UNIVERSITY OF WISCONSIN SEA GRANT COLLEGE PROGRAM

Effectiveness of a CD3 System at Removing Macrophytes and Small-Bodied Invertebrates from Watercraft

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INTRODUCTION

Once aquatic invasive species (AIS) are initially introduced to an area, they spread to nearby lakes and rivers through attachment to boats and trailers, in residual water, and by debris transported by watercraft (Johnson et al. 2001, Jensen 2010, Rothlisberger et al. 2010, Kelly et al. 2013). The most cost-effective strategy is prevention (Leueng et al. 2002), with the goal of reducing the number of propagules in transport producing meaningful prevention benefits (Jensen 2010, Fischer et al.2020).

Across the nation, watercraft inspections and education efforts are widely recognized for influencing boater behaviors, and these programs have been implemented with success. Where these programs are present boaters report understanding and performing AIS prevention actions that are known to reduce the amount of macrophytes (aquatic plants) and animals on watercraft (Connelly et al. 2014, Hammond et al. 2019, Rothlisberger et al. 2010). While these programs are useful and effective, they do not succeed in getting all boaters to take action (Whitzling and Shaw 2014, Hammond et al. 2019). One explanation could be that current inspection programs and decontamination stations are not present everywhere they are needed due to resource limitations, while another could be that there are barriers to boaters taking action.

One common barrier to action that boaters report is not having the tools needed to adequately clean their boats (Jensen 2010, Great Lakes Sea Grant Network 2014). The CD3 System is a recent advancement in technology designed to remove plants, animals and water from watercraft. However, it is unknown how effective these tools are at removing AIS from watercraft when compared to hand removal. Previous work has compared hand removal and high-pressure washing as removal strategies for aquatic macrophytes and small-bodied organisms, with hand removal and pressure washing being comparable for macrophytes and pressure washing being more effective at removing small-bodied organisms (Minnesota DNR 1994, Rothlisberger et al. 2010). Determining how CD3 System efficacy compares to these prevention tools can help AIS managers make decisions on whether and how to use this prevention tool.

Figure 1. An example of the CD3 Wayside Cleaning System used in this study.

METHODS

Evaluations were performed to determine the efficacy of cleaning method and duration on the removal of aquatic macrophytes and small-bodied organisms and plant seeds (SBO) from watercraft. Methods were based on similar comparisons in Rothlisberger et al. 2010. The invasive Eurasian watermilfoil (EWM, *Myriophyllum spicatum*) was the macrophyte used for removal evaluation, spiny water flea (SWF, *Bythotrephes longimanus*) and seeds of three wetland plants — mud plantain (*Alisma subcordatum*), blue vervain (*Verbena hastat*) and Frank's sedge (*Carex frankii*) — for the SBO evaluation.

Experimental design consisted of four cleaning treatments, including two lengths of removal time (90 seconds and 180 seconds) and two removal treatments (only CD3 cleaning system and only hand removal). There were seven replicates of each treatment. During the hand removal treatment the inspector was only allowed to use his hands to remove any attached specimens. During the CD3 trials, the inspector only used the CD3 tools.

A CD3 waterless watercraft-cleaning system, specifically the CD3 Wayside Solar model, is a commercially available solar-powered trailer unit. It was provided by the CD3 General Benefit Corporation. This CD3 System includes a wet/dry vacuum, a compressed air hose, a brush, a grabber, a universal drain plug wrench and lights (Figure 1). In addition to the physical tools, there are also video tutorials available for viewing through the wireless internet connection broadcasted from the system that demonstrate how to use the system and tools.

For the trials of both macrophytes and SBO, a known amount of macrophytes (measured in grams with a range of 63g to 139g and mean of 98g) or SBO (number of organisms with 100 SWF and 300 seeds for each trial) for each replicate was placed on the watercraft. Locations for placement were based on where experienced watercraft inspectors report finding plants and animals clinging to a fishing boat, motor and trailer. These included the hull, propeller, axels, wheel well, lighting wires and engine. Photos were taken with a reference number and a placement sheet documenting specimen location with each trial. A second person, a "Clean Boats, Clean Waters" trained watercraft inspector with two field seasons of experience, then cleaned the boat using the specified cleaning method (hand removal or only CD3 System tools) and time treatment (90 seconds or 180 seconds). The person placing the specimens (experimenter) and the person removing the specimens (inspector) were consistent throughout the entire evaluation.

After treatments were completed, the experimenter recovered any items still attached. For the macrophyte evaluation, a new replicate was not started until 100% of the plant material from the previous replicate was accounted for. Mass measurements and the placement sheets were compared to ensure all material was removed. Water loss and evaporation of the macrophtyes

Figure 2. A large tarp was placed on a wood frame to collect small-bodied organisms that were washed off the watercraft in between cleaning treatments.

(desiccation) was observed throughout the trials. To correct for weight loss due to desiccation, an evaporation percentage was calculated for each trial by calculating the percent difference between the 100% of the recovered ending mass and the starting mass. The starting mass was then multiplied by the percent difference to create an adjusted original mass.

For the SBO evaluation, the boat was washed and inspected between replicates. Water effluent was collected and filtered, and then the SBO counted to ensure that there was no accidental release of these invasive species and to ensure that all specimens were accounted for. The experimental set-up is shown in Figure 2.

To determine removal percentage for the macrophyte trials, the amount (in grams) of macrophyte recovered by the inspector was divided by the adjusted original amount placed by the experimenter. To determine SBO removal rates, the removed number of SBO was divided by the original number of SBO.

Due to unforeseen weather conditions, CD3 and hand removal trials were held at different locations. CD3 System trials were completed outdoors at Fischer Park near Browns Lake in Burlington, Wisconsin. The hand removal trials were held indoors at a nearby warehouse owned by the Browns Lake Sanitary District.

A two-way ANOVA (α= 0.05) was completed using JMP. Two analyses were conducted: 1) to test for the removal of EWM for efficacy based on methods and times, and 2) to test for the removal of SBO for efficacy based on methods and times.

RESULTS

Removal percentages of macrophytes by hand removal were 99.03% and 98.42% for the 90-second and 180-second treatments, respectively. Removal percentages for macrophytes using the CD3 cleaning system were 93.37% and 98.69% for the 90-second and 180-second treatments, respectively (Figure 3).

Removal percentages of SBO for hand removal were 80.75% and 92.02% for the 90-second and 180-second treatments, respectively. Removal percentages for SBO with the CD3 System were 81.64% and 83.82% for the 90-second and the 180-second treatments, respectively (Figure 3).

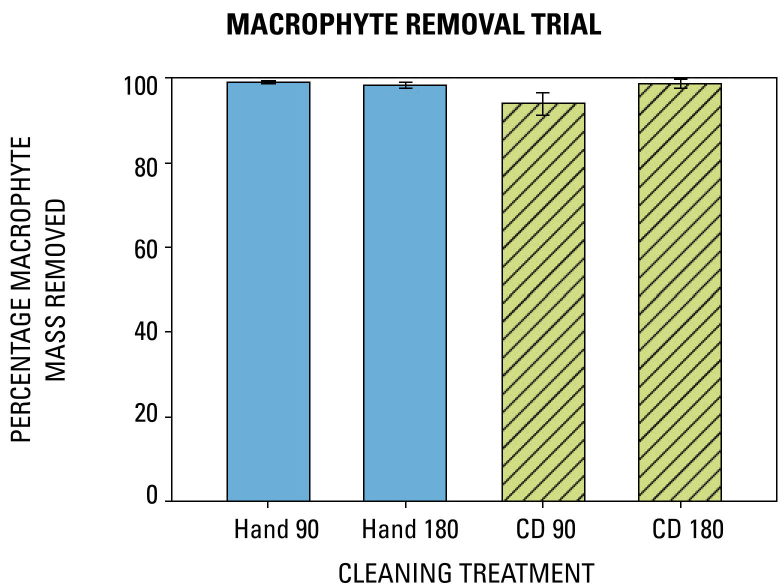
No statistical difference was found between hand removal and the CD3 System for removal of macrophytes (p=0.18) and SBO (p=0.14). There was also no difference found between the 90-second treatments and the 180-second treatments in both trials (p=0.12 for macrophytes and p=0.41 for SBO) and no interaction found between treatment and treatment length.

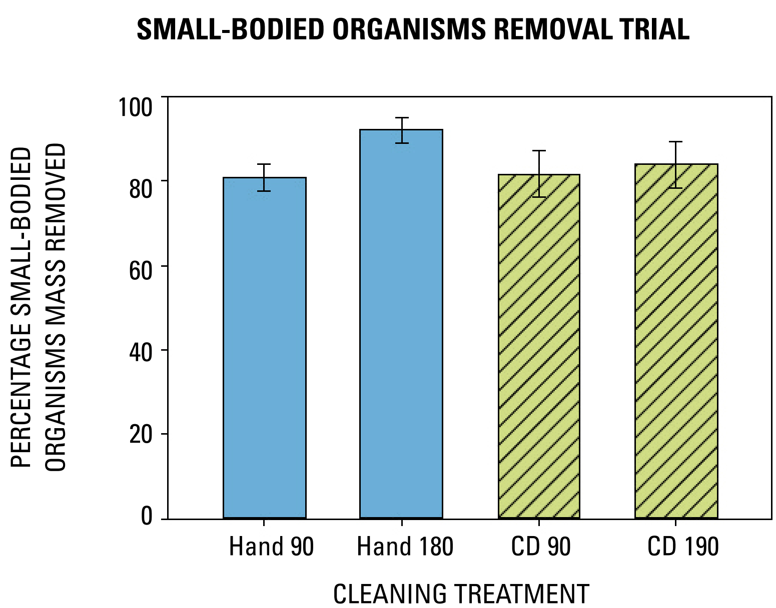
DISCUSSION

Overall, the efficacy of CD3 System AIS removal was not significantly different from hand removal, and all four cleaning/time treatments resulted in a high percentage of AIS removal. All treatments resulted in meaningful reductions of risk for AIS transport if performed consistently by boaters.

When compared to the Rothlisberger et al. 2010 study, our inspector had similar success removing macrophytes from the watercraft and was more successful at removing SBO while using hand removal. While using the CD3 System, again, our inspector had similar efficacy for removal of macrophytes from the watercraft and was more successful at removing SBO compared to the Rothlisberger et al. 2010 study.

Figure 3. Cleaning treatment and cleaning length did not have a statistical impact on the percentage of macrophytes and small-bodied organisms removed from a watercraft during cleaning trials.





While all cleaning treatments were demonstrated to be statistically equally effective at removing AIS from watercraft, nuances of the experimental design provide additional points to consider.

The inspector was employed as a watercraft inspector in Wisconsin for two summers and was skilled at removing AIS from watercraft without the use of tools. We believe that in both the hand removal and CD3 treatments the inspector's experience allowed him to be more successful at removing SBO than the Rothlisberger et al. 2010 study. Both studies suggest that trained inspectors are effective at removing aquatic invasive species from watercraft, and future work should explore the role experience plays in removal effectiveness.

Using only the CD3 System cleaning tools did not improve the inspector's ability to remove aquatic invasive species from the watercraft. However, this result may not extend to the general boating public given they are likely to use both hand removal and the tools, and may not be as effective at removing plants and animals from watercraft as the experienced inspector in this study. The general boating public is more likely to have a removal percentage closer to the Rothlisberger et al. 2010 study, which had a trained but not experienced inspector.

CD3 Systems may have the potential to reduce the number of plants and animals on watercraft in other ways than demonstrated here. CD3 Systems have been shown to be effective at removing more residual water (water that does not drain) from boats than just removing drain plugs (Anderson and Phelps 2018). When used with signage, a clean-out station and road lines, CD3 Stations can reduce AIS violation percentage by more than 70% and violation rate decrease over time as behavior adoption increased (Hennepin County 2017). Surveys of CD3 users indicate that most users found the systems easy to use and that most would use the system again – 61% of first-time users and 96% of repeat users indicated they were likely or very likely to use the system again (Three Rivers Park District 2018).

The availability of cleaning tools at landings, an often-mentioned barrier to action, may increase feelings of self-efficacy among boaters. Evidence suggests that watercraft users want effective tools at accesses. This suggestion is based on research that shows 15-22% of watercraft users claim not taking action because boat washing stations were not available (D. Jensen, pers. comm.). Increasing feelings of self-efficacy is known to promote environmentally sustainable behaviors (Tabernero and Hernandez 2011). CD3 Systems also seem to support development of social norms – boaters are more likely to use the system when there is a line of boaters waiting to use the system as compared to when there is not a line (Three Rivers Park District 2018). Lastly, 76% of CD3 System users have been documented using the system for longer times than were tested in this study (Three Rivers Park District 2018). All of these factors could lead to prevention benefits in addition to what exists with only hand removal.

Future efforts should compare boaters that are experienced in AIS prevention with those who are novices in AIS prevention, much like Anderson and Phelps 2018. This would provide more reliable data on how cleaning methods impact removal efficacy among the boating public. It would also be ideal for all trials to occur in the same place and preferably indoors to limit the impact from weather (wind, sunlight, and temperature). Weather factors influenced dessication rates of macrophytes occurring outdoors. Higher variability of the outdoor CD3 trials could be partially attributed to these factors.

Another line of inquiry could involve the optimization of the tools that are part of the CD3 System. Instructional videos on how to use the CD3 System and its individual tools are available as part of the system. These videos demonstrate the intended use for each of the tools. However, the inspector found additional value for the tools that were outside of their intended purpose, including use of the blower and vacuum to remove tough-to-reach AIS. The brush also had SBO stick to the bristles, which led to occasional SBO being moved on the boat as opposed to being removed. A study of tool optimization could improve the efficacy of the CD3 Systems.

Other future effort could focus on improved access and tool use. During 2019, more than 150,000 total prevention actions were taken by boaters using CD3 tools at 40 stations. An advantage of the units is that they are highly visible and have easy-to-use tools with 24/7 access. Tool use is monitored with data uploaded to a cloud server. Metrics gathered reveal when, how long and what tools are most popular. A study of those metrics could help improve AIS outreach aimed at getting more boaters to use CD3 Stations.

In summary, there was no statistical difference between removing macrophytes and small-bodied organisms from watercraft using two different time treatments (90 seconds or 180 seconds) or cleaning treatments (hand removal or CD3 tool use) for a trained and experienced watercraft inspector. However, this work suggests that experience may play a role in removal effectiveness, and this relationship should be better understood to know when tools like a CD3 System could improve AIS removal effectiveness. Additionally, other aspects outside of removal effectiveness, such as social norms and increased feelings of self-efficacy, may lead to additional prevention benefits when CD3 Systems are installed for use by the boating public.

ADDITIONAL RESOURCES

The raw data is available in table form in Appendix 1 or by emailing Tim.Campbell@wisc.edu.

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