Marine Policy 91 (2018) 161–166

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Evaluating the U.S. Estuary Restoration Act to inform restoration policy implementation: A case study focusing on oyster reef projects☆

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ARTICLE INFO

Keywords:
National Estuaries Restoration Inventory (NERI)
Economies of scale
Monitoring
American Recovery and Reinvestment Act (ARRA)
RESTORE Act
Transparency

ABSTRACT

Recent research revealing the extent of marine habitat degradation has ignited a surge of restoration efforts globally. Restoration of estuarine habitats became a priority in the United States with the Estuary Restoration Act (ERA) of 2000. In the present study, a synthesis of data from the National Estuaries Restoration Inventory (NERI), developed in response to ERA requirements to track and disseminate project data, was conducted in order to analyze U.S. oyster reef restoration efforts. From 2000–2011, more than $45 million was invested in 187 projects to restore over 150 ha of oyster reef habitat, with projects most heavily concentrated in the Chesapeake Bay area and Florida Gulf coast. Trends over time indicate that projects are being implemented at larger scales, increasing from an average of less than 0.4 ha in 2000 to over 1 ha on average in 2011. Costs per unit decreased from an average of more than $2.1 million per ha in 2000 to just over $500,000 per ha in 2011. However, our analysis confirms one major problem hindering the field of restoration ecology: a lack of monitoring data or project-specific assessments of success. Habitat restoration has become an increasingly common effort in the policy sector, and gaps identified through this analysis can help inform future policy making and implementation. Better facilitation of data dissemination and further research on economies of scale in restoration projects are two key areas for improvement. As the field of restoration ecology continues to grow, it is critical that both new and current restoration practitioners, scientists, and decision-makers are able to learn from past projects and apply that collective knowledge to future restoration efforts.

1. Introduction

Environmental change, natural perturbation, and anthropogenic activities have degraded marine habitats compared to historic levels [30,34,38]. Coastal wetlands, seagrasses, and oyster reefs alone have declined by 65–91% [26]. Marine habitat loss is of concern because of cascading effects on biodiversity [1,27,48] and ecosystem service provision [21,52,64]. In response, the science and practice of ecological restoration have expanded because of the potential to stimulate recovery of degraded or disturbed ecosystems [2,40] and restoration now plays a key role in natural resource management and policy decisions [58]. Synthesis and evaluation of previous restoration activities can provide key insights as to whether restoration approaches should be continued or changed, and can be used to support an adaptive resource management framework [23,65]. Similarly, evaluating restoration policies and management programs can provide important insight regarding the effectiveness and efficiency of policy goals and management actions.

In the United States, restoration of estuarine habitats became a national priority with the Estuary Restoration Act (ERA) of 2000 (Title 1 within the Estuaries and Clean Waters Act of 2000). The ERA defines restoration as “an activity that results in improving degraded estuaries or estuary habitat or creating estuary habitat (including both physical and functional restoration), with the goal of attaining a self-sustaining system integrated into the surrounding landscape” [18]. Goals outlined in the ERA include: promotion of estuarine habitat restoration, use of common monitoring standards, development of effective partnerships, improved cost-efficiency, and enhancement of monitoring and research capabilities to ensure sound science [18]. Monitoring of ERA-funded projects was mandated, and targeted guidance manuals were developed to promote the use of standardized metrics and methods [59,60]. Additionally, the ERA required public dissemination of all project

☆ Multiple attempts were made via email and phone over the course of six months to contact persons responsible for NERI database management to answer questions that still remain unanswered throughout this manuscript

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https://doi.org/10.1016/j.marpol.2018.02.014
Received 6 July 2017; Received in revised form 10 December 2017; Accepted 13 February 2018

information and monitoring data. To achieve this requirement, the National Oceanic and Atmospheric Administration (NOAA), in consultation with the established Estuary Habitat Restoration Council, was charged with the development and maintenance of the National Estuaries Restoration Inventory (NERI, https://neri.noaa.gov).

Oyster reefs have experienced global losses in abundance and extent greater than any other estuarine or coastal habitat and organism [26,5,67], despite management efforts that have been widespread for centuries [17,35]. Only recently have oysters gained greater recognition for the non-food benefits they provide that support and sustain human welfare, including nutrient regulation [47,8], shoreline stabilization [41,55], and recreational fishing opportunities [46,66]. Restoration efforts are increasingly focused on returning these valuable ecosystem services to society [11,15,21]. In 2009, the American Recovery and Reinvestment Act (ARRA) provided a funding boost to habitat restoration efforts by focusing on large-scale projects to stimulate coastal economies [16,3,67]. Over $10 million were awarded for oyster reef restoration.

Despite the thousands of hours and millions of dollars invested in oyster reef restoration projects [36,67], their effectiveness is equivocal ([14,36]; but see [53,49]), and comprehensive project assessments are generally sparse [24,28,31]. There are unprecedented opportunities for restoring coastal and marine habitats under the 2012 Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States (RESTORE) Act [51], which allocates 80% of all fines paid under the Clean Water Act in response to the Deepwater Horizon disaster to the Gulf Coast Restoration Trust Fund. Billions of dollars will be available over the next 30 years to restore coastal and marine habitats, with $200 million allocated to oyster reef habitat restoration alone [61]. To make the best use of these funds, lessons must be learned from previous efforts, and must be disseminated broadly in order to increase efficiency and maximize success of future efforts.

In the present study, oyster reef restoration efforts in the U.S. were examined to determine restoration progress and to identify challenges and opportunities. A database was created by compiling information from the NERI. Data were synthesized to assess: 1) spatial distribution of restoration effort and funding, 2) trends in project size and cost, and 3) effectiveness of the NERI in disseminating project information and monitoring data with respect to published guidance and Federal policies.

2. Methods

The NERI represents a national summary of restoration efforts implemented under the auspices of the ERA, and includes projects funded by the National Oceanic and Atmospheric Administration, Environmental Protection Agency, Army Corps of Engineers, Fish and Wildlife Service and the Department of Agriculture's National Resources Conservation Service. For inclusion in the NERI, projects must have been implemented after the ERA was signed into law (7 November 2000) and must not be mitigation or legally mandated restoration. Additionally, all projects must include monitoring to assess restoration success, and the monitoring plan must meet ERA monitoring standards [44]. This database, though not inclusive of all restoration projects implemented, represents an unbiased subset of projects implemented under the guidance and goals of federal policies and funding programs.

Data summary reports were reviewed, and the NERI was queried using the habitat type filter “oyster reef/shell bottom” within the “submerged” habitat category. Full reports were examined for each project returned in the search, and all available data were collected (including: location, year implemented, area restored, project budget and funding sources). Data for project costs were designated between federal and non-federal funding sources. Project size data (i.e., acreage restored) were converted to hectares, and each project was assigned to a size class based on NERI classifications: small (< 0.4 ha), medium (0.4–2.0 ha), or large (> 2.0 ha). Cost per hectare was calculated for each project containing data on acreage and funding amount. Monitoring data were not reported for any of the projects examined.

Regression analyses were performed to examine trends over time (R version 3.0.1; [50]) for number of projects, area restored, funding awarded, mean hectares per project, mean cost per project and mean cost per hectare. To examine trends since the ERA, regression analyses included only those projects implemented during or after 2000. Dollar values were converted into the same year dollars (2011 USD) according to:

$$Cost_y = (Cost_x)^*(CPI_y/CPI_x), \quad (1)$$

where *CPI* is the consumer price index and *Cost* is the project cost. Subscripts *x* and *y* denote the year of project implementation and year for which all values are converted to, respectively. Average CPI values for each year were obtained from the Bureau of Labor Statistics [10]. Data for number of projects, area restored and funding were $\log_{10}$ transformed, and all rate data —hectares per project, cost per project and cost per hectare— were square root transformed prior to analysis to improve statistical performance.

3. Results

A total of 192 projects were returned in the NERI search. Despite ERA definitions and rules for project inclusion in the NERI, five compensatory projects were identified and excluded. The remaining 187 non-compensatory projects were examined. Although only projects implemented after the enactment of the ERA are to be included in the NERI, eight projects occurred between 1995 and 1999, and 19 projects did not include a date. The NERI did not contain any projects implemented after 2011. Only one project in the compiled dataset did not provide any funding information. Other than the distinction between federal and non-federal sources, no other budget metadata were provided in the NERI. The NERI report format provided a place for “total cost estimate for monitoring,” but this was not reported for any project examined. Although all project records indicate a monitoring plan was developed, no data or assessments of restoration success were provided. Within each project summary, a table was devoted to “Monitoring Parameters and Success Criteria” and a space reserved for a URL for monitoring data. However, in every project examined, no data were available.

Oyster reef restoration projects included in the NERI spanned all coastal states of the contiguous U.S. except Maine (Fig. 1). Number of projects varied among states, with half of all projects implemented in Florida, Maryland and Virginia (43, 26 and 25 projects, respectively). Over 150 ha of oyster habitat have been restored, of which nearly 62% occurred collectively in Florida, Virginia and North Carolina (42.6, 26.2 and 24.1 ha, respectively).

Nearly 20% of all projects did not include data on acreage restored,

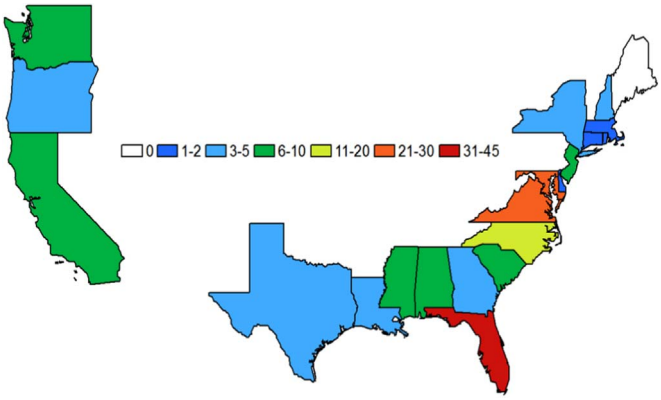

Fig. 1. Number of oyster reef restoration projects from the National Estuaries Restoration Inventory implemented in each state.