# FISH EXCLUSION OPTIONS FOR AQUATIC SPECIES AT RISK FOR DRAINAGE ACTIVITIES IN LITTLE BEAR CREEK, ONTARIO

## Context

Little Bear Creek drains into the St. Clair River via the Chanel Ecarte in the Township of Dover of the Chatham-Kent Region. This small tributary is located approximately 10 km south of the town of Wallaceburg, Ontario. Little Bear Creek is home to several species at risk (SAR) fishes including Pugnose Shiner (*Notropis anogenus*), Lake Chubsucker (*Erimyzon sucetta*), Grass Pickerel (*Esox americanus vermiculatus*), Blackstripe Topminnow (*Fundulus notatus*), Spotted Sucker (*Minytrema melanops*), and Pugnose Minnow (*Opsopoeodus emiliae*). Little Bear Creek, a tributary of Lake St. Clair, is classified as an agricultural drain and has been identified for drain maintenance by the Region of Chatham-Kent. There is increasing pressure to complete a drain clean out of Little Bear Creek with the goal to decrease flooding of land owned by private landowners.

The Municipality of Chatham-Kent has submitted a "Drain Maintenance Request" under the provincial *Drainage Act* to excavate and remove accumulated sediment from the Little Bear Creek Drain. In-water works are proposed from the mouth at Chenal Ecarte upstream for 29.5 km to Countryview Line, where the remaining drain portions are buried. Excavation will be a combination of drag-line crane rigging, and long and standard hydraulic excavators.  A number of culvert and enclosure works are also proposed in the headwater areas of the drain. Small brush and larger trees are also to be removed from the shoreline along the entire length of the drain.

There is a concern that a full agricultural clean out of Little Bear Creek will negatively impact aquatic species at risk and their habitat. This science response complements an existing Canadian Science Advisory Secretariat (CSAS) request to evaluate mitigation measures within various reaches of Little Bear Creek to minimize the potential impacts of the proposed drainage work on Pugnose Minnow, Blackstripe Topminnow, Pugnose Shiner, Lake Chubsucker, and Grass Pickerel. To provide science advice for the current request, the practicability of fish exclusion techniques to reduce harm to SAR fishes during drainage activities was examined.

Fisheries and Oceans Canada (DFO) Species at Risk Program requested that DFO Science address the following questions regarding agricultural drain maintenance mitigation within Little Bear Creek.

1. Could fish exclusion be used as a mitigation strategy to minimize harm to SAR fishes present in Little Bear Creek in the area proposed for drain clean out?
2. Would reach-specific physical parameters (e.g., size of waterway, water clarity) compromise the effectiveness of fish exclusion?
3. Could the resulting fish exclusion techniques be practically implemented on the scale required for Little Bear Creek?

This Science Response Report results from the Science Response Process of April 2015 on Options for exclusion of fish species at risk for drainage activities in Little Beach Creek, Ontario.

## Background

There is concern that the proposed dredging activity will negatively affect numerous fish species at risk historically and/or currently known to be present in this system. Science advice was requested to help assess the potential role that fish exclusion techniques might play in minimizing harm to individuals of fish SAR present (and as part of an overall mitigation approach for the clean out). In 2013, DFO Science conducted a detailed survey of the fish community and associated habitats within Little Bear Creek (Figure 1). The purpose of this survey was to provide an inventory of all fish species in the Little Bear Creek watershed. Prior to this study, four fish SAR were known to occur in Little Bear Creek: Pugnose Shiner (Endangered); Grass Pickerel (Special Concern); Blackstripe Topminnow (Special Concern); and, Pugnose Minnow (Special Concern). During the survey, Lake Chubsucker (Endangered) was detected for the first time in Little Bear Creek. Further, this survey provided additional information regarding the habitats associated with these fish SAR. A second study was conducted in 2014 to evaluate potential agricultural drain maintenance mitigation techniques for fish SAR in Little Bear Creek. During this study, Spotted Sucker (Special Concern) was detected for the first time in the creek. The 2014 study consisted of two experimental trials to determine how effective nets were at isolating fishes from a construction location. The objective of Experiment 1 was to determine how well fishes were removed from a hypothetical work site and isolated over time using two large isolation nets. The objective of Experiment 2 was to determine how effective block nets were at isolating fishes; using a combination of remote sensing and seining.

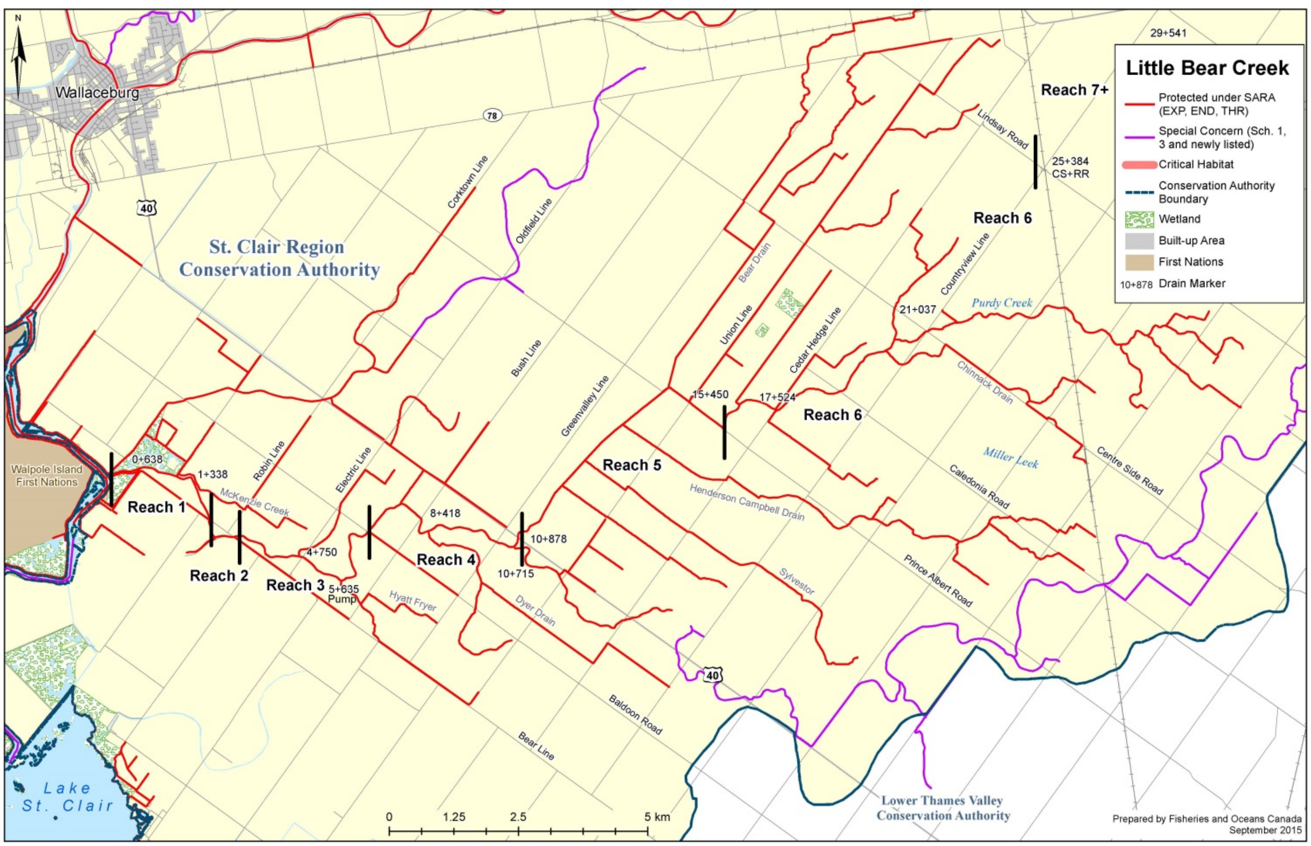


*Figure 1. Little Bear Creek, Ontario with river reaches identified.*

# Analysis and Response

## Methods

### Experiment 1

Experiment 1 employed two seining strategies to evaluate whether fishes could be

(i) removed from non-wadeable habitats in Little Bear Creek, and;

(ii) effectively held in isolation from drain maintenance activities.

This experiment was designed to mimic removal strategies commonly used in fish mitigation strategies. The two nets used for this experiment were 22 m x 1.8 m straight seines with 3 mm mesh. These nets are referred to as isolation nets during this experiment. To deploy these nets, DFO staff used a 4.9 m jon boat with a 40 hp outboard and 4-person crew. The isolation nets were deployed along a shoreline of the creek and parallel to the creek channel. Two 25 m lengths of rope were attached to the net and deployed across the creek to the opposite bank from the isolation net. Two of the four-person crew pulled the isolation net across the channel using the 25 m lengths of rope (Figure 2). The remaining two people secured the vessel near the sampling site and assisted in retrieving the isolation net. Once the net was pulled across the channel, it was secured against the bank using large cinder blocks. Once the first isolation net was secured, the time was recorded. The field crew would repeat this same process at another location nearby, within 200 m of the first isolation net (Figure 3). The first net would be left for a period of no less than one hour. This net is referred to as the Delayed Sample. The second net would be secured and processed immediately. This net is referred to as the Instantaneous Sample. Sampling within each net was done using a 9 m x 1.8 m bag seine. The crew would complete five repeated passes within the isolation net. Fishes from all five repeated samples were processed separately. Once the processing was completed for the Instantaneous Sample, the crew would return to the Delayed Sample and sample this net with five repeated passes. Upon completion of all sampling, the field crew would retrieve and prepare all nets for another sampling event.  A total of 11 pairs (22 sites) were sampled for this experiment. If isolation nets can successively hold fishes for one hour, the number of fishes caught by each seining sample (Instantaneous or Delayed) is be expected to be equal.

*Figure 2. DFO Science Field Crew deploying 22 m x 1.8 m isolation net during Experiment 1 in Little Bear Creek, Ontario.*

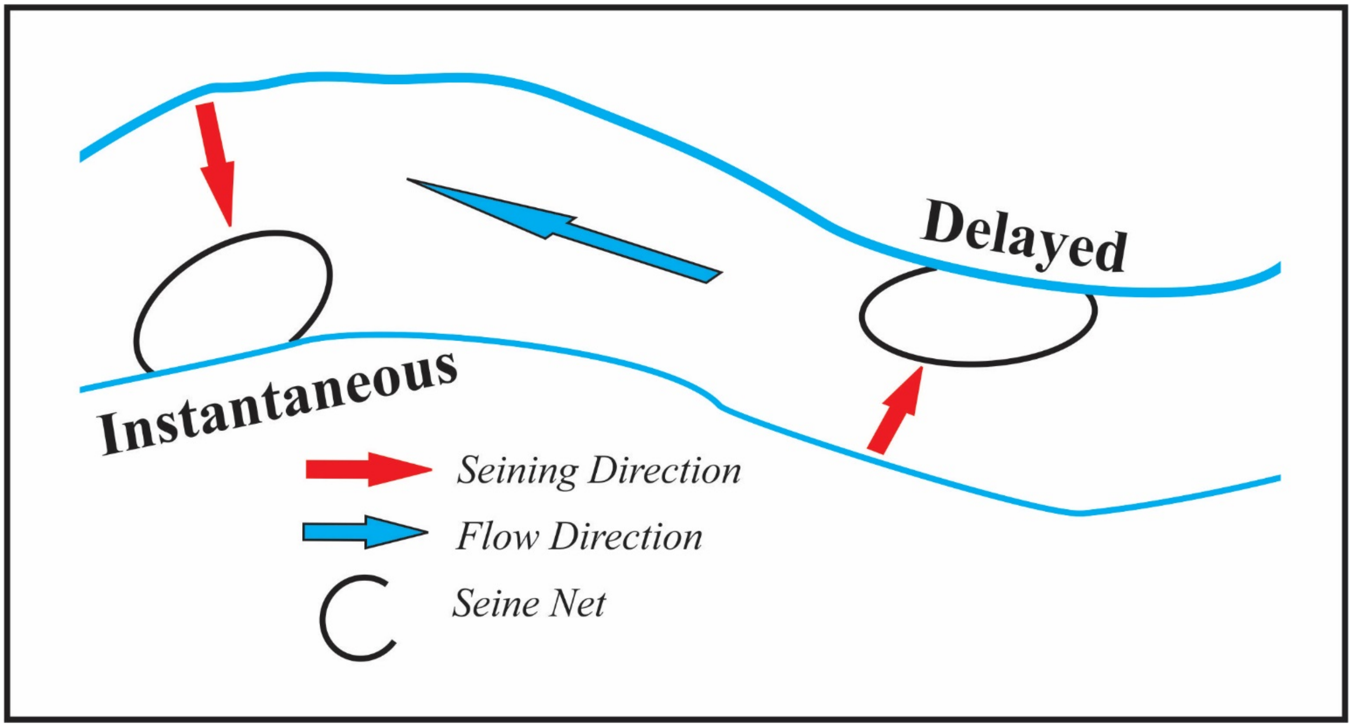


*Figure 3. Schematic of seining sites for instantaneous and delayed sampling with isolation nets in Little Bear Creek, Ontario.*

### Experiment 2

In addition to Experiment 1, further work was completed to assess the overall effectiveness of each exclusion method using high-frequency imaging sonar, assisted under contract by Milne Technologies. For complete details of methodology see Milne (2014). Sonar data provide an independent measure of the likelihood of fishes being removed by repeated hauls of a bag seine. Survey sites were located within Little Bear Creek downstream of the Highway 40 bridge crossing. Preferred sites for this experiment required stream widths less than 40 m and had depths less than 2 m to accommodate the isolation nets and bag seine for this experiment. Sonar data were collected using a dual-frequency identification sonar (DIDSON, Sound Metrics Corporation, WA.) system (Figure 4). The multibeam high frequency sonar and unique acoustic lens system of the DIDSON focuses the beam to create high-resolution, "video-like" images of fish and bottom substrates. The DIDSON can operate in two frequency modes – high-frequency (1.8 MHz) and low-frequency (1.1 MHz). In high frequency mode, there are 96 beams with a beam width (two-way) of 0.3° horizontally by 14° vertically and beam spacing of 0.3°; the range setting is 12 – 15 m. In low frequency mode, there are 48 beams with a beam width (two-way) of 0.4° horizontally and 14° vertically and beam spacing of 0.6°; the range setting is up to 40 m. For both modes, the field-of-view is 29°. Upon arrival at the site, the DIDSON system was deployed into the proposed sampling area. The DIDSON operator would record both high frequency (HF) and low frequency (LF) and switch between frequencies every five minutes. At each sampling site, the DIDSON tripod was deployed to record data (10 minutes in LF and HF modes) in an effort to describe the general activity, movement, and relative density of fishes within the area before significantly disturbing the site (pre-block net period; PREB). For this experiment, isolation nets were used to block off the area from which the DIDSON would record data (Figure 5). The nets had a depth of 2.5 m. The bag seine used for removing fishes from the isolated areas measured 15 m x 2.5 m with a 4.5 mm mesh. The bag dimensions were 2.5 m by 2.5 m. Isolation nets were then deployed across the entire channel width from small boats. The distance between the isolation nets varied between approximately 6.5 m and 13.5 m as measured by a Kongsberg M3 multibeam imaging sonar system (details of the M3 sonar system deployment are not discussed in this report). Once the isolation nets were set, the DIDSON tripod was re-deployed and the site was allowed to settle for approximately 10 minutes or more, if required. After this time, approximately 10 minutes of LF and HF mode data were collected (post-block net period; PSTB). Once the PSTB DIDSON recording period was completed, the crew began seining within the enclosed sampling area. Upon completion of each seining replicate (replicate “0001” through “0007”), the DIDSON was redeployed and the enclosed area was allowed to settle for approximately 10 minutes before collecting another 20 minutes of DIDSON data. In an effort to compare estimates of the rate of fish depletion using a repeat seining method to an imaging sonar automated fish counting method, Milne Technologies developed an automated counting method using Echoview (Echoview Software Pty Ltd.) processing software. The software not only provides a standardized method of generating estimates of fish flux (the count of fish moving upstream or downstream past a specific point where the count is standardized by time and area/volume) and fish size, but also behavioural information. The software provides several filters in the form of “virtual variables” that can be applied to the raw DIDSON echogram files to effectively remove background reverberation and enhance fish target detection, thus optimizing the signal to noise ratio.


*Figure 4. DIDSON sonar and Kongsberg sonar units mounted on adjustable tripod frame (left image). Sonar tripod deployed within isolation net enclosure (right image). Source: Milne Technologies.*

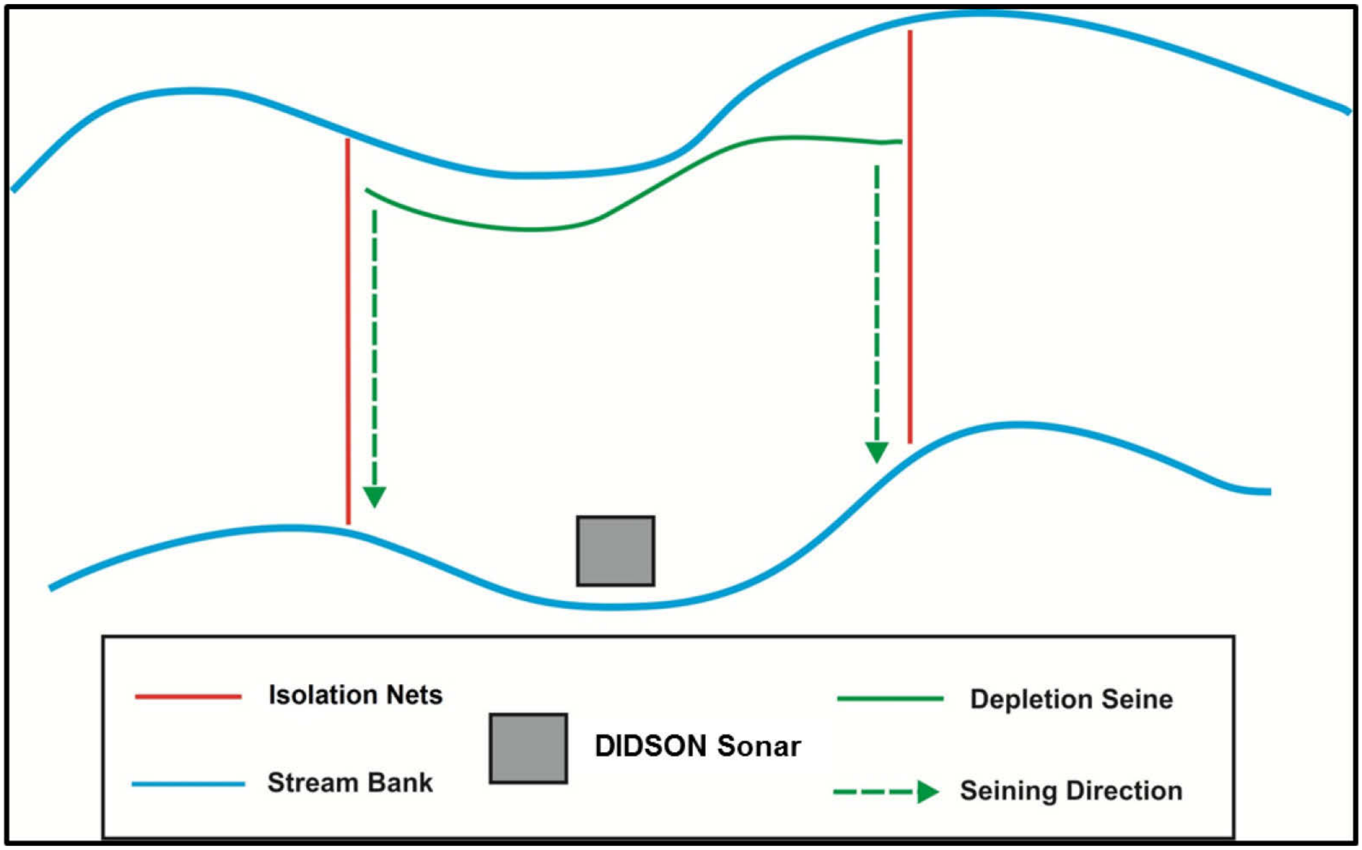


*Figure 5. Schematic of location of the DIDSON multibeam sonar system and isolation nets in Little Bear Creek, Ontario.*

## Results

### Experiment 1

Seining caught 4,430 individual fishes representing 39 species. Five fish SAR were detected: Pugnose Shiner, Lake Chubsucker, Grass Pickerel, Blackstripe Topminnow, and Spotted Sucker. Total catch (number of fishes) and capture probability (as estimated by Carle and Strub removal method) were not significantly different between instantaneous sampling and delayed sampling events (paired T-test; $p \geq 0.72$; Figure 6a). This result indicates isolation nets are able to capture and contain fishes for long periods of time. Further, when the total catch for both treatments were pooled, an average of 67% of all fishes were removed from the isolation nets with the first haul of the bag seine (Figure 6b). Mean capture probability was 0.46 for instantaneous sampling and 0.48 for delayed sampling.

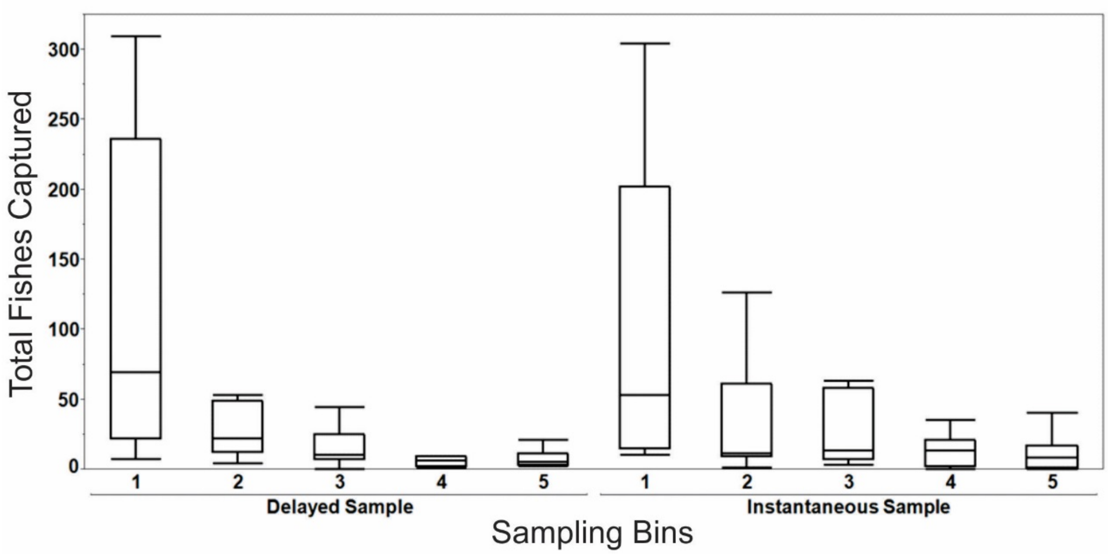


*Figure 6a. Total fishes captured by sampling bin for both delayed and instantaneous sampling of isolation nets in Little Bear Creek, Ontario. The upper horizontal line of box, 75th percentile; lower horizontal line, 25th percentile; middle line represents the median. Upper and lower whiskers represent the maximum and minimum values, respectively.*

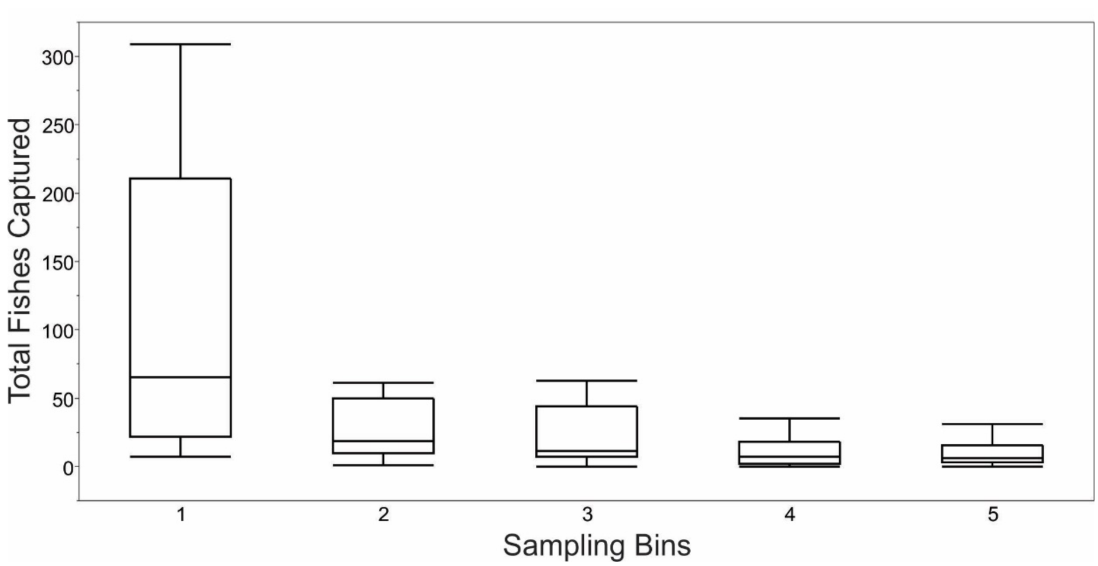


*Figure 6b. Pooled total fishes captured by sampling bin for delayed and instantaneous sampling of isolation nets in Little Bear Creek, Ontario. The upper horizontal line of box, 75th percentile; lower horizontal line, 25th percentile; middle line represents the median. Upper and lower whiskers represent the maximum and minimum values, respectively.*

### Experiment 2

A total of 4,116 individual fishes representing 33 species were captured during this experiment. Two fish SAR, Pugnose Shiner and Blackstripe Topminnow, were detected during this experiment. Estimates of relative fish activity (or relative fish density) were expressed as the total number of sonar-detected fishes per hour from the HF and LF DIDSON echograms. Line plots of the relative number of sonar-detected fish targets per hour with the observed number of fishes (all species and size classes) caught within the seine replicates are shown with Figure 7 (HF data) and Figure 8 (LF data). HF sonar-detected relative fish density (counts per hour) was highest during the PREB sonar survey period for three (Sept. 9, 10, 16) of the five survey sites/dates. However, the sonar-detected relative fish density (counts per hour) from the LF echogram data was highest during the PREB sonar survey period for only two (Sept, 10, 16) of the five survey sites/dates (Figure 8). Due to the limited horizontal resolution of the DIDSON sonar system and the difficulty of reliably detecting small fish at ranges > 10 m from the transducer face of the DIDSON sonar, the analyses below is limited to the high frequency data recorded within a range (or distance) of 10.5 m of the transducer (for details see Milne 2014).

An overall decrease between the pre- and post- block net sonar survey periods was observed at four of the five survey sites/dates (Figure 7). The observed decrease in fish density (HF) ranged between 33% and 81% lower than the PREB survey. This decrease is likely related to the overall site disturbance, boat wash, and outboard engine noise from activities related to setting the block nets. Although the PSTB survey densities were higher than the PREB surveys on September 17, the PSTB relative fish densities were only 12% higher than the PREB surveys. It is also important to note that there was an 89% decrease in the number of fishes caught between the first and second seine passes on September 17. This site had the greatest rate of fish depletion between the first and second seine passes, which may indicate that fishes were not readily displaced from the site during the block-net deployment exercise.

The overall observed decrease in fish density between the PREB and PSTB surveys also indicates that site disturbances (air bubbles, duckweed entrainment, etc.) associated with setting the block nets did not significantly impair the background elimination algorithm within Echoview. Although inspection of the PSTB raw echograms does show increases in the overall acoustic scattering (from suspended material such as duckweed, detritus), particle movement speeds of the material are significantly slower than the observed fish swimming speeds, thus allowing the background noise removal algorithm to operate effectively. Three of the five sites (September 9, 10, 17) showed an overall decrease in the proportion of sonar fish detections and the seining replicate from the HF echogram (Figure 9). This relationship was significant for the September 17 survey (Table 1).

DIDSON observed relative fish activity (counts per hour, HF) was positively correlated to the observed number of fishes caught with the seine (Figure 10). The slope and strength of the linear relationship varied among the five sampling dates.

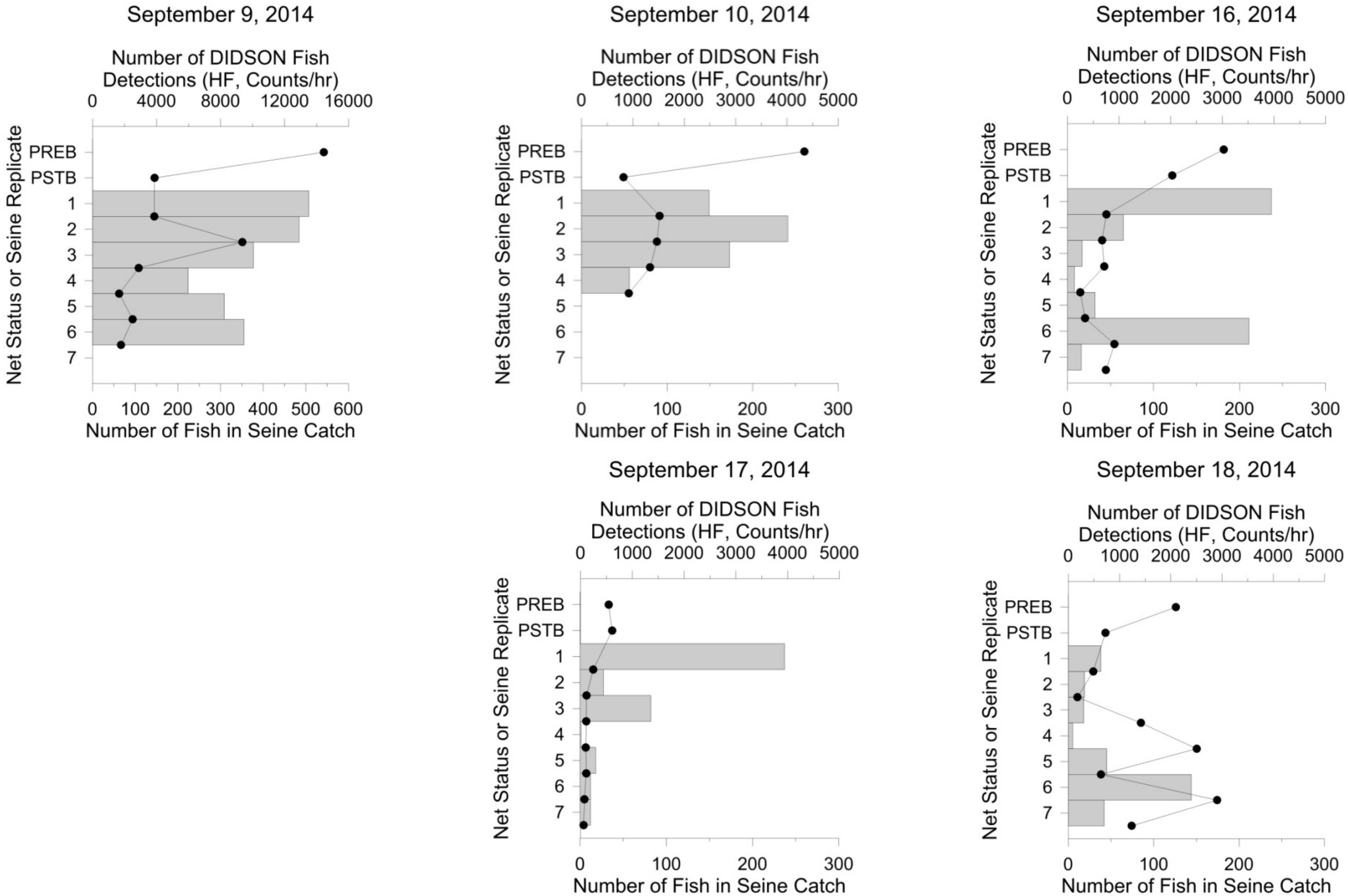


*Figure 7. Summary of the DIDSON-observed relative fish activity (counts per hour, High Frequency (HF), shaded circles and line plot, top x-axis) within 10.5 m range of the transducer and the total number of fish (all species and sizes) caught within each seine pass (shaded bars, lower x-axis). PREB – Pre-Block Net Period; PSTB – Post-Block Net Period.*

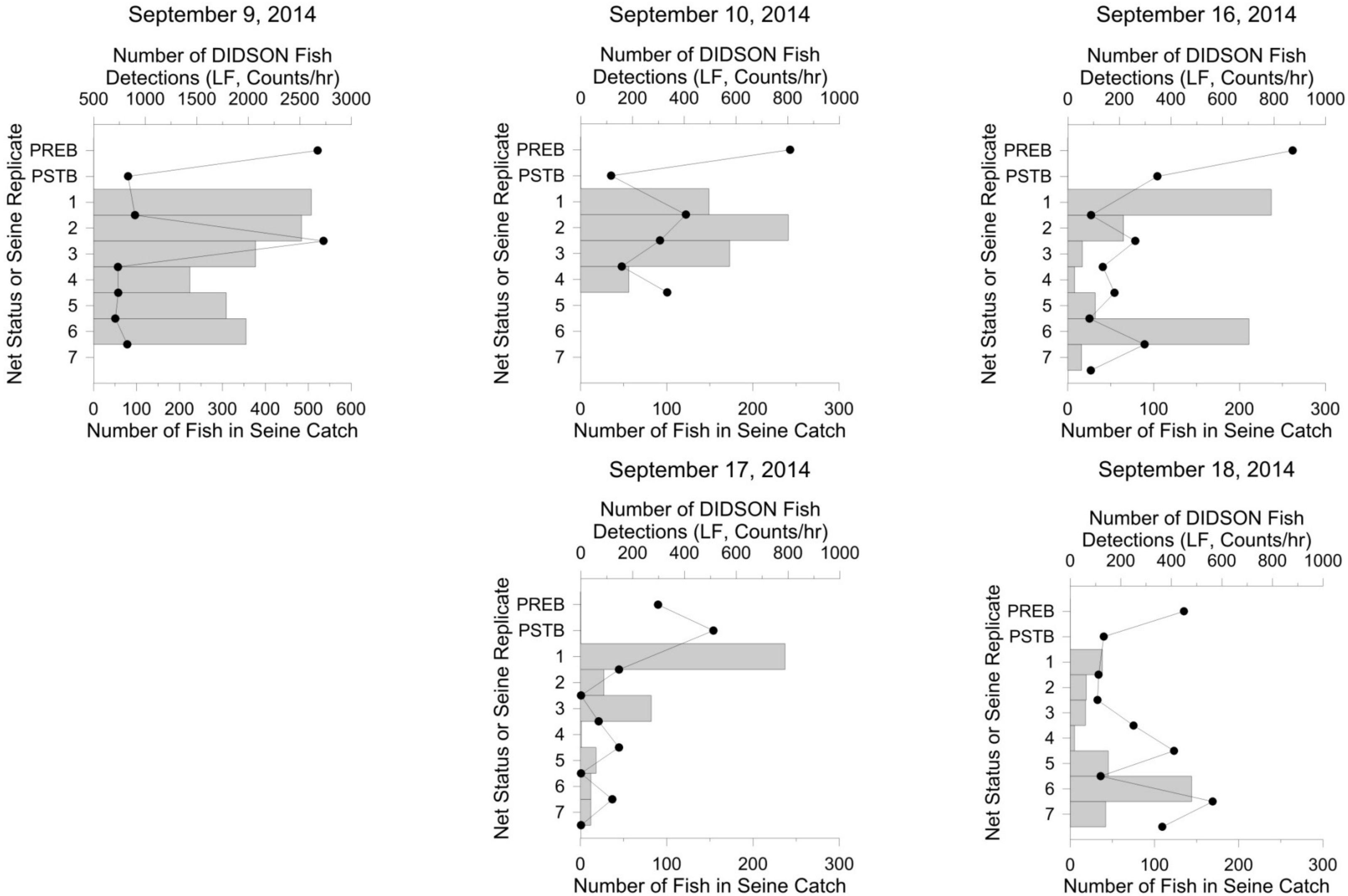


*Figure 8. Summary of the DIDSON-observed relative fish activity (counts per hour, Low Frequency (LF), shaded circles and line plot, top x-axis) across the entire channel width and the total number of fish (all species and sizes) caught within each seine pass (shaded bars, lower x-axis). PREB – Pre-Block Net Period; PSTB – Post-Block Net Period.*

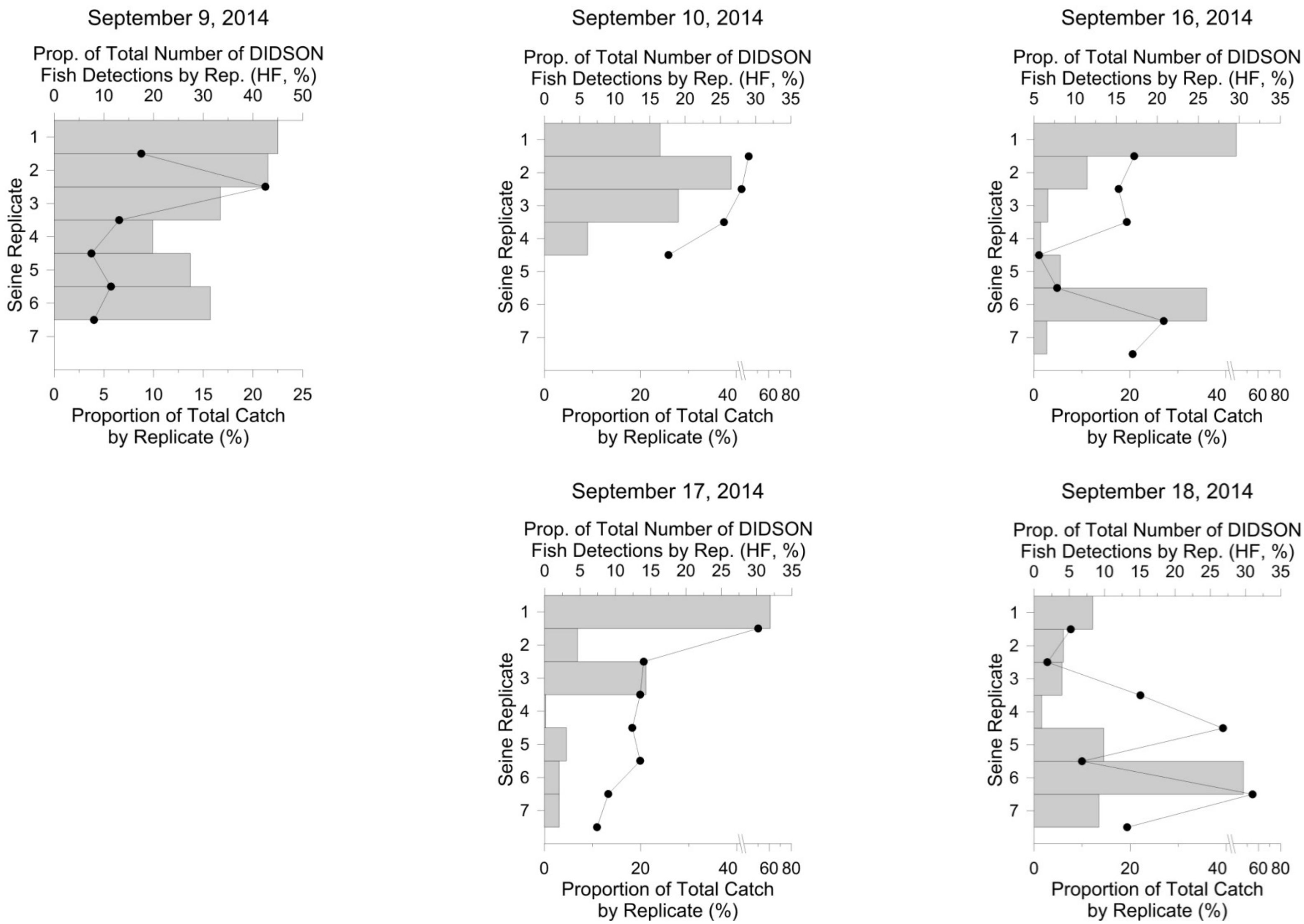


*Figure 9. Summary of the DIDSON observed relative fish activity (counts per hour, HF) expressed as the proportion of the total number of sonar detected fish targets by seine replicate (shaded circles and line plot, top x-axis). Also shown is the proportion of the total number of fish (all species and sizes) caught within the seine replicate (shaded bars, lower s-axis). Seine pass replicate number is shown on the y-axis.*

*Table 1. Summary of the estimated linear slopes between the DIDSON observed relative fish activity (expressed as the proportion of the total number of sonar detected fish targets) and fish seining replicate.*

| Frequency Mode | Survey Date YMD | Slope | $r^2$ | p-value |
|---|---|---|---|---|
| HF | 20140909 | -0.084 | 35.3 | 0.21 |
| HF | 20140910 | -0.229 | 84.1 | 0.08 |
| HF | 20140916 | 0.01 | 0.01 | 0.95 |
| HF | 20140917 | -0.235 | 65.8 | 0.03 |
| HF | 20140918 | 0.101 | 26.7 | 0.23 |

On September 9 and September 10, Milne Technologies was able to collect data using the Kongsberg M3 multimode multibeam imaging sonar system. The M3 sonar system provided a broader field of view (140$^o$) than the DIDSON system (29$^o$) and permitted observations of fish activity outside of the isolation net enclosure. Observations from these trials were not quantified during this survey but fishes were observed actively attempting to enter, and exit, the isolation nets. Fish schools and some larger fishes were observed on both the upstream and downstream side of the isolation nets outside of the fish survey area. Notably during the PREB period, large numbers of fishes were recorded within and outside the survey site with the Kongsberg M3 sonar unit. During the PSTB period, numbers of fishes observed declined considerably during isolation net deployment based on the Kongsberg M3 sonar unit.

### Influence of Gizzard Shad on Fish Removal

During most Experiment 2 sampling events, there was an inconsistent decline in the number of fishes captured over successive seine hauls (i.e., no depletion). The number of fishes within enclosed areas could, therefore, not be estimated using removal methods. It was suspected that the main source of the variability was a result of sporadic high numbers of Gizzard Shad (*Dorosoma cepedianum*) within many sampling replicates. To estimate fish abundance, removal-based estimates (Carle and Strub 1978), were calculated excluding Gizzard Shad. Fish abundance was then used to estimate the percentage of individuals removed by each of the seven seine hauls. A decline of 80% in the number of fishes was observed by seine haul two, with four hauls removing more than 90% of fishes from the sampling enclosure (Figure 11).

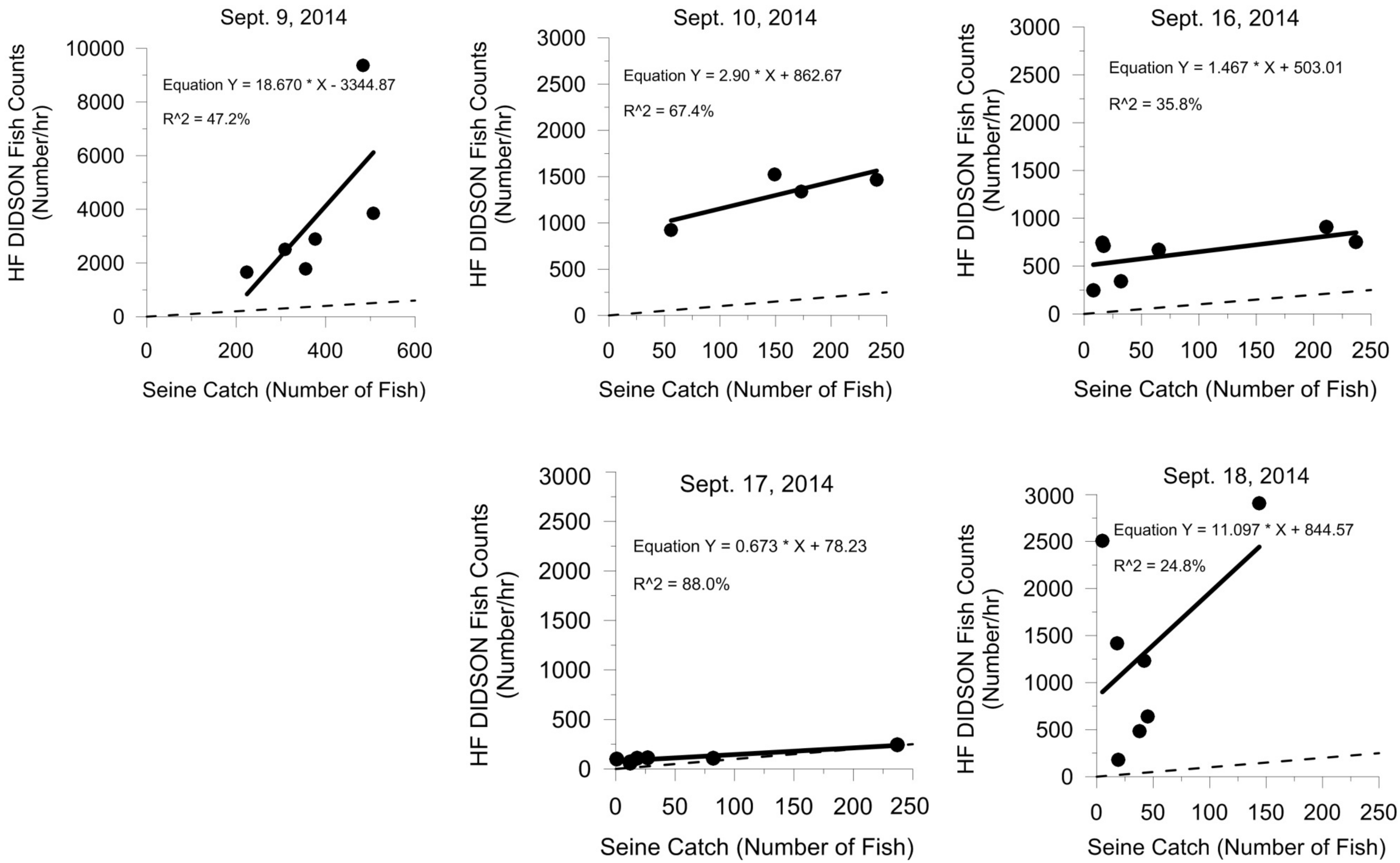


*Figure 10. Summary of the linear relationship between the observed number of fishes caught with the seine (x-axis) and the DIDSON-observed relative fish activity (counts per hour, High Frequency (HF), y-axis) by survey date or Little Bear Creek site. The solid line is the linear fit and the dashed line is the none-to-one line.*

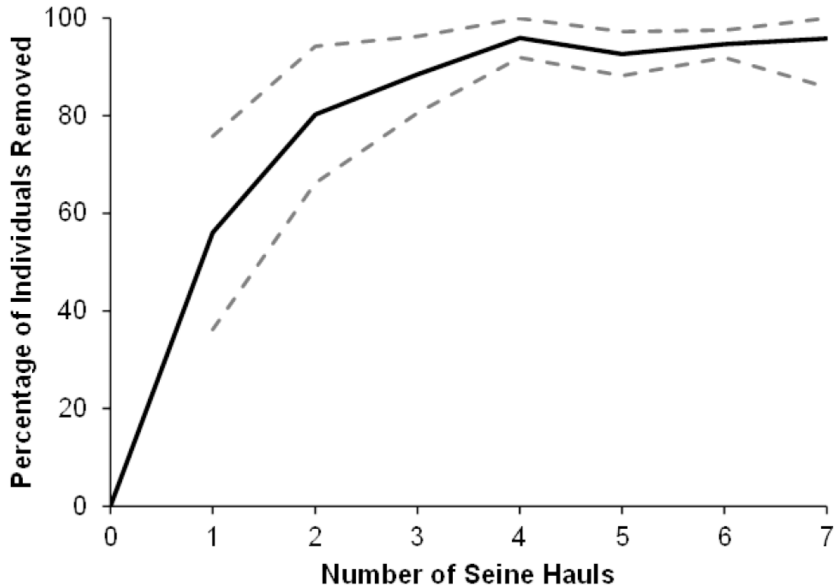


*Figure 11. The mean percentage of the fish population (not including Gizzard Shad) cumulatively removed by a bag seine from Little Bear Creek during Experiment 2 (including 95% CI).*

## Conclusions

There is a concern that a full agricultural clean out of Little Bear Creek will negatively impact fish SAR and their habitat. This request complements an existing project to evaluate mitigation measures within various reaches to minimize the potential impacts of the proposed drainage work on Pugnose Shiner, Lake Chubsucker, Grass Pickerel, Blackstripe Topminnow, Spotted Sucker, and Pugnose Minnow. The current request explores the practicability of fish exclusion techniques to reduce harm to SAR fishes during drainage activities.

**Could fish exclusion be used as a mitigation strategy to minimize harm to SAR fishes present in Little Bear Creek in the area proposed to be cleaned out?**

Fish exclusion could be used as a mitigation strategy in Little Bear Creek to minimize harm to SAR fishes in Reach 1 through Reach 6. Experiments 1 and 2 indicate fish SAR are in low abundance but have a wide distribution in Little Bear Creek, especially in Reach 1 through Reach 5 (Figure 1). Well-placed isolation nets are an effective tool to isolate fishes from proposed work areas. Results from this study suggest than an average of 80% of fishes could be removed from isolated work areas with as little as two hauls using a well-deployed and retrieved bag seine (Figure 10). In addition, crews must be diligent during seining activities to ensure safe capture, removal, and release of fish species at risk from prescribed work areas. Failure to do so could result in additional stress and/or mortality to captured fishes.

**Would reach-specific physical parameters (e.g., size of waterway, water clarity) compromise the effectiveness of fish exclusion?**

The wider the stream channel, the greater the challenge for deploying, securing, and maintaining fish isolation nets. The channel width of Little Bear Creek ranges between 46 m and 22 m from the confluence at the Chanel Ecarte upstream to Prince Albert Road. The two habitat variables that are most likely to impact fish exclusion are stream channel width and water depth. Depth in the main channel ranges from 1.2 m to 2.2 m in the same reach. Reach 1 has the widest channel with widths regularly exceeding 25 m. Fish exclusion in this reach would be the most challenging. Reaches 2 through 5 largely have channel widths less than 25 m, making fish exclusion easier. Stream flow (discharge) and wind did have some influence on net setup and maintenance during field experiments. Field crews would have to occasionally adjust nets that would move slightly due to the influence of stream flows and wind. Overall, these had little influence on activities in either experiment.

**Could the resulting fish exclusion techniques be practically implemented on the scale required for Little Bear Creek?**

From both experiments in this study, it was demonstrated that fishes can be captured and removed from sampling sites within the main channel of Little Bear Creek. Results demonstrate that large numbers of fishes can be captured using seine nets from non-wadeable habitats in large agricultural drains. Little Bear Creek is a large agricultural drain with channel widths exceeding 25 m and channel depths exceeding 1.5 m. Due to this, the traditional method of deploying nets by wading is not reasonable. Also, the banks of Little Bear Creek are heavily vegetated and steep. Accessing from shoreline areas is not practical for this activity. The most effective way to deploy isolation nets in Little Bear Creek is by using boats. Implementation of the techniques discussed in both Experiment 1 and Experiment 2 would require a minimum of 4 trained personnel with two (4.3 – 4.9 m) vessels. This technique involved accurate navigation of vessels across the channel and precise deployment of nets to avoid getting nets tangled or fouled in the outboard motor. Once nets are deployed and secured, field crews must be diligent as nets may require regular adjustments due to the channel flow/seiche and winds. Crews must also ensure the safe capture, removal, and release of fishes from prescribed work areas. Failure to do so could result in additional stress and/or mortality to captured fishes.

**Alternate Mitigation Strategies**

Additional mitigation strategies (Coker et al. 2010) should be considered for Little Bear Creek including project staging, timing windows, equipment maintenance, and shoreline/bank stabilization.

Project staging would involve implementing the drain maintenance activities over a period of several months or years. The length of recovery time for fish populations and their associated habitats is not known. Additional monitoring would be required post-impact to determine when recovery of fish populations has occurred.

Timing windows could help further reduce impacts to fish populations in Little Bear Creek. Windows should be developed to protect fishes including their eggs, juveniles, and spawning adults by scheduling activities to avoid these life history stages.

The operators conducting the agricultural maintenance should be certain that their equipment is in good working order and that all maintenance on equipment is current. Equipment should be operated on land, above the high water mark, whenever possible. Washing and refueling of equipment should occur well away from the watercourse to prevent any deleterious substances from entering the water. Any works that disturb the shorelines/banks can have serious impacts on fishes in the channel.

Clearing of riparian vegetation should be kept to a minimum as this change can cause changes in shade, water temperature, bank stability, etc. (Coker et al. 2010). When practical, vegetation should be pruned and trimmed rather than uprooted and removed. Debris (e.g., woody debris, logs, rocks) removal from the shoreline or stream bed should be minimized for all areas below the high water mark. Disturbed shoreline areas should be immediately stabilized to prevent erosion and/or sedimentation. Re-vegetating disturbed areas with native species suitable for the site is best. Shorelines gradients should be restored or enhanced to ensure shoreline stability during and after works are completed.

During the DIDSON survey there were many anecdotal observations made of fish movement within and outside of the net enclosures. The observed fishes did respond to disturbances in the water (people, boats, outboard motors) by moving away from the enclosures. They did seem to return to normal swimming patterns along the block nets during times with less noise (DIDSON recording/data collection). These observations suggest that noise from heavy equipment, boats, etc., could be used as a tool to chase, or scare, fish from areas of in-water works. Using noise to scare fish would be less intrusive than capturing, handling, transporting and releasing fish from work locations.

### Future Research

During the experiment with the DIDSON camera, there were some notable observations regarding the influence of noise on fish behaviour. During net deployment, boat activity would cause a considerable reduction in fish targets within the DIDSON field of view. Once nets were in place and the boats were removed from the work area the number of fish targets would increase again. The influence of disturbance (e.g., noise, vibration) on fish behaviour was not tested during these field experiments. However, noise could prove a useful mitigation tool if it can be used to move fish from work areas. Other control measures, such as underwater speakers, seismic plates, bubble barriers, and strobe lights should be evaluated as potential fish exclusion methods.

In addition, studies are required to determine timelines for recovery of fish populations and their associated habitats.

## Contributors

Jason Barnucz, DFO Science, Central and Arctic Region

Nicholas Mandrak, University of Toronto Scarborough

Kathleen Martin, DFO Science, Central and Arctic Region

Scott Reid, Ontario Ministry of Natural Resources and Forestry

Kelly McNichols-O’Rourke, DFO Science, Central and Arctic

Doug Watkinson, DFO Science, Central and Arctic Region

Scott Milne, Milne Technologies

## Approved By

Michelle Wheatley, Director of Science, Central and Arctic Region

Gavin Christie, Division Manager, Great Lakes Laboratory of Fisheries and Aquatic Sciences

(Approved September 11, 2015)

## Sources of Information

Carle, F. L., and Strub, M. R. 1978. A new method for estimating population size from removal data. Biometrics, 34, 621-830.

Coker, G.A., Ming, D.L., and Mandrak, N.E. 2010. Mitigation guide for the protection of fishes and fish habitat to accompany the species at risk recovery potential assessments conducted by Fisheries and Oceans Canada (DFO) in Central and Arctic Region. Version 1.0. Can. Manuscr. Rep. Fish. Aquat. Sci. 2904: vi + 40 p.

Milne, S. W. 2014. Depletion study – DIDSON assessment: Methodology and summary of results. Milne Technologies prepared for Great Lakes Laboratory of Fisheries and Aquatic Sciences, Fisheries and Oceans Canada. 49 p.

## This Report is Available from the

Center for Science Advice (CSA)
Central and Arctic Region
Fisheries and Oceans Canada
501 University Crescent
Winnipeg, Manitoba
R3T 2N6

Telephone: (204) 983-5131
E-Mail: xcna-csa-cas@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

ISSN 1919-3769


Correct Citation for this Publication:

DFO. 2015. Fish exclusion options for aquatic species at risk for drainage activities in Little Bear Creek, Ontario. DFO Can. Sci. Advis. Sec. Sci. Resp. 2015/036.

*Aussi disponible en français :*

*MPO. 2015. Options d'ouvrages visant à empêcher les espèces de poissons en péril d'avoir accès à des tronçons du ruisseau Little Bear, en Ontario, aux fins d'activités de drainage. Secr. can. de consult. sci. du MPO, Rép. des Sci. 2015/036.*