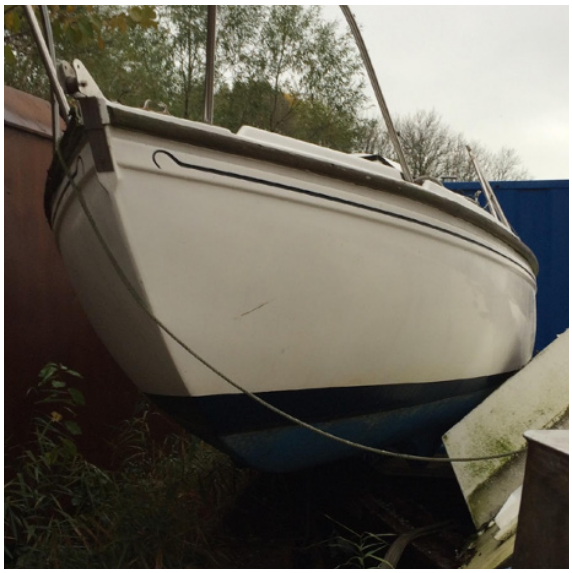

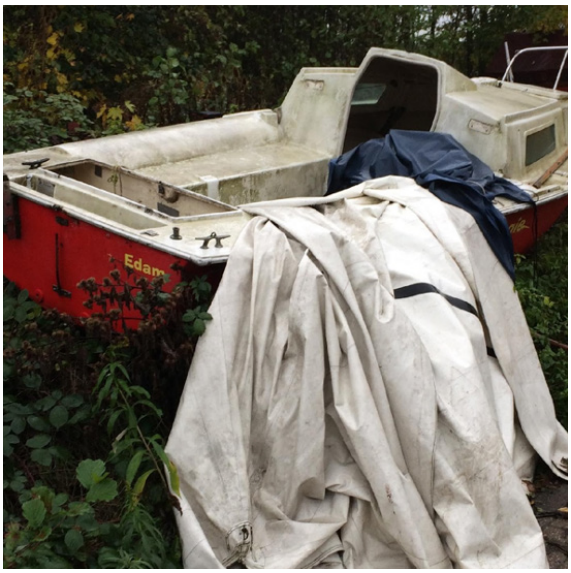

Recycling Opportunities for Abandoned, Derelict, and End-of-Life Recreational Vessels

National Oceanic and Atmospheric Administration
NOAA
U.S. Department of Commerce

RIMTA

National Marine Sanctuary Foundation

Recycling Opportunities for Abandoned, Derelict, and End-of-Life Recreational Vessels

Prepared By:
RIMTA Foundation

February 2023

The National Marine Sanctuary Foundation (the Foundation) in coordination with the National Oceanic and Atmospheric Administration (NOAA) Marine Debris Program provided support for the Rhode Island Marine Trades Association (RIMTA) Foundation to develop this report examining challenges and opportunities related to the recycling of abandoned, derelict, and end-of-life recreational vessels. This report was developed to meet the requirement established by Section 136 of Save our Seas 2.0 Act, P.L. 116-224 for NOAA and the Environmental Protection Agency (EPA) to jointly conduct a study to determine the feasibility of developing a nationwide vessel recycling program, using the pilot project in Rhode Island as a model. NOAA and EPA reviewed and provided comments on this report in the stages toward its completion and submission. The RIMTA Foundation is a 501c3 non-profit affiliate of RIMTA, an organization dedicated to supporting the recreational boating industry through advocacy, education, and promotion.

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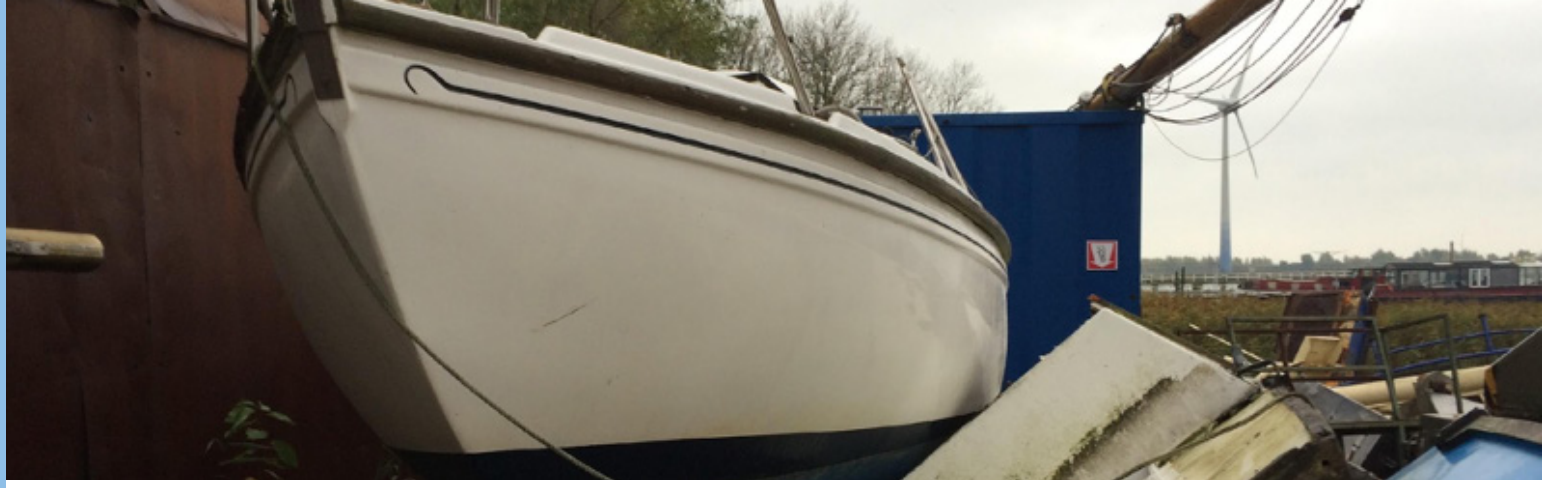
THIS STUDY IS PROVIDED PURSUANT TO THE SAVE OUR SEAS 2.0 ACT (P.L. 116-224) AND SECTION 136 OF THE ACT REQUIRES

Not later than 1 year after the date of the enactment of this Act, the Under Secretary and the EPA Administrator shall jointly conduct a study to determine the feasibility of developing a nationwide derelict vessel recycling program—

(1) using as a model the fiberglass vessel recycling program from the pilot project in Rhode Island led by Rhode Island Sea Grant and its partners; and

(2) including, if possible, recycling of vessels made from materials other than fiberglass.



Executive Summary

A centralized, nationwide fiberglass vessel recycling program would present a viable solution for abandoned, derelict, and end-of-life vessels, a pervasive source of marine debris. To be feasible, the following issue areas must be addressed: program development, supply chain integration, centralization of fiberglass recycling, recycling cost, environmental concerns, and policy development. Coordination and collaboration between the marine industry, trade and professional associations, local, state, and federal government, and the various other industrial sectors are important to address the barriers of establishing a nationwide fiberglass recycling program.

Introduction

Marine debris can range greatly in size, from microscopic plastic pieces to large abandoned and derelict vessels. These vessels, no longer maintained by their owners, litter ports, waterways, and estuaries around the country, posing a threat to people and the environment. Though the legal definitions of abandoned and derelict vessels vary, "derelict" often refers to neglected vessels with an identifiable owner, while "abandoned" refers to vessels with no known owner or an owner who has surrendered rights of ownership. Vessels become abandoned and derelict for many reasons: owners may no longer be able to afford maintenance, they may break loose from anchors or moorings and drift away, and some may be stolen. Severe weather events, like hurricanes or flooding, can also cause vessels to sink at moorings, become submerged in tidal areas, or strand on shorelines, marshes, or reefs. As many as 65,000 vessels are lost annually due to weather events alone (Rudow, 2017).

In addition to dereliction and abandonment, the National Marine Manufacturers Association has tracked the rate of vessel retirement across different portions of the national recreational fleet. In 2016 alone, 177,250 vessels were retired, representing 1.5% of the total fleet (NMMA, 2016). The accumulation of this legacy fleet is anticipated to continue. More than one million used recreational vessels of all types and ages changed hands in 2020, along with more than 320,000 new vessels sold during the COVID-19 pandemic (Chang, 2021).

The environmental risks generated by abandoned, derelict, and end-of-life vessels often begin when a vessel has remained in one place, on land or in water, over long periods of time. These vessels can block navigational channels, damage habitat, diminish the recreational value of the surrounding area, and create marine debris. Storage tank contents such as oil, gas, and human waste, as well as common maintenance products including paint, lubricant, varnish, and antifreeze can end up in water, soil, and critical habitat.

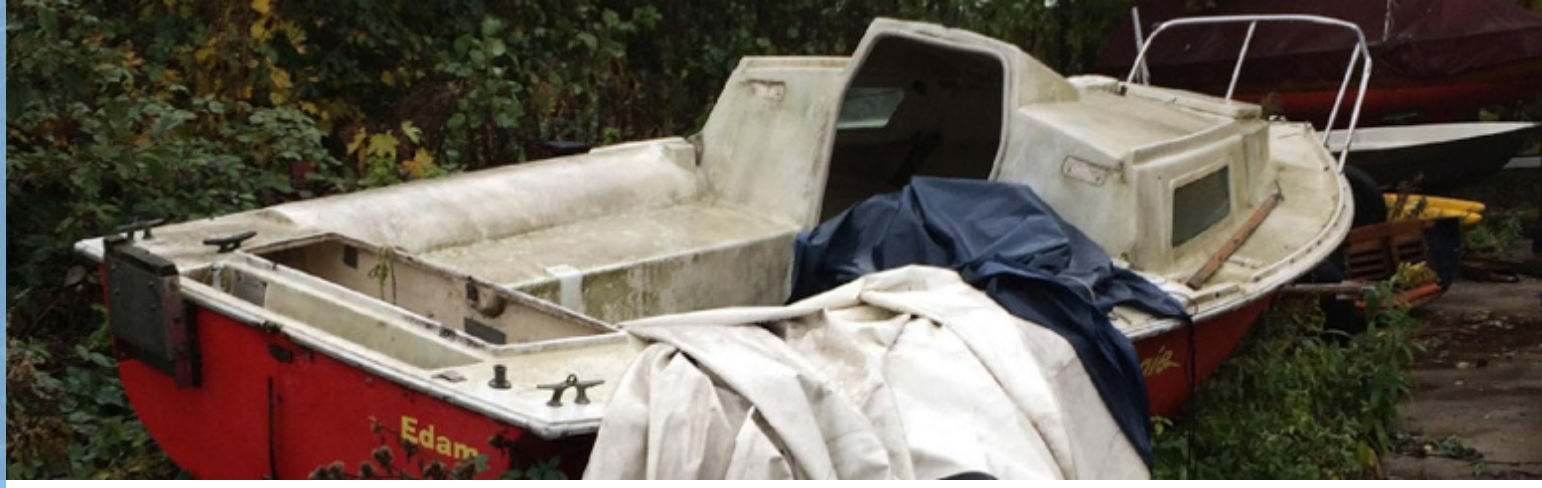
New information on the long-term degradation of fiberglass materials suggests damaging impacts may also be occurring on a microscopic scale. Like many polymer-infused composites, fiberglass is non-biodegradable and is susceptible to a gradual breakdown. Based on chemical composition, many believe that fiberglass compounds perform similarly to other plastic-based materials that contribute to the presence of microplastics in the environment (Bray, 2019).

The traditional method for disposal relies on a process of removing abandoned or derelict vessels from the environment or transporting end-of-life vessels to waste management sites. Vessels may be located in hard-to-reach areas, and require large, specialized equipment for recovery and transportation. Adding to the challenge, laws surrounding removal can vary across states. Once at a waste management site, the process continues with recovering valuable metals, disposing of hazardous materials, crushing the vessels in or near dumpsters, and hauling the compacted vessels to finally be buried in landfills. Landfill space is a finite resource and some communities are already facing constraints. Landfilling also destroys valuable materials that could be reused. Vessel waste management challenges are exacerbated in states that host large, year-round boating populations and are more commonly exposed to the impacts of major weather events such as hurricanes.

At this time, vessels made from materials such as wood or aluminum can be recycled through traditional recycling outlets. In general, large vessels are constructed with steel or aluminum, fishing vessels may be made from steel, wood, or fiberglass, and recreational vessels are largely constructed with fiberglass. Thus, this report focuses on the feasibility of recycling recreational fiberglass vessels that commonly become abandoned or derelict in coastal communities and the Great Lakes.

The Rhode Island Fiberglass Vessel Recycling Pilot Project (Pilot Project) became the first program in the United States to explore reuse of fiberglass material in cement co-processing. The Pilot Project was established by the Rhode Island Marine Trades Association (RIMTA) and Rhode Island Sea Grant in 2018 as a direct response to growing solid waste management and environmental concerns around materials from abandoned, derelict, and end-of-life vessels. Through the development of a diverse partnership network, the Pilot Project collected, tested, processed, and delivered 80 short tons of fiberglass material from a variety of abandoned, derelict, and end-of-life vessels for use by a cement manufacturing facility in Holly Hill, South Carolina. The Pilot Project can be used as a model to examine how a nationwide vessel recycling program could work.

The Save Our Seas 2.0 Act of 2020 (Public Law 116-224) mandates the National Oceanic and Atmospheric Administration (NOAA) and Environmental Protection Agency to complete a study to determine the feasibility of a nationwide vessel recycling program. The NOAA Marine Debris Program provided funding to RIMTA through a competitive award to expand their initial pilot program to inform the feasibility of developing a nationwide vessel recycling program. This report is a summary of that project and includes information and perspective on the challenges faced in developing new options to recycle fiberglass vessels as well as the status of emerging management strategies.



Disposing of Abandonded, Derelict, and End-of-Life Vessels

Recreational vessels are composed of interdependent materials and products that, when managed and separated properly, can be diverted to a salvage or secondary market for reuse. For example, the fiberglass hull can be processed into recyclate or reduced to resin and glass fibers. However, stripping and removing embedded materials from the hull can be a challenge.

Additionally, an overcrowded second-hand vessel marketplace, low salvage value for aging parts, and the high cost of storage and disposal present financial challenges to vessel owners. Because of this, owners often delay taking action, and vessels that are unused and unwanted accumulate in backyards, driveways, boatyards and, in some cases, are abandoned on the water.

Disposal in Landfills

Landfills are typically viewed as the least expensive pathway for disposal of abandoned, derelict, and end-of-life vessels based on the simple cost of the tipping fee per ton. Vessels may arrive at a landfill in many different forms, from intact on a trailer to crushed and disassembled in dumpsters. Unless it is prepared and inspected for removal of hazardous materials and fuels, a hull could be buried with hazardous residue.

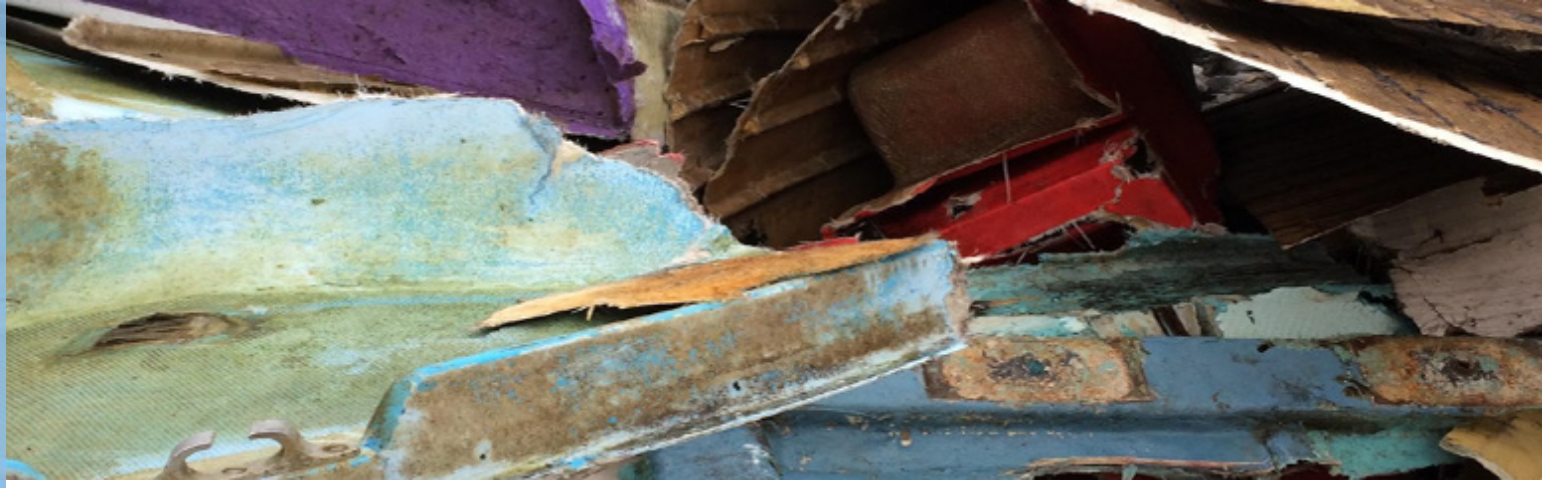
Prior to crushing and burial in a landfill, a certain degree of salvage might take place. However, it takes a lot of effort to properly disassemble and sort all materials typically found on a vessel. While specialized businesses do exist to support small-scale deconstruction and salvage, there is little or no infrastructure to connect with large-scale waste management partners capable of facilitating the processing and delivery of recovered materials and fiberglass recyclate to end-users. The cost of landfill disposal does not reflect the full cost of potential environmental impacts, nor the lost value of a refined material that offers potential energy, environmental, and resource benefits.

Although landfill space is available in many regions, some boating populations may face increasingly limited landfill access due to rising costs, limited operation, or legislation. For example, Rhode Island's Central Landfill is projected to reach capacity in 2040 (RIRRC, n.d.).

Alternatives to Landfilling

At present, cement kiln co-processing may be the most accessible emerging alternative for disposing of large volumes of fiberglass in the United States. When used in cement co-processing, fiberglass recyclate displaces fossil fuels, thus reducing greenhouse gas emissions, and replaces use of raw resources such as silica and alumina. Evaluations conducted by the European Composite Industries Association have demonstrated that the use of fiberglass recyclate in co-processing can reduce carbon dioxide produced by up to 16% per ton of virgin cement (EuCIA, n.d.). More recent research has illustrated that larger quantities of fiberglass taken from General Electric wind turbine blades can reduce overall carbon dioxide output from cement manufacturing by up to 27% (Veolia, 2020).

In addition to use in cement manufacturing, researchers are investigating chemical processes to separate fiberglass into resin and glass fibers. This is a new and developing avenue of exploration. As a result, this study focuses on cement co-processing and the general factors to consider for fiberglass recycling.



Challenges and Opportunities of a Nationwide Vessel Recycling Program

Rhode Island Fiberglass Recycling Pilot Project

The Rhode Island Fiberglass Vessel Recycling Pilot Project (Pilot Project) was the first project to recycle materials from abandoned, derelict, and end-of-life vessels through a multi-year coordination effort between state agencies and business partners. The core partners consist of: marinas, boatyards, and salvagers that contribute to the collection of vessels; transport and salvage partners who strip vessels according to Rhode Island Marine Trades Association (RIMTA) specifications; and a waste processing partner who crushes stripped vessels, grinds the fiberglass into specified recyclate material, and provides transport of the recyclate to a cement kiln.

The Pilot Project also worked with United States cement manufacturers to conduct sample tests of fiberglass materials to determine if they meet kiln specifications. The tests showed that properly processed fiberglass recyclate from vessels provided both energy and material benefits to the cement-making process. Media coverage of the initiative and conference presentations stimulated further conversations with both the cement-making industry and composite fiberglass manufacturers, including representatives of General Electric and Veolia, which have since launched their own fiberglass cement co-processing program to manage decommissioned wind turbine blades.

The Pilot Project demonstrated that successful recycling of vessel fiberglass is possible. Marine businesses are able to collect fiberglass vessels, separate the materials, and responsibly mitigate their potential to pollute the marine environment. Other entities including but not limited to original equipment manufacturers, raw material distributors, naval architects, retailers, and insurance providers have also demonstrated interest and ability in facilitating and supporting fiberglass vessel recycling activities.

With funding from the NOAA Marine Debris Program, the Pilot Project was expanded to replicate vessel recycling activity in additional coastal states, develop educational and technical resources for use by vessel recycling stakeholders, prepare qualitative and quantitative analyses on relevant recycling practices, and expand important partnerships within the marine industry. As part of this effort, RIMTA also developed an End-of-Life Vessel Material Management Guide to address the most relevant questions and concerns shared by vessel owners, marine businesses, waste managers, and

material end-users (RIMTA, 2021). Several states are now engaged at various stages in establishing vessel recycling programs.

Beginning in 2019, RIMTA organized conversations with stakeholders in Washington State and supported an effort in the legislature to establish a state vessel recycling program. State agencies in Washington initiated efforts to develop partnerships and trial the logistics necessary to support a vessel recycling pilot project (WA-DNR, n.d.). However, health and safety considerations surrounding the COVID-19 pandemic as well as the financial feasibility of the proposed vessel recycling logistics caused delays. RIMTA maintains ongoing coordination with the Washington Department of Natural Resources, Washington Sea Grant, and the NOAA Marine Debris Program to identify and re-engage stakeholders with capabilities to support vessel recycling activities.

Between 2019 and 2020, replication in the broader New England region was supported through existing relationships with the Marine Trades Associations in Connecticut, Massachusetts, and Maine. Each organization facilitated outreach to interested members and identification of relevant state authorities. Using the existing logistic model of the Pilot Project, vessels from Massachusetts, Maine, and Rhode Island were collected for deconstruction and recycling.

Engagement with the Southeast Abandoned and Derelict Vessel Working Group in February 2021 spawned conversations with stakeholders in North and South Carolina, including the South Carolina Department of Health and Environmental Control, North Carolina Sea Grant, marine businesses, and material recyclers.

Stakeholders in additional states including Ohio, Maryland, Virginia, and California received logistics insight, partner introductions, and general information on vessel recycling opportunities. RIMTA has also continued regular international communication and outreach with industry colleagues, researchers, and project organizers in Canada and Europe.

Through these efforts, the following challenges and opportunities in establishing a nationwide fiberglass vessel recycling program were identified.

Program Development

Individuals and businesses may struggle to find fiberglass recycling solutions on their own. Vessel manufacturers, vessel owners, marina operators, public officials, and material end-users must be part of the solution. The Pilot Project has proven the ability of a central party to coordinate a decentralized network of partners to carry out vessel recycling activities. The marine industry is well-positioned to coordinate the adoption of key standards or responsibilities related to vessel recycling. National industry organizations have frameworks and resources in place to establish protocols that can be further promoted by state and regional marine trade associations.

Action plans to prevent and address marine debris have been developed by stakeholders in states and regions across the United States. Including vessel recycling efforts in these plans would also help to facilitate funding and develop partnerships based on the experiences of the Pilot Project.

Supply Chain Integration

Abandoned, derelict, and end-of-life vessels do not produce a sufficiently large and stable stream of fiberglass recyclate to support a viable end use market. However, hundreds of other products across automotive, aerospace, construction, consumer services, and energy production use fiberglass. As of August 2022, a 7.1 percent annual increase in fiberglass demand is anticipated by 2027 (Markets and Markets, 2022). Subsequently, these diverse industry sectors also face challenges presented by fiberglass products at the end of their life.

The growth of a fiberglass recycling supply chain in the United States will rely on the successful consolidation of fiberglass material from a variety of sources. The efficiency of fiberglass recycling and the cost of associated processes are directly related to the volume of material that can be captured. Composites like fiberglass are widely used across a variety of industry sectors and, in some cases, in geographic locations that overlap with areas that contain large boating populations and marine industry activity.

As a practical matter, the cement industry has the capacity to use large volumes of composite materials like fiberglass annually through co-processing (EuCIA, n.d.). However, collecting and distributing relevant materials is a challenge. A central reporting and monitoring function could help quantify the volumes of fiberglass waste accumulated by specific industries and the potential to consolidate waste management practices through a shared supply chain.

Centralization of Fiberglass Recycling

Businesses within and adjacent to the marine industry have proven their ability to successfully contribute to a recycling supply chain. However, collection, processing, and transportation of end-of-life vessel materials often fall to third party businesses with varying capacity, capability, and interest in handling fiberglass. Variation in those businesses can greatly influence the cost and time required for vessel recycling activities.

Centralization of fiberglass recycling across multiple industries could help create better economic conditions and increase the visibility of recycling technologies and fiberglass recyclate to potential end-users. Centralized operations could take place through a public program that contracts with a private firm or business, or coordinated firms for various tasks. The cost efficiencies of centralization are reflected in a potential lower per-ton cost to access end-user outlets like cement kilns, streamlined material processing, lower transportation costs, and the management of market distribution and volume by specialized facilities. However, raising the capital needed for investment and business development in order to attract partnerships with the marine industry is a challenge.

As management practices for other fiberglass products like wind turbine blades continue to evolve, vessel recycling stakeholders will benefit from engaging with other industries, with the support of national associations, academic institutions, and government agency partners. The wind, automobile, aerospace, and construction sectors all are possible targets for coordination and centralization.

Recycling Cost

The labor and equipment costs of recycling activities such as deconstruction, shredding, and transportation can be a significant impediment to public or private business participants. Specialized labor and resources are ultimately reflected in higher prices for boat owners and recyclers alike. The recycling of fiberglass through existing end-user channels requires tipping and service fees just like traditional waste management outlets.

This low-profit outlook has historically limited vessel disposal to opportunistic, seasonal activity. As noted above, consolidation of waste streams and centralization of recycling processes could reduce the cost of producing fiberglass recyclate or resin and glass fiber to make it more competitive with other disposal options. Building vessels that are easier to disassemble without sacrificing safety and performance would also contribute to the effectiveness and cost efficiency of recovering and recycling materials.

Environmental Impacts

Although fiberglass waste is classified as a non-hazardous material, processing fiberglass for reuse has various health and safety requirements that must be carried out by an experienced staff working in a designated facility with proper amenities. High silica content produces harmful dust when fiberglass is broken down, shredded, or transported. Additionally, many elements of an abandoned, derelict, and end-of-life vessel, such as tanks, batteries, hazardous liquids, flares, paint, adhesives, and cleaners require specialized disposal to limit harmful environmental impacts. Measures to mitigate environmental and human health concerns can add to operational costs and further deter participation in vessel recycling.

Recycling abandoned, derelict, and end-of life vessels may require qualified waste management firms capable of handling other hard-to-manage materials (i.e. construction and demolition debris, tires, metals) with adequate facilities, equipment, and staff who are properly vetted and approved for such activities under all relevant state and federal laws and regulations.

Legislation and Policy Development

As discussed above, recycling fiberglass vessels currently costs more than traditional landfilling. Subsidies and funding of vessel recycling programs can help address that challenge before profitable markets are developed. Subsidies could then be retracted if a viable private sector market develops.

Legislation in other countries has successfully aided the redirection of fiberglass away from landfilling and towards innovative recycling solutions (see appendix). These policies have varied from outright landfill content bans to specialized taxes and funding allocations. Similar directives at federal and state levels in the United States could prove to be an effective tool in advancing recycling of abandoned, derelict, and end-of-life vessels.

Integrating Recycling into Existing Legislation and Programs

Some coastal and Great Lake states have enacted funding mechanisms to support removal and disposal of abandoned, derelict, and end-of-life vessels. In most cases, a central account receives revenue generated by annual registrations, vessel permit fees, mooring fees, or a portion of taxes on relevant services. Government agencies can then access the funds to remove abandoned, derelict, and end-of-life vessels within their areas of jurisdiction.

Vessel turn-in programs are also used as a mechanism to provide owners with a free and legal alternative to abandonment. These programs commonly offer collection periods several times a year. Owners able to provide proof of legal ownership can hand the vessels over for immediate disposal at no cost. This helps states to prevent the economic and environmental damages caused by abandoned and derelict vessels.

In the future, these government programs could prioritize recycling, rather than traditional landfilling, as the preferred method for disposing of collected vessels.

Supporting Continued Innovation

While cement co-processing is currently the most viable option for fiberglass vessel recycling, continued support for innovation in recycling processes and technologies could create new options. This could include pyrolysis and remanufacturing of recovered materials into a wide variety of products. Establishing a centralized pathway for processing fiberglass from various sources could make it easier for future uses and markets to develop. Support from governments, non-profits, and the private sector could advance further innovation in fiberglass recycling.

Summary

The following table provides a summary of the challenges discussed above, and the possible solutions to address them, based on the experiences of the Pilot Project.

Table 1. Challenges in developing a nationwide vessel recycling program and their solutions.

Challenge	Solution
Fragmented Supply Chain Abandoned, derelict, and end-of-life vessels do not produce a sufficient stream of fiberglass recyclate to support an end-use market	• Consolidating fiberglass material from a variety of sources
Decentralization There is little infrastructure to connect individual businesses with large-scale waste managers capable of processing and delivering recovered materials to end-users	• Establishing a central party to coordinate a network of partners • Including vessel recycling efforts in regional and state action plans • Engaging other industries, such as automotive, aerospace, construction, consumer services, and energy production
Cost The cost of current recycling options is higher than landfilling a vessel	• Building vessels that are easier to disassemble and enable clean recovery of materials, without sacrificing safety and performance • Assessing the true costs of vessel disposal options, including environmental impacts • Centralizing recycling processes • Establishing funding mechanisms for vessel recycling programs
Environmental Impacts Many components of abandoned, derelict, and end-of-life vessels require specialized disposal to limit harmful environmental impacts	• Working with qualified waste management firms capable of handling hard-to-manage materials with adequate facilities, equipment, and staff
Legislation and Policy The United States has gaps in legislation and policy to support vessel recycling	• Addressing policy gaps at federal and state levels in the United States • Prioritizing recycling in existing government programs, such as removal and disposal funding mechanisms and vessel turn-in programs • Continuing support for innovation in recycling processes and technologies

Conclusion

Abandoned, derelict, and end-of-life vessels pose many threats to coastal residents, wildlife, and the marine and Great Lakes environment. RIMTA developed a process to reuse the fiberglass from vessel hulls to replace virgin materials required for cement manufacturing. The complex logistics for breakdown, storage, transportation, and co-processing of recovered fiberglass are challenging and expensive, and further investigation, development, and collaboration is recommended. In order to enhance the feasibility of a nationwide vessel recycling program, local, state, and federal agencies could work with industry partners to address the solutions listed in **Table 1, page 14**.

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Appendix: International and Domestic Fiberglass Recycling Efforts

Marine industry and government efforts around the world have successfully advanced fiberglass and vessel recycling practices. While these examples vary in scale and approach, each demonstrates a commitment to coordinating vessel collection, processing, and reuse activities.

France

Founded by French marine industry association representatives in 2008, the Association La Plaisance Écoresponsable (APER) established a national network of collection sites, operated in partnership with waste management partners, where vessels can be delivered by owners for environmentally-conscious disposal.

The program transformed in 2018 when new legal statutes included vessels in regulatory requirements for extended producer responsibility. Today, the cost of disposal of end-of-life vessels with APER is covered by an "eco-contribution" attached to the sale of every new recreational vessel in France between eight and 72 feet in length. The cost of participation for vessel owners consists only of the transportation needed to deliver the vessel and time required to verify their ownership. Because of the legislative funding channel, the program is regularly audited and maintains transparency.

Recovered fiberglass has been used by both waste-to-energy facilities and cement kilns. As of 2020, approximately 2,500 vessels have been managed by APER at 23 collection sites (APER, n.d.).

Japan

Since 2005, the Japan Marine Industries Association has coordinated vessel recycling activities through a national program that receives government support. The ministry of Land, Infrastructure, Transport and Tourism provides administrative oversight of vessel collections at the local level. To participate in the voluntary program, owners must pay collection fees determined by the size of the vessel. As of 2018, typical costs ranged between $300 and $1,800 USD. Coordinating with waste management and cement kiln partners to facilitate the recycling process, the Japan Marine Industries Association uses the proceeds collected to pay for the process.

Approximately 8,000 vessels have been recycled since the program's inception. More than 450 businesses currently participate in the vessel recycling pathway through collection, deconstruction, processing, and cement kiln co-processing. Municipalities also host collection sites and coordinate with the Japan Marine Industries Association. Of the 725 metric tons of material managed by the Japan Marine Industries Association in 2018, more than 50% was fiberglass (Honda, 2020).

Sweden

In 2018, the Swedish Agency for Marine and Water Management provided subsidies to collect vessels at no cost to owners during specified amnesty periods. Outside of those periods, owners are responsible for covering those same costs (SwAM, n.d.).

In a separate effort, Stena, a waste management organization, has implemented a number of recycling solutions including pyrolysis, gas production, cement kiln co-processing, and inclusion as a roadway aggregate (Stena, n.d.). Stena uses materials collected and prepared by Båtskroten Sverige AB, a waste management partner offering 25 collection locations across Sweden. The process available to owners is coordinated and managed by Båtretur and Sweboat, marine industry organizations (Båtskroten, n.d.).

Germany

Neowa and Neocomp are two German companies established in 2015 with a joint venture formed to repurpose fiberglass as well as byproducts from the paper industry. Through extensive industry engagement, they now have a network of facilities to create recyclable materials (Neowa, n.d.). A majority of this is provided to cement kilns for co-processing. Working directly with manufacturers has enabled both companies to condense high volumes of material that can be used to leverage end-users. This approach was especially timely in addressing the concerns of industries facing the adoption of European Commission waste directives that limited the landfilling of composites as early as 2008 (EUR-Lex, 2008).

United States

Lifecycle Management of Fiberglass Wind Turbine Blades

Discussion of recycling fiberglass in the United States has largely centered on the development of lifecycle management and landfill alternatives for used wind turbine blades. Their size, composition, and geographic location can present waste management challenges that mirror those of abandoned, derelict, and end-of-life vessels. In states like South Dakota, Iowa, and Wyoming, thousands of decommissioned turbine blades are directed to a limited number of landfill sites with the capacity to take them (Martin, 2020). This has led to various legislative efforts to develop environmentally acceptable solutions, including a proposed ban on fiberglass municipal landfilling in Wyoming intended to shift burial of thousands of blades to open pit coal mines that are being filled and reclaimed (State of Wyoming, 2020; Johnson, 2021). The bill for this measure failed in the Wyoming Senate in 2020 (Waste360, 2020). As of 2021, no state has issued bans or limitations on the landfilling of fiberglass, although several have called for expanded evaluation of recycling and other landfill alternatives.

Through combining operations for material collection, processing, storage, and delivery, several businesses have demonstrated the ability to recycle high volumes of fiberglass, largely generated by wind turbine blades.

Veolia is a global waste management firm with a significant presence in the United States. In 2020,

Veolia dedicated a facility in Missouri to the collection and processing of fiberglass. The commitment was made possible by a contract with General Electric renewable energy, which was seeking an outlet for turbines scheduled to be decommissioned (Veolia, 2020). Fiberglass materials are collected and processed in a Veolia facility, and then delivered to cement industry partners.

Global Fiberglass Solutions is a Washington-based company that has advertised industrial fiberglass recycling solutions for a variety of products since 2009, including wind turbine blades. The company uses proprietary technology to manufacture new products that include recycled content. These products include fibers, pellets, and panels for construction (Global Fiberglass Solutions, n.d.).

Carbon Rivers is a certified small business in Tennessee that has partnered with industry leaders and research institutions to advance raw material recovery and product development using fiberglass (Carbon Rivers, n.d.). The company was selected by the Department of Energy via a Small Business Innovative Research/Technology Transfer project to commercialize recycling of wind turbine blades (Wind Energy Technologies Office, 2022). Carbon Rivers has successfully demonstrated a pyrolysis process to separate resin and fiber components from fiberglass. Their capacity has recently expanded to include a new recycling and production facility in Knoxville, Tennessee.

In addition to these commercial ventures to recycle fiberglass, trade and industry associations have worked to expand fiberglass recycling options and facilitate and coordinate potential vessel recycling solutions.

Emerging Recycling Activities in the United States

The Institute for Advanced Composites Manufacturing Innovation was established in 2015 as a part of the Manufacturing USA public-private research network (IACMI, n.d.). Compiling information and experience from academic and industry partners, technical working groups bridge communication between a number of sectors.

The American Composites Manufacturers Association operates in a similar capacity to emphasize the engagement and education of sectors working with materials like fiberglass (ACMA, n.d.). As a convener between industry, end-users, and government, the Association helps facilitate information sharing and partnership development. The American Composites Manufacturers Association hosted two national composites recycling conferences in 2018 and 2020. In 2020, special focus was placed on the engagement of marine industry members regarding solutions for end-of-life vessel materials.

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