Market Characterization of the U.S. Structural Composite Preformed Polyurethane Foam Industry for Marine and Trailer Use

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1. Summary

Structural composite preformed polyurethane (PU) foam is blown from polyurethane that is reinforced with fibers and with polymer resin during the blowing process, and is preformed into the required shape (e.g., specific boat or trailer design) to increase structural strength, while reducing the weight of such structures. It is used for structural integrity, weight reduction, and thermal efficiency in marine and trailer applications (Composites World 2013, Composites World 2019, EPW 2020a, EPW 2020f, EPW 2020h, EPW 2020i). The structural composite preformed PU foam manufacturers historically used hydrochlorofluorocarbons (HCFCs) as a foam blowing agent (i.e., HCFC-22) and transitioned to hydrofluorocarbon (HFC) blowing agents as replacements for HCFCs in the early 2000s, specifically HFC-134a.

In 2020, approximately 28 metric tons (MT) of HFC-134a blowing agent was used in structural composite preformed PU foam for marine and trailer use in the United States. Absent the use of alternatives or reclaimed HFCs, the use of HFC-134a blowing agent in structural composite preformed PU foam for marine and trailer use is expected to continue through 2025 in the United States due to performance issues with alternatives (e.g., lack of structural integrity, shrinking) with EPA estimating use of approximately 28.3 MT of HFC-134a blowing agent in this market.

2. Introduction

Structural composite preformed PU foams differ from other types of PU foam in that composite foams are reinforced with fibers and then with polymer resin during the blowing process. The structural composite foam is then preformed into the required shape (e.g., specific boat or trailer design). Structural composite preformed PU foams are used in the marine and trailer industries to increase structural strength, while reducing the weight of such structures (Composites World 2013, Composites World 2019, EPW 2020a, EPW 2020f, EPW 2020h, EPW 2020i). In the late 1980s, structural composite preformed PU foams were developed and employed for marine uses (e.g., recreational boats, commercial fishing boats). This technology then spread to use in the manufacturing of truck trailers (e.g., refrigerated trailers for transportation of perishable goods). It is estimated that this technology expanded into the trailer market roughly five years ago (BASF 2021).

In marine applications, structural composite preformed PU foams allow boat manufacturers to replace either heavier traditional foam cores or wood components with a more efficient, lighter weight, non-decaying product (General Plastics 2021, Composites Manufacturing 2015). In trailer applications, structural composite preformed PU foams increase thermal efficiency, while decreasing the overall weight of the system (EPW 2020a). The remainder of this report characterizes HFC use by the marine and trailer industries in the United States, including key market players and historical and current use of HFCs and blowing agents.

3. Market Characterization

This section provides an overview of the marine and trailer foam industries as well as the current market and key manufacturers using structural composite preformed PU foams for marine and trailer uses.

3.1. Overview of the Marine and Trailer Industries

Typically, system houses are chemical companies that develop formulations for foam blowing, such as the HFC-134a formulation currently in use, for manufacturing of structural composite preformed PU foams. The system house then sells these formulations for foam blowing to structural composite preform foam suppliers who work directly with boat and trailer manufacturers to create specific molds for their intended application. Finally, boat and trailer manufacturers install structural composite preforms into the specific boat and trailer models for sale to consumers (EPW 2020c, EPW 2020d, EPW 2020e, EPW 2020f, EPW 2020h).

3.1.1. Marine

In the marine industry, a variety of foams are utilized for comfort, insulation, structure, and flotation.[1] Structural composite preformed PU foams are typically used in internal structures of the boat, particularly stringers and bulkheads (Composites World 2013). Stringers are structures that run parallel along the boat's hull and provide structural integrity, e.g., keeping the boat from bending especially when going over waves. Bulkheads are vertical walls that provide structural integrity and partition the boat into watertight compartments to reduce damage in the case of an accident.

Historically, stringers and bulkheads were made of plywood and, more recently, sandwich foam cores (Composites Manufacturing 2015, Composites World 2013). The sandwich foam cores typically use HFCs, hydrocarbons, and, more recently, hydrofluoroolefins (HFOs) as blowing agents. The development of structural composite preformed PU foams, however, provided a lighter-weight and more durable alternative, which resulted in the ability to use less powerful engines and reduce fuel consumption, thus decreasing the overall purchase and operation cost of boats (EPW 2020e, EPW 2020f). The use of structural composite preformed PU foams is estimated to comprise 10% of the marine foam market (EPW 2020f). BASF (2021) estimates that marine applications of structural composite preformed PU foams make up the majority of the overall structural composite preformed PU foam market.

3.1.2. Trailers

In trailers, foams are used for insulation in two different applications, intermodal containers and reefer trailers. Intermodal containers are refrigerated containers that allow for uninterrupted

[1] U.S. Coast Guard regulations require recreational boat builders to equip vessels under 20 feet with flotation foam (33 CFR part 183) (EPW 2020f). While there are requirements for flotation foam for certain vessels, the U.S. Coast Guard regulations do not have specific requirements for structural composite preformed PU foam for marine use.

refrigerated storage during transport. Reefer trailers are insulated cargo space that are designed with a refrigeration system to maintain a certain temperature. These trailers can be found on trucks or trailer-mounted systems. Normally, these trailers are used to transport perishable or frozen goods (Zandstra 2020). Reefer trailers are moveable on their own while intermodal containers require shipment on a trailer.

Traditionally, both trailer types have used PU foam to provide insulation for their refrigerated system and metal to provide structure to the trailer or intermodal container. Trailers using PU foam typically use HFCs, hydrocarbons, and, more recently, HFOs as blowing agents. Structural composite preformed foam has been used in both intermodal containers and reefer trailers (Composites World 2019) to a limited extent. Certain trailer manufacturers have begun transitioning to trailer bodies within the last five years that replace traditional PU foam completely (Composites World 2019, Wabash 2019). Structural composite preformed PU foams are estimated to improve thermal efficiency of trailers up to 28% and reduce overall weight up to 10%, compared to traditional foam and aluminum insulation (Composites World 2019).

3.2. Major Manufacturers

As mentioned above in Section 3.1, systems houses develop PU formulations for foam blowing, such as the HFC-134a one currently in use, for use in manufacturing structural composite preformed PU foams. These formulations for foam blowing are then sold to structural composite preform PU foam suppliers who work directly with boat and trailer manufacturers to create specific molds for their intended application. In some cases, the boat and trailer manufacturers buy directly from the system houses, bypassing the structural composite preformed PU foam manufacturer (BASF 2021). For example, BASF and Wabash, a major trailer manufacturer, worked together directly to develop Wabash's all-composite refrigerated trailer and all-composite reefer trailer in 2016 (BASF 2016, FleetOwner 2016).

3.2.1. Structural Composite Foam Manufacturers

The major system houses manufacturing formulations for foam blowing for use in structural composite preformed PU foam include BASF, Dow, and Carpenter (EPW 2020f, EPW 2020h).

Companies such as Compsys and Structural Composites buy formulations for foam blowing from the system houses to create structural composite preformed PU foam for use in boats and trailers (EPW 2020a, EPW 2020b, EPW 2020h).

3.2.2. Marine Manufacturers

Major boat manufacturers that utilize structural composite preformed foam include, but are not limited to, Grady White Boats, HCB Center Console Yachts, and Parks Manufacturing, LLC (EPW 2020c, EPW 2020d, EPW 2020e). Additional major boat manufacturers include Boston Whaler, Mastercraft, Sea Ray, Chaparral, Ranger, Cobalt, Contender, and Malibu (Boat Trader 2020). These manufacturers are assumed to use structural composite preformed PU foam as

system houses indicated that the majority of the recreational boating market utilizes structural composite preformed PU foams (BASF 2021).

3.2.3. Trailer Manufacturers

Table 1 shows the estimated market share of each manufacturer in the trailer market. Manufacturers highlighted in blue represent manufacturers known to use structural composite preformed PU foams (EPW 2020i).

Table 1. Major Manufacturers of Trailers in the United States

Manufacturer	Estimated Market Share[a]
Utility Trailer Manufacturing	31%
Wabash	16%
Kidron Inc.	13%
Great Dane	14%
Morgan Corporation	9%
Hyundai Trailers	4%
Other	15%[b]

Source: Skeist (2004), Refrigerated Transporter (2010), and Wabash National (2019).
[a] Totals may not sum due to independent rounding.
[b] Assumed to be comprised of equal shares of Maersk Container Ind. (5%), Danteco (5%), and Vanguard National Trailer Corp. (5%).

4. Subsector Background and HFC Use

4.1. Blowing Agent Use in Structural Composite Preformed PU Foam

Prior to the introduction of structural composite preformed PU foam, marine manufacturers used plywood or sandwich foam cores and trailers used metal lined with PU foam to provide structure (Composites Manufacturing 2015, Composites World 2013). Structural composite preformed PU foam was first developed for marine applications using HCFC-22 as the blowing agent. Industry has indicated that in 2005, HCFC-22 began to be replaced with HFC-134a as the blowing agent for structural composite preformed PU foams in both the marine and trailer end-uses with the transition occurring over three years (BASF 2021, EPW 2020a, EPW 2020b, EPW 2020h, EPA 2007).

In 2015, manufacturers began research and development programs to establish alternative foam blowing agents for marine and trailer structural composite preformed PU foams (EPW 2020a, EPW 2020f). While most foams used in the marine and trailer industries in the U.S. have transitioned from HFC-134a to methyl formate and HFO formulations for foam blowing, an efficient alternative has yet to be developed for structural composite preformed PU foam (EPW 2020f).

According to information provided by the two largest companies using structural composite performed PU foam for their marine and trailer products, research for alternative foam blowing agents has been focused on HFO blowing agents, and as of 2020, has been unsuccessful. Trials by Structural Composites and Wabash with HFO-blown structural composite preformed PU foams have shown instability and shrinkage in the product after 14 days, which could cause safety concerns (EPW 2020a, EPW 2020h). Research continues on alternative blowing agents.

It is assumed that 100% of the current structural composite preformed PU foam for the marine market uses HFC-134a. Environmental characteristics of the current blowing agent used in structural composite preformed PU foams are summarized in Table 2. Environmental Characteristics of Current Blowing Agents for Structural Composite Preformed PU Foam

Table 2. Environmental Characteristics of Current Blowing Agents for Structural Composite Preformed PU Foam

Blowing Agent	ODP[a]	GWP
HFC-134a	0	1,430

Note: GWPs are aligned with the exchange values used in the AIM Act.
[a] Ozone Secretariat (1987).

Overall use of HFC-134a for use as a blowing agent for structural composite preformed PU foam was estimated by Structural Composites in comments made to the Senate Environmental and Public Works Committee to be 28 MT in 2020 (EPW 2020h) though other confidential data indicates less HFC-134a was used. Based on conversations with BASF (2021) about general market estimates for the structural composite preformed foam PU market, this document assumes that marine and trailer applications of structural composite preformed foam make up 95% and 5% of the overall market in 2020, respectively. Historic estimates of structural composite preformed PU foam for marine use were developed using the growth rates of recreational boat registrations from 2015 through 2019[2] (USCG 2020). Historic estimates of structural composite preformed PU foam in trailer applications were assumed to transition linearly from 2016, when they entered the market, to 2020. Table 3, Figure 1. Historic HFC Use of Blowing Agents for Structural Composite Preformed Foam in the United States (2015-2020) (MT), and Figure 2. Historic HFC Use of Blowing Agents for Structural Composite Preformed Foam in the United States (2015-2020) show the estimated historic use of HFC-134a blowing agent used in structural composite preformed PU foam in marine and trailer applications in the United States from 2015 to 2020.

Table 3. Historic HFC-134a Blowing Agent Use in Structural Composite Preformed Foam in the United States (2015-2020)

	2015	2016	2017	2018	2019	2020
Amount of HFC-134a Used in Structural Composite Preformed Foam (MT)						
Marine	28.4	28.1	28.1	27.6	27.33	26.60
Trailer	-	0.3	0.6	0.9	1.1	1.4
Total	28.4	28.4	28.7	28.4	28.47	28.00
Amount of HFC-134a Used in Structural Composite Preformed Foam (MMT CO_2 Eq.)						
Marine	0.04	0.04	0.04	0.04	0.04	0.04
Trailer	-	0.0004	0.0008	0.001	0.002	0.002
Total	0.04	0.04	0.04	0.04	0.04	0.04

Note: Totals may not sum due to independent rounding.
Source: EPW (2020h), EPA (2020), USCG (2020).

[2] Confidential manufacturer estimates indicate that blowing agent use in Table 3 may be overestimated in 2018 through 2020. This discrepancy could be due to a difference between the growth rate in the percentage of boats registered and the growth rate of boats utilizing structural composite preformed PU foam in their design.

Figure 1. Historic HFC Use of Blowing Agents for Structural Composite Preformed Foam in the United States (2015-2020) (MT)

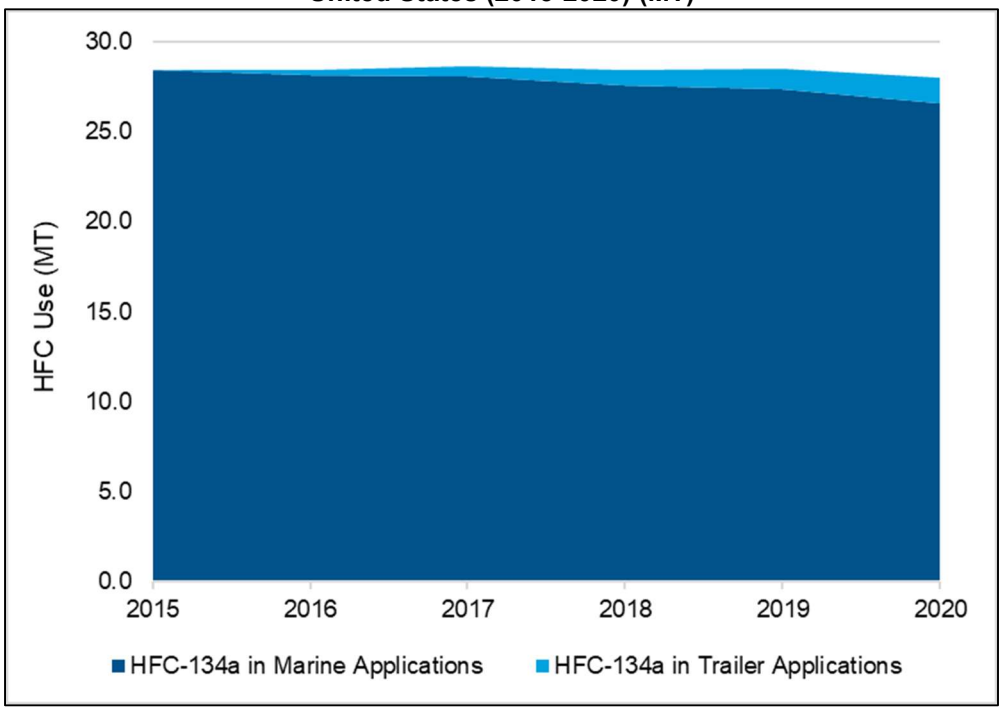
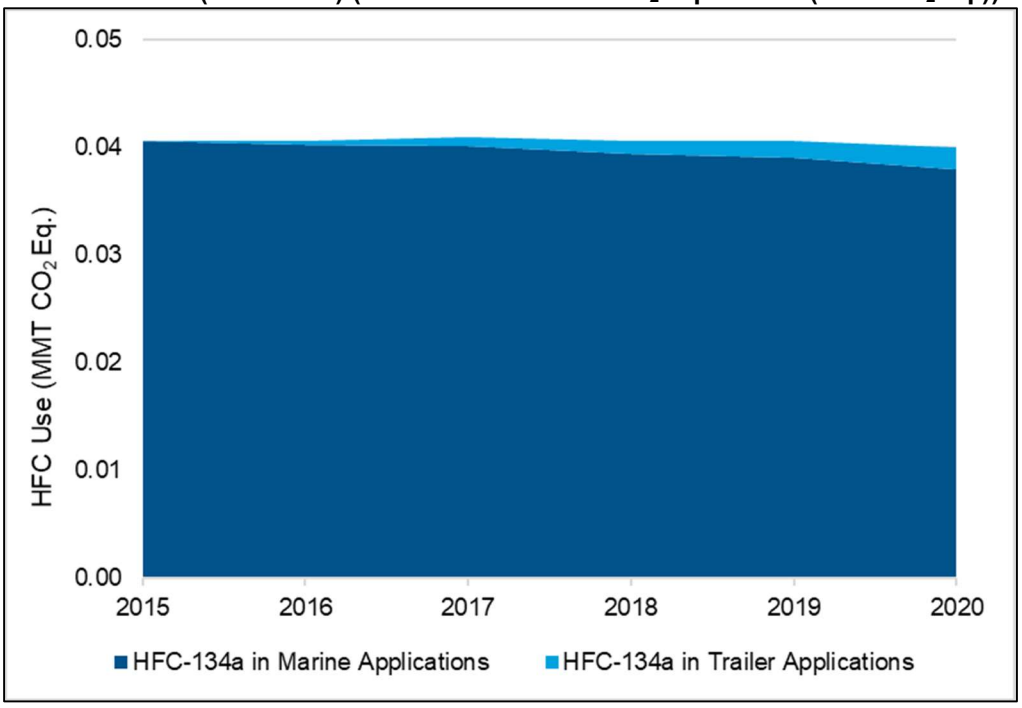


Figure 2. Historic HFC Use of Blowing Agents for Structural Composite Preformed Foam in the United States (2015-2020) (Million Metric Tons CO_2 Equivalent (MMT CO_2 Eq.))



4.2. Projected HFC Blowing Agent Use

Users in this industry estimate that the overall use of HFC-134a as a blowing agent for structural composite preformed PU foam was approximately 28 tons in 2020 (EPW 2020h). Research is

ongoing for HFC-134a replacements and industry stakeholders anticipate an effective replacement for HFC-134a in structural composite preformed PU foams will be developed within the next 15 years, and possibly within the next 5 years (EPW 2020a, EPW 2020b, Structural Composites 2021). Industry stakeholders have noted the potential for use of reclaimed HFCs in the market, which could impact projected use of virgin HFCs (Structural Composites 2021).

Over the last twenty years, recreational boat registrations have decreased on average by 0.38%; however, this value has fluctuated annually (USCG 2020). To project HFC use in structural composite preformed PU foams for marine use, it is assumed that boat registrations, and thus HFC-134a use in this sector, will remain constant from 2020 to 2025, which is more conservative than historical registrations. HFC-134a use in structural composite preformed trailer foams is assumed to grow at an average rate of 3.6% between 2020 and 2025, in line with the growth rate of intermodal containers in EPA (2020).

The projected HFC blowing agent use for structural composite foams can be found in Table 4, Figure 3, and Figure 4.

Table 4. Projected HFC-134a Blowing Agent Use in Structural Composite Preformed Marine Foam in the United States (2020-2025)

	2020	2021	2022	2023	2024	2025
Amount of HFC-134a Used in Structural Composite Preformed Foam (MT)						
Marine	26.6	26.6	26.6	26.6	26.6	26.6
Trailer	1.4	1.5	1.5	1.6	1.6	1.7
Total	28.0	28.1	28.1	28.2	28.2	28.3
Amount of HFC-134a Used in Structural Composite Preformed Foam (MMT CO_2 Eq.)						
Marine	0.04	0.04	0.04	0.04	0.04	0.04
Trailer	0.002	0.002	0.002	0.002	0.002	0.002
Total	0.04	0.04	0.04	0.04	0.04	0.04

Note: Totals may not sum due to independent rounding.
Source: EPW (2020h), EPA (2020), USCG (2020).

Figure 3. Projected HFC Use of Blowing Agents for Structural Composite Preformed PU Foam in the United States (2020-2025) (MT)

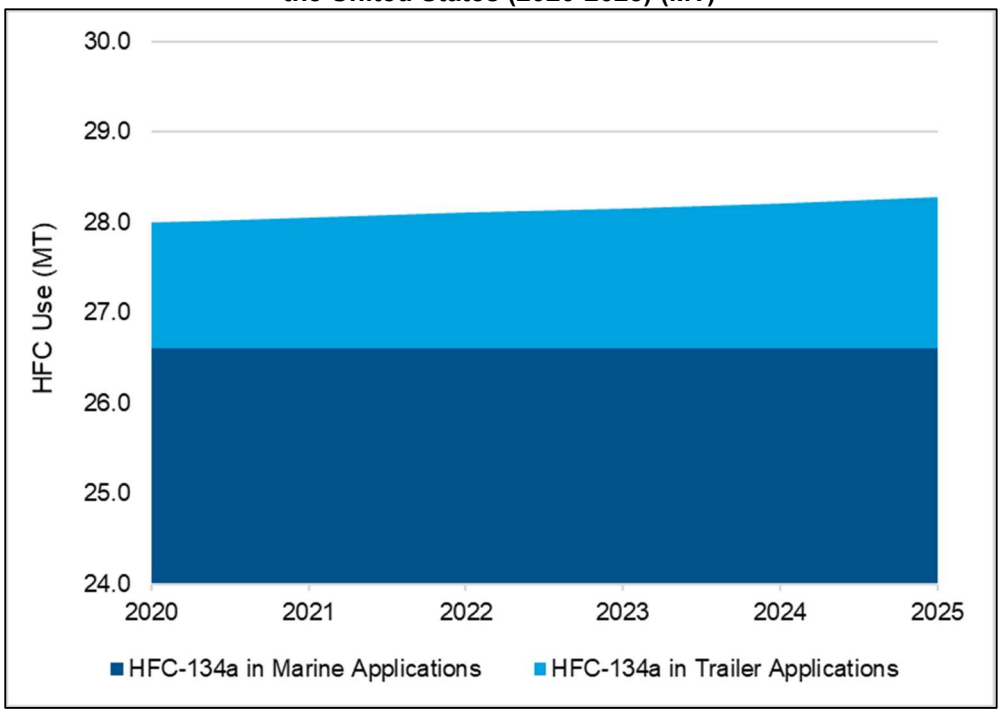
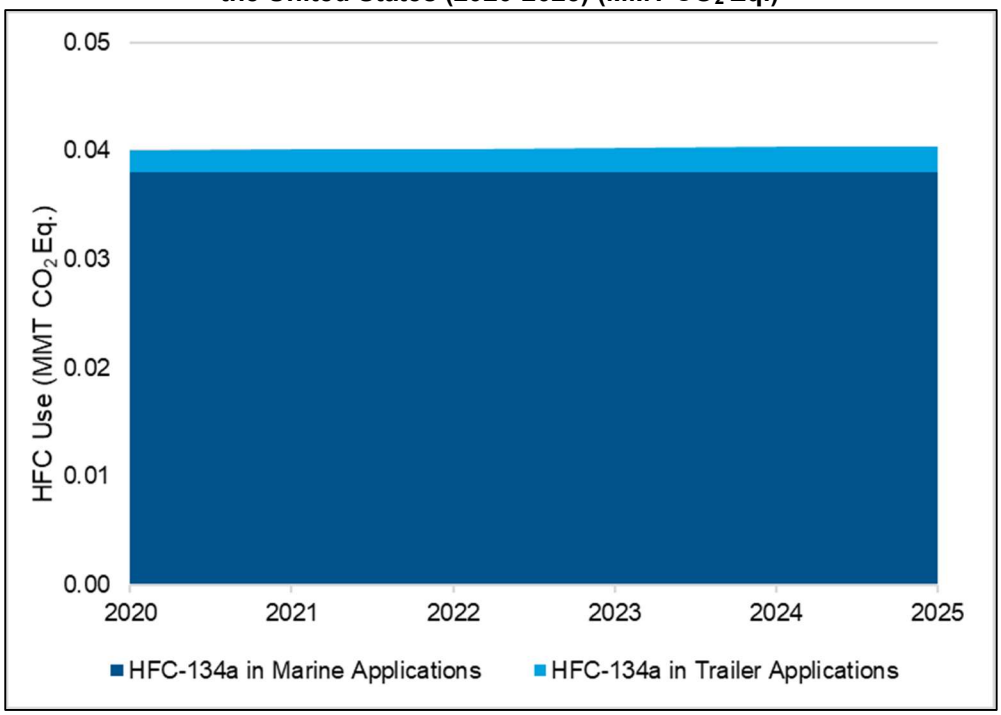


Figure 4. Projected HFC Use of Blowing Agents for Structural Composite Preformed PU Foam in the United States (2020-2025) (MMT CO_2 Eq.)



4.3. Imports and Exports of Trailer and Marine Foam in the United States

The import and export of structural composite preformed PU foams is primarily through the import and export of boats and trailers. While the majority of the boats and trailers using

structural composite preformed PU foams are anticipated to stay within the United States, there is some import and export of these materials, especially boats (BASF 2021). The United States is a leading manufacturer in recreational boats globally and exports them throughout the world. In 2017, 37% of recreational boats manufactured in the United States were exported to Canada, followed by 20% to Central and South America (ICOMIA 2018).

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