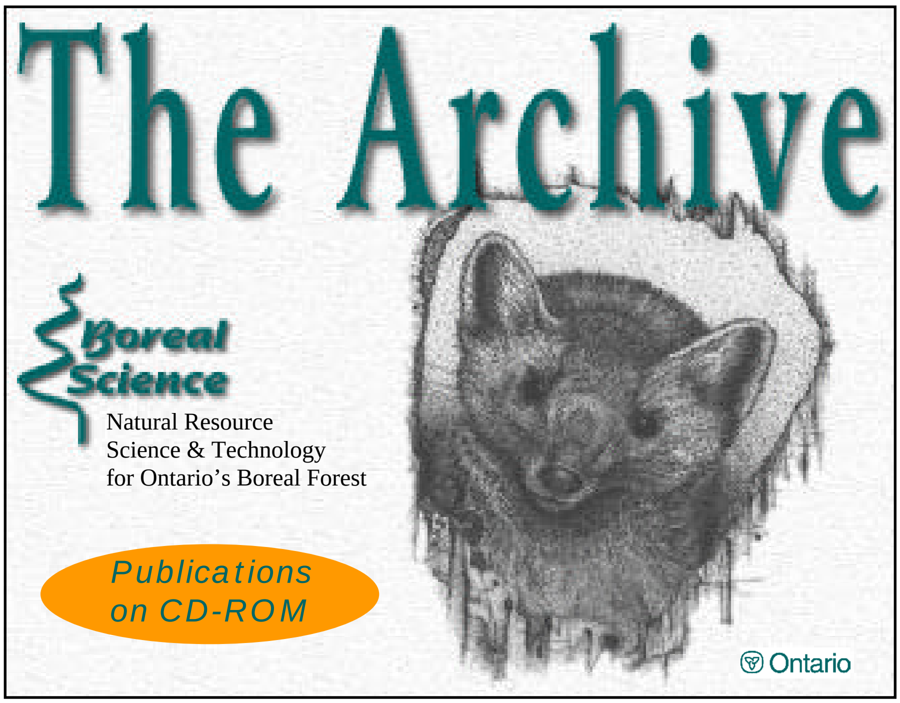
Return to Index



ADULT LAKE STURGEON (*ACIPENSER FULVESCENS*) HABITAT USE, GROUNDHOG RIVER 1996

by John Seyler

NEST Technical Report TR-035
October 1997

LREU
LARGE RIVER ECOSYSTEM UNIT

ADULT LAKE STURGEON (*ACIPENSER FULVESCENS*) HABITAT USE, GROUNDHOG RIVER 1996

by John Seyler

NEST Technical Report TR-035
October 1997

LREU

LARGE RIVER ECOSYSTEM UNIT

Canadian Cataloguing in Publication Data

Seyler, John.
Adult lake sturgeon (*Acipenser fulvescens*) habitat use, Groundhog River

(NEST technical report, ISSN 1192-8182; TR-035)
ISBN 0-7778-6677-3

1. Sturgeons–Habitat–Ontario – Groundhog River.   I. Ontario. Northeast Science & Technology.
II. Title. III. Series.

QL638.A25S49   1997   S97'.42   C97-964037-7

Printed in Ontario, Canada

NEST Technical Report TR-035
51096
ISBN 0-7778-6677-3
ISSN 1192-8182
(XX k PR.,15-Oct-97)

Copies of this publication are available from the Ontario Ministry of Natural Resources through:

Boreal Science Communications

http://www.borealscience.on.ca

Cette publication spécialisée n'est disponible qu'en anglais

This publication should be cited as:
Seyler, John, 1997. Adult lake sturgeon (*Acipenser fulvescens*) habitat use, Groundhog River 1996. OMNR, Northeast Science & Technology. Timmins, Ontario. TR-035. 28p.

Executive Summary

A field study designed to establish seasonal habitat use relationships for adult lake sturgeon was undertaken on the Groundhog River in 1996. The study reaches, which represent the upstream limits of lake sturgeon range, were inhabited almost entirely by adult (vs. juvenile) lake sturgeon. Adult lake sturgeon habitat use was restricted to low flow refugia in the spring. They were distributed across the entire study area (e.g. all habitat types) in the autumn when flows were lowest. Water velocity appeared to be the primary factor influencing habitat use by adult lake sturgeon.

Acknowledgments

This project was made possible through a partnership agreement between the large River Ecosystem Unit, Ontario Hydro and the Boreal Ecosystem Science Co-operative.

The field component of this project was completed due in no small part to the tireless efforts of Mike Michell of the Ontario Ministry of Natural Resources, Timmins District. I would also like to acknowledge the efforts of field technicians Bill McCord, Shelly Gervais, Jason Boisvert, Kim Brousseau and Laura Morrisette.

Critical review of this manuscript was provided by Rejean Fortin of L'Universite du Quebec a Montreal and by Steve McGovern, Charlie Henry and Chiadih Chang of Northeastern Science & Technology (NEST).

Thanks also to Diane Wahlman for administrative assistance, Wendy Copps for design and layout, and Doug Skeggs for co-ordinating the publication of this technical report.

Table of Contents

List of Figures

List of Tables

INTRODUCTION

Habitat suitability indices are based upon the premise that different species of biota select certain habitat types or conditions (preferred) over others (unsuitable). Preference or H.S.I. curves are a means of describing preferred conditions which may vary seasonally, diurnally and/or across various size ranges or age groups for a given species. Thus, at a given point in time, habitat preference is a function of the biology and behavior of an individual as well as the availability or supply of suitable conditions.

In recent years, there has been a great deal of research conducted to define habitat requirements of aquatic biota. A master library of H.S.I. models is maintained by the U.S. Fish and Wildlife Service and these are readily obtainable (Hays 1989). Many of these models are based upon fisheries research in climatic zones and conditions different from those experienced in Ontario. These populations may possess significant genetic differences from stocks found in northern Ontario and have likely developed behavioral and habitat use patterns suited to their local environments. Very little is known, regarding fish habitat use relationships in northeastern Ontario rivers despite the fact that a great deal of instream development has occurred. When faced with decisions related to flow alterations river managers must currently rely on habitat use relationships developed elsewhere. Defining the habitat requirements of fish species inhabiting Northeastern Ontario's rivers is a major priority for the Large River Ecosystem Unit (Seyler *et al*. 1994).

There has been a world-wide surge of interest into Lake Sturgeon ecology over the last decade. Despite the high commercial value and societal interest in this unique species, lake sturgeon stocks continue to decline across much of their range. Over exploitation and habitat loss have seriously reduced lake sturgeon populations across Ontario (Brousseau 1987). northeastern Ontario represents one of the last strongholds of this species.

This study represents one of the first initiatives undertaken in northeastern Ontario, to define the habitat requirements of fish species. It is the product of a collaborative agreement between Ontario Hydro, the Boreal Ecosystem Science Co-operative and the Large River Ecosystem Unit (LREU). The objective of this project was to study seasonal habitat use by adult lake sturgeon in a segment of the Groundhog River. The habitat use relationships generated through this project will be used by Ontario Hydro in the development of a lake sturgeon habitat suitability (H.S.I.) model (Ontario Hydro 1997). The project provided an opportunity for the LREU to collect habitat use information for a variety of fish species inhabiting the river. This data will contribute to the creation of a regional river fish habitat use data base.

Study Location

The Groundhog River is a fifth order tributary within the Moose River Basin. The Moose River and its tributaries flow northward, draining into James Bay (**Figure 1**). The Groundhog River is 360 km in length and drains approximately 12,518 square km, 11.4 percent of the Basin (Brousseau and Goodchild 1989). The River originates at the outflow of Horwood Lake, a hydro-electric storage reservoir and terminates at the Mattagami River. Lake sturgeon are one of 23 fish species known to inhabit the Groundhog River (Seyler 1997a). Lake sturgeon are distributed throughout the bottom 330 km of the river, from its mouth upstream to Upper Falls which is a natural barrier. This study focused on a 15 km section of the River representing the southern most reaches of the lake sturgeon's range in the Groundhog River.

The study area contains a diversity of channel forms including constricted, fast flowing reaches throughout the central portion and wide slow moving sections at both ends. Water clarity is poor year round (secchi < 1m) due to clay particles suspended in the water column, which create very turbid conditions.

The study area is divided by Camus Rapids which are 2 km in length, located approximately 5 km downstream of Upper Falls (**Figure 2**). Lake sturgeon are known to spawn at the base of Camus Rapids (Seyler 1996). Upper Falls is also a suspected spawning site (J. Cavanagh personal comm.).

Methods

The study area was accessed by forest access road and water at both the northern and southern extremities. A tent field camp was constructed at the northern end of the study area. A prospecting cabin served as field accommodation at the southern end.

Lake sturgeon habitat use was examined during the spring and autumn seasons representing high and low water conditions respectively. Flood flows created dangerous working conditions during the spring freshet and field work did not commence until June 10th. Spring assessment work continued until July 19th. The autumn field season extended from September 9th until October 4th.

Five-person crews were employed to carry out the field work. Crews worked out of aluminium boats equipped with halogen lights mounted on overhead frames for night work. A catamaran inflatable raft was used to access netting sites in the central reaches which were isolated by rapids.

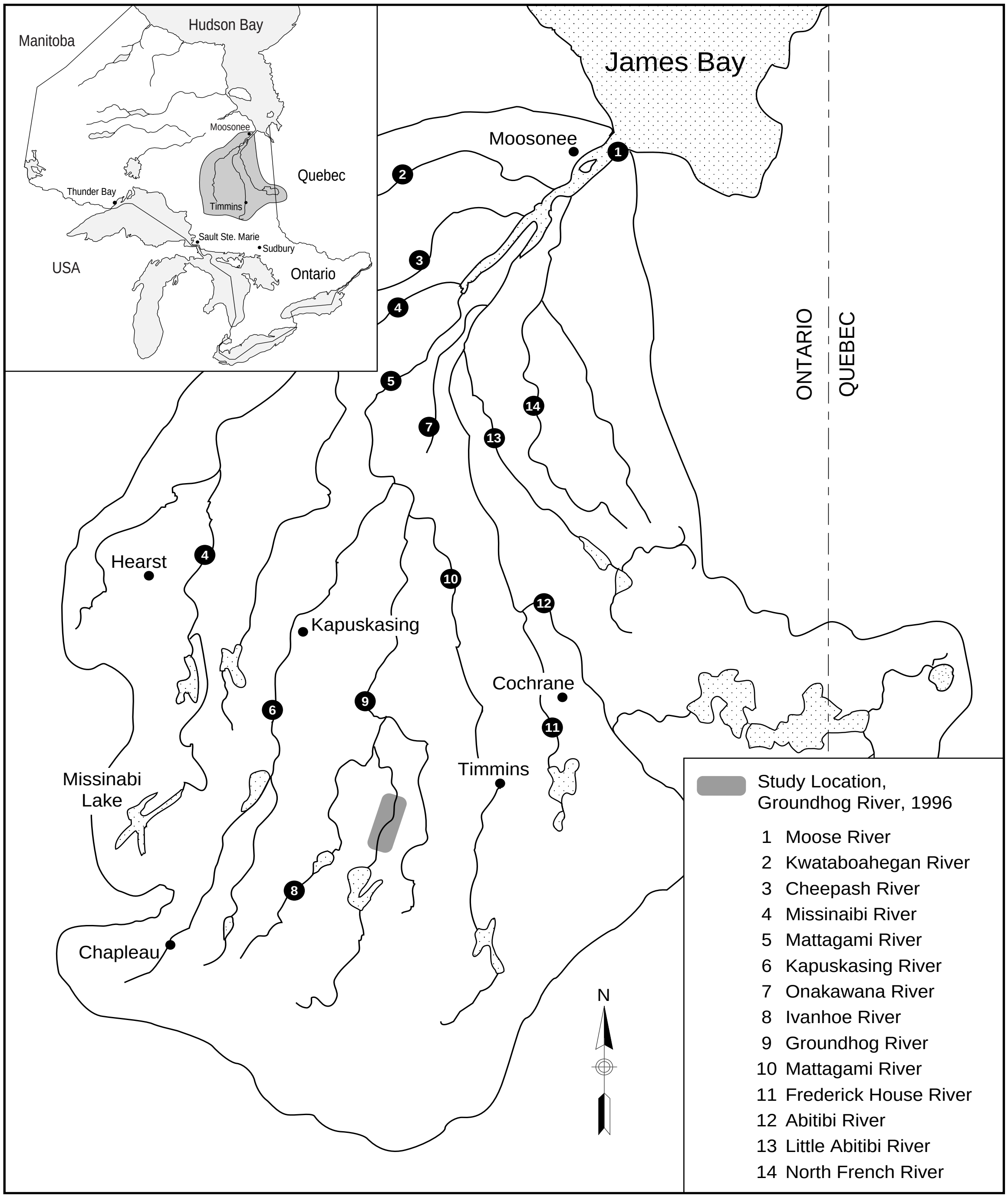


Figure 1. The Moose River Basin and its tributaries (Inset: Moose River Basin; Provincial perspective).

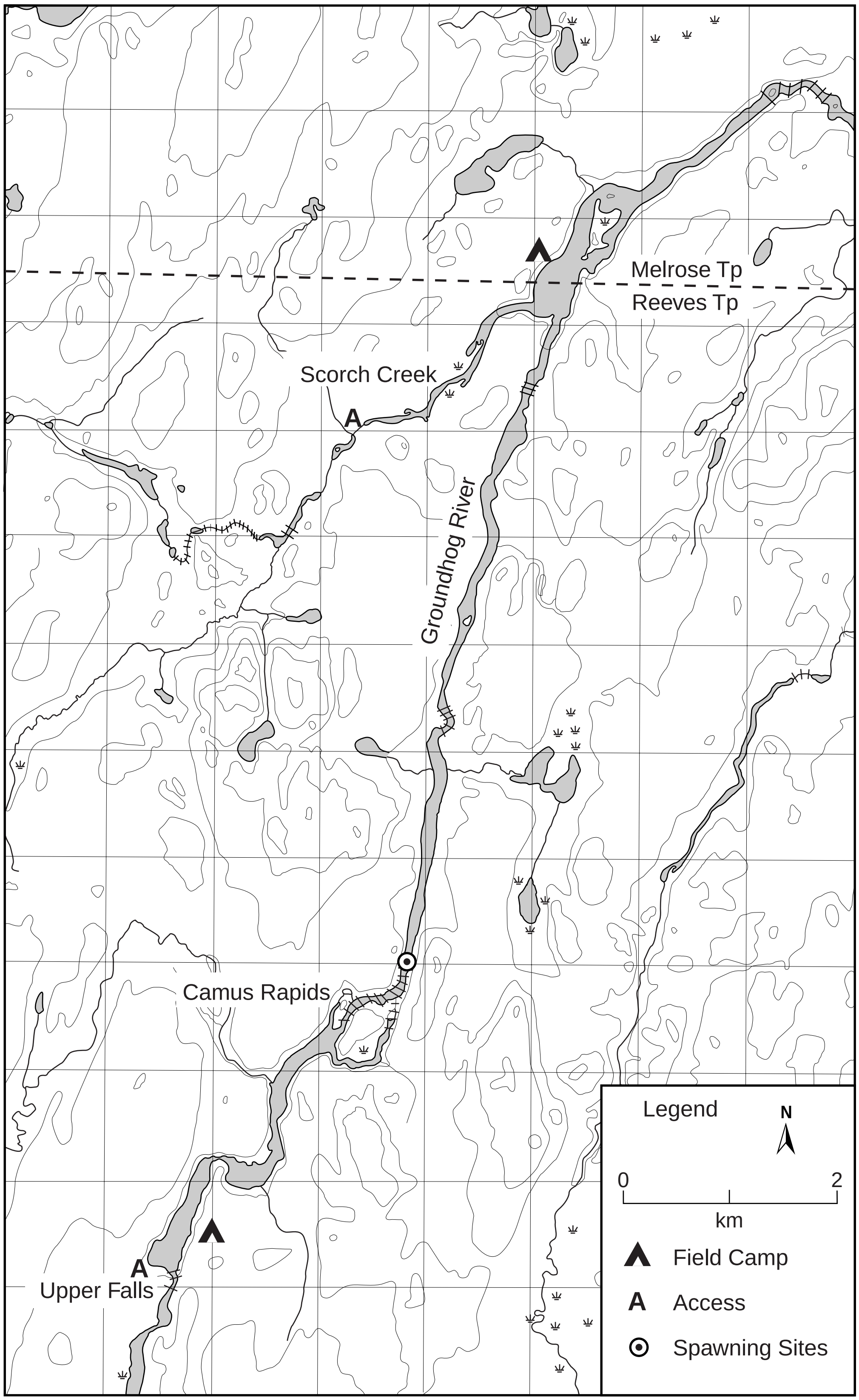


Figure 2. The Study Area, Groundhog River 1996.

Netting gear consisted 15 m panels of multifilament gillnet assembled in six panel small mesh (50 mm to 115 mm) and large mesh (130 mm to 305 mm) gangs. Substrates were sampled using a 40 cm^2 Eckman dredge. Substrate types were classified as sand (< 2.0 mm diameter.), clay, organic/detritus, gravel (2 to 5 cm diameter.), rubble (> 5 cm diameter.), bedrock or a combination of the above. Water velocities were measured at depths corresponding to the top, middle and bottom of each net panel using a General Oceanics flowmeter. The mean value of these three measurements was used to represent water at net depth. Depths were determined using an Eagle Ultra II depth finder.

Net locations were randomly chosen throughout the study area. Three small mesh and three large mesh gangs were fished during each shift. Netting commenced approximately four hours prior to sunset. Each gang was set for two three hour periods and were then left to fish overnight at each net location. Depth and velocity measurement and substrate sampling was conducted at each panel as nets were retrieved. All fish were measured, weighed, marked (streamer tags) and released. No aging structures were collected. Large and small mesh gangs were fished at each location on different nights. Nets were set at approximately a 30 degree angle to the flow. Nets were set a minimum of 15 m apart so they would not interfere with one another. Both shoreline and mid-channel sets were employed. The same net locations were used during each of the sampling seasons.

Catch, meristic and habitat parameter data were entered into an electronic data base and analysed using SYSTAT (Copyright SYSTAT inc. 1990). Habitat availability and use functions were derived from data using distance weighted least squares smoothing methods. Mean lengths of lake sturgeon captured at different geographic locations and during different sampling periods were contrasted using ANOVA techniques featured in SYSTAT software. Catch and meristic data were analysed and are discussed in terms of the ‘upper reach’ and ‘lower reaches’ which are physically separated by an extensive set of rapids. Habitat use relationships were derived for lake sturgeon captured across the entire study area.

Results

The bathymetry of the study area is illustrated in Figures 3a and 3b. Much of the study area was composed of narrow (mean width~40 m), steep sided troughs separated by small sets of rapids. The highest water velocities (e.g. >1.5 m/s) were recorded in these troughs, primarily in the spring. Water velocities in wide reaches located at the upstream boundary of the study area, below Upper Falls, and near the mouth of Scorch Creek were low over the duration of the study. Water velocities in pools (e.g. discrete areas where depth exceeded 6 m) were negligible throughout the study. Pools occurred infrequently across the study area.

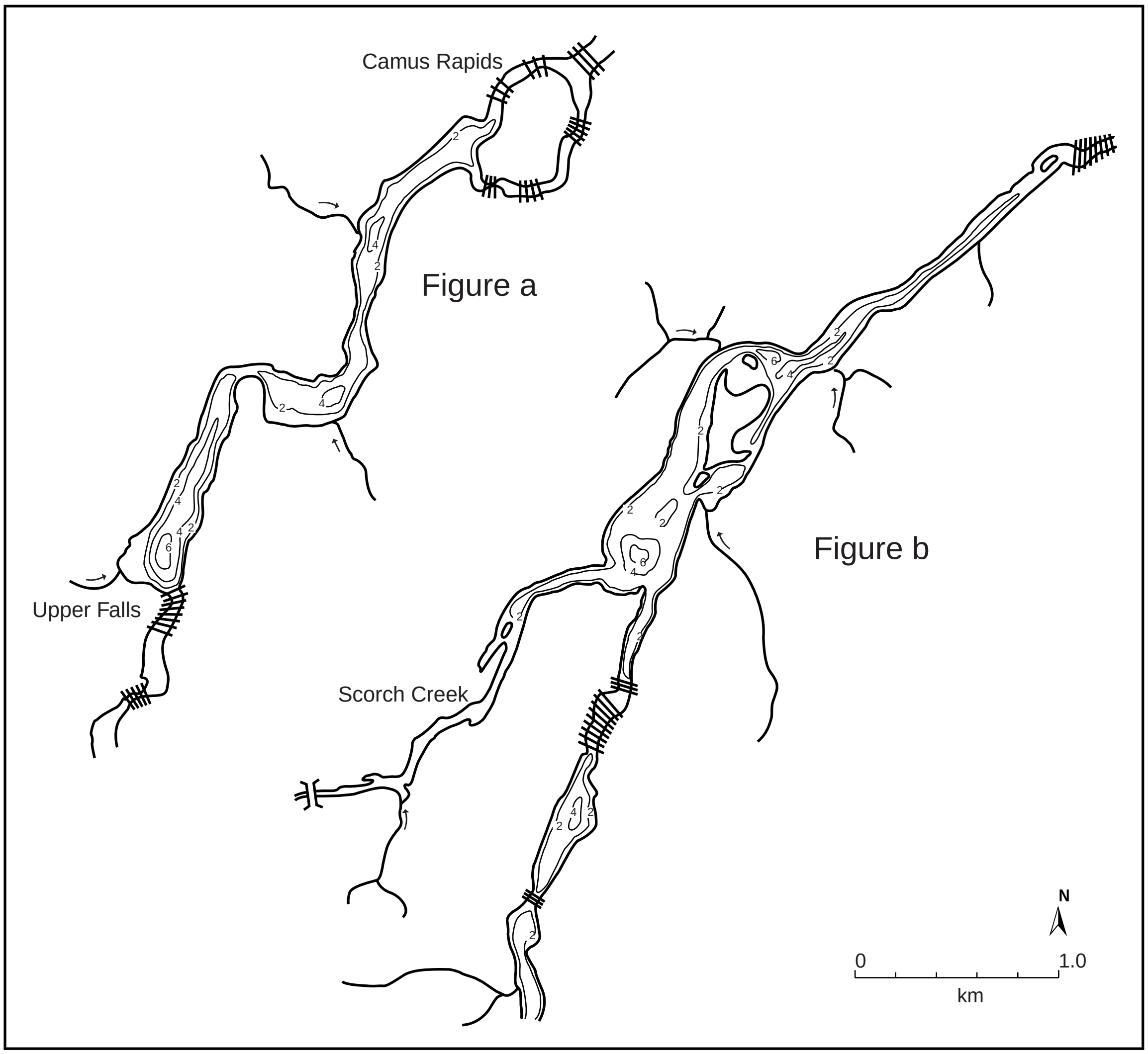


Figure 3. Study area bathymetry, Groundhog River 1996
a: upstream section, b: downstream section (all contour intervals are in meters).

Water velocities were generally low (e.g. < 0.5 m/s) across the entire study area during the autumn netting period. Seasonal velocity conditions as described by availability functions are illustrated in Figure 4. Mean values for velocities and depths measured in the study area are presented in Table 1. Mean flow data was recorded below the Horwood Lake dam, located 35 km upstream from the study area.

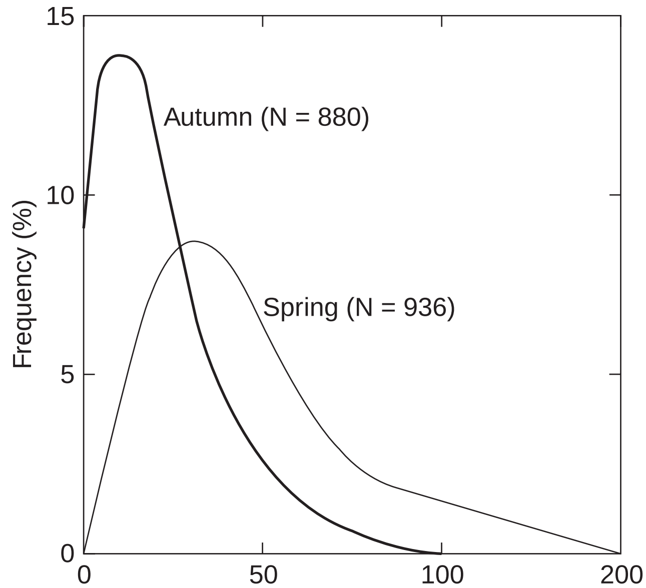


Figure 4. Velocity availability functions derived from spring and autumn sampling periods.

Table 1. Mean depth, velocity and flow characteristics recorded during spring and autumn sampling periods, Groundhog River study site 1996.

Sampling Period	Mean Velocity (cm/s)	Mean Depth (m)	Mean Flow (cms)
Spring (June 10 to July 14)	39.4	4.87	68.8
Autumn (Sept. 9 to Oct. 4)	19.4	4.62	19.8

The major substrate component in the study area was sand. Mixtures of sand and other fine materials were also common (**Figure 5**). Wide channel sections, where flows were generally lowest acted as depositional areas. Coarse substrates (e.g. rubble) and bedrock were encountered primarily in narrow fast flowing channels.

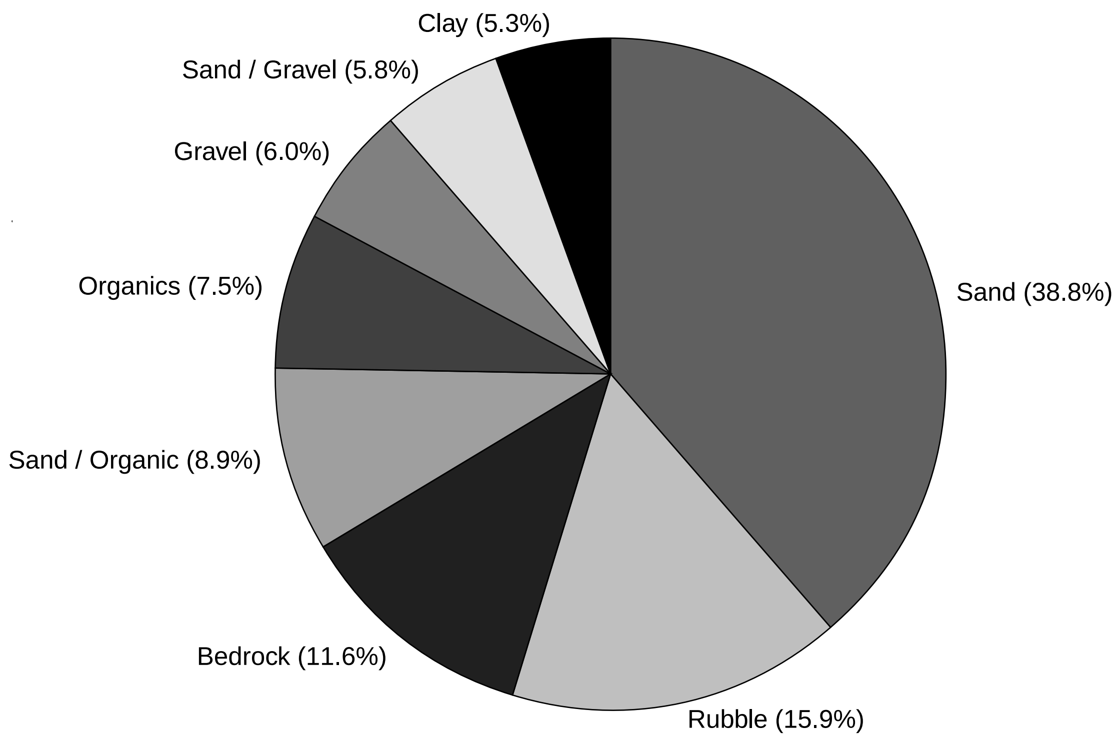


Figure 5. Substrate availability within the study area.

A total of 119 different lake sturgeon were captured during the study. Twenty-nine of these fish were subsequently recaptured. None of the recaptures had moved across Camus Rapids which separate the upper and lower reaches of the study area. Captured lake sturgeon exhibited a trimodal length frequency distribution (**Figure 6**). The majority, 86 percent, were greater than 1 m in length. Although no aging structures were collected during this study, a growth rate calculated for Groundhog River lake sturgeon (Seyler 1997b) suggests that most lake sturgeon captured were at least 30 years old (**Figure 7**). Fifteen juvenile lake sturgeon (total length = 35 to 70 cm) were captured near the downstream boundary of the study area. These lake sturgeon likely ranged in age between four and 16 years.

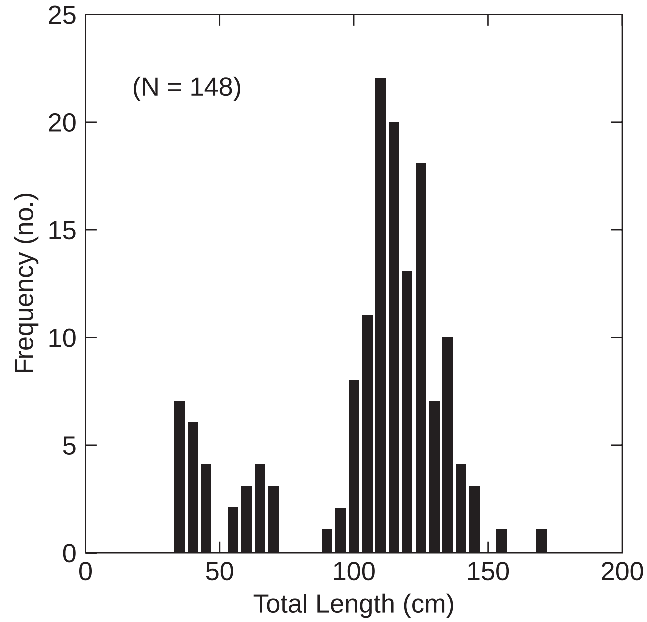


Figure 6. Length frequency distribution for lake sturgeon captured throughout the study area, 1996

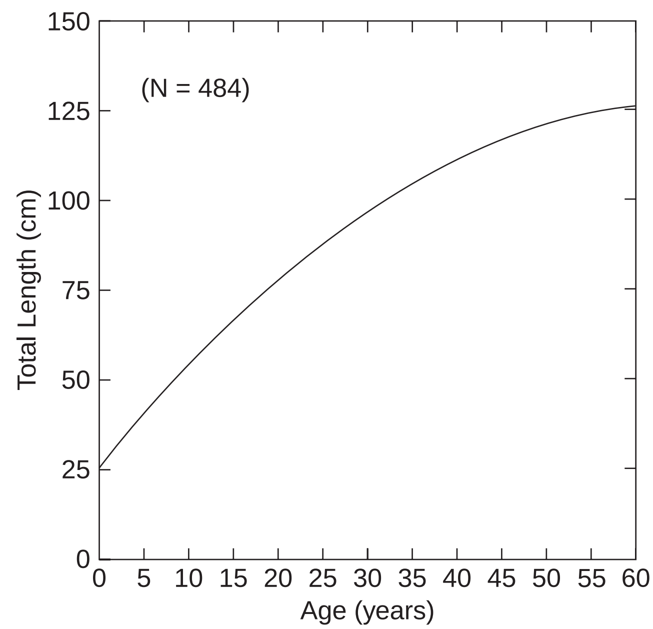


Figure 7. Total length-at-age function calculated for Groundhog River lake sturgeon (Seyler 1997b). T.L. = 26.35 + 2.904 (Age) - 0.018 $(\text{Age})^2$ (R^2 = 0.953)

76 percent of all lake sturgeon were captured in reaches located at the lower end of the study area. Length frequency distributions for lake sturgeon captured in the upper and lower reaches are illustrated in Figures 8a and 8b. Table 2 summarizes mean total lengths of lake sturgeon captured at each end of the study area during each sampling period. Mean lengths of lake sturgeon captured in the upper reach vs. lower reaches of the study area were significantly different ($p < 0.001$).

Figure a

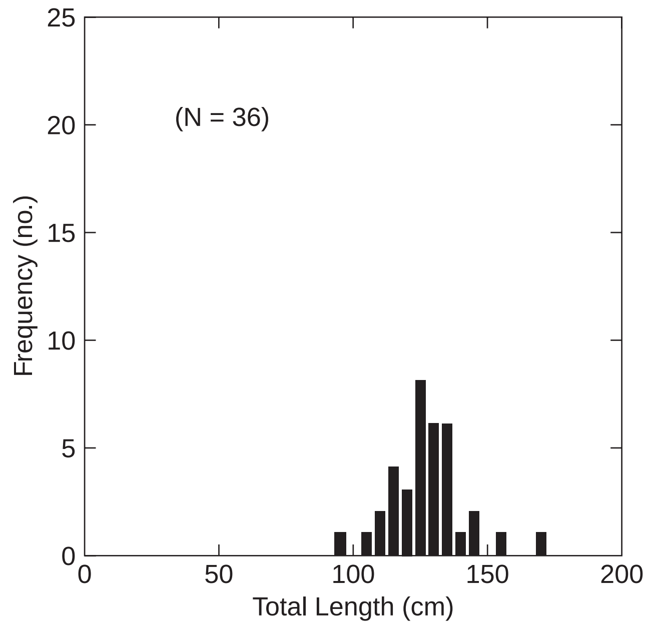


Figure b

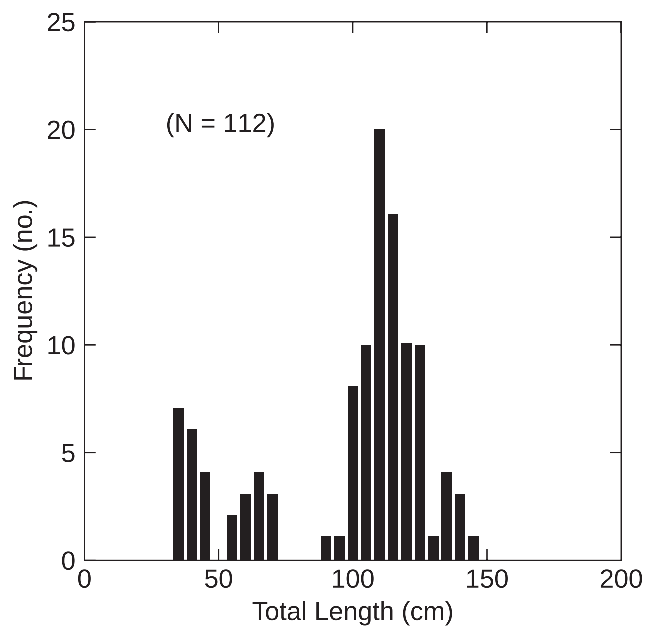


Figure 8. Total length (cm) frequency distributions for lake sturgeon captured in a: the upper and b: the lower reaches of the study area, Groundhog River 1996.

Table 2. Mean total length-at-age (cm) of lake sturgeon captured in upper and lower reaches by sampling season, Groundhog River 1996.

Season	Upper Reach	Lower Reaches	Total
Spring	128.8 + 8.7	109.6 + 21.3	114.1 + 19.9
Autumn	134.6 + 9.8	97.0 + 33.8	104.1 + 34.0
Total	130.5 + 10.2a	101.4 + 30.6a	107.9 + 29.9

a: Significant difference ($p < 0.001$).

Capture rates (CPUE's) for lake sturgeon were higher in the lower reaches than in the upper reach during each sampling period (**Table 3**). Overall the catch rate from the lower reaches was almost twice that of the upper section. Seasonal catches per unit effort were similar in the upper section of the study area but increased dramatically in the lower reaches in the autumn. There was no difference in capture rates during daylight versus darkness hours.

Table 3. Netting effort, catch and catches per unit effort (no. per panel hour) for lake sturgeon (juveniles, adults and recaptures), Groundhog River 1996.

Season	Upper Reach	Lower Reach	Total
Spring			
Effort (panel hr.)	685	1077	1762
Catch (n)	16	36	52
C.P.U.E.	0.023	0.033	0.030
Autumn			
Effort (panel hr.)	913	1455	2368
Catch (n)	20	76	96
C.P.U.E.	0.022	0.052	0.041
Total			
Effort (panel hr.)	1598	2532	4130
Catch (n)	36	112	148
C.P.U.E.	0.023	0.044	0.036

Figure 9 illustrates seasonal catches per unit effort for adult lake sturgeon within the three mesohabitat types encountered during the study. Capture rates during the spring sampling period were significantly lower in channel flats relative to other habitat. During the autumn period, catch rates were fairly uniform across mesohabitat types.

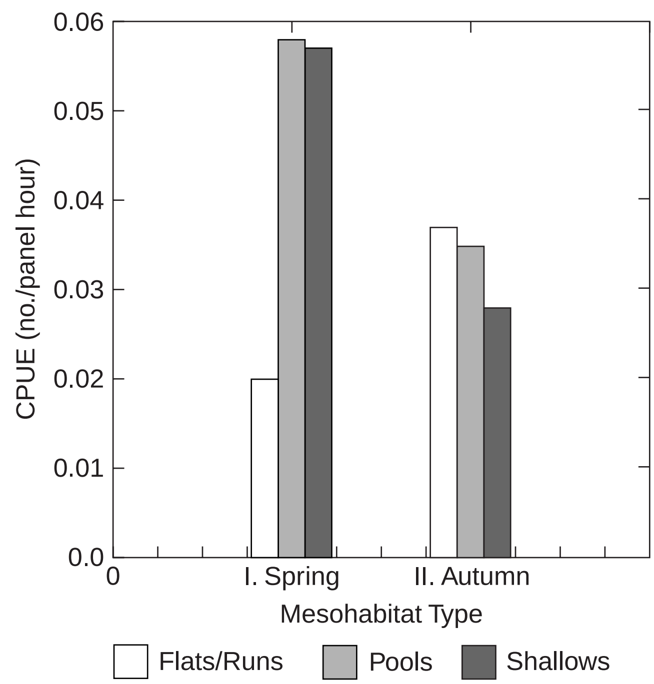


Figure 9. Seasonal catches per unit effort (no./panel hour) for adult lake sturgeon across mesohabitat types.

Adult lake sturgeon were captured over a variety of substrate types during both sampling periods. In the spring, a definite preference was demonstrated for substrates with organic or coarse material (gravel, rubble) components (**Figure 10**). These substrates were also heavily used during the autumn sampling period however, lake sturgeon were captured with greater frequency over clay and sand substrates.

Depth preference relationships developed for spring and autumn sampling periods have a similar shape although the latter is somewhat narrower (**Figure 11**). Lake sturgeon exhibited a high preference ($P > 0.75$) for habitat two to 6 m in depth. Water within this range represented 74.4 percent and 69 percent of available habitat measured during the spring and autumn sampling periods, respectively.

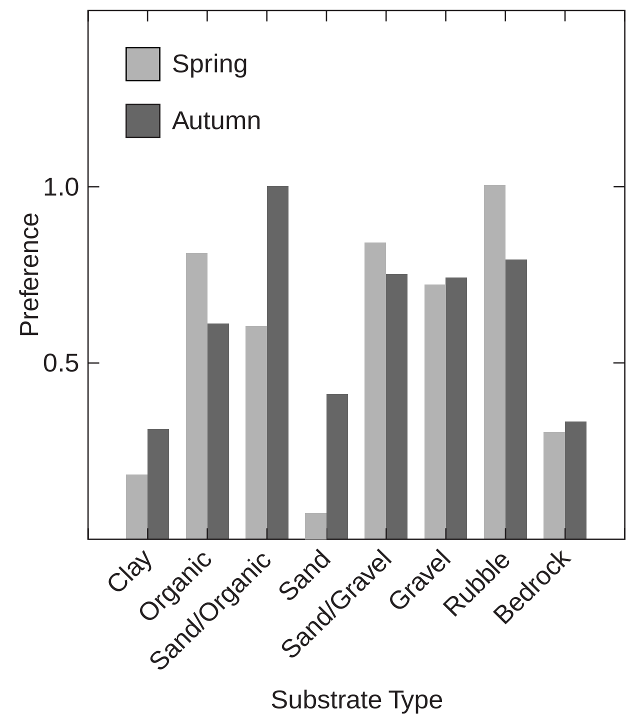


Figure 10. Substrate preference exhibited by adult lake sturgeon during a: spring and b: autumn sampling periods

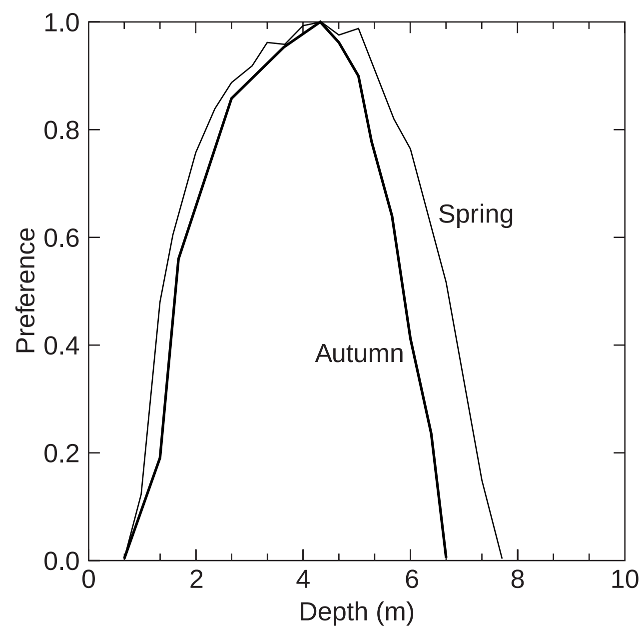


Figure 11. Depth preferences exhibited by adult lake sturgeon during spring and autumn sampling periods.

Velocity preferences during the spring were greatest at velocities ranging between 15 and 50 cm/s (**Figure 12**). The descending arm of this curve is very steep. Preference decreased rapidly at velocities exceeding 55 cm/s. The preferred range (P > 0.75) represents 67 percent of all measured conditions. In the autumn, the velocity preference relationship shifted to the left. The right arm of this curve exhibits a gradual descent. Lake sturgeon exhibited a high preference (P > 0.75) for 85 percent of all velocity conditions measured in the autumn. The ascending, left arms of both curves are very steep. Lake sturgeon frequently used the lowest velocities measured during both sampling periods.

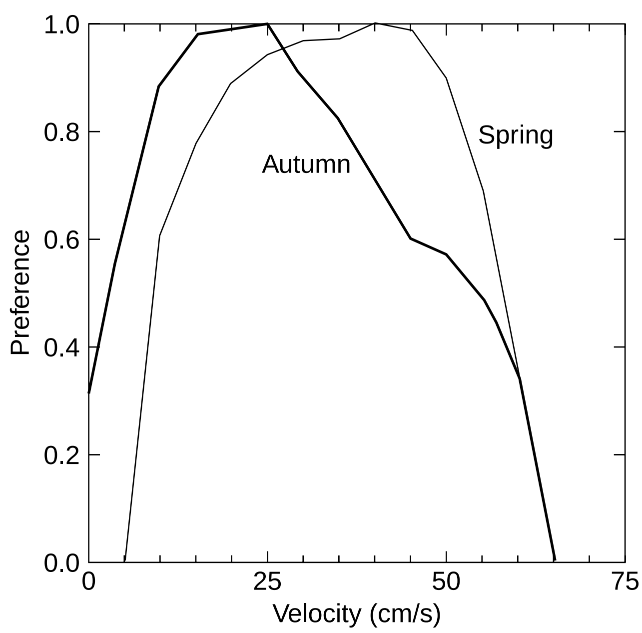


Figure 12. Velocity preferences exhibited by adult lake sturgeon during spring and autumn sampling periods.

Discussion

This study area represents the most southern, upstream distribution of lake sturgeon on the Groundhog River. Relative to downstream sections of the River, lake sturgeon abundance in the study area appears to be low. (**Table 4**).

Table 4. Catches per unit effort (no./panel hr.) for lake sturgeon captured at various locations on the Groundhog River.

Location	Time	Mesh Size (mm)	CPUE	Source
Upper Reaches	June Sept.	50 to 305	0.030 0.041	This Study
Carmichael Falls G.S.	June	40 to 228	0.034	B.A.R. 1995
Carmichael Falls G.S.	May June to Aug.	25 to 229	0.096 0.071	N.E.A. 1992
Carmichael Falls	May to June	50 to 252	0.109	Phoenix and Rich 1989
Faquier	June July to Aug. Sept.	25 to 203	0.098 0.105 0.079	Seyler 1997b

The first reaches netted during the spring sampling period were located near the downstream boundary of the study area. If lake sturgeon migrated and remained upstream, near the spawning area at Camus Rapids throughout the freshet, this would explain the low capture rates recorded at the beginning of the project. Consequently, capture rates for the autumn sampling period are likely more representative of overall lake sturgeon abundance.

Spawning activity has been documented below the Camus Rapids and there is anecdotal evidence that lake sturgeon once spawned below Upper Falls at the upstream edge of the study area. Lake sturgeon occupying the study reaches were predominately adults. Assuming that lake sturgeon in the study area successfully reproduce, it is possible that drift results in the displacement of most larvae to downstream reaches. LaHaye *et al.* (1989) tracked drifting lake sturgeon larvae up to 16 km. below spawning sites. Larval drift across impassable natural or man-made barriers, may predispose upstream population units to recruitment failure.

The low number of juveniles captured during this study suggests that unless lake sturgeon are capable of traversing waterfalls and rapids located below the study area, recruitment to this sub-group is low. If this is the case, even moderate levels of exploitation of adult lake sturgeon in the upper reaches of the Groundhog River may eventually lead to local extirpation. Poor lake sturgeon recruitment has been documented in the upper reaches of the Kenogami River (Sandilands 1987) which is undeveloped. The collapse of lake sturgeon populations in upstream sections of their distributions in the Mattagami and Abitibi rivers is thought to be due to the combined effects of commercial exploitation and recruitment failure associated with range fragmentation (Nowak 1984, Gibson *et al.* 1984, Payne 1987).

The low numbers of lake sturgeon captured, especially during the spring sampling period, is not conducive to the development of ‘strong’ habitat use relationships. Similarly, low catches per unit effort recorded across temporal sampling strata impedes our ability to identify/describe diel activity patterns with any degree of confidence. Bovee (1986) suggests that sample sizes of at least 150 individuals are necessary to construct smooth habitat use histograms. Logistic and budgetary constraints as well as low lake sturgeon abundance precluded the acquisition of a sample size of this magnitude. The study site was sampled intensively and habitat availability relationships are representative of microhabitat conditions that existed during the project.

Three distinct forms of mesohabitats were identified in the study area. During the spring sampling period, lake sturgeon catches were highest in pools and shallows, both of which were characterized by low water velocities. During the autumn sampling period capture rates in channel flats increased and lake sturgeon appeared to be fairly evenly distributed across the study area.

Adult lake sturgeon selected substrates dominated by coarse (gravel, rubble) and organic particles during both sampling periods however, substrate preference was more general in the autumn. Lake sturgeon have been described as generalist and opportunistic benthic feeders (Rossiter *et al.* 1994). Foraging studies involving juvenile lake sturgeon have shown that they are only able to detect food sources at close range (Rossiter and Leach 1994). This physiological limitation necessitates that lake sturgeon forage extensively in search of food. One would expect fish using this form of feeding strategy to be associated with a variety of substrate types. It is worth noting that adult lake sturgeon were rarely found over clay and bedrock substrates which are likely devoid of potential food items.

Depth preference relationships were not pronounced during either of the sampling periods. Lake sturgeon were captured at a variety of depths throughout the study. Ecologistics Ltd. (1987) notes that adult lake sturgeon were found at a variety of depths on the Kenogami River but tended to be most abundant where there was a range of depths available (e.g. pools adjacent to bars or rapids) and least abundant across areas of uniform depth. Several radiotelemetry studies on the Groundhog and Mattagami rivers have shown that lake sturgeon use deep water/pools in the spring following spawning and over the winter (McKinley 1991, NEA 1992).

Velocity appeared to be the most important parameter measured, determining sturgeon habitat selection. Habitat preference decreased sharply at velocities exceeding 60 to 70 cm/s during both sampling periods.

River managers and researchers have employed a wide variety of gears in their efforts to assess fish populations and habitat use (Casselman *et al.* 1990, EIFAC 1974). Many of these techniques have been tried in northeastern Ontario rivers with variable success (Seyler 1997a). The lack of an effective, standard assessment methodology impedes managers from accurately describing/comparing fish communities and defining habitat requirements for various species.

In order to define habitat conditions at a point in time and space occupied by fish, direct observation, biotelemetry and electrofishing are the most commonly used methods (Bovee 1986). The physical conditions encountered in Northeastern Ontario river systems (e.g. high turbidity, low conductivity) as well as the remote nature of these systems limits the effectiveness of many proven techniques. Short duration gill netting is a practical, inexpensive, efficient method of capturing fish. It is possible to derive meaningful correlations between fish presence and habitat parameters using this technique but only if sufficient netting effort is employed to sample across the full spectrum of available mesohabitats and microhabitat conditions. This requires a prior knowledge of targeted study areas. As a minimum, investigators should have a good understanding of study area bathymetry. Stratified random or proportional sampling of available habitat types are acceptable strategies (Bovee 1986).

High water velocities (e.g. > 1.5 m/s) and turbulent water adjacent to rapids limited the placement of the gear employed in this study. Some fish species may use these areas during migration and/or spawning however, it is unlikely that they are occupied for extended periods of time unless some form of refuge (e.g. plunge pools) is present. Additional studies, examining the effectiveness of this methodology in capturing pelagic species occupying the water column are necessary before it can be promoted as a standard fish community assessment technique.

Conclusions/Recommendations

Fish species are commonly characterized as habitat specialists or habitat generalists. Most fish species will exhibit habitat preferences in order to complete specific components of their life histories (e.g. spawning) and under severe conditions (e.g. floods). This is likely particularly true in hostile environments such as rivers, where conditions tend to be extremely variable. Hence most river dwelling fish can best be described as facultative habitat users, specialists, but only under certain conditions.

The results of this study suggest that velocity was the primary determinant of adult lake sturgeon habitat use in this section of the Groundhog River. High velocities measured during the spring sampling period constrained lake sturgeon to particular mesohabitat types. Within these habitat types, lake sturgeon were found over a variety of substrates, over a wide range of depths. Once high flows subsided in channel flats, lake sturgeon were distributed across the study area in all but the most hostile (e.g. high velocity) microhabitat conditions. Below critical water velocities, which appear to be in the 60 to 70 cm/s range, food availability, may be an important factor determining lake sturgeon presence or absence.

Future habitat use studies should incorporate invertebrate sampling into the study design as well as fish stomach contents analyses in order to ascertain the importance of prey availability as a determinant of microhabitat preference. Additional studies of this nature should be undertaken in the future in order to validate the habitat preference relationships established for the upper Groundhog River and to refine the sampling protocol.

The assessment of lake sturgeon abundance within upper reaches of their distribution in rivers across northeastern Ontario should be a priority for managers concerned with this species. In reaches sustaining fishing pressure, where adult abundance and recruitment are low, managers should consider the establishment of sanctuaries and/or juvenile lake sturgeon transfers as management strategies. It is recommended that late summer or autumn sampling be undertaken where the sole assessment objective is to quantify adult lake sturgeon abundance.

References

Bovee, K.D. 1986. Development and evaluation of habitat suitability criteria for use in the instream flow incremental methodology. U.S. Fish and Wildlife Service. Biological Report 86(7) 235p.

Brousseau, C.S. 1987. The lake sturgeon (*Acipenser fulvescens*) in Ontario. Ont. Fisheries Tech. Report Series No. 23.

Brousseau, C.S. and Goodchild, G.A. 1988. Fisheries yields in the Moose River Basin, Ontario. In D.P. Dodge [ed] Proceedings of the International Large River Symposium. Can. Spec. Publ. Fish. Aquat. Sci. 106.

Casselman, J.M., Penczak,T., Carl, L., Mann, R., Holcik, J. and Woitwich, W. 1990. An evaluation of fish sampling methodologies for large river systems. Pol. Arch. Hydrobiol., 37:4, p521-551.

Cavanagh, J. Ontario Ministry of Natural Resources; Timmins Ont. personal communication 1996.

Ecologistics Ltd. 1987. A lake sturgeon yield study on the Kenogami River; year three report. prepared for the Ontario Ministry of Natural Resources. 57p.

EIFAC. 1974. Methodology for the survey, monitoring and appraisal of fishery resources in lakes and large rivers. European Inland Fisheries Advisory Commission Tech. Paper (23), 33p.

Gibson, D.W., Aubrey, S. and Armstrong, E.R. 1984. Age, growth and management of lake sturgeon in a section of the Abitibi River. OMNR Tech. Report 33p.

Hays, R.L. 1989. Micro-HSI Reference Library. U.S. Fish and Wildlife Service. 75p.

LaHaye, M., Branchaud, A., Gendron, M., Verdon, R. and Fortin, R. 1992. Reproduction, early life history and characteristics of the spawning ground of the lake sturgeon (*Acipenser fulvescens*) in Des Prairies and L'Assomption rivers, near Montreal, Quebec.Can. J. Zool. 70: 1681-1689.

McKinley, R.S., Sheehan, R.W. and Kowlyk, H. 1991. Seasonal distribution and movement of radio tagged walleye and lake sturgeon in the vicinity of the proposed Mattagami River Hydroelectric Extensions. Ontario Hydro Tech. Report 91-104-H. 49p.

N.E.A. 1992. Carmichael Falls Hydroelectric Project; Year I of long term monitoring program prepared for Wm. R. Walker Engineering Inc. 86p + technical appendices.

Nowak, A.M. 1984. Status of the lake sturgeon fishery, lower Groundhog River, Kapuskasing District 1982-1984. OMNR Tech. Report 59p.

Ontario Hydro. 1996. Development of a habitat suitability index model for lake sturgeon (*Acipenser fulvescens*). Draft Report prepared by Tarandus Associates Ltd. 54p.

Payne, D.A. 1987. Biology and population dynamics of lake sturgeon (*Acipenser fulvescens*) form the Frederick House, Abitibi and Mattagami rivers in the Cochrane District. Ont. Fish. Tech. Rep. Series No. 23.

Rossiter, A., Beamish, H. and Noakes, D.L.G.1994. Feeding ecology of the lake sturgeon (*Acipenser fulvescens*) in Northern Ontario. Unpub. Manuscript.

Rossiter, A. and Leach, B. 1994. The foraging behavior of juvenile lake sturgeon (*Acipenser fulvescens*). Unpublished manuscript. 25p.

Sandilands, A. P. 1987. Biology of the lake sturgeon (*Acipenser fulvescens*) in the Kenogami River, Ontario. As found in Proceedings of a Workshop on the Lake Sturgeon. C.H. Olver [ed]. Ontario Tech. Rep. Series No. 23. P33-46.

Seyler, J.C. 1997a. Biology of selected riverine fish species of the Moose River Basin. NEST Tech. Report IR-024. 100p.

Seyler, J.C. 1997b. Population dynamics and habitat utilization by lake sturgeon (Acipenser fulvescens) in a Northern Clay Belt River (Draft manuscript). 26p.

Seyler J.C. 1996. Lake sturgeon spawning habitat utilization data, Groundhog River 1996 (unpub. Data).

Seyler, J.C., Fiset, B. and Hendry, C. 1994. Large rivers; a strategic plan. NEST Information Report IR-011. 36p.