Efficacy of Boat Stewards and New York State Regulations at Enhancing Visitor Adoption of Aquatic Invasive Species Spread Prevention Strategies

Report to the New York State Department of Environmental Conservation

Grant # DEC01-T00785GG-335000

PAUL SMITH'S COLLEGE
ADIRONDACK WATERSHED INSTITUTE

Michale Glennon, Ph.D.

Dan Kelting, Ph.D.

May 31, 2023

Executive Summary

Boat steward programs, or watercraft inspection programs, have emerged as the strategy of choice over the past decade to decrease the spread of aquatic invasive species (AIS) in New York State via the vector of overland transport of recreational watercraft. Paul Smith's College Adirondack Watershed Institute (AWI) implemented the first AIS spread prevention program on various Adirondack regional waterways in 2000 and since then its Aquatic Invasive Species Spread Prevention Program has expanded to more than 60 locations and interacted with nearly a million boaters. The 2015 New York State AIS Management Plan highlighted education and outreach as components of effective prevention strategies and called for the "immediate action" of expanding boat launch steward programs. In 2008, the New York State Department of Environmental Conservation established eight Partnerships for Regional Invasive Species Management (PRISM) units, and in 2018 began funding pilot boat steward programs in each of the PRISMs across New York State.

Boat stewards perform inspections, boat decontaminations, and educate visitors about AIS threats and proper Clean, Drain, Dry behaviors, playing front line offense and defense against AIS. Their education function is presumed to increase visitor compliance with CDD behaviors; however, research on visitor engagement as part of aquatic invasive species management is somewhat new, and identifying ways to engage effectively is a challenge. In addition to investing in boat steward programs, in 2016 New York State passed 6 CRR-NY § 576.3, establishing a statewide AIS transport ban on recreational watercraft, trailers and tow vehicles, known as the NYS AIS Transport Law. As with boat stewards, it is also important to assess the efficacy of the AIS transport ban to determine if its passage has resulted in greater visitor compliance with CDD behaviors.

The goal of this study was to determine the efficacy of visitor engagement by boat stewards and to identify factors that contribute to the relative rates of visitor adoption of recommended AIS spread prevention practices relative to the implementation of New York State's AIS Transport Law. Our objectives were to (1) determine the effectiveness of boat steward programs and the NYS AIS Transport Law at increasing visitor compliance with CDD, (2) identify the most influential variables contributing to visitor compliance with CDD, and (3) recommend enhancements to boat steward programs to further increase visitor compliance with CDD and follow up studies to more fully understand visitor behavior related to compliance with CDD.

We used data from the Watercraft Inspection Steward Program Application (WISPA) to assess the effectiveness of boat steward programs and the NYS AIS Transport Law, compiling all data for 2015-2020. We considered two measures of compliance with CDD. *Reported* compliance was measured in terms of the proportion of boaters who indicated having undertaken one or more of the recommended CDD practices. *Actual* compliance with CDD and the NYS AIS Transport Law was measured in terms results of boat inspections and the proportion of boats passing inspection (i.e., no organisms detected). We used chi-square tests of association to determine if a significant association existed between boaters' previous contact with boat stewards and their likelihood of reporting having used CDD practices and having clean boats

and also tested for an association between boaters' reporting of using CDD practices and having clean boats. Though information was not available for all years, we also used chi-square to determine if an association existed between boaters' responses to "Are you aware of the NYS AIS transport regulations?" and "Can we count on you? (to practice CDD)" and their reported use of CDD and having clean boats.

After establishing significant associations in all chi-square analyses, we used logistic regression to identify the best predictors of both reported and actual compliance with CDD. We tested date, time, watercraft type, registration, direction, previous waterbody, spread prevention measures, purpose of trip, previous steward contact, awareness of AIS regulations, and willingness to practice CDD for their influence on reported and actual compliance. Best predictors varied from year to year and included having a clean boat, previous steward contact, watercraft type, awareness of regulation, and willingness to practice CDD across all years. In contrast to reported compliance, actual compliance was best predicted by boat direction (i.e., launching vs retrieving) in all years, while several other variables also were also consistent and statistically significant predictors of actual compliance including purpose of trip, awareness of regulations, location of registration, watercraft type, and reported spread prevention practices. In terms of spread prevention practices boaters indicate having undertaken, there is strong consistency among those practiced most often across all years. Inspecting (mean = 56%) and washing the boat (49%) are reported most often, followed by draining the bilge (39%) and drying the boat (34%).

We found that the proportion of boaters reporting having undertaken at least one of the recommended CDD practices has demonstrated a slight but non-significant increasing trend from 2015-2020. Contrastingly, we found that actual compliance (i.e., proportion of boats that are clean upon inspection) has shown a steady and significant increasing trend since 2015. Relatedly, the proportion of boaters who report having encountered a steward before has also shown a significantly increasing trend, rising to as high a 93% in 2020, indicating the wide reach of the program. Identifying a clear "before" and "after" effect of the NYS AIS Transport Law implementation on reported boater practices is challenging given that some WISPA survey questions have changed over time. The extent to which boaters are aware of the transport law was only directly asked in 2018, but the proportion of clean boats has risen throughout the project period. Whether the increasing trend in boater compliance (i.e., having clean boats) is attributable to the transport law itself or to the very broad and long duration presence of boat stewards is challenging to determine, but a positive finding and one which indicates the overall efficacy of boat launch steward programs in general at increasing visitor compliance with CDD.

It is important to highlight the potential challenge of using reported boater behavior as a means of assessing efficacy of boat launch steward programs. There is often a disconnect with reported and actual human behavior patterns and we found that the proportion of boaters reporting adoption of CDD practices has not increased in the same manner as the increase in the proportion of boats passing inspection. It is possible that boaters are increasingly becoming more knowledgeable and better practitioners of AIS spread prevention practices, but that the majority of them have encountered stewards before and we are approaching the limits to their

interest in answering questions at the launch about their behaviors. In spite of this, we believe that boat stewards have been highly effective in reaching a very broad audience across the Adirondack region, providing critical education in terms of CDD practices, and enhancing the adoption of these practices by boaters. The overall risk of AIS transport in Adirondack lakes is relatively small, given that a very high proportion of boaters are launching for the first time in the season or only ever visit one waterbody (>80%), but the risk remains and boat launch steward programs remain one of the best approaches to addressing the spread of AIS in our waters. We provide several recommendations that may further increase the effectiveness of the program in the future including increasing the overall number of steward programs and waterbodies covered across the state, focusing initially on large, high-traffic waterbodies that are known or likely to be invaded by AIS, making boat cleaning equipment available to the broadest extent possible at launch locations and considering alternative measures such as automated inspection systems at waterbodies without stewards, encourage additional research on the effectiveness of boat launch steward programs and the levels of risk of AIS establishment and relatedness to waterbody characteristics, and maintaining consistency to the extent possible of survey questions and possible answers within the WISPA database such that long-term trends can be easily investigated.

Introduction

Overland transport of aquatic invasive species (AIS) by recreational watercraft has been clearly established as a primary vector in the spread of these organisms across North America (Johnson et al. 2001, Leung et al. 2006, Drury and Rothlisberger, 2008). Hand removal and high-pressure hot water boat decontamination measures taken by either boat stewards or boat owners to remove AIS have been shown to be effective means of reducing the risk of recreational watercraft spreading these organisms (Comeau et al. 2001, Morse 2009, Rothlisberger et al. 2010). As such, boat steward programs have emerged as the strategy of choice over the past decade to decrease the spread of AIS in New York State via the vector of overland transport of recreational watercraft. The New York State AIS Management Plan released in 2015 maintains that effective prevention strategies will include education and outreach components and calls for the "immediate action" of expanding boat launch steward programs (NYSAISMP 2015).

Paul Smith's College Adirondack Watershed Institute (AWI) implemented the first AIS spread prevention program on various Adirondack regional waterways in 2000. Since then, numerous boat steward programs have been implemented across New York State to address AIS spread prevention following the AWI's pioneering effort. The Lake Champlain Basin Program initiated a boat steward program focused on both the Vermont and New York sides of Lake Champlain in 2007. The following year the Lake George Association began a boat steward program, which evolved into the Lake George Park Commission program in 2014. The federal Great Lakes Restoration Initiative (GLRI) started funding New York State's Office of Parks, Recreation and Historic Preservation boat steward program and the Finger Lakes boat steward program in 2014. In 2008, NYSDEC established eight Partnerships for Regional Invasive Species Management (PRISM) units, modeled after the Adirondack Park Invasive Plant Program which was initiated in 1998. In 2018, NYSDEC began funding pilot boat steward programs in each of the PRISMs across New York State.

Over the last several years more than 400 million federal dollars have been invested in invasive species management through the Great Lakes Restoration Initiative (GLRI 2018) and millions more through the Lake Champlain Basin Program. About $17 million of this amount has been invested in education and outreach associated with spread prevention activities and programs. Though Clean Drain Dry (CDD) behaviors are known to be effective at prevention, compliance with these behaviors varies greatly (Wallen and Kyle 2018). Boat stewards perform inspections and educate visitors about AIS threats and proper CDD behaviors, playing front line offense and defense against AIS (Stewart-Koster et al. 2015). Their education function is presumed to increase visitor compliance with CDD behaviors; however, research on visitor engagement as part of aquatic invasive species management is fairly new, and identifying ways to engage more effectively remains an issue (Shackleton et al. 2019).

Given the significant investment of public financial resources and the presumed efficacy of boat stewards, it is essential to determine the effectiveness of such efforts in increasing boater

compliance (Cole et al. 2019). AIS prevention campaigns in the Midwest have been found to be moderately successful in raising general visitor awareness, engagement, and sense of personal responsibility and adoption of recommended spread prevention procedures (Seekamp et al. 2016). While an AIS transport campaign in Illinois was found to influence a majority of boat owners to take recommended spread prevention actions, a sizable minority of boaters remain sometimes or always non-compliant, leading to persistent risk of AIS transport (Cole et al. 2019). Both studies relied on voluntary surveys with comparatively small sample sizes, numbering in the hundreds. To our knowledge, no published studies exist specifically focused on efficacy of boat stewards at enhancing visitor adoption of prevention strategies.

The AWI's spread prevention program started with private funding for boat stewards stationed at public boat launch sites in Paul Smiths and the surrounding area. Our boat steward program underwent a major expansion in 2011 when we received the first of nine GLRI grants. In 2015, Paul Smith's College AWI received a series of contracts from the New York State Department of Environmental Conservation through the Environmental Protection Fund to expand further, adding an additional 45 locations, including decontamination stations. A new contract was bid on and renewed in 2023 and extends to more than 60 locations. AWI boat stewards have been collecting important information from visitors for two decades, resulting in a large database consisting of nearly 1 million surveys.

In addition to investing in boat steward programs, in 2016 New York State passed 6 CRR-NY § 576.3, establishing a statewide AIS transport ban on recreational watercraft, trailers and tow vehicles, known as the NYS AIS Transport Law. This regulation describes the following required spread prevention behaviors: cleaning – consisting of inspecting watercraft and appurtenances and removing and disposing of visible organic material from same; draining water from watercraft compartments and cooling systems; and treating the watercraft to remove living AIS fragments, seeds, eggs, and other propagules by drying, rinsing, or washing watercraft, trailers and tow vehicles. As with boat stewards, it's also important to assess the efficacy of the AIS transport ban to determine if its passage has resulted in greater visitor compliance with CDD behaviors.

The goal of this study was to determine the efficacy of visitor engagement by boat stewards and to identify factors that contribute to the relative rates of visitor adoption of recommended AIS spread prevention practices relative to the implementation of New York State's AIS Transport Law. Our objectives were to (1) determine the effectiveness of boat steward programs and the NYS AIS Transport Law at increasing visitor compliance with CDD, (2) identify the most influential variables contributing to visitor compliance with CDD, and (3) recommend enhancements to boat steward programs to further increase visitor compliance with CDD and follow up studies to more fully understand visitor behavior related to compliance with CDD.

Effectiveness of boat steward programs and the NYS AIS Transport Law

Approach

We used data from the Watercraft Inspection Steward Program Application (WISPA; NY iMapInvasives 2021) to assess the effectiveness of boat steward programs and the NYS AIS Transport Law. Partnerships for Regional Invasive Species Management (PRISMs) throughout New York State coordinate invasive species management actions and data acquisition is conducted via WISPA, allowing for the collection of real-time data on invasive species via stewards stationed at boat launches. The WISPA project is a collaborative effort of several public and private agencies, and the database contains information collected in the field by boat stewards including records of all launching and retrieving vessels, numbers and types of organisms detected via boat inspection, and information provided voluntarily by boaters on the last waterbody visited, awareness of aquatic invasive species, and actions taken to prevent their spread. We compiled all data for 2015-2020 from the WISPA database.

We considered two measures of compliance with CDD. Boaters are asked by boat stewards to report on their use of AIS spread prevention measures which include recommended CDD behaviors such as cleaning and inspecting their boat, draining the bilge and live well, etc, and reported practices are recorded in the WISPA dataset. These responses document the extent to which boaters *report* following CDD practices. They are, however, self-reported behaviors. *Actual* compliance with CDD and the NYS AIS Transport Law is reflected in results of boat inspections at launches and whether or not boats arrived clean. We considered both measures and investigated the effectiveness of the steward program at influencing both reported and actual compliance with CDD. We considered boaters who reported undertaking one or more of the recommended spread prevention measures as being in reported compliance, while boaters who did not report taking any spread prevention measures were considered non-compliant. Similarly, we considered boats on which no organisms were detected to be in actual compliance with CDD and the transport law, while boats on which organisms were detected were considered noncompliant.

To assess the efficacy of the steward program on influencing boater practices we investigated the association between boaters' response to "Have you met a steward before?" and reported and actual compliance. This question has been asked in all years from 2015-2020 except for 2017. We did not consider years prior to 2015 because the "Have you met a steward?" question does not appear to have been asked prior to that year. We used chi-square tests of association to determine if a significant association existed between boaters' previous contact with boat stewards and their likelihood of reporting having used CDD practices and having clean boats. We also used chi-square to assess the association between boaters' reporting of using CDD practices and having clean boats. In 2018, the only year for which this question was asked, we used chi-square to determine if an association existed between boaters' response to "Are you aware of the NYS AIS transport regulations?" and their reported use of CDD and having clean boats. In 2019 and 2020 the WISPA dataset also included answers to the question, "Can we count on you? (to practice CDD)." We therefore also tested whether there was an association

between boaters' answer to this question and their use of CDD behaviors and having a clean boat.

We conducted chi-square analyses within each year separately. Although categories representing specific CDD behaviors undertaken by recreational boaters have been consistently recorded, there is a large degree of variability in the way that some questions have been asked from year to year, as well as the questions included in the survey each year. For example, early responses to the question "did you undertake spread prevention measures?" were limited to yes/no/unknown, while in more recent years the possible answers to this question also include "no, because this is the first launch of the year" or "no because I am always launching in the same waterbody." While the additional information is informative, the change in the possible answers makes it challenging to interpret the overall response to this question across all years and we therefore assessed each year independently. To look at trends over time that may indicate the overall efficacy of the program and the influence of the NYS AIS transport law, we summarized the total proportion of boaters reporting having met a steward, proportion of boaters reporting using CDD, and proportion of boaters with clean boats for each year. We examined how these proportions have changed over time and compared findings for the individual years before the transport law and after it.

Findings: General Patterns

We found that the proportion of boaters reporting having undertaken at least one of the recommended CDD practices has demonstrated a slight but non-significant increasing trend from 2015-2020 ($R^2 = 0.55$, $P = 0.26$; Figure 1). These proportions are calculated only from among boaters who answered either "Yes" or "No" to the initial question of whether or not spread prevention measures had been taken and represent those for whom the initial answer was "Yes" and subsequently noted having employed at least one recommended practice. As mentioned, however, the spread prevention question has evolved within the WISPA survey over the course of the study period and in later years has included separate categories for boaters who respond that they were launching for the first time or that they always launch in the same waterbody. Whether or not first launches or boats always launching in the same waterbody should be considered in compliance is an important question and boaters may believe there is no need to undertake or report CDD practices under those circumstances.

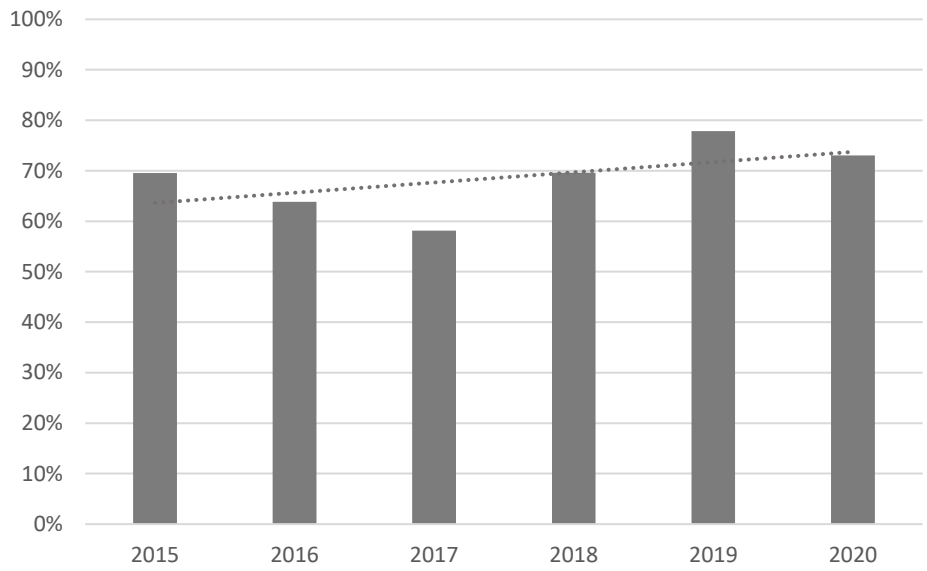

Figure 1. Proportion of boaters reporting having undertaken one or more recommended CDD practices, 2015-2020.

In contrast to reported CDD behaviors, we found that actual compliance (i.e., proportion of boats that are clean upon inspection) has shown a steady and significant increasing trend since 2015 (R^2 = 0.80, P = 0.05; Figure 2).

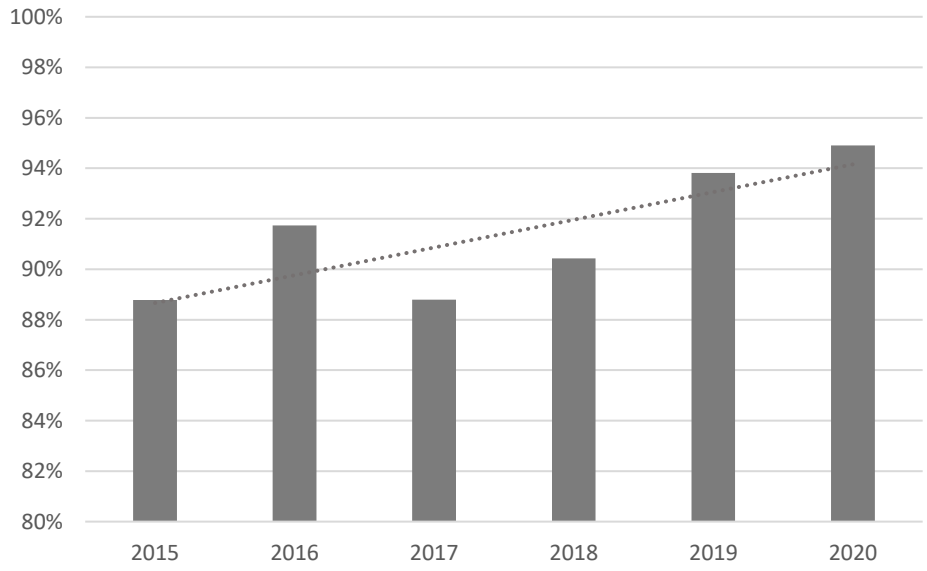

Figure 2. Proportion of boaters having clean boats upon inspection by boat launch stewards, 2015-2020.

These patterns do not show a clear “before” and “after” effect of the NYS AIS Transport Law implementation in 2016. It may, however, be more meaningful to note the overall trend given

that the transport law had a long and somewhat complicated history of implementation and the extent to which boaters are aware of it was only directly asked in 2018. Whether the increasing trend in boater compliance (i.e., having clean boats) is attributable to the transport law itself or to the very broad and long duration presence of launch stewards is challenging to determine, but a positive trend nonetheless and one which indicates the overall efficacy of boat steward programs in general at increasing visitor compliance with CDD. Relatedly, the proportion of boaters who report having encountered a steward before has also shown a significantly increasing trend ($R^2 = 0.88$, $P = 0.05$), rising from 86% in 2015 to 93% in 2020, indicating the wide reach of the program.

Findings: Tests of Association

We found that nearly all tests of association between measures of awareness and/or exposure to the steward program and reported or actual compliance with CDD were statistically significant (Table 1). The only exception to this was in 2017 in the chi square test for association between reported adoption of CDD practices and having a clean boat upon inspection. These tests indicate only that an association exists but do not provide information on the direction of the association; relationships were further explored in association with objective 2.

Table 1. Chi-square tests of association between measures of awareness and exposure to the boat launch steward program and reported or actual compliance with CDD practices, 2015-2020. Categories include whether or not boaters have met a steward previously, whether or not they are aware of the NYS AIS transport law, and whether or not we can count on them to practice CDD and the association of these variables with reported and actual CDD practices, as well as the association between reported CDD practices and actual compliance (i.e., clean boat). P values are as <0.0001 (***), < 0.001(**), and <0.05(*).

	2015	2016	2017	2018	2019	2020
Met a steward vs reported CDD	548.6**	1069.1**	NA	161.5**	35.4**	427.4**
Met a steward vs clean boat	11.9*	29.3**	NA	13.0*	194.9**	68.4**
Aware of law vs reported CDD	NA	NA	NA	687.3**	NA	NA
Aware of law vs clean boat	NA	NA	NA	11491.6**	NA	NA
Can count on them vs reported CDD	NA	NA	NA	NA	620.6**	1227.8**
Can count on them vs clean boat	NA	NA	NA	NA	35.9**	45.5**
Reported CDD vs clean boat	584.8**	64.1**	0.5	57.5**	140.7**	183.4**

Most influential variables contributing to visitor compliance with CDD

Approach

Following the results of chi-square tests of association, we used logistic regression to identify the best predictors of both reported and actual compliance with CDD. Reported compliance was defined as boaters who reported having undertaken one or more of the recommended CDD practices vs boaters who did not report any of these behaviors. Actual compliance was defined as having a clean boat (i.e., no organisms detected). Again, we ran logistic regressions separately in each year from 2015 to 2020 because the exact set of questions asked in the WISPA survey – and therefore the number of potential predictor variables – varies from year to year. We tested date, time, watercraft type, registration (coded as NYS vs Other), direction (i.e., launching, retrieving, roadside), previous waterbody (coded as Same/None vs Other), and spread prevention measures in all years and tested previous steward contact in all years but 2017. Activity, or purpose of trip (e.g., recreation, fishing) was also tested for its influence on reported and actual compliance in 2018-2020 and "can we count on you?" in 2019-2020. Last, awareness of the NYS AIS transport law was tested against reported and actual compliance in 2018, the only year for which this question was asked. We ran all logistic regressions in R (R Core Team 2021) and calculated McFadden's R^2 values as a means of assessing model fit.

Findings

There was high variability in the most influential variables for predicting reported compliance with CDD (Table 2). In all years, one top model was better than all alternatives (i.e., $\Delta AIC < 2$) but best predictors varied from year to year and included having a clean boat, previous steward contact, watercraft type, awareness of regulation, and willingness to practice CDD (i.e., can we count on you) across all years. Logistic regression results are interpreted in terms of odds ratios; the regression coefficients associated with each predictor represent the change in the log odds of having the predicted outcome per unit change in that variable (transformed parameter estimates are provided in Table 2). For example, in 2016, boaters who had met a steward had 3.04 times the odds of reporting having undertaken spread prevention measures compared to those who had not met a steward. Though there were clear top models in all years, other variables were also significant predictors of reported compliance with CDD, perhaps most notably having met a steward previously. In all years for which it could be tested, boaters who had met a steward before were more likely to report having undertaken CDD practices than those who had not, with effect sizes ranging from 1.22 to 3.04.

Table 2. Top predictors (AIC < 2) of reported compliance with CDD, from logistic regression, 2015-2020. Reference categories are as follows: Organisms Found (No), Met a Steward (No), Watercraft Type (Motorboat), Aware of Reg (No), Count on You (No).

Year	Predictor	Estimate	SE	P	Odds Ratio	McFadden's R^2
2015	Organisms (No inspection)	-0.99	0.08	< 0.0001	0.37	2%
2015	Organisms (Yes)	-0.83	0.04	< 0.0001	0.44	2%
2016	Met Steward (Not Asked)	0.48	0.18	< 0.001	1.62	2%
2016	Met Steward (Unknown)	0.16	0.23		1.17	2%
2016	Met Steward (Yes)	1.11	0.04	< 0.0001	3.04	2%
2017	Watercraft (Barge)	0.16	0.51		1.17	1%
2017	Watercraft (Canoe)	-0.55	0.04	< 0.0001	0.58	1%
2017	Watercraft (Dock)	-0.90	0.48	< 0.1	0.41	1%
2017	Watercraft (Kayak)	-0.49	0.04	< 0.0001	0.61	1%
2017	Watercraft (Multiple)	-0.52	0.03	< 0.0001	0.59	1%
2017	Watercraft (PWC)	-0.22	0.04	< 0.0001	0.80	1%
2017	Watercraft (Rowboat)	-0.80	0.16	< 0.0001	0.45	1%
2017	Watercraft (Sailboat)	-0.05	0.13		0.95	1%
2017	Watercraft (SUP)	-0.60	0.20	< 0.001	0.55	1%
2018	Aware (Not Asked)	2.15	0.06	< 0.0001	8.61	6%
2018	Aware (Refused)	0.77	0.31	< 0.05	2.17	6%
2018	Aware (Uncertain)	0.60	0.06	< 0.0001	1.82	6%
2018	Aware (Yes)	1.70	0.03	< 0.0001	5.45	6%
2019	Count On (Maybe)	-0.03	0.12		0.97	3%
2019	Count On (Not Asked)	1.13	0.10	< 0.0001	3.10	3%
2019	Count On (Previous)	2.09	0.16	< 0.0001	8.05	3%
2019	Count On (Refused)	1.07	0.45	< 0.05	2.92	3%
2019	Count On (Yes)	2.33	0.11	< 0.0001	10.30	3%
2020	Count On (Maybe)	1.54	0.09	< 0.0001	4.67	<1%
2020	Count On (Not Asked)	1.77	0.09	< 0.0001	5.85	<1%
2020	Count On (Previous)	2.92	0.09	< 0.0001	18.57	<1%
2020	Count On (Refused)	2.12	0.29	< 0.0001	8.30	<1%
2020	Count On (Yes)	2.58	0.08	< 0.0001	13.24	<1%

In contrast to reported compliance, actual compliance was best predicted by boat direction in all years (i.e., launching, retrieving, or does not apply (roadside decon); Table 3). Though effect sizes were relatively small, retrieving boats were less likely to pass inspection than launching boats, as would be expected for boats departing from infected waters. Boats at roadside decons were also less likely to pass inspection than launching boats in all years except 2015. Although boat direction was the top model for predicting actual compliance with CDD in all years, several other variables also were also consistent (direction of influence) and statistically significant predictors of actual compliance (Table 4).

Table 3. Top predictors (AIC < 2) of actual compliance with CDD (i.e., no organisms found on boat), from logistic regression, 2015-2020. The reference category is launching boats in all years.

Year	Predictor	Estimate	SE	P	Odds Ratio	McFadden's R^2
2015	Launching (Retrieving)	-1.22	0.03	< 0.0001	0.30	5%
2015	Launching (Roadside)	0.14	0.14		1.14	5%
2016	Launching (Retrieving)	-1.22	0.04	< 0.0001	0.29	5%
2016	Launching (Roadside)	-1.14	0.10	< 0.0001	0.32	5%
2017	Launching (Retrieving)	-1.30	0.02	< 0.0001	0.27	6%
2017	Launching (Roadside)	-0.40	0.11	< 0.0001	0.67	6%
2018	Launching (Retrieving)	-1.77	0.03	< 0.0001	0.17	9%
2018	Launching (Roadside)	-0.69	0.13	< 0.0001	0.50	9%
2019	Launching (Retrieving)	-1.86	0.03	< 0.0001	0.16	9%
2019	Launching (Roadside)	-1.69	0.08	< 0.0001	0.18	9%
2020	Launching (Retrieving)	-2.50	0.04	< 0.0001	0.08	13%
2020	Launching (Roadside)	-2.53	0.07	< 0.0001	0.08	13%

Table 4. Variables that were consistent (same positive or negative influence) and significant predictors (P < 0.05) of actual compliance with CDD in all years for which they were tested. All other variables had variable patterns of influence across years (mixed direction of influence or inconsistent significance).

Compared to boaters	Predictor	Compliance Odds	Effect Size
Whose purpose was recreation	Purpose of fishing	Lower	0.19-0.30
	Purpose of government	Lower	0.49-0.72
Unaware of transport law	Those who were aware	Higher	0.38
	Those who refused to answer	Lower	0.62
Unwilling to be counted on for CDD	Those who were willing	Higher	1.81-1.90
Launching boats	Retrieving boats	Lower	0.08-0.30
With NY registered boats	Boats registered in outside NY	Lower	0.39-0.86
	Unregistered boats	Higher	1.86-4.48
Reporting no spread prevention	Always launching in same water	Higher	1.11-1.80
With motorboats	With PWC	Higher	1.47-2.48
	With SUPs	Higher	2.38-23.12

In terms of spread prevention practices boaters report having undertaken, there is strong consistency among those practiced most often across all years. Inspecting (mean = 56%) and washing the boat (49%) are reported most often, followed by draining the bilge (39%) and drying the boat (34%). A much smaller proportion of boaters report having drained bait buckets (2%) and live wells (6%), or disposing of unused bait (4%) though these behaviors pertain to only a subset of recreational boaters. Last, a small but increasing proportion of boaters report using a decon station (9%). There are no statistically significant trends of increase or decrease in reported adoption of these behaviors over time.

Recommendations

Limitations

Two notable and potentially confusing patterns are apparent in some of our findings that are worthy of mention. One is the high proportion of tests that are statistically significant, and in most cases highly significant ($P < 0.0001$). The other is the overall low reported values for McFadden's R^2 in the results of the logistic regressions. We believe the two are both related to the same issue and that is the sheer volume of data contained in the WISPA database. We chose to look at as much information as possible because best practices in science would suggest that more data are generally better. However, one consequence of very large sample sizes is that the likelihood of detecting statistically significant patterns increases (Lin et al. 2013). Relatedly, McFadden's R^2 is not a direct analog of the R^2 values with which most audiences may be familiar and assessing the fit of logistic regression models is more ambiguous than that of linear regression models, but this measure nonetheless provides some information about the fit of the models and is quite small in all models we ran. This does not mean that P values and identified relationships are incorrect, merely that it is possible to find significant effects that are still small relative to the overall "noise" in the data. A dataset as large as those for any of the single years that we evaluated is bound to have a high degree of variability. One resulting recommendation, therefore, would be to further explore these patterns by subsetting the data in a variety of ways to determine if clearer patterns emerge, or if the variability exists at large and small scales. It might be instructive, for example, to look at boats registered in NY and influences on CDD and to separately analyze boats registered elsewhere. Despite the "good" challenge of having so much data, we believe these findings are very positive and indicate the overall positive effect of boat steward programs on increasing visitor adoption of CDD practices.

An additional and important consideration is the discrepancy between self-reporting of AIS spread prevention measures and actual compliance with CDD and the NYS AIS Transport Law. We found that the proportion of boaters reporting adoption of CDD practices has not increased in the same manner as the increase in the proportion of boats passing inspection. This makes challenging the prospect of gauging the effectiveness of boat steward programs if measured in terms of what boaters report they are doing. There are numerous examples of disagreement between reported and measured behaviors in the social science literature including discrepancies between self-reported and actual recycling (Barker et al. 1994), handwashing (Nichols 2013), water consumption (Lawrence et al. 1985), and Facebook use (Junco 2013) among others. It is also possible that even boaters with the best of intentions and practices may fail to detect or successfully remove AIS depending on the species and control methods employed. We note the discrepancy between intentions and measured behaviors, however, as a limitation of the power of the data and not a reflection on the effectiveness of boat steward programs or New York State's AIS transport law.

General Conclusions

In general, we believe that boat stewards have been highly effective in reaching a very broad audience across the Adirondack region, providing critical education in terms of CDD practices, and enhancing the adoption of these practices by boaters. We note the following general patterns:

- The overall risk of AIS transport in Adirondack lakes is relatively small, given that the majority of boaters are launching for the first time in the season or only ever visit one waterbody (>80%).
- Most boaters have encountered a boat steward before (>85%), and this proportion has increased over time, indicating the wide reach of the program.
- Although reporting of behaviors is somewhat variable, actual compliance with CDD (i.e., numbers of clean boats) shows a consistently high and increasing trend, indicating the success of the Aquatic Invasive Species Spread Prevention Program.
- Although only asked directly of boaters in 2018, awareness of the NYS AIS transport law was influential on and likely to have significant influence on both reported and actual compliance with CDD.

Recommendations

The following are recommendations we might suggest to further increase the effectiveness of the program in the future:

- Increase the overall number of steward programs and waterbodies covered across the state, focusing initially on large, high-traffic waterbodies that are known or likely to be invaded by AIS.
- Stage high profile education/enforcement actions related to the transport law to raise the profile of the issue and criticality of boater compliance.
- Make boat cleaning equipment available to the broadest extent possible at launch locations.
- Consider alternative measures such as automated boat inspection systems for boat launches and waterbodies that do not have boat stewards.
- Encourage additional research on the effectiveness of boat launch steward programs.
- Encourage additional research on the levels of risk of AIS establishment and relatedness to waterbody characteristics.
- To the extent possible, utilize a consistent set of questions, potential responses, and location names from year to year to increase the ability to merge information across years and use WISPA data for research purposes.

Literature Cited

Barker, K., L. Fong, S. Grossman, C. Quin, and R. Reid. 1994. Comparison of self-reported recycling attitudes and behaviors with actual behavior. Psychological Reports 75(1) https://doi.org/10.2466/pr0.1994.75.1.571

Cole, E., P. Reuben, and K. Garbach. 2019. Risk of invasive species spread by recreational boaters remains high despite widespread adoption of conservation behaviors. Journal of Environmental Management, 229, 112-119.

Comeau, S., S. Rainville, W. Baldwin, and E. Austin, E. 2001. Susceptibility of quagga mussels (*Dreissna rostiformis bugensis*) to hot-water sprays as a means of watercraft decontamination. Biofouling 27(3):267-274.

Drury, K.L.S., and J.D. Rothlisberger. 2008. Offense and defense in landscape-level invasion control. Oikos 117(2):1-14.

GLRI. 2018. Great Lakes Restoration Initiative Report to Congress and the President, Fiscal Year 2017. Retrieved from https://www.glri.us/documents on February 10, 2019.

Hamilton, L.C. 1985. Self-reported and actual savings in a water conservation campaign. Environment and Behavior 17(3) https://doi.org/10.1177/0013916585173003

Johnson, L.E., A. Ricciardi, and J.T. Carlton. 2001. Overland dispersal of aquatic invasive species: a risk assessment of transient recreational boating. Ecological Applications 11(6):1789-1799.

Junco, R. 2013. Comparing actual and self-reported measures of Facebook use. Computers in Human Behavior 29(3): 626-631.

Leung, B., J.M. Bossenbroek, and D.M. Lodge. 2006. Boats, pathways, and aquatic biological invasions: estimating dispersal potential with gravity models. Biological Invasions 8:241-254.

Lin, M., H.C. Lucas, Jr., and G. Shmueli. 2013. Too big to fail: large sample sizes and the *p*-value problem. Information Systems Research 24(4), https://doi.org/10.1287/isre.2013.0480

Morse, J. 2009. Assessing the effects of application time and temperature on the efficacy of hot-water sprays to mitigate fouling by *Dreissena polymorpha* (zebra mussels Pallas). Biofouling 27(3):267-274.

Nichols, A.L. 2013. Actual vs reported behavior: increasing handwashing in public restrooms. European Journal of Psychology https://doi.org/10.1024/1421-0185/a000119

NYSAISMP. 2015. New York State Aquatic Invasive Species Management Plan. July 2015. Retrieved from https://www.dec.ny.gov/docs/fish_marine_pdf/nysaisplan15.pdf on February 10, 2019.

Rothlisberger, J.D., W.L. Chadderton, J. McNulty, and D.M. Lodge. 2010. Aquatic invasive species transport via trailered boats: what is being moved, who is moving it, and what can be done. Fisheries 35(3):121-132.

Seekamp, E., A. McCreary, J. Mayer, S. Zack, P. Charlebois, and L. Pasternak. 2016. Exploring the efficacy of an aquatic invasive species prevention campaign among water recreationists. Biological invasions 18(6):1745-1758.

Shackleton, R.T., T. Adriaens, G. Brundu, K. Dehnen-Schmutz, R.A. Estévez, J. Fried, and M.C. Moshobane. 2019. Stakeholder engagement in the study and management of invasive alien species. Journal of Environmental Management 229:88-101.

Stewart-Koster, B., J.D. Olden, and P.T.J. Johnson. 2015. Integrating landscape connectivity and habitat suitability to guide offensive and defensive invasive species management.

Wallen, K.E., and G.T. Kyle. 2018. The efficacy of message frames on recreational boaters' aquatic invasive species mitigation behavioral intentions. Human Dimensions of Wildlife 23(4): 297-312.

Watercraft Inspection Steward Program Application. 2021. New York State watercraft inspection program database; [cited 1 May 2021]. https://www.nyimapinvasives.org/wispa.