The Nature Conservancy

The Economics *of* Oyster Shell Recycling

CLOSING THE 280-MILLION-POUND GAP BETWEEN WASTE & RESTORATION

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Written by Bryan DeAngelis, Dawn Musil & Alyssa Phelps.

Edited and designed by Claire Hirashiki.

** The findings presented here are currently in preparation for publication in peer-reviewed literature.*

PICTURED ON THE COVERS:

(external) Oyster restoration project in Mobile Bay, Alabama.
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(internal) Oyster reefs near McIntosh County, Georgia.
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Introduction

Oyster reefs are a global conservation priority, providing essential ecosystem services including water filtration, shoreline protection, and fishery habitat (Coen et al., 2007; Piehler & Smyth, 2011; Grabowski et al., 2012). Yet, despite their role as foundational coastal infrastructure, over 85% of oyster reefs have been lost globally (Beck et al., 2011; Zu Ermgassen et al., 2012). While this decline has spurred a restoration industry worth $70–$90 million annually in the United States (Hall & DeAngelis, 2024), efforts are increasingly bottlenecked by a critical shortage of substrate (North et al., 2025). However, total availability of shell is not the sole limiting factor. Instead, what is constrained is our collective ability to easily and efficiently access oyster shell for restoration.

We estimate that **only 3-5% of the nation's 279.9 million pounds of annual shell production is recycled** through Oyster Shell Recycling Programs (OSRPs).* **The remaining 95-97% (roughly 270 million pounds) is either diverted to secondary uses or discarded in landfills.** This volume is equivalent to filling 40% of the interior of the Empire State Building every year. This waste persists not because of supply scarcity, but because of market dysfunction.

Most OSRPs operate as isolated entities with limited awareness of regional capacity or neighboring demand. Some states seek millions of pounds of shell annually for restoration but can only access one-tenth of that through OSRPs. In other states, some OSRPs accumulate surplus with no mechanism to redirect it.

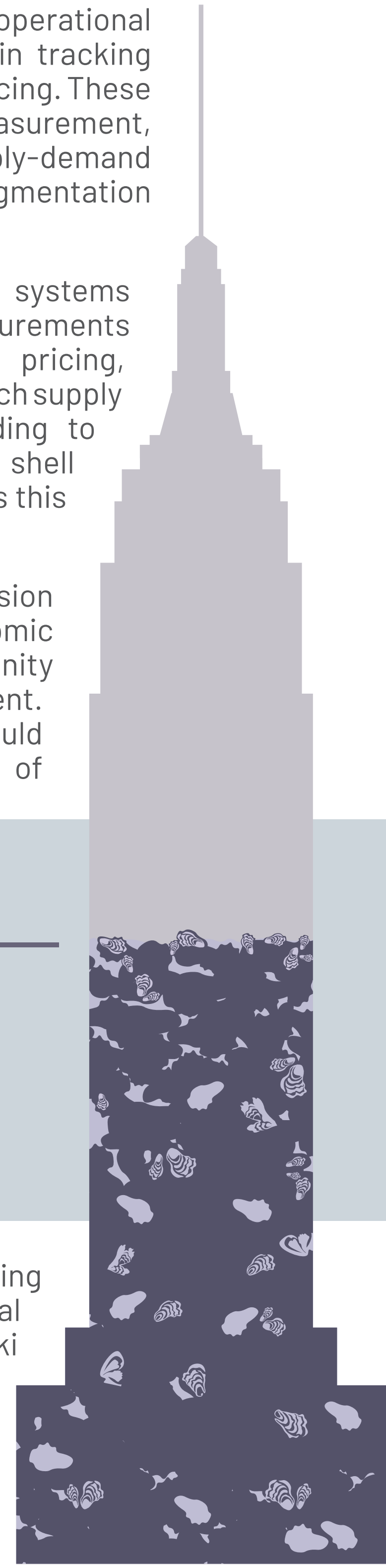
Across programs, OSRPs measure their collection in incompatible units: bushels (which can vary by state), tons, cubic yards, or pounds. The cost to collect a pound of shell ranges from $0.06 to $3.79 for functionally identical services — a 60-fold variation indicating operational inefficiency and high disparity in tracking costs rather than competitive pricing. These characteristics (inconsistent measurement, price variability, and supply-demand mismatch), signal market fragmentation rather than market equilibrium.

Efficient material recovery systems operate with standardized measurements to enable transparent pricing, coordination mechanisms to match supply with demand, and stable funding to support long-term planning. The shell recycling industry currently lacks this foundational infrastructure.

The ongoing shell diversion represents a massive economic "leak" and an untapped opportunity for ecological improvement. Redirecting this shell could contribute thousands of acres of reef habitat annually, capturing several million in net annual economic benefits (Grabowski et al., 2012). This analysis evaluates the underlying economics of OSRPs to identify the operational efficiencies and strategic investments required to close this gap.

40%

Annual shell volume discarded or diverted to secondary markets could fill 40% of the Empire State Building **every year.**



This project focuses on three strategic pillars:

- **National Landscape Mapping:** Quantifying domestic shell availability and tracing its flow across the United States.
- **Operational Benchmarking:** Analyzing OSRP practices through a "business lens" to identify cost-reduction and performance-optimizing best practices.
- **Supply-Demand Gap Analysis:** Surveying stakeholders to bridge the disconnect between available shell and restoration requirements.

For the last two pillars, we draw from parallel markets (e.g., food banks, municipal recycling, and logistics networks) that have successfully addressed similar operational challenges. While the oyster shell market has unique characteristics, these analogous industries offer proven playbooks for scaling collection infrastructure and reducing per-unit costs.

Market Landscape

The logistical barrier to shell recovery is rooted in a fundamental shift in the American oyster industry over the last half a century. Historically, centralized industrial hubs facilitated high-volume shell recovery at concentrated processing sites. Today, the market has pivoted to a premium half-shell trade, which reroutes the flow of shell away from coastal processing plants and into thousands of fragmented restaurant locations.

The Competition for Substrate

When shell is not captured by an OSRP, it typically follows one of two paths:

1. **The Wastestream:** In the absence of coordinated recovery, shell is discarded into landfills as a matter of logistical convenience.
2. **The Secondary Market:** Many seafood processors and vertically integrated farms operate "closed-loop" systems, retaining shell for their own operations. When shell is not used internally, it enters a secondary commercial market. Processors sell excess shell to state and federal agencies for commercial replenishing or to private buyers for use in industrial applications, agriculture, and pharmaceuticals.

Since restaurants are the primary destination before the landfill, increasing collection efficiency in the food service industry would directly tackle the substrate deficit and reintegrate shell into the restoration supply chain.

PICTURED:

(left) Recycled oyster shells.
© Jason Houston

(right) Oyster shell recycling program in Virginia.
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Oyster Shell Recycling Programs' Role in Restoration

OSRPs serve as the primary mechanism for intercepting shell before it enters the wastestream. At the time of this paper, only 36 active OSRPs are in operation across the entire United States. These organizations operate across a wide spectrum of scales and methodologies, but they generally follow a consistent value chain:

1. **Administrative Foundation and Planning:** Securing funding sources, establishing partnerships (restaurants, contractors, volunteers), and procuring specialized hauling equipment and containers.
2. **Collection:** Mapping driving routes and physically gathering shell-filled containers while tracking critical data like weight and volume at each stop.
3. **Curing and Storage:** Cleaning shell of debris and weathering it naturally for 6–24 months to ensure it is biologically safe before use.

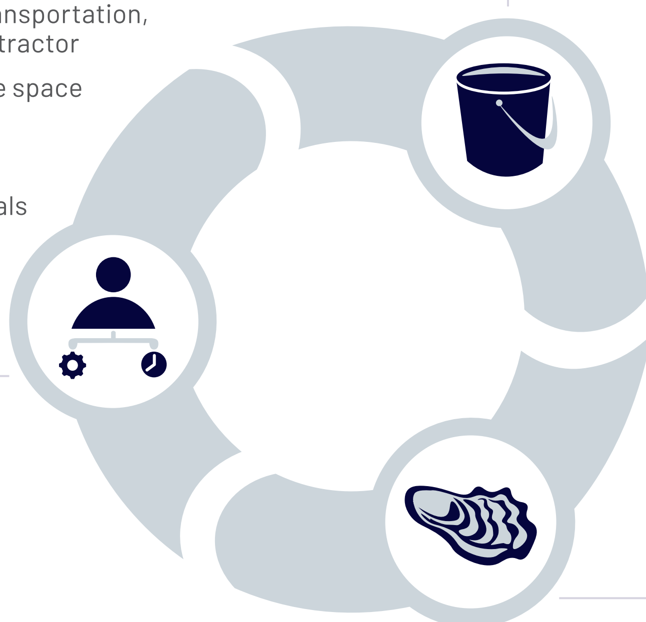
A detailed value chain of shell recycling is depicted below:

1: ADMINISTRATIVE FOUNDATION & PLANNING

- Assembling a team, securing funding as needed
- Identifying and reaching out to collection targets — restaurants and events
- Acquiring equipment and transportation, or identifying collection contractor
- Securing curling and storage space
- Onboarding and training restaurants, contractors
- Preparing marketing materials and advertising efforts — spreading the word

2: COLLECTION

- Establishing a pickup schedule, coordinating with restaurants
- Physically collecting shell, tracking and recording data (weight, volume, time)
- Transport to curing site



3: CURING & STORAGE

- Dropping off shell
- Cleaning equipment (bins, lids, trailers
- Organizing shell to track curing times
- Turning/rotating
- Transporting to secondary storage site (if needed)

While the steps of shell recycling are largely consistent, execution and outcomes across OSRPs vary greatly. Not only do operations differ based on equipment and collection methods (primarily in-house, volunteer, or contractor), OSRPs diverge in functional structure depending on program leadership (nonprofit, government, academia). No singular model or method is best; each OSRP is best designed to fit the local community.

Success in oyster shell recycling is multifaceted. Some OSRPs are able to collect significant amounts of shell and deploy in their local community, with the largest standing at 2.1 million pounds in 2024. However, this singular metric is not the only way to assess performance. Many OSRPs prioritize qualitative outcomes such as community stewardship, public education, and local advocacy.

This analysis does not make a value judgment on these diverse missions. Instead, it seeks to understand the economics of shell recycling to determine how programs can scale most effectively. Self-reported data from 12 different OSRPs (33% of all OSRPs) revealed a significant range in the cost per pound of shell collected, spanning from $0.06 to $3.79, with a national average of $1.14 per pound.[1] The wide variance in current output and costs suggests that there is significant room for optimization across the industry. Our interviews and data collection point toward several key levers for improvement. These levers serve as a roadmap for OSRPs to maximize their impact while maintaining a sustainable economic footprint.

1 Excludes OSRPs reporting solely collection costs or who were unable to remove restoration expenses from total costs.

Performance Improvement

OSRPs collectively recycled approximately 9.7 million pounds of shell in 2024.[2] Despite being a significant achievement, this represents only 3–5% of the 279.9 million pounds of oyster shell generated annually in the United States. To bridge the gap, OSRPs must transition to standardized, efficient systems. Mature sectors like food logistics and municipal waste management provide proven frameworks to increase collection volume and drive down costs.

The following recommendations draw on parallel markets (e.g., food banks, municipal recycling, and logistics networks) that have successfully addressed similar operational challenges: geographically dispersed supply, unpredictable volumes, and coordination across independent actors. While the oyster shell market has unique characteristics, these analogous industries offer proven playbooks for scaling collection infrastructure and reducing per-unit costs. Each recommendation below includes a precedent from a parallel market followed by specific implementation guidance for OSRPs.

1. Strengthen operational practices across OSRPs

LOCAL

OSRPs can decrease cost per pound by adopting a set of proven operational practices commonly used across high-performing non-profits and businesses. These include cost tracking by activity, route optimization, and resource planning tools to facilitate measurable performance metrics. Transportation and logistics costs are often one of the largest cost categories. OSRPs operating under $0.50 per pound often report particular attention paid to improving their route timing, right-sizing equipment to scale, and using data as a feedback mechanism for why certain operational choices worked well or did not.

Data collection is a major gap for the industry. Many OSRPs do not keep detailed, consistent records key to making operational changes. For example, only 6 of 17 interviewed OSRPs provided clear cost category breakdowns for operating expenses. Without a baseline, OSRPs have no way to gauge if changing pickup time, adjusting routes, or changing frequency of pickup saves time or cuts costs.

PROVEN ANALOGUE:

Food Bank Route Optimization:
Food banks face nearly identical operational challenges: unpredictable volumes, limited storage, and coordination of pickups across dispersed locations. Feeding America member food banks implemented systematic improvements (e.g., daily coordination huddles, standardized protocols, route optimization software), which increased throughput by 20–30% without adding staff. Feeding South Florida specifically documented COVID-19 improvements: route optimization reduced average miles per stop by 18% and standardized bin systems cut pickup time by 12 minutes per location, enabling 40% more volume with the existing fleet.

Implementation for Shell Recycling:
Use resource planning tools to compile collection data and establish an operational baseline. Start with logistics, as transportation is one of the largest cost categories and provides an immediate opportunity for improvement. Track total route duration, pickup frequency, and geographic clustering to transform daily logs into a feedback loop.

2 Total estimate takes into consideration data compiled from 19 OSRPs — comprising 17 primary interviews and two OSRPs with publicly reported 2024 collection totals.

2. Establish a common language and measurement standard

LOCAL

Oyster shell recycling faces fragmentation. From our interviews and survey, we found that some OSRPs measure and record data in bushels, others in tons, and others still in pounds. Even the definition of a bushel can vary within states. A Maryland OSRP collecting 50 bushels cannot easily be compared to a South Carolina restaurant reporting tons. This prevents easy comparison, coordination of excess supply, or establishing transparent pricing. Standardization would enable consistent comparison of cost per pound.

PROVEN ANALOGUE:

USDA Grain Grading:
Before federal standards (1916), farmers faced inconsistent pricing and disputes over quality. The U.S. Grain Standards Act established uniform grades (e.g., “No. 2 Yellow Corn” with specific moisture, test weight, damage tolerances), enabling commodity futures trading and transparent national pricing. This transformed the United States’ regional markets into one of the world’s most efficient agricultural systems, now trading $150+ billion annually. Similar patterns appear in lumber grading and voluntary carbon markets.

Implementation for Shell Recycling:
Adopt a universal unit, publish conversion factors for legacy measurements, and require standardized reporting in funding programs.

PICTURED:

(left) Shells are prepared to be deposited into the Piankatank River, Virginia.

(right) Oyster shell collection from a restaurant in Annapolis, Maryland.

3. Leverage existing logistics to cut transportation costs

LOCAL

Transportation is one of the largest cost drivers identified by OSRPs as a barrier to scaling. The fastest efficiency gains come from partnering with organizations already visiting restaurants so shell collection is integrated into existing routes rather than requiring dedicated trips. Some OSRPs have already successfully achieved this through partnerships with seafood distributors and waste haulers. For example, Wild Oyster Project partnered with Royal Hawaiian Seafood, allowing shells to be collected during oyster deliveries. Similarly, New Jersey Department of Environmental Protection (NJDEP) partnered with large distributors to rapidly expand restaurant participation with minimal incremental logistics cost. The NJDEP–Sysco partnership expanded access to hundreds of restaurants and increased shell collection volumes by an estimated 200–300% in participating areas (NJDEP, 2025). Adding collection to existing routes lowers cost per pound and enables faster scaling without additional capital investment in dedicated vehicles.

PROVEN ANALOGUE:

Reverse Logistics in Beverage Distribution: The beverage industry faced an analogous challenge with container returns under bottle deposit systems. Rather than creating dedicated collection infrastructure, distributors integrated returns into existing delivery routes — trucks that were delivering full cases collected empty bottles on the same trip. This "backhaul" model transformed economics: dedicated collection routes cost $0.15–0.25 per container mile, while integrated backhaul added only $0.03–0.05 per container mile (marginal fuel and handling time). California's beverage container system processes 18+ billion containers each year largely through distributor backhaul networks, achieving recovery rates above 80% compared to ~30% in non-deposit states without integrated logistics.

Implementation for Shell Recycling:
Capitalize on existing distribution and collection routes (e.g., seafood, produce delivery, or garbage/ waste collection) to scale shell recycling without the overhead of dedicated labor or a specialized fleet.

4. Improve collection efficiency with appropriate equipment and clear protocols

LOCAL

Simple operational upgrades can materially improve efficiency. OSRPs using appropriate handling equipment such as lift gates or hydraulic systems reduce labor needs and injury risk, while clearly labeled, standardized containers reduce contamination and confusion in busy kitchens. These changes shorten pickup time per stop, improve restaurant compliance, and increase usable shell collected without increasing headcount. Small execution details compound across hundreds of pickups and directly affect throughput and quality. OSRPs with highest efficiency and shell collection volume are examples of how equipment investment translates directly to lower per-pound costs at scale.

PROVEN ANALOGUE:

Curbside Recycling Cart Standardization:
Municipal recycling faced similar equipment challenges in the 1980s—'90s. Early programs used inconsistent containers. Residents provided their own bins, creating sorting delays, spillage, and worker injuries from lifting awkward loads. Collection times averaged 45–60 seconds per household. The transition to standardized wheeled carts with automated/semi-automated lift systems reduced collection time to 15–20 seconds per household while cutting worker compensation claims by 60–70%. Initial cart costs ($40–60 per household) were offset within 18–24 months through labor savings and increased participation (standardized carts improved capture rates 15–25% by making recycling more convenient). Waste Management and Republic Services documented that routes using automated systems achieved 30–40% higher productivity (households per hour) with 50% fewer injuries compared to manual collection. The equipment investment was substantial but economically rational at scale.

Implementation for Shell Recycling:
Standardize on clearly marked, appropriately sized containers to reduce contamination and handling time. Use 32- to 96-gallon wheeled toters for mechanized collection or 5-gallon buckets for manual tasks. Equip vehicles with lift gates or hydraulic trailers to enable single-person operations. OSRPs should verify that equipment investment is justified by collection volume, as this is typically economical only in circumstances with more than 20–30 regular restaurant partners. For smaller operations, prioritize partnerships with equipped haulers rather than direct ownership to maintain cost-effectiveness.

PICTURED:

(left) Volunteers transporting shells through the Virginia Oyster Shell Recycling Program.
© Aileen Devlin, Virginia Sea Grant. CC BY-ND 2.0

(right) Dylan's Oyster Cellar in Baltimore recycles its oyster shells.
© Greg Kahn

5. Stabilize funding to enable planning and lower unit costs

LOCAL

Unpredictable funding forces OSRPs to focus on near-term planning and diverts valuable time and attention. OSRPs that rely on short-term grants face higher implicit costs due to administrative overhead, contractor risk premiums, and inability to invest in multi-year assets. OSRPs with stable, predictable funding can plan staffing, secure longer term hauling contracts, and invest in infrastructure that lowers marginal cost per pound. Predictable funding enables efficiency investment rather than survival mode operations.

PROVEN ANALOGUE:

California Bottle Bill (1986):
California's beverage container recycling faced chronic funding instability in early years, with programs collapsing when commodity prices dropped. The California Redemption Value (CRV) system created predictable funding by charging deposits at purchase and funding redemption through unclaimed deposits plus recycling fees. As a result, California's beverage container recycling rate stabilized above 80% (compared to ~30% in non-deposit states), and the system became self-sustaining without ongoing appropriations. The CalRecycle program now handles 18+ billion containers annually with administrative costs under 5% of total program expenditures; an efficiency achievable only through stable, predictable revenue enabling long-term contracts and infrastructure investment.

Implementation for Shell Recycling:
Prioritize consistent funding as a core business strategy and increase its proportion of the total funding portfolio, while still supplementing with repetitive short-term, grant opportunities. These solutions will look different for different OSRPs, but successful examples have included transitioning to a restaurant fee model for shell collection and charging participating restaurants for waste diversion to offset operational costs.

6. Coordinate regionally to match supply with demand

NATIONAL

Shell supply and restoration demand are often mismatched due to siloed communication. Survey responses indicate that 76% of OSRPs receive inbound requests for shell, and 82% of OSRPs pre-allocate shell supplies to existing projects. Taken at face value, this suggests that supply and demand are broadly in balance and that there is limited "excess" shell in the system; however, these figures alone do not fully capture the dynamics of shell availability and use.

Qualitative evidence from interviews and field conversations reveals a more complex reality. OSRPs and partners described untracked or poorly tracked shell piles, including multi-year accumulations that were only identified opportunistically, as well as shell left stranded when programs lost funding and could no longer move material. At the same time, other practitioners reported difficulty sourcing shell and even attempts to obtain shell from distant regions or international sources. Together, these examples point to a systemic coordination problem, not a true absence of unmet demand.

This has important implications at scale. While today's relatively low collection rates partially mask the mismatch, any significant increase in shell recycling (e.g., a 50% or greater increase in volumes collected) will amplify these underlying disconnects. Without intentional mechanisms to track, coordinate, and reallocate shell, the system risks accumulating stranded surplus in some regions while others continue to experience binding constraints on access. Regional coordination would enable price discovery and ensure shell flows to its highest ecological use rather than being wasted or imported unnecessarily.

PROVEN ANALOGUE:

National Organ Procurement and Transplantation Network (OPTN) (1984):
Before OPTN, organ donation operated as disconnected local systems with independent wait lists and ad hoc interstate coordination. Organs went unused in one region while patients died waiting in another. The National Organ Transplant Act created centralized registry, standardized allocation criteria, and coordinated logistics. Transplant volume increased from ~8,000 annually (1984) to 40,000+ today. Critically, OPTN optimized allocation of existing supply rather than increasing supply — organ utilization increased from ~70% to over 90%.

Implementation for Shell Recycling:
Create a digital inventory-matching platform to bridge the gap between idle stockpiles and need. Modern cloud technology can facilitate this coordination at a modest cost; the primary barrier remains institutional alignment rather than technical capability.

PICTURED:

Bags of oyster shells in Mobile Bay, Alabama where volunteers came out to restore the oyster reefs.

Final Thoughts

A frequently cited challenge in oyster restoration is that "shell is limiting". However, this analysis indicates that total availability of shell is not the limiting factor. Instead, what is constrained is our collective ability to easily and efficiently access oyster shell for restoration.

Every year, hundreds of millions of pounds of shell is sent to landfills despite the fact that restoration organizations face substrate shortages. Restaurants incur disposal costs for shells, while restoration projects pay a premium to purchase them.

This inefficiency stems from a lack of formal market structures, but other material recovery industries have shown that this challenge can be tackled. Oyster shell recycling now stands at a similar crossroads — the pre-formalization stage that other sectors have already successfully navigated.

The interventions required are neither novel nor uncertain. Efficiency is possible; look only to the OSRPs achieving costs below $0.50 per pound while collecting millions of pounds annually. The difference between best-in-class and operationally constrained OSRPs reflects infrastructural and operational maturity, not geographic fate.

The blueprint is laid out here. With the restoration economy at $70–$90 million annually and growing, and substrate demand anticipated to rise as climate priorities drive coastal protection efforts, the oyster shell market is a smart investment. Shell recycling can continue to evolve through fragmented trial and error, or it can adopt the institutional architecture that formalized every other material recovery sector.

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PICTURED:

(left) Spat on shell loaded into tanks on the pier in Cambridge, Maryland.
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(right) Oyster reefs near McIntosh County, Georgia.
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