# The Use of Recycled Plastic For Bin Boards in Fishing Vessels





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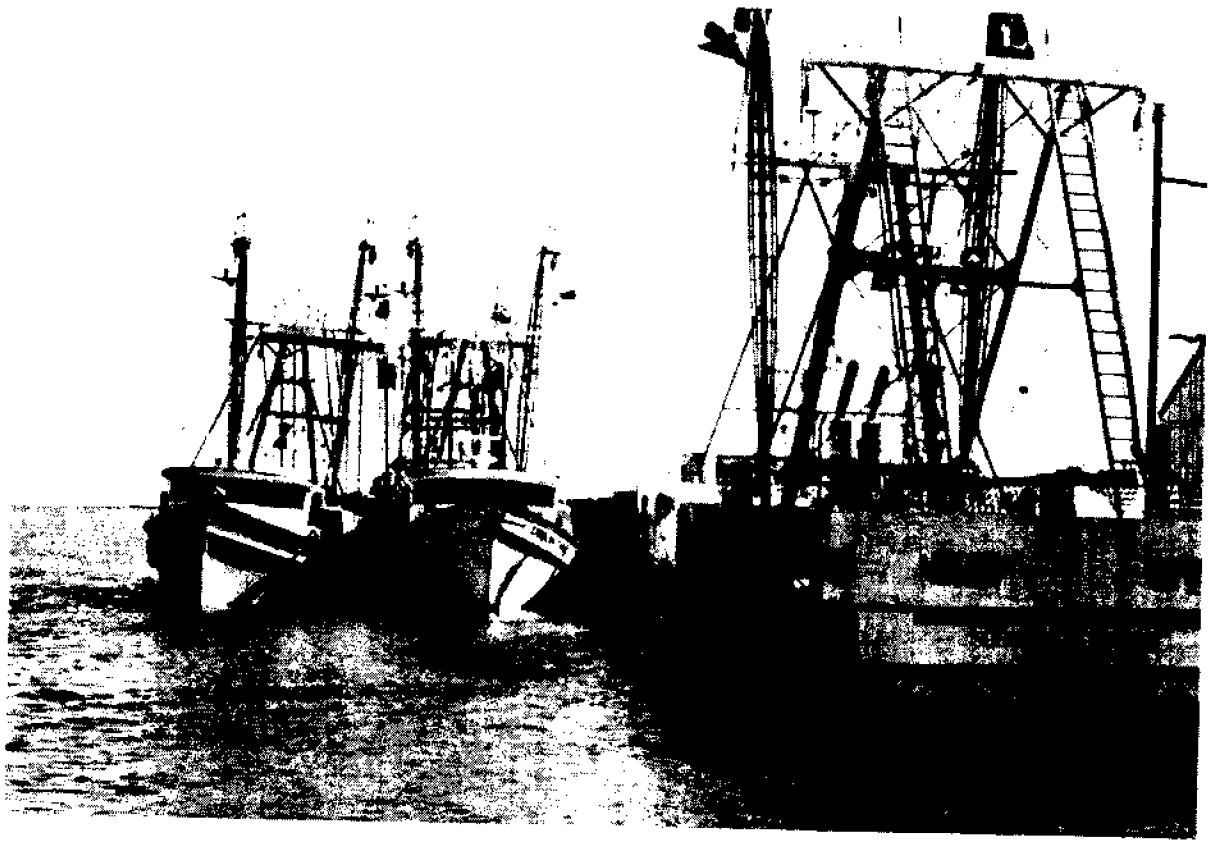

Virginia Sea Grant Marine Advisory No. 47
College of William and Mary
School of Marine Science
Virginia Institute of Marine Science

October 1993

# Introduction

Bin boards and bin shelving are used to contain and support ice-stowed fish and shellfish in the ice holds of fishing vessels. Traditionally, yellow pine or spruce construction lumber has been used. However, alternative materials are being sought to help reduce problems associated with product contamination by these supporting structures. Ideally, the boards and shelving would also be able to withstand rough treatment.

Wood is a porous, absorbent material which becomes soaked when ice—used to chill stowed fishery products at-sea—melts and comes in contact with the wood. This ice melt water often contains large amounts of spoilage bacteria which can originate from the ice, the stowed product, or both. Porous wood surfaces can provide a fertile media for bacteria growth. When a stowed product comes in contact with bacteria-rich surfaces, it can become contaminated, resulting in product off odors, discoloration, and a reduction in shelf life.

Bin boards are painted with a marine enamel paint to seal the wood surface. This serves a dual purpose: the boards are easier to clean and bacteria accumulation is reduced. A new, freshly painted wood board performs well. However, with normal use and handling, painted wood surfaces quickly become scratched or nicked, culminating in avenues for moisture and bacteria. With entry of moisture into the wood, paint loosens and subsequently chips off, resulting in yet another source of product contamination. Paint chips are unsightly and are an indication that the fish hold is not well maintained.

To ensure seafood safety and quality, federal regulatory agencies are in the process of implementing a mandatory seafood inspection program. The front-running inspection program is the Hazard Analysis Critical Control Point, or HACCP method. This inspection method is designed to prevent public health problems from occurring by controlling any point in the food production system where a "hazard and/or critical" situation could result, whether it be from contamination, economic adulteration, or problems resulting from raw materials (National Fisheries Institute, 1991). Furthermore, HACCP is to be implemented at all levels of food handling, from point of harvest (vessel operations), through processing, distribution, retail/wholesale handling, to consumer purchase.

In compliance with preliminary HACCP fishing vessel certification requirements (NFI, 1991), fish contact surfaces of vessel holds should be constructed of non-corrodible, smooth-surfaced material impervious to water. One example of such material is high-density plastic. Recent advancements in plastic recycling have provided high-density polyethylene material which can be extruded into sizes conforming to conventional construction lumber. The plastic lumber can be nailed, machined, and sawed the same as wood. The extruded polyethylene material possesses a high density, smooth, non-absorbent surface, which, theoretically, should facilitate cleaning and sanitizing. The high density nature of this material provides for a durable, long lasting, non-corrosive alternative to wooden bin and shelving boards, with various other on board applications possible.

The objective of this study was to evaluate recycled plastic lumber as a substitute for wood in fishing vessel holds. The performance of plastic lumber was compared to painted yellow pine boards with moderate wear. Evaluations were based on bacteriological sampling; a fishermen's written survey and informal interview results; and estimated cost efficiency.

# Materials and Methods

Three manufacturers of recycled plastic lumber products provided sample boards to be evaluated for this study. From these samples, Trimax™ 200 (Polymetrix, Inc. Lincoln Park, N.J.) recycled plastic lumber was chosen because its structural properties were considered more favorable for bin board application. Trimax™ 200 is extruded, glass-reinforced foamed polyolefin. This product is made by an continuous extrusion process which produces plastic lumber with a high density solid outer layer, and a less dense cellular inner core—both favorable characteristics for ice hold application. Physical properties of this material were tested by independent laboratories and are reported by Mack, 1990.

Plastic boards of 2x6 inch, nominal size were cut in length to spand bin openings, and "dog-eared" (corners cut off at 45° angles to ease placement into and removal from verticle support channels). A half inch wide, quarter inch deep groove was routed down the length of

This advisory was published by Virginia Sea Grant's Marine Advisory Program, School of Marine Science, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia 23062.

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Editor and Designer: Susan C. Waters
Typography: Ruth Hershner

*Virginia Sea Grant Advisory No. 47, VSG-93-08*

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each board on both wide board faces, which provided finger-holds to facilitate handling (Figure 1).

Two 95 ft. commercial sea scallop dredge vessels were outfitted with recycled plastic bin boards. The first vessel used both wood and plastic bin boards simultaneously, which enabled direct bacteriological comparisons. Four ice bins were used; two bins were fitted with recycled plastic lumber, and two bins were fitted with 2x6 inch yellow pine construction grade lumber painted with an oil base marine enamel. Wood boards were those currently being used on the vessel with a moderate amount of bare wood showing due to paint removal by normal handling and wear. These wood boards typified the average condition of wood bin boards after only several scalloping trips. The second vessel used plastic boards exclusively.

*Figure 1. Recycled plastic bin boards positioned in the ice bin's verticle channelling. The bin boards wall off ice stowed bags of sea scallop meats.*

## Bacteriological Evaluation

Three sets of two 2.54 cm (one inch) sampling squares were marked onto each of three boards of both plastic and wood. Care was taken in placing squares on wood boards so each sampling square would occupy surface area which was approximately half painted and half unpainted. The marked boards were placed in bin walls occupying the bottom, middle, and top positions. The boards were placed to expose the sampling squares to the inside of each bin, so contact with stowed ice, ice-melt water, and/or bagged scallops could be made. Before placement of bin boards, all boards were cleaned and sanitized. A second sanitization step on the wood boards was required to reduce the surface bacteria to a level more comparable to that achieved on plastic boards with only one sanitizing. Bacteriological sampling of squares was performed at the beginning of the trip prior to product stowage, at the conclusion of a typical 18 day fishing trip, and after boards were cleaned and sanitized. One sampling square from each set of two squares was sampled before cleaning and sanitizing, with the other square from each set sampled after cleaning and sanitizing.

Commercial laundry detergent and household chlorine bleach (50 ppm) were used as cleaning and sanitizing agents to conform to products routinely used on board fishing vessels. Cleaning and sanitizing conformed to current industry practices whereby boards are scrubbed with a nylon bristle brush, followed by a thorough rinse with dockside potable water. Bacteriological sampling was by swab contact method utilizing Petrifilm™ aerobic count plates (Petrifilm sampling procedures 1987) developed by 3M laboratories. Due to the likelihood of chlorine sanitizer residuals present upon sampling surfaces, letheen broth was used for rinse solutions and diluents. Serial dilutions of $10^{-1}$ through $10^{-7}$ were plated then incubated for 48 + 2 hrs at 24 + 2°C. Colony densities between 30 and 300 were enumerated and expressed as average (n=3) $\log_{10}$ cfu per $cm^2$.

## Survey and Interviews

After the completion of at least five scallop fishing trips, each crew member from both vessels was asked to complete a written survey. The survey questions were designed to determine the crews' preference between wood or plastic bin boards. First, an overall preference between wood or plastic was solicited, followed by preference rating of various structural, aesthetic and handling characteristics. The survey was also designed to indicate how the crew members perceive bin boards in relation to their job responsibilities and scallop quality. (See Table 1 for survey form and compiled results.)

Interviews were conducted by individually asking crew members who filled out survey forms for their opinion of plastic bin boards. Crews were asked to identify the pros and cons of plastic bin boards in comparison to traditional wood boards, and to provide an overall opinion.

## Cost Analysis

Initial, annual, and projected cost analyses were performed for marine enamel painted wood and recycled plastic bin boards used on a 95 ft. scallop dredge vessel with eight storage ice bins. Initial costs included material and labor needed to prepare boards for placement on vessel. Estimated annual and average yearly costs associated with both material types included maintenance and replacement costs. Maintenance of wood boards was estimated by industry to occur after every fourth trip, and included the labor and material associated with scraping loosened paint and re-painting. Annual costs were based on a 16 trip per year effort. Replacement of wood boards was estimated by industry as: 20% of new boards within a year; 33.3% within 2 years; 66.6% within 3 years; and complete replacement of original boards within 4 years. Plastic boards are currently still in use after 3 years of maintenance-free service, and are projected to last at least through 4 years.

# Results and Discussion

## Microbiology

Aerobic plate counts (APC) on bin board surfaces indicated that plastic boards can be more efficiently cleaned and sanitized than wood boards (figure 2).

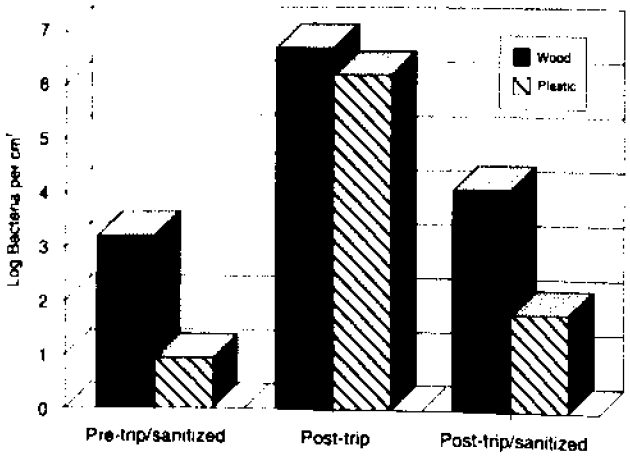


*Figure 2. Average aerobic plate counts (log cfu/cm2)of wood and plastic bin boards after an 18-day trip.*

Upon cleaning and sanitizing, reduction of surface bacteria was greatest on plastic boards. Wood boards averaged a 2.6 log, or 400X reduction in bacteria counts after sanitizing, while plastic boards averaged a 4.4 log, or 25,000X reduction. These differences in bacteria reduction indicate that wood more effectively harbors bacteria than plastic boards. In fact, multiple sanitizing steps would be needed to adequately reduce surface bacteria on wood bin boards, thereby intensifying cleaning efforts. Furthermore, results demonstrate that cleaning and sanitizing with household detergents and chlorine bleach (50 ppm)—the current industry norm–cannot effectively reduce the bacteria population on wood bin boards. The use of more specialized cleaning and sanitizing agents could provide greater efficiency in reducing bin board surface bacteria on wood and plastic bin boards.

The combined average APC per $cm^2$ recorded post-trip (figure 2) indicate no significant differences between wood and plastic in their capacity to become colonized by bacteria (the total amount of bacteria a surface can accommodate). However, total plate counts recorded on wood boards varied by their placement within the bin wall (figure 3), whereas plastic boards showed no significant difference in plate counts according to board placement. During scallop ice stowage, where bags of scallops are layered between layers of ice, ice-melt water trickles over stowed bags of scallops, providing a continuous rinsing effect. The bacteria present in the ice, and that which grows on stowed bags of scallop are, theoretically, washed downward. This rinsing effect results in both larger amounts and varying types of microorganisms collecting on the lower bin boards. Wood boards demonstrated increasing bacteria accumulation as board placement went from the top of the ice bin (2.7 logs) to the middle (3.4 logs), and to the bottom (4.6 logs) while plastic boards showed negligible differences as to board placement.

## Survey Results

A total of eighteen crew members responded to the survey, nine from each vessel which used the recycled plastic bin boards. Table 1 lists the questions presented to the fishermen, and the results. Survey results from both vessels combined are listed in Table 1 first, followed by results (in parentheses) from respondents from the vessel that used both wood and plastic bin boards.

Results from both crews combined showed a 88.9% preference for plastic boards, with the remaining 11.1% indifferent to board material type. Plastic was also overwhelmingly preferred over wood for all characteristics listed in survey question 2. All crew members preferred plastic boards for ease of cleaning and maintenance; 94.4% for appearance and durabil-

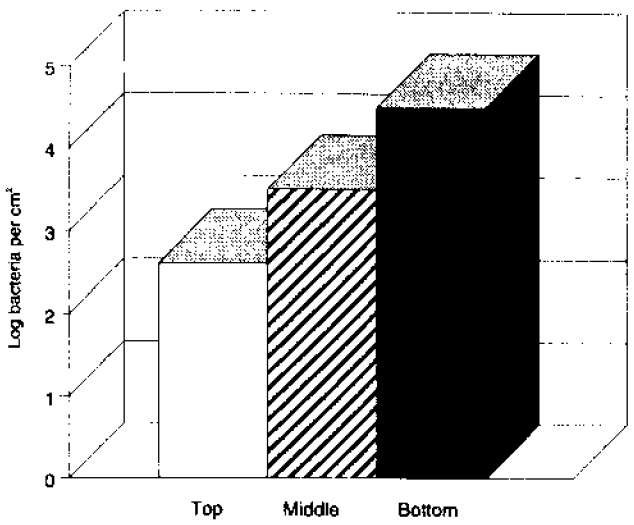


*Figure 3. Average log increases in aerobic plate counts on wood bin boards according to board placement in bin wall.*

ity; 88.9% for strength, insulating properties, sanitation, and prevention of odor; 83.3% for weight; and 77.8% for ease of handling.

Bin board weight and ease of handling characteristics provided the most variable results concerning board preference. These observed variabilities can possibly be explained by breaking down results by crew responsibilities. In regard to board weight, all of the crew members preferring wood (5.5%) or indicating no preference (11.1%), were captains and first mates, those who generally do not work in the ice hold. Furthermore, of the 16.7% which indicated wood boards are easier to handle, all were deckhands with no ice hold responsibilities. From crew members with ice hold responsibilities, 94.4% indicated that plastic boards were easier to handle and their weight factor was considered to be more favorable.

Survey results were most noticeably divided by which vessel respondents were working on. On the vessel where wood and plastic boards were used simultaneously (Table 1, values in parentheses), 100% of the crew preferred plastic for all bin board characteristics listed in survey question 2. Furthermore, the overall importance of bin board physical and aesthetic characteristics, and resulting scallop quality in relation to bin boards (Table 1, question 3) was rated higher by this crew than by the crew using only plastic boards. Because this crew had the opportunity to make direct comparisons while actually working with both board types, their unanimous preference for plastic bin boards, coupled with their higher level of importance rating placed on bin boards in general, may provide a more accurate indication of fishermen's acceptance of plastic bin boards than the results combining crew from both vessels.

A further difference in survey results was observed according to job responsibilities. Crew members with no ice hold responsibilities provided more variable responses. Of the respondents who worked directly with the bin boards on a daily basis (in the ice-hold), all (100%) generally preferred plastic boards over wood, and specifically preferred plastic in regard to ease of cleaning, durability, maintenance, strength, insulation, sanitation, and non-development of odors. With regard to ease of handling, weight differences, and appearance, 83.3% of ice hold workers surveyed indicated preference for plastic boards, while the other 16.6% indicated no preference between wood or plastic. These fishermen further indicated that board weight was less important to them than other board characteristics, with only 66.6% reporting that bin board weight was "very important," and 33.3% as "somewhat important." Plastic boards are approximately 1.8 times heavier than new painted wood boards of the same dimension. Weight difference, however, become negligible once wood boards become water-logged, which occurs during routine handling and usage.

## Interviews

All fishermen interviewed preferred the plastic bin boards over the traditional painted wood bin boards. All comments describing plastic bin boards were positive with a single exception. The most frequent positive responses for plastic boards were that they were easier to handle; cleaning and scrubbing much easier and quicker; quick drying; no board swelling (so boards did not stick in verticle channels); look a lot better; and there was less ice melt from bins. The one negative aspect of the plastic bin boards reported, was that they were a lot more slippery than wood boards. Slipperiness of the plastic boards caused problems when they were stacked on each other, or when they were used to stand on during product off-loading.

## Cost Analysis

Initial costs associated with outfitting a 95 ft. scallop vessel with enough bin boards to wall off eight storage ice-bins were $412.20 for marine enamel painted wood boards, and $720.00 for recycled plastic boards (Table 2). Recycled plastic lumber (1.25/bd ft.) was 3.5 times more expensive than yellow pine (.35/bd ft.). This initial price difference, however, was narrowed due to the cost of the paint and additional labor required in preparing wood bin boards. Overall, plastic boards were initially 1.7 times more expensive than wood boards. Due to maintenance and replacement costs attributed to the wood bin boards—and not to the

(continued on page 7)

**Table 1.** Survey Results. Fishermen were asked to evaluate recycled plastic bin boards. The numbers indicate percentages. The first number represents the results from both crews; the second number, the one in parentheses, is the response from the crew which used both wood and plastic.

1. Indicate your preference for enamel painted wood for plastic bin boards. (Check your preference.)

| | |
|---|---|
| 0 | Prefer wood |
| 88.9 (100) | Prefer plastic |
| 11.1 | Does not matter |
| | Do not know |

2. Relative to the following characteristics, indicate which type of binboard you prefer.

| | Wood | Plastic | Does Not Matter | Do Not Know |
|---|---|---|---|---|
| Ease of cleaning | | 100.0 (100) | | |
| Ease of handling | 16.7 | 77.8 (100) | 5.5 | |
| Weight | 5.5 | 83.3 (100) | 11.1 | |
| Appearance | | 94.4 (100) | 5.5 | |
| Durability | 5.5 | 94.4 (100) | | |
| Maintenance | | 100 (100) | | |
| Strength | 5.5 | 88.9 (100) | 5.5 | |
| Insulation | 5.5 | 88.9 (100) | 5.5 | |
| Sanitation (ice/scallop contamination) | 5.5 | 88.9 (100) | 5.5 | |
| Board/ice-hold odor | 5.5 | 88.9 (100) | 5.5 | |
| Other (specify)_____ | | | | |

3. Indicate whether or not the following characteristics are important to you with reference to bin boards.

| | Very Important | Somewhat Important | Not Important |
|---|---|---|---|
| Ease of cleaning | 88.9 (87.5) | 11.1 (12.5) | |
| Ease of handling | 61.1 (87.5) | 27.8 (12.5) | 11.1 |
| Weight | 55.5 (87.5) | 33.3 (12.5) | 11.1 |
| Appearance | 61.1 (75.0) | 27.8 (25.0) | 11.1 |
| Durability | 88.9 (87.5) | 11.1 (12.5) | |
| Maintenance | 66.6 (75.0) | 22.2 (25.0) | 11.1 |
| Strength | 88.9 (100) | 11.1 | |
| Construction (wood, plastic, metal, etc.) | 66.6 (87.5) | 22.2 (12.5) | 11.1 |
| Personal safety | 77.8 (87.5) | 11.1 (12.5) | 5.5 |
| Sanitation (ice/scallop contamination) | 83.3 (87.5) | 11.1 (12.5) | 5.5 |
| Board/ice-hold odor | 88.9 (87.5) | 11.1 (12.5) | |
| Scallop quality | 88.9 (100) | 5.5 | 5.5 |

4. Please indicate your job responsibilities* (Check more than one if applicable.)

| | |
|---|---|
| 16.6 (11.1) | Captain |
| 11.1 (11.1) | Mate |
| 33.3 (44.4) | Ice hold |
| 72.2 (13.3) | Deckhand |

**Table 2.** Initial cost comparison between the use of recycled plastic and enamel painted wood as bin boards. The commercial scallop vessel was 65 feet long and contained eight storage bins.

| Cost Categories | Wood[1] | | | Plastic[2] | | |
|---|---|---|---|---|---|---|
| | Cost/Unit | Amount | Total | Cost/Unit | Amount | Total |
| Boards | 0.35/bd/ft. | 512 bd.ft. | $179.20 | 1.25/bd.ft. | 512 bd.ft. | $640.00 |
| Paint | 20.00/gal. | 2.9 gal. | 58.00 | 0.00 | 0 | 0.00 |
| Labor | 5.00/hr. | 35 hrs. | 175.00 | 5.00/hr. | 16 hrs. | 80.00 |
| | | | $412.20 | | | $720.00 |

[1]Yellow pine 2x6 lumber with 2 coats of a marine enamel paint.

[2]Trimax 200™, 2x6 recycled plastic lumber.

**Table 3.** Estimated cost of enamel painted wood and recycled plastic bin boards used on a 65 foot commercial scallop vessel with eight storage ice bins.

| Board Material | Installation Cost | | Annual Cost | | Averge Yearly Cost | | | | Total Cost |
|---|---|---|---|---|---|---|---|---|---|
| | Material | Labor | Maintenance[1] | Replacement[2] | 1 | 2 | 3 | 4 | |
| Wood | 237.20 | 175.00 | 250.00 | 82.40 | 744.60 | 321.27 | 407.86 | 447.88 | 1921.60 |
| Plastic | 640.00 | 80.00 | 0.00 | 0.00 | 720.00 | 0.00 | 0.00 | 0.00 | 720.00 |

[1] Maintenance of painted wood bin board was estimated by industry to occur after every fourth fishing trip. Maintenance includes labor and paint cost associated with scraping loosened paint and repainting. Annual costs were based on a 16 trip/year effort.

[2] Replacement of wood bin boards was estimated by industry as: 20% of new boards are replaced within a year period; 33.3% within 2 years; 66.6% within 3 years; and complete replacement within 4 years. Plastic boards are still in use after 3 years of maintenance-free service and are projected to last at least through 4 years.

plastic bin boards—the cost associated with wood boards was estimated to exceed that of plastic boards within the first year of usage (Table 3). Furthermore, because plastic boards are currently still in use after 3 years of maintenance-free service, and are projected to last at least 4 years (by which time all original wood boards would have been replaced according to industry estimates), no costs are attributed to plastic boards through year 4. Wood boards, however, continually are in need of maintenance and replacement.

## SUMMARY

Results from this investigation indicate that recycled plastic lumber is a viable replacement for enamel painted wood as bin boards in fishing vessel ice holds. Plastic boards were observed to be more efficiently cleaned and sanitized than wood boards, were highly preferred over wood by fishermen who had worked with them, and were very cost-efficient due to the lack of

maintenance and replacement costs over years of usage. The positive characteristics of plastic bin boards, and the problems associated with painted wood bin boards, are summarized as follows:

**Positive Characteristics of Recycled Plastic Bin Boards:**

- **High Density, Non-porous Outer Shell**: facilitates cleaning and sanitizing; reduces wear rate; reduces friction in bin channeling; moisture resistant, water sheets off, allowing rapid air drying.
- **Rigid**: provides structural support.
- **Cellular Core**: reduces weight and provides additional insulating capacity.
- **No Shrinkage/Swelling Due to Moisture**: will not stick in bin wall channeling.
- **Specific Gravity 0.75**: boards will float if lost overboard.
- **Color Uniform Throughout**: 3 different colors, allowing color coding of hold to assist crew.
- **Cost**: more cost efficient than wood due to the lack of maintenance and replacement costs.

**Problems with Wood Boards not Observed with Plastic Boards:**

- **Ice/Product Contamination**: paint chips and higher levels of bacteria.
- **Unsanitizable Porous Surface**: build up of bacteria and associated spoilage odors.
- **Board Breakage**: knotty wood less structurally strong.
- **Wear**: wood board edges wear out and will no longer fit in bins.
- **Drying**: wood boards vary rarely dry out between trips, resulting in reduced effectiveness of re-painting and the development of off odors.
- **Swelling**: wood boards swell with moisture entry from ice-melt, resulting in boards becoming stuck in bin channels. Crew routinely pry wood boards free from channels with steel ice forks, which damages boards and creates avenues for bacteria.
- **Aesthetics**: worn wood boards are unsightly.
- **HAACP Program**: wood not recommended.

The non-porous, high density surface of recycled plastic bin boards allows for the use of a pressure washer to facilitate cleaning. Pressure washers can not be used on painted wood surfaces because paint dislodges from the wood surface from the force of the water spray. Pressure washing, used in conjunction with cleaning and sanitizing agents, can provide for a quicker and more effective means of hold sanitation.

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