Updated Review Considerations and Mitigation Guide for Habitat of the Grass Pickerel (*Esox americanus vermiculatus*)

George A. Coker, Julia E. Colm, Debbie L. Ming and Nicholas E. Mandrak

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by

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ABSTRACT

Coker, G.A., Colm, J.E., Ming, D.L., and Mandrak, N.E. 2021. Updated review considerations and mitigation guide for habitat of the Grass Pickerel (*Esox americanus vermiculatus*). Can. Manuscr. Rep. Fish. Aquat. Sci. 3218: vi + 23 p.

The Grass Pickerel (*Esox americanus vermiculatus*) is a member of the Pike family that has been designated as a species of Special Concern by the Committee on the Status of Endangered Wildlife in Canada and is listed on Schedule 1 of the federal *Species at Risk Act*. The Canadian distribution includes southwestern Quebec and southern Ontario. The Grass Pickerel frequently occupies the niche of top-predator in heavily vegetated, shallow, low-velocity areas where habitat conditions are unsuitable for larger top-predators. Despite being rather resilient to natural variations in environmental conditions, Grass Pickerel has fairly specific habitat requirements that result in a highly disjunct distribution in Ontario and Quebec. Threats to this species include, but are not limited to: habitat degradation and destruction through channel alterations that result in the loss of aquatic vegetation and other cover types, as well as the loss of low-velocity and shallow habitats; pollution and degradation of water quality; siltation of watercourses; low water levels; and diversion of cool or cold water into Grass Pickerel habitat. Mitigation strategies are proposed to minimize the impacts of watercourse modifications to this species.

RÉSUMÉ

Coker, G.A., Colm, J.E., Ming, D.L., and Mandrak, N.E. 2021. Updated review considerations and mitigation guide for habitat of the Grass Pickerel (*Esox americanus vermiculatus*). Can. Manuscr. Rep. Fish. Aquat. Sci. 3218: vi + 23 p.

Le brochet vermiculé (*Esox americanus vermiculatus*) est un membre de la famille des brochets qui a été désigné comme une espèce préoccupante par le Comité sur la Situation des Espèces en Péril au Canada et figure à l’annexe 1 de la *Loi sur les Espèces en Péril* fédérale. Son aire de répartition canadienne comprend le sud-ouest du Québec et le sud de l’Ontario. Le brochet vermiculé occupe souvent la niche du prédateur supérieur dans les habitats peu profonds, à forte végétation et à courant réduit, où les conditions sont défavorables aux plus grands prédateurs supérieurs. Malgré sa résilience aux variations naturelles des conditions ambiantes, le brochet vermiculé a des exigences assez précises en matière d’habitat qui donnent lieu à une répartition très disjointe de l’espèce en Ontario et Québec. Les menaces à celle-ci comprennent, entre autres : la dégradation et la destruction de l’habitat causées par les modifications des chenaux, lesquelles entraînent la perte de végétation aquatique et d’autres types de couvert, de même que la perte d’habitats à courant réduit et peu profonds ; la pollution et dégradation de la qualité d’eau ; turbidité élevée (envasement des cours d’eau); l’addition d’eau froide et fraîche. Des stratégies d’atténuation sont proposées pour réduire au minimum les répercussions des modifications des cours d’eau sur cette espèce.

PREFACE

This manuscript report is an update to a previous version (Coker et al. 2010) following new research on Grass Pickerel in Ontario related to movement patterns, habitat associations, and lessons-learned from a case-study of drain maintenance that integrated natural channel design principles. The updates to this manuscript report were peer-reviewed during a Canadian Science Advisory Secretariat (CSAS) meeting held October 4 – 5, 2016 in Burlington, Ontario, on the impacts of agricultural drain maintenance in Beaver Creek on Grass Pickerel (*Esox americanus vermiculatus*), a fish species at risk. Other products associated with this meeting can be found on the CSAS website.

Coker, G.A., Ming, D.L., and Mandrak, N.E. 2010. Review considerations and mitigation guide for habitat of the Grass Pickerel (*Esox americanus vermiculatus*). Can. Manuscr. Rep. Fish. Aquat. Sci. 2941: vi + 18 p

INTRODUCTION

The Grass Pickerel (*Esox americanus vermiculatus*; Figure 1) is a member of the Esocidae family, which also includes Northern Pike (*E. lucius*) and Muskellunge (*E. masquinongy*). It is one of the few North American fish subspecies with a formally recognized common name, being a subspecies of the Redfin Pickerel (*E. americanus*). The native global distribution of *Esox americanus* is restricted to the eastern half of North America, with the Grass Pickerel subspecies occurring in the central Mississippi valley and the southern Great Lakes basin, and the Redfin Pickerel subspecies (*E. a. americanus*) occurring on the Atlantic slope, and intergrades between the two subspecies occurring on the Gulf of Mexico slope (Jenkins and Burkhead 1993). In Canada, the Grass Pickerel is limited to extreme southwestern Quebec and southern Ontario [Committee on the Status of Endangered Wildlife in Canada (COSEWIC) 2005].

The Grass Pickerel has been designated Special Concern in Canada since May 2005, and is listed in Schedule 1 of the *Species at Risk Act* (SARA). The reason for designation is that small populations are known only from 15 disjunct locations between Lac St. Louis, Quebec and Lake Huron, Ontario, and a decline in the area of occupancy has been observed since 1970. The decline appears to be related to degradation and loss of habitat due to channelization and dredging operations in stream and wetland habitats where this species occurs (COSEWIC 2005). This conservation status was confirmed by the most recent status appraisal summary by COSEWIC (2014).

The purposes of SARA are to prevent wildlife species from being extirpated or becoming extinct, to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity and to manage species of special concern to prevent them from becoming endangered or threatened. For aquatic species at risk, Fisheries and Oceans Canada (DFO) is responsible for the coordination of recovery strategies and action plans for endangered and threatened species and management plans for special concern species. There are additional provincial and municipal regulations and legislation in Ontario and Quebec that offer protection to aquatic species at risk and their habitat.

The Management Plan for Grass Pickerel identifies habitat loss and degradation, specifically related to agricultural practices, as a widespread, continuous and high severity threat to Grass Pickerel in Canada (Beauchamp et al. 2012). This document is intended to provide guidance to managers and reviewers for mitigating impacts from agricultural drainage works on Grass Pickerel and its habitat. It provides a summary of Grass Pickerel life history and habitat information for government regulators and project proponents, pertinent to the assessment of development projects or other phenomena that affect Grass Pickerel habitat.

BACKGROUND INFORMATION

ECOLOGICAL SIGNIFICANCE

The Grass Pickerel is often the top predator in fish communities of which it is characteristic (COSEWIC 2005) and may have a significant role in the control of populations of small fishes (Jenkins and Burkhead 1993, Divens et al. 2001). Grass Pickerel is tolerant of a broad range of temperature, oxygen and certain physical habitat components, and may utilize an ecological niche in shallow, densely vegetated habitats that larger top predators have difficulty exploiting.

GENERAL HABITAT

Grass Pickerel is a resident of small, slow moving, mud, muck or clay bottomed, heavily vegetated lowland streams and small pond-like expansions of those streams or overflow ponds of larger streams. Occasionally, it is found in quiet weedy bays of lakes (Crossman 1962, Kleinert and Mraz 1966, Scott and Crossman 1973). The usual habitat for Grass Pickerel is water of mildly acidic to slightly basic nature, clear to tea coloured, with very slow to no flow, generally shallower than 2 m and abundant to dense submerged, floating and emergent aquatic vegetation (COSEWIC 2005). Photographs of typical Grass Pickerel habitat are presented in Figures 2 through 6.

COSEWIC (2005) stated that the water is characteristically clear in Grass Pickerel habitat, but Becker (1983) stated that it is found in clear to turbid water. Trautman (1981) observed that Grass Pickerel decreased in numbers or became extirpated whenever an increase in turbidity destroyed the aquatic vegetation. Increases in turbidity had a negative impact on Grass Pickerel feeding in Long Point Bay (COSEWIC 2005). The preferred water temperature for Grass Pickerel is 26°C (Crossman 1962, Wismer and Christie 1987); however, it is adapted to shallow, still waters that can warm rapidly and, thus, can tolerate higher temperatures (Scott and Crossman 1973, Coad et al. 1995). It has been reported surviving in streams with water temperatures as high as 32°C in Indiana and 34°C in Long Point Bay, Ontario (Cain et al. 2008, DFO unpbl. data). Grass Pickerel is also adapted to dissolved oxygen conditions as low as 0.3 mg/L, which allows it to utilize heavily vegetated, slow moving or still, shallow water that can be depleted of oxygen at night due to plant respiration (Crossman 1962, Scott and Crossman 1973). It can also tolerate high conductivity (e.g., over 2000 μs/cm) without any effect on abundance (Colm and Mandrak 2021, Colm et al. 2019). In fact, it appears tolerant of a broad range of water quality conditions provided in-stream cover (e.g., aquatic macrophytes, woody debris) is present (Cain et al. 2008).

Grass Pickerel is an ambush predator and is found in low velocity habitats. Cain et al. (2008) reported that all individuals captured in their study were found in low flow areas, generally runs or pools, while none were captured in riffles. Colm et al. (2019) found that sites with Grass Pickerel had significantly lower reach slopes than otherwise seemingly suitable sites without Grass Pickerel.

This species attains its highest population densities in shallow, weedy locations. The aquatic vegetation communities typically occupied by Grass Pickerel are similar to those in which Northern Pike and Muskellunge are found and include the pondweeds (*Potamogeton* spp.), coontail (*Ceratophyllum* spp.), pickerelweed (*Pontederia cordata*), knotweeds (*Polygonum* spp.), water lilies (*Nymphaea* spp. and *Nuphar* spp.), *Chara*, and filamentous algae (COSEWIC 2005, Kleinert and Mraz 1966, Colm 2015). These communities are fairly consistent across the range of Grass Pickerel, and a list of aquatic vegetation often associated with it can be found in Table 1. Ming (1968) noted that, in Oklahoma, it was sometimes found in pools without vegetation and was associated with a brush pile or overhanging shrubs. In studies conducted in Indiana and Ontario, catches of Grass Pickerel were positively correlated with prevalence of channel cover objects such as aquatic macrophytes and logs/woody debris (Cain et al. 2008, Colm et al. 2019).

In Canada, Grass Pickerel occurs in areas with clay plain physiography, and while the substrate associated with Canadian populations is usually clay, mud or muck, it is known to occur in areas with variable substrate types (COSEWIC 2005, Colm et al. 2019). The mean (± 1 standard deviation) composition of substrate types encountered with this species across Ontario was: 43 (± 24) % clay, 33 (± 27) % organic, 29 (± 21) % silt, 29 (± 27) % sand, 17 (± 20) % gravel, 12(± 17) % cobble, 9 (± 15) % boulder, and 2 (± 8) % bedrock/rubble/concrete (DFO unpbl. data). In winter, Grass Pickerel may burrow in mats of fallen leaves (Etnier and Starnes 1993).

A broad complex of warmwater species is usually associated with Grass Pickerel, including both pollution tolerant and intolerant species (Scott and Crossman 1973, Cain et al. 2008). Species most commonly detected with Grass Pickerel in Canada include Banded Killifish (*Fundulus diaphanus*), Bluntnose Minnow (*Pimephales notatus*), Brown Bullhead (*Ameiurus nebulosus*), Central Mudminnow (*Umbra limi*), Golden Shiner (*Notemigonus crysoleucas*), Largemouth Bass (*Micropterus salmoides*), Northern Pike (*Esox lucius*), Pumpkinseed (*Lepomis gibbosus*), White Sucker (*Catostomus commersonii*) and Yellow Perch (*Perca flavescens*) (Scott and Crossman 1973, AECOM 2015, Colm et al. 2019, DFO unpbl. data).

Grass Pickerel reportedly moves infrequently and only for short distances, presumably to hunt for food and shelter (Crossman 1962, Becker 1983, Kramski 2014). Spawning aggregations have been reported in lakes in Wisconsin (Kleinert and Mraz 1966); however, this behaviour has not been observed in Canada. In a movement study of Grass Pickerel in Beaver Creek, a stream in the Niagara region, Ontario, few individuals undertook long distance movements. There was no evidence of seasonal or cyclical patterns in these movements (as would be expected with spawning migrations), and the individuals that did move were typically of larger size and in better physical condition (Kramski 2014).

SPAWNING

In Canada, spawning takes place in water temperatures approximately 8 – 12°C (late March to early May), eggs hatch in 11 – 15 days at temperatures within or just below this range. Becker (1983) stated that spawning occurs at 4.4 – 11°C. The time between spawning to initiation of feeding by young is 2 – 5 weeks, depending on water temperature (COSEWIC 2005). No nest is built; the eggs are broadcast and abandoned, settling and adhering to vegetation (Becker 1983). Besides the main spring spawning period, there is evidence that a low intensity fall spawn can occur (Lagler and Hubbs 1943, Crossman 1962, Miller 1962, Kleinert and Mraz 1966, Tipton 1995); there is little information on the frequency of occurrence of a fall spawn, or if it leads to successful recruitment.

Neither reproductive migration nor homing are known in this species (COSEWIC 2005). Some older published sources refer to spawning migrations, which are apparently based on even older sources or on the assumption that spawning behaviour in Grass Pickerel is similar to that of Northern Pike, which does migrate. Kleinert and Mraz (1966) observed Grass Pickerel aggregated in a shallow slough attached to a Wisconsin lake, which warmed more quickly than the rest of the lake in the spring. Although a few Grass Pickerel could be seen scattered around the other shorelines and bays of the lake, suggesting that spawning occurred in many locations, eggs and fry were only abundant in the slough and were difficult to find elsewhere in the lake. Similarly, some locations in Beaver Creek, Ontario, yielded consistently larger catches of young-of-the-year Grass Pickerel than others; however, it is unclear whether Grass Pickerel preferentially spawned at these sites, or if spawning and recruitment were more successful in these locations (Colm and Mandrak 2021).

During the spawning period, Grass Pickerel was most often seen in groups of two to six fish in the shallow water bordering the margin of the slough (Kleinert and Mraz 1966). In support of these observations, adults of the closely related Redfin Pickerel congregate in small groups to spawn in shallow, heavily vegetated areas such as flooded pond banks or stream margins and in floodplains, overflow areas, and along grassy stream banks (Jenkins and Burkhead 1993, Smith 1985). Such floodplain habitats also act as nursery habitat for Grass Pickerel in the Niagara region (J. Barnucz, Fisheries and Oceans Canada, pers. comm.).

ADAPTABILITY

The Grass Pickerel has rather specific habitat requirements, as exemplified by its highly disjunct distribution in Canada. It is generally rare in Canada, but can be found in relatively high numbers inside and outside of its native range (successful introductions have occurred in the U.S.A.) where suitable habitat exists (COSEWIC 2005). It is tolerant of the natural fluctuations in water level, flow, temperature, dissolved oxygen and turbidity that are typical of its preferred habitat (Scott and Crossman 1973). However, extremes in water level (i.e., severe droughts) and flow that greatly reduce or eliminate habitat may have significant impacts on Grass Pickerel abundance. In Beaver Creek, Ontario, the abundance of Grass Pickerel declined from an average of 15 individuals captured per seine haul in three years prior to a drought, to an average of three per haul in the drought year and one year after (Colm and Mandrak 2021). Extreme climatic conditions like this are predicted to increase in frequency and intensity as a result of climate change (Intergovernmental Panel on Climate Change 2021).

THREATS TO GRASS PICKEREL

The greatest threats to Grass Pickerel are loss of aquatic or riparian vegetation, conditions resulting in low water levels, decreased water transparency, lowering of stream temperatures, and loss of connectivity to source or refuge habitats, most of which are associated with agricultural drain maintenance in Ontario and Quebec (Table 1; COSEWIC 2005, Beauchamp et al. 2012, Colm et al. 2019). Similarly, the general degradation of water quality, and the loss of still-water habitats may have negative impacts on this species. Other potential threats to Grass Pickerel are exotic species, climate change, disease, and to a lesser extent, interspecific interactions and fishing pressure (Beauchamp et al. 2012).

CONSIDERATIONS FOR THE PLANNING AND REVIEW OF PROPOSED WORKS THAT MAY IMPACT GRASS PICKEREL HABITAT

The effects of urbanization and agricultural practices on watercourses, either through direct impacts within these areas, or through indirect impacts from adjacent land-use practices, encompass most of the threats to Grass Pickerel populations. Agricultural drain maintenance negatively impacts this species across most of its native range in the United States and Canada. Although drain clean-outs may alleviate some drainage issues, the effects may only last for a short time if the true causes of the drainage problem are not addressed. Drainage issues resulting from insufficiently sized culverts, inadequate vegetated riparian buffer zones, and straightened, uniform channels that lack pools for water storage should be addressed directly to minimize the impacts on Grass Pickerel and its habitat. The following impacts on and potential mitigation measures for Grass Pickerel habitat should be considered in project planning and review. Additional mitigation measures for protecting fish and fish habitat during a variety of works and project activities can be found in Coker et al. (2010).

DIRECT DESTRUCTION AND ALTERATION OF HABITAT

Mechanism of Potential Impacts

The alteration of watercourses and associated wetlands through ditching, channelization, deepening and/or filling can remove aquatic vegetation and woody debris that are important components of Grass Pickerel habitat and alter shallow, vegetated areas that are used for spawning. Grass Pickerel decreased in numbers or became extirpated in Ohio streams wherever ditching, dredging or other forms of channelization destroyed its habitat or where an increase in turbidity destroyed the aquatic vegetation (Trautman 1981). Cain et al. (2008) found that Grass Pickerel could tolerate degraded water quality, provided that cover objects (aquatic macrophytes and woody debris) were present, which suggests cover may be the most important habitat element for this species. Sediment removal can destroy the seed bank, preventing the recovery of important aquatic and riparian vegetation, while sediment filling can add invasive plant species (Cromboux et al. 2002). If the watercourse is sufficiently deepened or substrate altered, the aquatic vegetation may not regenerate to its original quantity or quality.

Negative impacts to Grass Pickerel may also occur where the alteration of a watercourse results in the elimination or reduction of still-water habitats. Channelization of pool / riffle habitats results in the homogenization of flow velocity, and loss of large, slow pools most preferred by Grass Pickerel (COSEWIC 2005, Cain et al. 2008). Similarly, deepening or filling can alter the gradient of the stream bed and reduce the available area of still-water pools (Gorman and Karr 1978, Lau et al. 2006). Aquatic vegetation moderates flow velocity (Nepf 1999), and its removal can result in the loss of still water patches. The ditching or channelization of watercourses may also reduce or eliminate access to the floodplain, including sloughs and oxbow ponds where spawning and nursery habitat exist (Kleinert and Mraz 1966).

Although Grass Pickerel move infrequently, the species has declined in streams where passable connections to other waterbodies were lost (Colm 2015). This may be because larger waterbodies provide adequate refuge habitat during the summer and/or winter, or because they are a source for new individuals to recolonize from after extreme events (e.g., droughts) with high mortality (Colm 2015, Colm and Mandrak 2021). The largest individuals, most likely mature females, are more likely to undertake longer distance movements and are, therefore, important for gene flow and recolonization (Crossman 1962, Kramski 2014). Drainage activities that disconnect waterbodies (prior to spawning or permanently) or make movements between waterbodies undesirable (e.g., high flow), or risky (e.g., remove cover) should be avoided.

There is some evidence that local “hot-spots” exist for Grass Pickerel in Ontario streams. In a study conducted in Beaver Creek, Ontario, Kramski (2014) reported unidirectional Grass Pickerel movements exclusively into one branch of the creek despite there being no barriers that would restrict movement going the other way, suggesting this branch was more suitable (i.e., better habitat, greater food availability, predator avoidance). Habitat quality appeared to vary between pools in this creek, as some pools supported significantly greater numbers of Grass Pickerel than others across all years and seasons sampled (Colm and Mandrak 2021). Colm et al. (2019) found that habitat features at the local site scale were more important to Grass Pickerel in Ontario than at the reach scale suggesting this species is associating with specific microhabitat elements. Drainage activities that occur in these high quality areas could have a disproportionately greater impact on Grass Pickerel populations than works in other reaches.

Alternatives and Mitigation

For the construction or rehabilitation of watercourses containing Grass Pickerel, the use of natural channel design principles must provide shallow areas of quiet water where aquatic vegetation can establish and be maintained. Early spring flooded backwater areas for Grass Pickerel spawning habitat must remain flooded and connected to the main channel for at least two to five weeks once their preferred spawning temperature (8 °C) is reached.

If soil or vegetation must be removed from the channel bed or floodplain during maintenance works, it should be stockpiled on site (with appropriate sediment control) and some returned after maintenance. The soil is likely to contain a seed bank and organic matter with vegetative plant parts that can re-sprout quickly, promoting fast recovery of native vegetation. This is not recommended in cases where invasive plants (e.g., *Phragmites australis*) are common on the site (Cromboux et al. 2002). When soil and organic material preservation is not feasible, vegetation should be planted to achieve a similar community as what was found before drainage activities (see Table 2 for a list of species commonly associated with Grass Pickerel). There is limited information available regarding regeneration time of aquatic vegetation either through natural recolonization rates or success of replantings, and it is dependent upon many factors including climatic conditions, the primary reproductive strategy of the plant, timing of disturbance, turbidity (i.e., light penetration), and nutrient inputs (Duarte 1995, Vari 2013, Combroux et al. 2002), but macrophytes should regenerate by the end of the next growing season (Cromboux and Bornette 2004, Montgomery et al. 2017). If trees are removed from the site, branches or root wads should be placed in the stream or floodplain (overhanging) to provide cover. These may also be placed strategically to help promote the formation of pools or still back-water areas (Robison and Beschta 1989, Abbe and Montgomery 1996).

Habitat heterogeneity can be increased by adding woody debris objects, or by digging wide, deep pools that offer low velocity habitat preferred by Grass Pickerel. Carline and Kloseiwski (1985) found that the density of Grass Pickerel increased significantly after the installation of wing deflectors within a previously channelized watercourse, which resulted in the development of a meandering flow pattern, the creation of pools, and an increase in the area of rooted macrophytes. These pools will allow more water to be stored within the channel (and off the land), particularly during the summer and winter months, and will act as refuge habitat. An alternative to conducting drain cleanouts cross-sectionally from top of bank to top of bank, which often results in straight channels with homogeneous depth, is to dredge the interior of the channel only. This may allow for greater flow (and drainage) through the newly-formed thalweg, while leaving shallow, still water habitat with vegetation in-tact on the sides, ideal for spawning. Employing strategies such as limited or spot/phased cleanouts or culvert replacements (depending on the true cause of the drainage issue) will minimize habitat disruption, rather than a headwater to outlet approach. Spot or phased maintenance activities involve cleaning out some sections of a drain while ensuring that other sections are left untouched until habitat functions return to the maintained sections.

Although Grass Pickerel movement is limited, it may be necessary for population persistence, and care should be taken to ensure that fish passage is not permanently impaired. Potential effects from point-impact projects such as water crossings (e.g., culverts / bridges, pipelines) can be mitigated by using appropriate in-water work timing windows and sediment controls. Temporary disruptions to fish passage (e.g., temporary cofferdams to isolate and dewater a crossing during construction or replacement) should occur outside of the early spring and fall periods, when Grass Pickerel is not expected to move between spawning areas and overwintering habitats, providing sufficiently large habitat remains accessible as a summer refuge.

Local Grass Pickerel “hot-spots” (i.e., areas with high abundance) should be identified prior to drain maintenance and work should be conducted outside (preferably downstream) of these reaches wherever possible to achieve drainage goals. If maintenance is required in or near a hot-spot, local features (particularly woody debris, aquatic and riparian vegetation, and wetlands in the floodplain) should be preserved or restored as best as possible.

POLLUTION AND DEGRADATION OF WATER QUALITY

Mechanism of Potential Impacts

Pollutants can come from runoff from rural and urban landscapes containing pesticides, herbicides, fertilizers, residues of chemicals and fuels, and from de-icing salt applied to roads during the winter and drainage of private swimming pools. Some of these pollutants may settle out into the substrate but can become re-suspended during dredging operations. Additionally, cattle access to streams and runoff from stockyards can result in nutrient inputs. Besides the toxic effects of some of these pollutants on Grass Pickerel and other stream organisms, excess algae growth due to nutrient inputs can also negatively impact aquatic plants and dissolved oxygen levels. Grass Pickerel is tolerant of low dissolved oxygen concentrations and high conductivity (Crossman 1962, Scott and Crossman 1973, Colm et al. 2019), but direct and indirect effects from other pollutants are unknown.

Alternatives and Mitigation

Adequate vegetated buffer zones along watercourses in both urban and rural settings can mitigate much of the overland transport and input of pollutants by trapping and filtering particles. Cattle and other livestock can be excluded from watercourses by fencing. Where pollutants find their way into stormwater systems that discharge into Grass Pickerel habitat, appropriate stormwater quality treatment practices (e.g., vegetated swales/ bioretention cells, pervious pipe systems, oil and grit separators, etc.) should be installed to reduce these inputs.

SILTATION OF WETLANDS AND WATERCOURSES

Mechanisms of Potential Impacts

Runoff from construction sites, streets and parking lots, and tilled fields can carry soil particles as bedload or suspended particles that can gradually fill wetlands and low gradient watercourses and, at high concentrations, can also smother aquatic plants and benthic organisms. Cattle access to streams can result in the suspension of sediments and trampling of macrophytes. Floodplains denuded of vegetation during or resulting from maintenance, and dredgeate stockpiled on site may also contribute to siltation of watercourses. Very fine soil particles can remain suspended in the water column, blocking the sunlight necessary for submergent aquatic plant growth that is an important component of Grass Pickerel habitat. A reduction in Grass Pickerel abundance was observed at the site of a bridge construction on Twenty Mile Creek, Ontario soon after it was rebuilt. Heavy sedimentation resulting from lack of adequate controls may have contributed to the decline (N.E. Mandrak, University of Toronto - Scarborough, pers. comm.). Turbid water at a duration and intensity commensurate with a seasonally typical rainstorm event is likely little threat to Grass Pickerel, as it tends to be found in low gradient habitats with fine substrates. As a result, Grass Pickerel is probably less at risk from siltation than fish species that rely upon coarse substrates. However, turbidity of extended duration or high intensity that may result from improper sediment controls before, during or after drainage works may negatively impact submerged aquatic plants and / or Grass Pickerel hunting efficiency (Trautman 1981, COSEWIC 2005).

Alternatives and Mitigation

Adequate vegetated buffer zones along watercourses and wetlands in both urban and rural settings can mitigate much of the overland transport of sediment to these waterbodies. Standard soil conservation methods, such as no-till cropping, grassed waterways, and sediment catch basins can reduce sediment from agricultural lands entering watercourses and wetlands. Likewise, standard practices for keeping soils on construction sites (e.g., straw bales, sediment fencing, etc.) can be used to limit impacts from these sources. Where sediment accumulates in stormwater management systems (i.e., management ponds, tiled berms) that discharge into Grass Pickerel habitat, regular maintenance can remove some proportion of the suspended material and ensure these continue to trap sediments.

LOW WATER LEVELS

Mechanisms of Potential Impacts

Low water levels can be caused by drought, water extraction, and watercourse alteration that promote drainage. Low water levels can reduce access to shoreline, stream bank, or floodplain spawning and nursery areas. In a Wisconsin study, declining water levels due to drought trapped and subsequently killed young and adult Grass Pickerel within a slough where spawning had occurred (Kleinert and Mraz 1966). In an Ontario stream, an extreme drought reduced the stream habitat area to a few small, disconnected pools, leading to a decline in the Grass Pickerel population by almost five times (Colm and Mandrak 2021). Additionally, reductions in habitat area available to Grass Pickerel can result in increased predation risk from terrestrial and avian predators (J.Colm, Fisheries and Oceans Canada, pers. comm.).

Alternatives and Mitigation

While little can be done to mitigate drought conditions, the effect on Grass Pickerel habitat from changes in water levels caused by water extraction, watercourse alteration, or agricultural drain maintenance should be considered when evaluating any proposed works or activities. Constructed pools can provide refuge habitat during dry periods, as concentrations of Grass Pickerel have been observed in pools that had been dug wider and deeper than the rest of the watercourse for livestock watering (C. Portt and G. Coker, C.Portt and Associates, pers. comm.) and for increasing water storage following drainage off of fields (Glass et al. 2021). If a fish habitat mitigation plan includes the construction of Grass Pickerel habitat, pools of sufficient depth and width to provide area for refuge during droughts or extreme cold, and that allow for feeding and predator avoidance should be incorporated. These pools could include multi-level steps that would provide spawning habitat over a range of expected water levels. The dimensions of such pools will be specific to each stream and based on features such as natural channel width, available area of the floodplain, the stream gradient, contribution of ground water, etc.; however, pools with an area of 50 – 200 m^2 with a predicted minimum depth of 0.5

m in an average summer is desirable. If steps or terraces for spawning are to be incorporated into the design, they should be as wide and gradual as possible (Colm et al. 2019).

DIVERSION OF COLD OR COOL WATER INTO GRASS PICKEREL HABITAT

Mechanisms of Potential Impacts

Cooler water temperatures may have a detrimental impact on Grass Pickerel, which is a warmwater species and at the northern edge of its range in southern Ontario and Quebec. Deepening of watercourses may intercept groundwater sources, possibly resulting in the lowering of water temperatures that may negatively impact this warmwater species. Colm et al. (2019) found that Grass Pickerel only occupied sites and waterbodies with low groundwater input relative to surface water, suggesting it avoids cooler temperatures. Stormwater management facilities can maintain flow and lower water temperatures in downstream watercourses for longer periods of time.

Alternatives and Mitigation

Avoiding or mitigating the effect of cool and cold water discharge to Grass Pickerel habitats should be considered during the construction of infrastructure or the deepening of watercourses. The depth of groundwater flows should be measured before construction activities begin, and designs should ensure this depth is not breached. Stormwater management facilities can be designed to maintain downstream water temperatures (e.g. top-draw or shallow facility).

MITIGATION GUIDANCE PROVIDED IN THE MANAGEMENT PLAN FOR THE GRASS PICKEREL

In addition to the guidance provided above, the Management Plan for the Grass Pickerel (Beauchamp et al. 2012) provides general guidance on how to minimize impacts from drainage works to Grass Pickerel and its habitat. The text below is modified slightly from Beauchamp et al. (2012).

The following interim guidance on drainage activities has been provided to minimize impacts to Grass Pickerel habitat. Where possible, design considerations should seek to:

- Opt for point-impact projects such as road crossings to achieve drainage goals, rather than higher-impact activities such as channelization, dredging, etc.
- Encourage ‘spot (localized) clean-outs’ to minimize maintenance footprint.
- Incorporate natural channel design principles to recreate habitat complexity.
- Control sedimentation before, during, and after work to maintain clear water conditions.
- Select suitable timing windows. Projects within Grass Pickerel habitat should be avoided during the spawning / hatching / nursery period (from mid-March to the end of May).
- Conduct fish removals in isolated work areas, particularly pool habitats that may serve as important refugia during summer and winter months (DFO 2017).
- Maintain pool habitats that act as overwintering and summer refugia.
- Ensure floodplain connection is maintained: flooded terrestrial vegetation must remain wet for ~7 weeks to support development of eggs and larvae within known or suspected Grass Pickerel spawning habitats. Projects should minimize impacts to the duration and extent to which floodplains are inundated.

- Where vegetation is impacted, re-establish or enhance vegetative buffers along the channel. This may be achieved by returning soils that were dredged from the site that contain a seed bank or vegetative plant parts, or by replanting native vegetation found at the site prior to maintenance.

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TABLES

Table 1. Impacts of activities that threaten Grass Pickerel and its habitat and proposed mitigation measures. Please refer to summary of the functions, features and attributes of Grass Pickerel habitat found in the Appendix.

Activity/ Threat	Pathway of Effect (Coker et al. 2010)	Effect	Function Affected	Features Affected	Attributes Affected	Proposed Mitigation Measure
Direct destruction and alteration of habitat: removal of vegetation and soil	• Vegetation clearing • Riparian planting • Streamside livestock grazing • Placement of material or structures in water • Dredging • Addition or removal of aquatic vegetation • Change in timing, duration, or frequency of flow	Removal of vegetation results in the loss of cover that is important to Grass Pickerel during spawning and early development, and for predator avoidance and hunting. Vegetation also moderates flow, helping to create still-water areas preferred by Grass Pickerel. Ditching and dredging remove soil and the associated seed bank which may delay recovery or impact the quantity and quality of aquatic and riparian vegetation. Filling may result in the addition of invasive plant species or ones not native to the site; this could also occur through the usage of unclean construction equipment on the site.	Spawning, nursery cover, feeding cover	Margins of seasonally-flooded riparian areas, sloughs or associated wetlands and pool habitats of low-gradient, surface-fed streams	Dense submerged aquatic or terrestrial vegetation prone to flooding in spring or dormant perennial vegetation mats and mosses, with twigs and branches for eggs to adhere to above substrate and to provide cover for fry.	Use of natural channel design principles, where possible. Preserve soil and seed bank on site to help promote recovery of native vegetation. Planting native species that were present before maintenance activities. Adding coarse woody debris to channel and floodplain to provide cover.
Direct destruction and alteration of habitat: ditching/ channelization; deepening/dredging; filling	• Dredging • Placement of material or structures in water • Change in timing, duration, or frequency of flow • Structural removal	Channelization results in faster water velocity and a loss of pool habitats preferred by Grass Pickerel. Deepening or filling can alter the substrate and change the gradient of the stream, which will also influence flow velocity.	Spawning, nursery cover, refugia	Same as above	Calm water with little to no flow, often in low gradient pools of sufficient depth to decrease probability of die-off in winter months or drought periods. Shallow margins near edges prone to flooding in spring. Warm (23–29°C), clear water. Substrate dominated by clay/silt/organic/mud.	Identify true cause of drainage issue and ensure proposed project addresses this directly. Use of appropriate timing windows (i.e. work outside of spring and fall). Conduct limited/spot/phased clean-outs instead of a headwater to outlet approach. Use of natural channel design principles where possible. Digging wider, deep pools to store water. Adding coarse woody debris to promote the formation of pools and still water patches.

Activity/ Threat	Pathway of Effect (Coker et al. 2010)	Effect	Function Affected	Features Affected	Attributes Affected	Proposed Mitigation Measure
	• Placement of material or structures in water • Dredging • Change in timing, duration, or frequency of flow • Fish passage issues	All of these activities can result in the loss of access to the floodplain during spring flooding where spawning and nursery habitat exist. Activities could also reduce or eliminate access to the most productive spawning sites.	Spawning, nursery cover	Same as above	Shallow or flooded margins closest to edges. Ample aquatic and terrestrial/ riparian vegetation that is prone to flooding in spring that eggs can adhere to above the substrate.	Limit dredging to the centre of the channel (thalweg) leaving shallow vegetated habitat on the sides, ideal for spawning and nursery habitat. Use of timing windows outside of spawning season.
Pollution or degradation of water quality: on-site chemical spills; re-suspension of settled chemicals from: runoff from urban and rural lands containing pollutants (e.g., pesticides, herbicides, road salt, chemical spills, fuel, swimming pool water) and nutrients (e.g., fertilizers, manure)	• Grading • Excavation • Use of industrial equipment • Cleaning or maintenance of bridges or other structures • Riparian planting • Streamside livestock grazing • Placement of material or structures in water • Dredging • Organic debris management • Wastewater management • Addition or removal of aquatic vegetation • Change in timing, duration, or frequency of flow • Structural removal	Inputs of pollutants from various sources can reduce the quantity or quality of aquatic vegetation that is an important habitat element for Grass Pickerel. Nutrient inputs can result in excessive algae growth, reducing dissolved oxygen and out-competing macrophytes. Shifts in benthic invertebrate and forage fish communities resulting from their physiological tolerances to pollutants can have bottom-up impacts on Grass Pickerel.	Nursery cover, feeding cover	Same as above	Dense submerged aquatic or terrestrial vegetation prone to flooding in spring or dormant perennial vegetation mats and mosses, with twigs and branches for eggs to adhere to above substrate and to provide cover for fry. Ample submergent and emergent aquatic vegetation Substrate dominated by clay/silt/organic/mud. Warm water (23–29 °C).	Leaving adequate vegetated buffer strips to filter runoff and trap pollutants. Use of stormwater treatment practices (e.g., swales, pervious pipes, oil and grit separators).
Siltation of watercourses: increased siltation from agricultural field runoff; improper sediment controls on construction sites; cattle access to streams	Same as above.	Siltation can result in aquatic vegetation becoming smothered and suspended particles can block sun light from penetrating through water, reducing aquatic vegetation productivity. High or prolonged turbidity can reduce visibility and prey capture success for Grass Pickerel, a sight-predator.	Spawning, nursery cover, feeding cover, refugia	Same as above	Substrate dominated by clay/silt/organic/mud. Generally clear water.	Leaving adequate vegetated buffer strips to filter and trap sediments. Use of cattle exclusion fencing. On-site sediment controls (e.g., straw bales, sediment fencing).
Low water levels: water level alterations to increase drainage; drawing water/irrigation; drought	• Placement of material or structures in water • Water extraction • Dredging	Lowered water levels can result in a loss of habitat space, increased water temperature in the summer and decreased dissolved oxygen during summer and winter. This could lead to mortality events for Grass Pickerel or species it relies on.	Spawning, nursery cover, feeding cover, refugia	Same as above	All attributes.	Digging deep, wide pools to store more water during summer and winter months; these could contain multi-level steps that would provide spawning habitat regardless of water level.

Activity/ Threat	Pathway of Effect (Coker et al. 2010)	Effect	Function Affected	Features Affected	Attributes Affected	Proposed Mitigation Measure
	• Change in timing, duration, or frequency of flow					
Diversion of cold/cool water: dredging into groundwater	• Dredging • Placement of material or structures in water • Change in timing, duration, or frequency of flow • Structural removal	Inputs of cool or cold water could negatively impact Grass Pickerel, a warmwater species, or many of the other warmwater fishes it relies on.	Spawning, nursery cover, feeding cover, refugia	Same as above	Warm water (23–29 °C).	Conducting geological surveys/monitoring groundwater flows to ensure water table will not be breached during digging.

Table 2. Aquatic vegetation associated with Grass Pickerel across its range (based on data from Crossman 1962, Kleinert and Mraz 1966, Ming 1968, DFO unpbl data).

Frequency of Occurrence with Grass Pickerel	**Type**	**Name**	**Common name**
dominant	emergent	*Polygonum coccineum*	knotweed/smartweed
dominant	emergent	*Pontederia cordata*	pickerelweed
dominant	submergent	*Ceratophyllum demersum*	hornwort/coontail
dominant	submergent	*Stuckenia pectinata*	sago pondweed
dominant	submergent	*Potamogeton* spp.	pondweed
common	floating leaved	*Nuphar advena*	yellow pond lillies
common	floating leaved	*Nymphaea tuberosa, odorata*	white water lillies
common	floating	*Lemna minor*	common duckweed
common	floating		filamentous algae
common	submergent	*Elodea* spp.	waterweed
common	submergent	*Vallsineria americana*	water celery
common	submergent	*Myriophyllum* spp.	milfoil
occasional	emergent	*Typha latifolia*	broadleaf cattail
occasional	emergent/overhanging	*Alisma/ Veronica*	water plantain/ speedwell
occasional	overhanging (terrestrial)	*Cephalanthus occidentalis*	buttonbush
occasional	overhanging (terrestrial)	*Zizania* sp.	rice grass
occasional	submergent	*Chara* sp.	stonewort, muskgrass
infrequent	emergent	*Equisetum* sp.	water horsetail
infrequent	floating	*Callitriche* sp.	water starwort
infrequent	floating	*Spirodela* sp.	duckweed
infrequent	submergent	*Drepanocladus* spp.	aquatic moss
rare	overhanging	*Calamgrostis*	ornamental grass
rare	overhanging (terrestrial)	*Carex/ Eleocharis/Scirpus/Sparganium* spp.	sedge/bullreed/spikesedge
rare	overhanging (terrestrial)	*Phalaris arundinacea*	reed canary grass
rare	submergent	*Utricularia* sp.	bladderwort

FIGURES

Figure 1. Grass Pickerel (Esox americanus vermiculatus) from the Niagara River, Ontario. Photo credit: R. Gaspardy, DFO 2015.

Figure 2. Grass Pickerel habitat in southern Ontario. Photo credit: DFO 2009.

Figure 3. Grass Pickerel habitat in southern Ontario. Photo credit: DFO 2009.

Figure 4. Grass Pickerel habitat in southern Ontario. Photo credit: J. Barnucz, DFO 2009.

Figure 5. Grass Pickerel habitat in southern Ontario, April 16, 2009. Note that the vegetated habitat was observed to be continuously flooded for a minimum of one month. Photo credit: G. Coker, 2009.

Figure 6. Grass Pickerel habitat in southern Ontario, April 29, 2009. Note that the vegetated habitat was observed to be continuously flooded for a minimum of one month. Photo credit: G. Coker, 2009.

APPENDIX

Table A1. Summary of the habitat biophysical functions, features and attributes for Grass Pickerel.

Life Stage	Function	Features	Attributes
Spawn to Embryonic (<10 mm)	Spawning (late March-early May), 3–4 weeks from egg to swim-up	Margins of seasonally-flooded, vegetated riparian areas, sloughs or associated wetlands of low-gradient, surface-fed streams or quiet bays of lakes connected to Lake St. Clair, Lake Erie, Lake Ontario, Lake Huron/Georgian Bay	• Calm water with little flow / low gradient • Clear water† • Spawning initiated when water temp in margins reaches 8-12°C • Shallow water closest to edges (<0.5m) • Dense submerged aquatic or terrestrial vegetation prone to flooding during spring/ dormant perennial vegetation mats/ moss/ twigs and branches for eggs to adhere to above the substrate and to provide cover for fry
Young of Year (>10mm <100mm)	Nursery cover	Same as above	• Calm water with little to no flow / low gradient with pools of sufficient depth • Shallow or flooded margins (<1.5m) • Warm water (23–29°C) • Clear water† • Dominant substrate of clay/silt/organic/mud (occasionally sand and gravel) • Ample submergent and emergent aquatic vegetation (e.g. *Ceratophyllum* sp., *Potamogeton* sp., *Polygonum* sp., *Pontederia* sp.) and/or coarse woody debris
Juvenile - Age 1 until sexual maturity (2–3 yrs (100 to 140-160mm TL in Canada))	Feeding cover	Low-gradient, surface-fed streams or quiet bays of lakes (including coastal or associated wetlands, sloughs, flooded riparian areas) that are tributaries of/connected to Lake St. Clair, Lake Erie, Lake Ontario, Lake Huron/Georgian Bay	• Calm, shallow (<2.5m) water with little to no flow / low gradient • Warm water (23–29°C) • Clear water† • Dominant substrate of clay/silt/organic/mud (occasionally sand and gravel) • Aquatic vegetation and/or coarse woody debris
Adult	Feeding cover	Same as above	Same as above
YOY, Juvenile, and Adult	Refugia	Same as above	• Access to refuge areas with sufficient habitat to decrease probability of die-off in winter or drought periods

† Clear water is preferred by Grass Pickerel, but they may be found in turbid water in suboptimal conditions.