

Angler Awareness of Aquatic Invasive Species in Manitoba

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ABSTRACT

Aquatic invasive species (AIS) surveys were administered face-to-face to shore anglers, anglers using boats, and non-anglers in southern Manitoba between 1999 and 2002. Sixty-two percent of all surveyed were aware of purple loosestrife while 52% correctly answered that purple loosestrife was present in Manitoba. Sixty-nine percent of respondents were aware of zebra mussels while 50% correctly replied that they were not present in Manitoba. Only 15% of those surveyed could name another AIS with Eurasian watermilfoil being the aquatic plant most often cited, and 95% felt it is important to continue to monitor for AIS. Anglers using boats were found to have a higher AIS awareness level when compared to shore anglers and non-anglers. Anglers with the lowest awareness scores were the 0-20 year of age group, followed by shore anglers, and non-anglers. High levels of AIS awareness

were found in the 40+ year age group, followed by tournament anglers, 21-40 years of age, and anglers using boats. Anglers using live bait provide a pathway for further invasive species introductions. Anglers reported using a variety of methods to dispose of their unused live bait, however an alarming 25% reported returning unused live bait directly back into the waterbody where they were fishing. Survey results identified awareness "gaps" that should be addressed by aquatic plant and AIS awareness initiatives.

Key words: Aquatic invasive plants, invasive species awareness, purple loosestrife, zebra mussels, angling.

INTRODUCTION

Alien invasive species (AIS) have both environmental and economic impacts upon our natural ecosystems. Aquatic plants such as purple loosestrife (*Lythrum salicaria* L.), Eurasian watermilfoil (*Myriophyllum spicatum* L.), water hyacinth (*Eichhornia crassipes* (Martius) Solms), and hydrilla (*Hydrilla verticillata* (L.f.) Royle) are all examples of AIS that have caused unexpected ecological and economic impact (Great

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Lakes Commission 1996). It is estimated that 79 alien species alone cost the United States economy \$97 billion dollars from 1906 to 1991 (Stein and Flack 1996). In a more recent examinations, Pimentel et al. (2005) estimated that the economic damages associated with the more than 50,000 alien invasive species cost the United States economy \$120 billion/year. It is estimated that aquatic weeds cost \$100 million annually in control costs and a further \$10 million annually in losses and damages (Pimentel et al. 2005, Office of Technology Assessment 1993). In the Great Lakes Basin alone, at least 160 alien aquatic species have become established since the early 1800s (Office of the Auditor General 2002, Great Lakes Commission 1996).

Introductions and dispersal of aquatic invasive species in North American have resulted from escapes from aquaculture trade, sport fish stocking, ballast releases, recreational boating, and the live bait industry (Dextrase 2002, Johnson et al. 2001, Ludwig and Leitch 1996). Fish introductions have included government-sanctioned and illegal introductions by private individuals (Dextrase and Coscarelli 1999). Introduced fish species have been implicated in the decline of native fishes in North America (Wright 2002).

Anglers contribute inadvertently as well as intentionally to the dispersal of aquatic species including invasive aquatic plants (Dextrase and Coscarelli 1999, Ladd et al. 2001, Ludwig and Leitch 1996). Many of these introductions are overland and between non-connected waterbodies. For example, Eurasian zebra mussels (*Dreissena polymorpha* Pallas) are known have been transported overland by transient recreational boating (Buchan and Padilla 1999, Johnson et al. 2001, Johnson 1995). Invasive biota may also take the form of microscopic organisms in live wells or in bait buckets to aquatic plant materials (and seeds) attached to trailers and/or motors, and angler footwear.

The aquatic invasive plant purple loosestrife is recognized as an AIS having deleterious impacts on Manitoba's aquatic areas. Surveys conducted in Manitoba indicated that in 1991 there were 38 populations of purple loosestrife in Manitoba and by the fall of 2001, there were 492 populations covering an estimated 5,575 ha, a dramatic 13-fold increase (Lindgren 2003). While the economic impact of purple loosestrife in Manitoba has not yet been assessed, it is estimated to cost the United States \$45 million per year in control and forage losses (Pimentel et al. 2001).

Eurasian zebra mussels have yet to invade Manitoba, however established populations have been confirmed to the east of Manitoba in Thunder Bay, Duluth and to the south of Manitoba in the upper Mississippi river near Minneapolis, Minnesota (Ralley 2002). Recreational boating is perceived as the primary pathway for further overland introductions of zebra mussels into novel regions (Buchan and Padilla 1999; Johnson et al. 2001) including Manitoba. For example, dead zebra mussels and larvae were found attached to a recreational boat that was transported from Lake Simcoe, Ontario into Manitoba in 1999 (Ralley 2002).

The objective of this survey was to measure angler awareness of AIS based upon knowledge of the aquatic invasive plant purple loosestrife and zebra mussels as well as angler awareness of other AIS species. Purple loosestrife and zebra mussels were selected to measure AIS awareness as both are

recognized as high impact aquatic invasive species. Purple loosestrife was selected because it has invaded all the major river systems in southern Manitoba and zebra mussels were selected as they are an AIS having deleterious ecological impacts on many North America ecosystems, but have not yet established in Manitoba. The survey was also designed to examine angler use and disposal of live bait as well the extent anglers travel.

METHODS

AIS surveys were administered "face-to-face" to anglers using boats (hereafter referred to as boaters), shore anglers, and non-anglers. Non-anglers were respondents who were not in the act of angling, for example those surveyed at boat shows. Boater surveys were administered at boat launches in the Selkirk/Lockport (Red River) and Pine Falls (Winnipeg River) areas in southern Manitoba, Canada. Boaters (on a personal boat) were approached either prior to boat launching or upon egress from the water. Surveyors introduced themselves by explaining that they were conducting an AIS survey and asked respondents for permission to conduct the survey. Once the survey was complete, the surveyor provided them with an information pamphlet and an AIS education bait bucket sticker. Information on respondent's age was collected by visual estimation. Respondents were categorized as <21 years, 21-40 years of age and 40 + years.

Respondents were asked if they were aware of purple loosestrife and zebra mussels, if they knew if either species were present in Manitoba, and if they could name an additional AIS other than purple loosestrife or zebra mussel. Additionally they were asked 1) where they were from, 2) how many times a year they angled, 3) the last three waterbodies in which they had angled, 4) where they were going to angle next, 5) did they feel it was important to monitor for aquatic invasive species, 6) did they check their boat and trailer for zebra mussels or purple loosestrife, 7) were they angling with live bait, 8) what type of bait were they using, 9) where was the live bait purchased, 10) did they catch their own live bait, 11) how did they dispose of live bait, and 12) did they drain live wells after each use. An AIS awareness score was calculated for each respondent based on his or her answers to the above questions (Table 1). A mean awareness score was cal-

TABLE 1. CRITERIA USED TO CALCULATE AQUATIC INVASIVE SPECIES AWARENESS SCORES. AN AWARENESS SCORE WAS CALCULATED FOR EACH RESPONDENT BASED UPON ANSWERS TO SURVEY QUESTIONS INCLUDING THEIR KNOWLEDGE OF PURPLE LOOSESTRIFE (PL) AND ZEBRA MUSSELS (ZM).

Score	AIS Awareness Index Criteria
7	All answers correct and able to name at least 1 other AIS.
6	All Answers correct.
5	Aware of ZM and PL, wrong or unsure about presence of ZM.
4	Aware of ZM and PL, wrong or unsure about presence of PL.
3	Aware of ZM and PL, wrong or unsure about presence of both.
2	Aware of ZM only, know presence of ZM.
1	Aware of ZM only, wrong or unsure about presence of ZM.
2	Aware of PL only, know presence of PL.
1	Aware of PL only, wrong or unsure about presence of PL.
0	Unaware of AIS.

culated for each group of interest based upon the individual scores. The mean awareness score can be used to assess future changes in AIS awareness. A one-way analysis of variance (ANOVA) was used to analyze the mean awareness scores and multiple comparisons (Tukey adjustment) were conducted (see Conover and Iman 1981). Spearman's correlation (for ordinal data) was used post-hoc to test for strength of relationship between the number of days spent angling per year and a respondents AIS awareness score.

RESULTS AND DISCUSSION

A total of 1,470 individual surveys were administered between 1999-2002. Of these, 903 were administered to boaters, 370 to shore anglers and 197 to non-anglers. Surveys were administered to 1,270 males and 200 females. An ANOVA found the effect of group was statistically significant ($F = 16.62$, $df = 7$, 3263 ; $p < 0.0001$). Multiple comparisons (Tukey adjustment) of the least square means indicated the 0-20 year age group and shore anglers had significantly lower levels of AIS awareness when compared to the other groups (Table 2). Survey results indicated an overall AIS awareness score of 3.19 of a possible maximum score of 7.0.

Anglers using boats had a higher level of AIS awareness when compared to non-anglers and shore anglers (Table 2). These anglers may be exposed to higher levels of AIS awareness materials such as signage at boat launching sites, fish rulers, bait-bucket stickers, and information at roadside inspections. Anglers using boats fishing an average of 37.3 days a year while shore anglers and non-anglers reported fishing 16.9 and 13.4 days a year respectively. Hence anglers using boats may be exposed to more educational programs and materials.

Respondents in the 21-40 and 40+ age groups were found to have higher levels of AIS awareness when compared to younger respondents (<20 years) (Table 2). Anglers <20 years of age reported fishing an average of 20.5 days a year while anglers 21-40 and 40+ years of age fished an average of 31.2 and 28.5 days a year respectively. A weak positive relationship (Spearman's $\rho = 0.07$, p -value = 0.01, $df = 990$) was found between the number of days spent angling per year and AIS awareness scores. Anglers who fish more may be exposed to more AIS educational materials.

Sixty-two percent of respondents were aware of purple loosestrife while 52% knew that purple loosestrife was present in Manitoba (Table 3). Awareness of zebra mussels

was similar with 69% of respondents aware of zebra mussels and 50% correctly responding that they were not present in Manitoba (Table 3). Only 15% of those surveyed could name another AIS and many of those were not actual AIS. When asked to name another AIS, respondents provided twenty-six different answers with common carp (42%), rainbow smelt (21%), and the aquatic invasive plant Eurasian watermilfoil (13%) being the most frequent answers.

A greater number of Manitobans were aware of purple loosestrife as opposed to Americans (Table 4). Fifty-eight percent of Manitobans correctly answered that purple loosestrife was present in Manitoba while 67% of Americans did not know. Ninety percent of Americans were aware of zebra mussels compared to 75% of Manitobans.

The data indicated many anglers enter Manitoba watersheds unaware of what AIS are in Manitoba and unaware of what AIS were present in the last watershed they angled or boated. Aquatic plant managers and extension agencies need to expand AIS educational efforts so that anglers and boaters are aware of AIS both in their watershed and in adjacent watersheds frequently visited. For example, it is critical that non-resident anglers and boaters coming from watersheds invaded by zebra mussels are aware that zebra mussels are not found in Manitoba and the appropriate precautions should be taken to prevent such introductions.

Based on AIS awareness scores, boaters were found to have a statistically higher AIS awareness level when compared to shore anglers and non-anglers (Table 2). Seventy percent of boaters were aware of purple loosestrife compared to 47% of shore anglers and 54% of non-anglers (Table 5). When asked if purple loosestrife was present in Manitoba, 59% of boaters, 39% of non-anglers and 42% of shore anglers answered correctly. Awareness of other AIS was low across all three survey groups while at least 92% felt that it is important to continue to monitor for AIS. Eighty-nine percent of boaters, 53% of shore anglers, and 64% of non-anglers were aware of zebra mussels. Fifty-four percent of all boaters, 49% of shore anglers and 34% of non-anglers correctly answered that zebra mussels were not present in Manitoban waterways.

Past AIS surveys have reported varying degrees of AIS awareness. A zebra mussel awareness survey conducted in 1995 at Toledo Bend (a large man-made body of water in western Louisiana), found that 41% of boaters were aware of zebra mussels (Henning et al. 1997). A similar survey conducted in 1993 in western Connecticut found that 73% of

TABLE 2. AQUATIC INVASIVE SPECIES (AIS) AWARENESS SCORES. OVERALL, ANGLERS USING BOATS WERE FOUND TO BE MOST AWARE OF AIS. SURVEY DATA WERE COLLECTED BETWEEN 1999-2002 IN SOUTHERN MANITOBA.

Group	N	Score AIS	Least square mean	Standard error	Multiple comparisons
<20 Years of Age	106	2.07	2.08	0.22	A*
Shore Anglers	371	2.39	2.40	0.12	A
Non Anglers	198	2.76	2.77	0.16	AB
40+ Years of Age	603	3.21	3.22	0.09	BC
Tournament Anglers	296	3.31	3.31	0.13	BCD
21-40 Years of Age	746	3.35	3.35	0.08	CD
Anglers with Boats	902	3.61	3.62	0.08	D

*Groups with the same capital letters are not statistically different.

TABLE 3. SUMMARY TABLE OF RESPONDENTS' ANSWERS TO SURVEY QUESTIONS. SURVEY DATA WERE COLLECTED BETWEEN 1999-2002 IN SOUTHERN MANITOBA.

Survey question	Yes	No	Don't know
Aware of purple loosestrife?	62%	38%	n/a
Is purple loosestrife in Manitoba?	52%	21%	27%
Aware of zebra mussels?	69%	31%	n/a
Are zebra mussels in Manitoba?	21%	50%	29%
Can you name another AIS?	15%	70%	15%
Is it important to monitor for AIS?	95%	5%	n/a

boaters and 95.4% of individuals with fishing boats were aware of zebra mussels while 41% and 75.9% respectively, knew their boats represented a mechanism for spreading zebra mussels (Balcom and Rohmer 1993).

Survey respondents were divided into three age groups based upon estimation of respondents' age by the surveyors, <20 years of age, 21-40 years of age, and 40+ years of age. Respondents in the 21-40 age group were significantly "more aware" of AIS when compared to the other two groups (Table 2). All respondents were slightly more aware of zebra mussels than purple loosestrife, about 15% could name another AIS and over 92% indicated it was important to continue to monitor for AIS (Table 6).

Boaters and anglers represent a high risk pathway for AIS introductions especially those that travel between unconnected waterbodies (Balcom and Rohmer 1993, Dextrase 2002). The results of this survey found 16% of all boaters crossed the Ontario/Manitoba border, 13% indicated they crossed the Canada/USA border, <1% crossed the Saskatchewan border, and 71% indicated that they had previously angled outside of Manitoba. Respondents indicated they last boated or angled in Ontario (including Lake Superior), Minnesota, Alberta, British Columbia, Saskatchewan, North Dakota (including Devils Lake and the Missouri River), South Dakota, Texas, New York, Nova Scotia, Nebraska, Missouri, Iowa, Colorado, and Wisconsin—all regions with AIS not presently established in Manitoba. A similar Manitoba based survey found that in the five days preceding the survey 93% of the boats had recently been in waters known to have zebra mussels, and 31% of those surveyed incorrectly stated that zebra mussels were not present in their waterbody of origin (Fish Futures, Inc. 1994). Kiesling (1994) found 26% of respondents from Minnesota, Wisconsin and Ohio

boated or fished in waters they knew contained zebra mussels, Eurasian watermilfoil or the spiny water flea (*Bythotrephes longimanus*). Anglers and boaters travel long distances and overland between unconnected watersheds that contain AIS prior to entering Manitoba. Aquatic plant managers and invasive species managers need to address potential AIS introductions as a result of anglers and boaters traveling between states, provinces, and unconnected watersheds with and without AIS.

Dextrase (2002) noted that the use of live bait has long been recognized as a pathway for AIS introductions. Ludwig and Leitch (1996) reported that anglers are known to transport live bait across basin boundaries. Several AIS fish and one mollusk have been introduced into the Great Lakes basin through the use of live bait (Mills et al. 1993). Improved technologies have allowed anglers to travel greater distances with live bait thus increasing the potential for AIS introductions (Ludwig and Leitch 1996). This study found that 35% of Manitobans and 38% of Americans reported they used live bait while angling. Thirty-nine percent of boaters, and 21% of shore anglers used live bait with 10% and 8%, respectively, catching their own bait. Respondents reported using the following types of live bait, minnows (80%), leaches (13%), worms (3%), night crawlers (3%), crayfish (<1%) and chubs (<1%). These data are slightly lower than those reported by Ludwig and Leitch (1996) who found that 57% of anglers in North Dakota used live bait with only 4% capturing their own bait. These data are however higher than data reported by Balcom and Rohmer (1994) who found 14.6% of Connecticut anglers reported using live bait.

A variety of methods were used to dispose of unused live bait. Of management concern is the finding that 25% of all anglers using live bait disposed of their unused bait directly into the waterbody where they were fishing. Other modes of disposal reported included killing (28%), using up (23%) and keeping (17%). A survey conducted in Ontario by Litvak and Mandrak (1993) reported that 41% of anglers released unused baitfish directly back into the waterbody, and in doing so anglers reported they thought they were doing something beneficial for the ecosystem. Baitfish introductions are known to cause habitat alteration, trophic alteration, spatial alteration, gene pool deterioration and introduce diseases (Kohler and Courtenay 1986). Ludwig and Leitch (1996) concluded that aquatic biota would continue to be introduced across major water basin boundaries by anglers and

TABLE 4. A COMPARISON OF MANITOBA AND AMERICAN RESPONSES TO THE AQUATIC INVASIVE SPECIES SURVEY. SURVEY DATA WERE COLLECTED BETWEEN 1999-2002 IN SOUTHERN MANITOBA. CORRECT ANSWERS ARE SHADED IN GREY.

	Aware of ZM?	Are ZM in MB?	Aware of PL?	Is PL in MB?	Name another AIS?
Manitobans (N = 1,208)					
Don't Know	n/a	26%	n/a	21%	n/a
No	25%	52%	34%	21%	86%
Yes	75%	22%	66%	58%	14%
Americans (N = 196)					
Don't Know	n/a	50%	n/a	67%	n/a
No	10%	39%	65%	26%	86%
Yes	90%	11%	35%	7%	14%

TABLE 5. COMPARISONS OF BOATERS (ANGLERS USING BOATS) (BT), SHORE ANGLERS (SA), AND NON-ANGLERS (NA) AWARENESS OF AIS. SURVEYS WERE CONDUCTED IN MANITOBA ALONG THE RED RIVER AND WINNIPEG RIVER BETWEEN 1999-2002. CORRECT ANSWERS ARE SHADED GREY.

Survey question	Yes			No			Don't know		
	BT	SA	NA	BT	SA	NA	BT	SA	NA
Aware of purple loosestrife?	70%	47%	54%	30%	53%	46%	na	na	na
Is purple loosestrife in Manitoba?	59%	39%	42%	14%	37%	26%	27%	24%	32%
Aware of zebra mussels?	89%	53%	64%	11%	47%	36%	na	na	na
Are zebra mussels in Manitoba?	22%	18%	22%	54%	49%	34%	24%	33%	44%
Can you name another AIS?	16%	13%	12%	74%	65%	59%	10%	22%	29%
Is it important to monitor for AIS?	97%	92%	97%	3%	8%	3%	na	na	na

TABLE 6. COMPARISON OF RESPONSES OF DIFFERENT AGE GROUPS TO THE AQUATIC INVASIVE SPECIES SURVEY QUESTIONS. SURVEY DATA WERE COLLECTED IN SOUTHERN MANITOBA BETWEEN 1999-2002. CORRECT RESPONSES ARE SHADED IN GREY.

Survey question	Yes			No			Don't know		
	<20	21-40	40+	<20	21-40	40+	<20	21-40	40+
Aware of purple loosestrife?	45%	63%	64%	55%	37%	36%	na	na	na
Is purple loosestrife in Manitoba?	30%	54%	54%	32%	18%	24%	39%	28%	22%
Aware of zebra mussels?	47%	79%	78%	53%	21%	22%	na	na	na
Are zebra mussels in Manitoba?	9%	24%	22%	38%	48%	54%	53%	28%	24%
Can you name another AIS?	15%	14%	15%	44%	71%	73%	44%	15%	12%
Is it important to monitor for AIS?	92%	92%	95%	8%	2%	5%	na	na	na

bait vendors. Litvak and Mandrak (1993) noted that legislation appears insufficient to prevent introduction of AIS including live bait into non-native ecosystems. The data presented indicate that AIS educational programs need to educate anglers on proper disposal of unused live bait.

Water held in bait-buckets and live-wells can transport seeds of invasive aquatic plants over long distances and between un-invaded and invaded watersheds. For example, at the Pembina (North Dakota, United States) Emerson (Manitoba, Canada) border crossing, discarded waters from bait-buckets and live-wells contained seed that established a purple loosestrife population (Carl Wall, Manitoba Conservation, personal communication 2002). In this study, 92% of respondents indicated that they drained their livewells after each use. Aquatic plant managers and invasive species managers must also manage for potential AIS introductions at "draining" sites. When questioned about how often boaters check their equipment (boats, trailers and motors) for zebra mussels and aquatic vegetation, 94% of Manitobans and 93% of Americans always drained live wells after use.

Fifty-five percent of anglers indicated that they checked their boat for zebra mussels and for attached aquatic vegetation after use. Kiesling (1994) found that 79% of boaters from Minnesota, Wisconsin and Ohio visually inspected their equipment, while 60% of boaters cleaned vegetation or mussels from their boat and equipment. A survey conducted in the Twin Cities Metropolitan Area (Office of Planning 1997) reported that over 90% of boaters conducted visual inspections and cleaned vegetation or zebra mussels from their boat. When asked if respondents check their boating equipment for attached vegetation or zebra mussels, 52% of Manitobans indicated that they always visually inspected their equipment,

44% never inspect and 4% sometimes inspect. In comparison, 78% of Americans reported always inspecting their equipment for zebra mussels and attached vegetation, 20% never inspected and 2% sometimes inspect their boating equipment. The results of this study suggest that AIS programs in Manitoba need to further educate boaters on the importance of checking boats for potential AIS after each use.

The results of this study identify several AIS awareness "gaps" that aquatic plant managers and AIS programs can address. Boater surveys have indicated that newspapers, television, signage at water access points, inspection-education programs delivered at boat landings, brochures, and fact sheets are important sources of AIS education (Kiesling 1994, Office of Planning 1997). Awareness initiatives should target tournament anglers which annually travel long distances, commonly cross provincial and international borders, angle several unconnected waterbodies within a year, and fish more days than the average angler. Travel logs should be considered a tournament registration prerequisite for tournament anglers. Anglers and boaters should also be required to maintain a travel log of all waterbodies visited that can be compared against known AIS distributions at border crossing or at boat launch and roadside inspection programs. Prevention of novel introductions of invasive species such as zebra mussels by recreational boaters should focus on potential points of entry (Drake and Bossenbroek 2004). The importance of aquatic plant and AIS awareness initiatives is further elevated knowing that anglers generally prefer increased levels of aquatic vegetation reporting that aquatic plants help angling success (Henderson et al. 2003). There is a need to establish uniform guidelines for recreational boaters and anglers to minimize the introduction and spread of

AIS species into and between inland waters, as suggested by the Great Lakes Commission (1996).

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