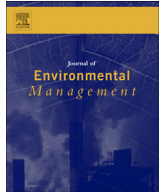




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Research article

Assessing the success of invasive species prevention efforts at changing the behaviors of recreational boaters

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ABSTRACT

Aquatic invasive species (AIS) pose major conservation challenges in freshwater ecosystems. In response, conservation organizations invest considerable resources in outreach to encourage AIS prevention behaviors among recreational boaters. Despite this, remarkably little is known about whether these efforts catalyze significant changes in boaters' perceptions, or whether they cause changes in behaviors that reduce AIS risk. We interviewed managers at the 14 Illinois organizations active in AIS outreach to determine regional priorities for, and investment in, AIS outreach. The results show a network of collaboration that reinforces a limited set of conservation messages. Next, we surveyed 515 recreational boaters to evaluate access to outreach, knowledge of AIS, and consistency of prevention behavior. Boater recognition of prevention slogans and knowledge of AIS and AIS prevention behavior was similar across Illinois regions despite large regional differences in investment in outreach. Most boaters (94%) report never intentionally moving organisms among waterbodies. Fewer reported that they *Always* perform recommended actions to reduce risk of AIS spread on their boat interior (68%), boat exterior (63%), or fishing tackle (47%). Recognition of prevention slogans and the number of AIS recognized were significantly, positively, associated with *Always* performing AIS prevention behavior on the vectors of the boat exterior, and fishing tackle, respectively. Our results suggest that increasing knowledge may be a necessary condition for higher adoption of AIS prevention behaviors, but that this alone may not be sufficient. Instead, efforts targeted at boaters who do not currently practice the recommended actions are likely to be necessary.

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1. Introduction

As global trade and other human actions continue to dismantle the natural barriers that separate aquatic ecosystems, the introduction of non-native species has risen causing severe negative impacts to freshwater ecosystems (Ricciardi, 2006; Strayer, 2010). Non-native species have been introduced via deliberate and unintentional release, including through shipping (e.g., dumping ballast water, biofouling), trade for the aquarium industry, and transport by recreational boaters and anglers (Mills et al., 1993). Protecting freshwater ecosystems from further introduction and spread of aquatic invasive species (AIS) is critical for many reasons, including

maintaining biodiversity (Gurevitch and Padilla, 2004), preventing economic losses (Keller et al., 2008), and avoiding adverse human health impacts (Pejchar and Mooney, 2009). Accordingly, there is a growing emphasis on the importance of public outreach and education designed to encourage conservation efforts that could halt introduction and spread of AIS. In particular, these efforts have targeted recreational boaters (U.S. Fish and Wildlife Service, 2009; 2015), with outreach and education representing a major investment in conservation funding.

However, remarkably little is known about whether public outreach and education catalyzes significant changes in boaters' perceptions, or whether it translates into changes in behavior that reduce AIS risk. As a result, our ability to strategically target public outreach and education to have maximum conservation benefit has been limited. This study builds understanding needed to bridge this critical knowledge and action gap in two ways.

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First, it investigates the context of AIS prevention through public outreach and education in the U.S. state of Illinois, which straddles the ecologically and economically important Laurentian Great Lakes and Mississippi River Basins where AIS comprise serious threats in both. Second, this study evaluates relationships between the extent and source of education received by boaters and a) their knowledge of invasive species and b) their behavior (or absence of behavior) to prevent the spread of AIS.

Conservation considerations related to AIS prevention are critical for lakes, rivers, streams, and other public waterways. A key vector by which these species are spread between bodies of freshwater is on recreational boats that are transported overland (Bossenbroek et al., 2007; Johnson et al., 2001; Leung et al., 2006). As boaters travel there are several ways that they can transport: on the outside of boat hulls; on boat interiors (e.g., live wells, bilge and free water at the bottom of the hull), on fishing equipment, and through intentional transport and release. If these organisms survive transit, they can be introduced into the next body of water where the boat is launched, potentially causing negative impacts. Despite the use of several technologies, including physical removal and pesticide application (U.S. Fish and Wildlife Service, 2009), complete eradication of AIS has rarely been achieved, and the costs of managing invaders should be seen as perpetual (Zavaleta et al., 2001).

Rather than relying on laws and regulations, many efforts to prevent AIS introduction and spread have been through public outreach and education; educational efforts have become common (Vander Zanden and Olden, 2008), increasingly targeting recreational boaters (Bossenbroek et al., 2007; Strayer, 2010). These programs operate on the premise that educating boaters about the risks of invasive species, and about behaviors that can prevent AIS introduction and spread, will result in boaters' adoption of behaviors needed to reduce AIS risk. U.S. programs include the 100th Meridian Initiative (U.S. Fish and Wildlife Service, 2016) and Protect Your Waters (U.S. Fish and Wildlife Service, 2015). These programs are demonstrative examples of public outreach and education for AIS prevention. The first emphasizes the risk posed by invaders in one genus, zebra (*Dreissena polymorpha*) and quagga (*D. bugensis*) mussels, and the importance of preventing the westward spread of aquatic nuisance species; the 100th Meridian Initiative coordinates efforts local, state, regional, and federal agencies. The second, Protect Your Waters, emphasizes general AIS prevention. While there are many AIS prevention programs, they often share slogans that link to recommended behaviors to prevent AIS. Examples include "Clean Boat, Clean Waters" (Wisconsin Dept. of Natural Resources, 2014) and "Be a Hero, Transport Zero" (Illinois-Indiana Sea Grant Program, 2015), each of which is accompanied by specific recommendations for boater behavior, such as conducting visual inspections of boat and fishing equipment and removing all plants and animals. In turn, the slogans and their associated AIS prevention behaviors are promoted through a range of media channels (e.g., television, internet, written materials), events (e.g., booths at fishing shows), and through personal communication between conservation managers (e.g., program managers at state and federal agencies) or conservation volunteers and the public. These public outreach and education efforts aim to reach boaters directly to transmit information about AIS identification and behaviors needed to prevent their introduction and spread.

Despite these well-developed campaigns, current program evaluation typically focuses on implementation metrics, such as the number of boaters contacted (Davenport and Shults, 2009; Illinois-Indiana Sea Grant Program, 2015), rather than impact metrics, such as reported behavior change. Using Illinois as an illustrative example, this study aims to advance previous program evaluation

by investigating the complete chain of communication of public education on AIS prevention, from slogans distributed by conservation organizations, to investigating where boaters receive information, boater recognition of prevention slogans and knowledge of AIS, and boaters' self-reported behavior to prevent the spread of AIS.

This study draws on diffusion of innovation theory to understand the uptake and consistency of AIS prevention behaviors. Diffusion theory describes how information about innovations is communicated through a group of individuals over time, with the innovation ultimately adopted or rejected at the individual level (Rogers, 2003). AIS prevention can be thought of as "best practices." It bears mentioning that best practices that support desirable conservation outcomes can be considered as a type of innovation in ecosystem management; specifically, they can be considered a preventive innovation that individuals adopt in order to lower the probability of an unwanted future event (Rogers, 2003, p. 234). Diffusion theory has been used to describe patterns of adoption of conservation behaviors (Lubell and Fulton, 2008; Pannell, 2008) including those supporting public goods (Garbach et al., 2012). This study builds on previous research by applying diffusion theory to adoption of AIS prevention behaviors that are conducted in public waterways. Addressing AIS prevention in public resources management is salient, given that introduction of an AIS to public waterways reduces resource quality and, in many cases, resource quantity (e.g., of desirable freshwater species).

Our first goal was to investigate the context of AIS prevention outreach and education in Illinois. To do this, we used network analysis—which describes who interacts with whom (Wasserman and Faust, 1994)—to quantify relationships among the conservation organizations that promote AIS prevention behavior to a critical group of primary resource users: recreational boaters. Specifically, we interviewed managers at the organizations involved with AIS prevention education in Illinois, measuring their investment of person power and financial resources, and the extent of coordination among organizations as these can each be important drivers of the outcomes. Often, Illinois conservation organizations interact with each other to coordinate messages, and these interactions form a network which can be analyzed for density, which measures proportion of existing relationships out of the total possible, and centrality, which measures the number of connections to each organization, as well as which organizations have unique connections (Wasserman and Faust, 1994). High network density facilitates communication and trust among actors (Bodin et al., 2006); a practical application of this theory is measuring which organizations are collaborating to share public education slogans for AIS prevention. Common slogans presented through multiple organizations to boaters can reinforce the conservation message, which is hypothesized to result in greater adoption of associated AIS prevention behavior. Organizations that are highly central in the network are often important distributors of information (Prell et al., 2009). This can be measured as in-degree centrality, or how frequently an organization is named by others as a key interaction partner, and out-degree centrality which measures the amount of interactions which an organization seeks with others (Wasserman and Faust, 1994).

Second, this study tests a hypothesis that is foundational to public outreach and education for conservation, such as AIS prevention: education will increase knowledge of the conservation challenge, and resource users with more knowledge of the challenge will take appropriate action. For our study, this hypothesis would hold that boaters who have greater knowledge about AIS are more likely to adopt and consistently use personal behaviors, such as cleaning their boats, which reduce the risk of AIS being spread.

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