The Nature Conservancy

The Business of Restoration

Assessment and recommendations for the oyster reef restoration industry in the United States

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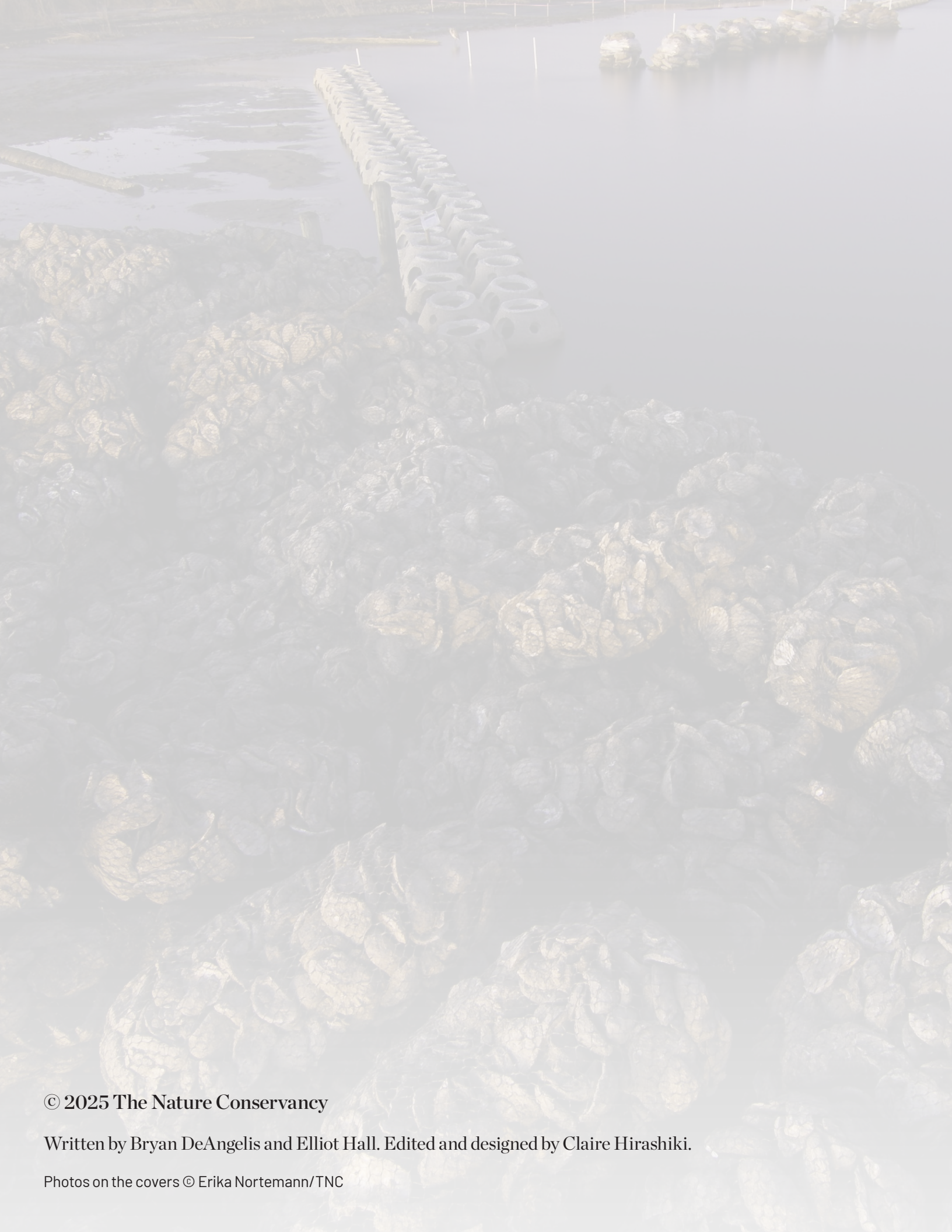
March 2025



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Introduction

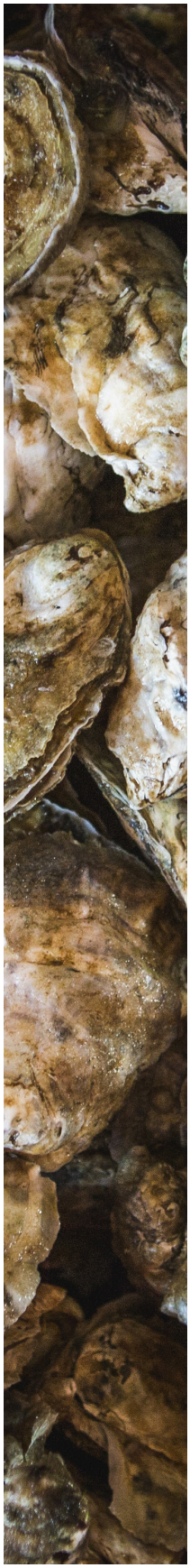
Oyster reefs once lined nearly every estuary and bay along the United States' coasts, yet today these critical habitats are among the most threatened ecosystems on Earth (Beck et al. 2011; Zu Ermgassen et al. 2012). We have already lost an estimated 85% of the world's oyster reefs due to climate change and increasing local pressures, such as overfishing, coastal development, and nutrient and sediment runoff from agriculture and deforestation (Beck et al. 2011; Zu Ermgassen et al. 2012). The loss of oyster habitat has resulted in a loss of the ecosystem services they provide, including water filtration, denitrification, shoreline protection, food production, and provision of aquatic habitat (Coen et al. 2007; Piehler & Smyth 2011; Grabowski et al. 2012).

Due to these dramatic habitat losses, oyster reef restoration has been prioritized by all three levels of government and many non-governmental organizations. This growing demand for restoration efforts has led to the development of an oyster reef restoration economy. However, despite encouraging advancements and successes in oyster habitat restoration, estimates suggest that operating at the current rate of restoration would require roughly 1,000 years of restoration efforts and nearly $100B to restore to estimated historic baselines. **We must radically increase the pace, scale, and impact of restoration to recover the abundance, resilience, and benefits of these invaluable coastal ecosystems.** Fortunately, incredible transformations have been made in the private sector through innovation, technology, and business efficiencies to unlock scale in many sectors.

This project's goal was to explore the current size of the oyster restoration industry nationally, identify existing constraints on effective scaling, and make actionable recommendations to overcome those barriers and to catalyze a new era in scaled oyster restoration. To accomplish this, The Nature Conservancy partnered with Bain & Company, a global management consulting firm, to co-lead the analysis. The study had two over-arching goals:

1. To conduct a market assessment to understand the industry's overall size and distribution. The direct annual spend was also used to estimate the industry's impact on jobs, indirect output, and induced output from the oyster restoration industry on the U.S. economy.

2. Evaluate current practices within the oyster reef restoration industry from a 'business lens' to identify opportunities to gain efficiencies and increase scale.

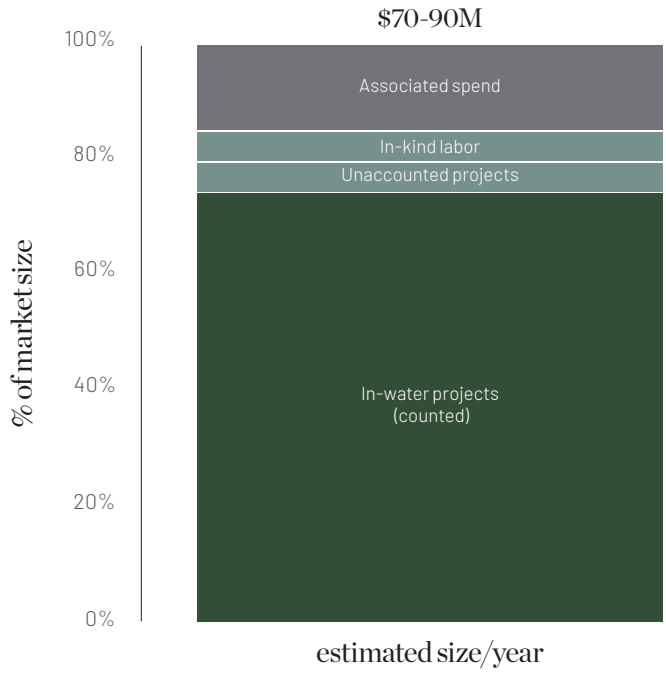


Market Assessment

MARKET SIZE ESTIMATES

The oyster reef restoration market size in the United States is estimated to be range $70–90M per year. Most of the market size ($60–70M) is in-water oyster reef restoration projects. Academic research relating to oyster reef restoration is known to be significant, but difficult to quantify and therefore was not included in the associated work gross-up factor. Similarly, no accounting for policy and advocacy-related work was included (see Hall & DeAngelis 2024 for methodology).

Of the national in-water spend, the majority is in the Mid-Atlantic (47%) and the Gulf of Mexico (38%). The Southeast (9%), Northeast (4%), and West Coast (2%) represent much smaller proportions of oyster reef restoration work, respectively.



Oyster restoration in the U.S. provides over $200M of total economic activity and supports thousands of jobs annually.

JOBS, INDIRECT, AND INDUCED OUTPUT SUPPORTED BY OYSTER REEF RESTORATION

Once we estimated the market size of U.S. oyster reef restoration, we could calculate the industry's impact on jobs, indirect output, and induced output, by leveraging a review of economic impact studies on restoration (BenDor et al. 2015, Edwards et al. 2013, Kroeger 2012).

Assuming an $80M annual investment, restoration activity directly supports ~1,484 jobs each year. Employment multipliers cited in BenDor et al. (2015) suggest that every restoration job supports an additional 742 to 4,155 jobs. Further, indirect output contributes $38.4M (48%) of business-to-business spending, and induced output adds $91.2M (114%) of household spending with the labor income. Therefore, the total economic impact of $80M in annual oyster reef restoration would be 2,226 to 5,639 jobs and $209.6M in direct, indirect, and induced output each year.

More information on the market analysis portion of this study can be acessed through our scientific publication linked here: https://doi.org/10.1111/rec.14143

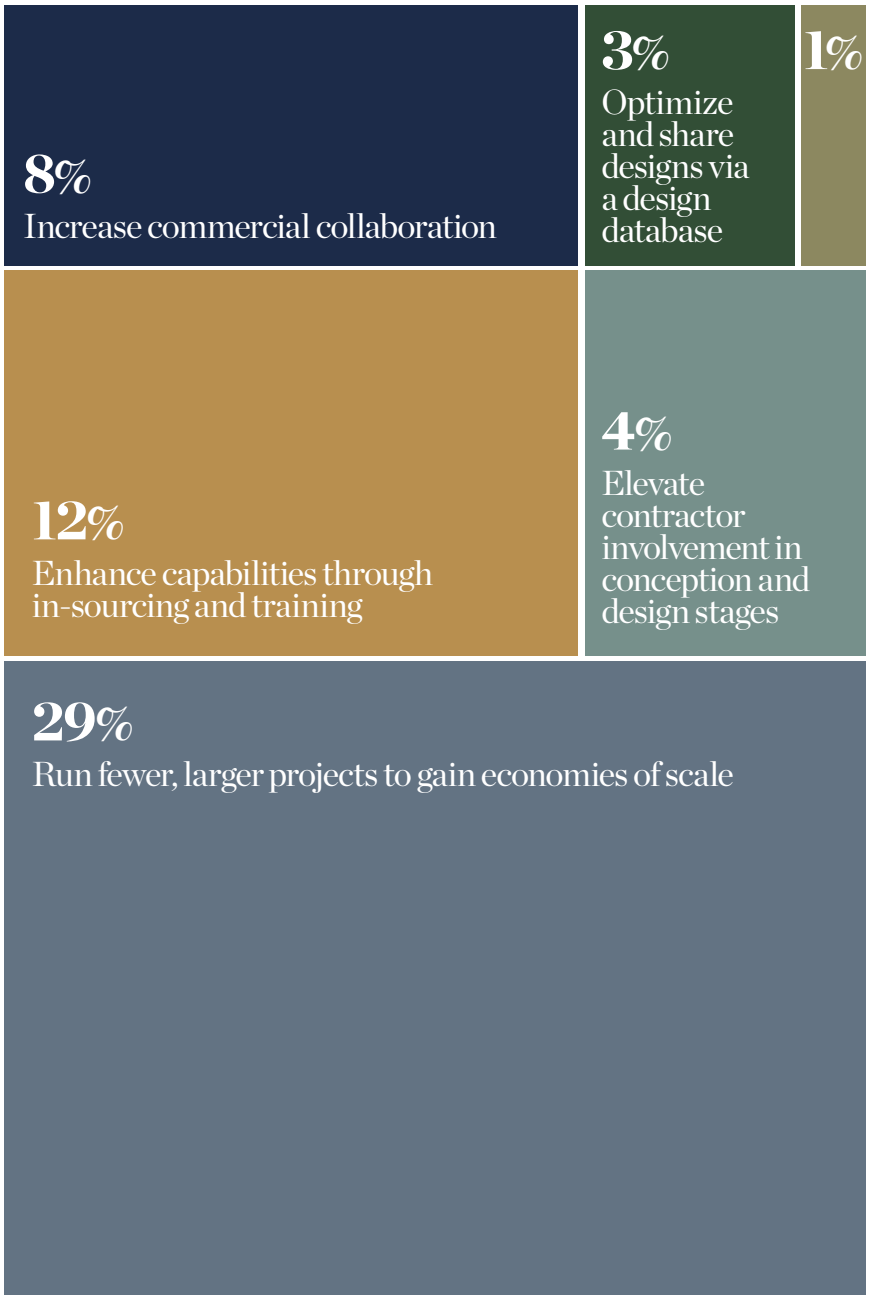
Performance Improvement

After decades of consistent work, costs for restoration remain extremely high – averaging well over $100K per acre, nationally. Therefore, this section explores opportunities to reduce these costs and recommend advancements to scale future efforts.

We conducted 68 one-hour interviews with project managers and sponsors, academics, government funders and regulators, design and engineering firms, construction companies, materials providers, hatcheries and nurseries, and others to gain insight into the entire value chain of an oyster reef restoration project. In total, 175 ideas were collected and then grouped into 15 key recommendations: six **Cost Reduction Opportunities** and nine **Advancements Required to Scale**.

The 15 recommendations were tested in later interviews to confirm their validity and usefulness. Potential savings estimates from the Cost Reduction Opportunities were generated using real-life proof points such as leveraging project budget and contract bid data from various projects ranging in size, type, and geography.

The cost of restoration can be reduced by more than 50% through six tactical Cost Reduction Opportunities.



COST REDUCTION OPPORTUNITIES

The six Cost Reduction Opportunities are recommendations any single project, or organization, could adopt to reduce project costs. Potential savings are estimated for each of the Cost Reduction Opportunities outlined. For economies of scale (Opportunity #1), the savings potentials were further broken down by project phases (planning, permitting, design, materials, construction, monitoring).

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OPPORTUNITY #1:

Run fewer, larger projects to gain economies of scale

Economies of scale refers to savings achieved by scaling. In the case of oyster reef restoration, economies of scale can be gained across the value chain, not only by bulk purchasing materials but also by sharing planning, permitting, design, and other resources across a larger restoration area, or by allowing a contractor to become more efficient with each subsequent reef installation. Estimates suggest by leveraging economies of scale, costs could reasonably be reduced by 29%.

Overall, there is a strong economic case to make projects larger to stretch funding further. Tactically, this means organizations should run fewer but much larger projects, explore opportunities to combine budgets with other organizations, and re-approach funders of small projects to make this business case. Additionally, once a project is underway, project sponsors could have contractors bid on varying sizes (i.e., contractor submits a bid for a project of 10-acres, 20-acres, and 50-acres), then share these bids to the funder to justify the ask for the additional investment.

OPPORTUNITY #2:

Enhance capabilities through in-sourcing and training

Although most organizations retain biologists and ecologists on staff for restoration work, they frequently contract out project management and engineering, often at significant expense.

Typically, the reason for outsourcing project management and engineering is two-fold. First, there are separate funding sources for project-specific resources. Restoration projects are typically funded by grants, but to write a grant application, the sponsoring organization will internally fund staff time – these costs are seldom recovered by the grant. Then, once a project has grant funding, the project sponsor will contract out project management and engineering on the grant's budget. While this is optimal for any organization running a single smaller project, it is sub-optimal when running larger and/or multiple consecutive projects where the more economical alternative can be to bring project management and engineering in-house.

Second, there is a lack of consistent funding to hire additional skillsets on staff (see also *Advancement #1: Consistent funding for restoration*). In-sourcing these roles would require the sponsoring organization to hire permanently, then run the risk of trying to recover salary costs through grant-funded projects. However, in-sourcing would save the margin that an engineering firm would charge on top of services, as well as provide substantial process efficiency gains. On-staff engineering support could help vet proposed projects and foresee expenses. For instance, by involving an engineer when siting a project, the organization could better predict if a specific location or design would be prohibitively expensive before a grant and/or permit locks in the specifications (also see *Opportunity #5: Optimize and share designs via a design database*).

Leveraging economies of scale

The following list outlines each step of the value chain and the potential to save costs from leveraging economies of scale:

PLANNING.
Project sponsor staff time and travel are the major costs of planning, but these costs do not scale with the restoration footprint. The amount of time required by the project sponsor for siting and stakeholder discussions would not be influenced by project acreage, although sourcing funding would typically involve additional effort.

PERMITTING.
Engineering surveys and project management staff time are the major permitting costs. Engineering surveys would take more time for a larger area but would save on travel, equipment set-up, and analysis; staff time to manage the permitting process would also require a similar amount of time no matter the restoration area.

DESIGN.
Reef designs and further engineering surveys are the major design costs. Engineering surveys would take more time for a larger area but would save on travel, equipment set-up, and analysis; reef designs could often be replicated across the project area with little added cost.

MATERIALS.
The purchase of shell, concrete, limestone, and/or oysters would generate savings as the most traditional interpretation of economies of scale: larger orders provide more opportunity to negotiate prices and lower transportation costs by using larger vehicles and vessels.

CONSTRUCTION.
Contractor labor and equipment, including mobilization and demobilization, are the major costs of construction. Mobilization and demobilization provide the most obvious savings, as people and equipment would only have to be transported to (often remote) sites once. Further, contractors suggest they would benefit from larger projects by gaining experience as the project progresses (i.e., each subsequent reef taking less time to construct than the last, especially for new or difficult designs).

MONITORING.
Staff or contractor field time and travel are the major monitoring costs. Time in-field will scale linearly for a larger area, but there would still be savings on travel, set-up, and analysis.

OPPORTUNITY #3:

Increase commercial collaboration

Commercial collaboration is another very tactical, but sometimes overlooked cost reduction opportunity that could lead to savings. Commercial collaboration refers to leveraging shared resources, which can be achieved in a variety of ways. For example, an obvious opportunity is collaborating with state-led wild reef cultching because it requires many of the same resources as restoration.

First, resources can be shared between restoration efforts and commercial fisheries replenishment work (e.g., cultch planting). This model is only applicable in select states that have wild reefs and practice cultch planting for fisheries harvest.

Second, when state agencies are able to lead restoration work, traditionally complicated permitting processes become more streamlined. Virginia leverages both of these approaches and has the lowest demonstrated restoration cost per acre of all projects reviewed. Even in places where states are not cultching, other collaboration opportunities exist, such as involving commercial labor or sharing other common resources from nearby projects.

Finally, interviewees suggested that when states partner on projects, often by taking the lead on permitting, efficiencies are gained. This does not mean states must take the work on independently or allocate their own budgets to restoration work; project managers simply found it helpful to have state agencies as implementation partners.

OPPORTUNITY #4:

Elevate contractor involvement in conception and design stages

Similar to the second opportunity of in-sourcing engineering and project management skillsets, there is material benefit to involving construction contractors earlier in each project. If we look to the for-profit world, vertically integrated companies not only achieve higher margins, but also make decisions optimal for the full system. Ideally, this would mean all parties involved in oyster restoration (e.g., biologists, project managers, engineers, construction contractors, materials suppliers) would be employed by the same entity and therefore have aligned incentives. However, while end-to-end vertical integration is not a feasible solution, oyster reef restoration projects would benefit from earlier construction contractor involvement.

Currently, a typical project requires getting permits approved, securing funding through explicit grants, and finalizing designs, all before engaging construction firms. This is often the process because projects are funded by phase, with later phase work not guaranteed, so bringing in construction contractors earlier is impractical, but not optimal. Construction contractors interviewed for this study suggested that if involved earlier, they could anticipate and reduce high-cost decisions related to design and implementation while maintaining restoration outcomes. For example, a given design may be unnecessarily complicated to construct or require additional time to verify certain design parameters are met.

OPPORTUNITY #5:

Optimize and share designs via a design database

Reducing the cost of design and engineering work presents another Cost Reduction Opportunity. Creating a design database represents an opportunity to share designs across the oyster reef restoration community. The database would include each design's summary and backup file, which would allow future projects to reference examples and build upon past designs for new locations. Further, the database would support engineering firms' efficiency by compiling potential designs and providing a set of alternatives for alternatives analysis.

Given that engineering surveys must be completed on each site, this does not represent a massive opportunity, but it would still directly reduce construction costs and optimize the design stage.

OPPORTUNITY #6:

Promote continued idea sharing to follow industry best practices

The final Cost Reduction Opportunity is to facilitate idea sharing among oyster reef restoration practitioners. A common theme in many interviews was the continuation of pilot projects, testing certain substrates or techniques, without a definitive plan to scale up the project to achieve meaningful restoration outcomes. Further, some pilots are conducted by neighboring organizations simultaneously, often an avoidable expense. With enhanced idea and outcome sharing, there would be less need for continual pilots, and more funds could be directed to larger scale work.

Advancements Required to Scale

The Cost Reduction Opportunities outlined above are tactical recommendations to reduce costs that could be adopted by any single organization or project. In contrast, the nine Advancements Required to Scale would require a regionally or even nationally coordinated effort, but once accomplished, would improve the success of all future projects. The Advancements Required to Scale could be interpreted as enabling conditions which gradually increase scalability across the entire industry.

ADVANCEMENT #1:

Consistent funding for restoration

Oyster reef restoration would benefit from more consistent funding. The majority of funding derives from grants, and while these may be relatively consistent sources, individual regions and organizations do not receive dollars consistently. The lack of consistent funding for organizations causes an unwillingness to invest for the longer term; instead, they make less economical decisions such as continually hiring short-term staff and making one-time purchases.

As mentioned under Cost Reduction Opportunities, the ability for project sponsors to hire engineers, project managers, and other staff full-time for the construction phase has great potential to save costs overall, but hinges on organizations' funding to conduct restoration long-term (e.g., greater than 5 years) which requires confident expectations of future funding. Additionally, contractors hire temporary staff and rent equipment because they also cannot anticipate future work, driving up their own costs and therefore the price they charge. One-time material purchases are also more expensive, compared to locking in annual contracts or having the ability to pre-purchase scarce commodities such as substrate materials.

The lack of consistency also impedes work that is required beyond construction such as baseline assessments and surveys that lay the groundwork for future restoration construction. In addition, an organization may lose their funding after a pilot project, resulting in few measurable outcomes to inform future full-scale projects. If said organization receives funding again, it may be a number of years later, and this second round of funding may need to support yet another pilot project to re-test efficacy due to the quickly changing nature of nearshore environments.

ADVANCEMENT #2:

State-wide oyster restoration planning, permitting and protection

In several states, obtaining a permit to implement restoration is extremely complex, time-consuming, and expensive. Each time a project is proposed, the state evaluates the permit application from scratch instead of against a specific framework or plan. Many examples exist where permitting took multiple years, with some projects expressing that permitting took over seven years. These long lead times for permitting compromise the project's ability to be successful or efficient. For example, rising costs while awaiting permits may result in the grant dollars not going as far as expected, resulting in the original project goals not being met, requiring further work to re-confirm funding.

State-wide oyster planning represents a significant opportunity to simplify and streamline restoration processes as well as encourage additional restoration to meet any state-set targets. State-wide oyster planning includes (among many other things) collectively designating sites for restoration, then prioritizing and executing on restoration goals. By making the effort upfront to designate specific sites for restoration, significant efficiencies can be gained. One major benefit would be that required regulatory procedures (e.g., select site reviews to avoid impacts to sensitive habitats), spatial planning, benthic surveys, habitat suitability analysis, and several other tasks could be approached at a system-wide level (e.g., entire bay or estuary). Communities could prioritize restoration sites, whereby organizations could simply approach the state and confirm they would take on restoring a predesignated site, instead of proposing to restore an unevaluated location.

There are multiple benefits to state-wide oyster planning. First, as alluded to above, permitting latencies are significantly reduced, resulting in fewer wasted resources from both the state regulators and the restoration organizations. Second, once a substantial area has been designated, preliminary environmental and engineering surveys could be conducted all at once, savings costs compared to mobilizing these resources for each individual project. Then, with range-wide data, detailed cost/benefit analyses could prioritize the best near-term investment decisions. Third, the relative ease of restoration in a state with a state-wide plan compared to one without would mean more investment would be directed there; restoration organizations may choose to focus efforts where restoration is easiest, drawing out-of-state dollars in the form of federal grants and private donations to local, often underfunded communities. And finally, state-wide oyster planning that further sets restoration goals at the bay/estuary scale is the best and most practical approach to achieving the economies of scale outlined previously in this document.

ADVANCEMENT #3:

Upfront investment in permitting efficiencies and simplification

The permitting process typically requires approximately 5% of a project's funding, but often lasts multiple years. Organizations involved in restoration (e.g., funders, project sponsors, regulatory agencies) would benefit from collaboratively developing a simpler, streamlined permitting process for natural habitat restoration. While this would involve initial investments, not tied to any single restoration project, it would yield considerable savings in the long run. By simplifying the permitting process there can be tangible costs savings resulting in more dollars directed to implementation, as well as intangible benefits such as increased ease of restoration for various stakeholders. Permitting a restoration site should generally not be held to the same standard as permitting a structure which is impacting the environment to provide another benefit (e.g., building a bridge over an estuary).

Additionally, there should be a separate and less arduous process for oyster reef living shorelines compared to grey infrastructure shorelines such as bulkheads. This would encourage implementation

of living shorelines by reducing the cost and effort involved. Several states have made living shorelines the default shoreline protection structure, thereby requiring landowners who desire grey infrastructure to prove a living shoreline will not work — a significant barrier.

ADVANCEMENT #4:

Alternative and innovative substrate

Oyster shell is often the preferred substrate for most oyster reef restoration projects; however, oyster shell is increasingly expensive or simply unavailable. The most common sources for oyster shell are collecting recycled shell from the commercial operations (e.g., restaurants), mining fossilized shell deposits, and dredging shell from deeper waters. None of these methods are perfect and each come with varying degrees of complications; particularly the latter two sources have other significant environmental concerns. Competition for oyster shell is also increasing, with aquaculturists crushing it into micro-cultch to serve the half shell market, as well as some non-oyster related purposes.

Shell is still the most biologically and logistically optimal substrate for hatcheries to set oyster larvae on to create spat-on-shell. Therefore, particularly for the seed-limited portion of the oyster restoration industry to scale, oyster shell supply must increase. Specifically, it is recommended for substrate-only projects to consider alternative substrates discussed below. Beyond this, oyster restoration would greatly benefit from increased regulations or incentives for shucking houses and restaurants to return shell for restoration purposes.

While interviewees acknowledged that oyster shell is a limiting factor, they also recognized the emergence of sufficient alternatives, including recycled materials, and a growing interest from the private sector to innovate in this space.

The final factor in substrate selection should be location. In the detailed project budgets collected, transportation costs were often greater than or equal to the cost of the substrate itself. Overall, the total cost of a given substrate should be considered before purchase, and it may be optimal to choose a substrate that requires additional considerations (e.g., more difficult deployment, heightened design requirements) if its total cost is cheaper.

ADVANCEMENT #5:

Restoration-earmarked hatchery capacity

When bays and estuaries have depleted oyster stocks, conservation aquaculture (e.g., spat-on-shell deployment) is required; however, typically hatcheries have more demand for larvae and spat-on-shell than they can supply. Further, this problem will likely only grow as aquaculture's prominence continues to rise. As hatcheries become more vital, the private market is likely to step up in search of potential profits to ease the supply-demand imbalance, leading to private hatcheries adequately supporting the commercial industry. These existing and new private hatcheries would also be able to supply restoration efforts – hatcheries interviewed said there is nothing inherently different required to serve a restoration customer – but they will not necessarily prioritize restoration over profits. This specific nuance around restoration projects not receiving formal prioritization will result in restoration projects paying high prices or otherwise having limited access to spat-on-shell. Some private hatcheries noted they would be reluctant to take on a restoration if that customer could not commit to frequent business as this would displace loyal commercial customers in a competitive industry (i.e., a further issue derived from a lack of consistent funding). Therefore, to move to large-scale projects, restoration-earmarked hatchery capacity must be a priority.

ADVANCEMENT #6:

Integration with commercial oyster fishery replenishment efforts

While a similar idea was presented under *Cost Reduction Opportunities* as an opportunity for individual project sponsors to explore, the integration of restoration efforts with state commercial fisheries replenishment efforts should be explored at a broader scale as well. First, resources should be shared between restoration and commercial fisheries replenishment work to reduce costs, such as substrate purchase and transportation,contractor mobilization and demobilization, and monitoring. Second, the decline in larvae availability on public reefs have made natural recruitment more unreliable, so several organizations are exploring restoration of adjacent sanctuary reefs as 'brood reefs' — this could bolster fisheries replenishment efforts as well. Therefore, research should continue to explore these potential benefits and communicate them to harvesters, restoration practitioners, and state resource managers, such that better synergies between efforts are more sought after.

ADVANCEMENT #7:

Multi-year monitoring of restored sites

Many funding sources do not provide capital for more than a couple years to monitor the restored oyster reefs. This results in limited knowledge of successful approaches and an inability to prioritize restoration across a region. When projects are monitored and documented properly (i.e., over a longer time horizon), restoration practitioners internal and external to the sponsor organization can learn more effective approaches for future work. Without multi-year monitoring, there is limited confidence in the results, often requiring further pilot projects, and when the aim is to maximize conservation, the industry cannot continue running pilot projects indefinitely. Additionally, multi-year monitoring would help direct future spend to the areas where it is expected to be most effective. In Ridlon et al. (2021), inconsistent monitoring data was cited as a key barrier to prioritization of the next set of restoration sites. Further, monitoring data must be standardized, which is the intention of the national oyster monitoring guidelines (Baggett et al. 2014; Baggett et al. 2015). Furthermore, standardized, longer-term monitoring data would need to be publicly accessible to be most useful. In a future with simple access to multi-year monitoring data, proposed restoration sites can be looked at more factually, based on the performance of past projects, to make the best use of scarce dollars.

ADVANCEMENT #8:

Increased prevalence of, and competition among, contractors

As oyster reef restoration efforts grow, marine contractor availability will increasingly become an issue. The construction phase, typically deployment of substrate and oyster seed, is the largest cost of most projects, but many regions have few options for contractors who can complete this specialized work. Interviews revealed that some projects would issue an RFP but receive no bids, or that only a single contractor operates in a given region. This represents a barrier to achieving lower prices when attempting to scale, given the lack of competition.

Additionally, marine contractors are often more comfortable building traditional grey infrastructure, since they lack experience or training in the skillsets required for nature-based projects such as living shorelines. One avenue organizations can pursue is contractor training programs. Several states, including Florida and North Carolina, have begun contractor training programs, often specific to living shoreline work, to increase both the availability of contractors as well as encourage contractors to present living shorelines as a viable alternative when private landowners require a shoreline protection solution.

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ADVANCEMENT #9:

Support for restoration from commercial and recreational sectors

In many regions, restoration remains at odds with the interests of commercial and recreational fisheries as it typically reduces harvestable area. Therefore, for the restoration industry to thrive and undertake large-scale efforts, support must be gained from these parties.

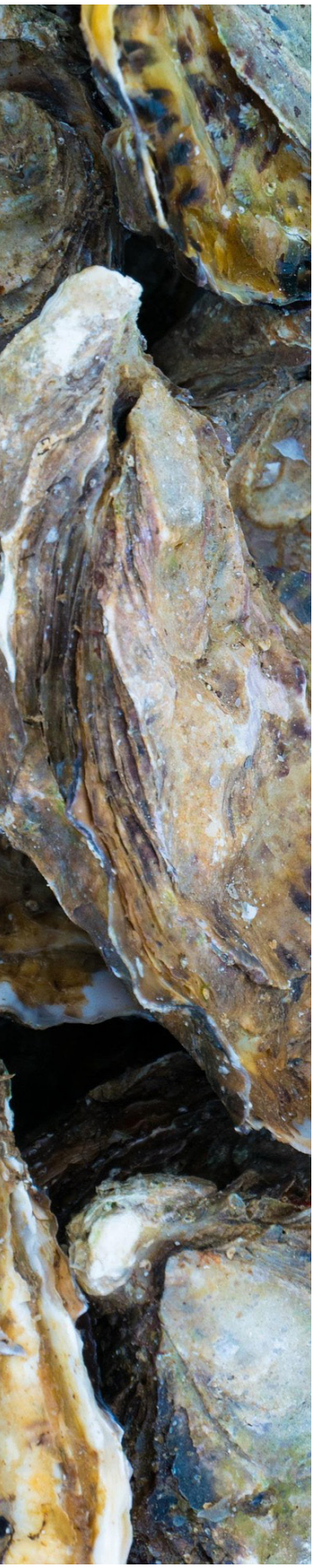
For example, there are some emerging programs which seem effective at gaining support from the commercial aquaculture industry. NRCS EQUIP's oyster purchase program in Rhode Island and The Nature Conservancy's SOAR oyster purchase program have aligned incentives of commercial growers and restoration. In both programs, aquaculture farmers grow oysters on their leases, then are paid to outplant the mature oysters on sanctuary reefs. This provides a stable source of income for the farmer and mature oysters for restoration. Although these programs have a higher restoration cost, they yield other benefits, including many mentioned previously, such as garnering support for restoration from the commercial industry, integrating industries to leverage efficiencies, securing restoration permits, and providing access to consistent funding sources.

In Australia, recreational fishing groups are in strong support of oyster reef restoration, due to the resulting increase in fish stocks. The U.S. has a significant recreational fishing industry, with a total recreational harvest over 350M pounds and nearly 250M pounds from inland or nearshore sources in 2019 (National Marine Fisheries Service, 2021). However, the U.S. has traditionally had limited success engaging the recreational fishing communities in supporting oyster reef protection and restoration, but the opportunity is significant, given the size of the recreational fishing community.

Conclusion

Oyster reef restoration is a substantial industry with $70-90M of annual spend, directly supporting nearly 1,500 jobs, and generating nearly $210M of total economic output. The market is regionally concentrated with nearly 85% of spend within the mid-Atlantic and Gulf of Mexico states. This analysis demonstrates the potential economic opportunity of increased restoration.

With an industry of this size, it is prudent to ensure dollars are used most effectively, especially given that despite the growth of the industry, the current pace and scale of restoration remains insufficient to achieve meaningful ecosystem goals in a reasonable timeframe. Therefore, this report sought to identify opportunities to support growth efficiently by making the most of limited funding to restore oyster reefs. Through the six Cost Reduction Opportunities, it is realistic to optimize how projects are run to reduce restoration costs by ~50%, doubling the pace of restoration with existing funding. Further, by supporting the nine Advancements Required to Scale, the entire restoration industry will be more efficient, simpler and cheaper, catalyzing a further step-change of reduced oyster reef restoration costs.



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