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RECOVERY POTENTIAL ASSESSMENT OF SILVER SHINER (*NOTROPIS PHOTOGENIS*) IN CANADA

*Silver Shiner (*Notropis photogenis*). Illustration by Joe Tomelleri, reproduced with permission.*

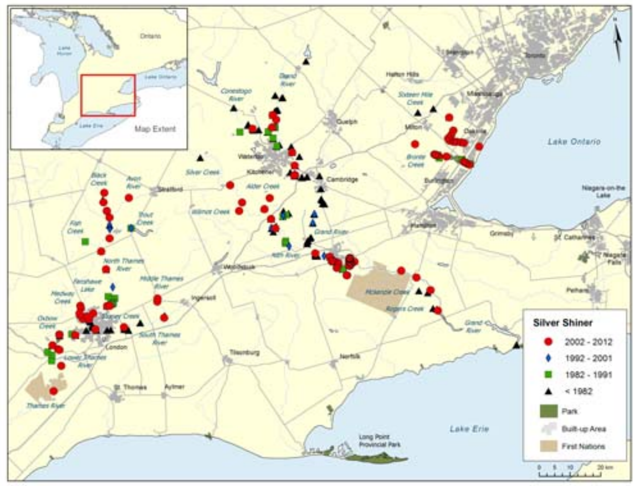

Figure 1. Distribution of Silver Shiner in Canada.

Context

*In April 1983, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the status of Silver Shiner (*Notropis photogenis*) and determined the designation to be Special Concern. In April 1987, the status was re-examined and confirmed by COSEWIC. This status was re-assessed in May 2011 at which time Silver Shiner was designated as Threatened. The reason given for this designation is that, "This small riverine fish is found at fewer than 10 locations and has a small area of occupancy. The susceptibility of the species to continuing habitat loss and degradation with increasing development pressure resulted in an increase in status." Silver Shiner is currently listed as Special Concern on Schedule 3 of the* Species at Risk Act *(SARA).*

A species Recovery Potential Assessment (RPA) process has been developed by Fisheries and Oceans Canada (DFO) Science to provide the information and scientific advice required to meet the various requirements of the SARA, such as the authorization to carry out activities that would otherwise violate the SARA as well as the development of recovery strategies. The scientific information also serves as advice to the Minister of DFO regarding the listing of the species under SARA and is used when analyzing the socio-economic impacts of adding the species to the list as well as during subsequent consultations, where applicable. This assessment considers the scientific data available with which to assess the recovery potential of Silver Shiner in Canada.

SUMMARY

- Silver Shiner is currently known to occur in four distinct watersheds of the Great Lakes basin: Bronte Creek, Sixteen Mile Creek, Grand River and Thames River. Records also suggest that Silver Shiner may also occur in the Saugeen River; however, it is plausible that these collections may have originally been misidentified.

- Adult Silver Shiner are generally found in run, riffle, and pool areas of streams with moderate to fast flow and little to no aquatic vegetation. Very little information exists related to Silver Shiner juvenile habitat preferences. Spawning is thought to occur in the spring when water temperatures are between 18.1 and 23.5°C.
- If Silver Shiner has a maximum age of 3 (short-lived): to achieve ~99% probability of persistence, given a 10% chance of catastrophic decline (50% reduction in abundance), requires ~780,000 adult Silver Shiner and at least 0.871 km^2 of suitable habitat,
- If Silver Shiner has a maximum age of 10+ (long-lived): to achieve ~99% probability of persistence, given a 15% chance of catastrophic decline (50% reduction in abundance), requires ~700 adult Silver Shiner and at least 0.07 km^2 of suitable habitat.
- At current abundances, and assuming all habitat is in fact suitable, there is very little risk of extirpation for any of the four populations, if Silver Shiner is long-lived. If the species is short-lived, Bronte Creek is at greatest risk of extirpation (up to 100%), followed by Sixteen Mile Creek (up to 33%), Thames River (up to 20%) and Grand River (up to 12%). Risk to Sixteen Mile Creek can be reduced if suspected habitat is occupied at the same densities as known habitat (up to 11%). Risk for each population is < 2% if the populations grow to carrying capacity.
- The greatest threats to the survival and persistence of Silver Shiner in Canada are related to the presence of contaminants and toxic substances, increases in nutrient loading, increase in turbidity and sediment loading, and issues related to water flow management. Lesser threats that may be affecting the survival of Silver Shiner include exotic species, barriers to movement and incidental harvest, although the current knowledge on the level of impact that these threats may have on Silver Shiner is very limited.
- Population growth of Silver Shiner is most sensitive to changes in the survival of immature individuals or the fertility of first time spawners. This is especially true if Silver Shiner is short-lived.
- There remain numerous sources of uncertainty related to Silver Shiner including their preferred habitat, the distribution and extent of suitable habitat, life history characteristics, specifically conflicting aging interpretations, and the factors limiting their existence.

BACKGROUND

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recommended that Silver Shiner (*Notropis photogenis*) be designated as a species of Special Concern in April 1983. This status was reconfirmed in April 1987. In May 2011, Silver Shiner was designated as Threatened due to its small area of occupancy and collection in fewer than 10 locations. Subsequent to the original COSEWIC designation, Silver Shiner was listed on Schedule 3 of the federal *Species at Risk Act* (SARA). When COSEWIC designates an aquatic species as Threatened or Endangered and the Governor in Council decides to list it, the Minister of Fisheries and Oceans Canada (DFO) is required by the SARA to undertake a number of actions. Many of these actions require scientific information such as the current status of the population, the threats to its survival and recovery, and the feasibility of its recovery. This scientific advice is developed through a Recovery Potential Assessment (RPA). This allows for the consideration of peer-reviewed scientific analyses in subsequent SARA processes, including permitting on harm and recovery planning. This RPA focuses on Silver Shiner populations in Canada, and is a summary of the conclusions and advice from a Canadian Science Advisory Secretariat peer-review meeting that occurred on 24-25 September 2012 in Burlington, Ontario. Two research documents, one providing background information on the species biology, habitat preferences, current status, threats and mitigations and alternatives (Bouvier et al. 2013), and a second on allowable harm, population-based recovery targets, and habitat targets (Young and Koops 2013) provide an in-depth account of the information summarized below. Proceedings that document the activities and key discussions of the meeting are also available (DFO 2013). Please note that reference citations have been removed from the following document to minimize the length of the document. Complete reference citations are available at Bouvier et al. (2013) and Young and Koops (2013).

Species Description and Identification

Silver Shiner is a small, elongate, silvery fish which reaches a maximum total length (TL) of approximately 144 mm (~ 115 mm standard length; SL). It has: a pointed snout and a large eye with a diameter equal to, or slightly less than, snout length; 36-43 lateral scales; 8-10 (usually 9) pelvic fin rays; and, 15-17 pectoral fin rays. Breeding males of the species are not brightly coloured, however, do express nuptial tubercles on the head, body and fins. Silver Shiner is morphologically similar to other shiners, primarily Rosyface Shiner (*N. rubellus*) and Emerald Shiner (*N. atherinoides*), and may be distinguished from congeners by having greater than eight anal fin rays, a pair of crescents between the nostrils, a clearly defined stripe along the back which is anterior to the dorsal fin, as well as a dorsal fin which originates directly opposite the base of the pelvic fins. Rosyface Shiner has 11-14 pectoral fin rays and reaches a maximum TL of 90 mm (as compared to 144 mm in Silver Shiner); whereas, Emerald Shiner has a shorter, blunter snout. The frequent confusion amongst congeners may be an impediment towards understanding distribution, abundance, and biology of all three species. In Ontario, growth rates are rapid in the first year, with juveniles attaining 38-71 mm (SL) by November and adults ranging from 39-110 mm. The maximum documented age is three years; however, recent examination of otoliths from individuals captured in 2011 suggests that they may be much longer lived. Silver Shiner appears to be an opportunistic feeder, foraging at both surface and mid-water levels

ASSESSMENT

Current Species Status

In Canada, Silver Shiner is restricted to southwestern Ontario where it has been found in tributaries of Lake Huron, Lake St. Clair, Lake Erie, and Lake Ontario (Figure 1). Although originally reported in 1971, Silver Shiner has been documented from museum collections from as early as 1936. The Canadian distribution comprises less than 2% of the global distribution based on extent of occurrence. Increased sampling has expanded the known extent of occurrence of Silver Shiner from an estimated 5,400 km^2 in 1983 to approximately 6,996 km^2 in 2008. This increase in range is largely the result of targeted sampling in lower sections of Sixteen Mile and Bronte creeks as well as the Thames and Grand rivers rather than an increase in the range of the species.The area of occupancy (AO) based on a 2 x 2 km grid is 896 km^2 (419 km^2 based on a 1 x 1 km grid; COSEWIC 2011). The biological AO was estimated to be 19.3 km^2 (COSEWIC 2011).

Grand River

Silver Shiner has been found in a 145 km stretch of the Grand River, extending from 7 km below Elora to the mouth of the Grand River. It is also known from the lower reaches of two tributaries, the Nith and Conestogo rivers, as well as in Laurel Creek, Schneider Creek, Speed River, and Whitemans Creek. In the Nith River, it has been found along a stretch of stream extending from the confluence with the Grand River to a location approximately 58 km upstream. In the Conestogo River, Silver Shiner has been recorded along a 25 km stretch, from the mouth of the river extending to Wallenstein. Recent collections using boat seining methods resulted in collections of Silver Shiner from the lower half of the Grand River and extended the known range of the species in the main stem of the river 44 km further downstream than previously reported. Limited collections have been made of the species in the upper half of the Grand River watershed (above Paris, Ontario). Prior to 1982, only four records had been identified, two from the lower Conestogo River [1989, Royal Ontario Museum (ROM) 5592; 1990, Wilfred Laurier University (WLU) 12832]. A third collection was recorded in 2002 near the upstream limit of the species distribution in the Grand River (A. Timmerman, Ontario Ministry of Natural Resources (OMNR), pers. comm. in COSEWIC 2011) as well as a fourth record in 2007 near Doon (DFO, unpubl. data). Collections made in 2010 and 2011 (DFO, unpubl. data) indicate that Silver Shiner is found along the length of the Grand River, as well as in a number of its tributaries; however, samples were captured in smaller numbers than previously observed.

Thames River

Within the Thames River watershed, Silver Shiner has been documented from Medway Creek through the Thames, North Thames, and Middle Thames rivers. The known range of the species has increased slightly in recent years, extending further downstream in the Thames River as well as in two additional tributaries of the North Thames River. In summary, Silver Shiner is located in a stretch of the Thames River proper extending from below Delaware to the mouth of the Middle Thames River. It has also been documented from a section of the North Thames River, from the confluence with the main stem to within 1 km above Motherwell. Silver Shiner is also found in the lower Middle Thames River and along Fish Creek, Medway Creek, and Trout Creek, three tributaries of the North Thames River. In addition to the lotic sites along the North Thames River, a single adult Silver Shiner and 95 juveniles were captured from a number of lentic sites in Fanshawe Lake, an artificial reservoir created by a dam 14 km upstream from the mouth of the North Thames River.

Bronte Creek

Silver Shiner was identified from Bronte Creek in 1983 at Zimmerman. In subsequent collections, 130 specimens (1994) and 116 specimens (1998) were captured 14 km further downstream in Oakville, suggesting that the species is widespread in the lower Bronte Creek system. Sampling efforts in 2011 were again successful. A total of 57 individuals were captured with a 30 ft bag seine at 8 of 10 sites that were sampled. Additional sampling was completed in 2012 at Petro Canada Park and seven individuals were recorded. Length of the occupied area in Bronte Creek is approximately 39 km.

Sixteen Mile Creek

A single individual was collected in 1998 (ROM 71697) from east Sixteen Mile Creek, located approximately 9 km ESE of Milton. Additional surveys were conducted by DFO in 2011 and multiple, successful collections (N=8, n ≥426) confirm the existence of a persistent population of Silver Shiner in this location. It should be noted that there has been no sampling on Sixteen Mile Creek between the QEW and Dundas Street creating a knowledge gap for this area.

Saugeen River

Records from the WLU collection suggest that Silver Shiner may also occur in the Saugeen River, a tributary of Lake Huron; however, it is plausible that these collections may have been originally misidentified. Subsequent re-examination (E. Holm, ROM) of one specimen has been identified as a Striped Shiner. The second specimen, previously identified as Silver Shiner, collected from a tributary of the Saugeen River near Port Elgin is missing from the collection and its identification cannot be confirmed. This record was not included in Baldwin’s (1988) status report. An additional collection, previously identified as Rosyface Shiner collected from the Saugeen River drainage (ROM 24831), was re-examined (K. Stewart, University of Manitoba, 2005) and determined to be Silver Shiner. The collection locality within the watershed is unknown. Additional surveys in the Saugeen River watershed are required to determine if an established population exists in this location. Additional sampling by seining, boat-electrofishing and backpack-electrofishing was completed in the Saugeen River in 2005 and 2006 but no Silver Shiner were captured.

Population Status Assessment

To assess the Population Status of Silver Shiner populations in Canada, each population was ranked in terms of its abundance (Relative Abundance Index) and trajectory (Population Trajectory). The level of certainty was associated with each assignment (1=quantitative analysis; 2=CPUE or standardized sampling; 3=expert opinion). The Relative Abundance Index and Population Trajectory values were combined in the Population Status matrix to determine the Population Status for each population. Each Population Status was subsequently ranked as Poor, Fair, Good, Unknown or Extirpated (Table 1). The Certainty assigned to each Population Status is reflective of the lowest level of certainty associated with either initial parameter. Refer to Bouvier et al. (2013) for detailed methods used for the assessment of Population Status.

Table 1. Population Status for all Silver Shiner populations in Canada, resulting from an analysis of both the Relative Abundance Index and Population Trajectory. Certainty assigned to each Population Status is reflective of the lowest level of certainty associated with either initial parameter (Relative Abundance Index, or Population Trajectory).

Population	Population Status	Certainty
Grand River	**Fair**	**3**
Thames River	**Fair**	**3**
Bronte Creek	**Poor**	**3**
Sixteen Mile Creek	**Fair**	**3**
Saugeen River	**Unknown**	**3**

Habitat Requirements

Spawning

Silver Shiner spawning habitat preferences are not well known; however, some evidence suggests that spawning occurs in relatively deep riffles and pools in habitat similar to that used by other shiners (e.g., *Luxilus* spp.) and chubs (*Nocomis* spp.). It is suggested that spawning occurs at dusk or at night as has been reported for Emerald Shiner (Jenkins and Burkhead 1994). Spawning in Ontario is thought to occur from late May through to mid-June, based on the capture of ripe and then spent individuals, when water temperatures reach 18.1-23.5°C. Spawning appears to vary widely throughout its range, June-early July in Ohio (Trautman 1981), late April-late May in Tennessee, and early May-mid-June in Virginia.

Larval & Juvenile

There is very limited information available on habitat preferences of larval and juvenile Silver Shiner. It has been reported that young-of-the-year Silver Shiner are most commonly associated with aquatic habitats of slower water than those preferred by adult fish.

Adult

Adult Silver Shiner are found primarily in medium or large streams with moderate gradients (0.5-1.9, mean 1.4 m/km). Additional information from Bronte Creek indicates a slightly larger gradient range (0.34-3.02 m/km) but does indicate a similar mean range (1.56 m/km). Most often associated with alternating pools and riffles or more turbulent regions below dams, they are rarely found in small stream habitats. In smaller systems (e.g., Sixteen Mile Creek), Silver Shiner do occupy, in similar abundances, the riffle, run and pool segments of the river. Recent collections from the Grand River have occurred in gradients as low as 0.3 m/km and also from a reservoir; indicating the use of both lentic and lotic habitats. Silver Shiner is typically found in the mid-upper water column in schools or small groups in pools and large backwaters with sufficient current. Sampling completed by DFO between 2003-2010 noted that Silver Shiner was captured in slow to fast current, although flow rate was more commonly classified as ‘medium’ flow. Unfortunately, prior to 2011, flow rates were only recorded as qualitative estimates (slow, moderate, fast). In 2011, DFO standardized sampling included recording water velocity, resulting in water velocities between 0.05 and 1.98 m/s (mean=0.45 m/s; DFO, unpubl. data) where Silver Shiner were recorded.

Stream widths where Silver Shiner are found in Ontario varied from 5 to 200 m but tended to be larger than 20-30 m. In 1997, Silver Shiner was captured in Ontario from streams 24-50 m wide. Stream widths recorded by DFO during sampling efforts were similar to those previously recorded in the literature, and ranged from 11.5 to 135 m. Following the review of 21 environmental factors influencing Silver Shiner distribution, water depth was found to be the most important variable for supporting a population. Greater stream depth was positively correlated with Silver Shiner presence. More recently, Silver Shiner were captured in water ranging in depth from 0.24 to 1.24 m.

Water temperature likely limits the northern extent of the range of Silver Shiner; however, actual thermal preferences and tolerances of the species are unknown. In Ontario, Silver Shiner has been captured from streams with summer temperatures ranging from 8.3-27.6°C; however, no correlation has been found between warmer temperatures and species presence, with the exception that warmer temperatures appeared to be preferred during spring months.

It is likely that no relationship exists between water clarity and Silver Shiner occurrence. The species has been captured from sources where the water was identified as “clear”, “muddy” and also “cloudy”. Water colour, dissolved oxygen, pH, and conductivity (a measurement of the amount of dissolved solids in water) are also unrelated to the presence of Silver Shiner.

Silver Shiner may selectively avoid habitat areas with rooted aquatic vegetation, as has been observed among some populations from Ohio. In Ontario, it has been noted that aquatic vegetation may be present or absent where Silver Shiner was recorded and is not likely correlated with the presence of the species. This was also observed by Holm and Boehm (1998 as cited in COSEWIC 2011) who noted that Silver Shiner was captured at sites with and without submerged vegetation. More recent studies by DFO indicated that 99% of the sites where Silver Shiner was captured were classified as being open water dominated; a single site was classified as having submergent vegetation as the dominant vegetative type.

Descriptions of Silver Shiner substrate preference are quite varied in the literature, including boulder, rubble, gravel, pebble, sand, silt, mud, and clay. Recent field sampling by DFO supports the literature, in that Silver Shiner was caught over a large range of substrate types. A total of 119 sites were sampled in the four areas where Silver Shiner is known to exist. At each site the dominant substrate type was recorded. From this information, there does not appear to be a preference for any substrate type. Although Silver Shiner was most often caught over a substrate described as being cobble-dominated, it should be noted that a comparatively similar number of cobble-dominated sites in each system yielded no Silver Shiner. Silver Shiner were never recorded from sites categorized as silt-, or clay-dominated; however, very few sites with these characteristics were sampled.

Functions, Features and Attributes

A description of the functions, features, and attributes associated with Silver Shiner habitat can be found in Table 2. Please see Bouvier et al. (2013) for definitions of functions, features and attributes. Habitat attributes from the literature for each life stage have been combined with habitat attributes from current records (records from 2001 to present) to show the maximum range in habitat attributes within which Silver Shiner may be found. This information is provided to guide any future identification of critical habitat for this species. It should be noted that habitat attributes associated with current records may differ from the habitat attributes described in the literature as Silver Shiner may be occupying sub-optimal habitat in areas where optimal habitat is no longer available.

Residence

Residence is defined in SARA as a, “dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating”. Residence is interpreted by DFO as being constructed by the organism. In the context of the above narrative description of habitat requirements during larval, juvenile and adult life stages,
Silver Shiner does not construct residences during its life cycle.

Recovery Modeling

Population Growth

Two subsets of individuals were aged by independent interpreters. Both interpreters were provided with specimens of various lengths captured using the same protocol during the same sampling periods. Both interpreters utilized the right or left lapillus otolith to interpret age. Age analysis results varied greatly between interpreters with one interpreter determining maximum age (T_{max}) to be 3, and the other determining maximum age to be greater than 10 years (Figure). This difference in life history had a large effect on population dynamics. We therefore present model results for both scenarios, henceforth referred to as the short-lived model (T_{max}= 3) and the long-lived model (T_{max} > 10).

Table 2. Summary of the essential functions, features and attributes for each life stage of Silver Shiner. Scientific Literature habitat attributes, borrowed from published literature, and habitat attributes recorded during recent Silver Shiner surveys (captured since 2001) have been combined to derive the habitat attributes required for the delineation of critical habitat (see text for a detailed description of categories).

			Habitat Attributes		
Life Stage	**Function**	**Feature(s)**	**Scientific Literature**	**Current Records**	**For Identification of Critical Habitat**
Spawning	Reproduction (spawning likely occurs in late May through to late June)	Run, riffle or pool areas of streams.	• Spawning thought to occur when water temperatures are between 18.1-23.5°C (Baldwin 1988)		• Spawning thought to occur in the spring when water temperatures are between 18.1-23.5°C
Egg to juvenile	Nursery Feeding Cover	Run, riffle or pool areas of streams.			
Juvenile (<60 mm TL)	Feeding Cover	Run, riffle and pool areas of streams with slow to moderate flow and little to no aquatic vegetation.		• Individuals <60 mm TL have been recently caught in the same habitats as adults (DFO, unpubl. data)	• Same features as adult habitat, with the exception of the flow characteristic, in that juvenile are found in streams with slow to moderate flow
Adult (from age 1 [onset of sexual maturity])	Feeding Cover	Run, riffle and pool areas of streams with moderate to fast flow and little to no aquatic vegetation.	• 0.245-0.405 m - water depth was the most important variable for supporting a population with greater stream depth positively correlated with Silver Shiner presence (Baldwin 1983) • Most often associated with alternating pools and riffles (Baldwin 1988) • Substrate described as varying from boulders, rubble, gravel, pebbles, sand, mud, silt and clay (Parker and McKee 1980; Trautman 1981; Lavett-Smith 1985) • Usually avoided habitats with rooted aquatic vegetation (Trautman 1981)	• 0.24 – 1.24 m depth (DFO unpubl. data) • Water velocity – 0.05 and 1.98 m/s (mean=0.45 m/s; DFO, unpubl. data) • Captured at sites dominated by bedrock, boulder, cobble, gravel and sand (DFO, unpubl. data) • Dominant vegetative classification – Open Water (100% open water at 76% of the sites; DFO unpubl. data)	• 0.245-1.24 m water depth • Moderate to fast flowing riffles, runs, and alternating pools • Most often present in open water-dominated habitats

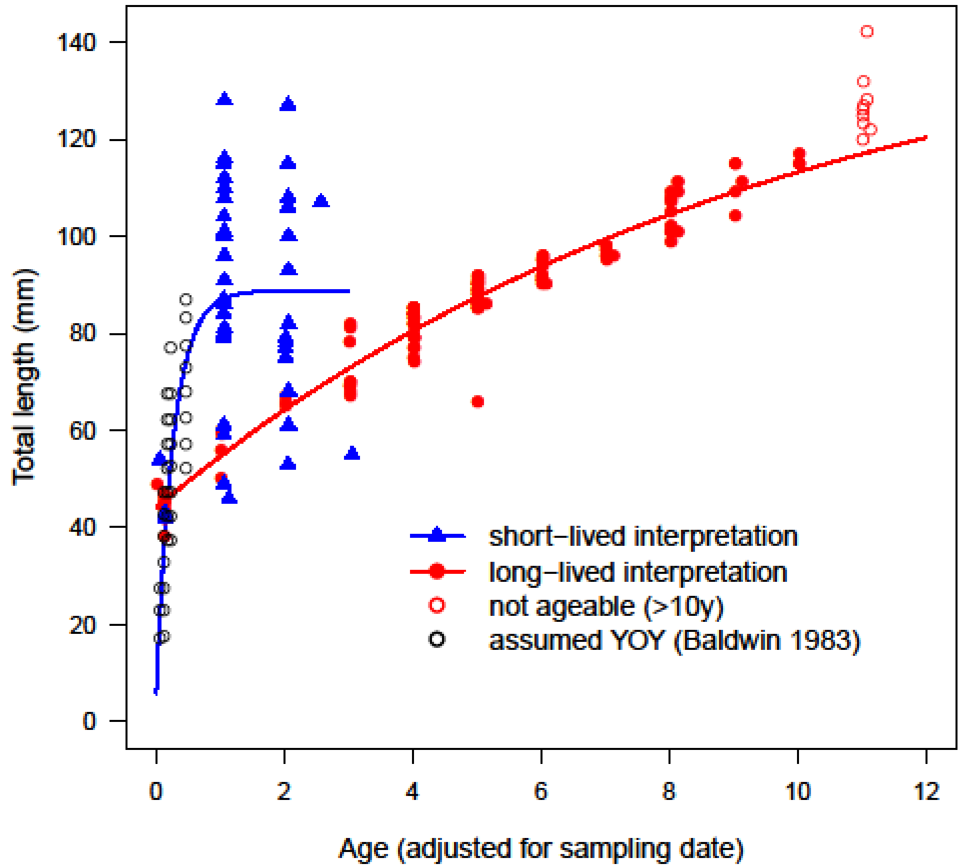

Figure 2. Comparison of size-at-age of Silver Shiner from Ontario sampling in 2011 as interpreted by two independent consultants. Young-of-the-year from previous Ontario sampling are included (Baldwin 1983). Fitted von Bertalanffy growth curves for both interpretations overlaid.

Allowable Harm

Estimates of allowable harm are based on the estimated population growth rate. Due to a paucity of data we were unable to determine population growth rate, and therefore did not assess allowable harm. Instead we focused on quantifying sensitivity of the model to perturbations, and identifying those parts of the life cycle that are most sensitive to change.

Summary of Science Advice on Allowable Harm

- For the purposes of the recovery potential assessment modeling, harm refers to a negative alteration to a vital rate that reduces a population growth rate.
- If a population is stable and exceeds the recovery target (MVP) then harm may be considered that does not result in a decline of the population growth rate.
- When population trajectory is declining there is no scope for allowable harm to the population.
- When population trajectory is unknown the scope for allowable harm can only be assessed once population data are collected
- Scientific research to advance the knowledge of population data should be allowed

Population Sensitivity

The assessment of population sensitivity involves perturbation analyses of population projection matrices, and includes a stochastic element. Outputs of the analyses include calculation of a population growth rate and its sensitivity to changes in vital rates. See Young and Koops (2013) for complete details of the model and results. Population growth of a short-lived Silver Shiner is extremely sensitive to perturbations of young-of-the-year survival, the fecundity of first time spawners, and the proportion of individuals that spawn at age 1 (Figure). The population is virtually insensitive to changes in survival or fertility of age 2 or 3 individuals.

If a long lifespan is assumed, the population growth of Silver Shiner is most sensitive to changes in the survival of immature individuals, and is sensitive to changes in proportion of individuals who spawn for the first time at age 3 (ρ_3), as well as the fertility of those who do so (Figure 4).

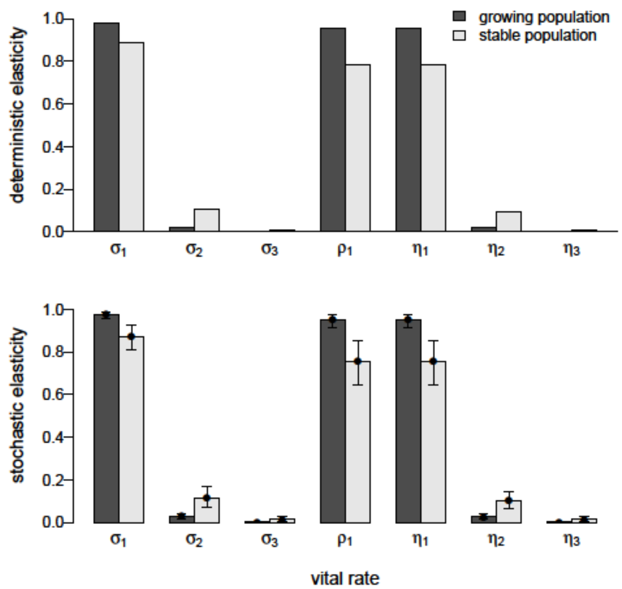

Figure 3. Results of the stochastic perturbation analysis showing elasticities (ε_v) of vital rates for the short-lived model: annual survival probability of age j-1 to age j (σ_i), fertility (η_j), and the proportion of reproductive age 1 individuals (ρ_1). Stochastic results include associated bootstrapped 95% confidence interval. Exact values listed in Table 3 of Young and Koops (2013).

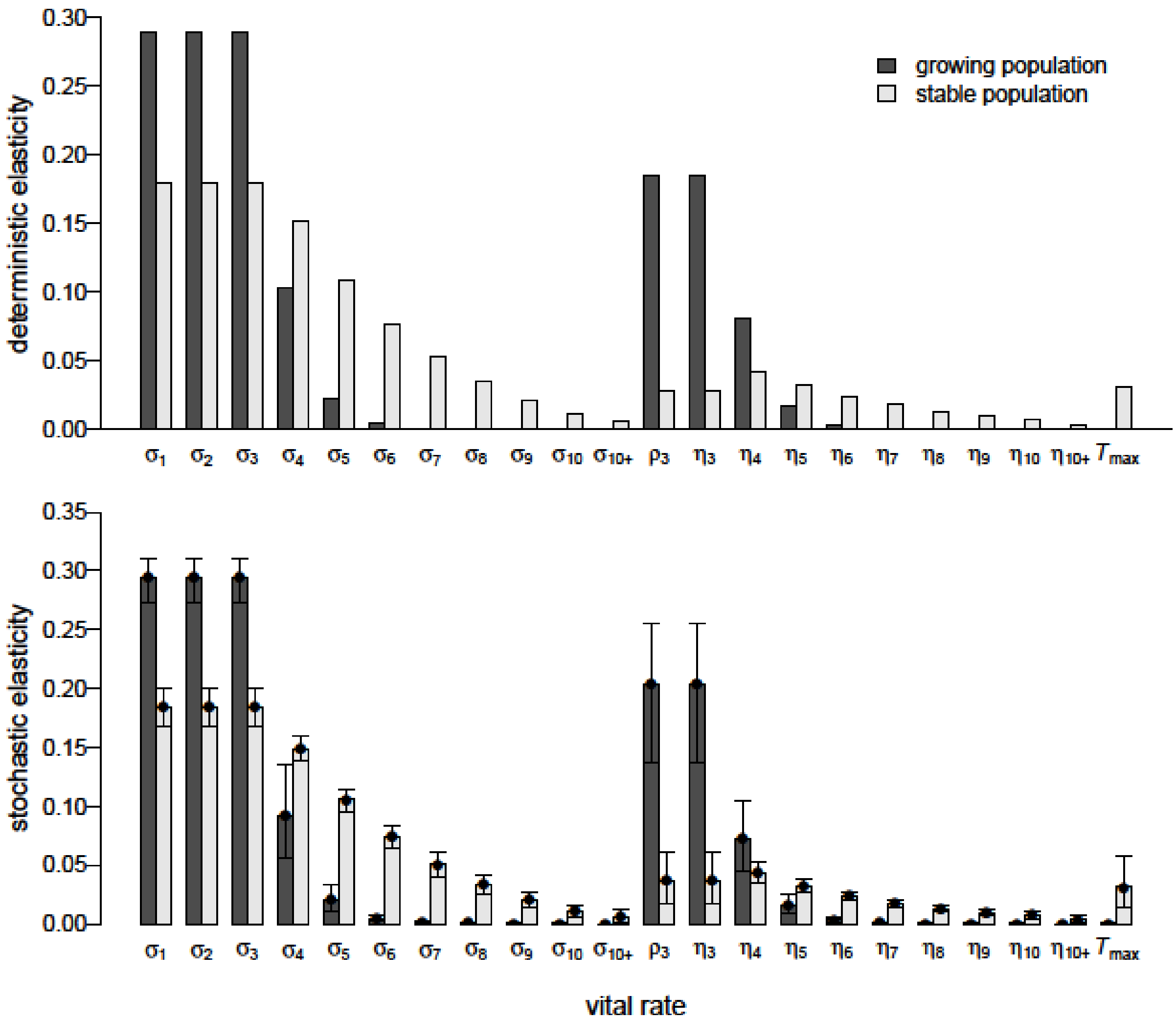

Figure 4. Results of the deterministic (panel 1) and stochastic (panel 2) perturbation analysis showing elasticities (ε_v) of the vital rates for the long-lived model: annual survival probability of age j-1 to age j (σ_j), fecundity (f_j), and the proportion of reproductive age 3 individuals (ρ_3). Stochastic results include associated bootstrapped 95% confidence interval.

Recovery Targets

Demographic sustainability was used as a criterion to set recovery targets for Silver Shiner. Demographic sustainability is related to the concept of a minimum viable population (MVP; Shaffer 1981), and was defined as the minimum adult population size that results in a desired probability of persistence over 100 years (approximately 77 or 18 generations for the short- or long-lived model, respectively). MVP targets were chosen to optimize the benefit of reduced extinction risk and the cost of increased recovery effort, and resulted in a persistence probability of approximately 99% over 100 years. Recovery targets were presented for both models assuming a variety of risk scenarios (see Young and Koops 2013). Recommended targets for the short-lived model were estimated at ~780,000 adults (ages 1+) per population, assuming the probability of a catastrophic decline (50% reduction in abundance) was 0.10 per generation and an extinction threshold of 2 adults. For the long-lived model, the recommended target of ~700 adults (ages 3+) per population assumes a catastrophic decline of 0.15 per generation.

Minimum Area for Population Viability

Minimum area for population viability (MAPV) is a quantification of the amount of habitat required to support a viable population. Variables included in the MAPV assessment include MVP values and area required per individual (API values). API values were estimated from an allometry for river environments from freshwater fishes. MAPV for the recommended recovered populations above was 0.87 km^2 or 0.07 km^2 for the short- or long-lived model respectively

Current Abundance and Available Habitat

Available habitats for the four populations were estimated as, approximately: 0.3 km^2 (Bronte Creek), 0.2 km^2 (Sixteen Mile Creek), 3.9 km^2 (Thames River), and 8.0 km^2 (Grand River). Including suspected habitat extends the total estimates of Bronte Creek (0.35 km^2), Sixteen Mile Creek (0.6 km^2) and the Grand River (8.4 km^2). These estimates assume the entire reach of Silver Shiner habitat consists of suitable habitat for the species.

Abundances of the four Silver Shiner populations in known habitat were estimated to be approximately (Young and Koops 2013; Table 7ii): 5,700 (2,100 - 15,300) in Bronte Creek; 31,600 (18,300 - 54,500) in Sixteen Mile Creek; 53,800 (31,000 - 188,300) in the Thames River population, and 135,100 (51,700 - 355,600) in the Grand River. These estimates were based on sampling densities of 0.0190, 0.1775, 0.0139 and 0.0169 respectively (Young and Koops 2013; Table 6). If densities were extended to include suspected habitat, approximate abundance estimates were, respectively: 6,600 (2,500 - 17,700); 101,100 (58,700 - 174,300); 53,700 (31,000 - 188,300); and 140,500 (53,900 - 368,500).

None of these abundances meet the recommended short-lived MVP target of 780,000. If, however, Silver Shiner populations reach carrying capacity of known plus suspected available habitat, the MVP target will be exceeded by both Grand and Thames River populations (Young and Koops 2013; Table 7iii). All of these abundances exceed the recommended long-lived MVP target of ~700 adults.

Risk of Extirpation at Current Abundances

If Silver Shiner are long-lived, the risk of extirpation is very low (< 0.2%) for each of the populations at their estimated abundance, assuming a risk scenario of 15% per generation catastrophe and an extinction threshold of 2 (Young and Koops 2013; Table 8iii). The overall probability of persistence for all four populations under this scenario is 99.9%.

The Bronte Creek population is at greatest risk (Figure 5). If Silver Shiner is short-lived, assuming a risk scenario of 10% per generation probability of catastrophe and an extinction threshold of 2 adults, the risk of extirpation at current abundance, over the next 100 years, is 97.6% (range 38.5-100%) based on current density. Bronte Creek is both the smallest habitat, and one of the least dense populations. Increasing the density of Bronte Creek to carrying capacity can reduce this risk to as little as 2.3%. Sixteen Mile Creek and Thames River populations are at some risk of extinction over the next 100 years (3.6-32.5%). The Sixteen Mile Creek population has the highest density of the four, but the smallest known habitat. Its risk of extinction falls in the lower end of this range if suspected habitat is indeed suitable (3.9-10.9%), and a saturation density can further reduce risk to 1.4%. Risk to the Thames River population can be reduced to 0.2% by saturating the suspected habitat. The Grand River population is currently at lowest risk of extinction over the next 100 years (1.9-12.3%), and can also reduce risk to 0.1% through increased density. The overall probability of persistence of all four populations is low due to the risk to Bronte Creek (~12%, range 0-60%). However, if catastrophes happen at a rate of 5% probability per generation (with an extinction threshold of 2 adults), persistence is much more likely (82-98%). In addition, if saturation is achieved in all four populations, probability of persistence is large (92%) even under the more conservative risk scenario (10% catastrophe and extinction threshold of 50).

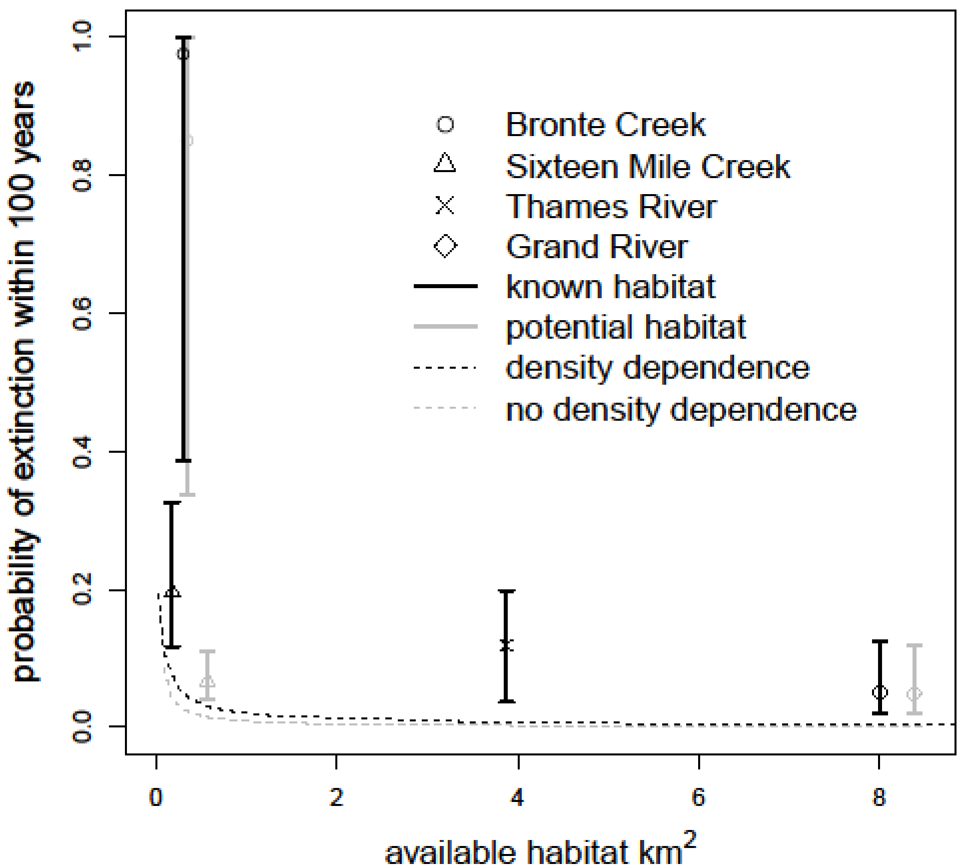

Figure 5. Probability of extinction within 100 years of 10 simulated Silver Shiner populations as a function of available habitat. Simulations assume no population growth or decline, on average, and a short lifespan. Dashed curves assume saturation of the available habitat and either density dependence (black) or no density dependence (grey). Error bars show ranges of extinction risk for each of four Silver Shiner populations given current estimates of density and either known (black) or suspected plus known available habitat (grey).

Threats to Survival and Recovery

A wide variety of threats negatively impact Silver Shiner across its range. Our knowledge of threat impacts on Silver Shiner populations is limited to general documentation, as there is a paucity of threat-specific cause and effect information in the literature. The greatest threats to the survival and persistence of Silver Shiner in Canada are anthropogenic threats such as habitat reduction, fragmentation or habitat degradation attributed to turbidity and sedimentation; contaminant or other toxic substance introductions; dams and other physical barriers that impede movement; aquatic exotic species; as well as incidental harvest. Silver Shiner in Ontario is found in waterbodies immediately adjacent to agricultural lands and in areas with increasing urban populations and development pressures. Poor land- and water-management practices result in a reduction in water quality, such as sedimentation; increased turbidity; nutrient loading; and introduction of contaminants to the ecosystem, all of which are known to negatively impact fish habitat and population survival. Physical modifications, such as the creation of impoundments and dams, can create barriers to movement, alter flow regimes and contribute to increased sedimentation into aquatic habitats. Habitat reduction or degradation, attributed to river modifications, can result in altered flow regimes which may cause a loss of Silver Shiner habitat. These factors can be detrimental to Silver Shiner populations in Ontario and decrease the likelihood of recovery.

Threat Level Assessment

To assess the Threat Level of Silver Shiner population, each threat was ranked in terms of the Threat Likelihood and Threat Impact on a population basis (see Bouvier et al. 2013 for complete details on classification approach). Threat Impact categorization was assigned on a location-by-location basis. If no information was available on the Threat Impact at a specific location, a precautionary approach was used - the highest level of impact from all sites was applied. The Threat Likelihood and Threat Impact for each population were subsequently combined in the Threat Status Matrix resulting in the final Threat Status for each location (Table 3). Certainty has been classified for Threat Impact and is based on: 1= causative studies; 2=correlative studies; and, 3=expert opinion.

Table 3. Threat Level for all Silver Shiner populations in Canada, resulting from an analysis of both the Threat Likelihood and Threat Impact. The number in brackets represents the level of Certainty associated with the Threat Impact assignment and was classified as: 1=causative studies; 2=correlative studies; and 3=expert opinion.

	Grand River	Thames River	Bronte Creek	Sixteen Mile Creek
Turbidity and sediment loading	Medium (3)	Medium (3)	High (3)	Medium (3)
Contaminants and toxic substances	High (3)	High (3)	High (3)	High (3)
Nutrient loading	High (3)	High (3)	High (3)	High (3)
Barriers to movement	Medium (3)	Medium (3)	Low (3)	Low (3)
Flow management	Medium (3)	Medium (3)	Medium (3)	High (3)
Exotic species	Medium (3)	Low (3)	Medium (3)	Medium (3)
Incidental harvest	Low (1)	Low (1)	Low (1)	Low (1)

Mitigations and Alternatives

Threats to species survival and recovery can be reduced by implementing mitigation measures to reduce or eliminate potential harmful effects that could result from works or undertakings associated with projects, or activities in Silver Shiner habitat. Although currently recognized as a species of Special Concern in Schedule 3 of the SARA, prohibitions do not apply to Silver Shiner. In Ontario, the species is listed as Threatened under the *Endangered Species Act*, which necessitates the preparation of a formal provincial recovery strategy for Silver Shiner to manage the species and to mitigate impacts to prevent further decline. Legislation exists to prevent the intentional harvest of Silver Shiner as bait; however, due to its morphological similarity to other shiners, it may be inadvertently taken. Silver Shiner has previously been identified and included in recovery plans for both the Grand and Thames rivers, both of which recommend initiating a monitoring plan to more accurately determine its distribution and abundance.

Within Silver Shiner habitat, a variety of works, undertakings, and activities have occurred that have directly or indirectly affected Silver Shiner habitat (please see Bouvier et al. 2013 for a complete list of works, undertakings, and activities). Research has been completed summarizing the types of work, activity, or project that have been undertaken in habitat known to be occupied by Silver Shiner (Table 3).

Based on the assumption that historic and anticipated development pressures are likely to be similar, it is expected that comparable projects and activities will likely occur in Silver Shiner habitat in the future (i.e., the majority being water crossings, instream works, and the placement of structures in water). Research also indicated that the primary project proponents were municipalities since much of the work occurred in major urban areas or was along roadsides.

As indicated in the Threat Analysis, numerous threats affecting Silver Shiner populations are related to habitat loss or degradation. Habitat-related threats to Silver Shiner have been linked to the Pathways of Effects developed by DFO Fish Habitat Management (FHM) (Table 4). DFO FHM has developed guidance on mitigation measures for 19 Pathways of Effects for the protection of aquatic species at risk in the Central and Arctic Region (Coker et al. 2010). This guidance should be referred to when considering mitigation and alternative strategies for habitat-related threats. At the present time, we are unaware of mitigation that would apply beyond what is included in the Pathways of Effects.

Table 4. Summary of works, projects and activities that have occurred during the period of August 2009 to August 2011 in areas known to be occupied by Silver Shiner. Threats known to be associated with these types of works, projects, and activities have been indicated by a checkmark. The number of works, projects, and activities associated with each Silver Shiner population, as determined from the project assessment analysis, has been provided. Applicable Pathways of Effects have been indicated for each threat associated with a work, project or activity (1 - Vegetation clearing; 2 – Grading; 3 –Excavation; 4 – Use of explosives; 5 – Use of industrial equipment; 6 – Cleaning or maintenance of bridges or other structures; 7 – Riparian planting; 8 – Streamside livestock grazing; 9 – Marine seismic surveys; 10 – Placement of material or structures in water; 11 – Dredging; 12 – Water extraction; 13 – Organic debris management; 14 – Wastewater management; 15 – Addition or removal of aquatic vegetation; 16 – Change in timing, duration and frequency of flow; 17 – Fish passage issues; 18 – Structure removal; 19 – Placement of marine finfish aquaculture site).

Work/Project/Activity	**Threats** (associated with work/project/activity)						**Watercourse / Waterbody** (number of works/projects/activities between 2009-2011)			
	Turbidity and sediment loading	**Contaminants & toxic substances**	**Nutrient loading**	**Barriers to movement**	**Exotic species**	**Incidental harvest**	**Grand River**	**Thames River**	**Bront e Creek**	**Sixteen Mile Creek**
Applicable pathways of effects for threat mitigation and project alternatives	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 15, 16, 18	1, 4, 5 ,6 ,7 ,11 ,12 ,13 ,14, 15, 16 ,18	1, 4, 7, 8, 11, 12, 13, 14, 15, 16	10, 16, 17						
Water crossings (e.g., bridges, culverts, open cut crossings)	✓	✓		✓			23	14	9	4
Shoreline, streambank work (e.g., stabilization, infilling, retaining walls, riparian vegetation management)	✓	✓					7	3	1	1
Dams, barriers (e.g., maintenance, flow modification, hydro retrofits)	✓			✓	✓		2	2		
Instream works (e.g., channel maintenance, restoration, modifications, realignments, dredging, aquatic vegetation removal)	✓	✓	✓				3	3	7	1

Work/Project/Activity	Threats (associated with work/project/activity)						Watercourse / Waterbody (number of works/projects/activities between 2009-2011)			
	Turbidity and sediment loading	Contaminants & toxic substances	Nutrient loading	Barriers to movement	Exotic species	Incidental harvest	Grand River	Thames River	Bronte Creek	Sixteen Mile Creek
Applicable pathways of effects for threat mitigation and project alternatives	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 15, 16, 18	1, 4, 5 ,6 ,7 ,11 ,12 ,13 ,14, 15, 16 ,18	1, 4, 7, 8, 11, 12, 13, 14, 15, 16	10, 16, 17						
Water management (e.g., stormwater management, water withdrawal)	✓	✓	✓				3	5	1	
Structures in water (e.g., boat launches, docks, effluent outfalls, water intakes)	✓	✓	✓				9	5		
Baitfishing						✓				
Exotic species introductions (authorized and unauthorized) (e.g., sportfish stocking, Round Goby)					✓					

Additional mitigation and alternative measures, specific to the Silver Shiner, related to exotic species and incidental harvest are listed below.

Exotic Species

As discussed in the **THREATS** section, aquatic invasive species (e.g., non-native Brown Trout) introduction and establishment could have negative effects on Silver Shiner populations.

Mitigation

- Physically remove non-native species from areas known to be inhabited by Silver Shiner.
- Monitor watersheds for exotic species that may negatively affect Silver Shiner populations directly, or negatively affect Silver Shiner preferred habitat.
- Develop a plan to address potential risks, impacts, and proposed actions if monitoring detects the arrival or establishment of an exotic species.
- Introduce a public awareness campaign and encourage the use of existing exotic species reporting systems.
- Implement targeted education for resource users (e.g., fisheries management groups) on the potential effects of stocking on Silver Shiner populations.
- Increase the enforcement of existing regulations.

Alternatives

- Unauthorized
  - None.
- Authorized
  - Use only native species.
  - Follow the National Code on Introductions and Transfers of Aquatic Organisms for all aquatic organism introductions (DFO 2003).

Incidental Harvest

As discussed in the **THREATS** section, incidental harvest of Silver Shiner through the baitfish industry was recognized as a potentially low risk threat.

Mitigation

- Provide information and education to bait harvesters on Silver Shiner to raise awareness, and request the voluntary avoidance of occupied Silver Shiner areas.
- Immediate release of Silver Shiner if incidentally caught, as defined under the Ontario Recreational Fishing Regulations (OMNR 2012).
- Education through mandatory training on species at risk for baitfish harvesters.
- Increase the enforcement of current baitfish regulations.

Alternatives

- Prohibit the harvest of baitfish in areas where Silver Shiner is known to exist.

If Silver Shiner is listed under the SARA, it is possible that alternatives in addition to mitigation may be required. However, alternatives, such as redesigning projects, have also been used as mitigation approaches for many of the works that have taken place in the last few years. Offsetting may be required in some instances if future projects are permitted to result in the destruction of critical habitat.

Sources of Uncertainty

Despite recent sampling efforts for Silver Shiner in Ontario, limited monitoring and research has been conducted on the species. Accordingly, a number of key sources of uncertainty exist for this species. Resolving these sources of uncertainty would greatly enhance our understanding and detection of Silver Shiner in Ontario.

There is a need for a continuation of quantitative sampling of Silver Shiner in areas where it is known to occur to determine population size, current trajectory, and trends over time. There is also a need for targeted sampling of historic sites throughout southern Ontario to determine the persistence or extirpation of a number of populations [e.g., Fanshawe Lake (2003), Fish Creek (1984), Laurel Creek (1982), Saugeen River (1983); date in brackets represents most recent record]. Targeted sampling at known sites of capture should be completed in these systems to determine population sizes. In terms of distribution, there is a known knowledge gap on Sixteen Mile Creek between the Queen Elizabeth Highway and Dundas Street. This reach of the river should be sampled as it is currently unknown whether Silver Shiner is present. Additional sampling is also necessary for all populations with low certainty identified in the population status analysis. These baseline data are required to monitor Silver Shiner distribution and population trends as well as the success of any recovery measures implemented. There is a need to assess genetic variation across all Silver Shiner populations in Canada to determine population structure. Results of genetic analysis should help to determine the similarity between the north and south Thames populations.

The current distribution and extent of suitable Silver Shiner habitat is unknown and should be investigated and mapped. These areas should be the focus of future targeted sampling efforts for this species. There is also a need to identify habitat requirements for each life stage. There is very little information available for both larval and juvenile habitat requirements, necessitating the inference of these requirements from other life stages. Larval surveys are needed to identify both spawning and nursery grounds. Through qualitative observations, it was determined that flow may play a large role on the presence and abundance of Silver Shiner. Historically, flow was not measured quantitatively but categorized qualitative during site visits. Since this variable can be very subjective, it is suggested that flow be recorded quantitatively in all further studies on Silver Shiner.

Certain life history characteristics, required to inform Silver Shiner population modelling efforts, are currently unknown. Conflicting aging interpretations have resulted in two very different possible life histories. Model results and consequent recommendations based on the two interpretations differ dramatically. Studies to validate the growth, maturity, and longevity of Silver Shiner are needed. Further studies should focus on acquiring additional information on fecundity, population growth rate, and survival of young-of-the-year.

Numerous threats have been identified for Silver Shiner populations in Canada, although the severity of these threats is currently unknown. There is a need for more causative studies to evaluate the impact of each threat on Silver Shiner populations with greater certainty as well as an estimation of the cumulative effects of interactive threats. There is a need to determine threshold levels for water quality parameters (e.g., nutrients, dissolved oxygen, salinity) and to determine physiological parameter limits including temperature, pH, dissolved oxygen, and pollution tolerance. It is also recommended that a study should be completed to look at whether the introduction and stocking of Brown Trout is having a negative impact on Silver Shiner populations, and if so, to what degree.

SOURCES OF INFORMATION

This Science Advisory Report is from the September 24-25, 2012 Recovery Potential Assessment of Silver Shiner (*Notropis photogenis*). Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

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