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EVALUATION OF POTENTIAL IMPACT OF SPRINGBANK DAM RESTORATION ON BLACK REDHORSE (*Moxostoma duquesnei*) AND OTHER SUCKER SPECIES IN THE THAMES RIVER, ONTARIO

by

Scott M. Reid
Species at Risk Unit, Biodiversity Section,
Ontario Ministry of Natural Resources
300 Water St.
Peterborough, Ontario
K9J 8M5

and

Nicholas E. Mandrak
Great Lakes Laboratory for Fisheries and Aquatic Sciences,
Central & Arctic Region, Fisheries and Oceans Canada
867 Lakeshore Road,
Burlington, Ontario
L7R 4A6

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ABSTRACT

The Thames River in southwestern Ontario supports over 90 species of fish, including 11 fish species at risk (SAR). The planned restoration of the Springbank Dam, the most downstream barrier along the Thames River, requires an assessment of fish passage requirements. Historically, the Springbank Dam has been operated seasonally, from approximately mid-May to November, and during this period represented a barrier to fish passage. Dams and impoundments exert a negative effect on species such as the resident black redhorse (a federally Threatened species). Study objectives were to characterize: 1) the effects of dams on black redhorse and other sucker species found in the Thames River; 2) the timing (and associated water temperatures) of spawning and spawning-related migrations for these species; and, 3) the fish assemblage in the vicinity of Springbank Dam during the spring spawning period. Past monitoring studies at other dams indicate that adverse effects on black redhorse and other sucker species are the result of permanent (and often multiple) barriers to migration and large changes to habitat related to large impoundments and regulation of downstream flows. Such cases resulted from longer-term, and more severe, habitat alterations than those associated with the Springbank Dam. Impacts to black redhorse from the Springbank Dam are likely limited to the temporary barrier to migration when dam gates are in place. Based on past observations and long-term Thames River water temperature data, the previous dam operation schedule had the potential to block upstream spawning migrations of later spawning sucker species such as black redhorse and river redhorse, and post-spawn migrations downstream. Adverse effects could be mitigated by delaying the timing of dam gate operation, or by constructing a fishway. Confidence in the need for, and design of, such mitigation would be improved by further research on: 1) the distribution of spawning activity relative to Springbank Dam and the Forks of the Thames; 2) springtime migratory behaviour of species such as black redhorse, river redhorse and spotted sucker; and, 3) whether access to upstream spawning habitat at the Forks is a limiting factor for population persistence of these species.

RÉSUMÉ

La rivière Thames au sud-ouest de l'Ontario accueille plus de 90 espèces de poissons, dont 11 constituent des espèces en péril (EEP). La restauration envisagée du barrage Springbank, la barrière la plus en aval le long de la rivière Thames, nécessite une évaluation des exigences reliées au passage des poissons. D'un point de vue historique, le barrage Springbank fonctionnait de façon saisonnière, d'environ mi-mai jusqu'à novembre, et pendant cette période, il représentait une barrière obstruant le passage des poissons. Les barrages et les bassins de retenue exercent un effet négatif sur les espèces comme le chevalier noir résident (qui se trouve sur la liste fédérale des espèces menacées). Les objectifs de l'étude étaient de décrire : 1) les effets qu'ont les barrages sur les chevaliers noirs et les autres espèces de meuniers se trouvant dans la rivière Thames ; 2) les temps de fraie (et les températures d'eau reliées) et les migrations de fraie de ces espèces ; et, 3) les populations de poissons à proximité du barrage Springbank pendant la période de fraie printanière. Les études de suivi précédentes effectuées à d'autres barrages indiquent que les effets négatifs sur les chevaliers noirs et les autres espèces de meuniers sont le résultat de barrières permanentes (et souvent multiples) à la migration et de changements considérables à l'habitat reliés aux grands bassins de retenue et la réglementation des débits en aval. De tels cas étaient dus aux altérations de l'habitat à plus long terme et plus sévères que celles associées au barrage Springbank. Il est probable que les effets sur les chevaliers noirs causés par le barrage Springbank se font sentir seulement lorsque les vannes de barrage sont en place, causant une barrière temporaire à la migration. Selon les observations antérieures et les données à long terme sur les températures d'eau de la rivière Thames, l'ancien horaire de fonctionnement du barrage risquait de bloquer les migrations de fraie en amont des espèces de meunier dont le fraie a lieu plus tard, comme par exemple le chevalier noir et le chevalier de rivière. Les migrations en aval après le fraie risquaient aussi d'être bloquées. Les effets négatifs pourraient être atténués par soit le délai du calendrier de fonctionnement des vannes de barrage, ou la construction d'une passe migratoire. La confiance dans le besoin et la conception de telles mesures d'atténuation serait améliorée grâce à une recherche plus approfondie des suivants : 1) la répartition des activités de fraie par rapport au barrage Springbank et aux fourches de la rivière Thames ; 2) le comportement migratoire printanier des espèces comme le chevalier noir, le chevalier de rivière et le meunier tacheté ; et, 3) si

l'accès aux frayères en amont au niveau des fourches limite le maintien de la population de ces espèces.

1.0 INTRODUCTION

The Thames River in southwestern Ontario supports over 90 species of fish, including 11 fish species at risk (SAR). In the draft Recovery Strategy for the Thames River Aquatic Ecosystem (TRRT 2005), dams are identified as a threat that has reduced the amount of suitable habitat and blocked fish spawning migrations. Hydrological and ecological changes associated with dams have contributed to the loss of migratory and smaller-bodied riverine fishes, freshwater mussels and other taxa dependent on flooding in North America (Pringle *et al.* 2000). A recent *Allowable Harm Analysis for Freshwater Species at Risk in Central and Arctic Region* conducted by Fisheries and Oceans Canada identified dams and impoundments to be a strong threat to the recovery of black redhorse (*Moxostoma duquesnei*) populations in the Thames River (Table 1). Case studies from the United States indicate that dams have a negative effect on many of the redhorse species found in Ontario (Patriarche and Campbell 1958, Travinchek and Maceina 1994, Quinn & Kwak 2003, Santucci *et al.* 2005).

The Springbank Dam, situated in northwest London, is the most downstream barrier along the mainstem of the Thames River. The dam was constructed in 1929, and is operated by the City of London as a recreation dam, under the direction of the Upper Thames River Conservation Authority. Currently, rehabilitation of the dam is required to ensure its integrity and safe operation, and to minimize future operational and maintenance requirements. When stop-gates are in place from mid-May to early November, it is a barrier to fish passage and creates a small upstream run-of-the-river type impoundment (55 hectares). The current seasonal operations schedule reflects the timing of walleye (*Sander vitreus*) spawning migrations and recreational use of the reservoir by rowing and canoeing clubs. However, as walleye are early spring spawners, the operations schedule do not protect later spring-spawners such as black redhorse and river redhorse (*M. carinatum*). During the mid-May to November operating season, the reservoir water level is maintained at a near constant level with outflows from the dam varying directly with inflows into the reservoir. With the exception of filling the reservoir in mid-May and draining the reservoir in November, Springbank Dam has little effect on downstream flows. Three upstream reservoirs (Fanshawe, Wildwood and Pittock) are operated by the Upper Thames Conservation Authority to control downstream flooding and to augment low summer flows. Currently, at Springbank Dam, flows are passed through one bottom-draw gate and over top of three stop-log controlled sluices. After dam restoration, all flows will be passed over new dam gates.

The planned restoration of the Springbank Dam requires an assessment of fish passage requirements. It has been estimated that, during the non-operating season, the planned new dam design may increase water velocities over the lowered gates and impair upstream fish movement (Acres 2004). Potential mitigation of presumed adverse effects on upstream fish passage includes the placement of baffles on dam gates, fishway construction, and changes to the timing of stop-gate operation. These options have the potential to reduce the adverse effects of dams and assist SAR recovery. However, successful design of any option is dependent upon understanding the mechanisms responsible for dam impacts, identifying species likely to migrate upstream past Springbank Dam to spawn, the timing of migrations and spawning, and the location of important spawning habitats. Therefore, the objectives of this study are:

i. to identify the magnitude, frequency of occurrence and mechanism of dam-related effects on black redhorse and other catostomids (sucker species) found in the Thames River;
ii. to identify the timing and associated water temperatures of spawning and spawning-related migrations for black redhorse and other Thames River catostomids; and,
iii. to describe the fish assemblage upstream and downstream of Springbank Dam during the spring spawning period.

These objectives were addressed through a combination of literature review (objectives i and ii) and field sampling (objective iii).

2.0 METHODS AND MATERIALS

2.1 LITERATURE REVIEW OF DAM IMPACT ASSESSMENT STUDIES

Forty-five monitoring studies published in either peer-reviewed conference proceedings or scientific journals were reviewed to determine the magnitude, frequency of occurrence and mechanism of effect related to dam impacts on catostomid species found in the Thames River. The following species were targeted by the literature review:

- bigmouth buffalo (*Ictiobus cyprinellus*) (Special Concern)
- black redhorse (Threatened)
- golden redhorse (*M. erythrurum*)
- greater redhorse (*M. valenciennesi*)
- northern hog sucker (*Hypentelium nigricans*)
- river redhorse (Special Concern)
- shorthead redhorse (*M. macrolepidotum*)
- silver redhorse (*M. anisurum*)
- spotted sucker (*Minytrema melanops*) (Special Concern)
- quillback (*Carpiodes cyprinus*)
- white sucker (*Catostomus commersonii*)

Published studies reviewed were either already known by the authors or identified by searches on electronic databases (Aquatic Sciences and Fisheries Abstracts, BioOne, Conference Papers Index, Science Citation Index, and Water Resources Abstracts).

2.2 IDENTIFICATION OF TIMING OF SPAWNING AND SPAWNING RELATED MIGRATIONS

For the same species, timing and associated water temperatures of spawning and spawning-related migrations were identified through a literature review. In addition to published studies, long-term (1995-2004) spring monitoring data from the Dunnville Fishway on the Grand River was used to define the timing of upstream migrations (Ontario Ministry of Natural Resources and Grand River Conservation Authority, unpublished data).

Across the North American range of catostomids, differences exist in the timing of spawning and related migrations. Water temperature and discharge have a strong influence on the timing of these activities (Lucas and Baras 2001). To account for some of this variation, the timing of migration and spawning in the Thames River was predicted using:

- observations from the nearby Grand River watershed;
- reported literature values; and,
- mean daily flow and water temperature data (1989 to 2004) at the Byron stream gauge (02GE001) located downstream of Springbank Dam.

2.3 FIELD SAMPLING

Between May 1 and 27, 2005, six sites from below Springbank Dam upstream to the confluence of the North Thames River and the South Thames River ("the Forks of the Thames") were sampled (Figure 1). Five sites upstream of the Springbank Dam were sampled with a Smith Root boat-mounted electrofishing unit. Due to the lack of boat site access, the site below Springbank Dam was sampled with two backpack electrofishing crews, sampling in tandem. While less effective at capturing large bodied fishes than the boat-mounted electrofishing unit, this approach has been very effective for detected the presence of *Moxostoma* species at similarly sized sites along the Grand River. Timing, sampling effort and the geographic co-ordinates of the sampling sites are provided in Table 2.

All fishes captured were identified to species before release. At each site, the range (minimum and maximum) of total length for each species captured was recorded. The spawning condition of catostomids was visually assessed. In addition to fish sampling, the following site characteristics were described: geographic co-ordinates (latitude and longitude); substrate composition (visual assessment of different sediment size classes); water quality (water temperature, conductivity, Secchi depth); and, channel width and maximum water depth.

3.0 RESULTS

3.1 IMPACTS OF DAMS ON BLACK REDHORSE AND OTHER SUCKER SPECIES

Of the 46 case studies reviewed, 25 provided information on dam-related impacts to catostomid species found in the Thames River. Most studies were undertaken in the southeast and midwest regions of the United States. Nineteen monitoring studies provided the timeframe of post-impoundment inventories relative to year of dam construction. The mean time since dam construction of post-impoundment surveys was 16.2 years (range: 2-36 years). As most studies compared pre- and post-impoundment inventory data, responses to impoundment were predominantly measured as changes in distribution and occurrence. Case studies reviewed are summarized in Table 3 and Appendix 1.

Poor downstream tailwater habitat conditions, resulting from variable flow levels and releases of cold hypolimnetic water, was the most frequently identified reason for declines in the distribution or abundance of catostomid species. Black redhorse and river redhorse appeared to be the most sensitive species to impoundments. Golden redhorse and white sucker were least likely to be negatively affected. In these cases, warmwater fish communities in downstream tailwater areas were generally less diverse and contained fewer fluvial-specialist species than before impoundment. Other mechanisms of effect identified included barrier to migration and flooding of riverine habitats. Mean time since dam construction of post-impoundment surveys detecting a negative effect (mean = 25.5 years, range: 6-50) was greater than surveys that did not (mean = 17.4 years, range: 2-50), although there was a high degree of overlap.

Seven of the 12 studies reporting the response of black redhorse to dams identified a negative effect on distribution or abundance. Most of these studies had evaluated the impact of hydro-electric and flood control dams which, in addition to having large upstream impoundments, created downstream tailwater habitats characterized by releases of cold hypolimnetic water and variable flows. Poor downstream tailwater habitat conditions were the most frequently identified cause of large decreases in distribution or abundance. Over a 7-year period after the damming of Black River, Missouri, declines in black redhorse abundance and juvenile growth rate were also reported within the upstream reservoir (Patriarche and Campbell 1958). At a larger spatial scale, Santucci *et al.* (2005) suggested that the presence of multiple dams (barrier to migration) along a heavily impounded reach of the Fox River, Illinois (8 dams over 22km) had limited the distribution of black redhorse, as well as river redhorse and bigmouth buffalo.

Negative effects on bigmouth buffalo, river redhorse and spotted sucker were reported in 50%, 44% and 31% of dam monitoring case studies, respectively. Barrier to migration and poor tailwater habitat conditions were the hypothesized causes. For black buffalo and spotted sucker, the intermittent nature of streams upstream of impoundments compounded the barrier effect.

3.2 TIMING OF UPSTREAM MIGRATIONS AND SPAWNING

Past studies indicate that, in the Thames River, upstream spring migrations and spawning by catostomids are likely to be temporally segregated. Upstream migrations are expected to begin during April as water temperatures increase towards 10^{o}C (Table 4). Based on water temperatures and projected timing of spawning, there are two relatively discrete groups of early and late spawners. Early spawning species include bigmouth buffalo, northern hog sucker, quillback, shorthead redhorse, silver redhorse and white sucker. Later spawning species include black redhorse, golden redhorse, greater redhorse and river redhorse (Table 5).

Few studies have characterized the timing and extent of post-spawning downstream migrations by redhorse or other catostomids. Within two weeks of spawning, Bunt and Cooke (2001) found greater redhorse were no longer present in spawning areas below the Mannheim Weir, Grand River. Most post-spawning migrations (up to 15.2 km downstream) were complete within two to three weeks of spawning. Downstream migrations of shorthead redhorse along the Ochre River, Manitoba occurred primarily within two weeks after the peak upstream migration period (Harbicht 1990). Barton (1980) found longnose sucker (*Catostomus catostomus*) and white sucker to move downstream six to 13 days after the initial upstream spawning migration.

Although sometimes variable, the stop-log installation schedule at the Springbank Dam was generally as follows (personal communication, Chris Tasker, Upper Thames River Conservation Authority):

i. during the first week of May, the first stop-log (1.8 m high) was installed. Depending on river discharge, the first row of stop-logs create a 0.3 to 0.6 m difference in water level;

ii. to permit the downstream passage of walleye (adults and larvae) after spawning, the second and third row of stop-logs were not installed until the week before Victoria Day (May 22nd); and,

iii. stop-logs were removed in early November.

Therefore, the previous stop-log installation schedule had the potential to block upstream spawning migrations of later spawning species such as black redhorse and river redhorse.

It also had the potential to interfere with post-spawn downstream migrations of most catostomids.

3.3 SPRING FISH COMMUNITY SAMPLING

Twenty-eight fish species and one hybrid (carp (*Cyprinus carpio*) x goldfish (*Carassius auratus*)) were captured from the six sites sampled along the Thames River (Table 6). This included four species at risk: black redhorse, bigmouth buffalo, greenside darter (*Etheostoma blennioides*) (Special Concern) and spotted sucker. Collections of bigmouth buffalo and spotted sucker indicate that they occur much further upstream in the Thames River than previously known. Other catostomid species captured included golden redhorse, greater redhorse, quillback, shorthead redhorse and white sucker. Sportfish species captured included northern pike (*Esox lucius*), rainbow trout (*Oncorhynchus mykiss*), smallmouth bass (*Micropterus dolomieu*) and walleye. During summer and fall of 2005, MNR sampled downstream of Springbank Dam, and upstream in the reservoir and along the north and south branches of the Thames River. At all three study reaches, all six redhorse species plus northern hog sucker, quillback, spotted sucker and white sucker were captured (Trevor Friesen, Southern Science and Information Section, Ontario Ministry of Natural Resources, unpublished data).

During spring sampling, channel widths ranged between 73 and 130 m with maximum water depths from 1.5 to greater than 3 m (Table 7). Over the course of sampling, water temperature increased from 8.2 to 20.5^{o}C. Secchi depth and conductivity measurements ranged between 1.1 and 2 m and 611 and 707 µS/cm, respectively. Along the study reach, riverbed materials were a mix of sand, gravel, cobble and boulder. At the Forks of the Thames (site: TH1) and below the Springbank Dam (site: TH6), the bed material was composed of greater amounts of larger particle sizes and less sand than other sites (TH2-5). Based on the composition of riverbed material, sites below Springbank Dam and at the Forks are likely to provide more suitable spawning substrates for redhorse spawning (Kwak and Skelly 1992). Redhorse (black redhorse, golden redhorse and silver redhorse) displaying signs of either sexual maturity (e.g. spawning tubercles) or spawning readiness (e.g. runny milt) were captured only from the Forks of the Thames and only at the end of the month (May 26th).

4.0 DISCUSSION

Multi-species recovery strategies (Portt *et al.* 2004, TRRT 2005) and COSEWIC status assessments (COSEWIC 2005b) contend that dams negatively affect redhorse populations in Ontario. However, the hypothesized negative effect of dams on Canadian populations has not been tested through empirical study. Monitoring studies reviewed in this study indicate that reductions in the distribution and abundance of black redhorse and other species are the result of permanent (and often multiple) barriers to migration and large-scale changes to riverine habitat related to large impoundments and downstream habitat conditions. These impacts resulted from longer-term, and more severe, habitat alterations than those presented by the Springbank Dam. Therefore, it is likely that the extent of any impact of Springbank Dam to black redhorse is limited to the temporary barrier to migration when the stop-logs are in place.

When the gates are in place, resident fish populations are restricted to 22 km of river habitat upstream of Springbank Dam. It is unlikely that this level of temporary fragmentation would have an adverse effect. In the nearby Grand River watershed, redhorse populations persist in river fragments ranging between 18 and 129 km in length (S. Reid, unpublished data). Along the Trent River, Ontario, viable redhorse populations are found in river fragments greater than 2 km in length, providing that some spawning habitat is present in dam tailwaters (S. Reid, unpublished data).

The adverse effect of Springbank Dam on spawning-related migrations could be mitigated by delaying the installation of dam gates until either spawning is predicted to be complete (to permit upstream migrations), or two weeks after (to permit downstream migrations). However, there are uncertainties regarding how to define these periods. First, the timing of spawning is strongly influenced by spring flow conditions. In comparison to years with low and stable flows, high spring flows can delay upstream migrations and spawning by redhorse species by as much as three to four weeks (Curry and Spacie 1984, Harbicht 1990, Cooke and Bunt 1999, Reid 2006). Secondly, knowledge of the migratory behaviour and spawning sites of these species along the Thames River has not been characterized. However, bed material present at sites below Springbank Dam and at the Forks is of a size range suitable for redhorse spawning.

It is also uncertain that providing access to a larger area of suitable spawning habitat will improve the status of these species in the Thames River. From a review of past monitoring studies, Geiling *et al.* (1996) found little evidence that the enhancement of riverine spawning habitat resulted in increased abundance of adult walleye. Habitat supply modelling undertaken by Mandrak and Casselman (in press) for black redhorse in the Grand River suggests that the availability of young-of-year habitat is likely the limiting factor for population growth. Although the availability of spawning habitat is often considered the limiting factor for populations, modelling and empirical data for other freshwater species (northern pike, lake trout (*Salvelinus namaycush*) and deepwater sculpin (*Myoxocephalus thompsonii*)) indicate that, while spawning habitat may be rarer in absolute terms, other lifestages (especially YOY and juveniles) require larger amounts of suitable habitat for populations to persist (Casselman and Lewis 1996, Minns *et al.* 1996, Minns 2003). For young redhorse, important habitats include shallow pools, and other shallow habitats along shorelines, backwater area and side channels, often associated with submersed aquatic vegetation (COSEWIC 2005, Reid unpublished data).

Past studies of the impacts of dams and impoundments, and of the timing of redhorse spawning and related migrations suggest that the Springbank Dam could be a temporary (late May to November) barrier to the migration of later spawning species. Adverse effects to black redhorse or river redhorse could be mitigated by delaying the timing of dam gate operation, or by constructing a fishway. However, confidence in the need for, and design of, such mitigation would be improved by further research on: i) the distribution of spawning activity relative to Springbank Dam and the Forks of the Thames; ii) springtime migratory behaviour of species such as black redhorse, river redhorse and spotted sucker; and, iii) the role of spawning habitat at the Forks as a limiting factor for population persistence.

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Table 1. Summary of population based threat rankings (magnitude/probability) for black redhorse as identified in the Allowable Harm Analysis for Central and Arctic Freshwater Species at Risk (Mandrak *et al.* 2006). Threat rankings are based on expert opinion provided at the second Allowable Harm Analysis workshop, Burlington, Ontario, February 8-9, 2006.

	Population						
Threats	**Ausable R.**	**Bayfield R.**	**Grand R.**	**Maitland R.**	**Thames R.**	**Catfish Cr.**	**Spencer Cr.**
Siltation/turbidity	High/High	High/High	High/High	High/High	High/High	High/High	High/Med
Agricultural development	High/High	High/Med	High/High	High/High	High/High	High/High	Low/Low
Urban development	High/Low	High/Low	High/High	High/Low	High/High	High/Low	High/Med
Dams and impoundments	Low/Med	Low/Low	High/High	Low/Low	High/High	Low/Low	High/High
Recreational fishing	Low/Low	Low/Med	Low/High	Low/Med	Low/Med	Low/Low	Low/Low
Baitfish harvesting	? /Low	? /Low	? /Low	? /Low	? /Low	? /Low	? /Low

Table 2. Summary of Thames River site details and sampling effort.

Site Code	Date	Start Time	Effort (sec)	Latitude	Longitude	Site Narrative
TH1	05-May-05	9:30	1641	42.98102	-81.25743	Forks of the Thames
TH1	11-May-05	9:18	1833			
TH1	26-May-05	12:35	882			
TH2	01-May-05	12:00	792	42.97868	-81.27221	1.2 km downstream Forks, upstream train trestle
TH2	05-May-05	12:05	770			
TH3	25-May-05	15:30	1230	42.97757	-81.27512	2 km upstream of boat launch, off Wonderland Rd.
TH4	05-May-05	12:14	2143	42.97696	-81.28196	Upstream sewage treatment plant
TH4	11-May-05	13:32	2058			
TH5	05-May-05	14:23	1360	42.96931	-81.29480	300 m downstream Wonderland Rd bridge
TH5	12-May-05	9:45	1933			
TH6	27-May-05	8:30	1110+	42.96069	-81.32731	Downstream Springbank Dam

Table 3. Review of the frequency of negative effects, and hypothesized causes, on Thames River sucker species reported in past dam impact monitoring studies.

Species	Number of Case Studies		Hypothesized Mechanism of Negative Effect (number of studies in parentheses)
	Negative Effect	No, or Positive Effect	
bigmouth buffalo	2	2	- barriers to migration (2)
black redhorse	8	4	- barriers to migration (1) - flooding of riverine habitat (1) - variable flow/release of hypolimnetic water (6)
golden redhorse	2	11	- variable flow/release of hypolimnetic water (2)
northern hog sucker	3	6	- barriers to migration (1) - variable flow/release of hypolimnetic water (3)
river redhorse	4	5	- barriers to migration (1) - flooding of riverine habitat (1) - variable flow/release of hypolimnetic water (2)
silver redhorse	2	1	- barriers to migration (1) - flooding of riverine habitat (1) - variable flow/release of hypolimnetic water (2)
spotted sucker	4	9	- barriers to migration (1) - variable flow/release of hypolimnetic water (3)
quillback	2	2	- variable flow/release of hypolimnetic water (2)
white sucker	1	6	- flooding of riverine habitat (1)

Table 4. Water temperatures reported in past studies of sucker upstream spawning migrations (green squares) and spawning activity (red hatched squares).

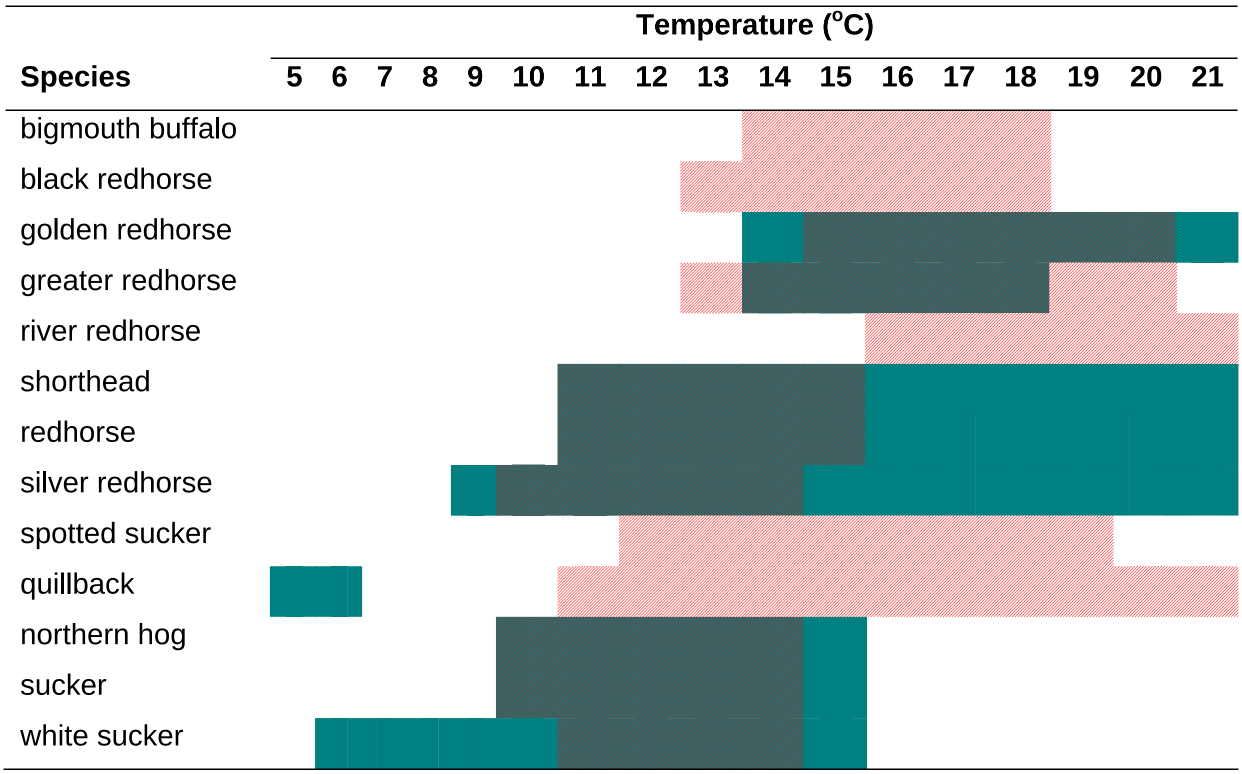

Table 5. Projected timing of Thames River upstream spawning migrations and spawning activity.

Species	April			May			June		
	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late
bigmouth buffalo									
black redhorse									
golden redhorse									
greater redhorse									
river redhorse									
shorthead redhorse									
silver redhorse									
spotted sucker									
quillback									
northern hog sucker									
white sucker									

Spawning

Upstream Migration

Table 6. Summary of spring 2005 Thames River fish collections. Scientific names are provided in Appendix 2.

Site Code **Date**	**TH2** **01-May-05**	**TH1** **05-May-05**	**TH2** **05-May-05**	**TH4** **05-May-05**	**TH5** **05-May-05**	**TH1** **11-May-05**
Species						
black redhorse	0	2	0	0	1	4
blackside darter	0	0	0	0	0	0
bluntnose minnow	0	1	0	0	0	0
brown bullhead	0	0	0	0	0	0
carp x goldfish hybrid	0	0	0	0	0	0
common carp	0	8	0	5	4	0
golden redhorse	13	34	31	41	39	4
greater redhorse	0	0	1	0	1	1
greenside darter	1	0	0	0	1	1
bigmouth buffalo	1	0	0	0	0	0
Ictiobus spp.	0	0	0	0	0	0
johnny darter	0	0	0	0	0	1
lamprey spp.	0	1	0	0	0	0
logperch	0	0	0	0	0	0
longnose dace	0	0	0	0	0	0
mimic shiner	0	20	0	0	0	88
northern hog sucker	0	2	0	0	3	1
northern pike	0	0	0	0	0	0
quillback	0	2	0	0	1	3
rainbow trout	0	1	0	0	0	0
rock bass	3	1	0	1	1	2
rosyface shiner	0	1	1	0	0	1
shorthead redhorse	4	32	19	45	69	19
silver redhorse	4	6	0	0	4	21
smallmouth bass	4	7	0	4	7	2
spotted sucker	0	0	1	1	0	0
stonecat	0	0	0	0	1	0
striped shiner	0	1	0	0	0	0
walleye	0	0	0	0	0	0
white sucker	4	8	7	4	5	2

Table 6 (con't). Summary of spring 2005 Thames River fish collections.

Site Code Date	TH4 11-May-05	TH5 12-May-05	TH3 25-May-05	TH1 26-May-05	TH6 27-May-05
Species					
black redhorse	0	0	0	7	0
blackside darter	2	0	0	0	0
bluntnose minnow	0	0	0	0	0
brown bullhead	1	1	0	0	1
carp x goldfish hybrid	0	0	0	1	0
common carp	20	5	1	12	1
golden redhorse	16	32	39	56	0
greater redhorse	0	0	2	0	0
greenside darter	1	0	0	0	12
bigmouth buffalo	0	0	0	0	0
Ictiobus spp.	0	1	0	0	0
johnny darter	0	0	0	0	0
lamprey sp.	0	0	0	0	0
logperch	0	0	0	0	11
longnose dace	0	0	0	0	1
mimic shiner	2	0	0	0	6
northern hog sucker	0	3	1	7	1
northern pike	1	0	0	0	0
quillback	2	0	0	3	1
rainbow trout	0	0	0	0	0
rock bass	4	3	0	0	0
rosyface shiner	1	1	0	0	0
shorthead redhorse	35	25	18	46	2
silver redhorse	5	3	2	14	0
smallmouth bass	5	8	0	7	1
spotted sucker	0	0	0	2	0
stonecat	0	0	0	0	0
striped shiner	0	0	0	0	0
walleye	0	1	0	1	0
white sucker	5	14	2	5	0

Table 7. Summary of habitat measurements at Thames River sampling sites.

Site Code	Date	Air Temp. (°C)	Water Temp. (°C)	Conductivity (µS/cm)	Secchi Depth (m)	Channel Width (m)	Maximum Water Depth (m)	Bed Material[A]
TH1	05-May-05	12.2	8.2	707	1.28	86	1.5	80% sa; 20% co
TH1	11-May-05	15.6	13.6	654	1.2	86	1.5	20% gr, 80% co
TH1	26-May-05	23.4	18.3	640	1.2	89	4	30% sa; 40% gr, 20% co, 10% bo
TH2	01-May-05	16.1	17.3	689	1.2	82	1.75	30% sa; 30% gr, 40% co
TH2	05-May-05	15	9.8	615	1.75	82	1.75	30% sa; 30% gr; 40% co
TH3	25-May-05	24.2	20.5	634	1.14	NA	2	30% sa; 30% gr, 40% bo
TH4	05-May-05	13.8	10.1	713	2	73	2	30% sa; 30% gr, 40% co
TH4	11-May-05	14	14.9	645	1.2	73	2	30% sa; 30% gr, 40% co
TH5	05-May-05	14.6	12.9	611	NA	69	2	20% sa; 40% gr; 40% co
TH5	12-May-05	5.3	11.5	704	1.2	69	2	20%sa; 40% gr; 40% co
TH6	27-May-05	21.8	18.3	700	1.42	130	> 3m	10% sa; 50% gr; 20% co; 20% bo

A: bed material notation: sa: sand; gr: gravel; co: cobble; and bo: boulder;

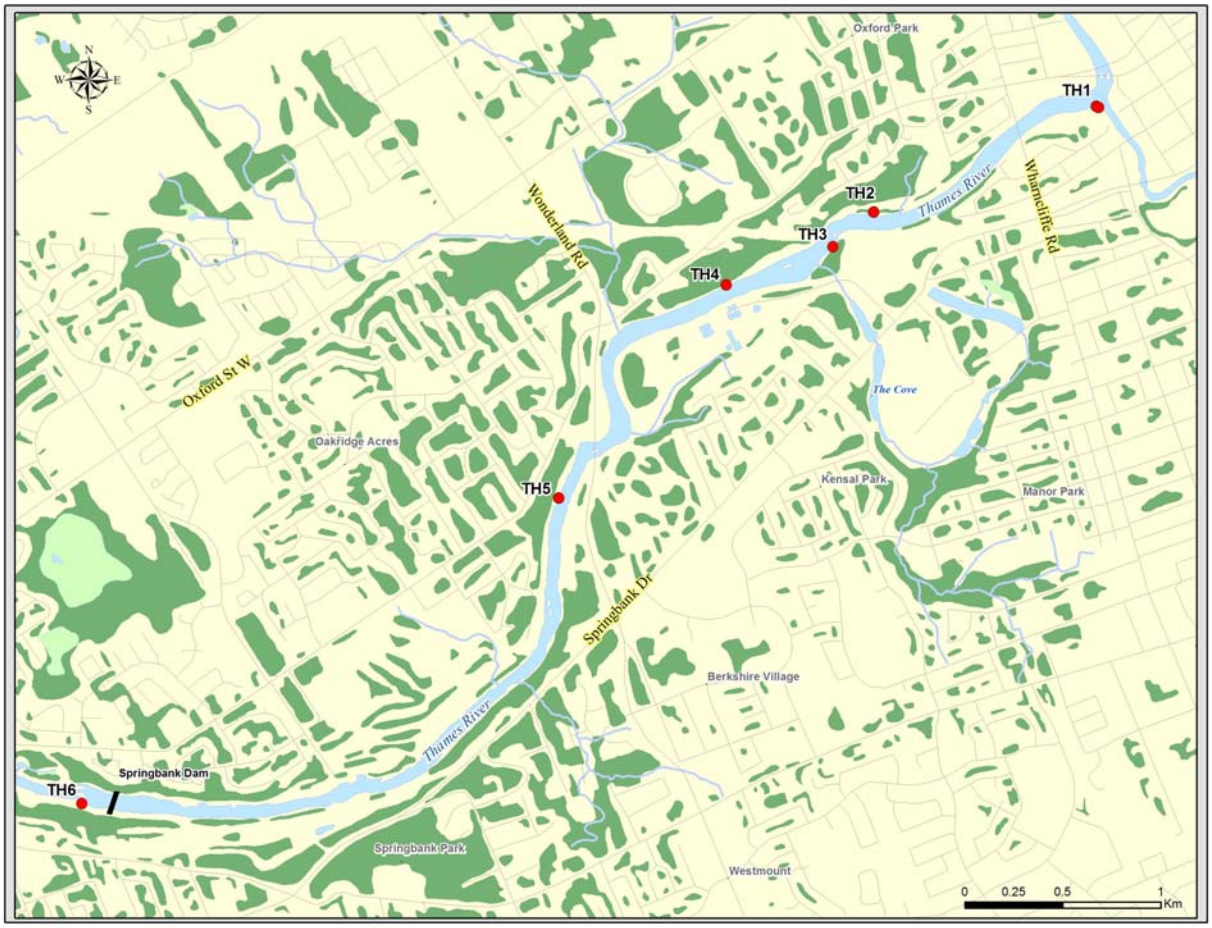

Figure 1. Distribution of Thames River sampling sites, spring 2005.

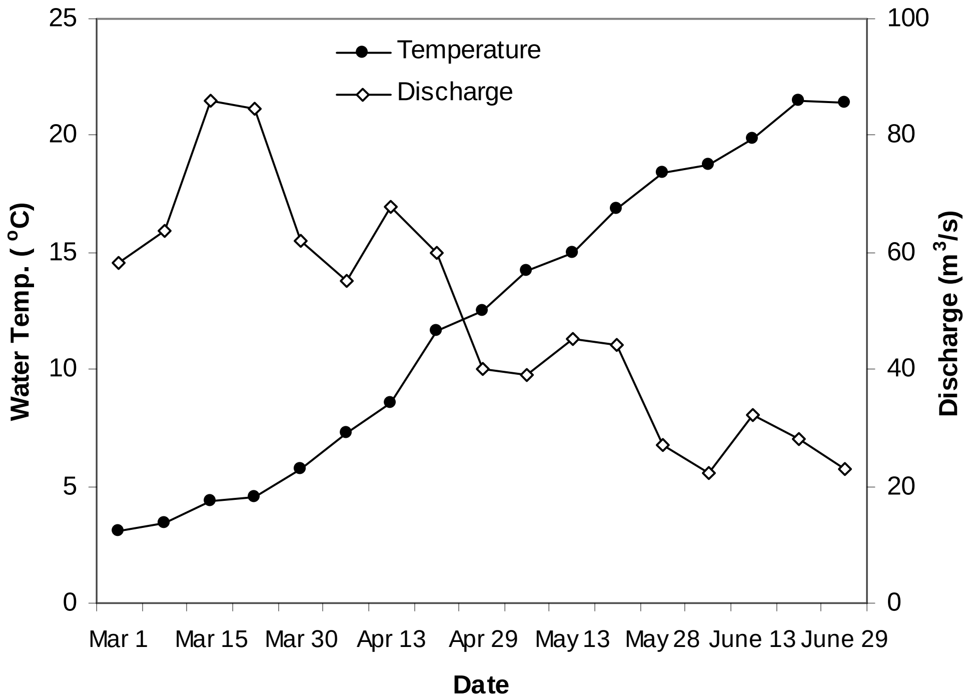

Figure 2. Mean (1989-2004) Thames River mean daily water temperature and discharge measured at the Byron stream gauge (02GE001) (Upper Thames River Conservation Authority, unpublished data).

Appendix 1. Summary of dam impact case studies.

Study	Monitoring Design	Effects of Impoundment	Post-Impoundment Effect[A]
Barren R., Kentucky (Hoyt and Robison 1980)	- pre- (1958-66) and post-impoundment (1978-79) surveys of downstream tailwaters	- variable flow/release of hypolimnetic water	GR: no effect on distribution NH: increase in abundance SP: no effect on distribution, long-term reduction in abundance
Bear Cr., Alabama/Mississippi (Phillips and Johnston 2004)	- pre- (1968) and post-impoundment (1998-2000) surveys	- disruption of natural longitudinal gradient by multiple impoundments	BR: no effect on distribution GR: little effect on distribution NH: absent from several sites within 1-5 km of impoundments
Black R., Missouri (Patriarche and Campbell 1958)	- post-impoundment surveys	- flooding of riverine habitat	BR: lower abundance
Buncombe Cr., Oklahoma (Lienesch *et al.* 2000)	- pre- (1954-55) and post impoundment (1995) surveys	- barriers to migration	BB: absent but rare before impoundment GR: found only after impoundment SP: absent but rare before impoundment
Chattahoochee R., Alabama (Timmons *et al.* 1978)	- pre- (1972-74) and post-impoundment (75-77) surveys	- flooding of riverine habitat	SP: present before and after
Clinch R., Tennessee (Fitz 1968)	- pre- (1960-62) and postpimpoundment (1964) surveys within impounded area	- flooding of riverine habitat	BB: no effect on distribution BR: no effect on distribution GR: no effect on distribution NH: no effect on distribution QL: no effect on distribution RR: no effect on distribution SP: present only after impoundment SR: no effect on distribution
San Jacinto R., Texas (Herbert and Gilwick 2003)	- compared impounded and free-flowing sites	- barriers to migration - flooding of riverine habitat	SP: greater relative abundance in unimpounded reach

Appendix 1 (Con't). Summary of dam impact case studies.

Study	Monitoring Design	Effects of Impoundment	Post-Impoundment Effect[A]
Fox R., Illinois (Santucci et al. 2005)	- post-impoundment survey along fragmented reach	- barriers to migration	BB: reduced distribution BR: reduced distribution RR: reduced distribution
Green R., Kentucky (Swink and Jacobs 1983)	- pre- (1960-62) and post-impoundment (1979-80) sampling - sites upstream and downstream of impoundment	- variable flow/release of hypolimnetic water	BR: more abundant upstream of reservoir than downstream GR: more abundant downstream of reservoir NH: more abundant downstream SP: more abundant upstream of reservoir than downstream
Green R., Kentucky (Hoyt and Robison 1980)	- pre- (1960-62) and post-impoundment (1978-79) surveys of downstream tailwaters	- variable flow/release of hypolimnetic water	BR: no effect on distribution GR: no effect on distribution NH: no effect RR: present only in post-impoundment survey SP: large reduction in abundance
Indian Cr., Illinois (Rogner and Brinton 1982)	- pre- (1971) and post-impoundment (1980-81) surveys	- flooding of riverine habitat - species introductions	GR: no effect on distribution NH: no effect on distribution
John's Cr., Virginia (Young and Maughan 1980)	- pre- (1945) impoundment and post-impoundment survey (1976)	- flooding of riverine habitat - increased downstream water temperature	NH: wider downstream distribution
Kincaid Cr., Illinois (Taylor et al. 2001)	- pre- (1959) and post-impoundment surveys of sites throughout watershed	- flooding of riverine habitat - species introductions	BB: no effect on distribution GR: present only in post-impoundment survey SP: no effect on distribution
Mountain Fork R., Oklahoma (Eley et al. 1981)	- pre- (prior to 68-69) and post-impoundment (1971-75) surveys sites throughout watershed	- variable flow/release of hypolimnetic water	BR: reduced downstream abundance + absent upstream GR: no effect on distribution QL: absent from middle and lower reaches RR: absent upstream of impoundment SP: no change in distribution

Appendix 1 (Con't). Summary of dam impact case studies.

Study	**Monitoring Design**	**Effects of Impoundment**	**Post-Impoundment EffectA**
Savannah R., South Carolina (Barwick and Oliver 1982)	- post-impoundment survey (18-20 years after dam construction) of downstream tailwaters	- variable flow/release of hypolimnetic water	NH: lower abundance and biomass within first 4 km downstream SP: lower abundance and biomass within first 4 km downstream SR: lower abundance and biomass within first 4 km downstream
Shoal Cr., Alabama (Kelley *et al.* 1981)	- pre-(1966-68) and post-impoundment (1974-78) sampling of sites throughout watershed	- small increase to downstream water temperature	BR: reduced abundance during last year of post-impoundment sampling (1978) SP: no effect
Tallapoosa R., Alabama (Travinchel and Maceina 1994; Travinchel et al 1995)	- sampling of regulated and unregulated flow sites	- variable flow/release of hypolimnetic water	BR: lower abundance at flow-regulated sites GR: no effect on abundance QL: more abundant at regulated sites, reduced abundance after minimum flows set RR: rare, found only at single unregulated site SP: only found at regulated sites
White R., Arkansas (Quinn and Kwak 2003)	- pre- (1962-63) and post-impoundment (1965-66, 68 and 95-97) surveys of downstream tailwaters	- variable flow/release of hypolimnetic water	BR: reduced abundance NH: large reduction in abundance QL: rare prior, absent after impoundment RR: absent
White R., Arkansas (Rainwater and Houser 1982)	- post-impoundment surveys of Beaver Lake (1964-80)	- flooding of riverine habitat	BR: increased abundance and frequency of capture GR: increased abundance and frequency of capture QL: increased abundance and frequency of capture RR: increased abundance and frequency of capture

Appendix 1 (Con't). Summary of dam impact case studies.

Study	Monitoring Design	Effects of Impoundment	Post-Impoundment Effect[A]
White R., Arkansas (Brown *et al.* 1967)	- post-impoundment (2 to 20 years after construction) survey of tailwaters in 1965 and 66	- variable flow/release of hypolimnetic water	GR: present in Bull Shoals and Norfolf tailwaters + absent from Beaver Lake tailwater NH: present below Bull Shoals and Beaver tailwaters + absent from Norfolk tailwaters
Holston R., North Carolina, Tennessee, and Virginia (Hughes 1994)	- pre- and post-impoundment surveys	- variable flow/release of hypolimnetic water - flooding of riverine habitat - barriers to migration	BR: reduced distribution RR: no effect SR: reduced distribution

A. Species Codes - BB: bigmouth buffalo; BR: black redhorse; GR: golden redhorse; NH: northern hog sucker; QL: quillback; RR: river redhorse; SP: spotted sucker; and, SR: shorthead redhorse.

Appendix 2. Common and scientific names of species collected from the Thames River in 2005 (according to Nelson *et al.* 2004).

Common Name	Scientific Name
bigmouth buffalo	*Ictiobus cyprinellus*
black redhorse	*Moxostoma duquesnei*
blackside darter	*Percina maculata*
bluntnose minnow	*Pimephales notatus*
brown bullhead	*Ameiurus nebulosus*
common carp	*Cyprinus carpio*
golden redhorse	*Moxostoma erythrurum*
greater redhorse	*Moxostoma valenciennesi*
greenside darter	*Etheostoma blennioides*
johnny darter	*Etheostoma nigrum*
unidentified lamprey spp.	Petromyzontidae spp.
logperch	*Percina caprodes*
longnose dace	*Rhinichthys cataractae*
mimic shiner	*Notropis volucellus*
northern hog sucker	*Hypentelium nigricans*
northern pike	*Esox lucius*
quillback	*Carpiodes cyprinus*
rainbow trout	*Oncorhynchus mykiss*
rock bass	*Ambloplites rupestris*
rosyface shiner	*Notropis rubellus*
shorthead redhorse	*Moxostoma macrolepidotum*
silver redhorse	*Moxostoma anisurum*
smallmouth bass	*Micropterus dolomieu*
spotted sucker	*Minytrema melanops*
stonecat	*Noturus flavus*
striped shiner	*Luxilus chrysocephalus*
walleye	*Sander vitreus*
white sucker	*Catostomus commersonii*