

Summary of a Survey of Baitfish Users in Canada

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ABSTRACT

Ward, J.M., Cudmore, B., Drake, D.A.R., and Mandrak, N.E. 2011. Summary of a survey of baitfish users in Canada. *Can. Manuscr. Rep. Fish. Aquat. Sci.* 2972: v + 22 p.

The Great Canadian Baitfish Survey was an online and paper questionnaire designed to collect information about the practices of baitfish users, relevant to the spread of aquatic invasive species (AIS). A total of 1815 surveys were completed, of which 1625 respondents (90%) indicated they use live baitfishes at least one day per year. The survey results suggest that the use of live baitfishes for angling may be an important vector for the spread of AIS in Canadian freshwaters. Anglers commonly transported and released live bait into waterbodies other than where it was harvested. Notably, 51% and 34% of respondents indicated they release unwanted baitfish species or leftover baitfishes, respectively, into the water. The results of this survey will contribute information to a risk assessment currently being undertaken on this invasion pathway.

RÉSUMÉ

Ward, J.M., Cudmore, B., Drake, D.A.R., and Mandrak, N.E. 2011. Summary of a survey of baitfish users in Canada. *Can. Manuscr. Rep. Fish. Aquat. Sci.* 2972: v + 22 p.

Le *grand sondage canadien sur les appâts* a été publié sur le web et sous forme papier afin de récolter de l'information sur les pratiques d'utilisation d'appâts étant associées à la propagation des espèces aquatiques envahissantes (EAE). Un total de 1815 sondages ont été complétés, dont 1625 des répondants (90%) ont signalé l'utilisation d'appâts vivants au moins une fois par année. Les résultats du sondage suggèrent que l'utilisation d'appâts vivants pour la pêche pourrait constituer un important vecteur à la propagation des EAE dans les plans d'eau douce canadiens. Les pêcheurs transportaient et relâchaient communément les appâts vivants dans des cours d'eau autres que ceux où ils avaient été pêchés. 51% et 34% des répondant ont indiqué qu'ils relâchaient dans les cours d'eau les espèces d'appât non-désirées et les appâts en surplus respectivement. Les résultats de ce sondage vont contribuer à fournir l'information nécessaire à une évaluation du risque présentement menée sur cette voie d'entrée aux espèces invasives

1 INTRODUCTION

Aquatic invasive species (AIS) have been, and will continue to be, introduced into Canadian freshwaters through various vectors, including stocking (authorized and unauthorized), canals and diversions, ballast water, baitfish use, live fish markets, pet stores, and garden centres. An understanding of the relative risk posed by each of these vectors is essential to prioritize and direct prevention efforts. Data exist for stocking (Kerr 2006), canals and diversions (Emery 1981), ballast water (Ricciardi and Rasmussen 1998), and live fish markets (Mandrak and Cudmore 2004; Rixon et al. 2005). Data are poor for baitfishes (Litvak and Mandrak 1993, 1999; Goodchild 1999) and pet stores (Rixon et al. 2005; Gertzen et al. 2008), due to limited sample sizes, and are entirely lacking for garden centres.

Surveys were conducted with partner organizations to determine the origin and fate of AIS in various live trade pathways. Three surveys were developed and directly marketed to aquarium owners, water garden owners, and the users of baitfishes. One of these surveys was the 'Great Canadian Baitfish Survey', which was designed to collect information regarding what, where, and how baitfishes are used for angling in Canadian fresh waters.

The Great Canadian Baitfish Survey was conducted in collaboration with the Ontario Federation of Anglers and Hunters (OFAH), Bait Association of Ontario, University of Toronto, Ontario Ministry of Natural Resources, and Fisheries and Oceans Canada. The survey included questions for baitfish users regarding where they capture or purchase their bait, as well as the types of baitfishes used and disposal mechanisms. The results of the survey will contribute information to a risk assessment currently being undertaken on this pathway.

2 MATERIALS AND METHODS

The Great Canadian Baitfish Survey was distributed as both an online and a paper questionnaire. The online version of the survey was developed using SurveyMonkey (www.surveymonkey.com) and advertised on the Ontario Ministry of Natural Resources website and various conservation websites throughout Ontario, trade shows, as well as through flyers and posters distributed to bait shops and other angling retailers.

The survey was first distributed to Ontario recipients at the Spring Fishing Show held in Toronto, ON, 16–19 April, 2006. Both paper and online versions of the survey were provided in a trade show booth designed specifically for survey respondents. Individuals who were unable to complete the survey at the trade show booth were provided with information on how to access the website (through promotional material including magnets, mouse pads, and pens that advertised the survey and included the website address), and paper copies were distributed to those individuals preferring that format. Completed paper copies of the survey were subsequently entered into the online database for analysis.

Following the Spring Fishing Show, the survey was advertised at additional trade shows (Toronto Sportsman's Show, Toronto, ON, 15–19 March, 2006; Hamilton Harbour Fishing Derby, Hamilton, ON, 18 May, 2006), in several newsletters and magazines (e.g., Newsletter of the American Fisheries Society – Ontario Chapter), within the recreational fishing regulation summary in Ontario (2005–2006 Recreational Fishing Regulations Summary, Ontario Ministry of Natural Resources), at fishing retailers and marinas, and online through various partner organizations involved in the baitfish trade. In addition, paper surveys ($n = 5,000$) were distributed by mail using a stratified random process to ensure geographic coverage consistent with the spatial densities of licensed anglers in Ontario. Recipients of mailout surveys were randomly selected anglers in Ontario who held valid fishing licenses for the 2007 season (i.e., anglers in Ontario greater than or equal to 18 years old and less than 65 years old).

The survey was comprised of 16 questions, most of which were multiple-choice format (see Appendix 1 for survey contents). These consisted of questions regarding the self-harvest, purchase, transport, and release of baitfishes by anglers. The intention was to create a survey that was succinct, so that individuals would complete it, while providing as much relevant detail as possible for informing the risk assessment. Each survey required approximately 10 minutes to complete. A second component of the survey concerning fish identification skill was distributed to a subset of respondents; however, due to reduced distribution, the results are omitted here.

Some of the questions (5, 8, 9, 12, 14, and 16) provided the option for free-form responses, which were subsequently interpreted and, where appropriate, were placed in the provided response categories. The interpretation of these 'other' responses resulted in very few answers that were not consistent with the categories provided; as such, additional 'other' categories (i.e., alternative responses) were not included in this analysis.

3 RESULTS

3.1 NUMBER AND GEOGRAPHICAL DISTRIBUTION OF SURVEY RESPONDENTS

Online and paper surveys were completed by a total of 1815 respondents; however, 187 of those surveyed (10%) reported that they never use live baitfishes, eliminating further response throughout the survey. A total of 1625 respondents (90%) indicated that they use live baitfishes at least one day per year.

While many of the questions were described as mandatory to complete in order to proceed to the next question in the online version of the survey, many were not completed, or were improperly completed. In addition, many respondents failed to provide responses to several questions; for example, 186 respondents did not indicate whether they catch their own baitfishes. Therefore, the sample size varies among questions, and such inconsistent responses may provide a misinformed understanding of certain activities. As well, many respondents gave multiple answers for several of the questions (e.g., disposed of leftover baitfishes in multiple ways), causing the cumulative

number of answers to be greater than the total number of respondents for certain questions.

The survey asked respondents to provide the postal code for their permanent place of residence. This information was used to identify the geographical distribution of respondents within Ontario (Figure 1). Of the 1815 respondents that completed the survey, 1792 provided their home postal code. Of those, 619 were located in the 'Greater Toronto Area (GTA) and surrounding region' (Postal Unit L), 356 in 'southwestern Ontario' (Postal Unit N), 282 in 'northern Ontario' (Postal Unit P), 279 in 'eastern Ontario' (Postal Unit K), and 167 in 'metropolitan Toronto' (Postal Unit M). Eighty-nine respondents provided home postal (or zip) codes corresponding to areas outside of Ontario, including 33 from Manitoba and 20 from outside of Canada.

3.2 FREQUENCY OF BAITFISH USE

The survey asked respondents how often they use live baitfishes during the year. Of the 1625 respondents who indicated that they do use live baitfishes, 48% reported that they use live baitfishes eleven days or more per year. Twenty-six percent of respondents indicated that they use live baitfishes between two and five days per year, 20% specified between six and ten days per year, and 6% specified one day per year (Figure 2).

3.3 BAITFISHES HARVESTED BY RESPONDENTS

The survey included several questions regarding whether, where, and how respondents use baitfishes they harvest themselves. There were a total of 1629 respondents who indicated how often they catch their own baitfishes. Of those, 48% indicated that they sometimes catch their own baitfishes, 44% indicated that they never catch their own baitfishes, and 8% indicated that they always catch their own baitfishes (Figure 3). The next five questions in the survey were directed toward respondents who catch their own baitfishes at least some of the time.

A total of 848 respondents indicated how they self-harvested baitfishes. Respondents most often reported that they use minnow traps (83%), followed by dip nets (35%) (Figure 4). The total of the percentages is greater than 100 because 151 respondents (18%) used both methods to capture baitfishes.

There were a total of 910 respondents who indicated where they use the baitfishes they catch. Respondents most often reported that they use baitfishes in the same waters where they are caught (75%), while 38% of respondents indicated that they use baitfishes in waters other than where they are caught (Figure 5). The total of the percentages is greater than 100 because 114 respondents (13%) gave both answers, indicating that both behaviours occur for those respondents within a given year.

In total, 910 respondents indicated whether they sort (i.e., purposefully select) certain fishes when harvesting their own bait. Of those, 63% indicated that they sort the fish they catch, while 37% reported that they do not sort their catch (Figure 6).

Respondents who sort their catch were asked to specify which species they keep to use as bait. A total of 878 respondents indicated at least one type of baitfish. Respondents most commonly indicated that they kept shiners (77%), chubs (58%), crayfishes (47%), suckers (42%), and dace (31%). Respondents also reported that they kept perch (19%), sticklebacks (13%), darters (12%), basses (7%), carps (4%), gobies (4%), sculpins (4%), catfishes (4%), and Goldfish (3%) (Figure 7); however, the accuracy of these identifications remains untested.

Respondents who sort their catch were also asked to specify which species they throw back (i.e., release at point of capture following sorting). A total of 876 respondents indicated at least one type of baitfish. Respondents most commonly indicated that they throw back basses (70%), catfishes (62%), perch (59%), carps (50%), and sticklebacks (44%). Respondents also reported that they throw back sculpins (38%), Goldfish (38%), darters (36%), gobies (31%), suckers (28%), crayfishes (28%), dace (27%), chubs (16%), and shiners (6%) (Figure 8).

3.4 ADDITIONAL BAITFISH ACTIVITY

The survey included several questions regarding whether, where, and how respondents use baitfishes they purchase. A total of 1571 respondents indicated whether they buy baitfishes. Of those, 1437 (91%) indicated that they buy baitfishes at least some of the time. Those respondents who purchase baitfishes most commonly indicated that they buy their baitfishes close to their fishing spot (47%), followed by, on the way to their fishing spot (43%), and close to where they live (36%) (Figure 9). The total of the percentages is greater than 100 because 290 respondents (20%) indicated that they buy baitfishes at multiple locations, indicating multiple behaviours occurring throughout a given year.

There were a total of 1309 respondents who submitted the names of up to three cities or towns where they usually purchase baitfishes. Respondents most commonly indicated that they purchase baitfishes in Orillia, North Bay, Sudbury, Toronto, and Barrie. The top 20 cities or towns where respondents reported that they usually purchase baitfishes are shown in Figure 10.

The final responses pertain to all respondents within the survey (i.e., individuals who indicate that they self-harvest, purchase, or exhibit both behaviours concurrently throughout a given year). Of these individuals, a total of 1435 respondents indicated how they transport their baitfishes. Respondents most commonly reported that they use bait buckets to transport baitfishes (63%), followed by bags with oxygen (30%), and live wells (7%) (Figure 11).

Respondents who either purchased or self-harvested baitfishes were asked to identify the top three lakes or rivers in which they use baitfishes for angling. A total of 1195 respondents submitted the names of at least one location. Respondents most commonly indicated that they use baitfishes for angling in Lake Simcoe and Lake Erie. Other popular locations were Lake Nipissing, Lake Ontario, Lake Scugog, and Georgian

Bay. The 20 most common locations where respondents reported that they use baitfishes for angling are shown in Figure 12.

Respondents were asked to specify which species they sometimes find in their purchased or self-harvested bait and don't like to use. A total of 999 respondents identified at least one type of baitfish. Respondents most commonly indicated that they find, and don't like to use, basses (44%), sticklebacks (41%), catfishes (39%), perches (34%), gobies (29%), and carps (26%). Respondents also reported that they find and don't like to use Goldfish (20%), suckers (20%), sculpins (17%), crayfishes (16%), darters (16%), dace (13%), chubs (10%), and shiners (5%) (Figure 13). As with other responses concerning species-level information, the accuracy of these identifications remains untested.

3.5 DISPOSAL OF UNUSED BAITFISHES

The disposal of unwanted or leftover baitfishes was the focus of the final two questions in the survey. A total of 1148 respondents indicated how they dispose of baitfishes they don't want to use (i.e., species identified in Question 14). Of those, 56% percent reported that they dispose of unwanted baitfishes on land and 51% reported that they release unwanted baitfishes into the water (Figure 14). The total of the percentages is greater than 100 because 91 respondents (8%) dispose of unwanted baitfishes both on land and into the water at different times throughout the year. An additional 362 respondents indicated that they do not dispose of unwanted baitfishes because they use all of them.

In total, 1374 respondents indicated what they do with leftover baitfishes (i.e., those remaining in an angler's possession following an angling event). Respondents most often reported that they give leftover baitfishes to another angler (50%), followed by disposal on land (43%). Respondents also indicated that they release leftover baitfishes into the water (34%), and salt or freeze leftover baitfishes (21%) (Figure 15). The total of the percentages is greater than 100 because 542 respondents (39%) gave multiple answers, indicating the occurrence of multiple behaviours within a year.

4 DISCUSSION

The Great Canadian Baitfish Survey was conducted to collect information regarding what, where, and how baitfishes are used for angling in Canadian freshwaters, with specific regard to how the practices of anglers might influence the spread of aquatic invasive species (AIS). The results of this survey suggest that the trade and use of live fish as bait may represent an important vector for the introduction and spread of AIS in Canada.

Many of the baitfishes listed in this survey and selected by some of the survey respondents (e.g., carps, gobies) are nonindigenous species within Ontario (Table 1); however, assessment of angler fish identification skill by Drake (Department of Ecology and Evolutionary Biology, University of Toronto, Toronto, ON, pers. comm.) suggests that many fishes are frequently misidentified by anglers. While it is difficult to prove that

a particular past introduction was the direct result of baitfish use, several AIS are hypothesized to have been introduced or spread to Canadian freshwaters through the use of live bait, including Rudd (*Scardinius erythrophthalmus*), Round Goby (*Neogobius melanostomus*), Margined Madtom (*Noturus insignis*), and rusty crayfish (*Orconectes rusticus*) (Mills et al. 1993; Goodchild 1999) (Table 1). The original introduction of Goldfish (*Carassius auratus*) to the Great Lakes basin is also thought to have occurred through the release of unused bait into the water (Mills et al. 1993).

The use of live fishes as bait is also a vector for the intracontinental transfer of native species. Many species that are native to North America and commonly used as bait have been introduced to waterbodies where they are not native, or to waterbodies that previously contained reproductively isolated and genetically distinct populations (Goodchild 1999; Litvak and Mandrak 1999). Litvak and Mandrak (1993) identified 12 fishes, four nonindigenous species and eight native species, which exhibit disjunct distributions in Ontario and are hypothesized to have been introduced into areas isolated from their principal ranges by bait bucket transfer (Table 1). In the United States, the live baitfish trade is thought to be responsible for the introduction of 16% of the freshwater fishes that occur beyond their native range (Fuller et al. 1999).

The introduction of baitfish species beyond their native range, or of non-native genotypes within the native range of a fish species, has been associated with negative effects on recipient ecosystems, including the loss or degradation of fish and wildlife habitat, alteration of food webs, competitive displacement of native species, genetic degradation through intragression, and the spread of diseases or parasites (Litvak and Mandrak 1993, 1999; Goodchild 1999). For example, the Round Goby (*Neogobius melanostomus*) and rusty crayfish (*Orconectes rusticus*) have displaced native benthic fishes and crayfishes, respectively, while Goldfish (*Carassius auratus*) and Common Carp (*Cyprinus carpio*) have caused significant alteration to fish and wildlife habitats through the removal of aquatic vegetation and increased turbidity (Goodchild 1999; Global Invasive Species Database 2010).

The use of live baitfishes poses an additional risk of introducing non-target or 'hitchhiking' organisms into waterbodies where they are not native. For example, the use of live fishes as bait may result in the transmission of diseases or parasites through the transfer of infected fish or the contamination of containers used to transport baitfishes (Goodchild 1999). Nonindigenous species possessing planktonic larval stages might also be introduced through the disposal of water in containers used to transport baitfishes; these include spiny water flea (*Bythotrephes cederstroemi*), zebra mussel (*Dreissena polymorpha*), and quagga mussel (*Dreissena bugensis*) (Goodchild 1999). As well, the fertilized eggs of invasive fish species, such as Rainbow Smelt (*Osmerus mordax*), may remain viable after several hours in bait buckets (Franzin et al. 1994). Non-native plants, such as Eurasian watermilfoil (*Myriophyllum spicatum*), may also be transferred by bait bucket release should those species be inadvertently contained within holding water (Goodchild 1999).

The results of this survey indicate that several common practices by anglers may cause the introduction and spread of nonindigenous species in Canada. Many (38%) of the respondents who harvest their own baitfish indicated they use these baitfishes in waters other than where they were harvested. As well, 91% of respondents indicated they purchase baitfishes at least some of the time. Live bait obtained through retail sale is frequently transported to recipient waterbodies other than where it was harvested (Litvak and Mandrak 1993). These results indicate aquatic species are commonly transported to waterbodies other than where they were harvested by anglers in Canada.

This survey indicates aquatic species are commonly released into the water by anglers. More than half of the survey respondents reported they release unwanted baitfish species into the destination waterbody, and more than one third indicated they release leftover baitfishes into the destination waterbody. These figures may misrepresent the actual proportion of anglers that release unused baitfishes, given that respondents may have been aware that the release of live baitfishes is prohibited in Ontario and may have altered their responses accordingly. In comparison, only 1–2% of aquarium owners in Canada reported that they release unwanted aquarium plants or animals into the wild (Marson et al. 2009).

The large proportion of anglers that release unwanted or unused baitfishes into the water is particularly concerning given the baitfish species identified by anglers in this survey. For example, 29% and 20% of anglers indicated that they sometimes find, but don't like to use, gobies and Goldfish, respectively, despite these being illegal baitfish species in Ontario. However, we caution direct interpretation of these results given the uncertainty of correct species identification. An additional six species of illegal baitfishes were detected in a survey of baitfish dealers in Toronto in 1988 (Litvak and Mandrak 1993) (Table 1). In a more recent survey, four species that are nonindigenous to the Great Lakes were purchased from bait dealers located around the southern basin of Lake Michigan: Western Mosquitofish (*Gambusia affinis*), Golden Shiner (*Notemigonus crysoleucas*), Fathead Minnow (*Pimephales promelas*), and rusty crayfish (*Orconectes rusticus*) (Keller and Lodge 2007), indicating the potential for nonindigenous species to be introduced by anglers.

The Great Canadian Baitfish Survey collected additional information about the practices of anglers relevant to the risk assessment of baitfish use as a vector of AIS in Canada. For example, information about the locations where anglers purchase and use baitfishes may be used to determine the transfer distances of baitfishes. In addition, the different methods used by anglers to catch or transport baitfishes may be associated with different risks of introducing non-native baitfish species, or of incidentally transferring non-target or 'hitchhiking' organisms. The results of this survey thus contribute information relevant to future assessments of the risks associated with this pathway.

The results of this survey suggest that aquatic species are commonly transported and released into Canadian waterbodies by baitfish users. A better understanding of how,

where, and what baitfishes are used for angling in Canada is important in order to quantify the risk posed by this vector of aquatic invasive species.

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6 REFERENCES

- Emery, L. 1981. Range extension of Pink Salmon (*Oncorhynchus gorbuscha*) into the lower Great Lakes. *Fisheries* (Bethesda) 6: 7-10.
- Franzin, W.G., Barton, B.A., Remmant, R.A., Wain, D.B., and Page, S.J. 1994. Range extension, present and potential distribution, and possible effects of Rainbow Smelt in Hudson Bay drainage waters of northwestern Ontario, Manitoba, and Minnesota. *North American Journal of Fisheries Management* 14: 65–76.
- Fuller, P.L., Nico, L.G., and Williams, J.D. 1999. Nonindigenous fishes introduced into inland waters of the United States. American Fisheries Society, Bethesda, MD.
- Gertzen, E., Familiar, O., and Leung, B. 2008. Quantifying invasion pathways: fish introductions from the aquarium trade. *Canadian Journal of Fisheries and Aquatic Sciences* 65: 1265–1273.
- Global Invasive Species Database. 2010. www.issq.org/database. (accessed March, 2010).
- Goodchild, C.D. 1999. Ecological impacts of introductions associated with the use of live baitfish. *In* Nonindigenous freshwater organisms: vectors, biology, and impacts. Edited by R. Claudi and J. H. Leach. Lewis Publishers, Boca Raton, FL. pp. 181–200.
- Keller, R.P., and Lodge, D.M. 2007. Species invasions from commerce in live aquatic organisms: problems and possible solutions. *BioScience* 57: 428–436.
- Kerr, S.J. 2006. An historical review of fish culture, stocking and fish transfers in Ontario, 1865–2004. Fish and Wildlife Branch, Ontario Ministry of Natural Resources, Peterborough, ON. 154 p. + appendices.
- Litvak, M.K., and Mandrak, N.E. 1993. Ecology of freshwater baitfish use in Canada and the United States. *Fisheries* 18: 6–13.

- Litvak, M.K., and Mandrak, N.E. 1999. Baitfish trade as a vector of aquatic introductions. *In* Nonindigenous freshwater organisms: vectors, biology, and impacts. Edited by R. Claudi and J. H. Leach. Lewis Publishers, Boca Raton, FL. pp. 163–180.
- Mandrak, N.E., and Cudmore, B. 2004. Biological synopsis of Grass Carp (*Ctenopharyngodon idella*). Canadian Manuscript Report of Fisheries and Aquatic Sciences 2705: v + 44 p.
- Marson, D., Cudmore, B., Drake, D.A.R., and Mandrak, N.E. 2009. Summary of a survey of aquarium owners in Canada. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2905: iv + 20 p.
- Mills, E.L, Leach, J.H., Carlton, J.T., and Secor, C.L. 1993. Exotic species in the Great Lakes: a history of biotic crises and anthropogenic introductions. *Journal of Great Lakes Research* 19: 1–54.
- Ricciardi, A., and Rasmussen, J.B. 1998. Predicting the identity and impact of future biological invaders: a priority for aquatic resource management. *Canadian Journal of Fisheries and Aquatic Sciences* 55: 1759–1765.
- Rixon, C.A.M., Duggan, I.C., Bergeron, N.M.N., Ricciardi, A., and MacIsaac, H.J. 2005. Invasion risks posed by the aquarium trade and live fish markets on the Laurentian Great Lakes. *Biodiversity and Conservation* 14: 1365–1381.

Table 1. Species of concern with regard to aquatic introductions in Ontario

Type of baitfish	Species of concern	
	Scientific name	Common name
Basses	<i>Ambloplites rupestris</i> ⁴	Rock Bass
	<i>Lepomis gibbosus</i> ⁴	Pumpkinseed
	<i>Micropterus dolomieu</i> ⁴	Smallmouth Bass
	<i>Micropterus salmoides</i> ^{1,4}	Largemouth Bass
Catfishes	<i>Ameiurus nebulosus</i> ^{1,4}	Brown Bullhead
	<i>Noturus insignis</i> ^{2,3,5}	Margined Madtom
	<i>Pylodictis olivaris</i> ¹	Flathead Catfish
Carp	<i>Cyprinus carpio</i> ^{1,2,3,4,5}	Common Carp
	<i>Scardinius erythrophthalmus</i> ^{1,2,3,5}	Rudd
Chubs	<i>Nocomis biguttatus</i> ^{3,5}	Hornyhead Chub
	<i>Nocomis micropogon</i> ^{3,5}	River Chub
Crayfishes	<i>Orconectes rusticus</i> ¹	Rusty Crayfish
Dace	<i>Clinostomus elongatus</i> ^{3,5}	Redside Dace
Darters	<i>Percina maculata</i> ³	Blackside Darter
Gobies	<i>Neogobius melanostomus</i> ^{1,2}	Round Goby
	<i>Proterorhinus marmoratus</i> ²	Tube-nose Goby
Goldfish	<i>Carassius auratus</i> ^{1,2,3,5}	Goldfish
Perches	<i>Gymnocephalus cernuus</i> ^{1,2}	Ruffe
	<i>Morone americana</i> ^{1,2}	White Perch
Shiners	<i>Luxilus chrysocephalus</i> ^{3,5}	Striped Shiner
	<i>Notropis buechanani</i> ^{2,5}	Ghost Shiner
Sticklebacks	<i>Apeltes quadracus</i> ²	Fourspine Stickleback
	<i>Gasterosteus aculeatus</i> ^{3,5}	Threespine Stickleback
Suckers	<i>Hypentelium nigricans</i> ^{3,5}	Northern Hogsucker

¹ Species listed as Aquatic Invasive Species (www.issg.org (accessed March, 2010); www.invadingspecies.com (accessed March, 2010)).

² Species listed as Aquatic Nonindigenous Species in the Great Lakes (<http://www.glerl.noaa.gov/res/Programs/glansis/glansis.html>).

³ Species hypothesized to have been introduced by bait bucket transfer in Ontario (Litvak and Mandrak 1999; www.invadingspecies.com (accessed March, 2010)).

⁴ Illegal baitfish species found in holding tanks of Toronto baitfish dealers (Litvak and Mandrak 1993).

⁵ Species with disjunct distribution indicating possible bait bucket transfer within Ontario (Litvak and Mandrak 1993; Mills et al. 1993).

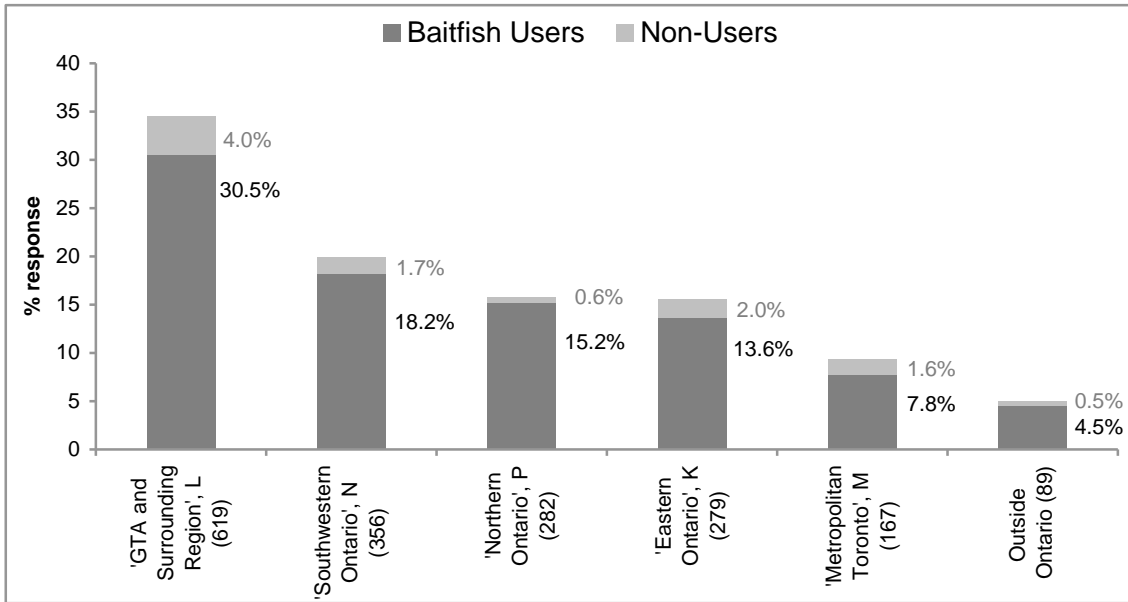


Figure 1. Graphical summary of the geographical distribution of survey respondents based on the first letter of the postal code, determined through responses to survey question #2, asking: 'In what city do you live?'

Values in brackets indicate the number of responses (*n*) corresponding to each selection. Values to the right of each bar indicate the percentage of total respondents corresponding to each selection.

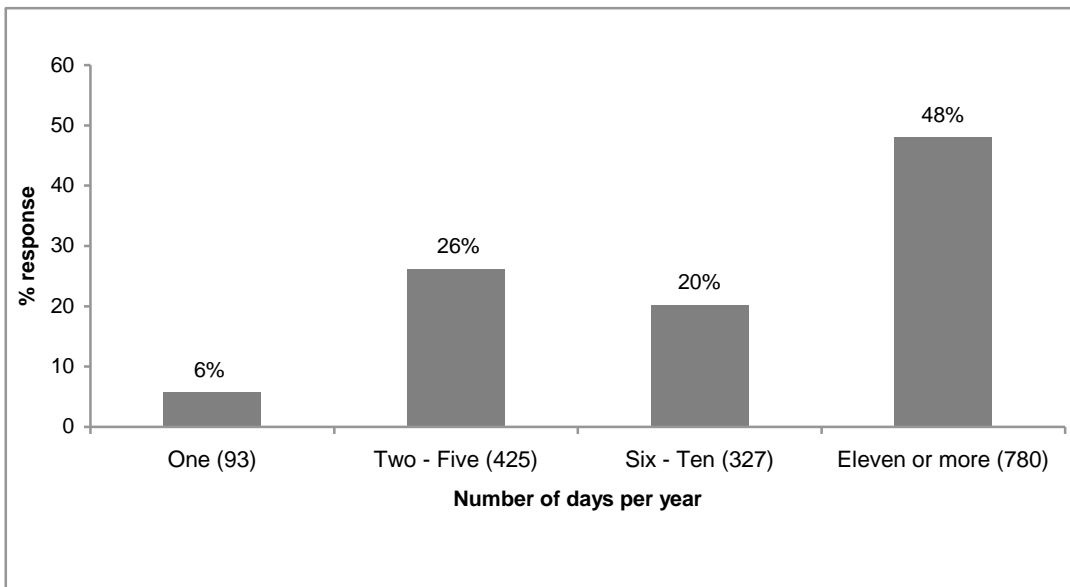


Figure 2. Graphical summary of responses to survey question # 3, asking: 'How often do you use live baitfish during the year?'

Values in brackets indicate the number of responses (*n*) corresponding to each selection. Values above each bar indicate the percentage of total respondents corresponding to each selection.

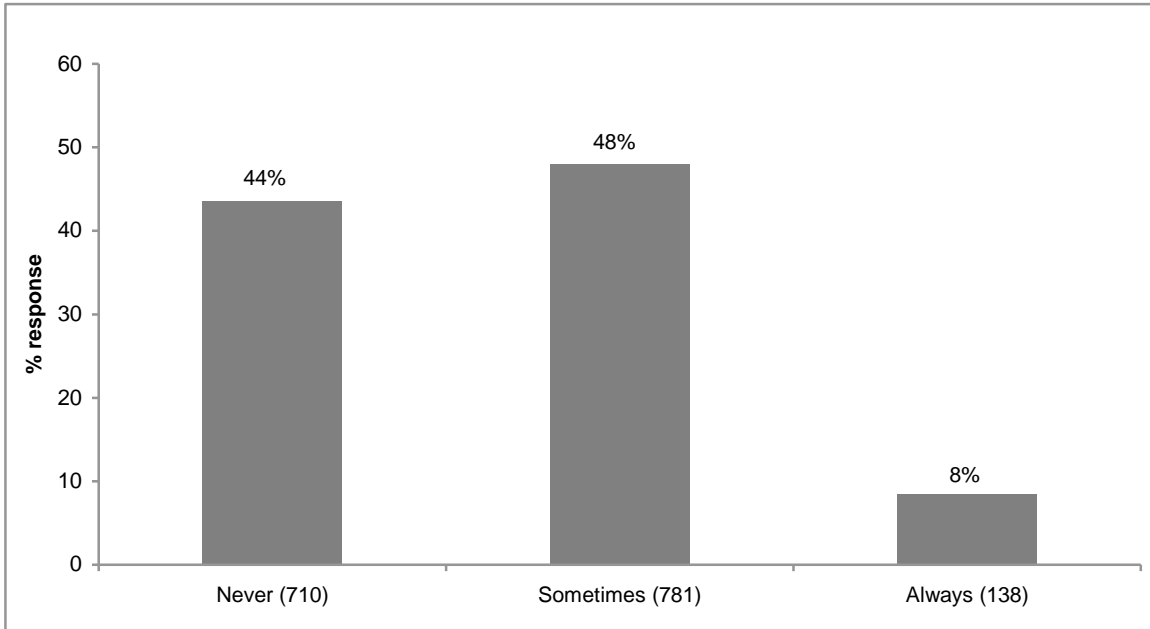


Figure 3. Graphical summary of survey question # 4, asking: ‘Do you catch your own baitfish?’ Values in brackets indicate the number of responses (*n*) corresponding to each selection. Values above each bar indicate the percentage of total respondents corresponding to each selection.

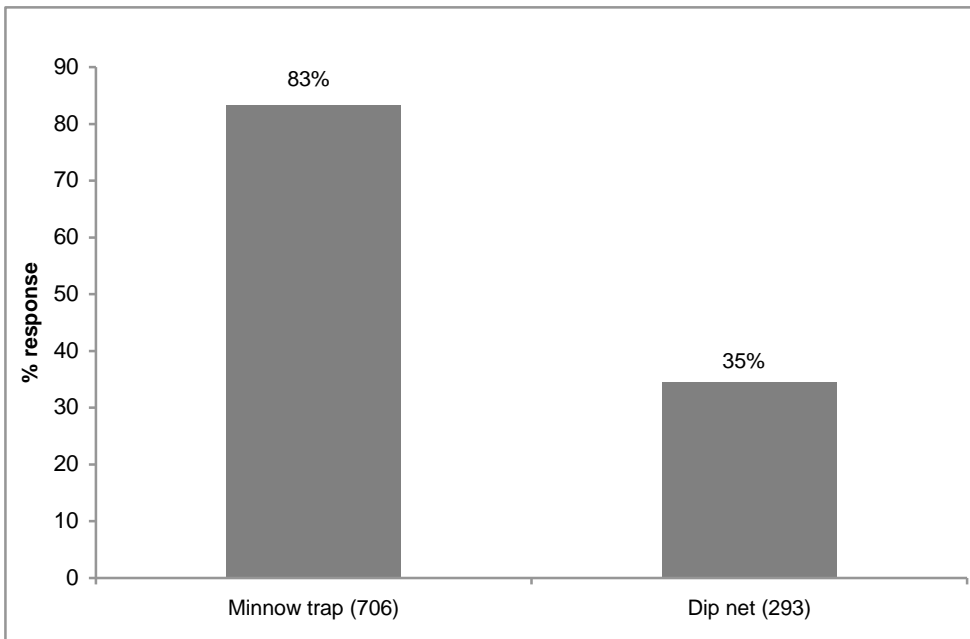


Figure 4. Graphical summary of survey question # 5, asking: ‘How do you catch your baitfish?’ Values in brackets indicate the number of responses (*n*) corresponding to each selection. Values above each bar indicate the percentage of total respondents corresponding to each selection.

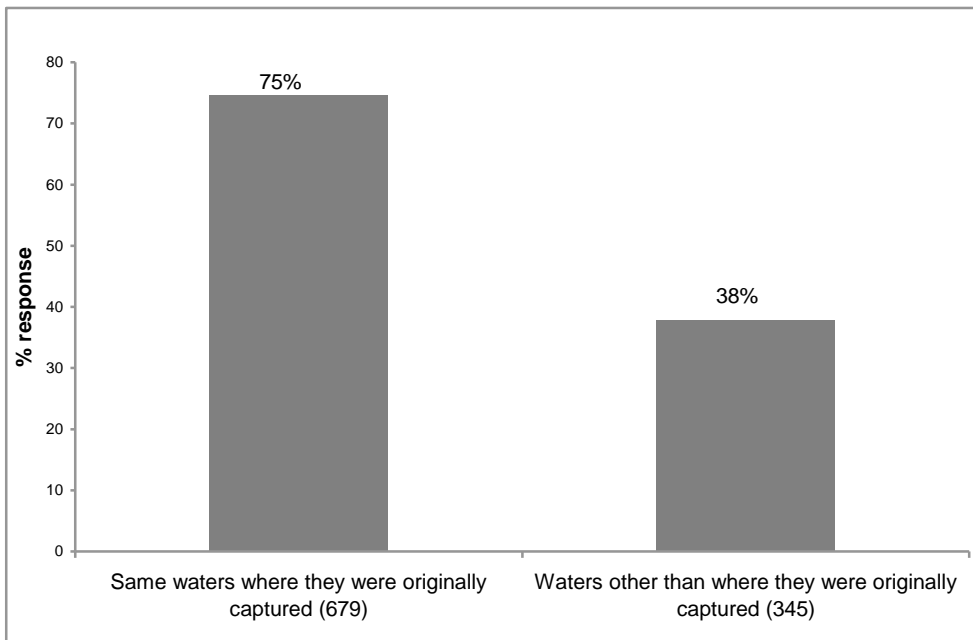


Figure 5. Graphical summary of survey question # 6, asking: ‘Where do you use the baitfish that you catch?’
 Values in brackets indicate the number of responses (*n*) corresponding to each selection. Values above each bar indicate the percentage of total respondents corresponding to each selection.

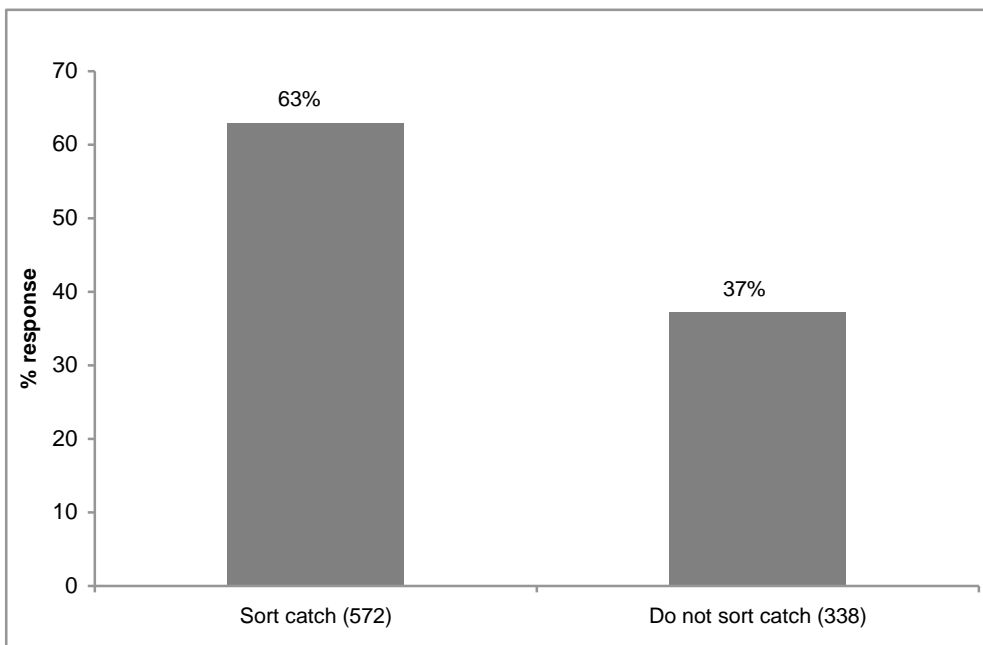


Figure 6. Graphical summary of survey question # 7, asking: ‘When catching your own bait, do you sort your catch?’
 Values in brackets indicate the number of responses (*n*) corresponding to each selection. Values above each bar indicate the percentage of total respondents corresponding to each selection.

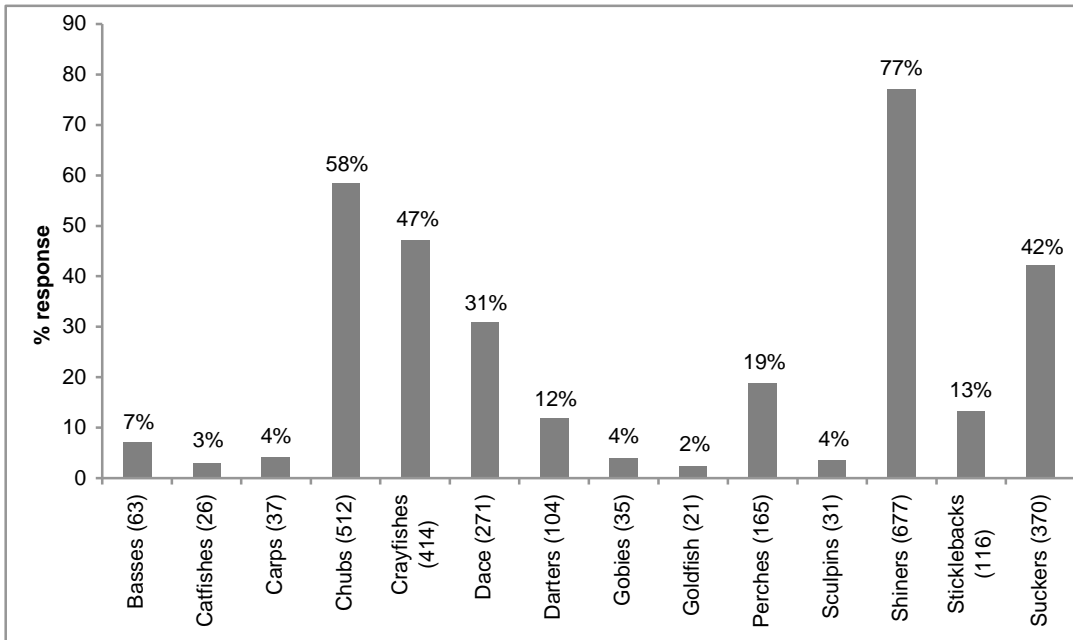


Figure 7. Graphical summary of survey question # 8, asking: ‘When catching your own bait, what species do you keep to use as bait?’

Values in brackets indicate the number of responses (*n*) corresponding to each selection. Values above each bar indicate the percentage of total respondents corresponding to each selection.

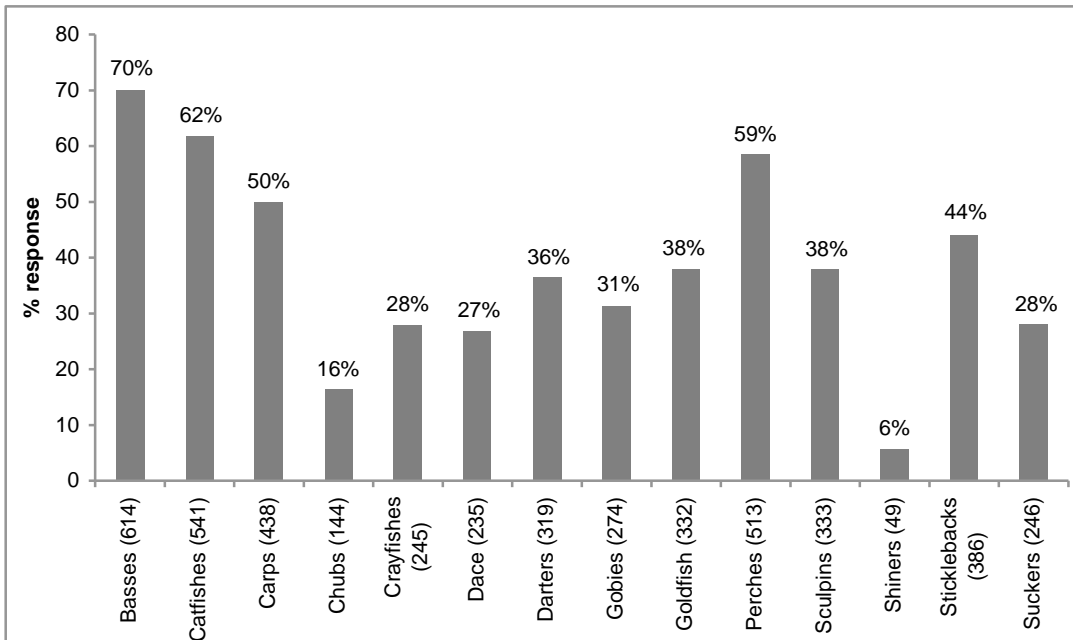


Figure 8. Graphical summary of survey question # 9, asking: ‘When catching your own bait, what species do you throw back?’

Values in brackets indicate the number of responses (*n*) corresponding to each selection. Values above each bar indicate the percentage of total respondents corresponding to each selection.

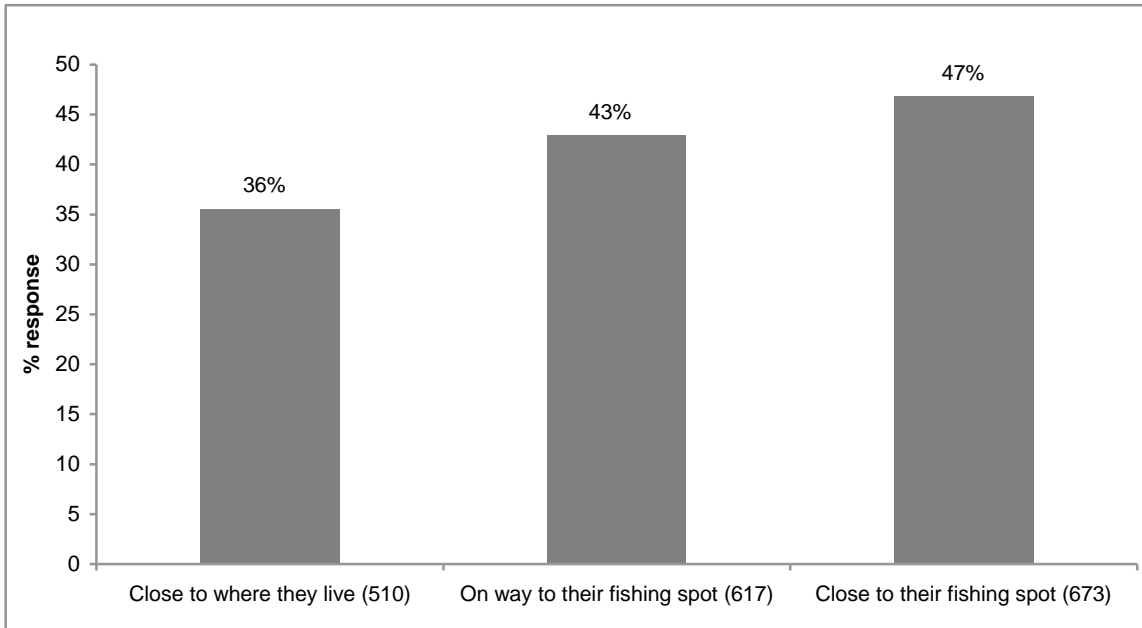


Figure 9. Graphical summary of survey question # 10, asking: ‘Where do you usually buy your baitfish?’

Values in brackets indicate the number of responses (*n*) corresponding to each selection. Values above each bar indicate the percentage of total respondents corresponding to each selection.

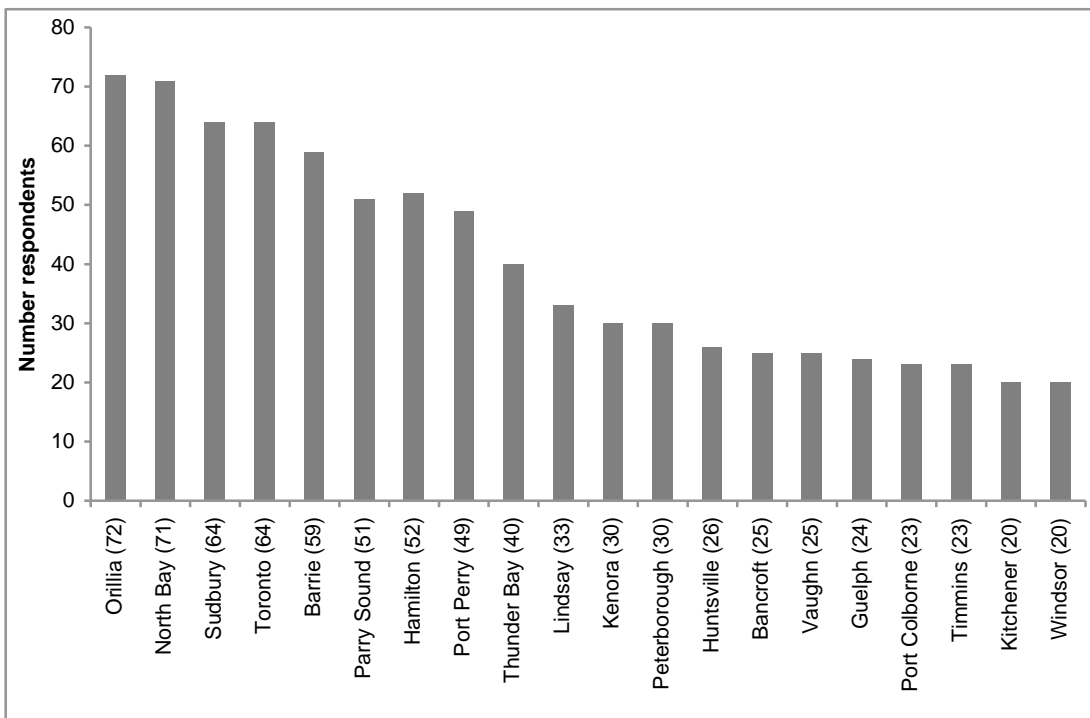


Figure 10. Graphical summary of top 20 cities or towns determined from survey question #10, asking: ‘List the top three cities or towns where you buy your bait.’

Values in brackets indicate the number of responses (*n*) corresponding to each selection.

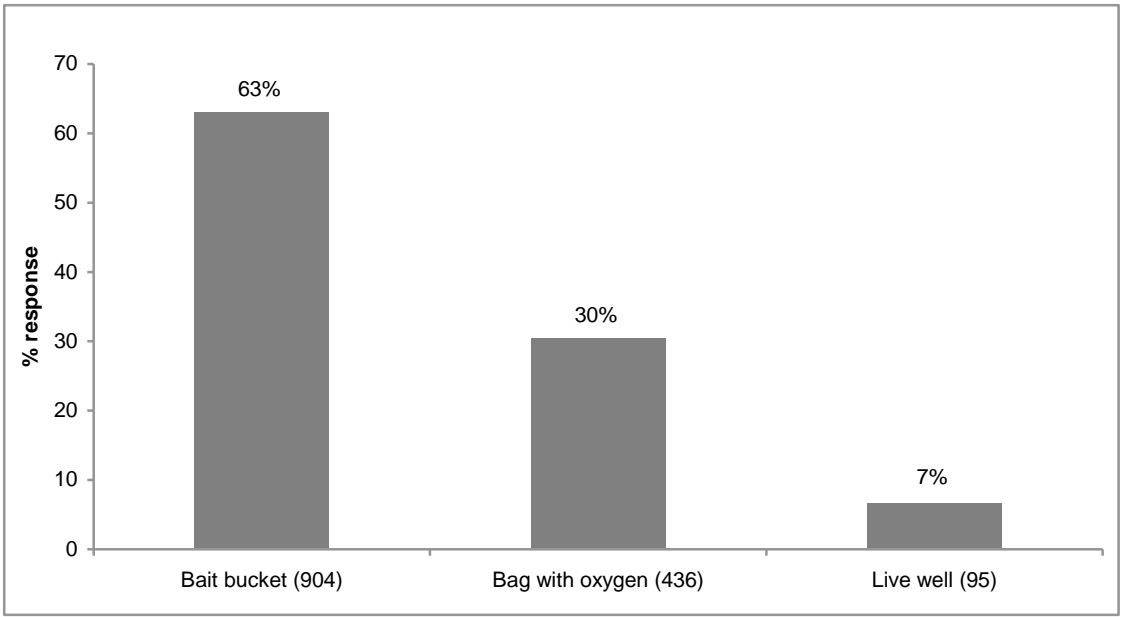


Figure 11. Graphical summary of survey question #12, asking: 'How do you transport your baitfish?'
 Values in brackets indicate the number of responses (*n*) corresponding to each selection. Values above each bar indicate the percentage of total respondents corresponding to each selection.

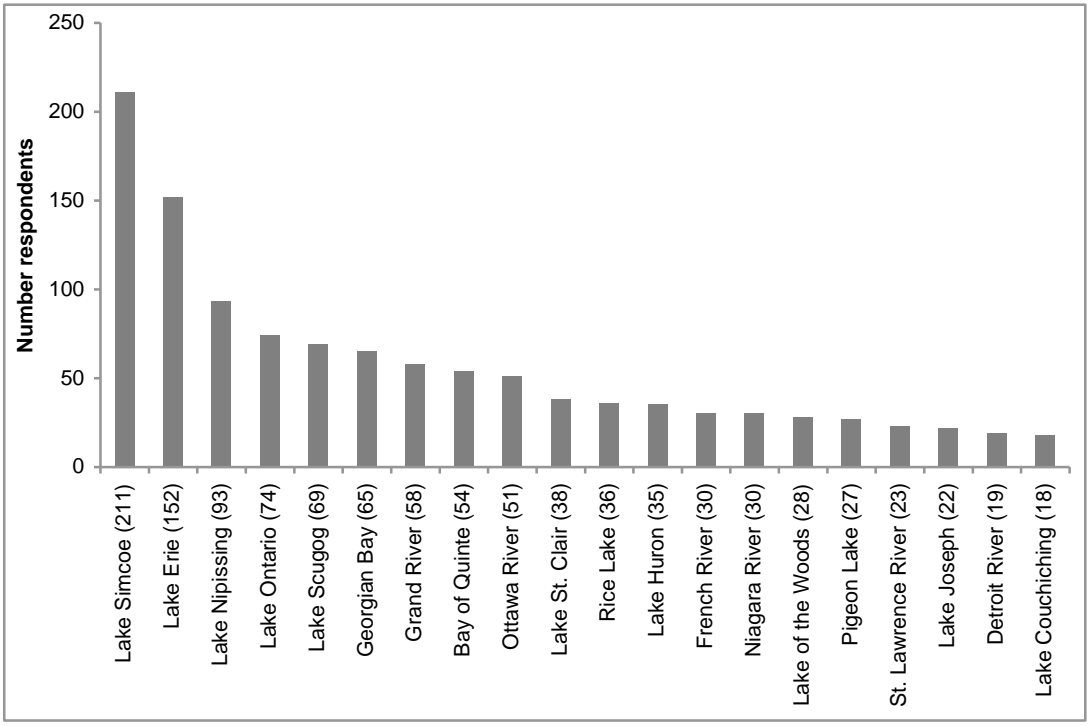


Figure 12. Graphical summary of top 20 waterbodies determined from survey question #13, asking: 'List the top three places (lake or river name, province) in which you use baitfish for angling.'
 Values in brackets indicate the number of responses (*n*) corresponding to each selection.

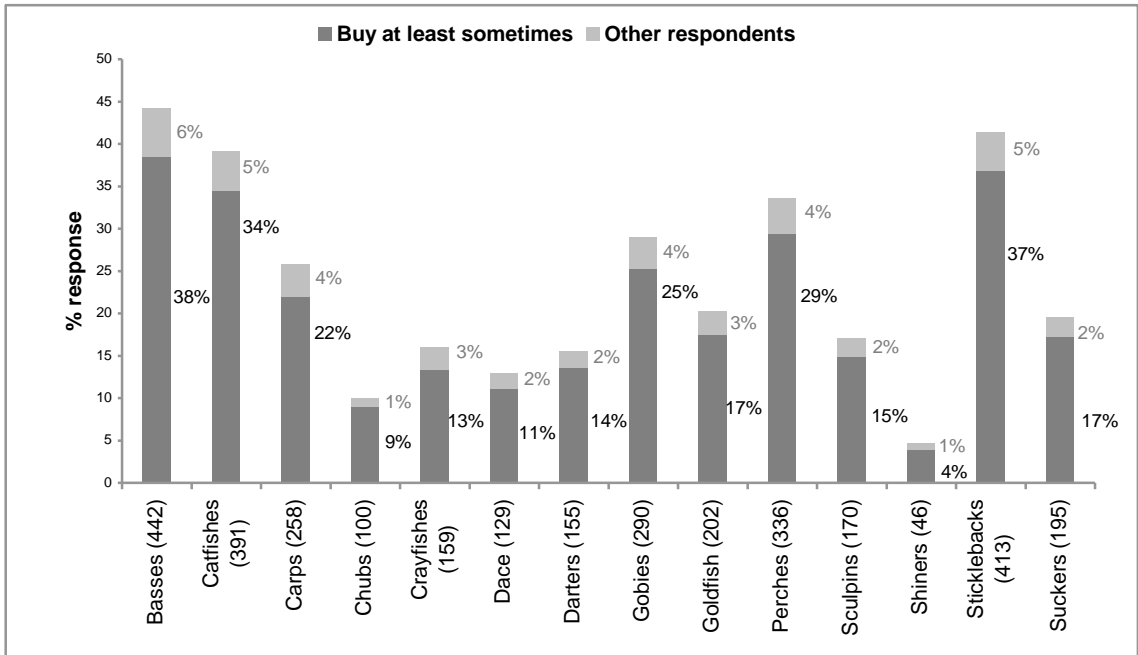


Figure 13. Graphical summary of survey question #14, asking: ‘What fish do you sometimes find in your bait that you don’t like to use?’
 Values in brackets indicate the number of responses (*n*) corresponding to each selection. Values above each bar indicate the percentage of total respondents corresponding to each selection.

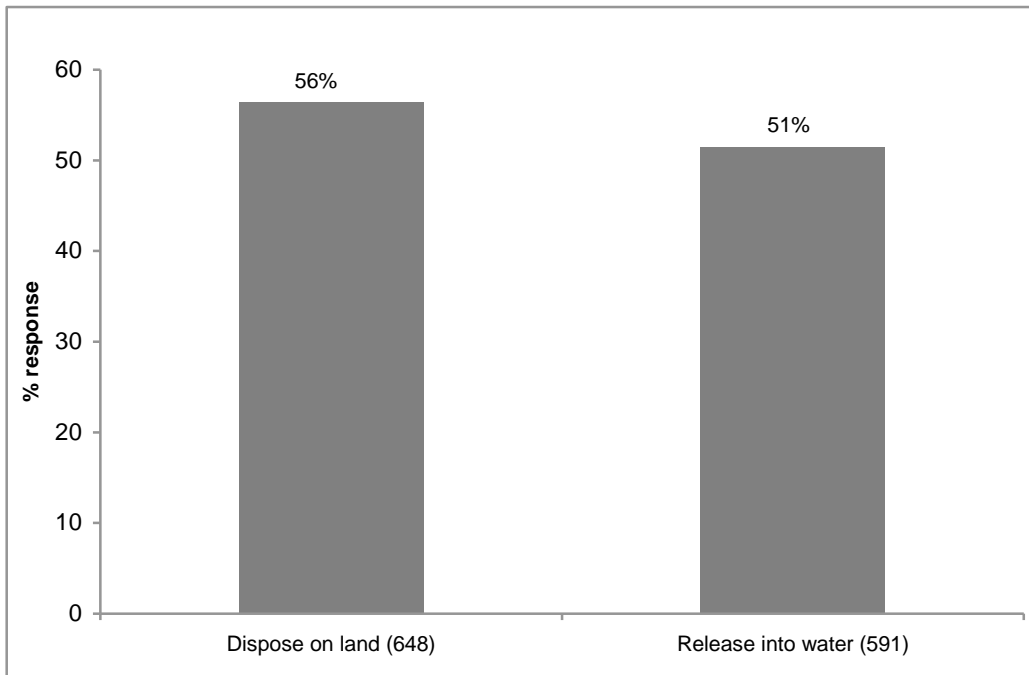


Figure 14. Graphical summary of survey question #15, asking: ‘What do you do with baitfish that you don’t want to use?’
 Values in brackets indicate the number of responses (*n*) corresponding to each selection. Values above each bar indicate the percentage of total respondents corresponding to each selection.

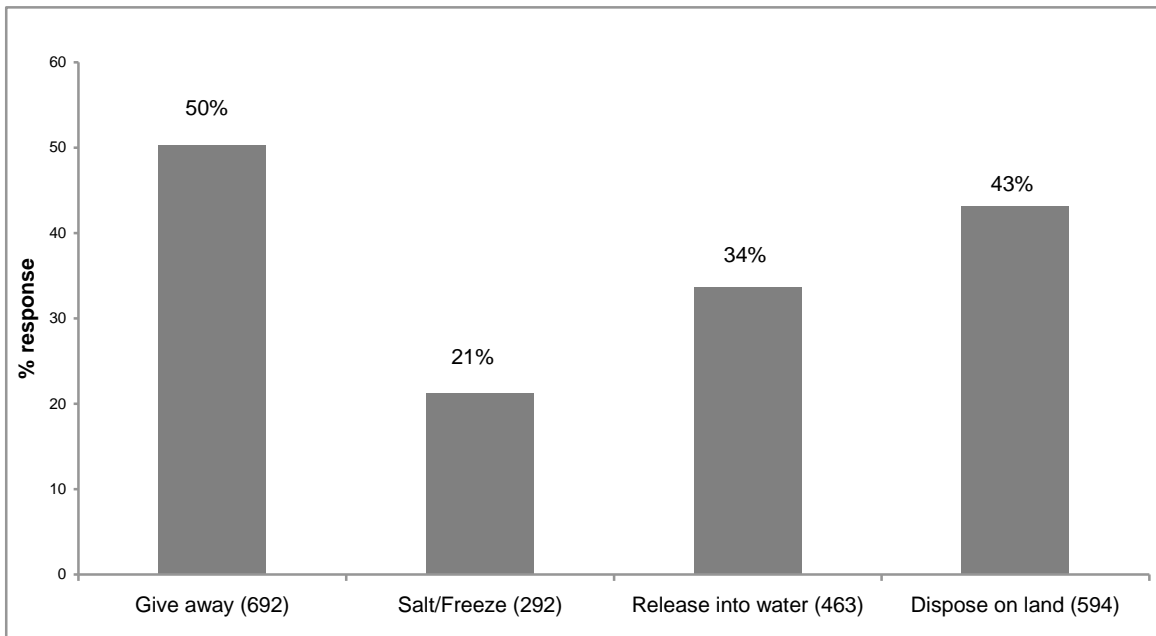


Figure 15. Graphical summary of survey question #16, asking: 'What do you do with your leftover baitfish?'

Values in brackets indicate the number of responses (*n*) corresponding to each selection. Values above each bar indicate the percentage of total respondents corresponding to each selection.

APPENDIX 1. THE GREAT CANADIAN BAITFISH SURVEY

Welcome to the Great Canadian Baitfish Survey. The purpose of this survey is to get a better understanding of what, where and how Canadians use baitfish for angling. The survey is being conducted by the University of Toronto in collaboration with the Bait Association of Ontario, the Ontario Federation of Anglers and Hunters, the Ontario Ministry of Natural Resources and Fisheries and Oceans Canada

The survey is divided into two parts. Part A (pages 1 and 2) should relate to your baitfish use throughout a given year. Part B (pages 3 and 4) will test your fish identification skill (*note – Part B is not included in this appendix*). Please complete both part A and B of the survey even if you have already completed this survey through the Internet or at a tradeshow. Thank you in advance for your participation.

Part A:

1. Choose a unique username and password. Use the same username and password that you used if you filled out this survey over the Internet. These unique identifiers will be used to track your baitfish use through the year anonymously by logging onto the online survey (see bottom of second page). They will in no way be linked to, or reveal, your identity.

Username:

Password:

2. In what city do you live?

City:

Postal code:

3. How often do you use live baitfish during the year?

Never

Proceed to Page 3.

One day per year

Proceed to Question 4.

2-5 days per year

Proceed to Q. 4.

6-10 days per year

Proceed to Q. 4.

11 or more days per year

Proceed to Q. 4.

4. Do you catch your own baitfish:

Never

Proceed to Question 10.

Sometimes

Proceed to Question 5.

Always

Proceed to Question 5.

5. How do you catch your baitfish?

Minnow trap

Dip net

Other:.....

6. Where do you use the baitfish that you catch?
- In the same waters where they are caught
 - In waters other than where they are caught
7. When catching your own bait, do you sort your catch?
- Yes Proceed to Question 8.
 - No Proceed to Question 10.
8. When catching your own bait, what species do you keep to use as bait?
- Basses
 - Catfishes
 - Carps
 - Chubs
 - Crayfishes
 - Dace
 - Darters
 - Gobies
 - Goldfish
 - Perches
 - Sculpins
 - Shiners
 - Sticklebacks
 - Suckers
 - Others:.....
9. When catching your own bait, what species do you throw back?
- Basses
 - Catfishes
 - Carps
 - Chubs
 - Crayfishes
 - Dace
 - Darters
 - Gobies
 - Goldfish
 - Perches
 - Sculpins
 - Shiners
 - Sticklebacks
 - Suckers
 - Others:.....
10. Where do you usually buy your baitfish?
- Close to where I live
 - On the way to my fishing spot
 - Close to my fishing spot

Not applicable – always catch my own bait

List the top three cities or towns where you buy your bait.

City: Province:
 City: Province:
 City: Province:

11. What type and size of baitfish do you prefer to use when fishing for the fish listed below?

(Small < 3”) (Medium 3-5”) (Large >6”)

	Shiners			Chubs			Suckers			Other:		
Sportfish	S	M	L	S	M	L	S	M	L	S	M	L
Bass												
Brown Trout												
Lake Trout												
Muskellunge												
Panfish												
Perch												
Pike												
Rainbow Trout												
Walleye												
Other:												

If other baitfish used, specify:
 If other sportfish fished for, specify:

12. How do you transport your baitfish?

- Bait bucket
- Bag with oxygen
- Live well
- Other:.....

13. List the top three places (lake or river name, province) in which you use baitfish for angling. Leave blank if you always catch your own baitfish.

Waterbody: Province:
 Waterbody: Province:
 Waterbody: Province:

14. What fish do you sometimes find in your bait that you don't like to use?

- Basses
- Catfishes
- Carps
- Chubs
- Crayfishes

- Dace
- Darters
- Gobies
- Goldfish
- Perches
- Sculpins
- Shiners
- Sticklebacks
- Suckers
- Others:.....

15. What do you do with baitfish that you don't want to use?

- Dispose on land
- Release into water
- Not applicable – use all

16. What do you do with your left-over baitfish?

- Give to another angler
- Salt or freeze
- Release into water
- Dispose on land
- Other:.....

Thank you for completing our survey. Please visit www.surveymonkey.com/bait_survey and log your baitfishes use every time that you actually use baitfishes for angling.