eventually hybridize (interbreed) with wild populations. The desired outcome of hybridization *is* incrogression of disease resist:tnt alleles into the natural population. Imrogression ,;.,-ill have a positive benefit if it contributes to the welfare (fitness) in subsequent generations of oysters. This benefit is most likely in the character of disease resistance, giving rise to incrcasc<l longcvity and higher fecundity.

The brightest scenario is that the level of introgrcssion and gene flow from disease-resistant stocks to subsequent generations could be controlled. In reality, several obstacles prevent a precise application of an introgression (or *gemtic rr:habilitation)* strategy. A specific model for controlling introgression of favorable traits into a wild population, regardless of species, is lacking. There is inherent unpredictability to the population dynamics of oyster recruitment, e.g., proximity of adults for spawning, synchronicity of spawning, larval distribution, variance in reproductive success. At present, there are limitations to the extent to \vhich disease-resistant strains can be amplified through hatchery propagation, i.e., magnified from a few hundred brood stock to a few hundred million spat.

Despite the limited understanding of the parameters of the *genetic rehabilitation* strategy, there was a sense of congruence in the workshop that the so-called wild oyster-especially where diseases were prevalent-was in a downward spiral and that trial implementation of the *genetic rehabilitation* str.ategy was warranted.

Recommendations-.

1. Disease resistant stocks should be stocked in closed/retentive systems where autorecruitment rates are expected to be high, establishing a "disease resistant stock preserve." Autorecruitment will a) enable the magnification of the stocks through natural recruitment and b) allow monitoring of the system to help parameterize the *genetic rehabilitation* strategy.
2. Progeny from the "disease resistant stock preserve" could then be used as part of a larger secondary stocking program by collecting spat and relocating them to other newly developed reef systems.
3. Genetic markers of disease resistant alleles should be developed to monitor differential rates of inrrogression within and among "disease resistant stock preserves" and in secondary stocking programs.

Issues in need of clari.icatiorr.

1. Effective population size in wild oyster populations figures prominently in setting parameters for the controlled introgression *(gemtic rehabilitation)* strategy and this is unknown at present.
2. Theories of gene flow are abundant, but specific models that apply to oyster population dynamics are lacking.
3. Technologies for stocking of secondary reefs (i.e., from seed derived from "disease resistant stock preserves") presumably \Vould be identical to that used for the *wild set mhancemmt* strategy, both undeveloped at present.
4. Molecular nurkers have been developed and \\.-ill pro..,;de the foundation of tracking b.rval dispersal. But linbge to disease resistant genes has not been examined :ind more marker development is needed co find chose chat m:irk disease resistant genes specifically.

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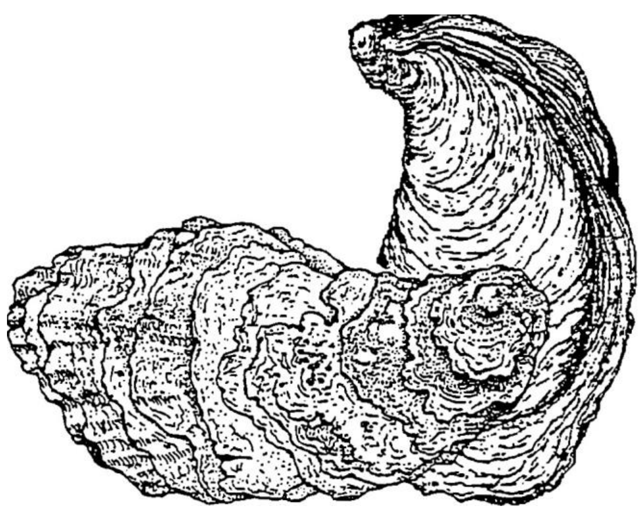

Glossary

Allele (allelic) - one of a number of alternative forms of a given gene. Each allele may affect the function of that gene and therefore the function of the organism.

Allo-recruitment - Recruitment is the addition of new members to a population under consideration. Allo-recruitment refers to the addition of new members from spa,vning individuals other than from the population under consideration.

Auto-recruitment - the addition of new members from spawning population under consideration. Auto-recruitment would occur if oysters on reefs provided progeny that would settle on the source reef, or nearby.

Biogenic (potential) - Biogenesis is the production of a living cell from another living cell. In the context of oyster restoration, biogenic potential refers to the ability of a reef system to produce :. other oysters in and around the reef.

Effective population size - the average number of individuals in a population that contribute genes to succeeding generations. Effective population size will always be smaller than the total number in a population because not all indiv-idun.Is v.-ill contribute progeny. In oysters, effective population size is believed to vary widely because of the wide variety of environmental conditions that determine recruitment success and because of the huge fecundity in some incfo-iduals.

Family (family size) - a set of parents together v.-ith their children. Family sizes can vary \vi.dely in oysters bec:mse each male x female pairing can derive millions of children. Successful families, for whatever reason, can greatly outnumber unsuccessful ones.

Fecundity- potential fertility. Specifically, the term refers to the quantity of gametes, generally eggs, produced per individual over some time period.

Gene flow - the exchanges of genes between different populations of the same species. Gene flow occurs from migration of individuals from one population to the next and can change the frequencies at which genes are found in the recipient population. Gene flow among oyster populations used to maintain homogeneiry among all oysters in the Bay. No\v; gene flow may be severely restricted from lack of contiguous reef structure.

Genetic markers - a gene used to identify an individual that carries it, or as a probe to mark a chromosome or gene location. Generic markers take various forms and can be used to monitor the migration of indiv-iduals - in oysters, t.i.1us would be the larvae - from one place to another, such as from a reef to surrounding substrate.

Genetic variability - the heteroge:1ei.r:; of alldes in :1 population.. -\t any one gene, m:iny alleles are possible.• -\cross m:iny genes, OYerall v:u±ibilicy can be characcerized as an attribute of the population. It is ·wi.cely agreed that such genetic variability (allelic diversity) is beneficial by eru.bl.ing organisms to adapt to a ra.nge of envi.ronmenta.l conJitions.

Introgression - the incorporation of genes from one population into the gene pool of another. The first step in introgression is the formation of hybrids between the t<w·o populations. Aftern-·ard, hybrids tend to breed subsequently with the more abundant population. This process results in a population of indiv;duals that look mostly like the abundant parent but who also possess some characters of the other population.

Recruitment shadow - that area around the primary spawning population where progeny may appear. The recruitment shadow of oyster reefs is dictated by the length of time larvae spend in the water column as well as their incipient potential for dispersal from water currents, tides, etc.

Replenishment - the intentional stocking of designated areas for subsequent harvesting by the fishery. Replenishment is widely practiced in Maryland where hatchery seed is distributed into designated areas.

Restoration - in its literal sense, restoration would imply bringing something back to its original state. With oysters, restoration in the literal sense is likely not possible. Most of the activ;ties now are associated with rehabilitation of areas that will promote oyster biogenic activity. These activ;ties include replenishment, reef rebuilding, adding substrate to sedimented areas, and creation of sanctu- anes.

Stock (of oyster) - the natural genetic unit of a population determined by its isolation from other populations. Stocks of oysters vary over a fairly large geographic scale. It is unlikely that there is any genetic difference among populations of oysters within the Chesapeake Bay, although things may have changed with the decline of stocks and reduction of gene flow in the last 50 years. Stocks are a evolutionarily determined entity.

Strain (of oyster) - an artificial genetic unit of a population determined by the breeding structure of how these individuals were propagated. Strains obta.in by closing the life cycle so that progeny grow up to become parents of the next generation. Generally, new material is not allowed in and strains become more genetically distinct and less genetically variable. Artificial selection may be applied to accelerate the genetic differentiation of a strain, and this is how disease resistant stocks are produced.

Wild (oyster) - a naturally occurring oyster that is unchanged from its natural (normal) genetic state. Oysters in the Bay are more or less wild, although several events have conspired to change its natural st'lte: movement of oysters within the Bay and from outside the Bay, selection pressures brought on by diseases, and selection pressures brought on by fishing pressure, all of which are in some way the result of human influence.