

Profile of the Distribution Structure for Materials Used in Waterfront Applications:
Implications for Innovative Wood-Plastic Composites

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ABSTRACT

The use of wood-plastic composite (WPC) technologies may provide a more cost effective and environmentally benign alternative to traditional waterfront materials such as preservative treated wood. The examination of the distribution structures and promotional strategies employed by primary suppliers of traditional waterfront materials may be useful in the exploration of this potentially viable market. More information is needed to determine product needs of potential end users and to assess perceived limitation of WPCs for intended applications. These issues were addressed in this study through the use of guided telephone interviews conducted with national providers of preservative treated wood and manufacturers of vinyl, plastic, and wood-plastic composite (alternative) products. A mail survey was also conducted with marina owners and operators in the United States in effort to generate feedback from potential end-users of WPCs for waterfront applications. Marina owners and operators indicated that they most frequently purchased waterfront construction materials from retailers followed by manufacturer agents or representatives and wholesale distributors. Manufacturers of preservative treated wood most frequently distributed their products through direct sales followed by retailers. Marina owners and operators identified numerous trade shows and print media and rated them as the most effective promotional tools for learning about waterfront construction materials. The importance of product samples as well as the advantages of experiencing a new WPC construction material first hand through demonstrations was repeatedly stresses throughout the study. Major concerns of potential users of WPCs for waterfront construction included the large initial investment often associated with WPCs, availability of products, and the color degradation of WPC products due to exposure to UV radiation.

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INTRODUCTION

The development of non-traditional construction materials for waterfront applications was initiated in 1997 when the United States Office of Naval Research awarded a 3-year contract to address the declining status of United States waterfront structures (Anonymous 1998a). Exposure to harsh coastal environments since WWII has left many of the Navy's waterfront structures in disrepair. The immense costs required for annual maintenance of Naval waterfront facilities has exemplified the importance of durability in material selection. A great deal of literature has been focused on the integration of polymer based materials with traditionally designed structures as replacements for chemically treated wood, concrete, and steel structural components (Iskander 2002, Lampo 1998, Magee 1999). The perceptions of U.S. waterfront decision makers as well as U.S. Port authorities and engineering consulting firms regarding materials use in waterfront construction, were evaluated by Bright and Smith (2002) and Smith and Bright (2002), respectively. Synthetic polymeric materials have been shown to be a highly durable to marine boring organisms and fungal decay (Bultman 1973, Pendleton et al. 2002). The United States Navy is now investigating the possibility of utilizing engineered wood materials, commonly referred to as wood-plastic composites (WPCs). Several studies have already been conducted to evaluate the effectiveness of WPCs on an experimental basis for various marine applications (Malvar 2001, March 1999). These materials could offer a more cost effective alternative by exceeding the lifecycle of traditional waterfront construction materials.

The Navy's annual repair and maintenance cost of treated wood alone is nearly \$20 million (Anonymous 1998a). Navy expenditures in the mid-1990s ranged between \$40 and \$50 million on treated wood for replacement of waterfront components (Malvar et al. 1998). These costs were approximately evenly divided between decking and fendering components (Anonymous 1998a). Decking, as defined by Hoffard and Pendleton (1998), includes deck-boards, bull rails, and spacer blocks. Fendering

components consist of chocks, whales, fender piles, and camels. These seven structural components were identified to be most suitable for the substitution of WPCs for treated wood (Hoffard and Pendleton 1998, Smith and Bright 2002).

The Navy's concrete and steel structures are also in need of repair and replacement. In California, the United States Naval Facilities Engineering Service Center estimates that 75 percent of Port Hueneme's 582 concrete piers and wharves are expected to require repair within the next decade (Busel and Barno 1996). One conservative estimate that takes into account the approval of only 50 percent of proposed projects approximates the Navy's costs of concrete repair at \$200 million (Busel and Barno 1996). Structural steel is also frequently used for waterfront piling and various waterfront components because of its availability and ease of fabrication. Unprotected steel is subjected to rapid deterioration, particularly in tidal zones where changing tides create an ideal environment for corrosion (Anonymous 1998b).

The development of a WPC suitable for waterfront applications could also be utilized outside of structures affiliated with the Navy. The costs incurred by the more than 750,000 public and private waterfront structures has been estimated by the United States Army Corps of Engineers at \$2 billion annually (March and Colturi 1998). Others have estimated the cost of deteriorating waterfront structures at \$1 billion annually (Lampoet et al. 1998). Despite the discrepancy, it is clear that a substantial amount of capital is allocated for repair and replacement of waterfront infrastructure each year.

The demand for modernization of waterfront facilities has also been compounded by the rise of international trade, which has more than doubled since 1990 (March 1998). The magnitude of waterborne domestic and foreign traffic in the United States is immense. More goods travel to and from the United States than any other country in the world (Anonymous 2003c). Waterfront structures are essential to coastal and commercially navigable inland waterways found in 41 states, including every state east of the Mississippi, and 16 capitol cities (Anonymous 2003c). Since 1990, waterborne

foreign trade has more than doubled and steady growth is expected to continue for the next 20 years at about the same rate. The increase in trade was reflected by the 33,888.5 thousand short tons of inbound transits and 3,548.9 thousand short tons of outbound transits in the United States in 2001 (Anonymous 2003c). Many ports are experiencing the burden of the increase in traffic and added stress to deteriorating structures.

Technological advancements and careful engineering of material leading to improved performance of WPCs for waterfront applications could present viable opportunities to the WPC industry. The purpose of this research is to generate quantitative and qualitative information to gain a better understanding for the potential of utilizing WPCs for waterfront applications. This information is derived from two series of telephone interviews and a mail survey. United States manufacturers of preservative treated wood products intended for waterfront applications were interviewed to understand how their products are promoted and to analyze distributions structures and other business functions in this market. A similar series of interviews was also conducted with United States providers of vinyl, plastic, and WPCs to provide a relative comparison to the preservative treated wood products providers. Producers of vinyl, plastic, and WPCs materials were also asked to provide their opinions about entering waterfront construction materials markets, as well as about perceived barriers to market entrance.

Lastly, a mail survey was used to gather information from potential end users of WPCs for waterfront construction. Prospective participants included members of the Marina Owners and Operators Association of America (MOAA). Previous research by Bright and Smith (2002) examined the importance of material attributes in material selection as perceived by members of MOAA. The study also evaluated overall knowledge of composite materials and the perceived receptiveness of their marina to new technologies. The purpose of this survey is to expand on their work to assess the distribution channels and promotional methods used by potential users to purchase materials, as well as to understand how marina owners and operators learn about new

waterfront materials. The survey was also used to generate additional feedback regarding the concerns and perceived limitations of using WPCs for the intended purposes.

The objective of this study is to provide both primary and secondary data that can be used to aid in the technology transfer of WPCs into waterfront construction applications, as well as to provide a link to potential end users of this technology. Information provided by potential end users may also be used to confirm the importance of past and current WPC research, thereby providing a more focused direction for future research related to development of alternative materials for waterfront construction.

LITERATURE REVIEW

Wood Preservatives

Wood use in moist environments is especially susceptible to decay-causing fungi. These fungi diminish the structural integrity of the wood as they thrive on lignin and cellulose (Dolby et al., 1988). Wood is susceptible as a food source and for habitation by innumerable species of beetles, ants, bees, wasps, moths, flies, and termites (De Belie et al. 2000). According to Highley and Scheffer (1989), waterfront structures constructed of wood are susceptible to three types of destructive agents “(1) biological (destructive utilization of wood by various micro-organisms such as decay fungi), (2) physical (damage by breakage or deformation), and (3) chemical (such as electrolytic breakdown around iron fasteners).”

The growing population of wood boring organisms may present the greatest threat to waterfront structures utilizing preservative treated wood. Highley and Scheffer (1989) noted that biological agents have the greatest impact on the deterioration of the structures. Wood boring organisms damage the structural integrity of the wood by consuming cellulose from the exterior of the wood or by creating tunnels within the wood. Several factors have contributed to the expansion of wood boring organisms. Higher summer temperatures, cleaner coastal waters resulting from tighter environmental controls, and more efficient treatment of wastewaters have created an ideal environment allowing woodborer populations to thrive. An increased number of storms have also contributed to rising populations by increasing oxygen levels in the water. In addition, the use of low quality wood containing a high proportion of juvenile wood has increased the susceptibility of waterfront structures to marine borer attacks (Anonymous 2003d). Marine borers are found in both the mollusk and crustacean classes (Tanal and Matlin 1996). The mollusk known as *Teredo navalis*, or shipworm, is capable of tunneling through two centimeters of wood per day and is considered the most threatening species to waterfront structures (Tanal and Matlin 1996). The

crustacean *Limnoria tripunctata* is also known to cause severe damage to waterfront structures; here, the organism attacks the exterior of the wood and in severe cases can cause wood piling to lose an inch in diameter in a single year (Tanal and Martlin 1996).

Exposed wood is also susceptible to destructive conditions in the environment due to weathering. Wood surfaces can be eroded by wind-blown sand and discolored by ultra violet radiation, which degrades a thin surface layer of cellulose (De Belie et al. 2000). The expansion from the freezing and thawing of moisture within wood pores cracks surface layers. Waterfront structures directly exposed to seawater experience the deteriorating effects of continuous wetting and drying of the wood. This repeating effect from tidal change and ocean spray can cause the wood's grain to lift. It can also result in checking and case hardening, which is a distortion of the wood caused by drying tension (De Belie et al. 2000).

The type of preservative used, degree of penetration, and levels of chemical retention in wood are tailored to the application of the wood and local environmental conditions (Ibach 1999). Retention refers to the amount of preservative solution that remains in the wood following the treatment process, and is measured by unit weight of the preservative per unit volume of wood. Three use categories have been established based on the severity of exposure noted by Ibach (1999): "1) ground contact (high decay hazard that needs a heavy-duty preservative), 2) aboveground contact (low decay hazard that does not usually require pressure treatment), and 3) marine exposure (high decay hazard that needs a heavy-duty preservative or possibly dual treatment)." The American Wood Preservers Association, as well as nine other agencies, publish chemical specifications and minimum retention levels for various applications of treated wood (Prestemon 1994).

Wood preservatives can be characterized as either a waterborne or oilborne solution (Ibach 1999). Waterborne preservatives refer to leach-resistant solutions whereby the chemical is either dissolved purely in water or in water containing ammonia or acidic

compounds that which hold the chemicals in solution (Prestemon 1994). Waterborne preservatives often include pentavalent arsenic, a naturally occurring chemical that can be found in plants and animals. Its advantages over oilborne preservatives include cleanliness, paintability, and absence of odor (Prestemon1994). Waterborne preservatives include copper arsenate (ACA), ammoniacal copper zinc arsenate (ACZA), acid copper chromate (ACC), and three chromated copper arsenate (CCA) based preservatives (Ibach 1999). These preservatives are typically used for docks, bridges, fences, piers, poles, piling, retaining walls, and structural framing (Ibach 1999). Oilborne preservatives and creosote solutions contain chemicals dissolved in non-aqueous substances. The major component of creosote solutions is the oil derived from the distillation of coal tar. Creosote based preservatives include creosote, creosote-coal tar, and creosote-petroleum (Prestemon 1994). Creosote is extremely effective against wood boring organisms; however, it possesses an unpleasant odor and is highly combustible. Wood products treated with creosote solutions are suited for exterior applications such as ties, bridge timbers, poles, piling, posts, and laminates (Ibach 1999). Examples of non-creosote oilborne preservatives include pentachlorophenol (penta), copper naphthenate, and oxine copper (copper-8-quinolinate). Penta and copper naphthenate are only suitable for exterior uses due to its toxicity and are not recommended for waterfront piles or timbers due to their ineffectiveness against marine borers. Creosote solutions, ACZA or ACA, and CCA are the only preservatives suitable for salt-water applications. Salt-water applications with a moderate marine borer hazard require the following retention for submerged wood according to Ibach (1999):

- Creosote-320 kg/m³ (20 lb/ft³)
- ACZA/ACA-24 kg/m³ (1.5 lb/ft³)
- CCA-24.1 kg/m³ (1.5 lb/ft³)

Water repellants are also used to extend the life of exposed wood and may or may not be used in combination with a petroleum solvent to prevent fungal degradation (Prestemon 1994). Water repellants are not effective for applications where wood is exposed to salt water.

Environmental, health, and disposal concerns regarding CCA, the primary chemical preservative used to treat wood, has helped to generate an interest in more environmentally benign building materials such as WPCs. Smith (2001) noted that consumer fears regarding health and environmental risks associated with treated wood are major factors influencing the rapid growth of the WPC decking market. Alternative preservatives for waterfront applications such as creosote and ACA or ACZA also present some health risks. Excessive exposure to creosote can cause dermatitis and inflammation of the skin; it has also been linked to skin cancer (Anonymous 1997). ACA and ACZA both contain arsenic, the same carcinogen found in CCA. CCA is the most widely used preservative for building construction materials since it is an effective and inexpensive preservative. Studies have documented adverse affects when humans come in contact with CCA, which may contribute to an increased risk of lung, skin, bladder, liver prostate, and kidney cancer. The dangers of CCA to humans occur only after overexposure to the chemical, which may result from acute or chronic exposure, both of which cause different symptoms in humans (Felsot 2001). Arsenic and a second carcinogenic component of CCA, hexavalent chromium, are also known to be teratogenic, that is, capable of causing birth defects or fetal malformations (Kidd 2001).

CCA is used to preserve more than 90 percent of the 6.5 billion board feet of treated lumber sold in the United States (Weis 1995). In 2002, nearly 7 billion board feet of CCA treated wood were sold, generating nearly \$4 billion (Hechler 2003). Three major manufacturers of CCA made an agreement with the Environmental Protection Agency (EPA) to end the production of the CCA treated wood for consumer applications as of December 31, 2003 (Freeman 2003). Although CCA can be found on the Environmental Protection Agencies top ten list of hazardous pollutants, the mixture's primary poisonous component, the element arsenic, a known carcinogen and mutagen, is also one of the 103 naturally occurring elements found in rocks, soil, and drinking water (Felsot 2001). Note that the EPA concluded that CCA treated wood did not cause

unreasonable risk to the environment or the public and has not recommended the removal of existing treated products (Hechler 2003).

CCA has been the subject of a growing number of lawsuits in the past five years. A Lexis Nexis search revealed that over one hundred lawsuits concerning CCA have been filed. A number of class action lawsuits have been filed because of injury claims as a result of contact with CCA treated lumber, yet none have been successfully certified (Hechler 2003). Currently, there are class action suits pending in Alabama and Louisiana; about 35 cases have been tried or settled, while another 10 cases are still pending as of March 2003 (Hechler 2003). The financial burden of legal fees from the growing number of lawsuits and threat of additional lawsuits involving CCA could be significant factors affecting the future role of CCA in the wood preservation industry.

CCA treated wood has also been criticized for the preservative's adverse effects on the aquatic environment. The leaching of all three chemicals in low to moderate amounts has been shown in a number of studies in both fresh water by Warner and Solomon (1990), and in sea water by Hegarty and Curran (1986). Weis and Weis (1995) found uptake of arsenic and copper by local biota and benthic organisms, as well as toxic effects including death and retardation of estuarine biota and a decline in aquatic diversity. According to their study, the amount of treated wood, its age, water-quality parameters, and the dilution caused by water movement are all factors in the extent to which aquatic life are impacted by CCA leaching. In spite of these studies, many supporters of the preservative contend that treated wood retains the original levels of chemicals after many years of exposure. Many studies have found no indication of leaching of the preservative, including a study by the USDA Forest Products Laboratory. The study examined CCA treated southern pine posts after one, three, five, and eight years of exposure. The samples had been treated with three pounds per cubic foot (pcf) of preservative at the start of the study and were found to have the same retention levels at each level of exposure (Graham 1991). Another study at Wrightsville Beach, North Carolina, tested the retention of a CCA treated pole and found no significant loss of any

chemical components (Graham 1991). According to Weis and Weis (1995), studies such as these, where the extent of leaching is measured by the retention of preservative in the wood rather than its presence in the local environment are seriously flawed. These studies only measured the presence of the chemicals retained to the parts per hundredth unit, when in fact the aquatic environment begins to experience the toxic effects at the parts per million level (Weis and Weis1995).

The disposal of treated wood, an added cost that is often overlooked when choosing construction materials, may add to the cost justification of alternative materials with relatively higher initial costs. The USDA Forest Products Laboratory has estimated that 2.5 billion board feet of treated wood is being disposed of annually. The agency expects that by 2020, that eight billion board feet of treated wood will be in need of disposal (Anonymous1997). Commercial and industrial disposal of treated wood no longer in service is subjected to fees at many disposal sites. Commercial and industrial treated wood waste can be incinerated in a specialized incinerator in accordance with state and federal laws (Bellinger 2002). According to the EPA, residential treated wood waste can be disposed as "ordinary trash."

Smith (2003) compared the disposal costs of treated wood waste at Class I, II, and III disposal levels. Under EPA guidelines, treated wood can be disposed of as municipal waste under Class II (non-hazardous). Smith estimates the disposal of Class II treated wood to be \$61.42/ton, taking disposal tipping fees, separation, and handling costs into consideration. Under Class I disposal (non-RCRA hazardous), Smith estimates the disposal of treated wood at \$291.63/ton, which takes into consideration tipping fees, state and local taxes, generator fees, collection and transportation, and separation and handling costs. California is the only state that currently requires Class I disposal of treated wood (Smith 2003). Some states, however, are considering imposing more stringent requirements for the disposal of CCA treated wood.

The implications of CCA on the environment and its health risks to consumers are not clear and can be conflicting. It is certain, however, that these issues have acquired a great deal of attention (generally negative) by consumers who are becoming increasingly concerned about the preservative's impact on their health and the environment. The loss of a substantial market for CCA treated wood resulting from its discontinued use for residential construction, rising disposal costs, and liability issues may lead to the elimination of CCA from the industry completely or, alternatively, higher prices for CCA products (Bellinger 2002). As a major preservative used in waterfront construction, higher prices or the discontinued use of CCA in the wood preservation industry could dramatically affect the waterfront construction material segment in favor of an alternative building material such as WPCs.

Wood-plastic Composites

Wood-plastic composites are composed of wood fibers or flour fused with thermosets, thermoplastics, resins and similar substrates (Clemons 2002). Thermosets are resins and plastics that can not be melted by reheating once they have been cured. Conversely, thermoplastics are capable of being repeatedly melted, for this reason they are most commonly used for the manufacture of WPCs. Thermoplastics are utilized for numerous consumer products such as plastic bags, milk jugs, luggage parts, and siding (Clemons 2002). Common plastics used in the production of WPCs include polyvinyl chloride (PVC), polyethylene (PE), polypropylene (PP), and polystyrene (PS). Both wood and plastic raw material may be virgin or derived from recycled products and processing waste such as sawdust. Non-virgin material typically requires reconditioning before it is suitable for final processing. Wood must be converted to the desired particle size and dried to the appropriate moisture content. Foreign matter is removed from plastic, before being washed and is often flaked to create a more uniform material. Other additives such as pigments, coupling agents, foaming agents, and lubricants may be included into the formulation to improve processing, control mechanical properties, and improve long-term durability (Clemons 2002, Mapleston 2001a, Youngquist 1995).

Coupling agents are chemicals such as titanates, zirconates, and organic acid-chromium chloride coordination complexes, which are added to improve the bonding, interface between wood and plastic (Berenberg 2004). Lubricants improve dispersion of the components and reduce friction between the matrix and processing equipment. Foaming agents can reduce material costs by 50 percent and reduce weight but compromise mechanical properties (Schut 2001). Preservatives such as zinc borate may inhibit fungal decay in WPCs (Pendleton et al 2002) Antioxidants and ultra violet absorbents are sometimes included to protect the product from oxidation and ultra violet degradation (Gardner 2004).

A few small companies in the United States were using WPCs by the early 1980's for interior car paneling (Clemons 2002). Initially, wood was integrated with plastic to act as a filler to reduce material costs. As the manufacturing process improved, the potential of wood particles as reinforcement to enhance mechanical properties was realized. A common problem with early WPCs was a decline in physical properties as a result of poor adhesion and dispersion of the wood particles. The physical nature of wood and plastic are responsible for the adhesion difficulties in the manufacturing process (Clemons 2002). Wood is polar and hydrophilic or "water-loving" because of the presence of $-OH$ on the surface of cellulose. Plastic on the other hand, is hydrophobic and non-polar, and therefore repels water.

Developed in Italy in the late 1970's, continuous extrusion is the most common processing method used today for the production of WPCs (Clemons 2002). Less common processing techniques include injection molding, flat pressing, and compression molding. These processes are used for products that entail complex designs or when a continuous profile is not required or advantageous (Clemons 2000). The extrusion process begins by compounding formulation components in a batch or continuous mixer, which evenly disperses material before it is fed into the extruder. The components can also be introduced into the system individually and integrated within the extruder. The mixture is pushed through the extruder by a single or twin co-rotating,

or counter rotating screw system through a die, which determines the form of the composite (Clemons 2000). Salient processing parameters include screw speed, temperature, and dwell time. The screw speed controls the production rate; if not properly monitored, it may lead to a defect known as voiding whereby a hollow area results within the product. According to Mapleston (2001b), extrusion production rates of up to three meters per minute (10 feet /minute) are possible with current extruders. Temperature must be closely regulated to achieve the desired level of viscosity and crystallinity or brittleness of the polymer component. The temperature also must be monitored to prevent thermal degradation of the wood component, which occurs at 200° C (392° F) (Clemons 2000). Dwell time, the period of time in which the formulation remains in the extruder, may also cause thermal degradation and has an effect on the distribution of the components in the product.

The merging of the materials essentially creates a middle ground in terms of the two material's inherent characteristics in the new product. These characteristics include both positive and negative traits from the product's parent materials (Clemons 2002). The result is a product with unique attributes that creates opportunities as a replacement of existing materials, as well as for end uses that may not have previously been considered by the plastics or wood products industries or have yet to be discovered.

WPCs are superior to wood or plastic alone because they combine desirable attributes from both materials. For instance, the addition of wood fiber to plastic not only improves mechanical properties and reduces material costs, but also decreases weight and thermal expansion. Wood fibers also improve the product's resistance to fire and ultra violet rays in comparison to solid plastic. The advantages of WPCs over solid wood include: lower moisture uptake, a greater resistance to biodegradation, and more product flexibility in profile design. WPCs can be extruded to specific profiles, thereby limiting costly secondary remanufacturing processes that are often necessary in the production of many solid wood products. Another cost advantage of WPCs is that the

raw materials can be derived from recycled plastic and wood waste from other manufacturing processes. There are over 65 million metric tons of sawdust generated by primary timber processors alone in the United States (McKeever 1999). According to the National Sanitation Foundation, an independently certified organization by the EPA, Americans generated 14.4 million tons of plastic wastes in 2000 (Anonymous 2003b).

US Navy Waterfront Construction Material Use and Requirements

Before the United States Navy can utilize WPCs technology, components must first be engineered to meet the same specifications applied to various wood elements used in waterfront construction. The Navy follows National Design Specifications (NDS) for construction of waterfront structures (Malvar et al.1998). There are six general categories of sawn lumber used in waterfront construction:

- **Boards** – lumber that is nominally less than 2 inches thick and 2 or more inches wide
- **Dimension lumber** – lumber with a nominal thickness of from 2 to 4 inches thick and a nominal width of 2 or more inches
- **Beams and Stringers** – lumber that is nominally 5 inches or more thick, with width more than 2 inches greater than thickness
- **Posts and Timbers** – lumber that is nominally 5 inches or more in least dimension with width not more than 2 inches greater than thickness
- **Decking** – lumber that is 2 to four inches nominal thickness, grooved and intended for use as a roof, floor, or wall membrane
- **Round Piles or Poles** – cut logs typically 12 to 18 inches in diameter

Table K indicates sawn lumber categories for waterfront components that are most suitable for utilizing WPCs. These components are demonstrated in the illustration of a typical pier in Figure 1. Table 1 compares the properties of several popular brands of WPCs to ponderosa pine, Douglas fir, and white pine.

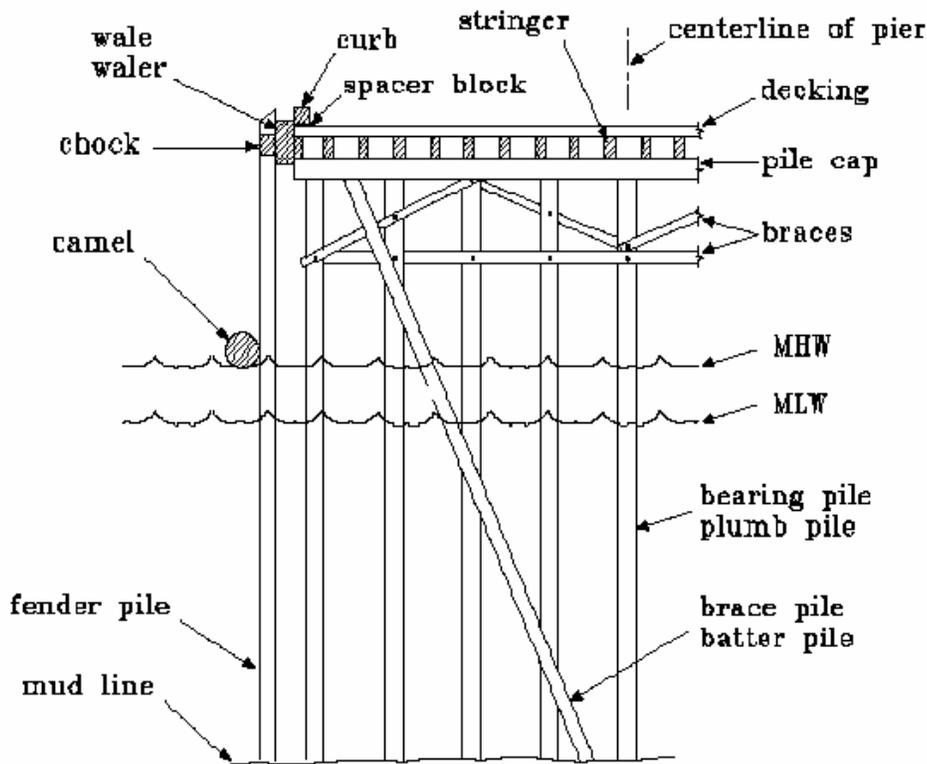


Figure 1. Cross sectional view of typical pier construction elements.

Source: Malvar et al. 1998

Table 1. Mechanical and physical properties of wood and wood plastic composites.

Property	Wood (12% moisture content)	Strandex®	Trex®	Timber-Tech®
Modulus of Elasticity (psi) ASTM D79	Douglas fir	1,950,000		
	Ponderosa pine	1,290,000	505,000	175,000
	White pine	1,168,000		621,000
Modulus of Rupture (psi)	Douglas fir	12,400		
	Ponderosa pine	9,400	1,700	1,423
	White pine	9,700		3,260
Compression Parallel to Grain (psi) ASTM D198	Douglas fir	7,240		
	Ponderosa pine	5,320	2,428	1,806
	White pine	5,040		1,217
Specific Gravity	Douglas Fir	.50		.91-.95
	Ponderosa pine	.40	.96-1.23	(ASTM D2395)
	White pine	.35		1.23 (ASTM D792)

Sources: Green et al. (1999), Malvar et al.(1998)

In 1994, Seaward International, Inc., developed two composite products for waterfront applications. The products were composed of 100 percent recycled plastics reinforced with fiberglass structural elements. The company's piling (Seapile®) and timber (Seatimber®) products are manufactured in large dimensions ranging from 10 to 16 inches (0.3 to 0.4 m) in diameter and up to 100 feet (33 m) in length. The products were first used in a wharf at the Port of New Orleans in 1996 (March and Jarvis 1999). March and Jarvis (1999), later experimented with four formulations using high-density polyethylene (HDPE) and a 4020 grade, 425-micron, southern pine wood fiber master blend. The master blend consisted of 40 percent wood, 60 percent HDPE, and was compounded at the USDA Forest Products Laboratory in Madison, Wisconsin. This blend was combined with PE resins at 10, 15, 25, and 35 percent wood fiber formulations and extruded by an unvented single screw extruder into 4.5 inch (11 cm) and 8 inch (20 cm) diameter cylindrical profiles. Irregularities and voids were a common problem during this experiment with those formulations using greater than 10 percent wood fiber. The study concluded that the addition of the wood fiber component enhanced dimensional stability, reducing linear shrinkage by 21 to 49 percent compared to unfilled material.

Construction Material Use in United States Naval Waterfront Structures

A database compiled in 1984 included 526 waterfront structures in use by the United States Navy (Western Instrument Corporation 1984). These structures consisted of 177 that were constructed primarily from wood timbers, 144 from steel, and 315 of concrete (Western Instrument Corporation 1984). A 1989 estimate of naval waterfront structures recognizes 511 piers and 280 wharves utilizing approximately 400,000 piles, 160,000 of which were estimated to be timber piles (Scola 1989). This 1989 estimate also concluded that the majority of the wood used for decking, piling, and the superstructure of the Navy's 145 miles of berthing facilities was treated with creosote. The most recent estimate of the Navy's use of timber piling estimates 118, 000 wood piles are in use in the United States (Hoffard and Pendleton 1998). Hoffard and

Pendleton (1998) conducted a detailed inventory of the Navy's wood use for waterfront structures. The study estimates that the Navy has over 12 million square feet of decking currently in service and over 500,000 lineal feet of wood used for chocks and whales. This data summarizes the study's estimates of components currently in service. This data provides an indication of the Navy's demand for various waterfront components which may be a pertinent consideration in the development of a WPC for these applications. Pendleton and Hoffard also investigated the annual volume of removal of treated wood from naval structures, as well as the cost of annual disposal. These may be important factors that could be minimized by the use of a more durable material. According to their study, the Navy disposes approximately 20,000 tons of treated wood per year at an average landfill or hog fuel cost of \$50 a ton. The total disposal cost of the Navy's treated wood was \$667,000 during the year of their study. Removal cost estimates by product type and by disposal destination from their study are summarized in Table 4, where pilings account for the majority of the material removed from service. Table 4 provides the estimated quantities of treated wood removed by region as determined by their study. The research also determined that about 60 percent of the wood removed is treated with creosote followed by penta (25 percent) and CCA/ACA/other (15 percent).

Table 2. Wood use in waterfront components in United States Naval service, 1998.

Parameter	Hawaii	Pacific Northwest	California	North Atlantic	Mid-Atlantic	South Atlantic	Gulf Coast
No. of Structures	76	53	78	45	229	44	45
Total Area of Superstructure and Decking (sq. ft.)	1,724,672	2,844,179	2,851,358	1,339,698	2,064,669	908,645	461,441
Total No. of Piles	38,000	28,000	48,000	23,000	48,000	12,000	5,000
No. of Non-fender Wood Piles	700	5,100	16,000	9,200	18,300	1,100	1,900
No. of Fender Wood Piles	7,300	5,000	13,000	7,000	12,600	2,000	400
Total No. Wood Piles	8,000	10,100	29,000	16,200	30,900	3,100	2,300
Total Wales and Chocks (lineal feet)	87,600	60,000	156,000	84,000	151,200	24,000	4,800
Total Wood Piles Corrected by 20% (excluding Hawaii)	8,000	12,000	35,000	19,500	37,100	3,700	2,800
Tons in Service	10,848	16,272	47,460	19,600	37,300	3,720	2,810

Source: Hoffard and Pendleton (1998)

Table 3. Estimated removal and disposal costs of treated wood components from United States Naval service.

Wood Component	Removal and Disposal Costs (thousands of \$)					Total
	South and Southeast	North and Northeast	Southwest	Northwest	Hawaii	
<i>Costs by Product Type:</i>						
Lumber and Timber	24	26	6	4	2	62
Railroad Ties	56	50	50	15	0	171
Utility Poles	39	43	68	24	6	180
Pilings	7	87	113	19	28	254
Total Cost:	126	206	237	62	36	667
<i>Costs by Destination:</i>						
Landfilled	101	182	237	62	36	618
Recycled or Reused	0	0	0	0	0	0
Hog Fuel/Energy	25	24	0	0	0	49
Total Cost:	126	206	237	62	36	667

Source: Pendleton and Hoffard (1998)

Table 4. Estimated quantities of treated wood removed from service from United States Naval waterfront structures.

Wood Component	Quantity of Treated Wood Removed (tons)					Total
	South and Southeast	North and Northeast	Southwest	Northwest	Hawaii	
Lumber and Timber	947	763	171	132	43	2,056
Railroad Ties	2,232	1,460	1,378	441	0	5,511
Utility Poles	1,553	1,263	1,865	724	161	5,566
Pilings	294	2,565	3,085	570	7,085	7,219
Total:	5,026	6,051	6,499	1,867	909	20,352
Percent Landfilled	40	60	73	66	80	319
Percent Recycled or Reused	50	32	27	34	20	163
Percent Hog Fuel/Energy	10	8	0	0	0	18

Source: Pendleton and Hoffard (1998)

Civilian Waterfront Construction Material Use

Civilian waterfront structures utilize an array of materials for various components and waterfront accessories including pilings, dolphins, bulkheads, decking, fendering, building frames, seawalls, and breakwaters (Tobiasson and Kollmeyer 1991). Dock structures can be categorized as either fixed or floating. Bright and Smith (2002) examined U.S. waterfront decision makers and found that larger marinas (i.e., those with 300 or more wet slips) tend to utilize floating systems compared to smaller marinas (less than 300 wet slips). Larger marinas and marinas employing floating dock systems were also found to be more familiar with composite materials and more receptive to the adoption of new technology (Bright and Smith 2002). Participants of this study were asked to rate the importance of twenty key decking and piling attributes. Their findings indicate that resistance to decay, reliable strength, and low maintenance cost are of greatest concern in material selection and should be emphasized in the initial marketing communications strategies for WPCs (Bright and Smith 2002).

The material needs for the construction and maintenance of the 750,000 public and private piers, wharves, and docks in the United States may provide a viable market for WPCs (March and Colturi 1998). Experts estimate that there are approximately 12,000 marinas and small-craft harbor facilities in the United States (Bright and Smith 2002). These structures frequently utilize such materials as aluminum, composites, concrete, fiberglass, stone, and wood (Tobiasson and Kollmeyer 1991). The use of composite materials is becoming more prevalent within the waterfront construction segment. According to the American Composites Manufacturers Association (2004), sales for waterfront and waterfront accessories were over 271 million pounds in 2003, a 6.6 percent increase from 2002. Although the familiarity of various composite materials may be improving, the lack of experience regarding novel applications of WPCs may cause potential user to hesitate in the adoption of these materials as Bright and Smith 2003 noted. Additional information with respect to the specific avenues used by potential end user to become familiar with new materials could be beneficial in the commercialization of WPCs for these novel applications. In particular, the means by

which the most innovative potential end users communicate and learn about new products is of interest because of their ability to facilitate and advance the adoption process.

Diffusion and Adoption of Innovations

Most recent literature, including discussion pertaining to new technology adoption, includes Rogers' interpretation of an innovation as "an idea, practice, or object that is perceived as new to an individual or another unit of adoption" (Rogers 1995). Rogers is considered to be a leading researcher in the study of adoption of innovations and is widely cited across a broad spectrum of fields of study. He describes an innovation as having the following five characteristics: 1) relative advantage, 2) compatibility, 3) complexity, 4) trialability, and 5) observability. The argument could easily be made that WPCs satisfy the conditions of Rogers' definition. WPC durability over other building materials have been observed by numerous researchers, which would be an example of a relative advantage (e.g., Iskander and Hanna 2002, Johnson et al. 1999, Khavkine et al. 2000). WPCs can be extruded into exact profiles replicating dimensional lumber and can be worked in a similar manner to wood, thereby being compatible with contemporary wood use practices. Finally, WPC success in the residential decking market has fueled the demand for WPCs in retail outlets making it widely available for consumers to experience.

North and Smallbone (2000), have offered a more complex approach by defining innovation on the basis of four key principles:

1. Innovations are part of the process of maintaining and improving competitiveness.
2. Innovations may include changes in products and services, market development, marketing methods, production processes, and the technology used in administration.
3. The need to recognize different degrees of innovation.

4. Recognition of the importance of the sectoral context as a framework for assessing the role of innovation as a factor influencing competitiveness.

According to Boer and During (2001), innovations can be categorized into one of three classifications; products, processes, or organizational. In this regard, we might consider the use of WPCs for waterfront structures as both an innovation in the sense of a product and a process. Despite its conception in the early 1900s, WPCs are still considered to be a relatively new alternative to traditional construction materials (e.g. concrete, steel, wood). Advancement in the processing aspects of WPCs to improve product designs, formulation, and the efficiency of processing are ongoing. The discovery of new applications for WPCs, such as for waterfront structural components, can also be considered innovative and often stem from technological breakthroughs (Toensmeier 1994).

Zaltman (1973) has defined an innovation as an idea, practice, or material artifact that is new and different to consumers; diffusion occurs when the innovation is transferred from producer to consumer. The most innovative user members of a social system, therefore, facilitate the adoption process.

The process of diffusion exists in part because new technologies generally do not entirely replace existing technologies (Shook 1999). Subsequently, the market share of the older technology declines as adoption of the new technology occurs. Furthermore, new attributes of the technology may lead to end uses not previously feasible, resulting in an expansion of the total market for the new innovation (Shook 1999).

Most scientific research focuses on the more recognizable steps that occur during the early stages of the innovation process. Engineers and scientists generate ideas, determine their feasibility, develop them, and implement necessary design modifications (Cox 1974). However the outcomes from their endeavors are insignificant to the private industry and to the public without additional steps necessary for an

innovation to be successful (Cox 1974). Before an innovation can be commercialized, a suitable market must be identified having needs that can be satisfied by embracing the new technology. Appropriate market channels must be employed to facilitate the flow of information in order to ultimately deliver the innovation to potential users. Existing communication networks and strategies that have been established for conventional technologies (e.g., treated wood used for waterfront structures) must be identified to effectively communicate with potential adopters.

Rogers (1995) indicates that the success of the introduction stage of a new industrial product (e.g., WPCs for waterfront structures) is a critical determinant for successful adoption (full use of an innovation); in other words, the introduction or launch stage of an innovation will often dictate a new product's success or failure. Research and development is costly and time consuming. Many innovations with superior attributes to existing products have failed simply because of an insufficient launch strategy. The rate at which the adoption occurs is dependant on five variables according to Rogers (1995):

1. Perceived attributes of innovations
2. Type of innovation-decision
3. Communication channels
4. Nature of the social system
5. Extent of change agent's promotion efforts

In the initial introduction stages of an innovation, the adoption process is maintained through effective communication of information. This would include technical information regarding the technology and the needs fulfilled by it (Mornarty and Speckman 1984).

Innovations may encounter a number of barriers that prevent them from being successfully adopted by potential users. Controlled laboratory environments where conditions are ideal frequently lead to exaggerated findings (Rosenberg et al. 1990).

Skepticism over an innovation's claims of efficiency or productivity may cause potential users to be reluctant to adopt the technology (Rosenberg et al. 1990). Innovations also commonly require additional expenses such as costly manufacturing and processing equipment. The advantages provided by new innovations can easily be diminished after all of the various switching costs have been accounted for by the adopter of the innovation. Such additional costs are very significant considerations for adopters since the demand for new technologies is very often driven purely by economics (Rosenberg et al. 1990).

The introduction of new technology, especially technology that is radically different than traditional technologies, typically requires a trial period by users to make an adequate evaluation. The observation period for new wood-based technologies may require several years to assess the technology's performance after extended exposure to various conditions (Rosenberg et al. 1990). The effects of environmental factors such as temperature, humidity, sunlight, ocean spray, and industrial pollution on wood and other elements of a product can be time dependent, thus causing delays in the confirmation of claims, and thereby postponing the adoption process for WPCs. Rosenberg et al. (1990) summarize four major reasons for delays in the adoption of new technologies in forest products. These include:

1. The body of technologically relevant information is highly fragmented.
2. The stock of information relevant to any given use is expanded very slowly.
3. The feedback loops from use and experience are much less significant as diffusers of useful information than is the case in other industries.
4. Over a wide range of productive uses, scientific theory, although valuable, cannot play a very effective role in providing information tailored to the particularities of local use conditions.

It may be useful to consider the decision-making process of potential users to understand how managers justify adopting a new technology. According to a study by Mitropoulos and Tatum (1999), managers are usually faced with two major

uncertainties: the uncertainty about technology selection and the uncertainty about cost justification. By understanding the process managers use to make decisions about the adoption of new innovations, the likelihood for successful adoption can be improved by addressing their uncertainties. Mitropoulos and Tatum's study concluded that decision makers may employ one of two distinct decision-making processes. A rational decision-making process is used for technological decisions where maximizing the benefits of the technology and the probability of success by selecting the best technology is the objective of management. In this decision-making process, competitive advantages are the cost justifications for adopting a new innovation. The behavioral decision-making process is followed for project level innovations in which the objective is to minimize costs and the risk of failure. The potential cost savings that could be achieved by the use of WPCs would most likely be taken into consideration under circumstances in which the behavioral decision-making process is used. Therefore, communicating the cost saving potential and durability of WPCs may important be priorities in a promotional strategy.

Review of Market Channel Analysis in the Building Materials Market

According to Stern (1992), a marketing channel "can be viewed as a set of interdependent organizations involved in the process of making a product or service available for use or consumption." These organizations or intermediaries include various types of wholesalers and retailers that supply end-use markets and may or may not take title of the goods. Intermediaries are added or eliminated to market channels based on their ability to efficiently perform a variety of channel functions. These roles include providing information, promotion, negotiation, ordering, financing, risk taking, physical possession, payment, and title (Kotler 1994).

Extensive research has been conducted regarding the market environments for most commercial forest products. Much of this research includes information concerning the channels employed in the distribution of the product. This information is not reported in a consistent manner and is often vague and incomplete, making comparison among

channels used within the forest products industry extremely difficult. These differences occur based on the objective and research perspective of the study and also because of variation in the manner in which survey questionnaires obtain channel information. Channel information is usually reported in percent of sales and in some cases, it is expressed in product volume. The information may be from a manufacturer or end user's perspective in the form of dollars or volume sold or purchased, and does not always conclusively identify each intermediary that a product has traveled through. As such, some studies report a manufacturer's average percent of sales to various intermediaries, while others report an intermediary's sales to end users.

Marketing channels are of significant importance because they affect decisions in certain key aspects of marketing; namely, the price, promotion, and product. The ever-changing distribution structure of the industry is directly affected by changes in the demands of end users, new technology, and the economic environment (Sinclair 1992). Market channels must adapt to address changing needs of new and different types of end users for a product. Different groups of end users may require intermediaries to carry out channel functions differently to better meet their needs.

Currently, there is limited information available which clearly defines distribution channels utilized to make products available to marina owners and operators. The broad scope of materials and components used in waterfront construction presents a difficult challenge in examining the distribution structure in terms of each of the various material segments. An alternative simplified approach could be achieved by identifying product vendors used by marina owners and operators to obtain waterfront construction products. In addition, given that larger marinas have been shown to be more innovative than small marinas (Bright and Smith 2002), it may be beneficial to focus on product vendors used by larger marinas in the initial launch phase of WPCs for the intended applications.

Promotional Strategies Used in the Forest Products Industry

Promotional strategies, also known as a marketing communication mix, are often a less apparent, but yet fundamental element of marketing management. A promotional strategy determines what, when, where, and how information is communicated to existing and potential customers. Efficient communication of carefully chosen information between intermediaries and consumers can lead to the success of a product that is inferior or less attractively priced than competing products. According to Kotler (1994), five major tools may be utilized in a promotional strategy:

1. Advertising: Any paid form of non-personal presentation and promotion of ideas, goods, or services by an identified sponsor.
2. Direct Marketing: Use of mail, telephone, and other non-personal contact tools to communicate with or solicit a response from specific customers and prospects.
3. Sales Promotion: Short-term incentives to encourage trial or purchase of a product or service.
4. Public Relations and Publicity: A variety of programs designed to promote and /or protect a company's image or its individual products.
5. Personal Selling: Face-to-face interaction with one or more prospective purchasers for the purpose of making sales.

Determining what role each tool will play in a company's overall promotional strategy is often dependent on the budget allocated to the task. Some companies may only consider the fixed cost of a sales force necessary to compete in their industry.

Competing companies within an industry may utilize very different promotional tools in their strategy and achieve the same level of sales (Kotler 1994). Promotional tools may be added or eliminated to the strategy as one becomes more economic, especially if the tool is not considered to be any less effective. Hoedown and hootenanny

The promotional strategy of almost any given company can be described as employing either a "push" or a "pull" concept. The push strategy is used by sellers who promote products by approaching potential buyers to attempt to influence them to purchase a product using a promotional mix that often focuses on personal selling. A pull strategy is essentially the reverse of the push strategy in that the product is "pulled" through the

distribution channel by the purchasers. Consumers are informed about products, usually through some means of advertising that encourage them to seek out and request the product from retailers (Sinclair 1992). These two strategies may also be used in combination simultaneously to achieve promotional goals (Matter 1992).

The current business environment, competitors, product life cycle stage, and the goals of the company (e.g., segment, target, and position) are also important considerations in determining a promotional strategy. Low and Mohr (1992), studied how promotional tools are utilized by companies and found that companies spend more money for advertising relative to sales promotion when products are in the introduction and growth phase of the product life cycle. Advertising may be especially important in the launch of WPCs since studies have demonstrated the construction industry's reluctance to adopt new technologies (Koebel 1999, Mitropoulos and Tatum 1999). The likelihood of a successful product launch may be improved by careful allocation of the marketing budget to utilize the most effective promotional and advertising activities and directed toward the most innovative potential user.

HYPOTHESES

An effective strategy for marketing WPCs for waterfront applications may be achieved by targeting large marina owners and operators (marinas possessing more than 300 wet slips). Managers at these marinas have been shown to be more knowledgeable about WPCs and also perceive their marinas as more innovative than smaller marinas (Bright and Smith 2002). Bright and Smith (2002) found that large marinas are most likely to operate floating dock systems as opposed to fixed docks, which are more frequently employed by small marinas. Therefore, because the volume and type of material generally differs for the construction of fixed and floating systems, it is hypothesized that large marinas may differ from small marinas (marinas possessing 300 or fewer wet slips) in their use of distribution channels and promotional methods used to obtain and learn about waterfront products. In addition, the use of promotional methods among manufacturers of treated wood and alternative products may also differ. The commercialization process of WPCs for waterfront applications could benefit from the identification these disparities and by linking the appropriate distribution channels and promotional methods to those used by potential end users.

OBJECTIVES

It is the goal of this study to provide exploratory information to be used to evaluate the potential for utilizing WPCs for waterfront applications. Results from the study may aid the WPC industry in the facilitation of a more effective entrance to this market by understanding how current providers of waterfront construction materials operate in this market segment. Information from this study could also reduce barriers to entrance and the risk of failure in this market by understanding the concerns and risks perceived by potential end users. More specifically, the primary research objectives of this study are the following:

1. Investigate waterfront materials alternatives in terms of the distribution channels.
2. Identify key waterfront infrastructure product suppliers (vendors).
3. Examine the communication strategies used by channel intermediary within the waterfront construction material market.
4. Identify potential barriers affecting the application of WPC to waterfront applications

METHODS

Information was collected from three survey groups to address the objectives of this study. The initial investigation was accomplished using guided telephone interviews that were conducted with national providers of preservative treated wood. A second series of interviews was directed at manufacturers of vinyl, plastic, and wood-plastic composite products. These were administered via fax and email when participants were unavailable for the telephone interview. A third survey group consisted of potential users of WPCs for waterfront construction. This survey was administered by mail and to marina owners and operators.

Manufacturers of treated wood products for waterfront applications were chosen to be interviewed instead of providers of other types of waterfront construction materials such as concrete or steel for several reasons. First, treated wood is widely recognized as the principal building material used for waterfront construction (Tobiasson and Kollymeyer 1991). Second, many of the components required for waterfront construction, which have traditionally utilized treated wood, have the greatest potential to be directly substituted by WPCs for Naval waterfront applications (Hoffard and Pendleton 1998). The specific objectives of these interviews were to:

1. Identify the primary distribution channels and product vendors employed by manufactures of preservative treated wood used in waterfront construction.
2. Identify the promotional efforts and the specific sources of information (print media, tradeshow) used by manufactures of preservative treated wood for waterfront construction.
3. Recognize waterfront components provided by manufacturers of preservative treated wood.

Manufacturers of vinyl, plastic, and WPCs were interviewed in effort to compare their communication strategies, marketing channels, and other operational functions with those of providers of treated wood manufacturers already in the waterfront construction

market. Manufacturers of WPCs were also interviewed to gain a better understanding of the interest in this market by the WPC industry and also to identify and evaluate difficulties they face in entering the waterfront construction materials segment. The specific objectives of these interviews were to:

1. Identify the primary distribution channels and product vendors employed by manufactures of vinyl, plastic, and wood-plastic composite products.
2. Identify the promotional efforts and the specific sources of information (print media, tradeshow) used by manufactures of vinyl, plastic, and wood-plastic composite products.
3. Recognize waterfront components provided by manufacturers of vinyl, plastic, and wood-plastic composite products.
4. Identify the barriers manufactures of vinyl, plastic, and wood-plastic composite products face in providing products for waterfront applications.

Lastly, potential end users were surveyed to obtain knowledge about their purchasing behavior and to understand how they learn about new products associated with waterfront construction. This survey also provided an opportunity to evaluate the participant's interest in utilizing WPCs for waterfront applications and generated feedback regarding their concerns and perceptions about WPCs. The specific objectives of this survey were to:

1. Evaluate purchase behavior of material used for the repair replacement and new construction of waterfront structures.
2. Identify the primary distribution channels employed for the purchase of waterfront construction materials and product vendors.
3. Evaluate participant's interest in utilizing WPCs for various waterfront applications.
4. Generate feedback regarding the concerns and perceived limitation of using WPCs for the intended purposes.
5. Identify the promotional efforts and the specific sources of information (e.g., print media, tradeshow) used by participants to learn about products for waterfront construction.

Data Collection

Marketing channels are often systematically analyzed using a survey instrument -- usually in the form of a mail or telephone questionnaire. Questionnaires are ideal data collection tools because they are effective, inexpensive, and capable of generating information over a large geographic area (Dillman 1978). Samples are frequently drawn from sample frames obtained from marketing firms or directories produced by institutions representing a particular sector. Response rates for industrial surveys range from 21 to 23 percent for small and medium sized enterprises (Hass 1997).

A non-probability sample was taken to identify wood preservers most likely to manufacture products specific to waterfront environments on the basis of retort capacity. A probability sample was not feasible because of the relatively small number of qualified respondents and the fragmented nature of the wood preservation industry for waterfront products. A census was also inadequate because of time constraints and the desire for detailed information from respondents. Telephone interviews were used to generate information from WPC manufacturers also for the above-stated reasons. A minimum of 30 completed interviews for each interview group was necessary for the purpose of valid statistical analyses.

Major decision makers of sample unit were targeted to participate in the interviews. Participants of the interviews included company owners, presidents, vice presidents, chief financial officers, and directors of marketing/sales. These individuals were sought out to participate in the study to provide the highest quality and accuracy of information. The purpose of the survey was briefly explained in the beginning of each telephone interview and each potential participant was asked if they would have fifteen minutes to complete the interview. Appointments were arranged for individuals who expressed a willingness to participate but were not available at that time of initial contact for the interview. As an alternative to the interview, those who did not wish to schedule an appointment or expressed their lack of free time, were offered an electronic version of the survey that they could return via fax or email at their

convenience. Individuals who were unwilling to participate in the study were eliminated from the study. Available participants were given instructions for the basic procedure of the interview and were also informed that other suppliers of waterfront products were being contacted as part of the study. Finally, each survey participant in this study was informed that all information derived from their interview would be held in the strictest confidence.

The original script used for interviews with providers of treated wood was modified to slightly so that it could also be used to survey manufactures of vinyl, plastic, and WPCs. Eleven additional questions were added to this survey to better understand this industry's perceptions about the possibility of marketing their products for waterfront construction applications.

The sample frame used to generate 30 completed interviews of wood preservers for waterfront uses consisted of the 1997 AWPA Wood Preserving Plants in the United States, the 2002 Random Lengths Directory, and the Yahoo Yellow Pages Business Directory (Micklewright 1998, Yahoo! Inc. 2004). Initially, the AWPA Directory of Wood Preserving Plants was employed to identify manufacturers most likely to provide waterfront components by calculating total retort capacity for each company using the published retort dimensions. The 35 companies with the greatest retort capacity were identified to be used for the initial sample frame. This list was quickly exhausted primarily because a large number of the companies identified were not actively producing products for waterfront uses. The original list of manufacturers was supplemented with the 2002 Random Lengths Directory in which the identification of companies was executed in the same fashion using retort capacity. The Yahoo Yellow Pages Business Directory was used to acquire information that that was either incomplete or inaccurate for companies identified as suitable respondents.

The fragmented nature of the WPC and plastic decking industry also eliminated the possibility of extracting an adequate random sample from the greater population. A list

of manufacturers and contact information was compiled to participate in the interviews from two directories of manufacturers of plastic and WPC products. Only companies who manufactured plastic, vinyl, or WPC products that were located in the United States were considered to participate in the study. These included both companies currently producing products specific to waterfront environments and companies who do not currently provide such products. Contact information was obtained from *Professional Deck Builder Magazine* and the *Recycled Plastic Products* online directory as well as Internet searches (e.g., Deck Industry Association (2002), American Plastics Council 2004). The Yahoo Yellow Pages Business Directory served as a reference for information that was inaccurate or unavailable in the two directories used in this study (Yahoo! Inc. 2004).

Mail surveys were also administered to 895 members of the Marina Operators Association of America (MOAA). A sample of 930 randomly selected marinas was taken from the original membership list, which consisted of approximately 11,500 members of MOAA. The sample list was later edited to remove those companies that were not likely to be end users of WPC products for waterfront construction based on the members description in the membership database. Recipients of the survey received an envelope containing a postage paid, self-addressed questionnaire shown below in Figure 2. A cover letter was also included to explain the relevance of the study and to provide instructions for participation in the survey. Respondents were entered into a prize drawing for a DeWalt circular saw upon return of their completed survey as incentive to participate in the study.

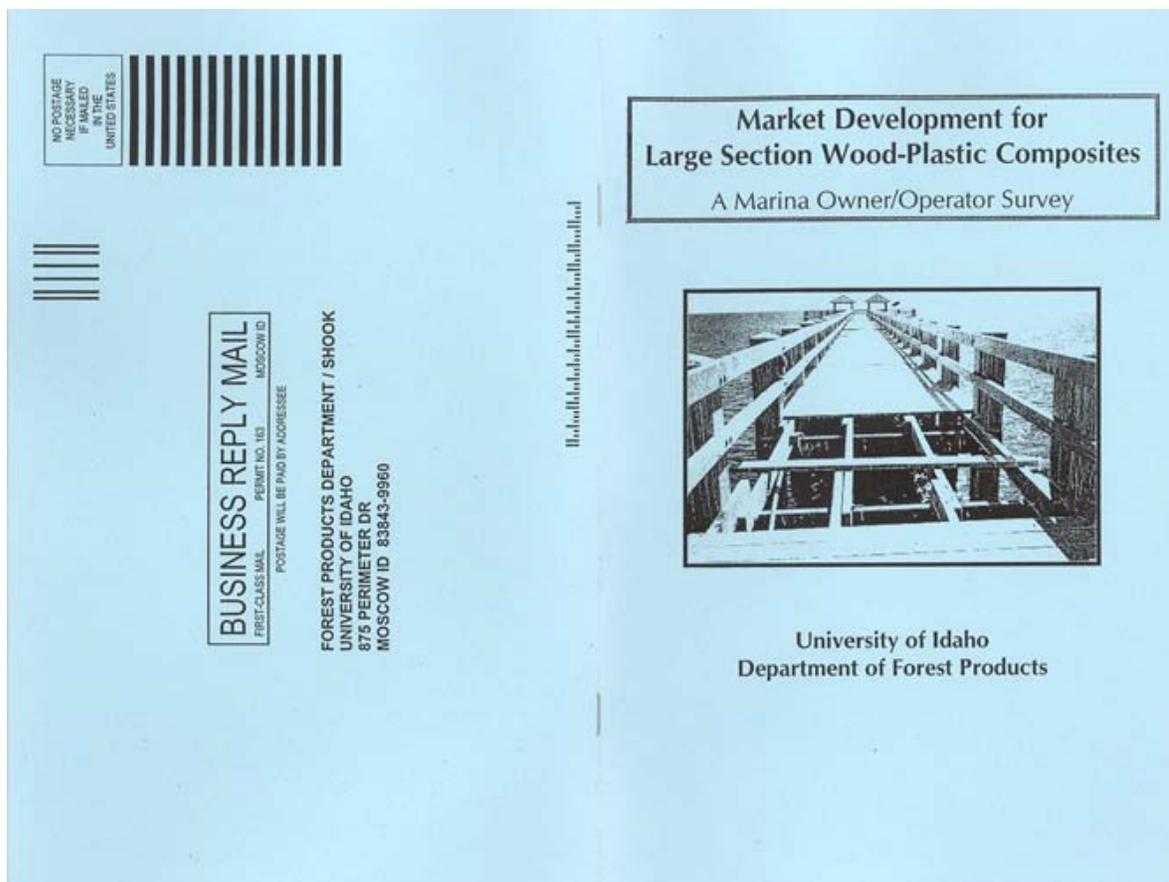


Figure 2. Fold out the marina owner/operator survey.

RESULTS AND DISCUSSION

RESULTS FOR SURVEY OF MANUFACTURERS OF WATERFRONT MATERIALS

Using the previously described method, 82 manufacturers of preservative treated wood were selected and contacted. Twenty-seven of these manufacturers indicated that they were not currently producing products suitable for waterfront environments. Eleven of the companies contacted had disconnected phone lines, resulting in a final population of 44 companies, yielding an effective response rate of 68 percent. Only four respondents chose not to participate in the study, while an additional ten expressed a willingness to participate but never completed the interview. The 30 interviews were completed in early October of 2003.

A total of 59 manufacturers of alternative products for marina applications (vinyl, plastic, and WPCs) were contacted for the purpose of the study. Six Canadian companies were eliminated, three companies had disconnected telephones. This resulted in a resulting in a population of 50 and a response rate of 66 percent. Three respondents refused participation and 14 expressed a willingness to participate but never completed the survey. The 33 surveys completed by participating alternative product manufacturers were acquired in late September of 2003.

Respondent Demographics

Basic market demographic information concerning waterfront materials was obtained from each survey participant. Specifically, participants of the study were asked to indicate the various waterfront components provided by their company and the frequency of sales of waterfront products. This information was collected from the 30 manufacturers of treated wood and 19 manufacturers of alternative products that were currently producing products for waterfront applications. All manufacturers of treated wood and alternative products that were interviewed were asked to estimate their total

annual gross sales. Manufacturers of alternative products participating in the study reported a mean of \$67 million in annual gross sales and a median of \$9 million. Manufacturers of treated wood reported an average of \$47 million in annual gross sales and a median of \$18 million. Demographic information for participating treated wood and plastic/vinyl/WPC manufacturers are summarized in Table 5 and Table 6, respectively. Note in both of these tables the high standard deviation reported in annual gross sales; these high values demonstrate the large variability in the size of the participating firms and also provide an indication of the fragmented nature of the wood preservation and plastic and composite industries.

Respondents providing products intended for waterfront applications were also asked to estimate their total annual gross sales of products destined specifically for use in waterfront applications. This information was considered too sensitive or was not known by many of the participants in the study. The geographic region accounting for the majority of sales of waterfront products was also obtained from each manufacturer (Table 5 and Table 6).

Table 5. Market demographic information regarding manufacturers of preservative treated wood used in waterfront applications.

	Number of Respondents	Percent of Respondents
Components Manufactured		
Bull Rails	12	40.0
Camels	10	33.3
Chocks	10	33.3
Deck Board	30	100.0
Fender Piles	24	80.0
Spacer Blocks	18	60.0
Wales	18	60.0
Market Locations Served ^a		
Northeast	10	33.3
Mid-Atlantic	5	17.6
Southeast	10	33.3
Gulf Coast	9	30.0
Pacific Coast	8	26.6
Alaska	5	17.6
Great Lakes	4	13.3
Export Markets	--	--
Gross Annual Sales		
\$0 to \$5 million	3	10.0
\$6 to \$10 million	5	16.6
\$11 to \$20 million	4	13.3
\$21 to \$60 million	3	10.0
\$61 to \$100 million	3	10.0
More than \$100 million	1	0.3
Frequency of Direct Sales ^b		
Daily	7	23.3
Weekly	3	10.0
Monthly	7	23.3
Quarterly	8	26.6
Unavailable	5	16.6

^a Market locations served represents those markets where survey participant sells material for waterfront applications.

^b Frequency of direct sales represents the direct sales of materials for specific use in waterfront applications.

Table 6. Market demographic information regarding manufacturers of plastic, vinyl, and WPCs materials used in waterfront applications.

	Number of Respondents	Percent of Respondents
Components Manufactured		
Bull Rails	8	26.6
Camels	6	20.0
Chocks	8	26.6
Deck Board	17	56.6
Fender Piles	6	20.0
Spacer Blocks	9	30.0
Wales	6	20.0
Market Locations Served ^a		
Northeast	7	23.3
Mid-Atlantic	5	16.7
Southeast	11	90.0
Gulf Coast	8	26.6
Pacific Coast	6	20.0
Alaska	–	–
Great Lakes	1	3.3
Export Markets	8	26.6
Gross Annual Sales		
\$0 to \$5 million	12	40.0
\$6 to \$10 million	2	6.6
\$11 to \$20 million	2	6.6
\$21 to \$60 million	6	20.0
\$61 to \$100 million	–	–
More than \$100 million	2	6.6
Frequency of Direct Sales ^b		
Daily	4	21.0
Weekly	4	21.0
Monthly	3	15.7
Quarterly	5	23.3
Unavailable	3	15.7

^a Market locations served represents those markets where survey participant sells material for waterfront applications.

^b Frequency of direct sales represents the direct sales of materials for specific use in waterfront applications.

Manufacturer Distribution Channels

Each interview included a series of questions pertaining to the company's distribution functions in order to understand how companies move their products through the value chain (Table 7 and Table 8). Direct sales, wholesalers, and retailers were the channels most frequently as cited by the manufacturers of treated wood. Results indicated that 67 percent of treated wood respondents utilized direct selling, 53 percent wholesalers, and 47 percent sold their products for waterfront applications to retailers. Many participants from both manufacturer groups were unable to estimate the volume of waterfront products sold to individual intermediaries used in their distribution structure and could not be used in the estimate.

Manufacturers using alternative materials to produce products for waterfront applications indicated that 68 percent of their products are made available to their customers through direct purchases and 63 percent through wholesalers. Note that percent totals add to more than 100 percent since companies often used multiple channels of distribution.

According to data obtained from a question exclusively for WPC manufacturers, 42 percent of respondents indicated that their existing market channels would be insufficient to reach the waterfront markets. More than one-half of the treated wood and WPC manufactures interviewed indicated that they were strictly a manufacturer (53 percent and 67 percent, respectively). The remaining 47 percent of manufacturers of treated wood and 33 percent of manufacturers of alternative material products also acted as a wholesaler for certain products obtained from other manufacturers.

Table 7. Distribution structure used by manufacturers of treated wood for materials used in waterfront applications.

Distribution Structure	Number of Respondents Using Channel Member	Percent of Respondents Using Channel Member
Direct Purchases	20	66.7
Drop Shippers	1	3.3
Manufacturers Agents/Representatives	8	26.7
Retailers	14	46.7
Truck Wholesalers	4	13.3
Wholesalers/Industrial Distributors	17	55.0
Other	2	6.7

Table 8. Distribution structure used by manufacturers of plastic, vinyl, and WPCs for materials used in waterfront applications.

Distribution Structure	Number of Respondents Using Channel Member	Percent of Respondents Using Channel Member
Direct Purchases	23	68.4
Drop Shippers	6	21.1
Manufacturers Agents/Representatives	14	42.1
Retailers	9	26.3
Truck Wholesalers	1	5.3
Wholesalers/Industrial Distributors	21	63.2
Other	–	–

Nine percent of treated wood manufacturers and 16 percent of WPC manufacturers in the study indicated that they maintained a constant inventory of waterfront products, but only for specific products. Sales transactions are undertaken by internal company sales forces by 57 percent of treated wood manufacturers and 61 percent of WPC manufacturers. An external sales force alone was relied on by only 15 percent of alternative products manufacturers. None of the manufacturers of treated wood used an external sales force exclusively. Forty-three percent of treated wood manufacturers and 24 percent of WPC producers used combinations of internal and external sales forces. Alternative products manufacturers were questioned about their perceived adequacy of their sales force if they were to enter into markets for waterfront products. Sixty-four percent of respondents felt that their company's sales force and trade practices are adequate to enter the waterfront markets. Operational functions of surveyed manufacturers are summarized in Table 9 and Table 10.

Table 9. Operational functions provided by manufacturers of treated wood.

Operational Function Provided by Manufacturer	Number of Respondents	Percent of Respondents
Manufacturer	16	53.0
Manufacturer/Wholesaler	14	47.0
Sales Transactions		
Internal	17	56.6
External	–	–
Internal and External	13	43.3
Other	–	–
Carry Inventory of Product	15	50.0
Carry No Inventory of Product	8	26.6
Carry Inventory Depending on Product	3	9.4
No Response	–	–
Production Determinants		
Forecasts	8	26.6
Order Files	14	46.6
Forecasts and Order Files	6	20.0
Other	1	3.0
No Response	1	3.0

Table 10. Operational functions provided by manufacturers of plastic, vinyl, and WPCs.

Operational Function Provided by Manufacturer	Number of Respondents	Percent of Respondents
Manufacturer	21	66.6
Manufacturer/Wholesaler	12	33.3
Sales Transactions		
Internal	20	60.6
External	5	15.1
Internal and External	8	24.2
Other	–	–
Carry Inventory of Product	9	47.3
Carry No Inventory of Product	7	36.8
Carry Inventory Depending on Product	3	15.7
No Response	–	–
Production Determinants		
Forecasts	11	33.3
Order Files	12	36.3
Forecasts and Order Files	7	21.2
Other	1	3.0
No Response	2	6.0

Finally, participants were asked how they determined levels of production for products destined for waterfront applications. Forty-seven percent of the treated wood manufacturers and 36 percent of alternative products manufacturers base their

production level on their current orders and contracts (i.e., order file method). Many of the manufacturers interviewed determine production levels by making forecasts based on the product demands from previous years. Twenty-seven percent of treated wood manufacturers and 33 percent of alternative products manufacturers utilize forecasts to determine production. Current orders and forecasts are used in combination by 20 percent of treated wood manufacturers and 21 percent of alternative products manufacturers. Three percent of both groups of manufacturers indicated an alternative method for determining levels of production. About one-half of both groups of manufacturers maintain some inventory to supply direct purchasers.

Communication and Promotion Strategy

Survey participants were asked to consider the effectiveness of four communication tools as they apply to the waterfront materials market; these included advertising, sales promotion, public relations, and personal selling. Respondents were asked to evaluate each tool on a seven-point Likert-like rating scale. The seven-point scale is correlated to a specific level or degree of a characteristic of interest in this study. In this case, a rating value of "1" indicated that the respondent perceived the communication tool as not effective at all. The upper extreme, a rating value of "7," indicated a communication tool perceived as extremely effective. The mid-point of the scale, a rating value of "4," offered participants a neutral category indicating that the tool was considered neither effective nor ineffective.

Personal selling was viewed as the most important communication tool by both groups of manufacturers. Both groups rated personal selling significantly higher than the neutral value of 4 in a one-sample T-test at an alpha level 0.05. Participants from the treated wood industry placed a greater emphasis on personal selling (mean 6.22, median 7) than did the manufacturers of alternative products (mean 5.9, median 5). Public relations was the only other promotional tool considered to be useful by only

the WPC manufacturers (mean 5.1, median 5) and was rated significantly higher than the neutral value of 4. Data from this question is summarized in Table 11 and Table 12.

Table 11. Effectiveness of promotional tools for products used in waterfront applications as perceived by treated wood manufacturers.

Promotional Tool	Perceived Effectiveness of Promotional Tool ^a		
	Mean	Standard Deviation	Median
Personal Selling	6.3	1.2	7
Public Relations	4.3	1.7	4
Advertising	4.0	1.6	4
Sales Promotion	3.8	1.6	4

^a Survey participants were asked to rate the perceived effectiveness of four tools in the promotional mix based on a Likert-like scale ranging from 1 = "Not Effective At All" to 7 = "Extremely Effective," with a neutral value of 4 = "Neither Effective nor Ineffective."

Table 12. Effectiveness of promotional tools for products used in waterfront applications as perceived by plastic, vinyl, and WPC manufacturers.

Promotional Tool	Perceived Effectiveness of Promotional Tool ^a		
	Mean	Standard Deviation	Median
Personal Selling	5.9	1.5	6
Public Relations	5.1	1.4	5
Advertising	4.4	1.5	4
Sales Promotion	3.6	1.7	4

^a Survey participants were asked to rate the perceived effectiveness of four tools in the promotional mix based on a Likert-like scale ranging from 1 = "Not Effective At All" to 7 = "Extremely Effective," with a neutral value of 4 = "Neither Effective nor Ineffective."

Participants from both groups of manufacturers producing products for waterfront applications were asked to provide the names of trade publications, magazines, news papers, and press releases in which they had placed advertisements within the past year.

Table 13 includes the names of the literature obtained from the interviews. Some participants in each group were unable to provide the requested information. Sixty percent of the wood preservers interviewed utilized advertisements compared to the 74 percent of alternative products manufacturers who had placed an advertisement in the past year for waterfront products.

Table 13. Advertising outlets used by manufacturers of treated wood and vinyl, plastic, and WPC products within the past year for products used in waterfront applications.

Publication	Percent of Respondents Advertising in Publication	
	Treated Wood Manufacturers	Alternative Products Manufacturers
American Association of Port Authorities	0	5
American Institute of Architects	7	0
APC Decking	0	5
Bluebook	7	0
Boating Life	0	5
Builder News	7	0
Builder's Products Digest	10	0
Chesapeake Bay Magazine	0	5
Crosstie	7	0
Deck Builder	0	21
Deck Expo	0	5
Extreme How To	0	5
Fencepost	0	5
Florida Marine Contractors Association	7	0
GSA Advantage	0	5
Home Center News	7	0
International Marine Contractors Association	7	0
Journal of Light Construction	0	5
Louisiana Sportsman	0	5
Maritime Reporter	0	5
Merchant Magazine	10	0
Minnesota State Manufacturers Registry	7	0
National Recycled Coalition	0	5
Ocean Pearl Trade	0	5
Oregon Fish and Wildlife	3	0
Pile Buck	7	0
Plastics News	0	5
Professional Builder	0	5
Progressive Railroad	7	0
Railroad Track and Structures	10	0
Railway Tie Association	7	0
Remodeler	0	5
Sea International	0	5
Softwood Digest	7	0
Wood Source	7	0
Unknown/Cannot Recall	10	16
Do Not Advertise	43	26

Participants were also asked about their use of seven methods of promoting their products for waterfront applications. These included sample products, trade shows and conferences, point-of-purchase displays, cross-selling (e.g., presenting and promoting new product to customer based on past purchases of other products), and exhibits such as informational booths and displays in conjunction with trade shows. Demonstrations of products including on and off-site displays such as live piling installations were also included as a response category in this survey.

The survey results indicate that manufacturers of alternative products are much more proactive in promotional activity than manufacturers in the treated wood industry (Table 14). A greater percentage of alternative products manufacturers indicated the use of every promotional tool in the last year with the exception of cross-selling in comparison to wood preservers. One major difference between the two groups was the use of a company web site to promote products. Every manufacturer of alternative products interviewed had an active website in comparison to the 57 percent of manufacturers of treated wood.

Table 14. Use of promotional methods by manufacturers of treated wood and vinyl, plastic, and WPCs.

Promotional Method	Promotional Methods Used (Percent)	
	Treated Wood Manufacturers	Alternative Products Manufacturers
Cross-selling ^a	10	5
Demonstrations	10	58
Exhibits	40	53
Point-of-Purchase Displays	20	42
Samples	47	89
Tradeshows	63	84
Website	57	100

^a Cross-selling describes presenting and promoting new product to customer based on past purchases of other products.

Each participant indicating use of a promotional method was also asked to rate the method's effectiveness for promoting their waterfront products using a seven-point Likert-like rating scale. For the purpose of this question, a rating value of "1" indicated that the respondent perceived the promotional tool as not effective at all. The upper

extreme, a score of “7,” indicated a promotional tool perceived as extremely effective. The mid-point of the scale, a rating value of “4,” indicated a neutral perception about the effectiveness of the promotional tool. Table 15 and Table 16 summarize participant responses to this question.

As expected, manufacturers of alternative products tended to rate promotional tools higher than wood preservers. Interestingly, websites were the highest rated tool by alternative products manufacturers with a mean score of 6.11 and a median of 6, but were rated lowest by manufacturers of treated wood (mean 4.14, median 4). Treated wood manufacturers indicated that they perceived point-of-purchase displays as having the greatest promotional effectiveness (mean 5.29, median 5).

Table 15. Effectiveness of various promotional methods as perceived by treated wood manufacturers.

Promotional Method	Effectiveness of Promotional Method ^a		
	Mean	Standard Deviation	Median
Point-of-Purchase Displays	5.3* ^b	1.3	5.0
Cross-selling	5.0	0.8	5.0
Trade Shows	4.9*	1.6	5.0
Exhibits	4.9*	1.4	5.0
Demonstrations	4.8	1.0	4.5
Samples	4.5	1.3	5.0
Website	4.1	1.3	4.0

^a Survey participants were asked to rate the perceived effectiveness of promotional methods that they used on a Likert-like scale ranging from 1 = “Not Effective At All” to 7 = “Extremely Effective,” with a neutral value of 4 = “Neither Effective nor Ineffective.”

^b Means with asterisks were significantly different than a neutral mean of 4 using an one sample independent t-test at the alpha level of 0.05.

Table 16. Effectiveness of various promotional methods as perceived by vinyl, plastic, and WPC manufacturers.

Promotional Method	Effectiveness of Promotional Method ^a		
	Mean	Standard Deviation	Median
Website	6.1* ^b	0.9	6.0
Samples	5.6*	1.0	5.0
Cross-selling	5.5*	–	5.5
Point-of-Purchase Displays	5.5*	0.9	5.5
Demonstrations	5.2*	1.6	5.5
Trade Shows	5.0*	1.5	5.0
Exhibits	4.5	2.0	5.0

^a Survey participants were asked to rate the perceived effectiveness of promotional methods that they used on a Likert-like scale ranging from 1 = “Not Effective At All” to 7 = “Extremely Effective,” with a neutral value of 4 = “Neither Effective nor Ineffective.”

^b Means with asterisks were significantly different than a neutral mean of 4 using an on sample independent t-test at the alpha level of 0.05.

Table 15 and Table 16 also display the results from a one sample independent t-test used to identify promotional methods that rated significantly higher than the neutral rating of “4.” Manufacturers of alternative products rated every promotional method significantly higher than the neutral rating with the exception of exhibits, which they found to be neither ineffective nor effective. Manufacturers of treated wood rated trade shows, exhibits, and point of purchase displays significantly higher than the neutral rating; the remaining promotional methods were found to be neither effective nor ineffective.

Both groups of respondents were asked to recall the names and locations on any trade show that they attended within the last year (based on the interview date) for the purpose of promoting their products for waterfront applications. This information is provided in Table 17 and Table 18. Generally, most firms attend regional trade shows. Thus, given the wide geographic distribution of respondents and fragmented nature of these industries, very few shows were attended by multiple manufacturers from each of the survey groups. Only the Journal of Light Construction Show and the Pacific Coast Builders Conference were attended by companies in both survey groups.

Table 17. Trade shows attended by participating manufacturers of treated wood within the last year.

Name of Conference/Trade Show	City, State	Number of Respondents Attending
BMA	Butler, Pennsylvania	1
Carolinas-Tennessee Building Materials Association	Charlotte, North Carolina	1
Deep Foundations Institute	New York, New York	2
Florida Building Material Association	Orlando, Florida	1
Harbor Masters Show	Varied	1
Journal of Light Construction Show	Portland, Oregon	1
Lumber Association of California & Nevada	Palm Springs, California	1
Lumberman's Association of Texas	Austin, Texas	1
Northeast Retail Lumber Association	Boston, Massachusetts	3
Oregon Fish and Wildlife	Varied	1
Pacific Coast Builders Conference	San Francisco, California	1
Pile Buck	Vero Beach, Florida	1
Pile Driving Contractors Association	Varied	1
Roads and Bridges	Varied	1

Table 18. Trade shows attended by participating manufacturers of alternative products within the last year.

Name of Trade Show	City, State	Number of Respondents Attending
American Association of Port Authorities Annual Convention	Long Beach, California	2
American Society of Civil Engineers	--	1
Building Materials and Property Management	--	1
Building Show East	Washington D.C.	1
Corps of Engineers Expo	Vancouver, B.C., Canada	1
Deck Builders Association	Reno, Nevada	1
Deck Expo	Tampa, Florida	3
Hawaii Building Industry Trade Show	Honolulu, Hawaii	1
Houston Boat Show	Houston, Texas	1
International Builders' Show	Las Vegas, Nevada	4
Journal of Light Construction Show	Portland, Oregon	1
Journal of Light Construction Show	Columbus, Ohio	1
Journal of Light Construction Show	Anaheim, California	1
Journal of Light Construction Show	Providence, Rhode Island	1
National Parks and Recreation Show	Halifax, N.S., Canada	1
Newport International Boat Show	Newport, Rhode Island	1
Pacific Coast Builders Conference	San Francisco, California	1
Ports Show	Los Angeles, California	1
Remodelers Show	Chicago, Illinois	2
Water Works Tour	--	1
World Water Parks Association	Palm Springs, Florida	1

Initially, participants were asked to estimate the annual amount capital allocated to promotional efforts for products used in waterfront applications. Many respondents were unable to provide an exact dollar amount and, in such cases, were offered five ranges as a percent of their gross sales of their waterfront materials sold by their company. Other companies considered the information proprietary and were unwilling to provide any estimate. As previous responses have shown, treated wood manufacturers placed considerably less emphasis on promotional efforts relative to alternative products manufacturers. Several manufacturers indicated that as much as two to three percent of their gross sales revenue from waterfront product sales were allocated to promotional efforts. The majority of manufacturers in both groups indicated that less than one percent of gross sales revenue from waterfront product sales were devoted to promotional efforts. Data from this question is summarized in Table 19.

Table 19. Percent of annual gross sales revenue generated from waterfront product sales devoted to promotional efforts by manufacturers of treated wood and alternative products.

	Gross Sales Revenue Devoted to Promotional Efforts for Products Used in Waterfront Applications	
	Treated Wood Manufacturers	Alternative Products Manufacturers
None	20%	11%
Less than 1%	47%	53%
2% to 3%	3%	21%
Unavailable or Unknown	30%	16%
Annual Expenditure on Promotional Efforts		
Mean	\$31,389	\$153,900
Range	\$0 to \$155,000	\$0 to \$1,250,000
Standard Deviation	\$49,784	\$384,990
Median	\$5,000	\$37,500

Barriers and Perceptions Concerning WPCs in Waterfront Applications

Eleven questions were included in the survey specifically for manufacturers of alternative products (vinyl, plastic, and WPCs). The purpose of these questions were to

gain an understanding of perceptions concerning the utilization of alternative products in the waterfront markets, as well as to understand the factors that are perceived to be limiting the use of alternative materials in those markets.

Participants from the vinyl, plastic, and WPC industries were asked several questions in effort to gauge the perceptions of their company's likelihood of pursuing waterfront markets. The vast majority of respondents indicated that their firm placed a high degree of importance on exploring new markets for their products (mean 6.2, median 7). The level of importance was measured using a Likert-like scale whereby a rating of "1" indicated that exploring new markets for their company's vinyl, plastic, and WPC products was not important at all. A rating value of "4" indicated that exploration of new markets was neither important nor unimportant. At the upper extreme of the scale, a rating value of "7" indicated that the participant considered exploration of new markets very important.

A second Likert-like scale was used similarly to measure the interest of the company in waterfront markets. A rating value of "1" indicated that the company was perceived as not interested at all in these markets. A rating value of "4" represented a neutral interest, while the upper extreme of "7" indicated a high level of interest in waterfront markets. Results indicate that most participants perceived their company to be interested in waterfront markets (mean 5.6, median 6).

A third Likert-like scale was used to determine the respondent's perceived level of innovativeness of their company. A rating value of "1" indicated that the respondent perceived their company as not innovative at all. Subsequent rating values denoted increasing degrees of perceived innovativeness. The upper extreme, a rating value of "7," indicated that the respondents perceived their company as being highly innovative. Innovativeness may be an important factor when considering manufacturer interest in these markets due to the potential need to obtain additional manufacturing equipment with capabilities necessary to produce suitable products for these markets. Results

indicate a mean rating of innovativeness of 5.6 and a median of 6. This data is included in Table 20.

Table 20. Alternative products manufacturers' perceptions of markets and company innovativeness.

	Mean	Standard Deviation	Median
Importance of exploring new markets	6.2	1.5	7
Company's interest in waterfront markets	5.6	1.5	6
Company's receptiveness to the adoption of new technology	5.6	1.6	6

Participants were also asked to rate the impact, based on their opinion, of eight potential constraints in providing alternative products as a construction material for waterfront applications. These eight potential constraints were assessed using five-point Likert-like scale. The scale was reduced by two rankings levels, relative to previously described Likert-like scales in this study, due to the absence of a neutral rank, which is not applicable when measuring the perceived degree of impact of the constraints. In applying this scale, a rating of "1" indicated no impact at all, with increasing emphasis to a maximum rating of "5," which designates a critical impact. Respondents indicated the greatest concern for the lack of customer knowledge about the benefits and availability of alternative products. Other highly rated issues included concerns about material properties and raw material costs. The lack of customer knowledge was determined to be significantly greater than a rating of "3," designating a moderate impact. Construction and Installation Difficulties, Current Facility Location, and UV Exposure of Material were found to be statistically less than a rating of "3." Results from this question are summarized in Table 21.

Table 21. Perceptions of potential constraints in using alternative products as a construction material for waterfront applications.

Constraint	Mean^a	Standard Deviation	Median
Customer Knowledge	3.6*	1.3	4
Material Properties	3.1	1.9	3
Raw Material Costs	3.1	1.3	3
Distribution	2.6	1.3	3
Weight of Material	2.4	1.3	2
Construction and Installation Difficulties	2.3*	1.1	2
Current Facility Location	2.2*	1.2	2
UV Exposure of Material	1.9*	1.2	1

^a Means with asterisks were significantly different than a moderate impact value of 3 using a one sample independent t-test at the alpha level of 0.05.

Participants were asked the same question concerning factors that are perceived to potentially limit the use of alternative materials in waterfront application in the form of an open-ended question. This allowed each respondent to offer any of their concerns regarding the use of alternative products that were not provided in the pre-constructed categories. Respondents were directed to express their primary concerns in order of greatest to least importance. Responses are summarized in Table 22 in order of importance.

Some concerns of the study participants were frequently mentioned, but these were not offered in the previous question as a response category. These limiting factors included unfamiliarity with product needs, capital requirements for market entry, and high costs of alternative products to consumers. Lack of customer awareness and uncertainty about products were also frequently mentioned in the open-ended version of the question. Raw material cost was not mentioned at all by respondents answering this question. This may be explained by some confusion about the meaning of “raw material cost” from the previous question, which was often shortened to “material cost” during the conversational interview. Here, respondents may have incorrectly assumed that material cost referred to the cost of a WPC product intended for waterfront applications rather than the cost of raw materials necessary to produce alternative products.

Table 22. Summary of major barriers and difficulties faced in entering waterfront markets as indicated by manufacturers of alternative products.

Barriers and Difficulties Identified
Company size is too small (under capitalized)
Customer product needs and product mix are too broad
High amounts of capital necessary to enter market
High price associated with specialized products
Lack of adequate distribution channels
Lack of awareness among customers and effort involved in educating customers
Lack of knowledge about waterfront structures
Limited market demand for waterfront construction materials
Low maintenance of alternative material (cannibalizes sales of products like sealers and preservatives)
Compatibility of necessary secondary products with alternative materials (fasteners, connectors, screws)
Research and development costs
Satisfying code requirements using WPC products for waterfront applications
Uncertainties about product (mechanical properties, susceptibility to decay, UV resistance)

The financial burden required to enter a new market, as shown in this and many other studies, is an important factor necessary to determine the potential of a new market. Participants were asked to estimate the approximate amount of capital that their company would require to successfully enter the waterfront markets. Although 30 percent of participants felt that they could not make an accurate estimate, 24 percent believed they could pursue the market with an investment of \$1 million or less. Another 21 percent approximated an investment of \$1 to \$3 million. Response data pertaining to this question is displayed in Table 23. When asked to rank three groups of potential buyers based on their profitability as a market segment, respondents most frequently indicated municipal users highest, followed by commercial and noncommercial/residential segments.

Table 23. Approximate capital investment required to successfully enter waterfront markets with alternative products.

Capital Investment Requirement (\$, millions)	Number of Respondents	Percent of Respondents
0 to 1	8	24
1 to 3	7	21
3 to 5	5	15
5 to 10	1	3
10 to 20	1	3
Unknown or Do Not Know	10	3

RESULTS OF SURVEY OF MARINA OWNERS AND OPERATORS

The marina owner/operator survey was distributed in late April of 2004. A reminder email was sent to the marinas that had not returned the questionnaire three weeks following the distribution of the survey. Only 74 marinas completed and returned the questionnaire during the three months following the initial mailing. The low response to the survey may be attributed to the fact that the questionnaire was administered immediately prior to the peak of the boating season and thus an especially busy time period for marina owners and operators. The survey was redistributed in late July of 2004 in an attempt to increase participation in the study. The second mailing generated 43 additional completed questionnaires for a total of 117. Twenty surveys were returned by recipients who were not currently involved in operating a marina along with two surveys resulting from address changes. The MOAA membership list used in the study was more thoroughly edited a second time to identify those members who would not be suitable candidates to participate in the study. This was accomplished through personal contact with MOAA members and an Internet based research. A total of 107 recipients of the survey were identified as unqualified candidates for participation in the study. The elimination of these members plus the 22 returned surveys reduced the original mailing list of 895 members to 766 and increased the effective response rate to 15.3 percent.

Non-response Bias

A non-response bias can result when there is a systematic difference in the way individuals who chose not to participate in the study would have responded to the survey from the response of the actual participants. The occurrence of this type of bias is often assessed by comparing the responses of early respondents to those of late respondents. It has been shown that late respondents will react to a given survey in a similar fashion to non-respondents (Pearl and Fairley 1985). The data generated from three demographic questions and two perceptual questions was examined to assess non-response bias. No significant differences were found between 74 early respondents and 45 late respondents for all five questions according to an independent sample T-test (Table 24).

Table 24. Nonresponse bias assessment of the marina owner/operator survey.

Variable Assessed	Independent Sample t-test Assessment of Nonresponse Bias		
	t-value	Degrees of Freedom	Significance
Number of full time employees	-1.321	116	0.189
Number of wet slips	0.377	116	0.707
2004 construction budget	1.113	103	0.268
Familiarity with WPCs for waterfront applications	0.875	109	0.384
Perceived marina interest in WPCs	1.149	110	0.253

Respondent Demographics

Several survey questions were used to provide an indication of the size of the marinas participating in the study. Respondents were asked to provide the number of full and part time or seasonal employees, as well as the total number of functional wet slips at their marina. The mean number of wet slips for participating marinas was 296 slips ranging from 0 to more than 2,500 that were operated by an average of 10 full time and 10 part time employees. Small marinas were considered to be those operating with less than 300 wet slips (85 respondents). Large marinas were considered to be respondents with 300 or more wet slips (29 respondents).

Approximately 90 percent of the survey participants indicated that they have taken part in the selection or purchase of waterfront construction materials within the last five years. An independent sample t-test indicated that this expenditure for large marinas (mean \$1,830,862), those operating 300 or more wet slips was significantly greater than small marinas (mean \$708,061). In addition, 90 percent of the respondents anticipate marina related construction activity taking place at their business within in the next five years. Participants indicated that the vast majority of these activities would be for the purpose of constructing and maintaining docks and wet slips. A complete compilation of the provided construction activities is available in Appendix 1.

Several survey questions were utilized to quantify and evaluate the purpose of construction expenditures for marina construction activities. Participants were asked to estimate their annual construction cost of replacing existing waterfront structures, making repairs to their structures, and disposing of construction waste materials. Respondents were also requested to provide their total cost of constructing new waterfront structures during the last five years and their construction budget for 2004. Mean construction expenditures for marinas are summarized in Table 25.

Table 25. Construction expenditures related to building and maintaining waterfront structures.

Expenditure	n	Mean (\$)	Standard Deviation
2004 waterfront construction budget	103	376,316	2,032,548
Cost of new construction over last five years	109	1,001,405	2,496,266
Annual disposal cost of construction waste	86	8,641	24,367
Annual marina repair cost	101	38,708	77,428
Annual marina replacement cost	86	131,386	313,037

Distribution Channels Used by Marina Owners/Operators

Information pertaining to the intermediary and distribution channels used by marina owners and operators to obtain waterfront construction materials for waterfront

structures was generated from a two-part survey question. First, participants were asked to indicate all intermediaries from whom they have made purchases from for waterfront components. This provided an estimate of the percent of surveyed marinas that have utilized each of the provided intermediaries for purchasing waterfront construction materials. Participants were also directed to indicate the percent of the total value of their waterfront-specific purchases made from each of the provided intermediaries. The percent of total marina construction material purchases generated is important information in analyzing the distribution structure by providing an indication of how heavily marinas rely on each intermediary.

The majority of marinas make purchases for waterfront construction materials from retailers, which accounted for approximately 32 percent of surveyed marinas' cost for waterfront construction materials. Drop shippers and direct purchases represented the other channels of distribution with significant dollar volume. The distribution channels used by participating marinas for waterfront construction materials are provided in Table 26. Respondents were also asked to provide the names and location of their top five vendors, on a volume basis, from which they have purchased materials for waterfront applications (Appendix 2).

Table 26. Distribution channels used by marina owners/operators to purchase construction materials.

Channel	Number of Respondents Using Intermediary	Percent of Respondents Using Intermediary	Mean Percent of Total Value of Waterfront Specific Purchases
Direct Purchases	21	19	24.2
Drop Shippers	5	4	32.0
Manufacturers Agents	37	33	0.1
Retailers	76	67	32.1
Truck Wholesalers	2	2	7.1
Wholesale Distributors	55	49	2.7
Other	9	8	1.8

Distribution channels were also assessed in terms of marina size (small marina's being defined as less than 300 wet slips; large marina's being defined as 300 or more wet slips) An independent sample t-test indicated that distribution channels did not differ significantly between large and small marinas at the alpha level of 0.05.

Respondents were asked to rate their level of agreement with the following statement:

Our suppliers are important to us because they are our partners in a long-term relationship.

This question was used to understand the importance of utilizing the same distribution channels used by traditional waterfront construction materials when introducing a new product to marina owners and operators. Sixty-three percent of respondents either agreed (43 percent) or strongly agreed (20 percent) with the statement, and thus may be less apt to deviate from the current supplier channels when purchasing waterfront construction materials. Only 16 percent of the respondents indicated disagreement with the statement, while 20 percent were neutral in their response. A one-sample t-test using a test value of "3" (neither agree nor disagree with statement) indicated that the mean level of agreement (3.6) was significantly greater than the neutral level of agreement at the alpha level of 0.05. Large marinas were found to have a greater level of agreement with this statement than small marinas when assessed with an independent sample t-test at the alpha level of 0.05.

Promotional and Advertising Effectiveness

A seven-point Likert-like rating scale was used to measure the perceived degree of effectiveness of promotional and advertising methods used to communicate the benefits of waterfront construction materials. Specifically, study participants were directed to rate the effectiveness of four basic elements of a communication or promotional strategy for communicating the benefits of products. A rating value of "1" indicated that the respondent perceived the communication tool as not effective at all. The upper

extreme, a rating value of “7,” indicated a communication tool perceived as extremely effective. The mid-point of the scale, a rating value of “4,” offered participants a neutral category indicating that the tool was considered neither effective nor ineffective. A one-sample t-test using a neutral value of “4” indicated that the mean ratings for all four promotional tools were significantly greater than the neutral value at the alpha level of 0.05. As with manufacturers of preservative treated wood and alternative products, marina owners and operators also perceive personal selling to be the most effective communication tool. Results from this question are shown in Table 27.

Table 27. Perceived effectiveness of promotional tools in communicating information about waterfront construction materials.

Promotional Tool	Perceived Effectiveness of Promotional Tool ^a		
	Mean ^b	Standard Deviation	n
Personal Selling	5.4*	1.7	103
Advertising	4.9*	1.4	103
Public Relations	4.4*	1.7	97
Sales Promotion	4.4*	1.6	100

^a Survey participants were asked to rate the perceived effectiveness of four tools in the promotional mix based on a Likert-like scale ranging from 1 = “Not Effective At All” to 7 = “Extremely Effective,” with a neutral value of 4 = “Neither Effective nor Ineffective.”

The mean effectiveness ratings provided by participating marina owners and operators, manufacturers of alternative products, and treated wood were analyzed using Scheffe’s multiple comparison of means test. Significant differences were found in the way these groups view the effectiveness of personal selling and advertising (Table 28).

Specifically, marina owners/operators were significantly less likely to rate personal selling and advertising as effective promotional tools relative to manufacturers of treated wood. Manufacturers of alternative products were found to perceive the effectiveness of personal selling and advertising similar to that of manufacturers of treated wood and marina owners/operators. No significant differences were found to exist between small and large firms in the perceived effectiveness of any of the four promotional tools when assessed with an independent sample t-test at the alpha level of 0.05.

Table 28. Comparison of the perceived effectiveness of promotional tools in communicating information about waterfront construction materials between manufacturers of alternative products, manufacturers of treated wood, and marina owners and operators.

Mean Perceived Effectiveness of Promotional Tools in Communicating Information About Waterfront Construction Materials^{a,b}			
Promotional Tool	Manufacturers of Alternative Products	Manufacturers of Treated Wood	Marina Owners And Operators
Personal Selling	6.3a,b	6.3a	5.4b
Public Relations	5.1	4.4	4.4
Advertising	4.1a,b	4.1a	4.9b
Sales Pomotions	3.6	3.9	4.4

^a Survey participants were asked to rate the perceived effectiveness of four tools in the promotional mix based on a Likert-like scale ranging from 1 = "Not Effective At All" to 7 = "Extremely Effective," with a neutral value of 4 = "Neither Effective nor Ineffective."

^b Comparison of means across subgroups (i.e., row data) is represented by lowercase alphabetic notations (Scheffe;s contrast test, 0.05 α -level). Subgroups with statistically identical means share the same letter; the lack of alphabetic notation indicates that the means were statistically similar across all subgroups.

Participants were also requested to indicate whether they have learned about waterfront construction materials through seven specific promotional tactics. The seven-point Likert-like scale was again used to rate the effectiveness of these tactics for communicating information about waterfront construction materials. A large percentage of marinas indicated that they learned about waterfront materials from attending trade shows (mean 5.9) and from product samples (mean 5.7), as shown in Table 29. With the exception of cross-selling, all the promotional tactics were rated significantly greater than the neutral value except cross selling when tested against a neutral value of 4.

Table 29. Effectiveness of specific promotional tactics for communicating information about waterfront construction materials.

Promotional Tactic	Mean ^{a,b}	Standard Deviation	n
Trade Shows	5.9*	1.2	104
Samples	5.7*	1.1	104
Demonstrations	5.5*	1.4	95
Websites	5.4*	1.5	94
Exhibits	5.3*	1.3	92
Point-of-Purchase Displays	4.5*	2.0	78
Cross-selling	4.4	1.8	74

^a Survey participants were asked to rate the perceived effectiveness of each promotional tactics with regard to learning about various materials that can be used for constructing waterfront structures. The rating scale ranged from 1 = "Not Effective At All" to 7 = "Extremely Effective," with a neutral value of 4 = "Neither Effective nor Ineffective."

^b Means with asterisks were significantly different than a neutral mean of 4 using an one sample independent t-test at the alpha level of 0.05.

The mean effectiveness ratings of promotional tactics between participating marina owners and operators, manufacturers of alternative products, and treated wood manufacturers were analyzed using Scheffe's multiple comparison of means. Statistical differences were found in the way these groups view the effectiveness of product samples, tradeshow, and websites (Table 30). Manufacturers of alternative products and marina owners/operators perceived that the promotional tactics of samples and websites were more effective than manufacturers of treated wood. In addition, marina owners/operators perceived that trade shows are more effective than manufacturers of alternative products and treated wood. In an independent sample t-test, small marinas (mean 5.1) were found to perceive exhibits more valuable for learning about waterfront construction materials than large marinas (mean 5.7) at the alpha level of 0.05.

Table 30. Comparison of the effectiveness of specific promotional tactics for communicating information about waterfront construction materials between manufacturers of alternative products, manufacturers of treated wood, and marina owners and operators.

Promotional Tactic	Mean Perceived Effectiveness of Promotional Tactics in Communicating Information About Waterfront Construction Materials ^{a,b}		
	Manufacturers of Alternative Products	Manufacturers of Treated Wood	Marina Owners And Operators
Cross-selling	6.0	5.0	4.4
Demonstrations	5.2	4.8	5.5
Exhibits	4.5	4.9	5.3
Point-of-Purchase Displays	5.5	5.3	4.5
Samples	5.6a	4.3b	5.7a
Tradeshows	5.0a	4.9a	5.9b
Website	6.1a	4.1b	5.4a

^a Survey participants were asked to rate the perceived effectiveness of four tools in the promotional mix based on a Likert-like scale ranging from 1 = "Not Effective At All" to 7 = "Extremely Effective," with a neutral value of 4 = "Neither Effective nor Ineffective."

^b Comparison of means across subgroups (i.e., row data) is represented by lowercase alphabetic notations (Scheffe;s contrast test, 0.05 α -level). Subgroups with statistically identical means share the same letter; the lack of alphabetic notation indicates that the means were statistically similar across all subgroups.

In addition, study participants were asked to provide the names and locations of any trade shows attended by their marina in 2003 or 2004. A complete list of trade shows generated from this survey can be found in Appendix 3.

Trade publications and magazines are the primary source of advertising used by 86 percent of participating marina owners and operators (Table 31). A seven-point Likert-like scale was again used to measure the perceived effectiveness of advertising method, and results are shown in Table 32. Trade publications/magazines were the only category rated significantly greater than the neutral value of 4 when utilizing a one sample t-test. A complete list of the trade publications and magazines provided by participants is available in Appendix IX. Billboards and television/radio were found to be significantly less than the neutral value of 4, thereby being ineffective as agents for information concerning waterfront construction materials in the marina owner/operator market. Other common types of advertising such as newspapers, press releases, television, and radio were rarely indicated by respondents as vehicles for learning

about products. Alternative forms of advertising provided by respondents included mailers and product catalogs.

Table 31. Advertising methods used by marinas to learn about waterfront construction materials.

Advertising Method	Number of Respondents Obtaining Information from Advertising Method	Percent of Respondents Obtaining Information from Advertising Method
Billboards	--	--
Newspapers	4	3
Press Releases	3	3
Television/Radio	--	--
Trade Publications/Magazines	101	86
Other	20	17

Table 32. Perceived effectiveness of advertising methods used by marinas to learn about waterfront construction materials.

Advertising Method	Mean^{a,b}	Standard Deviation	n
Trade Publications/Magazines	6.1*	1.1	108
Other	4.9	2.3	24
Press Releases	3.5	1.8	83
Newspapers	3.1	1.7	83
Billboards	2.5*	1.5	78
Television/Radio	2.3*	1.7	76

^a Survey participants were asked to rate how effective each of the following types of advertising were with regard to learning about various materials that can be used for constructing waterfront structures. The rating scale ranged from 1 = "Not Effective At All" to 7 = "Extremely Effective," with a neutral value of 4 = "Neither Effective nor Ineffective."

^b Means with asterisks were significantly different than a neutral mean of 4 using an one sample independent t-test at the alpha level of 0.05.

Waterfront Construction Material Purchase Behavior

Marina owners/operators were asked a series of questions to provide information that could be used to better understand their purchase behavior for materials used in waterfront construction. Respondents were provided with a list of waterfront components and asked to indicate those components that they had purchased in 2003,

as well as the type of material purchased (e.g., treated wood, concrete, WPC) for each. Survey participants were also asked to estimate the total expenditures for each component in 2003. Deck boards accounted for the vast majority of components purchased for waterfront construction by marinas, representing an expenditure of over \$22,000 in 2003 (Table 33). Note that respondents were allowed to list two “Other” components in the survey, as well as the expenditures that had been made on these components in 2003. The expense of components specified by respondents in the “Other” categories were higher than all of the provided components but were highly variable as indicated by the large standard deviations. Specified components provided by respondents in the “Other” category included steel frames, floatation systems, anchors, buoys, and various dock hardware.

Table 33. Waterfront construction components purchased by marina owners/operators in 2003.

Component^a	Number of Respondents Purchasing Component in 2003	Percent of Respondent Purchasing Component in 2003	Mean Total Expenditure for Component in 2003 (\$)	Standard Deviation of Total Expenditure for Component in 2003 (\$)
Bull Rails	16	13	4,100	4,613
Camels	1	1	–	–
Chocks	2	2	500	–
Deck Boards	100	84	22,273	62,957
Fender Piles	35	29	12,833	12,742
Spacer Blocks	8	7	10,050	14,071
Stringers	35	29	23,879	68,508
Wales	15	13	5,813	3,703
Other 1	29	24	33,890	76,943
Other 2	8	6	39,613	101,197

^a Respondents were allowed to list two “Other” components in the survey, as well as the expenditures that had been made on these components in 2003. These components included steel frames, floatation systems, and dock hardware, among others.

Table 34 represents the valid percent of marinas currently using a given material for various waterfront components. Treated wood accounted for the vast majority of

materials used for waterfront components. Seven marinas surveyed indicated that they are currently using a WPC product for deck board applications. Many respondents neglected to provide the materials used for their components in this question.

Table 34. Current use of construction materials in waterfront applications.

Material	Marinas Using Material in the Following Applications (Percent)					
	Bull Rails	Deck Boards	Fender Piles	Spacer Blocks	Stringers	Wales
Concrete	--	2	--	--	--	--
Exotic Hardwoods	--	2	--	--	--	--
Material Not Indicated	31	12	20	13	26	13
Multiple Materials	--	24	--	--	--	--
Plastic	13	1	6	--	--	--
Steel	--	11	6	--	11	--
Treated Wood	56	68	60	75	63	87
WPCs	--	7	--	--	--	--
Other	--	--	9	13	--	--

Respondents were asked to rate the importance of long term durability as a factor in their purchase decision for eight waterfront components. This information may be useful in identifying applications where the durability advantages of WPCs could provide a more desirable alternative to treated wood. A five-point Likert-like rating scale was used to measure the level of impact durability has in the purchase decision for waterfront components. A value rating of "1" indicated no impact at all. The maximum rating of "5" was used to identify components in which durability imposed a critical impact on their purchase decision. Of the provided components, durability was most important for the purchase of deck boards, stringers, and fender piles (Table 35). The "Other" categories gave respondents the opportunity to specify components not included in the question and were rated highest by 42 marinas. Some components specified by respondents included seawall, bulkheads, and steel frames. An independent sample t-test (alpha level of 0.05) indicated that small marinas (mean 4.4) considered the durability of stringers more important than large marinas (mean 3.8).

Table 35. Marina owner/operator perceived level of importance of durability as a factor in the purchase of waterfront construction components

Component ^a	Mean Effectiveness ^{a,b}	Standard Deviation	n
Deck Boards	4.4*	0.7	107
Stringers	4.3*	1.0	76
Fender Piles	4.2*	1.1	73
Wales	4.1*	1.2	59
Bull Rails	3.9*	1.3	60
Spacer Blocks	3.8*	1.3	58
Chocks	3.7*	1.3	53
Camels	3.6	1.5	52
Other 1	4.6*	0.8	14
Other 2	4.5*	0.8	28

^a Respondents were allowed to list two "Other" components in the survey. These components included seawalls, bulkheads, and steel frames, among others.

^b Means with asterisks were significantly different than a response of 3 (Moderate impact) using a one sample independent t-test at the alpha level of 0.05.

Interest in Utilizing WPCs for Waterfront Construction Applications

Three survey questions were used to understand participants' perceptions regarding the use of WPCs for waterfront construction applications. Respondents were asked to indicate how familiar they were with WPC materials for waterfront construction applications. The majority of respondents indicated that they were somewhat familiar (43 percent) or familiar (30 percent) with WPC for use in waterfront construction applications. Eight percent of the respondents were not familiar at all with WPCs for waterfront construction applications, and another 19 percent were extremely familiar with WPC use in waterfront construction applications.

Participants were also asked how they perceive their marina's interest in WPCs for waterfront applications. Forty-four percent of respondents indicated that their marina was interested in the use of WPCs in waterfront construction applications, and another 16 percent indicated extreme interest. Fifteen percent of the responding participants indicated that their firm would be somewhat interested in the use of WPCs, while 16 percent of the respondents were neutral toward WPC use. Nine percent of the respondents indicated no interest in using WPCs for waterfront construction applications. The five categories of interest were later assigned numerical values

ranging from one through five (“1” = not interested at all, “5” = extremely interested) in order to conduct a one sample t-test against the neutral value. When interpreted numerically, the mean interest value is 3.4 and is significantly greater than the neutral value of 3.

Respondents were asked to rate their perception of how receptive their marina would be to exploring the use of WPCs as a replacement for eight components traditionally utilizing preservative treated wood. The purpose of this question was to gain a better understanding of the components marina owners and operators would be most interested in a WPC substitute. A seven-point Likert-like scale was implemented using a rating value of “1” to indicate that the respondent felt that their marina would be not receptive at all to the WPC as a substitute and a rating value of “7” indicated an extreme degree of receptiveness for a WPC substitute. Deck boards were the only component rated significantly greater than the neutral value of “4” in a one-sample t-test. The mean receptiveness ratings for each component are shown in Table 36.

Table 36. Marina owner/operator receptiveness to exploring the use of WPCs as replacement for waterfront components traditional using treated wood.

Component^a	Mean Receptiveness Rating^{b,c}	Standard Deviation of Receptiveness	n
Deck Boards	5.5*	1.7	106
Bull Rails	4.2	2.3	68
Stringers	4.2	2.2	73
Fender Piles	3.9	2.2	67
Wales	3.8	2.4	65
Chocks	3.4	2.2	58
Spacer Blocks	3.4	2.3	58
Camels	3.0*	2.1	51
Other 1	3.9	2.8	17
Other 2	2.9*	2.7	12

^a Respondents were allowed to list two “Other” components in the survey. These components included seawalls, bulkheads, and steel frames, among others.

^b Survey participants were asked to rate how receptive their marina would be to exploring the use of wood-plastic composites as a replacement for various components that are traditionally constructed with treated wood using a scale ranging from 1 = “Not Receptive At All” to 7 = “Extremely Receptive,” with a neutral value of 4.

^c Means with asterisks were significantly different than a neutral mean of 4 using an one sample independent t-test at the alpha level of 0.05.

Interestingly, survey data indicates that small marinas may be more receptive than large marinas to exploring the use of WPCs. This is especially surprising since small marinas consider themselves as significantly less knowledgeable about WPCs, and perceived their marinas as less innovative than large marinas according to Bright and Smith (2002). The results of this study indicate that familiarity with WPCs for waterfront applications is essentially the same between large (mean 2.6) and small marinas (mean 2.6). Small marinas (mean 3.5) indicated a slightly higher degree of interest than large marinas (mean 3.3) in using WPCs for waterfront applications. An independent sample t-test indicates that the interest of small marinas for camels and spacer blocks is significantly greater than large marinas at the 0.05 alpha level (Table 37)

Table 37. Receptiveness of large small and large marinas to exploring the use of WPCs as replacement for treated wood in waterfront component applications.

Component ^a	Mean Receptiveness Rating by Small Marinas ^{a,b}	Mean Receptiveness Rating by Large Marinas	Significance (p-value)
Deck Boards	5.5	5.5	.88
Bull Rails	4.3	3.9	.61
Stringers	3.5	3.0	.48
Fender Piles	3.2	2.3	.17
Wales	3.6	2.7	.13
Chocks	4.0	3.5	.35
Spacer Blocks	4.1*	2.6	.02
Camels	4.5*	3.2	.05

^a Means with asterisks were significantly greater than the mean of large marinas in an independent sample t-test at the alpha level of 0.05.

^b Large marinas are defined as marinas with 300 or more wet slips, while small marinas possess fewer than 300 wet slips.

Constraints to WPC's in Waterfront Construction Applications

Participants were asked to rate the impact of nine potential constraints in effort to identify major areas of concern when using a WPC as a construction material for waterfront applications. A five-point Likert-like rating scale was used whereby a rating

value of “1” indicated a potential constraint having no impact at all. A rating value of “3” indicated a constraint possessing moderate impact, while the maximum rating of “5” indicated a potential constraint capable of a critical impact on the use of WPCs for waterfront applications. The “Other Potential Constraints” category was given the highest mean rating; however, it was utilized by only 13 respondents. All of the pre-listed constraints, except weight of WPCs, were found to be significantly greater than a rating value of “3,” which represented a constraint of moderate impact. The mean rating for each potential constraint is shown in Table 38.

Table 38. Marina owner/operator perceived impact of potential constraints in using WPCs in waterfront construction applications.

Potential Constraint ^a	Mean ^{b,c}	Standard Deviation	n
Cost of WPCs	4.3*	0.8	101
Cost of Raw Materials	4.0*	1.3	93
UV Exposure	4.0*	1.2	100
Availability of WPCs	3.9*	1.4	87
Fastening Capabilities	3.8*	1.3	99
Material Properties	3.7*	1.1	100
Construction and/or Installation Difficulties	3.6*	1.4	102
Delivery Costs	3.5*	1.5	98
Weight of Material	3.4	1.5	98
Other Potential Constraints	4.5*	1.5	13

^a Respondents were allowed to list one “Other” component in the survey.

^b Survey participants were asked to rate several pre-listed constraints of wood-plastic composites as a construction material for waterfront applications using a scale ranging from 1 = “No Impact At All” to 5 = “Critical Impact,” with a central value of 3 = “Moderate Impact.”

^c Means with asterisks were significantly different than a response of 3 (Moderate Impact) using an one sample independent t-test at the alpha level of 0.05.

Exposure to UV radiation was rated as having a strong impact on the decision to use a WPC for waterfront applications, second to only to cost. This result shows a clear disconnect of communication between potential users of WPCs for waterfront applications and the manufacturers of alternative products who rated exposure to ultraviolet radiation the lowest of all provided potential constraints.

A similar open-ended question asked respondents to provide their four greatest concerns in ranked order regarding the use of WPC products as a replacement for applications where treated wood has traditionally been used. This question gave participants an opportunity to relate their concerns and perceived constraints of WPCs that were not available in previous survey questions. Two major areas of concern that had not been considered in the previous questions became apparent in the responses. Participants frequently mentioned the slipperiness of wet WPCs and the resulting safety issues. A second reoccurring issue involved the potential dangers of using a material perceived to be prone to static electricity, such as WPCs, adjacent to flammable material when used for constructing fueling docks. The complete compilation of answers resulting from this question can be found in Appendix 4. The final survey question provided participants with an opportunity to relate any comments or suggestion with regard to the use of WPCs in waterfront applications. Nearly one-half of all respondents used this question to provide additional insight for the study. This information is provided in Appendix 5.

CONCLUSIONS

It was hypothesized that the use of distribution channels and promotional strategies would differ among small marinas and large marinas. In particular, past research has shown that participants from large marinas were significantly more knowledgeable about WPCs and consider themselves to be more innovative relative to participants from small marinas (Bright and Smith 2002). Large marina owners were also more likely to operate floating dock systems as opposed to fixed marine structures. Such innovative marina owners and operators may provide an ideal segment to target in the initial marketing strategy of WPCs for the intended applications. This study found that the difference in distribution and promotional aspects between large and small marinas was minimal. Surprisingly, statistical analysis revealed that a difference existed in the way that WPCs are perceived by large and small marinas. Specifically, small marinas in fact have a greater degree of interest in the use of WPCs for waterfront applications than do larger marinas. Smaller marinas also rated their interest in all eight waterfront components higher than large marinas. Thus, small marinas may represent an important user group to target new innovative marine products toward despite previous research that indicates their lack of innovativeness. It was also hypothesized that promotional methods may differ among each of the participating survey groups. Statistical analysis indicates that the effectiveness perceived by survey groups differs for several promotional tools (advertising, public relations, personal selling, and sales promotion) as well as among specific promotional tactics. Providers of waterfront materials may more effectively allocate promotional budgets to promotional activities that are rated most effective by marina owners and operators.

The distribution channels used by manufacturers of alternative products and treated wood differ primarily in their dependence on retailers and manufacturer representatives. Although direct purchases accounted for the majority of the distribution structure for both groups of manufacturers, only 25 percent of manufacturers of

alternative products distribute their products through retailers in comparison to nearly one-half of the treated wood manufacturers. Manufacturers of alternative materials supplement this difference by the use of wholesalers and manufacturer agents and representatives. The use of multiple distribution channels by both groups of manufacturers may be required to distribute the various products produced by a given firm. This study, however, did not examine the distribution structure of these industries on a product basis due to the difficulty of attaining such detailed information given time and cost constraints.

The survey of marina owners and operators provided a more definitive profile of the distribution structure of waterfront construction materials. The survey results reaffirmed the results found in the treated wood and alternative products surveys concerning the importance of retail and wholesale intermediaries. The presence of direct purchasing by marina owners and operators (only 19 percent of respondents) was less apparent than expected given that 67 percent of treated wood manufacturers indicated that direct purchases accounted for the distribution of 67 percent of the total volume of waterfront materials they produce. Although less than 20 percent of marina owners and operators indicated making direct purchases, they did account for an average of nearly 24 percent of total waterfront-specific purchases (Table 26). This suggests that there is a large volume of material produced by treated wood manufacturers that is sold directly to consumers, and also that a small number of marina owners and operators make purchases directly from manufacturers at a significant expense. It is plausible that these direct purchase transactions are for the sale of large dimension products such as pilings, which cannot be easily distributed through a retail and wholesale intermediary due to size handling difficulties and the infrequent demand for these specific products.

The data collected through the interviews with manufacturers of preservative treated wood showed that the promotion of their products is minimal in comparison to providers of alternative plastic-based materials. Promotional activities were found to be utilized by approximately 60 percent of the firms interviewed and were generally

limited to a small number of industry trade shows and industry trade journal advertisements. The necessity of an extensive promotional program may not be essential because of the long established role of treated wood in the forest products industry. In contrast, according to results from the marina owner/operator survey, 51 percent of respondents are only "somewhat familiar" with WPC materials, thus demonstrating the importance of raising the level of awareness within this market, as well as the necessity of an effective communication strategy. Marina owners/operators provided a substantial amount of information regarding the trade shows and print media where they frequently learn about waterfront construction materials. The importance of products samples as well as the advantages of experiencing a new WPC construction material first hand through demonstrations was repeatedly stressed throughout the telephone interviews. An effective communication strategy could be realized through the blending of these promotional elements.

The information generated in this study suggests some positive degree of interest in the use of WPCs as a waterfront construction material by current manufacturers of alternative products and participants in the marina owner and operator survey. More than two-thirds of the alternative products manufacturers interviewed indicated intentions of developing products for waterfront applications within the next five to ten years. Seventy-five percent of surveyed marina owners and operators indicated that their marina is at least somewhat interested in the use of WPCs for waterfront applications. As indicated in a separate survey question, this interest currently appears to be limited to deck boards. Although respondents indicated mean interest rating greater than the neutral value for several components, they were not found to be statistically significant from the neutral value.

The overall lack of knowledge about WPCs and, more specifically, the challenge of communicating the cost savings potential of products that require a large initial investment were major concerns conveyed by manufacturers of alternative products in this study. Other concerns of manufacturers of alternative products regarding the

waterfront materials market included the high cost of WPCs in comparison to treated wood and the difficulty of attracting traditionally non-innovative building contractors to adopt WPCs for novel waterfront applications. The results of this study also suggest that manufacturers of alternative products would likely need to utilize a retail intermediary to provide products to the marina market. This is supported by the 67 percent of marina owners and operators who indicated that they purchased, on average, 32 percent of the total value of waterfront specific purchases from retailers. Additionally, 63 percent of survey respondents indicated that they value their suppliers because they have established long-term relationships.

The large initial investment often associated with WPCs was a major concern of surveyed marina owners and operators. Other perceived barriers were largely product related disadvantages of WPCs. In three separate survey questions, respondents repeatedly acknowledged the color degradation of WPC products due to exposure to UV radiation which could result in color mismatches. Other concerns included safety issues with regard to the slipperiness of WPCs when wet and the lack of availability of adequate dimensions of WPCs, specifically nominal 2 x 8s and 2 x 10s.

Presently, there are still many unknown factors that render a conclusive prediction as to the ultimate success or failure of WPCs in the waterfront construction materials market. Two vital issues are the unknown product cost of a WPC adequate for waterfront applications and product life expectancy in harsh marine environments. Without this information, it is difficult to ascertain the key material and labor cost saving potential of WPCs. If the initial expenditure can be justified, there are many other factors that could affect the success of WPCs as a waterfront construction material. The population of marine boring organisms, the availability of CCA treated wood, and the cost of substitute products are all variables that could affect the demand for an alternative building material for waterfront construction. Lastly, the ability of technological advancements to overcome the barriers identified in this study will undoubtedly be a critical factor in WPCs future role in this market.

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**APPENDIX I – NEW MARINA RELATED CONSTRUCTION ACTIVITIES OF
SURVEYED MARINA OWNERS AND OPERATORS EXPECTED IN THE NEXT 5 YEARS**

Type of Construction Activity	Number of Marinas Participating in Activity
Boat Slips	25
Bulkheads	6
Docks	34
Floatation	5
Maintenance/Repairs	9
New Structures	10
Piling	5
Re-decking	6
Wake Break/Seawall	3
Other Construction	7

**APPENDIX II – WATERFRONT CONSTRUCTION MATERIAL VENDORS PROVIDED
BY MARINA OWNERS AND OPERATORS**

Name	Location
Advantage Docks	Knoxville, Tennessee
Apaliechea Piling	Florida
Atlantic Industries	North Carolina
Atlantic-Mecco	McAlester, Oklahoma
Atlantic-Mecco	Oklahoma
Atlantic-Mecco	Ardmore, Oklahoma
Atlantic Rod	Atlanta, Georgia
Aviston Lumber	Carlyle, Illinois
BB&S Lumber	North Kingston, Rhode Island
BB&S Lumber	Richmond, Rhode Island
Bellingham Marine	Bellingham, Washington
Bellingham Marine	Jacksonville, Florida
Big Buck Lumber	Racine, Wisconsin
BK Marine	Deerfield, Florida
Boat US	Cleveland, Ohio
Calumet Lumber	Chicago, Illinois
Cambridge Lee Industries	Stone Mountain, Georgia
Canadian Rolling Mills	Southgate, Michigan
Carolina Water Works	South Carolina
Corrugated Industries	Tampa, Florida
Crystal Marine	McAlester, Oklahoma
Custom Steel and Wood	Anderson, South Carolina
Diversified Products	Los Angeles, California
Dixie Concrete	Larollette, Tennessee; Morristown, Tennessee
Dock Boxes Unlimited	Irving, Texas
Dock Hardware	–
Eagle Docks	Maynardville, Tennessee
Ellett Brothers	South Carolina
Falbo's Concrete	Lorain, Ohio
Floatation Dock MPG	-
Floating Dock	Indianapolis, Indiana
Formex	-
Formex Encaced	GA
Fourshee	Cadiz KY
Fox Marine	Los Angeles, California
Foxworth Galbraith	Torc, New Mexico
Galva Foam	--

Name	Location
GalvaFoam	Missouri
GalvaFoam	Camdenton, Missouri
Golden State Lumber	San Rafael, California
Gwenmor	Mystic, Connecticut
Henderson Marine	Richmond, California
Holbort Steel	Little Rock, Arkansas
Home Depot	Albuquerque, New Mexico
Home Depot	Atascadero, California
Home Depot	Austin, Texas
Home Depot	Chattanooga, Tennessee
Home Depot	Dallas, Texas
Home Depot	Ft. Worth, Texas
Home Depot	Key West, Florida
Home Depot	Knoxville, Tennessee
Home Depot	Las Cruces, New Mexico
Home Depot	Little Rock, Arkansas
Home Depot	Naples Florida
Home Depot	Quincy, Massachusetts
Home Depot	San Rafael, California
Home Depot	Sherman, Texas
Home Depot	Texas
Home Depot	Waukegan, Illinois
Hydro Hoist of Tennessee	Baxter, Tennessee
Hydrohoist	Clarkemont, Oklahoma
Hypower	McAlester, Oklahoma
J & I Manufacturing	Madill, Oklahoma
J.B. Harrison	Gallatin, Tennessee
Kellogg Marine	Old Lyme, Connecticut
Kemah Hardware	Kemah, Texas
Kent Fab Engineering	Norwell, Massachusetts
Lakeland	Arkansas
Lakeside Docks	Winchester, Tennessee
Lakeway Concrete	Abingdon, Virginia
Lewis Marine	–
Local Lumber Yard	–
Long Life Treated Wood	Salsbury, Maryland
Lowes	–
Lowes	Atlanta, Georgia
Lowes	Ft. Worth, Texas
Lowes	Hermitage, Tennessee
Lowes	Knoxville, Tennessee

Name	Location
Lowes	Sherman, Texas
Lumber Yard	Sanger, Texas
Lumberman's	Tacoma, Washington
M and G Industries	Rockland, Massachusetts
Marine Lumber	New Jersey
Marine Lumber Piling	Barnegat, New Jersey
Marine Lumber Supply	Naples, Florida
Martin Piling	New Jersey
Material International	Atlanta, Georgia
Mecco Marine	North Carolina
Mecco Industries	Oklahoma
Mecco Marine	Richmond, California
Menards	Eau Clair, Wisconsin
Merco Marine	West Virginia
Meredith and Sons	Pensacola, Florida
Metal Sales, Inc.	Gainesville, Texas
Moaley DeBour Lumber	Key West, Florida
Myricle Marine	Savannah, Georgia
Oman Lumber	Long Beach, Washington
One Stop Building Supply	Newport, Rhode Island
Ozark Boat Docks	Mountain Home, Arkansas
Poralu Dumarin	Quebec, Canada
Port Lumber	Riverhead, New York
Port Supply	Jacksonville, Florida
Premier ACE	Minnesota
Riverhead Supply	Riverhead, New York
Rock Hall Lumber	Rock Hall, Maryland
Rusko Docks	Sweden
San Lumber	Wilmington, California
Shoreline Dow	Texas
Sound Marine	Wilmington, North Carolina
Storemaster	—
Sullivan Flootation	Warwick, New York
Sullivan Flootation	New York
Swift Lumber	Orange Beach, Alabama
Swift Slip	Newport Beach, California
Swinnie Supply	Andrews, South Carolina
Thermal Industries	Pittsburgh, Pennsylvania
Triple S Steel	Knoxville, Tennessee
Tripp Marine	Westport, Massachusetts
Tuckerton Lumber	Surf City, New Jersey

Name	Location
Utility Supply	New Jersey
Walcoal	--
Waterway Marine	Statesville, North Carolina
Welder Supply	Massachusetts
West Marine	Port Clinton, Ohio
Wood Preservers	Warsaw, Virginia
Wood Treaters	Jacksonville, Florida

APPENDIX III – TRADE SHOWS ATTENDED BY SURVEYED MARINA OWNERS AND OPERATORS

Name	Location	Number of Respondents
ABBMA	-	1
AC Boat Show	Atlantic City, New Jersey	2
ARVC	Las Vegas, Nevada	1
Austin Boat Show	Austin, Texas	1
Boat Show	Seattle, Washington	1
Boatyard and Marina Conference	Ft. Lauderdale, Florida	1
California Harbormasters	California	1
Canton Sport Show	Canton, Ohio	1
Charleston Boat Show	Charleston, South Carolina	1
Charleston-in-Water	Charleston, South Carolina	1
Cleveland Boat Show	Cleveland, Ohio	1
CNY Boat Show	Syracuse, New York	1
Dallas Boat Show	Dallas, Texas	4
Diversified	Las Vegas, Nevada	1
Everett Boats	Everett, Washington	1
Fox Marine	Palm Springs, California	1
Ft Lauderdale Boat Show	Ft. Lauderdale, Florida	5
Ft. Worth Home and Garden	Ft. Worth, Texas	2
Goodyear Sport Show	Akron, Ohio	1
IBEX	Ft. Lauderdale, Florida	2
IBEX	Miami, Florida	4
IMA	-	1
IMI	Ft. Lauderdale Florida	6
IMTEC		1
International Marina Conference	Ft. Lauderdale, Florida	2
Kellogg Show	Ledyard, Connecticut	3
KMA	Bowling Green, Kentucky	2
Knoxville Boat Show	Knoxville, Tennessee	1
KTA	Bowling Green, Kentucky	1
Kentucky Marina Association	Bowling Green, Kentucky	2
Kentucky-Tennessee Marina Operator Association	Bowling Green, Kentucky	2
Kentucky-Tennessee Marina Operator Association	Nashville, Tennessee	1
Louisville Boat Show	Louisville, Kentucky	3
Marina and Boat Yard Conference	Ft. Lauderdale, Florida	1
Marina Association of Texas	San Antonio, Texas	4
Marina Recreation Association	California	1
Mesco, Marine Equipment and Supply Company	New Jersey	1
Miami Boat Show	Miami, Florida	10
Mid America Boat Show	Cedar Point, Ohio	2
MOAA Trade Show	Ft. Lauderdale, Florida	7
MRA Conference		2

Name	Location	Number of Respondents
Nashville Boat Show	Nashville, Tennessee	1
National Marina Boat Yard Conference	Ft. Lauderdale, Florida	5
New England Boat Shows	Boston, Massachusetts	1
Newport International Boat Show	Miami, Florida	1
NMMA	-	1
New York MTA	New York, New York	1
Pacific Coast Harbormasters	Alaska, California, Oregon, and Washington	3
Savannah Boat Show	Savannah, Georgia	1
South Carolina Boat Show	Columbia, south Carolina	1
South Carolina Marine Association	Charleston, South Carolina	1
Sea Food Trade Show	Boston, Massachusetts	1
SHAPC, San Francisco	California	1
Southern CG	Cherokee, North Carolina	2
St Pete Show	Tampa, Florida	1
St. Louis AMMA Show	St Louis, Missouri	1
Strictly Sail	Chicago, Illinois	1
Tennessee Marina Association	Nashville, Tennessee	13
Texas Marine Association	Texas	1
TMA	Bowling Green, Kentucky	3
TNARVC	Nashville, Tennessee	1
Tri-City Boat Show	Kingsport, Tennessee	1
University of Wisconsin	Madison, Wisconsin	1
Work Boat Show	New Orleans, Louisiana	1

APPENDIX IV – MAJOR CONCERNS REGARDING THE USE OF WPC AS A REPLACEMENT FOR TREATED WOOD OF MARINA OWNERS AND OPERATORS

- Ability to fasten
- Ability to hold shape
- Ability to work with it
- Aesthetics of composites versus wood
- All testing that has been done shows problems
- Appearance
- Availability
- Chafing/abrasion resistance
- Construction installation difficulties
- Construction methods
- Cost
- Cost is #1, about 3 x the cost of wood
- Cost must come down to acceptable levels
- Cost of installation
- Cost of material
- Cost of products
- Cost prohibitive
- Cost relative to lumber
- Cost too high
- Dimensional stability
- Does it break down?
- Durability
- Ease of installation
- Ease to cut
- Expense of product
- Heat, too hot to walk on
- High cost of labor/installation
- High cost of material
- How it will wear in 3 to 4 years, and look
- How long does it last
- If manufacturer would stand behind product, I would take risk
- Installation process
- Life
- Life of product
- Life span
- Lifecycle cost
- Long term endurance issues
- Longevity
- Looks

- Mainly would use the WPC when bugs in water would eat normal pressure treated wood
- Material Cost
- Material Longevity
- Need more stringers in current construction in order to use deck boards
- No history on how long product will last (how many years)
- Not compatible with our construction
- Not sure of the strength of WPC
- Not tested enough
- Piling driven 70 to 90 feet long required
- Poor structural integrity
- Price
- Promotion
- Safety (walking on surface when wet)
- Sagging between stringers
- Save trees, environmentally friendly
- Slip and fall
- Slippage, slickness when wet
- Slippery
- Splintering
- Strength
- Strength (too weak)
- Strength of material
- Strength of material for pilings and walers from boat impact
- Structural integrity - must be supported at smaller distance than wood or it sags
- The warranty on plastic not good - (same as wood but cost different)
- Too saggy, needs to be stronger
- Total cost of ownership
- Unavailability of products
- Unproven
- UV exposure
- Weight

APPENDIX V – OTHER COMMENTS AND SUGGESTION RECEIVED FROM PARTICIPANTS OF THE MARINA OWNER AND OPERATOR SURVEY

- 12 years should be the life of product, 24-7 puts a lot of strain on
- All new construction in last 10 years has been of galvanized steel frame and roof with 2x6 and 2x8 treated yellow pine decking
- Also, can you paint it?
- Bracing must be close together
- Cost
- Dark ones get extremely hot in sun
- Does not have to match cost but 3-4 times cost of material will make use of WPCs prohibitive to use
- Facts regarding lifespan vs wood or other materials common to application
- Foam small docks and swim floats
- Good product. The problems are associated with installation
- Great concept but cost is prohibitive
- Great idea
- Have seen it all around the country and am intrigued with its many advantages
- I have seen at many marina
- I think it looks good
- I think they are a great improvement and I would like to see lower costs along with stronger boards so that they would be compatible with switching out for traditional lumber- especially dock decking.
- I think WPCs will be the way to go: softer then concrete- cosmetically, easier to use in construction, longer lifespan
- If cost is equal or below pressure treated wood and construction/installation are equal I will use when available
- If you can afford to use it, it's great
- In our area, planking goes for \$6 per lineal foot
- Installers (contractors) seem more comfortable recommending traditional wood materials because that's what they know and don't want to take a risk
- Integrity on 24 inch center support
- Keep them light in color
- Less (no) splintering
- Lower cost will attract more interest in the material
- Lower the cost more would use it
- Moisture content to high with wood fiber as content
- Most I've seen have been very slippery
- Need to lower cost compared to treated wood
- Needs to be less heat absorbent
- No skid surfaces
- None too interested

- Not in cold or ice water
- On parts of dock it is used on now, it by far out lasts/out performs all other products bar none
- Our interest is in preserving the character of an old fishing village, wood has been traditionally used
- Our Trex decking has worked well so far
- Prices must come down
- Sells better if you can see it in use
- Some early materials are not holding up, but they are improving
- Spend time explaining the specific requirements for correct installation
- Static electricity-electrical shock-sparks in hot humid interactions NM, TX, AZ, NV, ect.
- Tax breaks for using
- The material may replace wood components however we use concrete and steel which is stronger and lasts longer than either
- The products we have, have been hit by 6 hurricanes in 5 years with no damage to docks
- There is very little product info. We need more info on technical and install info on these products
- Tough to get definitive, good info on whether it is applicable to #23 above
- Very pleased with 30 year old metal docks and roof, not interested in changing
- Very slippery at low temperatures, even with rough surface
- Want it to work
- Weight is an issue
- Where are installed sites?
- Wider board availability, i.e. 2x8, 2x10
- With the current situation on CCA treated wood (EPA) now is the time to get into the market
- Would want to talk to and visit other marinas with this type of material in use

APPENDIX VI – SUMMARY OF PARTICIPATING MANUFACTURERS OF ALTERNATIVE PRODUCTS

- Aeolian Enterprises, PO Box 888 Latrobe, Pennsylvania 15650-0888; 800-269-4672
- AERT, PO Box 1237, Springdale, Arkansas 72765 ; 800-951-5117
- Aloha Plastic Manufacturing, PO Box 1429, Puunene, Hawaii 96784; 808-877-0822
- American Ecoboard, 200 Finn Court, Farmingdale, New York 11735; 632-753-5151
- American Recycled Plastic Inc., 1500 Main Street, Palm Bay, Florida 32905; 321-674-1525
- Bedford Technology LLC, 2424 Armour Road, PO Box 609, Worthington, Minnesota 56187-0609; 800-721-9037
- Certain Teed Corporation, 750 East Swedesford Road, Valley Forge, Pennsylvania 19482; 800-782-8777
- Correct Building Products, 15 Morin Street, Biddeford, Maine 04005; 888-290-1235
- Crane Materials International, 4501 Circle 75 Parkway, Suite E-5370, Atlanta, Georgia 30339; 800-256-8857
- Digger Specialties Inc., PO Box 241, Bremen, Indiana 46506; 800-446-7659
- Engineered Plastic Systems, 740 B Industrial Drive, Cary, Illinois 60013; 847-462-9001
- Everx Extruded Wood Products Universal; 616-364-6161
- Fiber Composites, LLC, 181 Random Drive, New London, North Carolina 28127; 704-463-7120
- J-Mac Lumber Inc., 4154 Faust Street, Bamberg, South Carolina 29003; 803-245-1700
- Kenaf Industries of South Texas, Route 2, #50 Kenaf Road, Raymondville, Texas 78580; 956-642-3395
- Kroy Building Products, 2719 North Division Ave, York, Nebraska 68467; 800-933-5769
- L.B. Plastics, 150 Hwy, Mooresville, North Carolina 28115; 800-752-7739
- Louisiana-Pacific Corp., 10115 Kinsey Avenue, Suite 150, Huntersville, North Carolina 28078; 704-632-4775
- Nebraska Plastics, PO Box 45, Cozad, Nebraska 69130; 800-445-2887
- Ocean Pearl Trading Co., 3772 Harton Road, Virginia Beach, Virginia 23452; 757-486-4241
- Outwater Plastics, 4 Passaic Street, Wood-Ridge, New Jersey 07075; 888-688-9283
- Plastic Lumber, 115 West Bartges Street, Akron, Ohio 44311-1034; 800-886-8990

- Plastic Pilings, Inc., 1485 South, Willow Rialto, California 92376; 909-874-4080
- Plastic Recycling of Iowa Falls, 10252 Highway 65, Iowa Falls, Iowa 50126; 800-338-1438
- Poly-Wood Inc., PO Box 636, York, Nebraska 68467; 219-457-3284
- Recycled Plastic Man, Inc., PO Box 2248, Englewood, Florida 34295; 800-253-7742
- Recycled Plastic Products Inc., 1630 W. Evans Avenue, Unit L, Englewood, Colorado 80110; 303-975-0033
- Rumber Materials, Inc., 3420 Executive Center Drive, Austin, Texas 78731; 512-794-8473
- Tek-Rail, 473 Dividend Drive, Peachtree City, Georgia 30215 ; 800-983-5724
- Tendura, 220 South Brundidge Street, Troy, Alabama 36081; 757-546-7414
- Thermal Industries, 301 Brushton Avenue, Pittsburgh, Pennsylvania 15221; 800-245-1540
- Timbertech, 849 Prairie Road, Wilmington, Ohio 45177; 800-307-7780
- U.S. Plastics, 1390 Neubrecht Road, Lima, Ohio 45801-3196; 866-272-8775

APPENDIX VII – SUMMARY OF PARTICIPATING MANUFACTURERS OF PRESERVATIVE TREATED WOOD PRODUCTS

- Acme Wood Preserving, PO Box 1717, Princeton, West Virginia 24740; 304-425-8769
- All Weather Wood Treaters, PO Box 227, 725 South 32nd Street, Washougal, Washington 98671; 800-759-5909
- Amelia Lumber, 16951 Leidig Street, Amelia, Virginia 23002; 800-989-2155
- Atlantic Wood Industries, Inc., PO Box 1608, Savana, Georgia 31498; 912-964-1234
- BB & S Treated Lumber of New England, PO Box 982, Devil's Foot Road, North Kingstown, Rhode Island 02852; 800-322-4006
- Cahaba Pressure Treated Forest Products, Route 1, Box 65-A, Brierfield, Alabama 35035; 205-926-9888
- Cal Coast Wholesale Lumber, PO Box 673, Ukiah, California 95482; 707-468-0141
- Camrin Company PSR Company, PO Box 3423, Kirkland, Washington 98034; 206-932-0445
- Cox Industries, Augusta Wood Preserving, 115 Laney-Walker Boulevard Extension, PO Box 2425, Augusta, Georgia 30903-2425; 706-724-7634
- Curt Bean Lumber Company, PO Box 200, Glenwood, Arkansas 71943; 870-356-4165
- Exterior Wood, Inc., PO Box 206, Washougal, Washington 98671; 260-835-8561
- General Wood Preserving, Inc. PO Box 370, Leland, North Carolina 28451; 910-371-3131
- International Paper Company, PO Box 809024, Dallas, Texas 75380; 713-413-4700
- J.H. Baxter & Company, PO Box 5902, San Mateo, California 94402-0902; 650-349-0201
- Kerr-McGee Chemical Corp., PO Box 25861, Oklahoma City, Oklahoma 73125; 405-270-2426
- Koppers Industries, Inc., PO Box 15490, North Little Rock, Arkansas 72231; 501-945-4581
- Langdale Forest Products Company, PO Box 328, Sweetwater, Tennessee 37874; 423-337-6105
- Long Life Treated Wood, PO Box 340, Hebron, Maryland 21830; 800-451-3137
- Lufkin Creosoting Co., Inc., PO Box 1207, Lufkin, Texas 75901; 936-634-4552
- Maine Wood Treaters, Inc., Walker Road, Mechanic Falls, Maine 04256; 207-345-8411
- Midwest Wood treating, 4832-T Plank Road, PO Box 610, Norwalk, Ohio 44857-0809; 419-668-9112

- Northeast Treaters, 796 Schokarie Turnpike, Athens, New York 12015; 518-945-2660
- Pacific Wood Treating Corp., PO Box 40698, Bakersfield, California 93384-0698; 520-466-7801
- Page and Hill Forest Products, Inc., PO Box 7, Big Falls, Minnesota 56627; 218-276-2251
- Permapost Company, 4066 Southeast Tualatin Valley Highway, PO Box 100, Hillsboro, Oregon 97123; 503-648-4156
- Phillips Building Supply of Gulfport, Inc., 9185 Highway 49, Gulfport, Mississippi 39505; 228-868-1101
- Robbins Manufacturing Company, 3250 Metro Parkway, Ft. Myers, Florida 33916; 941-334-2219
- Southern Lumber and Treating, PO Box 7450, Jacksonville, Florida 32238; 904-781-0604
- Thunderbolt Wood Treating, 3400 Patterson Road, PO Box 890, Riverbank, California 95367; 209-869-4561
- Webster Wood Preserving Company, PO Box 297, Bangor, Wisconsin 54614; 608-486-2341

**APPENDIX VIII – WATERFRONT CONSTRUCTION MATERIAL VENDORS
PROVIDED BY MANUFACTURERS OF PRESERVATIVE TREATED WOOD**

Company Name	Location
Alan Forest Products	Oregon
American Marine	Honolulu, Hawaii
B.C. Wood Products	Virginia
Buoy Forest Products	Richmond, Virginia
Channel Wood Products	Bay Area, California
Cyclone	Tahiti
Dock and Deck	North Carolina
Dunn Lumber	Washington
GE supply	Honolulu, Hawaii
Gemini Forest Products	California
Gleisle Lumber	Fort Myers, Florida
Great N. Poles and Piling	New Hampshire
H&W Distributors	Pompano Beach, Florida
Handcock Lumber	Catskill, New York
Lacrip Wood Products	Lacrip, California
Lumbermans	Washington
M&M Supply	Tracy, California
Marine Lumber	Seattle, Washington
Marine Products	Naples, Florida
Mathew Lumber	Seattle, Washington
Meredith Miller	–
Nor Pack	Portland, Oregon
Parr Lumber	Portland, Oregon
Phoenix Enterprise	Fresno, California
Pile Brothers Lumber	Maine
Porters	Missouri
Southland Floatation	–
Sullivan Floatation	Warwick, New York
Sullivan and Mann	Anaheim, California
Thomason Lumber	Philadelphia, Mississippi
Transit Lumber	Virginia
Treated Forest Products	Santa Ana, California
Voorhees Wood	Eugene, Oregon
Voorhees Wood Products	Oregon

**APPENDIX IX– TRADE PUBLICATIONS SUBSCRIBED TO AND/OR READ BY
SURVEYED MAINA OWNERS AND OPERATORS**

Publication	Number of Surveyed Marina Owners and Operators Reading and/or subscribing to Publication
Marina Dock Age	16
Soundings	13
Trade Only	9
Boating Industry	4
Marina	4
Boat Trade Magazine	3
Marine Operators Association	3
Boat US	2
Boats and Harbors	2
Maritime Reporter	2
House Boat	1
Lemta	1
Marine Business Today	1
Marina Docks	1
Marina Management	1
Marina News	1
Marine Business Journal	1
Marine Hog	1
Motor Dealer	1